BRITISH COLUMBIA SEABIRD COLONY INVENTORY: REPORT #6 - MAJOR COLONIES ON THE WEST COAST OF GRAHAM ISLAND

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ABSTRACT

The west coast of Graham Island in the Queen Charlotte Islands supports over half a million breeding seabirds of 10 different species. Over 90% of that population is concentrated in three large colonies; on Langara, Frederick and Hippa Islands. The region supports 49% of the total population of Ancient Murrelets nesting in British Columbia.

Surveys on the west coast of Graham Island were conducted in 1980, 1981, 1983, 1986, and 1988. Only the major colonies on Langara, Frederick and Hippa islands have been surveyed under the Canadian Wildlife Service inventory program. Baseline population estimates for burrowing species at smaller colonies are lacking. The Ancient Murrelet colony on Langara Island was surveyed in 1981 and again in 1988 to determine population trends and evaluate the impact of introduced mammalian predators. Cox and Lucy islands, which are adjacent to Langara Island and historically supported sizeable colonies, were explored in 1981 to determine their current status.

Introduced mammalian predators are the most serious threat to breeding populations in the region. Alexandrian rats have likely contributed to the disappearance of storm-petrels, Cassin's Auklets, Rhinoceros Auklets, and Tufted Puffins and to the decline of Ancient Murrelets on Langara Island. All colonies in the region should be monitored for the presence and potential impact of raccoons.

RESUME

La côte ouest de l'île Graham des îles de la Reine-Charlotte abrite plus d'un demi-million d'oiseaux de mer reproducteurs appartenant à dix espèces différentes. Plus de 90 % de cette population est concentrée dans trois grandes colonies, à savoir les îles Langara, Frederick et Hippa. Dans cette région vit 49 % de la population totale d'alques à cou blanc, qui nidifie en Colombie-Britannique.

On a procédé en 1980, 1981, 1983, 1986 et 1988 à des études de la côte ouest de l'île Graham. Seules les principales colonies des îles Langara, Frederick et Hippa ont fait l'objet de recensements dans le cadre du programme d'inventaire du Service canadien de la faune. On ne possède pas les estimations des populations de base pour les espèces de colonies plus petites nichant dans des terriers. La colonie d'alques à cou blanc de l'île Langara a été recensée en 1981, puis de nouveau en 1988, afin de déterminer l'évolution de la population et les effets de l'introduction de mammifères prédateurs. Les îles Cox et Lucy, qui sont voisines de l'île Langara et qui ont depuis toujours abrité des colonies assez importantes, ont été explorées en 1981 afin de faire le point sur la situation actuelle.

Les mammifères prédateurs introduits sur ces îles représentent la menace la plus grave pour les populations reproductrices de la région. Les rats gris ont probablement contribué à la disparition des pétrels, des alques de Cassin, des macareux rhinocéros et des macareux huppés, ainsi qu'à la diminution de la population d'alques à cou blanc sur l'île Langara. Toutes les colonies de la région doivent faire l'objet de mesures de surveillance à cause de la présence de ratons laveurs et des effets qui pourraient en découler.

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ACKNOWLEDGEMENTS

Colony inventories were conducted on Langara, Frederick and Hippa Islands along the west coast of Graham Island as part of the Migratory Birds Conservation Program of the Canadian Wildlife Service, supervised by K. Vermeer (1980 - 1983) and G.W. Kaiser (1983 and 1988). Special technical advice has been received from G.E.J. Smith, J-P.L. Savard, and A.J. Gaston.

We are grateful to the Canadian Coast Guard, the Federal Department of Fisheries and Oceans crew on the Sooke Post, and Art Babcock on the Bajo Point who provided transportation of field crews and supplies to the various field camps.

Permission to work on Hippa Island, part of the Port Chanal Provincial Ecological Reserve, was granted by J.B. Foster.

Field work was lead by Moira Lemon on Frederick Island in 1980 and 1981, Michael Rodway on Langara Island in 1981, Moira Lemon and Michael Rodway on Hippa Island in 1983, Michael Rodway in 1986, and Doug Bertram on Langara Island in 1988.

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1986: Christine Rodway, Joy Ann Rodway

1988: Heather Hay, Kent Henderson, Norman Holmes, Mike McKay

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INTRODUCTION

The west coast of Graham Island in the Queen Charlotte Islands supports over half a million breeding seabirds of 10 different species (Rodway 1991). Over 90% of that population is concentrated in three large colonies on Langara, Frederick and Hippa islands (Fig. WG-1 and Appendix I). The region supports 49% of the total population of Ancient Murrelets (*Synthliboramphus antiquus*) nesting in British Columbia (Rodway 1991).

Surveys in 1977 (Campbell and Garrioch 1979) located most seabird colonies in this region, and provided estimates of nesting populations. Accurate nest counts were made in 1977 for Pelagic Cormorants (*Phalacrocorax pelagicus*), Black Oystercatchers (*Haematopus bachmani*) and Glaucous-winged Gulls (*Larus glaucescens*), providing population estimates to which future counts could be compared (see Rodway 1988). Census methods for burrowing species were not systematic, and could only be used to detect large changes in nesting distribution and population size. Historical data and known changes are presented in Seabird Colonies of British Columbia (Rodway *et al.* in prep.).

The Canadian Wildlife Service began inventories of nesting seabirds in the Queen Charlotte Islands in 1980. The goal of that inventory program was to establish a replicable baseline estimate of all colonial nesting seabird populations that could be used to make effective management decisions, to monitor future population trends, and to identify current and potential threats to those populations. Breeding distribution and populations of the non-colonial Marbled Murrelet (*Brachyramphus marmoratus*) which likely nest in this region are unknown. Special survey methodology will be required to address the unique conservation problems presented by that species (Sealy and Carter 1984; Rodway 1990).

Surveys on the west coast of Graham Island were conducted in 1980, 1981, 1983, 1986 and 1988. Only the major colonies on Langara, Frederick and Hippa islands have been surveyed under the Canadian Wildlife Service inventory program. Baseline population estimates for burrowing species on Marble Island and at smaller colonies are lacking. The Ancient Murrelet colony on Langara Island was surveyed in 1981 and again in 1988 to determine population trends and evaluate the impact of introduced mammalian predators. Cox and Lucy islands, which are adjacent to Langara Island and historically supported sizeable colonies, were explored in 1981 to determine their current status. Previously produced reports on those surveys (Rodway *et al.* 1983; Bertram 1989) have been edited and included here to present all recent survey data for the region in a standardized format. Population estimates presented in those reports have been revised using standardized methodology (see Methods). Data on surface nesting species from 1986 has been extracted from Rodway (1988), to include all survey data for major colonies on the west coast of Graham Island in this report. Detailed data on breeding chronology, population parameters and predation on Frederick and Langara islands gathered under the supervision of Dr. K. Vermeer have also been included (see Vermeer *et al.* 1984, 1985, and 1988, Vermeer and Devito 1988, Vermeer and Lemon 1986).

This volume is the sixth in a series of technical reports that present detailed information on the status of nesting seabirds in various regions of the British Columbia coast and on the survey methods that have been used to determine that status. The level of detail in this series is intended to facilitate future surveys and research on the coast. We have attempted to provide precise descriptions of colony characteristics and helpful suggestions on the logistics of working on colony islands.

Introduced mammalian predators are the most serious threat to breeding populations in the region. First black rats (*Rattus rattus*) and more recently Norway rats (*R. norvegicus*) (R. Taylor, pers. comm.) have likely contributed to the disappearance of storm-petrels (*Oceanodroma* sp.), Cassin's Auklets

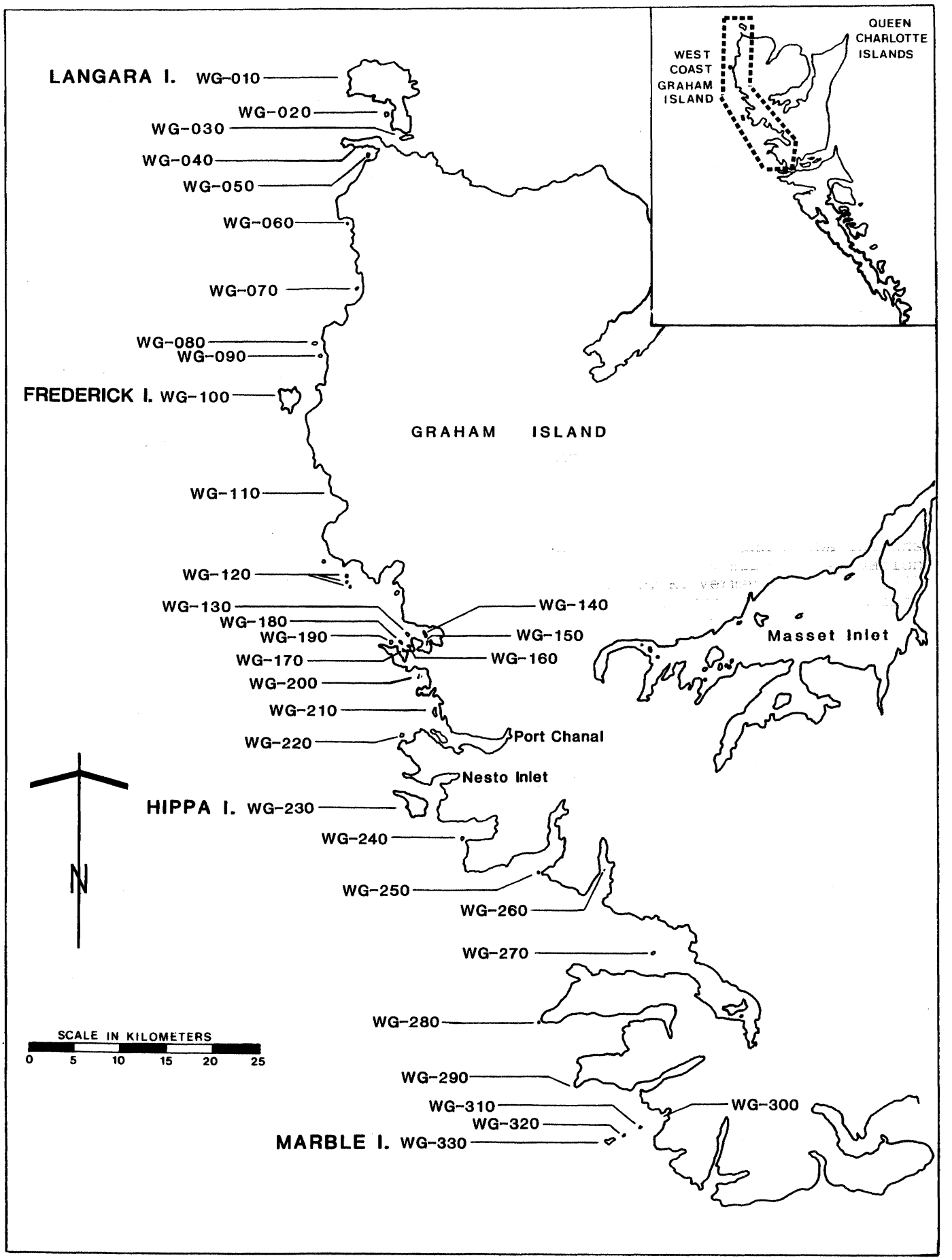

Fig. WG-1. Locations of seabird colonies on the west coast of Graham Island.

(*Ptychoramphus aleuticus*), Rhinoceros Auklets (*Cerorhinca monocerata*) and Tufted Puffins (*Fratercula cirrhata*) and to the decline of Ancient Murrelets on Langara Island (Bertam 1989; Rodway *et al.* in prep.). Marten (*Martes americana*), though indigenous to larger islands in the Queen Charlotte Islands (Foster 1965), were introduced to Lucy Island, off the south end of Langara Island, in the 1920's (Cumming 1931) and probably contributed to the elimination of the Ancient Murrelet colony there. Lighthouse keepers on Langara Island have reported marten on Langara Island in recent years (K. Bruun pers. comm.). Raccoons were introduced into the Queen Charlotte Islands in the 1940's and have since spread the entire length of the archipeligo. They have reached colony islands on the east coast of Moresby Island (Rodway *et al.* 1988; Summers and Rodway 1988; L. Hartman pers. comm.) and may be the most serious threat to nesting populations in that area. There have been reports of raccoons on Langara Island (Beebe 1960; K. Bruun pers. comm.), and we have sighted them on the beach in Peril Bay adjacent to Frederick Island.

A rat extermination program on Langara Island is currently being implemented (G. Kaiser pers. comm.). All colonies in the region should be monitored for the presence and potential impact of raccoons.

METHODS

Most surveys were timed to coincide with the nesting periods of Ancient Murrelets and Cassin's Auklets (April to June). In 1983 we remained on Hippa Island through September to census and study Fork-tailed and Leach's storm-petrels (*Oceanodroma leucorhoa* and *O. furcata* - see Vermeer and Devito 1988 and Vermeer *et al.* 1988). To census surface nesting species an independant survey was conducted in July 1986 (Rodway 1988).

Census methods were selected according to the area, habitat, and species of birds nesting on an island (Nettleship 1976). Islands were explored to determine the extent of nesting. Cox and Lucy islands were completely examined. On the larger islands the entire perimeter was explored to a distance of 50 m from shore, plus frequent sections of the interior up to 200m from shore. If no nesting seabirds were found no further searching was undertaken. If nesting was encountered exploration was continued to determine colony boundaries and the appropriate census techniques. On Langara Island in 1988, only the main areas where Ancient Murrelets had been found nesting in 1981 were explored.

1. Total Count. Total nest counts were made for Pelagic Cormorants, Black Oystercatchers and Glaucous-winged Gulls. Population estimates equal the number of nests counted. Within the text, lists of nests counted use these abbreviations: Emp - empty; E - egg; Y - young; Ad - adult.

Total numbers of Pigeon Guillemots (*Cepphus columba*) seen around colonies were counted, but no standardized observation techniques were employed (see Nettleship 1976), and no attempt was made to estimate actual nesting populations.

2. Line Transects With Quadrats. Line transects were used to sample burrow densities in storm-petrel and alcid colonies.

2.1. **Transect location.** After the colony was mapped during exploration, transects were run throughout colony areas. On Langara Island in 1981, transects were distributed around the entire island to sample habitat both in and out of colony areas. Transects were laid out upslope, generally perpendicular to the shoreline, except on the narrow north end of Hippa Island, where transects were laid out along parallel bearings to avoid convergence or divergence inland. Those transects were run across the long axis of the north peninsula of Hippa Island to insure representative sampling of variations in species distribution and burrow density which are more pronounced in a direction perpendicular to the

shoreline than parallel to it. On Hippa Island transects were evenly spaced 200 m apart while on Frederick Island they were placed at varying distances between 80 and 500 m. On Langara Island in 1981, transects were arbitrarily placed 600 to 1000 m apart in an effort to obtain representative samples of predominant local vegetation (ie. stream beds were avoided). In 1988 on Langara Island, transects were run through extant Ancient Murrelet colony in the same locations as in 1981. Sampling was intensified by running additional transects between those laid out in 1981. We attempted to sample 1% of the area of a colony. That value was the maximum sampling effort we found possible within the time allotted. Transects were located either by measuring the spacing distance along a line perpendicular to the transect bearings (along the shore if this was feasible), or by locating reference points plotted on air photos (for areas where the topography was extremely dissected or impassable).

2.2. **Quadrats:** Quadrats were set at predetermined intervals along transect lines, with the first quadrat at the shore edge of the vegetation, unless that was inaccessible, and the last placed beyond the interior extent of the colony. Plots ranged in size from 3x3 m to 7x7 m, depending on the density of burrowing. The size was selected so that an average of at least one burrow occurred in each quadrat. Low density colonies of Ancient Murrelets often required large plots to obtain burrows within them, while dense colonies of storm-petrels or Cassin's Auklets could be sampled with smaller, more frequent plots (Savard and Smith 1985). Quadrat spacing varied from 15 m for 3x3 m plots, to 40 m for 7x7 m plots.

Burrows were counted within each quadrat and their characteristics recorded: location (ie, under roots, stumps, logs, grass tussocks, etc.), accessibility (whether it was obscured, or obstructed), and signs of activity (droppings, feathers, etc.), both at the entrance and in the tunnel. Habitat parameters were measured: distance from shore, altitude, slope, percent and species composition of ground cover, shrub cover, and forest canopy. To place the quadrat in the context of the overall habitat, tree species, percent composition, and average size (dbh), and general terrain features were documented for the area surrounding each quadrat within a radius equal to half the distance between quadrats. Evidence of predation (eggshells, carcasses, feather piles) within each quadrat was recorded. Detailed analyses of habitat data are not included in this report.

2.3. **Colony area**: Colony area was defined to include all portions of an island where burrows with recent signs of activity (droppings, feathers, regurgitated food, fragments of eggshell or egg membrane, worn entrances or tunnels, excavation, or fresh nesting material) were located. If burrows were located, but no signs of recent activity were observed in an area, the colony was considered abandoned. If there were no burrows within a quadrat, the surrounding area was searched for colony evidence to determine if the plot fell within the colony and should be used in density calculations. If no burrows were found within a distance halfway to adjacent quadrats along the transect, nor within a lateral radius half the distance to adjacent transects, then that area was not considered colony and the plot data was not used in density calculations. If burrows and signs of activity did occur within this range, then the area was considered colony and the plot data was used as part of the burrow density sample. If active looking burrows were observed in the vicinity of one quadrat, but were absent from the area surrounding an adjacent quadrat the colony boundary was delimited halfway between the two quadrats, unless an obvious border was encountered. The same criteria was applied between transects. This degree of resolution of colony boundaries was as accurate as time and equipment allowed for extensive Ancient Murrelet colonies. For storm-petrels and Cassin's Auklets, whose colony boundaries were usually less extensive and more distinct, a finer resolution could be obtained, and precise measurements were often possible.

Distance, elevation, and slope measurements taken along the transects, as well as during the exploration, were used to draw colony areas on detailed topographic maps or air photos. The horizontal surface area of the colony was measured on that map with a compensating polar planimeter. Adjusting for slope, the area of the colony was given by:

$$C_s = A_h \, T^2 (\cos\theta)^{-1}$$

where C_s is the colony surface area, A_h is the area on the map, T is the scale of the map, and θ is the mean slope along the transects. Previous colony area estimates on Langara Island (Rodway *et al.* 1983; Bertram 1989) were calculated using the perimeter length of the colony along shore multiplied by the average inland extent of the colony as measured along transects. To maintain consistency with the methodology employed for other colonies, we recalculated colony areas mapped from those surveys using a compensating polar planimeter as described above. The colony area calculations take into account the average uphill slope, but not the undulations between quadrats or between transects. Therefore our calculations give a conservative estimate of the total surface area available to the birds for nesting.

2.4. **Burrow density**: Counts from all plots within colony area were used to calculate an average burrow density for the entire colony. This average density was used for population calculations. If marked and consistent differences in densities were encountered in different parts of a colony, those areas were separately mapped and individual density rates were calculated. Assigned density classes are unique to a particular colony and cannot be equated to those designated for other colonies. Their purpose is to demarcate areas of nesting concentration within a colony. Densities are quoted plus or minus one standard error. On figures, burrows/ha is abbreviated to b/ha.

2.5. **Burrow occupancy:** The percentage of burrows that actually contained nesting birds was determined by complete examination of a sample of burrows. If an adult, egg, chick, or freshly hatched egg membrane was found, the burrow was considered occupied. Burrows were considered empty if all tunnel branches were explored and none of the above were found. Signs such as a well worn entrance or droppings were not used to distinguish between occupied and empty burrows. Exploring burrows longer than an arm's reach required digging one or more access holes until the end was reached. Excavated holes were immediately patched with sticks and soil. The contents of many burrows were impossible to determine because they extended under roots or fallen trees or into cavities within tree bases. To minimize disturbance, adults were not pulled from burrows except to confirm species identification.

To obtain a representative sample of the entire colony, we attempted to determine the occupancy of each burrow located within surveyed quadrats. Due to time constraints we were often unable to accomplish this. In those cases we selected quadrats from different areas of the colony and explored every burrow in each quadrat selected. The selection process was not systematic (see Methodological Considerations and Recommendations). Occupancy tables within the colony accounts indicate quadrats where occupancy data was obtained. They do not list quadrats where effort was spent but no burrow contents determined.

When we had data on occupancy from several plots, we calculated the occupancy rate according to the formula:

$$R = \frac{\bar{x}}{\bar{y}}$$

where x_i is the number of occupied burrows in the ith quadrat, and y_i is the total number of occupied plus empty burrows in the ith quadrat and $\bar{x}$ and $\bar{y}$ are, respectively, the mean of the x_i and y_i over all quadrats.

The variance of R is calculated from:

$$Var(R) = \frac{\bar{x}^2}{\bar{y}^2}\left(\frac{s_x^2}{\bar{x}^2} + \frac{s_y^2}{\bar{y}^2} - \frac{2s_{xy}^2}{\bar{x}\,\bar{y}}\right)$$

where s_x is the standard error of $\bar{x}$, s_y is the standard error of $\bar{y}$, and s_{xy}^2 is the covariance of $\bar{x}$ and $\bar{y}$.

The standard error of R is the square root of Var(R).

2.6. **Total burrows and current nesting estimates:** The total number of burrows (**B**) is the product of the overall average density of burrows as determined in the quadrats and the total area of the colony. **B** multiplied by the occupancy rate, (**R**) gives an estimate of nesting pairs (**P**). Calculations are quoted plus or minus one standard error.

$$P = BR$$

The variance of P is calculated from

$$Var(P) = B^2\,Var(R) + R^2\,Var(B) - Var(B) \cdot Var(R)$$

The standard error of P is the square root of Var(P).

3. Distinguishing species:

The burrows of different species are often mixed. This presents problems for surveyors when burrow contents cannot be determined. Identification of burrows must then be based on indicative signs found in the burrow or at the burrow entrance. We developed a set of criteria for distinguishing burrows of storm-petrels, Ancient Murrelets and Cassin's Auklets: size of entrance; wear at the entrance; droppings in and around the burrow entrance; regurgitated food (for Cassin's Auklet); feathers found in the burrow; eggshell fragments found in the burrow; and odour. No Rhinoceros Auklets or Tufted Puffins were found nesting in association with other species on the three major colonies on the west coast of Graham Island (see Rodway et al. 1988; 1990a,b).

Storm-petrels often nest in conjunction with Cassin's Auklets and less often with Ancient Murrelets. Storm-petrel burrows at colonies along the west coast of Graham Island were readily distinguished according to size (5-7cm wide). The musty odour of petrels was also helpful.

Ancient Murrelets and Cassin's Auklets were found nesting in the same areas. Their burrows are similar in size (10-12cm wide). Droppings, regurgitated food, eggshell fragments, and feathers provide evidence for differentiating burrows of those species. Ancient Murrelets have relatively clean burrow entrances. Their droppings are yellowish-white and are usually placed away from the entrance. Cassin's Auklets leave white fecal streaking along the approach and into the entrances of their burrows. Cassin's Auklet droppings also have a more arresting odour, as does their regurgitated food, some of which they invariably lose at the entrance to their burrows when delivering it. Abdominal feathers (which are often lost in the burrows) of each species can be distinguished by the colour pattern of their plumules (size is not reliable). Ancient Murrelet plumules are half

dark and half white. Cassin's Auklet plumules are mostly dark with a tip of white. Eggshell fragments of Cassin's Auklets are white and are easily distinguished from those of Ancient Murrelets which have a pale olive background with dark speckling throughout.

4. Predation:

During exploration, notes were kept of all signs of predation or mortality encountered. Areas around Bald Eagle, Peregrine Falcon, and Common Raven nests, and around river otter runs and dens were examined in detail. This gave an indication of the degree and the kind of species being preyed upon. To quantify the level of predation, we calculated the density of prey remains recorded in quadrats, using the minimum possible number of birds represented by the evidence found. We assumed that one feather pile represented one bird. Estimates only allow coarse comparisons between colonies because surveys occurred at various times in the nesting season. It underestimates total predation because plots only sample remains left within the colony before the end of the season. Locations of Bald Eagle nests and Peregrine Falcon eyries are indicated on colony maps.

5. Staging:

Near dusk, prior to flying into their nesting slopes, Ancient Murrelets typically aggregate on the water adjacent to their colony. To locate these staging areas, water transects were run in inflatable boats when the weather was calm enough to see birds on the water. Bearings, distance from shore, time, and number of birds sighted were recorded for each water transect. Locations of staging concentrations were determined by proximity and bearings to recognized points of land. If birds were not encountered, the boat was often stopped so that birds might be heard calling from the water.

In 1988 on Langara Island, staging activity was monitored from shore by telescope (see island account).

6. Time:

Times quoted are Pacific Standard Time, adjusted to Daylight Savings Time at 0200 h on the last Sunday in April of each year (26 April 1981, 24 April 1983, 31 April 1988) unless otherwise noted. Subtract one hour from Daylight Savings Time to calculate Pacific Standard Time.

ISLAND ACCOUNTS

WG-010 LANGARA ISLAND 103 K/2,3,6,7

Location: Northwest tip of Graham Island. 54°14'N 133°W

Land status: Crown Land; Canadian Coast Guard Lighthouse reserve on NW corner.

Date of visit: 6 May to 15 June 1981 (exploration and transecting of entire perimeter); 1 July 1986 (1430-1730 h - total count of cormorants and gulls); 6 May to 7 June 1988 (transects through Ancient Murrelet colony).

Colony access: Boat landings can be made on the bouldery beach at McPherson Point. The beach is subject to intense wave action during rough weather. Landings also can be made on beaches along the east, south and west sides of the island.

Base camp: In 1981, we located our base camp in Lord Bight on the west coast of the island. The 1988 camp was placed on the south side of McPherson Point which is a more appropriate location if studies are confined to the remaining Ancient Murrelet colony. Bays at the south end of the island also provide suitable camp sites.

Observers: 1981: M. Rodway, N. Hillis, L. Langley. 1986: M. Rodway, C. Rodway, J. Rodway. 1988: D. Bertram, H. Hay, K. Henderson, N. Holmes, G. Kaiser, M. McKay.

Census method: **1981:** Line transects: 229 quadrats, 5x5 m, were surveyed every 40 m along 36 transects placed 600 to 1,000 m apart around the perimeter of the island (Fig. WG010-1; Table WG010-1). Total numbers of cormorants, gulls and guillemots were counted.

Observations on the nocturnal behaviour of Ancient Murrelets and the number of birds heard flying into and out of the colony were made just south of McPherson Point on four nights from 16 to 19 May, and on the north side of Cohoe Point, approximately 80 m above sea level, on the nights of 1 to 3 June. To monitor nocturnal behavior of Ancient Murrelets three observers entered the colony prior to 2200 h, stationed themselves in inconspicuous slope locations, and remained there until 0600 h. Activity of predators was also monitored.

To augment data on predation recorded during exploration and along transects, a 20x60 m plot was established in a relatively dense nesting area south of McPherson Point. Depredated remains were counted and nocturnal observations were conducted within the plot.

Observers thoroughly explored the staging areas outlined by Sealy (1976), zigzagging the areas by boat and counting Ancient Murrelets on the water. Locations and times of water surveys were: Cloak Bay - 2045-2315 h on 25 May, 2200-2230 h on 31 May, 2310-2330 h on 9 June, and 2150-2220 h on 11 June; Parry Passage - 2020-2030 h on 8 June; Explorer Bay and east - 2210-2230 h on 11 May; Egeria Bay to Langara Rocks - 2030-2230 h on 8 June.

1986: Total count for Pelagic Cormorants and Glaucous-winged Gulls.

1988: Line transects: 108 quadrats, 5x5 m, were surveyed every 40 m along 16 transects placed 300 to 500 m apart through Ancient Murrelet colony mapped in 1981 along the northeast side of the island (Fig. WG010-2; Table WG010-2).

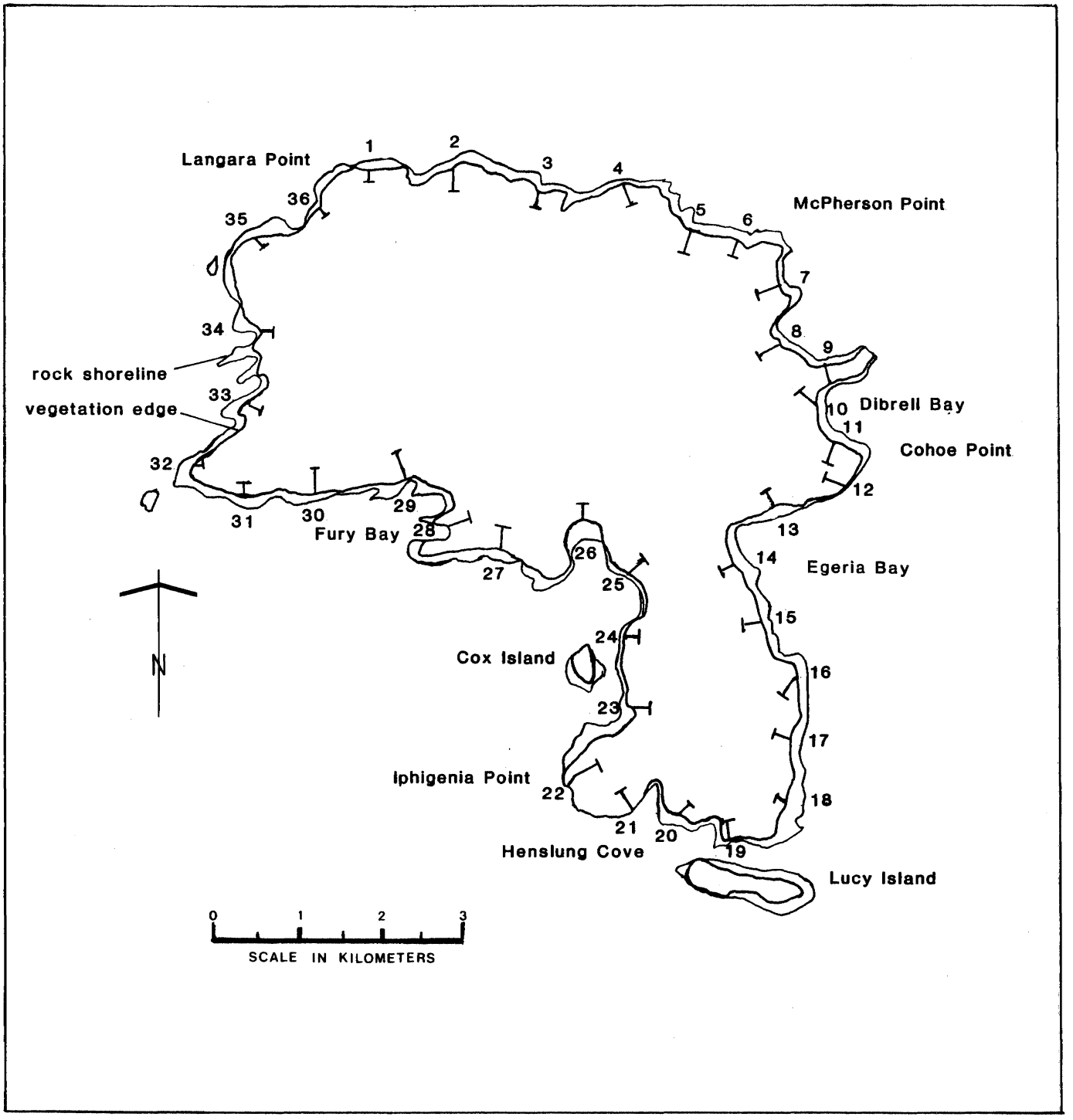

Fig. WG010-1. Locations of transects on Langara Island in 1981.

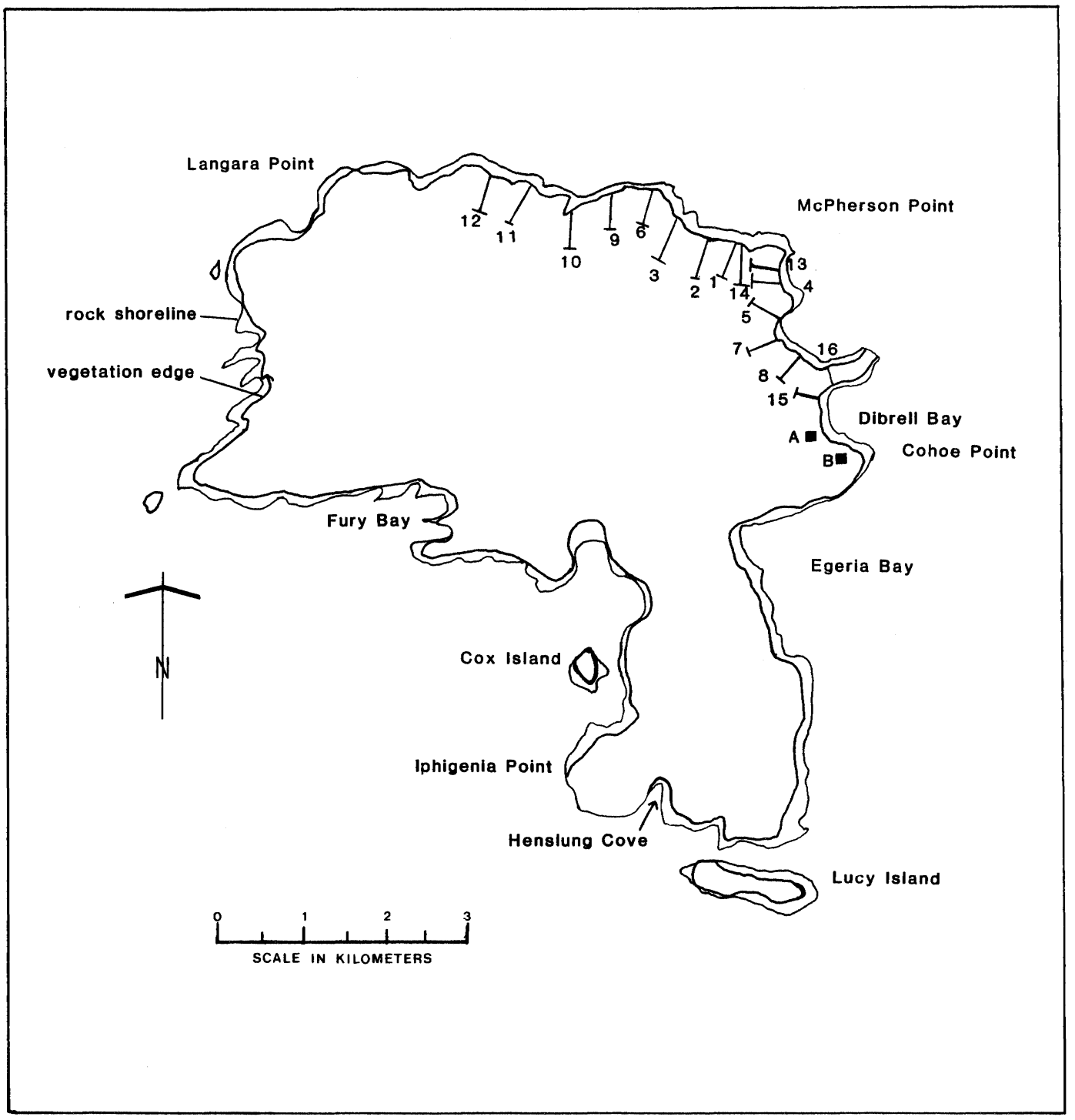

Fig. WG010-2. Locations of transects and exploration plots on Langara Island in 1988. (adapted from Bertram,1989)

Table WG010-1. Transect parameters on Langara Island in 1981.

Transect No.	Bearing (o)	Length of transect (m)	Elevation Beg. (m)	Elevation End (m)	Average slope (°)	Range of slopes (°)	Closest approximate location
1	180	155	1	30	12	8-17	NE of Langara Pt. E of 3 tidal rocks offshore.
2	180	280	7	17	7	0-42	W side of point E of bay E of Langara Pt; 600 m E of boathouse.
3	190	200	1	20	7	3-20	Halfway between Langara and McPherson Pt.; bearing 38° to 3 eastern Langara Rocks.
4	150	280	10	34	5	2-14	West side of point NW of McPherson Pt.; bearing 324° to eastern most Langara Rock.
5	200	280	2	50	10	2-40	700 m W of Bay on N side of McPherson Pt.
6	200	240	2	35	8	4-15	First projecting knoll on W side of Bay on N side of McPherson Pt.
7	250	280	10	65	12	2-22	S of McPherson Pt. Second point N of Explorer Bay.
8	240 (at 80 m bearing changed to 225 due to creek bed)	280	1	35	8	0-14	Explorer Bay 5 m S of creek mouth.
9	343	180	1	3	13	3-32	N corner of Dibrell Bay (across point).
10	315	280	1	40	17	0-64	Dibrell Bay N of creek in Indian Reserve.
11	200	280	1	40	13	2-45	NW of Cohoe Pt. S of Dibrell Bay.
12	290	280	3	51	15	2-45	S side of Cohoe Pt.
13	326	200	1	15	4	2-12	N side of Egeria Bay 600 m N of N boundary of Indian Reserve.
14	240	200	1	35	11	1-52	Egeria Bay S end of Indian Reserve.
15	260	200	2	30	8	5-14	S side of Egeria Bay, 800 m S of southern boundary of Indian Reserve.
16	220	240	3	55	14	0-34	S end of Egeria Bay N end of solid conglomerate shore.
17	290	200	1	30	9	4-21	1200 m N of Holland Pt. between Holland Pt. and Egeria Bay.
18	290	80	1	4	3	1-4	N of Holland Pt.
19	0	160	1	10	4	0-15	Dadens-middle of beach facing Solide Passage.

Table WG010-1. cont'd

Transect No.	Bearing (o)	Length of transect (m)	Elevation Beg. (m)	Elevation End (m)	Average slope (°)	Range of slopes (°)	Closest approximate location
20	50	160	1	80	13	5-27	Between Beal Cove and Henslung Cove 30 m W of Testlatlints Rock.
21	330	240	1		25	4-81	At SE tip of Iphigenia Pt. on W side of Henslung Cove.
22	40 (at 80 m bearing changed to 60 due to cliff)	400	30	110	11	3-25	Western most projection Iphigenia Pt.
23	90	200	1	25	8	3-16	Kusgwai Passage middle of first beach N of Iphigenia Pt.
24	90	200	1	40	13	2-28	Kusgwai Passage and from N tip of Cox Island.
25	50	200	1	12	4	0-9	E side of Hazardous Cove.
26	0	160	1	45	21	4-64	Middle of beach at N end of Hazardous Cove.
27	10	280	2	10	3	0-8	Projecting rock knoll W of Hart Pt.
28	70	240	1	6	1	0-4	N corner of Bay S of Fury Bay.
29	340	320	8	120	23	2-53	N corner of Bay N of Fury Bay.
30	0	280	2	100	11	2-18	Halfway between Fury Bay and point by Lacy Is. (due N from E end of small offshore islet).
31	0	100			20	5-40	1,000 m E of Lacy Is. point.
32	80	120	1	12	14	0-23	Point by Lacy Is.
33	110	160	5	40	22	0-47	Lord Bight, second point S of Bay with cabin.
34	90	160	1	20	11	0-45	Lord Bight - middle of Northern Bay N of cabin.
35	130	160	1	25	8	0-15	Point just N of Thrumb Islet end of Radar Pt.
36	135	120	1	50	28	9-57	Bay just S of Langara Pt.

Table WG010-2. Transect parameters on Langara Island in 1988. Transect numbers from 1981 are given in brackets for those transects run in the same locations as in 1981.

Transect No.	Bearing (o)	Length of transect (m)	Elevation Beg. (m)	Elevation End (m)	Average slope (°)	Range of slopes (°)	Closest approximate location
1 (6)	200	280	15	43	11	5-20	First projecting knoll on W side of Bay on N side of McPherson Pt.
2	200	320	7	80	14	0-45	Roughly halfway between transects 1 and 3.
3 (5)	208	280	3	77	12	0-43	700 m W of Bay on N side of McPherson Pt.
4 (7)	250	240	13	60	12	2-43	S of McPherson Pt. Second point N of Explorer Bay.
5	240 (switched to 225 at 80 m due to obstruction)	200	1	38	11	3-27	Midpoint of NW side of Explorer Bay.
6	208	320	1	58	10	3-25	Middle of point NW of McPherson Pt.
7 (8)	240 (at 80 m bearing changed to 225 due to creek bed)	280	2	70	12	3-20	Explorer Bay 5 m S of creek mouth.
8	185	200	2	40	11	3-36	S part of Explorer Bay, 300 m SE of transect 7.
9 (4)	152	280	20	80	12	0-33	West side of point NW of McPherson Pt.; bearing 324° to eastern most Langara Rock.
10	180	240	8	60	12	5-32	East of large cut; bearing 6° to midpoint of most easterly Langara Rk.
11 (3)	190	200	2	30	8	2-33	Halfway between Langara and McPherson Pt.; bearing 38° to 3 eastern Langara Rocks.
12	202	160	2	45	18	2-45	Large bent spruce tree E of creek near sandy beach.
13	250	280	6	45	11	0-27	S of S bay of McPherson Pt.
14	204	160	3	20	6	0-15	W arm of bay W of McPherson Pt. at 'flower pot' rock.
15 (10)	315	80	1	10	7	5-11	Dibrell Bay N of creek in Indian Reserve.
16 (9)	343	180	1	3	9	0-19	N corner of Dibrell Bay (across point).

Relative numbers of staging birds were monitored by counting the number of birds flying through the field of view of a telescope (24x80 mm). Counts were conducted each night for 10 minutes, two hours before sunset. Observations were made from the west shore of the south bay at McPherson Point with the telescope on a bearing of 52°, looking just above the rocks on the south end of McPherson Point.

To investigate the fate of unattended clutches, pairs of chicken eggs were placed in 13 empty burrows. Burrows selected were in areas where spruce cone chewings were located and in one area where a rat had been trapped. In each experimental clutch, one egg was carefully cracked (with a light blow from the edge of a knife), to determine if cracked eggs were more susceptible to predation than intact eggs. The two eggs in each clutch were placed together at the end of empty burrows on twigs. After initiating the experiment on 17 May the clutches were inspected every three days until observers departed.

Description: Langara Island has a total area of 3105 ha and rises to a maximum elevation of 160 m. Most of the shoreline is rocky with numerous steep bluffs and cliffs. There are sandy and bouldery bays on the south end and east side. The forest composition around the perimeter is consistent, except in areas that have been cut or blown down. Sitka Spruce (*Picea sitchensis*) is dominant along the shore extending 80 to 120 m inland (Fig. WG010-3). Western Hemlock (*Tsuga heterophylla*) is uncommon at the shore, generally beginning about 40 m inland in association with spruce, then becoming the dominant species between 80 m and 120 m inland, at times being the sole species present at those distances. Western Red Cedar (*Thuja plicata*) usually begins between 120 m and 160 m from shore growing in conjunction with hemlock. Red Cedar predominates after about 200 m from shore, though hemlock is always found in association with it along transects. Further inland hemlock becomes sparse.

The ground cover varies. Open grass fringes most of the island, usually ending within 40 m of shore, but at times extending as much as 80 to 120 m inland (eg. at Dadens and Lord Bight). The dominant grass species is *Calamagrostis* plus *Elymus* close to shore. After 40 m, where the forest floor is open, it is predominantly covered with moss and moss covered logs and stumps. The open moss in many areas extends to the ends of the transects and continues under the predominantly red cedar forest beyond. In some areas, patches of salal, huckleberry and false azalea begin to grow at about 200 to 240 m from shore and are interspersed with the open moss. In the areas that are not open near the shore, the main growth is salal or thick hemlock and spruce saplings.

Nesting species:

Pelagic Cormorants: Cormorants were regularly observed at Langara Point in 1981 (Fig. WG010-4). The following numbers were counted. Birds were roosting. No nest building was observed during our visits, though birds in breeding plumage were noted after 10 May.

10 May - 37
11 May - 67
16 May - 20
20 May - 32
23 May - 4
1 June - 20

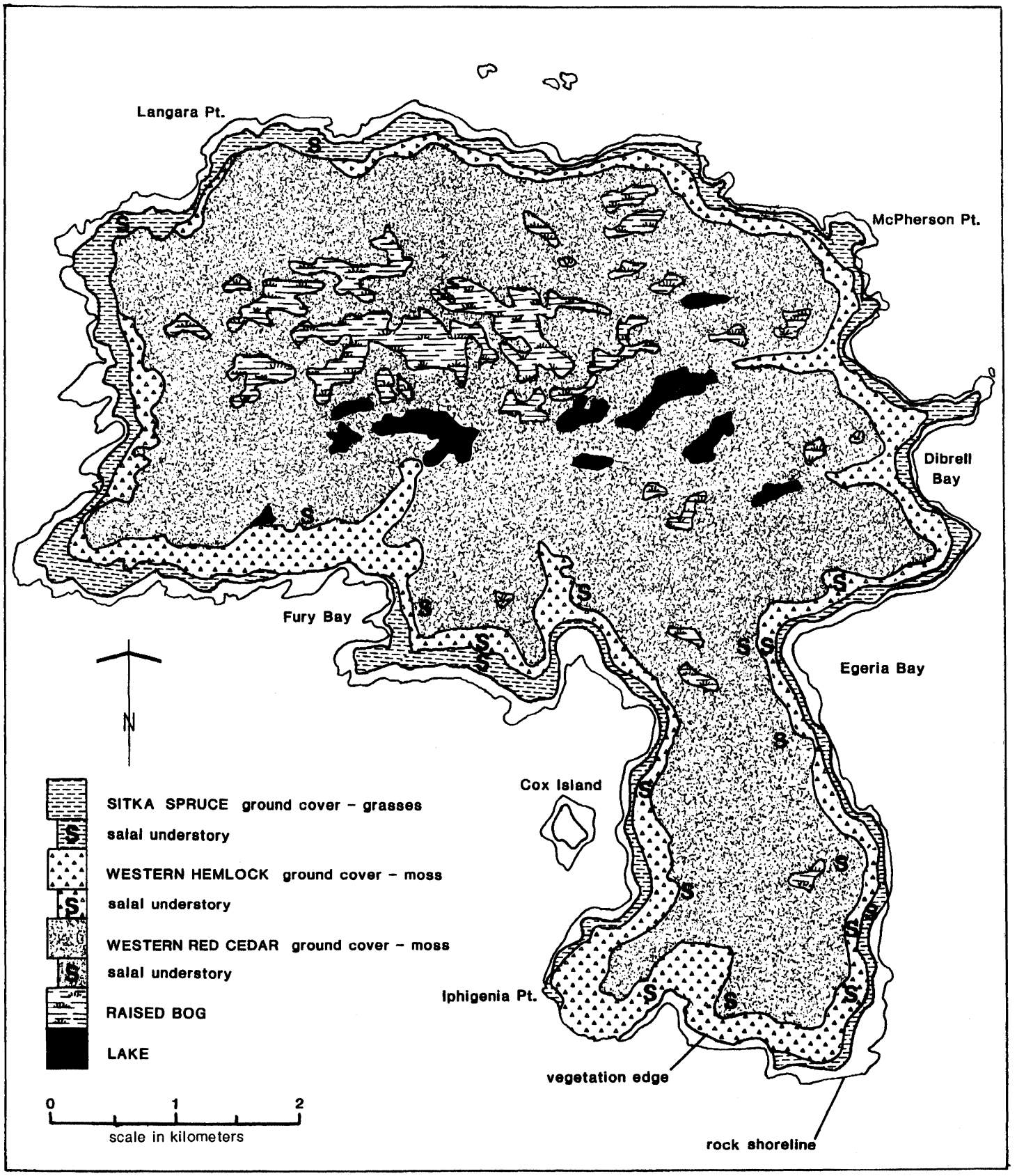

Fig. WG010-3. Vegetation map of Langara Island in 1981.

In 1986, we counted 52 nests at Langara Point. All but two nests were located in the crevice directly below (north of) the light (Table WG010-3). The two separate nests were located on the southwest corner of the main gull rocks directly below (west of) the light.

Table WG010-3. Pelagic Cormorant nests at Langara Point on Langara Island in 1986. Nests are tallied separately for the east and west sides of the crevice.

	Unknown	Empty	2E	3E	4E	5E	4Y	Total
E side crevice	2	19		1		1		23
W side crevice	2	16	2	1	5	1		27
SW corner of rock				1			1	2
Total	4	35	2	3	5	2	1	52

Black Oystercatchers: A total of 6 oystercatcher nests were located around Langara Island on 7 and 8 June 1981: 3 with 1 egg; 2 with 2 eggs; and 1 with 3 eggs (Fig. WG010-4). All of the nests sighted were composed of rock chips and attended by two adults. In 1986, 1 nest with 2 eggs was found at Langara Point on the rock east of the Pelagic Cormorant crevice. The nest was made of rock chips and attended by two adults.

Glaucous-winged Gull: The main nesting area was located at Langara Point in both 1981 and 1986 (Fig. WG010-4). Single pairs were sighted west of Fury Bay and at Iphigenia Point. From the maximum number of birds standing on territories, the 1981 nesting population was estimated to be 104 pairs, 102 at Langara Point and 2 west of Fury Bay and at Iphigenia Point (Table WG010-4).

Table WG010-4. Numbers of Glaucous-winged Gulls counted at Langara Island in 1981.

Date	Location	Number seen	Notes
10 May	Langara Point	168	30 immatures; rest adults
11 May	Langara Point	230	40 imm.; rest territorial ad.
16 May	Langara Point	514	80 imm.; rest territorial ad.
20 May	Langara Point	464	100 pairs on territory, rest roosting
23 May	Langara Point	223	20 imm.; rest territorial ad. 1200 h
23 May	Langara Point	320	roosting; 2130 h
		200	territorial - 2130 h
1 June	Langara Point	204	nesting pairs
1 June	Langara Point	208	roosting on tidal zone
1 June	Langara Point	412	204 adults in pairs on territory; 110 immatures and 98 adults roosting
8 June	Iphigenia Point	2	nesting pair
8 June	small islet 1/2 way between Fury Bay and Lacy Island	2	nest with 1 egg

In 1986, we counted 71 nests at Langara Point (Table WG010-5). Nests made of grasses, were located on the rock below (west of) the lighthouse, and continued around on the east side of the Pelagic Cormorant crevice to the next crevice east (Peregrine Falcon crevice - Fig.WG010-4). Chicks were just beginning to hatch at the time of our survey. Additionally, on the west side of Iphigenia Pt. there were two nests, each with an attending adult, situated on grassy cliff ledges on June 29, 1986. This gives a total nesting population of 73 pairs.

Table WG010-5. Glaucous-winged Gull nests at Langara Point on Langara Island in 1986. Nests were tallied separately west and east of the Pelagic Cormorant crevice.

	Start	Empty	1E	2E	3E	1E2Y	2Y	3Y	Total
West of crevice	1	4	1	6	19		1	1	33
East of crevice	2	5		3	20	1	5	2	38
Total	3	9	1	9	39	1	6	3	71

Pigeon Guillemot: In 1981, Pigeon Guillemots were sighted often while travelling offshore, with concentrations occurring east of Langara Point, off Cox Island and west of Iphigenia Point (Table WG010-6). Birds were observed on nesting sites west of Iphigenia Point, west of the wharf at Henslung Cove and on Testlatlints Rock. In 1986 at Langara Point, we found one nest with two newly hatched young and observed one bird fly out of a crevice and one bird on the water.

Table WG010-6. Numbers of Pigeon Guillemots seen around Langara Island in 1981.

Date	Location	Numbers seen	Notes
7 May	Solide Pass	19	flying
11 May	Pt. W of McPherson Pt.	35	flying
11 May	Langara Point	16	flying and on rocks
12 May	Pt. W of McPherson Pt.	41	flying
16 May	Langara Point	14	flying
19 May	Explorer Bay	22	flying (0700 h)
20 May	Andrews Point	24	flying (1000 h)
22 May	Cloak Bay	14	flying
23 May	Langara Point	6	flying
26 May	Cloak Bay	12	flying
1 June	Langara Point	14	flying
6 June	Langara Point	25	flying
8 June	Cox Island	23	flying
8 June	Testlatlints Rock	22	flying and on nesting sites
8 June	SE corner of Iphigenia Pt.	26	on ledges and burrow entrances
	Minimum total	160	

Ancient Murrelet: 1981: Three distinct nesting areas were found in 1981. The area where the vast majority of the murrelets were nesting was on the northeast corner of the island, extending continuously from 3,000 meters west of McPherson

Point around to the south side of Cohoe Point (Fig. WG010-4; Tables WG010-7, 8). The other two areas were small; one on the western side of Iphigenia Point, and one midway between Fury Bay and Lacy Island. Burrowing occurred primarily in open mossy areas under a hemlock or spruce-hemlock forest over a wide range of altitude (from 3 m to 99 m) and slope (from 2° to 45°, though more commonly on slopes less than 20°). Burrows usually began 40 to 80 m from shore but were sometimes found near shore on open mossy knolls. They were never found in level grassy areas adjacent to shore. Burrowing generally ended around 200 m from shore, except at Iphigenia Point (transect 22) where it extended as far as 340 m inland (Table WG010-7).

Burrowing at Iphigenia Point was sparse (Table WG010-8). It occurred disjointedly along transect 22, and sporadically on some of the knolls around the point. Because of the irregular distribution, no attempt was made to determine the total area of burrowing or to calculate a population estimate. Based on data from transect 22 (total of 8 burrows in 5 quadrats) and from walking the entire point, the total nesting population in that area was estimated at a maximum of 500 pairs.

Between Fury Bay and Lacy Island two small areas of burrowing (50x50 m each) were found on open ridge tops, one on transect 30 and one just west of it. Only one burrow was found in plots along transect 30. The nesting population in those two areas was estimated to be only about 50 pairs.

Most burrow entrances were under live tree roots or bases of trees or stumps (Table WG010-9). Burrows were difficult to excavate and we were able to reach the ends of only 38 of 80 burrows examined within plots (Table WG010-10). Four of 10 occupied burrows contained cold or depredated eggs (checked 11 May to 3 June). No chicks were found in burrows but freshly depredated chicks were found at the entrances to two burrows on 2 and 3 June. First chicks heading to sea were recorded on 2 June.

1981 Population estimate:

Main colony area around northeast corner:

Number of sample plots:	39 (975 m^2 - 0.1 % of colony)
Average density:	820 ± 139 burrows/ha
Colony area:	116.6 ha
Total burrows:	95,612 ± 16,207
1981 Occupancy rate:	26.3 ± 8.0%
1981 Nesting population:	25,146 ± 8660 pairs
Plus estimated populations at:	
Iphigenia Point:	500 pairs
Fury Bay:	50 pairs
Total 1981 nesting population:	25,696 ± 8660 pairs

1988: In 1988, the main nesting area was located on the north side of the island, extending approximately 3000 m west of McPherson Point (Fig. WG010-5; Tables WG010-7, 11). There was a small area (20x70 m) with dense, active burrows on the north side of Cohoe Point. In an arbitrarily placed 5x5 m plot in that area (Plot B-Fig.WG010-2 and see Bertram 1989), 10 burrows were counted, half of which were active. A few small pockets of burrows were found on the

south side of Cohoe Point, and fresh, dead Ancient Murrelet chicks were found in a cave west of Fury Bay, indicating recent breeding activity in that area (W. Nelson pers. comm.).

1988 Population estimate:

Main colony area around northeast corner:

Number of sample plots:	31 (775 m^2 - 0.2 % of colony)
Average density:	1358 ± 225 burrows/ha
Colony area:	45.6 ha
Total burrows:	61,925 ± 10,260
1988 Occupancy rate:	38.4 ± 7.7% (10 of 26 known; Tables WG010-12 and WG010-13)
1988 Nesting population:	23,779 ± 6149 pairs
Plus estimated population at: Cohoe Point:	280 pairs
Total 1988 nesting population:	24,059 ± 6149 pairs

Comparison between surveys:

Large areas historically used by Ancient Murrelets on Langara Island (Sealy 1976; B.C. Nest Record Scheme) were unused in 1981. No evidence of burrowing was found in old colony areas south of Egeria Bay (Sealy's plot B), at Dadens, at Iphigenia Point (Sealy's plot A), and north of Fury Bay (Nelson pers. comm.). Those areas provided extensive open mossy habitat similar to that used at McPherson Point, though at Iphigenia Point and north above Fury Bay, large areas of recent windfall were encountered that disrupted open habitat.

In 1988, colony area was less than half that found in 1981. Areas south of McPherson Point were abandoned in 1988, except for small pockets of active burrows around Cohoe Point. Old, abandoned burrows were found in Dibrell Bay, (Plot A-Fig.WG010-2 and see Bertram 1989), south of Cohoe Point on the north side of Egeria Bay (near 1981 transect 12) and at Iphigenia Point. Of the eight transects surveyed in both 1981 and 1988, only four still had active burrowing in 1988 (Tables WG010-7 and WG010-12). On three of those transects burrowing occurred further inland in 1988 than in 1981, but the average width of the colony was less (175 m in 1981 and 150 m in 1988 along the four duplicated transects; 161 m in 1981 and 157 m in 1988 over all transects), suggesting that the colony had shifted inland as well as contracting.

Though the colony area was reduced, population estimates in 1981 and 1988 were similar. Higher burrow density and occupancy rates in 1988, though not significantly different from 1981 estimates, accounted for the similar population figures (see Bertram 1989). Due to the high variability of estimates in both years, comparisons are inconclusive. The lower number of burrows, and smaller colony size in 1988, suggest that the population size has decreased. [Estimates of colony area presented here, are derived from measuring an outline of the colony boundaries, drawn on a composite airphoto, with a compensating polar planimeter, the method used for all other colonies along the coast (see Methods). The resulting size of the colony in both 1981 and 1988 and, therefore, population estimates, differ slightly from those given in Bertram 1989].

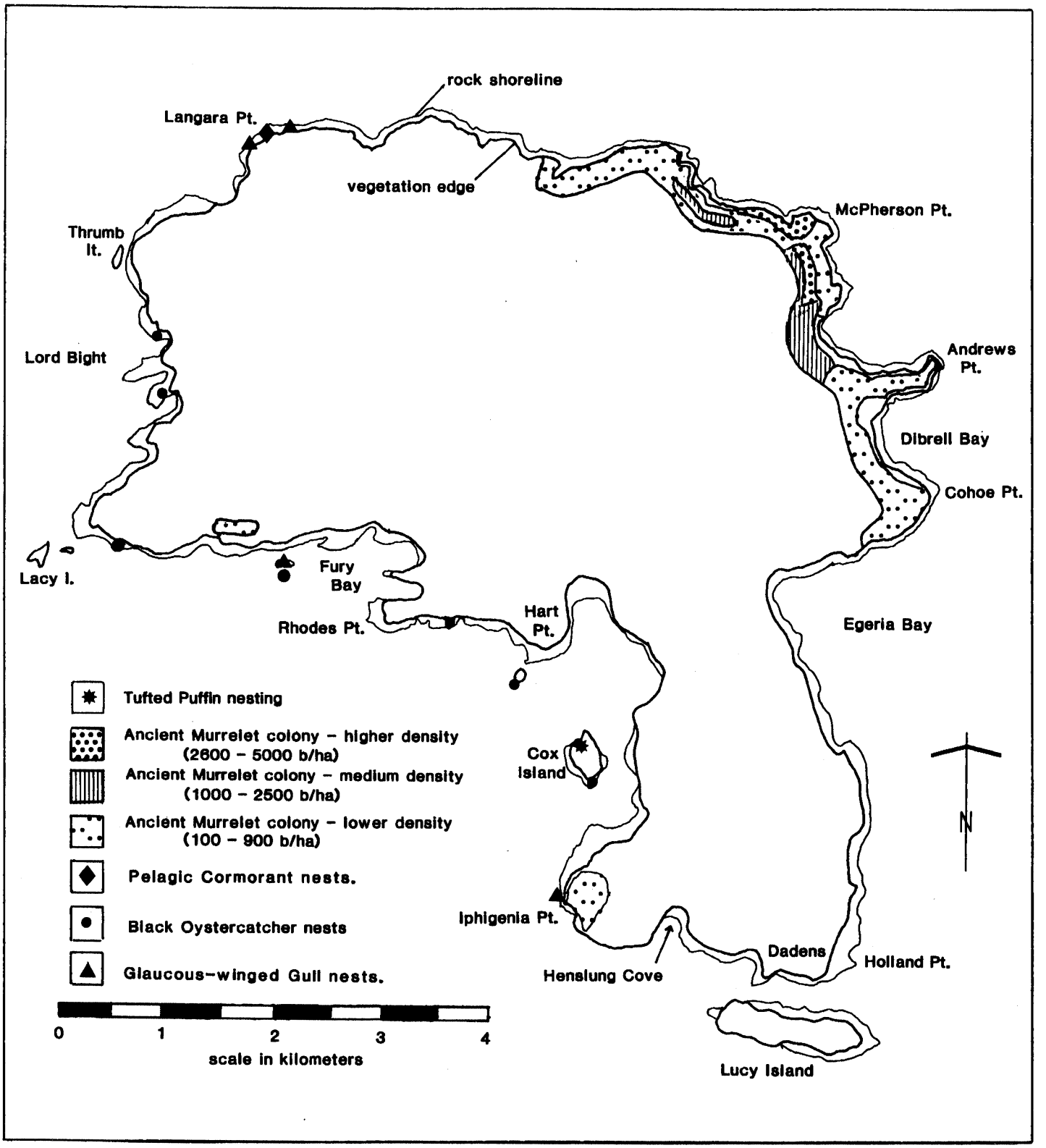

Fig. WG010-4. Seabird nesting locations on Langara Island in 1981.

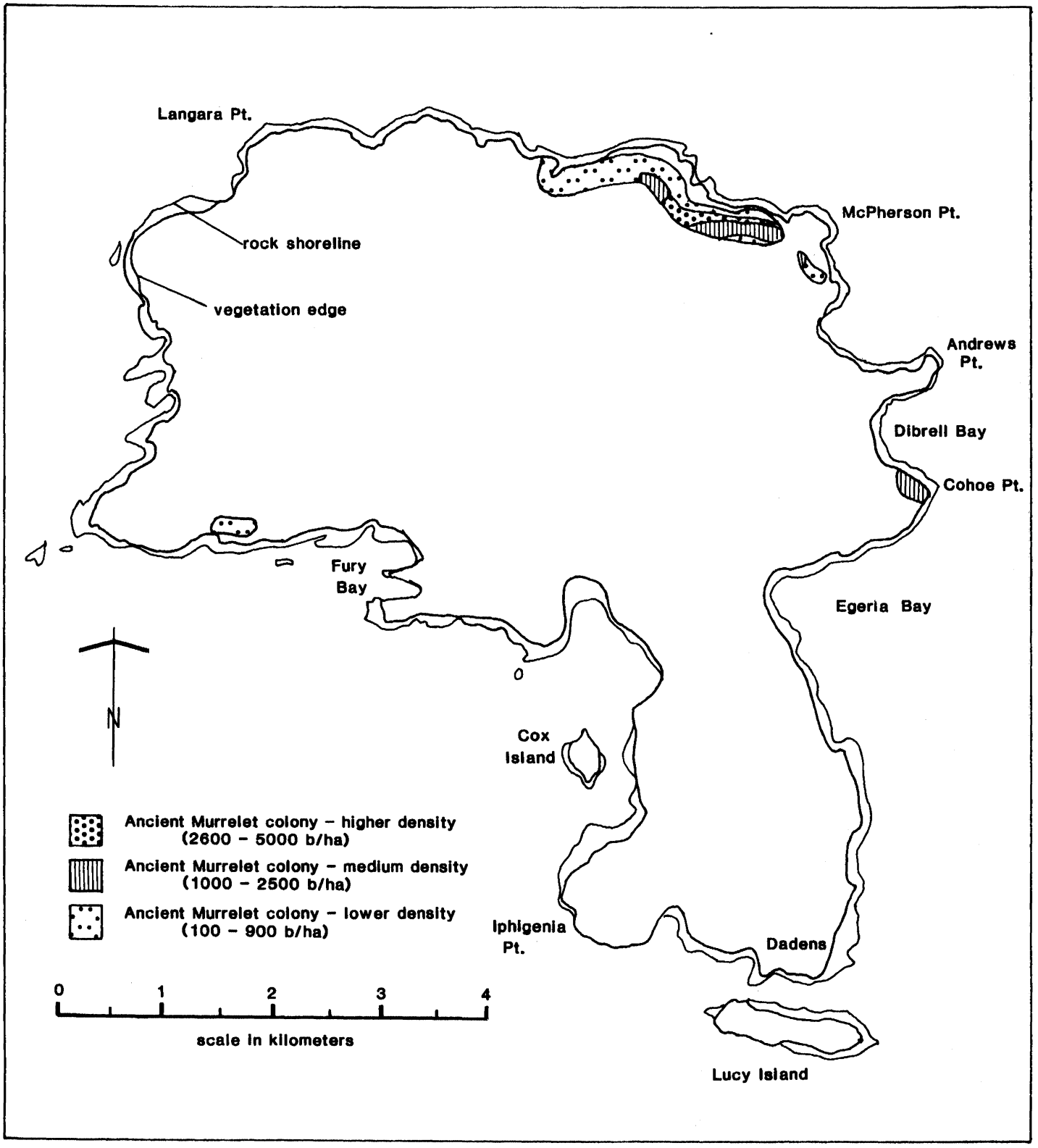

Fig. WG010-5. Ancient Murrelet colony on Langara Island in 1988. (adapted from Bertram 1989) The colony reported west of Fury Bay in 1981 was assumed to be active in 1988.

Table WG010-7. Extent of Ancient Murrelet colony along transects on Langara Island in 1981 and 1988. Transects are listed in sequence from northwest to southeast. Data from transects done in the same locations in 1981 and 1988 are presented on the same line. Elevation measurements taken in the field in both years were distorted, and those listed here are best estimates derived by comparing field measurements with a 1:72921 scale topographic map.

1981				1988			
Transect	Distance along transect (m)	Range of elevation (m)	Average slope (°)	Transect	Distance along transect (m)	Range of elevation (m)	Average slope (°)
not done				10	0-180	8-40	11
4	0-180	10-33	6	9	40-220	16-40	17
not done				6	120-260	30-45	5
5	20-180	3-45	17	3	120-220	20-60	27
not done				2	40-220	32-75	21
6	0-140	15-28	17	1	0-220	15-43	13
not done				14	abandoned		
not done				13	abandoned		
7	0-220	10-50	14	4	80-180	33-45	19
not done				5	abandoned		
8	60-210	3-24	10	7	abandoned		
not done				8	abandoned		
9	40-186	4-10	17	16	abandoned		
10	140-220	38-45	7	15	abandoned		
11	60-220	30-38	12	not done			
12	0-210	3-50	20	not done			
22	20-340	38-99	13	not done			
30	80-130	75-86	15	not done			

Table WG010-8. Numbers of Ancient Murrelet burrows in 5x5 m plots along transects on the northeast side of Langara Island in 1981. Only transects considered within colony are listed. Plots considered outside the colony are indicated by a dash.

Transect	Plot 1	2	3	4	5	6	7
4	1	2	0	2	1	-	-
5	-	1	1	4	2	-	-
6	12	0	1	2	-	-	-
7	0	0	0	8	4	3	-
8	-	-	3	2	2	3	-
9	-	2	2	1	1	-	-
10	-	-	-	-	1	1	-
11	-	-	2	1	1	1	-
12	2	2	2	2	3	2	-

Table WG010-9. Habitat locations of Ancient Murrelet burrow entrances on Langara Island in 1981.

Burrow location	Number of burrows	Percent of total
Live tree roots	55	69
Tree base	13	16
Stump	8	10
Mossy deadfall	3	4
Rock	1	1
Total	80	

Table WG010-10. Occupancy of Ancient Murrelet burrows on Langara Island in 1981.

Date	Transect	Plot	Empty	1 cold egg	2 cold eggs	Adult + 2 eggs	Depredated egg(s)	Total occupied	Total known
11 May	6	1	3			1		1	4
11 May	7	4	2					0	2
11 May	7	5		1				1	1
18 May	8	3	2					0	2
18 May	8	4	2					0	2
20 May	10	5	1					0	1
23 May	4	4	1			1		1	2
23 May	4	5	1					0	1
23 May	5	3	1					0	1
23 May	5	4	1		2	1		3	4
23 May	5	5	1			1		1	2
2 Jun	12	1	2					0	2
2 Jun	12	2	2					0	2
2 Jun	12	3	1			1		1	2
2 Jun	12	4	2					0	2
2 Jun	12	5	1			1	1	2	3
2 Jun	12	6	1					0	1
3 Jun	11	3	1					0	1
3 Jun	11	4	1					0	1
3 Jun	11	5	1					0	1
3 Jun	11	6	1					0	1
	Total		28	1	2	6	1	10	38

Table WG010-11. Numbers of Ancient Murrelet burrows in 5x5 m plots along transects on the northeast side of Langara Island in 1988. Only transects and plots considered within colony are listed. Transect numbers from 1981 are given in brackets for those transects run in the same locations as in 1981.

Transect	Plot 1	2	3	4	5	6	7
1 (6)	1	8	5	3	5	1	
2		2	8	1	5	2	
3 (5)				1	16	6	
4 (7)			2	1	6		
6				2	2	4	3
9 (4)		4	2	4	2	2	
10	3	0	0	2	2		

Table WG010-12. Burrow occupancy rate and related information collected from transects (Trans) run on Langara Island during May, 1988. The number of burrows represents the sum total of burrows found in quadrats along a transect. Occupancy rate was calculated using only burrows whose entire contents were searched. Status (Stat) refers to the presence or absence of active nesting along a transect (A = abandoned, C = colony). The proportion of burrows containing bones is presented in two ways: 1) for all burrows found, and 2) for burrows whose ends were reached. Fp = feather piles; De=depredated eggs; Sc = spruce cone chewings found in quadrats (Y = yes; N = no). * not available.
From Bertram 1989.

Trans	Stat	Number of burrows	Burrows ends reached	Occ. rate	Proportion burrows with bones		Fp	De	Sc
					All burrows	End reached			
12	A	1	1	0.00	0.00	0.00	0	0	Y
11	A	5	5	0.00	0.60	0.60	0	0	Y
10	C	7	4	0.25	0.43	0.50	1	0	N
9	C	14	3	0.67	0.00	0.00	0	2	Y
6	C	11	0	*	0.09	*	1	2	N
3	C	23	3	0.33	0.00	0.00	3	1	Y
2	C	18	7	0.42	0.00	0.00	3	3	Y
1	C	23	2	0.50	0.13	0.00	0	2	Y
14	A	12	9	0.00	0.33	0.44	1	0	N
13	A	22	10	0.00	0.27	0.20	0	0	Y
4	C	9	7	0.29	0.33	0.29	3	1	Y
5	A	0	*	*	*	*	0	0	N
7	A	7	4	0.00	0.43	0.75	0	0	Y
8	A	7	1	0.00	0.14	0.00	0	0	Y
16	A	1	0	*	0.00	*	0	0	N
15	A	0	*	*	*	*	0	0	Y
Totals		160	56	0.38†	0.17‡	0.29‡	12	11	

† 10 occupied burrows out of 26 completely searched in the colony.
‡ Average value

Table WG010-13. Occupancy of Ancient Murrelet burrows along transects in the active colony on Langara Island in 1988.

Date	Transect	Plot	Contents: Empty	4 cold eggs	Adult + 2 eggs	Occupied (contents not recorded)	Total occupied	Total known
9/05	1	4			1		1	1
9/05	1	5	1				0	1
10/05	2	3	1		2		2	3
10/05	2	5	3		1		1	4
10/05	3	5	2			1	1	3
11/05	4	3	2				0	2
11/05	4	5	3		2		2	5
18/05	9	2	1				0	1
18/05	9	5		1			1	1
18/05	9	6			1		1	1
18/05	10	4	2				0	2
18/05	10	5	1		1		1	2
Total			16	1	8	1	10	26

Staging:

1981: In 1981, Ancient Murrelet staging grounds were observed in three areas around Langara Island: southeast of Lacy Island and northwest of Iphigenia Point in Cloak Bay, and north from Egeria Bay to Langara Rocks (Fig. WG010-6).

Western staging areas: On 25 May, we counted 65 murrelets staging in the Lacy Island area, about 1.0 km from shore, and 680 murrelets in the Iphigenia Point area, about 1.5 km from shore. On 31 May, relative numbers were reversed, with 420 birds in the Lacy Island area and 65 northwest of Iphigenia Point.

Although these sightings would locate the western staging grounds in the areas mapped on Fig. WG010-6, we did not find the patterns of murrelet distribution to be consistent. In contrast to the two sightings above, while travelling through the Lacy Island and Iphigenia Point areas on 9 June we found no birds present in either vicinity, despite similar weather and time of day. On 11 June, no murrelets were sighted in either suspected staging area, but a group of 74 was counted between the areas, in the middle of Cloak Bay. Such variable distribution of Ancient Murrelets in these areas allows only an approximate estimate of the location of the western staging grounds.

Eastern staging areas: The eastern staging ground stretched from Egeria Bay to Langara Rocks, on the north coast of the island. On 12 May, we counted 1,072 Ancient Murrelets east of Explorer Bay. On 8 June, a total of 3,336 Ancient Murrelets were counted flying north over the water in groups of from 6 to 100. The greatest concentrations were seen south of Cohoe Point, about 3 km from shore, and north from McPherson Point to Langara Rocks, about 2 km from shore. All other Ancient Murrelets on the eastern side of Langara Island were seen between 1.5 km and 4 km from shore.

Parry Passage: Although Sealy (1976) identified Parry Passage as a staging area, we travelled through this area on 8 June at 2020 h, running a zigzag water transect, and found no trace of Ancient Murrelets.

Occasional sightings: Few Ancient Murrelets were sighted offshore of Langara Island during daylight. On 12 May, at 1410 h, in a bay south of Langara Rocks,

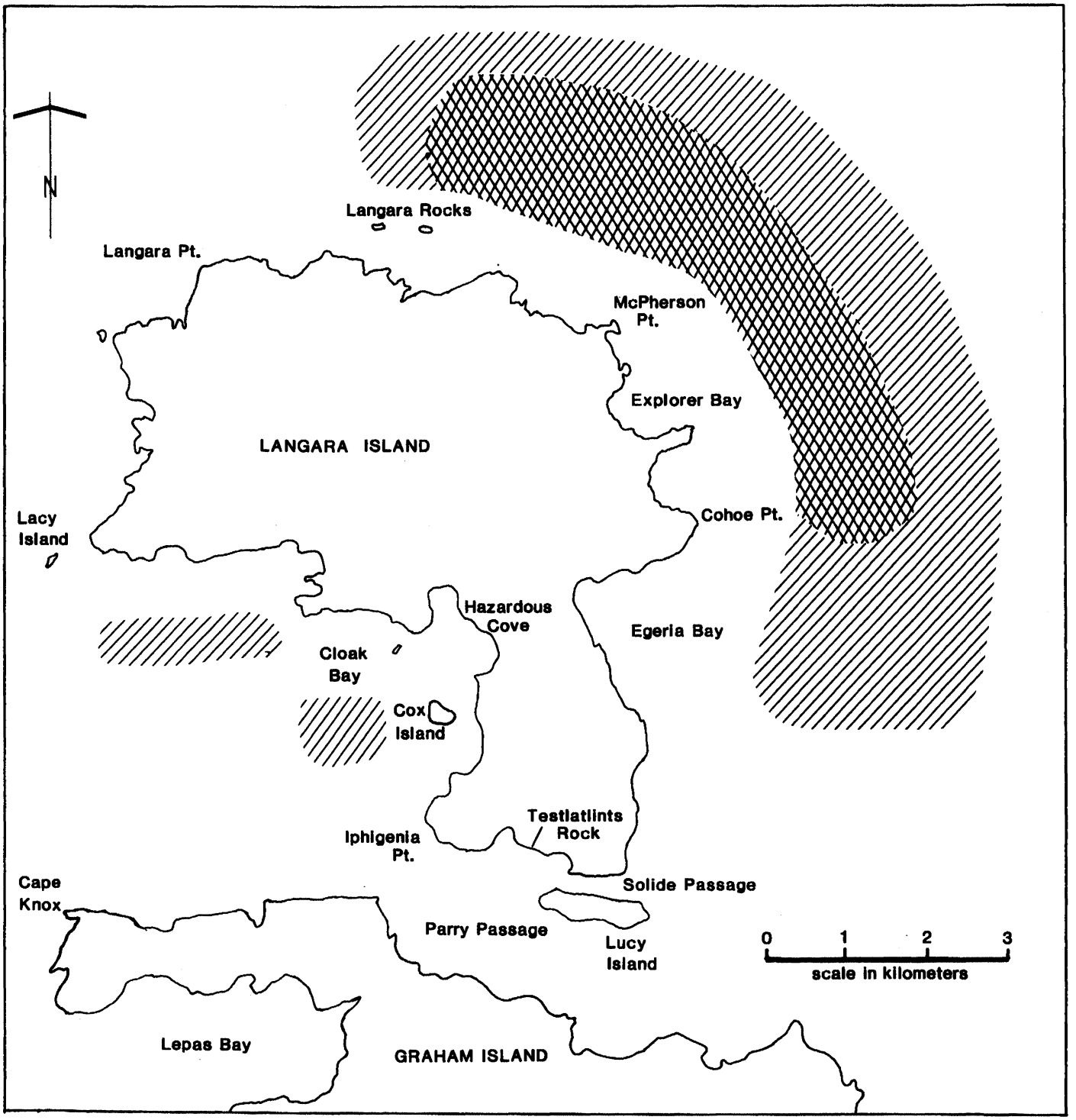

Fig. WG010-6. Ancient Murrelet staging areas around Langara Island in 1981.
(Area with higher concentration of sightings shown by crosshatching.)

2 murrelets were seen 0.5 km from shore, and on 22 May, in Cloak Bay, 1 Ancient Murrelet was sighted near shore at roughly the same time of day.

1988: Ten minute counts by telescope of birds staging off McPherson Point in May 1988 ranged from 5 to 4,620 (Fig. WG010-7). On nights when few birds were seen, observation conditions were generally poor. Visibility was often reduced by rain, and wave action frequently obscured birds from sight. The number of staging birds tended to increase as the season progressed. There was a significant positive relationship between the number of birds observed staging and the number of burrows entered in an experimental knock-down plot that evening, suggesting that staging counts provide an index to colony activity on a given night (see Bertram 1989).

Colony behaviour:

Adult behaviour: In 1981, birds were heard or seen flying into the colony at McPherson Point from 2300 to 0330 h. Most birds entered the colony between 2300 and 0130 h (Table WG010-14). On a number of occasions, after hearing an adult land, vocalizations were heard from a burrow within close proximity to the incoming bird. Activity and vocalizing on the colony peaked between 0100 and 0300 h. At times, pairs of birds could be heard calling from the same burrows and were observed singly and in pairs sitting outside burrows. Birds were heard leaving the colony until 0430 h. The highest concentration of birds heard leaving occurred between 0100 and 0200 h. Arrival and departure times of birds on Cohoe Point were similar to those recorded south of McPherson Point. Highest activity levels occurred between 0100 and 0300 h.

Table WG010-14. Observations of Ancient Murrelets on nesting slopes on Langara Island in 1981.

Location	Date	Time (h)	Number of Ancient Murrelets	Notes
McPherson Point	16 May	2315-0110	19	IN (arriving on colony from seaward direction)
		2400-0100	6	OUT (leaving colony, flying seaward)
	17 May	2300-0400	132	IN
		0100-0400	101	OUT
		0100-0300	-	Much activity (movement and vocalizing). Vocalizing from birds sitting on slopes, in trees, inside and out of burrows.
	18 May	2300-0400	371	IN
		2320-0430	131	OUT
	19 May	2330-0130	145	IN
		2330-0130	44	OUT
Cohoe Point	1 June	2345	-	1st bird heard flying in
	2 June	2255	-	1st bird heard calling
		2328-0200	44	IN
		0200-0500	38	OUT
	3 June	2305-0015	7	IN
		0015-0315	-	Vocalizations
		0433	-	Last bird heard leaving

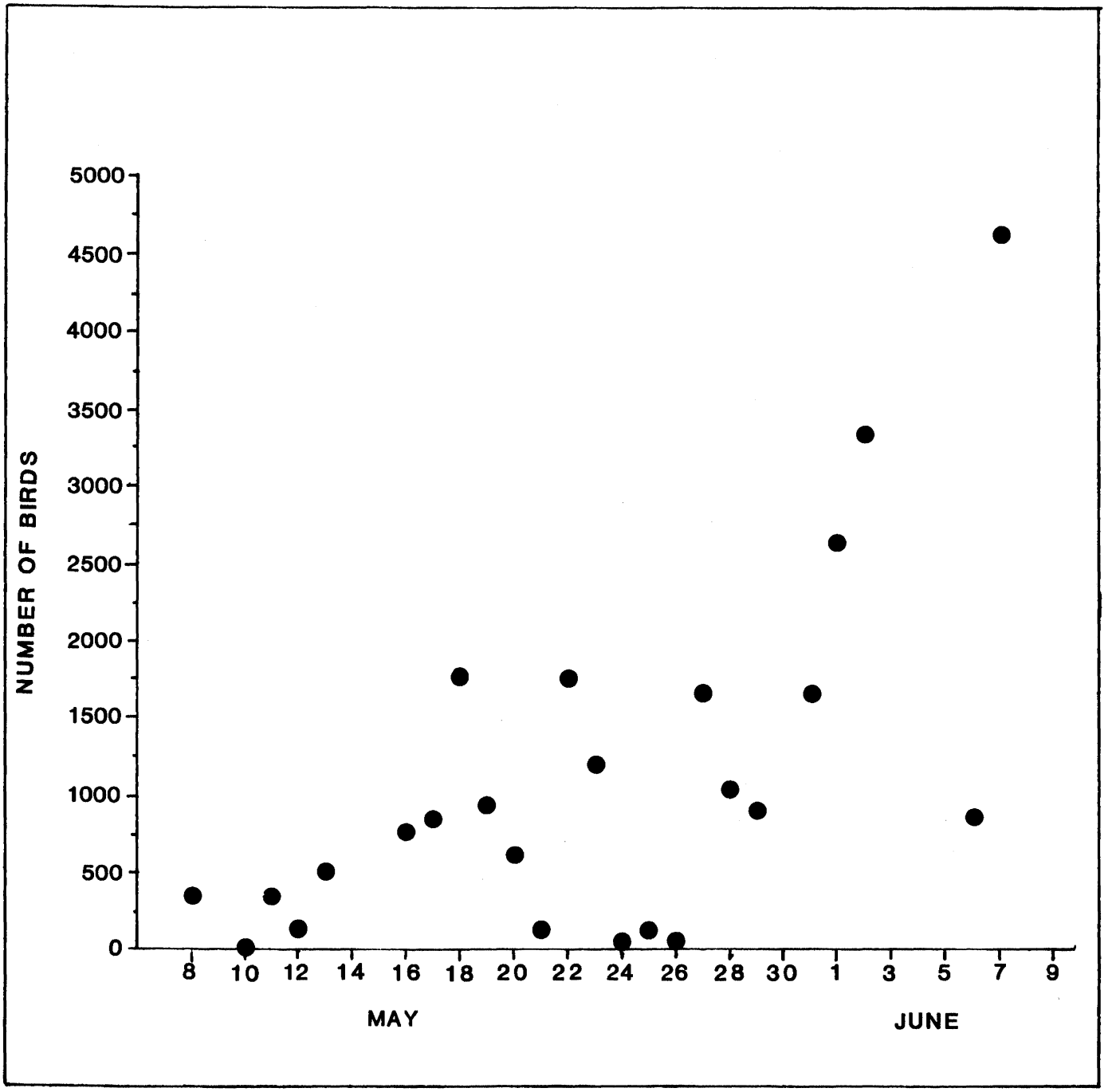

Fig. WG010-7. Number of Ancient Murrelets seen staging off McPherson Point on Langara Island during nightly 10 minute telescope counts in 1988. (from Bertram 1989)

Ancient Murrelet activity on the nesting slopes prior to 2300 h was rare. On two occasions Ancient Murrelets were observed on or near a colony during daylight hours. On 1 June, at 1830 h an Ancient Murrelet was seen flying from the nesting slopes. On 6 June, at 1410 h a freshly killed Ancient Murrelet was found on the forest floor (see Predation).

Chick behaviour: On the night of 2 June 1981, an Ancient Murrelet chick was seen walking north towards the sea at Cohoe Point. The chick was led by an adult approximately 3 m ahead. On the following night, 3 June, an adult and chick were heard calling from a burrow at 2120 h. They continued vocalizing intermittently until 2240 h at which time the adult came out of the burrow and sat approximately 2 m from it, still calling. The chick could be heard peeping inside the burrow. The adult returned to the burrow shortly after. Vocalizations continued within the burrow, then abruptly ceased at 2310 h. A Bald Eagle swooped low through the forest just after. Most of this behavior preceded the arrival of the first adult Ancient Murrelet to the slopes, which was recorded at 2305 h.

In 1988, departing chicks were recorded from 31 May to 6 June. Movements began around midnight, peaked near 0100 h, and generally stopped by 0230 h.

Predation:

1981: Abundant evidence of predation was found in 1981 (Table WG010-15). Considering only recent remains found within plots along transects 4-12 running through the main nesting area (11 birds and 9 eggs in 39 plots), we calculated densities of 113 ± 29 depredated birds/ha and 92 ± 37 eggshells/ha. Extrapolating over the 116.6 ha colony area, yields estimates of 13,176 ± 3381 birds and 10,727 ± 4314 eggs preyed upon in the colony at the time of our survey. In the 20x60 m plot at McPherson Point, a total of 39 piles of murrelet feathers, 5 eggshells, and 33 eagle pellets were counted, giving a density of 325 birds/ha if we assume that each feather pile represents one bird.

We discuss the evidence found in relation to the predators we suspected were responsible.

Bald Eagles: On nesting slopes, large pellets were often found in close proximity to piles of murrelet feathers (Table WG010-15). The pellets consisted almost entirely of Ancient Murrelet bones and feathers, and measured up to 10 centimeters in length. Observers who sat in the 20x60 m predation plot above McPherson Point and at Cohoe Point noted 2 to 4 eagles present on the nights of 16, 17, 18, and 19 May, and 1, 2, and 3 June. The eagles arrived in the colonies before dusk and were sighted at various times during the night (2330, 0200, 0300 and 0400 h).

The first direct evidence of predation was obtained at 2300 h on 19 May, when a Bald Eagle was heard and seen in silhouette to dive from low in the trees to the forest floor, where an incoming murrelet had just landed. The eagle stayed on the ground for about 4 minutes, and then rose to a perch in the trees. At 0200 h, an eagle dove from the trees to the forest floor. After 10 seconds, it was seen carrying off a murrelet.

At Cohoe Point, an observer walking through the colony with a flashlight at 0400 h on 3 June, flushed an adult Bald Eagle from the ground at a distance of 3 m. The eagle left behind a freshly killed Ancient Murrelet surrounded by a pile of feathers. The still warm murrelet had been plucked clean of feathers along the wings, neck, and on areas of the back and breast. Further exploration of that area of the colony (a section about 200 m by 50 m) revealed a total of six such fresh piles of feathers. Large streaks of eagle feces radiated from three of those feather piles. Such fecal strips were common at fresh feather piles seen in other areas.

Table WG010-15. Depredated remains of Ancient Murrelets found within and between 5x5 m plots along transects on Langara Island in 1981.

Tran.	Plot	Feather pile	Single wing	Attached wings	Whole carcass	Minimum no. of dead birds	Depredated egg	Bald Eagle pellet
Remains found within plots:								
2	2			1		1		
2	4						1	
4	3						2	
4	4	1				1	2	
4	6	2				2		
5	2				1	1		
5	5	1				1		
6	3	1				1		
6	5	1				1	1	
6	6	1				1		
7	1	1	1			1		1
7	4	1				1		
7	5				1	1		
7	6	1				1		1
9	2							1 (old)
9	3							4 (old)
9	5	1				1		1 (old)
11	3				1 (old)		1	
11	4	1				1		
11	6							1*
12	3						1	
12	5						2	
12	6	1				1	1	
22	2			2		2		
22	7						1	
22	9	1				1	1	
Total		14	1	3	2	19	13	9
Remains found along transects outside plots:								
2		5		3				
3		1						
between 3&4		6	1			1		
4		6					1	5
between 4&5		50					28	12
5		3					5	2
6		3					4	2
7		5	3			1	3	5
8		1						1
10		5					3	
11		1					4	5
12		5	1				7	
22		3		1			5	4
30		5		3		1 (old)		1

* small pellet containing Ancient Murrelet chick.

Observations were also made during daylight hours. At 1410 h on 6 June, an immature Bald Eagle was flushed from the ground on the nesting slopes, leaving behind a freshly killed, still warm Ancient Murrelet. This murrelet was not plucked, but was decapitated and slit open down the breast. The internal organs had been removed (see Common Raven below). It seemed unusual for Ancient Murrelets to be exposed on land during the day, since we had only one other daylight sighting. Perhaps the bird had been disoriented the previous evening, or had been dug out of a burrow.

Peregrine Falcon: In two areas where burrowing was minimal - at Andrews Point and west of Fury Bay - scattered piles of pairs of murrelet wings, still connected at the breastbone, were discovered. The piles measured about 3 m by 3 m, and consisted of the remains of 6 to 10 decapitated murrelets, with breastbone and clavicle picked clean, and blood on the wings. Peregrine Falcons were suspected to be the predators (though see Common Raven below).

On 19 May, we discovered an Ancient Murrelet carcass just above an active falcon eyrie on McPherson Point. On a nearby plucking perch, all of the feathers scattered about appeared to be from Ancient Murrelets.

In Cloak Bay at 2130 h on 25 May, a Peregrine Falcon dove to a place on the water where Ancient Murrelets had been seen five minutes before. The falcon rose from the water with a bird in its talons and flew toward land.

Common Raven: We found a decapitated Ancient Murrelet carcass on the forest floor east of transect 4 at 1600 h on 23 May. The skin had been torn off the breast and abdominal area and all internal organs except the liver had been removed. Pectoral muscle was intact and wings were still attached. A pair of ravens were calling close-by. The depredated bird resembled early stages of what we thought to be Pergrine Falcon predation (ie., sternum picked clean and wings still attached).

Rat: On two occasions, at McPherson Point, and Egeria Bay, while checking burrow occupancy along the transect lines, we found dead Ancient Murrelets just inside burrow entrances. Carcasses were intact with the breast exposed, the skin partially rolled back, and the flesh eaten away around the ribs. It is suspected that rats may be responsible for such predation. Bones found in two empty burrows on transects 11 and 12 probably indicate past predation by rats.

Broken murrelet eggshells were found scattered throughout nesting areas on Langara Island. Many of these shells were two-thirds intact, with a large hole on the longitudinal surface. Some were bloody, indicating that incubation was at an advanced stage. The interior of one egg showed three-pronged scratch marks about 0.5 cm long. These eggs may have been preyed upon by rats. Northwestern Crows, often found active at dawn in the forest, may also prey on eggs.

Northwestern Crow: At 0540 h on 3 June, three crows were scavenging the Ancient Murrelet carcass from which we had flushed a Bald Eagle. The eagle was perched close above the carcass, watching intently as the crows alternately flew in and then out with portions of the carcass. Within 10 minutes they had removed the entire carcass, at which time the eagle flew off.

The above observations suggest that most feather piles found within colony areas result from Bald Eagle predation. Common Ravens may also pluck birds and leave feather piles. Peregrine Falcons appear to catch and pluck most of their prey outside colony areas. Carcasses found in burrows are likely a result of rat predation. Comparing the number of carcasses to feather piles found suggests that rats were responsible for 18% of the predation on adult murrelets recorded within the colony. This comparison would underestimate rat predation if murrelet carcasses were hidden in burrows we could not access, if carcasses left by rats were scavenged by crows or other predators, or if rats removed remains from

colony areas. Rats may have been responsible for much of the egg predation recorded. Further evidence of rat predation was recorded in 1988.

1988: In 1988, 12 feather piles, 2 whole carcasses, and 11 depredated eggs were found within surveyed quadrats (Table WG010-12). Again considering only remains found along transects within extant colony (5 feather piles, 2 carcasses, and 10 eggs in 31 plots), we calculated densities of 90 ± 36 birds/ha and 129 ± 43 eggs/ha. Extrapolating over the 45.6 ha colony indicates that 4104 ± 1642 birds and 5882 ± 1960 eggs had been preyed upon in the colony at the time of the 1988 survey. Estimated densities of prey remains were not significantly different between 1981 and 1988 (Kruskal-Wallis test for numbers of birds: $p = 0.57$).

Carcasses, suspected to have been preyed upon by rats, represented a larger proportion (29%) of the predation evidence found within the colony in 1988 than in 1981. On 9 May, on transect 1, two freshly killed Ancient Murrelets were found in a burrow, within 15 cm of each other. Both birds had open, bloody wounds near the back of the neck. Weights of the carcasses were 185 and 189 g; neither had brood patches. Old bones were discovered in the same burrow. On 18 May, along transect 10, a fresh, dead murrelet with an open wound extending from the base of the skull at the back of the neck to the pectoral girdle was found at the mouth of a burrow. Within 2 m, another kill was located with a similar gaping wound to the upper back near the pectoral girdle. One of the two birds had a brood patch. Two older (perhaps a month old) carcasses were found on 22 May in the vicinity of transect 14. One had the skull chewed open and the upper abdomen eaten. The other, further in along the same cavity under a log, had its skull intact.

Many of the burrows examined in 1988 contained skeletal remains of adult Ancient Murrelets. While some transects had no burrows with bones, others had bones in 60% of the burrows examined. Of the 160 burrows counted within quadrats, 17% contained bones. This figure is likely an underestimate since many of those burrows (65%) were not completely searched. Twenty-nine percent of the 56 burrows whose ends were reached contained bones (Table WG010-12).

On a given transect the proportion of burrows that contained bones was found to be dependant on the occupancy rate of burrows along that transect. As occupancy rate increased the proportion of burrows containing bones declined significantly (Bertram 1989). The highest proportion of bones occurred in abandoned areas of the colony (Table WG010-12). In a group of abandoned burrows in the south corner of Dibrell Bay near 1981 transect 11, observers found one burrow with fresh rat dung at the entrance and spruce cone chewings inside. Another burrow contained what may have been an old rat cache - 5 skulls (all chewed), 2 sterna, various other bones, old murrelet eggshell and eggshell membrane. If only plots within extant colony were considered, the proportion of burrows with bones was 13%. In knock-down plots (see Bertram 1989) established in main sections of the colony, four (9%) of the 47 burrows whose ends were reached contained bones.

Murrelet skulls found in burrows along transects 7-16 were examined for signs of chewing. Of nine whole skulls found, the craniums of three appeared to have been chewed open, presumably by rats. Other skulls were either too decayed for their condition to be determined or the information was not recorded.

In addition to depredated eggs recorded along transects, observers in 1988 found two eggs in knock-down plots (see Bertram 1989) on 30 May. The eggs, found within 1 m of a burrow, were largely intact but both had holes (2x3 cm) along the top that were apparently caused by chewing. Neither egg showed signs of incubation and both contained roughly half of their contents, including most of the yolk. Bits of shell lay scattered around the eggs. No scrape marks, thought to be indicative of avian predators such as crows, were visible inside the eggs.

Between 18 May and 6 June, only one egg of the 13 experimental chicken egg clutches was depredated. On 22 May, the cracked egg of an experimental clutch was found opened on one side, in a manner similar to that described above for the two murrelet eggs found in knock-down plots.

Spruce cone chewings were found on 11 of the 16 transects run in 1988. (Table WG010-12). No two side by side transects were devoid of such chewings, suggesting that the animals responsible (rats) are present in a continuous band on the northeast coast of the island. Five rats (2 adult females and 3 young of the year) were trapped in the McPherson Point area between 12 May and 7 June (see Bertram 1989).

Associated species in 1981:

Bald Eagles - A total of 42 eagle nests were located around the circumference of Langara Island and on Cox and Lucy islands in 1981(Fig. WG010-8). Of the 42 nests, 31 were sighted with eagles in the vicinity, 11 of which had birds sitting on the nest. Fifty-four eagles including 5 immatures were seen around nests (not including the 11 adults sitting on nests). On 19 May the nest on the south side of McPherson Point contained a single egg. The highest concentration of nests occurred along the north slope east of Langara Point. Bald Eagle skeletons were found on the forest floor just west of McPherson Point and one carcass was found on the beach at Dibrell Bay. Bald Eagles were frequently seen flying through the Ancient Murrelet colonies and were found preying on the murrelets (see Predation).

Nest numbers correspond to those mapped on Fig. WG010-8. Nests were located on Langara Island unless otherwise noted:

1. 10 m high in spruce 12 m from shore; 1 adult nearby on 7 June.
2. 12 m high in spruce 20 m from shore; no adults present on 7 June.
3. Nest was 2 m long, 10 m high in spruce on rocky knoll 3 m from shore; 1 adult present in snag on nearby hill, 1 adult circling in air on 7 June.
4. Small nest 10 m high in spruce 4 m from shore; 2 adults present in tree S of nest on 7 June.
5. 15 m high in spruce 9 m from shore; grass growing from top of nest; 2 adults sitting on top of same tree on 7 June.
6. 13 m high in spruce 2 m from shore; 1 adult on nest; 4 adults in trees S of nest on 7 June.
7. 16 m high in multi-forked hemlock 30 m from shore; no eagles present on 7 June.
8. 12 m high in spruce 5 m from shore; 1 adult on nest, 1 nearby on 7 June.
9. 7 m high in spruce at shore; no adults present on 7 June.
10. Cox Island - nest located on top of a rocky pillar (called "hole-in-the-wall") 35 m high; 1 adult on nest, 1 nearby on 7 June.
11. Lucy Island - 18 m high in a spruce snag 50 m from shore; 1 adult on nest, 1 nearby on 8 June.
12. 30 m high in spruce 30 m from shore; 1 adult circling in air nearby on 18 June.
13. 23 m high in spruce 15 m from shore; salal growing from nest; 5 adults circling in air nearby on 8 June.
14. 18 m high in spruce 30 m from shore; grass and salal growing from nest; 2 immature and 2 adults perched in trees nearby on 8 June.
15. South side Cohoe Point. 13 m high in spruce at shore; 2 adults perched in trees nearby on 8 June.
16. 12 m high in spruce at shore; 1 adult on nest, 3 adults in trees nearby on 8 June.
17. 25 m high in spruce 30 m from shore; grass growing out of top of nest; adults nearby on 8 June.
18. 22 m high in spruce 5 m from shore; adults nearby on 8 June.

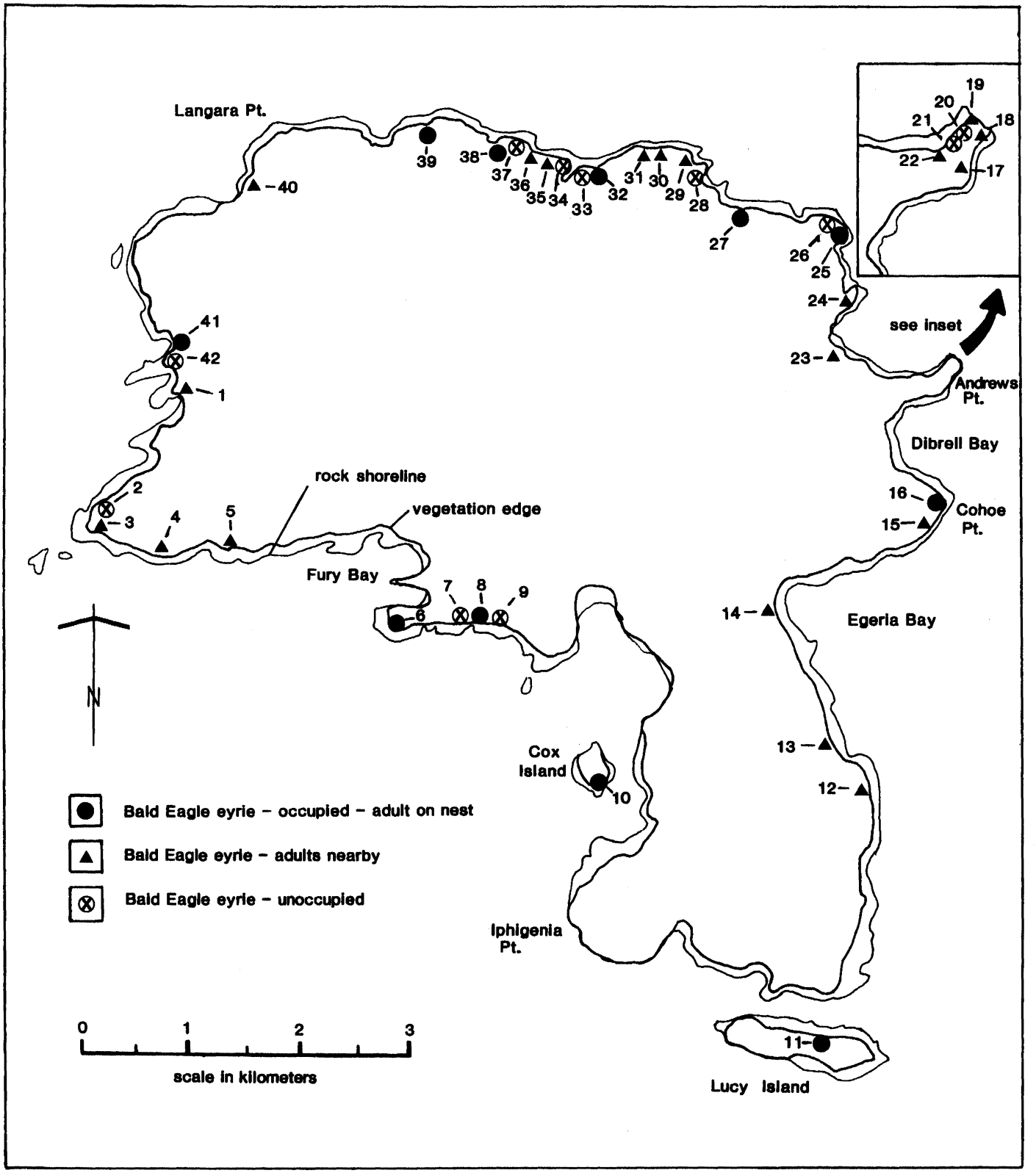

Fig. WG010-8. Locations of Bald Eagle eyries on Langara, Cox, and Lucy islands in 1981.

19. 20 m high in spruce 8 m from shore; 3 adults and 1 immature present in immediate vicinity of nests 17, 18, and 19 on 8 June.
20. 15 m high in spruce 5 m from shore; no eagles in vicinity on 8 June.
21. 15 m high in spruce 18 m from shore; salal growing out of top of nest; no eagles in vicinity on 8 June.
22. 18 m high in spruce 1 m from shore; 2 adults flying over nests on 8 June.
23. 22 m high in spruce 15 m from shore; 1 adult present in tree nearby on 8 June.
24. 25 m high in spruce 5 m from shore; salal growing from top of nest; 2 adults in tree on nearby point on 8 June.
25. 9 m high in spruce 1 m from shore; 1 adult present on nest on 8 June.
26. 16 m high in spruce 2 m from shore; no eagles in vicinity on 8 June.
27. 10 m high in spruce 2 m from shore; 1 adult on nest, 2 flying over nest on 8 June.
28. 12 m high in spruce 3 m from shore; no eagles present on 8 June.
29. 15 m high in spruce 5 m from shore; 2 adults in area on 8 June.
30. 12 m high in spruce 10 m from shore; 2 adults present on 8 June.
31. 12 m high in spruce 5 m from shore; salal growing out of top of nest; 1 adult, 1 immature perched in trees nearby on 8 June.
32. 14 m high in spruce 20 m from shore; 1 adult in nest on 8 June.
33. 12 m high in spruce 15 m from shore; grass growing from top of nest; no eagles present on 8 June.
34. 20 m high in spruce snag 7 m from shore; no eagles in vicinity on 8 June.
35. 12 m high in spruce 5 m from shore; grass growing from top of nest; 1 immature circling in air nearby on 8 June.
36. 12 m high in spruce 10 m from shore; 1 adult circling in air above nest on 8 June.
37. 10 m high in spruce 10 m from shore; no eagles in vicinity on 8 June.
38. 12 m high in spruce 10 m from shore; 1 adult on nest, 1 adult perched in nearby tree on 8 June.
39. 13 m high in spruce at shore; 1 adult in nest, 1 adult perched in tree nearby on 8 June.
40. 10 m high in spruce 15 m from shore; 1 adult perched in adjacent tree on 8 June.
41. 12 m high in spruce 8 m from shore; 1 adult on nest, 2 adults nearby on 8 June.
42. 13 m high in spruce 30 m from shore; no adults present on 8 June.

Peregrine Falcons - Five nesting pairs of Peregrine Falcons were found on Langara Island. On 19 May an eyrie at McPherson Point held 3 downy young, approximately 12 cm in length. On 14 May a female Peregrine Flacon was found sitting on a nest just east of Langara Point. Evidence of Peregrine Falcons preying on Ancient Murrelets was found (see Predation).

Common Murre - 12 off Langara Rocks on 23 May.

Marbled Murrelet - 10 in Dibrell Bay on 31 May.

Cassin's Auklet - 1 off Rhodes Point on 30 May; 2 in Parry Passage on 8 June.

Rhinoceros Auklet - 35 in breeding plumage off Thrumb Islet on 23 May; 85 off Langara Rocks on 6 June.

Tufted Puffin - 1 flying off east side of Langara I. on 8 June.

Common Raven - A Common Raven nest was located just west of McPherson Point. A pair of ravens was seen and heard just south of the cabin at Lord Bight on a number of occasions. Although no nest was sighted, the birds were territorial and were often seen chasing eagles from the area. One pair of ravens was sighted at Dadens but no nest was found.

Northwestern Crow - 44 between Lord Bight and Iphigenia Point on 8 June.

Rats - On 8 May a rat was seen on the point by Lacy Island. As well, rats were seen on a number of occasions around the cabin at Lord Bight. Rats were assumed to be preying on Ancient Murrelets (see Predation).

River Otter - 2 south of cabin in Lord Bight, and 1 at point by Lacy Island on 8 May, and 1 north of the cabin on 14 June. All scats seen were composed of fish.

Other birds and mammals sighted in 1981:

Red-throated Loon - 2 on 25 May.
Pacific Loon
Common Loon - 1 on 20 May.
Horned Grebe - 1 on 23 May.
Red-necked Grebe - 3 on 7 May.
Northern Shoveller - 1 on 22 May.
Harlequin Duck - 28 male, 7 female in Egeria Bay on 24 May.
Surf Scoter - 7 pairs flying north on 10 May.
White-winged Scoter - 22 on 13 May; 7 immatures on 4 June.
Common Merganser - 2 males on 13 May.
Semipalmated Plover - 3 on 8 May.
Wandering Tattler - 2 on 25 May.
Spotted Sandpiper - 1 on 8 May.
Whimbrel - 6 on 10 and 24 May.
Black Turnstone - 2 on 16 May.
Western Sandpiper - 2 on 9 May.
Belted Kingfisher
Rufous Hummingbird
Red-breasted Sapsucker
Hairy Woodpecker - young calling from nest 30 m high in spruce snag on 31 May.
Northern Flicker
Western Flycatcher
Tree Swallow
Barn Swallow
Chestnut-backed Chickadee
Red-breasted Nuthatch
Winter Wren - adult with juvenile on 29 May.
Golden-crowned Kinglet
Ruby-crowned Kinglet
Swainson's Thrush - first heard singing on 3 June.
Hermit Thrush
American Robin
Varied Thrush
Orange-crowned Warbler
Townsend's Warbler
Wilson's Warbler
Savannah Sparrow
Fox Sparrow
Song Sparrow - adult with juvenile on 30 May .
Golden-crowned Sparrow
Dark-eyed Junco
Rosy Finch - 1 female in 8 May.
Red Crossbill
Pine Siskin - 240 on 14 May, 300 on 30 May.

Hair Seal - 2 or 3 seals were regularly seen around Lord Bight. Sightings also were made south of Thrumb Islet, west of McPherson Point, and from Langara Point to Langara Rocks where 3 adults with pups were seen on 6 June.

Northern Sea Lion - 12 south of Thrumb Islet on 10 May; 28 on Langara Rocks on 12 May; and 4 at Lacy Island on 8 June.

Northern Fur Seal - 2 east of McPherson Point on 19 May.

Dall's Porpoise - 20 east of McPherson Point on 19 May.

Killer Whale - 1 male, 3 females, and 4 young northwest of Iphigenia Point on 13 May.

Sitka Deer - commonly sighted throughout the island and most often along the shoreline. Deer scats and trails were numerous.

WG-020 COX ISLAND 103 K/3

Location: In Cloak Bay off the southwest side of Langara Island.
51°12'20"N 133°00'45"W

Land Status: Crown Land.

Date of visit: 26 May (transect and exploration), 8 June (exploration) 1981.

Colony access: Boat landing on beaches on the southeast side.

Base camp: We camped on Langara Island.

Observers: M. Rodway, N. Hillis, L. Langley.

Census method: Exploration and line transect: six 5x5 m quadrats surveyed at 40 m intervals along one 168 m long transect run across the middle of the island at a bearing of 180°. Altitude along the transect ranged from 80 to 85 m, and slope averaged 5°.

Description: The perimeter of Cox Island consists of cliffs, steep, grassy slopes, and rock pinnacles rising abruptly from the sea. The island rises to 114 m elevation and has a total area of 10.6 ha. On the plateau-like top is a predominantly spruce forest with an understory of grass around the edges and bare ground in the middle.

Nesting species:

Black Oystercatcher: One nest with 3 eggs was found on 7 June on the southern tip of the island. There were two adults nearby.

Glaucous-winged gull - One pair was sitting on the western pinnacles on 8 June.

Pigeon Guillemot - 23 birds were counted on the water north of the island on 8 June.

Tufted Puffin: Puffins were counted flying to and from the west and north cliff-faces and steep grassy slopes: 13 May - 1; 26 May - 12; 8 June - 19.

No evidence of other burrow-nesting species was found.

Associated species:

Pelagic Cormorant - 1 nonbreeding bird; no cormorants were nesting in 1981.

Bald Eagle - One nest on the ground atop "hole-in-the-wall" pinnacle on the southeast side of the island. One adult was sitting on the nest, and another was perched in the trees nearby on 26 May.

Peregrine Falcon - One eyrie in the gully on the south side of the island, with 2 adult falcons nearby.

Marbled Murrelet - 22 off north side on 8 June, 8 in partial winter plumage.

Northwestern Crow - 2 on 26 May.

Other birds and mammals sighted:

Red-necked Grebe - 2 on 26 May.
Chestnut-backed Chickadee - recorded on 26 May.
Red-breasted Nuthatch - 2 juveniles just fledged on 26 May.
Winter Wren - 4 young out of nest but unable to fly on 26 May; nest under grassy hummock.
Townsend's Warbler - 1 singing on 26 May.
Pine Siskin - 15 on 26 May.
Sitka Deer - Deer droppings were common, and evidence of browsing on salal was recorded.

WG-030 LUCY ISLAND 103 K/2

Location: Off the southwest tip of Langara Island. 51°11'N 132°59'W

Land Status: Crown Land.

Date of visit: 25 May 1981.

Colony access: Boat landing on beaches along the south side.

Base camp: We camped on Langara Island.

Observers: M. Rodway, N. Hillis, L. Langley.

Census method: Exploration and line transect: nine 5x5 m quadrats surveyed at 40 m intervals along one 353 m long transect run across the middle of the island at a bearing of 190°. Altitude along the transect ranged from 0 to 37 m, and slope averaged 20°.

Description: Lucy is a cigar-shaped, 37.2 ha island lying east-west off the south tip of Langara Island. It is covered with a hemlock and spruce forest, with an understory of salal opening into mossy slopes in the interior. There are rock bluffs at the west end, and the island rises to a maximum elevation of 69 m.

Nesting species:

No evidence of nesting seabirds was found. One Ancient Murrelet feather pile was encountered along the transect, but no sign of burrows was seen.

Associated species:

Bald Eagle - 1 nest on the north side of the island about 50 m from shore; 1 adult was seen on the nest.

Black Oystercatcher - 2 birds seen on the south side of the island. No nest was located.

Glaucous-winged Gull - 2 adults roosting.

Other sightings:

Wandering Tattler - 2.

WG-100 FREDERICK ISLAND 103 F/14

Location: West coast of Graham Island off Peril Bay. 53°56'N 133°10'W.

Land Status: Crown Land.

Date of visit: May-July 1980 (transects and reproductive studies); May-August 1981 (reproductive studies - see Vermeer 1987); 7 July 1986 (gull rock off Dalton Point).

Colony access: Boat landings on small beaches at the northeast corner, and, at higher tide levels, on shelf areas on the southeast side.

Base camp: There is an excellent camp site at the northeast corner, with a seasonal stream. A permanent creek flows into the north bay.

Observers: 1980: M. Lemon, T. Carson, K. Vermeer; 1981: M. Lemon, D. Herlinveaux, B. Hay, N. Hillis; 1986: M. Rodway, C. Rodway, J. Rodway.

Census method: Line transects: 263 quadrats, 5x5 m, were surveyed at 45 m intervals along 28 transects spaced 80 to 500 m apart around the perimeter of the island (Table WG100-1).

To calculate occupancy rates for Ancient Murrelets and Cassin's Auklets, we included only those burrows investigated before 11 June. At that time the majority of the Ancient Murrelet chicks had departed their burrows and Cassin's Auklet chicks were beginning to fledge.

To obtain an estimate of predation throughout the colony, we searched a 10 m wide strip along the length of each transect and recorded all depredated remains found within those areas.

Two Peregrine Falcon eyrie sites were checked periodically from the first week in June until the end of July to determine the relative importance of Ancient Murrelets and Cassin's Auklets in the falcon's diet.

To monitor the number of Ancient Murrelets being killed throughout the nesting season, we set up four predation plots within the Ancient Murrelet colony. We thoroughly searched each of these areas periodically during the 1981 season, marking any remains found so that we would only count new depredations in subsequent surveys. These plots were set up in dense areas of the colony where the predation rate appeared heavy. Plots 1-4 were located: near the plateau edge on the north coast just east of transect 22, on the north coast near transect 23, on the main forest plateau behind the north bay in the vicinity of transect 24, and on the east coast of the island, just north of transect 3, respectively.

We spent a total of 14 hours on 6 days in 1980 and 45 hours on 15 days in 1981 concealed in the forest, watching the actions of Bald Eagles and Peregrine Falcons in the colony at dusk and at night when the seabirds returned.

Table WG100-1. Transect parameters on Frederick Island in 1980.

Transect	Bearing (°)	Total length (m)	Elevation Beg. (m)	Elevation End (m)	Elevation Max. (m)	Average slope (°)	Range of slope (°)
1	231	230	5	45	45	9	2-30
2	210	320	5	40	40	15	1-45
3	240	320	5	115	130	20	5-45
4	240	500	20	145	145	17	1-60
5	272	500	5	85	85	18	11-30
6	316	365	1	100	100	16	3-40
7	295	590	1	40	40	4	0-18
8	5	320	2	21	21	6	0-32
9	245	275	10	25	30	9	0-41
10	264	140	5	30	30	14	1-45
11	5	1175	1	65	75	11	0-52
12	84	185	4	30	30	13	5-25
13	65	230	1	15	15		
14	54	365	30	75	75	9	3-21
15	77	545	3	50	50	7	1-35
16	75	320	5	40	40	11	2-23
17	67	275	5	40	40	14	2-39
18	74	275	4	40	40	10	1-28
19	51	590	5	35	45	6	0-22
20	100	500	5	35	35	3	0-15
21	174	320	5	35	35	9	0-45
22	231	275	10	35	35	17	0-68
23	200	230	10	45	45	10	3-18
24	174	275	1	45	45	10	5-23
25	144	275	10	40	40	23	5-50
26	125	365	5	45	45	7	2-16
27	179	635	7	35	35	4	0-20
28	244	320	2	9	13	9	0-40

Studies on Cassin's Auklet chick growth and diet, and reproductive success and chronology of both Ancient Murrelets and Cassin's Auklets were conducted between 3 May and 25 July 1980 and 7 May and 7 August 1981 (see Vermeer *et al.* 1985). Burrows were located and marked in three areas along the north and northeast coast of the island. We monitored a sample of 107 occupied Ancient Murrelet burrows in 1980 and 86 in 1981. For Cassin's Auklets the sample size was 111 in 1980 and 160 in 1981. Burrows were revisited once a week and eggs were checked for signs of hatching. When cracks were detected in the eggs, burrows were checked daily to establish hatching dates. Once Ancient Murrelet chicks had hatched, burrows were checked daily until chicks had departed. Growth parameters of Cassin's Auklet chicks were monitored daily (see Vermeer 1987).

In the 1980 field season we recorded casual observations of Ancient Murrelets on the water surrounding Frederick Island. We circumnavigated the island by boat on 17 June 1981 between 2215 and 2300 h to locate staging areas of Ancient Murrelets.

Total counts were made for oystercatchers and gulls in 1986.

Description: Frederick Island has a total area of 420 ha., of which 373 ha. are vegetated. The coastline is rocky with many abrupt knolls on the north, west and south sides. Behind these knolls is a more uniform slope rising to the higher areas of the island. Isolated cliffs occur on some of the knolls and on the

interior slopes. Towards the north-west end the slope levels into an interior bog forest of windswept red cedar and Lodgepole Pine (*Pinus contorta*), surrounding open areas of thick sphagnum moss and small pools of water. On the north-east side, south of Dalton Point, the main slope occurs closer to shore and rises more steeply to the highest point on the island at 180 m elevation. Most of the knolls and perimeter slopes are a predominantly sitka spruce forest with the grass, *Calamagrostis nutkaensis* as the most common understory species. Some of the knolls are mossy on top. Wet seepage areas occur between the knolls as well as on the steeper slopes. North of Ellis Point on the east side is an expansive flat, wet area, extending up to 160 m from shore. Around most of the island, from 30 to 60 m inland (but in areas of wind exposure as far as 100-200m inland), the ground cover changes from grass to moss (generally dominated by *Eurhychium oreganum* and *Rhytidiadelphus loreus*) under a hemlock, red cedar and spruce forest. Red cedar becomes more plentiful further from shore (Fig. WG100-1). There is very little shrub cover around Frederick Island, though salal was encountered at higher elevations south of Dalton Point. Windfalls had occurred (before 1977) on the ridge above Ellis Point, and along the west side north of Ellis Point. There is a small, bare, creviced limestone rock off Dalton Point, which we named "Battleship Islet".

Nesting species:

Black Oystercatcher: Oystercatchers were seen daily around the shoreline, most commonly at "Battleship Islet" off Dalton Point, at Hope Point, and along the southwest coast. Maximum numbers seen were nine birds at Battleship Islet on 21 June 1980, and at least six pairs were recorded on the rocky areas of Hope Point and south of Hope Bay on 28 June 1980.

Four nests were found on Battleship Islet in 1980. On 26 June we located three of these nests, one gravel scape held one egg, the other two nests contained one chick each. On 28 June an additional nest containing two eggs was found.

No search for oystercatcher nests was conducted in 1981.

In 1986 we found three empty scrapes of rock chips on Battleship Islet. Two adults were present.

Glaucous-winged Gull: Gulls were frequently seen gathering in large feeding flocks in Peril Bay Passage between Frederick Island and Graham Island. Maximum number of birds recorded was 200 on 18 July 1980.

A search for nests on 26 June 1980 revealed only one nest on "Battleship" Islet. On 16 July, one large chick and one dead chick were found in a second search.

In a casual search of "Battleship Islet" on 3 July 1981, one chick was found hiding in a rock crevice.

There were five nests on "Battleship Islet" in 1986: 3 partially constructed; 1 empty with a broken eggshell; and 1 with 2 eggs and 1 recently hatched young. Nests were made of *Cochlearia* with some *Elymus*.

Pigeon Guillemot: A maximum of 40 birds was seen roosting on "Battleship Islet" at 0800 h on 26 June 1980. Three nests were found there in rock crevices on 28 June 1980. One nest held one egg and the other two held two eggs each. When we revisited these nest sites on 16 July, one nest was empty and the other two each contained one chick.

On 3 July 1981, we found two nests in clefts in the rock, each with one egg.

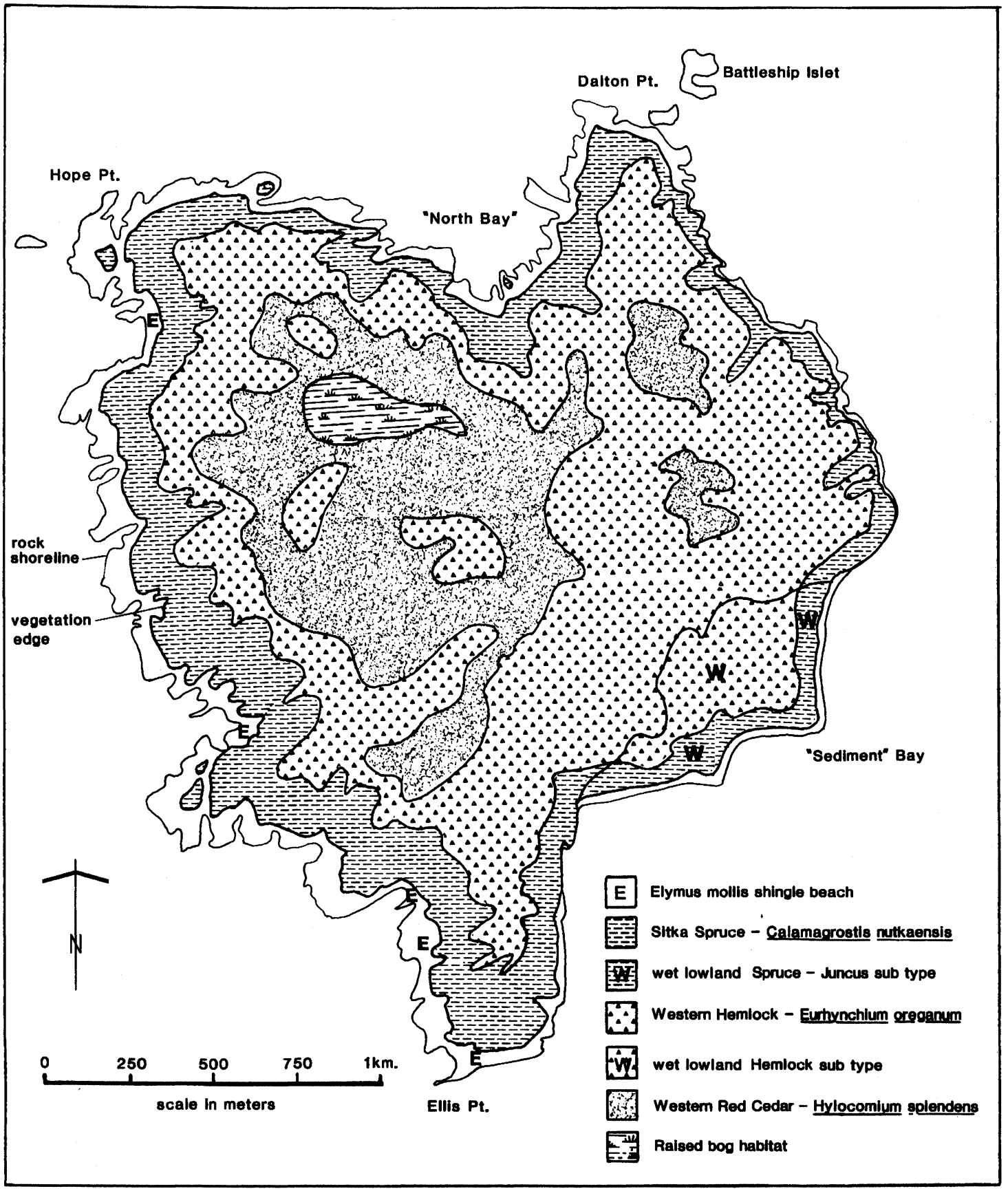

Fig. WG100-1. Vegetation map of Frederick Island in 1980.

We counted 73 birds on and around "Battleship Islet" in 1986. They were nesting in holes in the limestone, where we found 2 nests with 2 eggs, 1 nest with 1 young, and 1 nest with 2 young.

Ancient Murrelet: Ancient Murrelet colony was continuous around the island, except in the level, red cedar and spruce wetland on the southeast corner. Burrows were most abundant in hemlock and red cedar forest on upper slopes and on the main plateau, and were absent from open spruce forest and grass covered knolls and slopes that fringe the island.

The colony began at a mean elevation of 20 m and a mean distance of 80 m from the vegetation edge, though it occurred as close as 25 m from shore on the east and north coasts. It began further from shore on the west coast where the spruce-*Calamagrostis* zone was broader (Table WG100-2). The mean width of the colony on the northeast coast was 310 m, elsewhere it formed a band averaging 150 m in width. On the northeast coast the colony reached its furthest inland extent of 475 m, at an elevation of 145 m at the summit of the island.

Highest burrow densities occurred on the eastern and northern sides of the island. Nesting on the west coast was sparse with occasional pockets of denser burrowing (Fig. WG100-2). Assigned low, medium, and high density areas contained 0-2, 3-6 and 7-14 burrows per plot, respectively. Plots containing fewer burrows were included in the medium density area if they were bordered by plots on the same transect or on adjacent transects by plots with more burrows (Table WG100-3).

The majority of Ancient Murrelet burrows were found beneath tree roots, tree bases, stumps and fallen logs (Table WG100-4). Occasionally, they were found under grass tussocks in the spruce-*Calamagrostis* zone. The mean length of a sample of 40 burrows was 67 ± 4 cm.

1980 Population estimate:

Number of sample plots:	Higher density:	10
	Medium density:	67
	Lower density:	51
	Total:	128 (3200 m² - 0.3% of colony)
Average Density:	Higher density:	3600 ± 292 burrows/ha
	Medium density:	1319 ± 87 burrows/ha
	Lower density:	463 ± 39 burrows/ha
	Overall:	1154 ± 89 burrows/ha
Colony Area:	Higher density:	12.31 ha
	Medium density:	52.41 ha
	Lower density:	44.65 ha
	Total:	109.4 ha
Total burrows:	126,212 ± 9734	
1980 Occupancy rate:	54.2 ± 4.9% (45 of 83 known - Table WG100-5)	
1980 Nesting population:	68,407 ± 8114 pairs	

Table WG100-2. Extent of Ancient Murrelet and Cassin's Auklet colonies along transects on Frederick Island in 1980.

Transect	Ancient Murrelet					Cassin's Auklet				
	Distance along transect (m)	Distance from nearest shore Min. (m)	Distance from nearest shore Max. (m)	Range of elevation (m)	Average slope (°)	Distance along transect (m)	Distance from nearest shore Min. (m)	Distance from nearest shore Max. (m)	Range of elevation (m)	Average slope (°)
1	70-230	25	185	20-45	11	0-160	0	115	5-45	11
2	115-295	45	225	20-40	12	0-160	0	90	5-30	25
3	70-295	70	295	38-130	19	0-70	0	70	5-38	25
4	25-465	25	465	25-145	14	0-25	0	25	20-25	60
5	70-475	70	475	30-80	18	0-70	0	70	5-30	17
6	115-295	115	295	37-85	19	70-115	70	115	20-37	16
7	-	-	-	-	-	-	-	-	-	-
8	115-160	115	160	9-13	2	-	-	-	-	-
9	160-205	90	135	30	2	0-160	0	90	10-30	20
10	25-160	20	160	12-30	4	0-25	0	25	5-12	45
11	205-475	160	180	20-30	6	0-160	0	160	1-20	14
	720-1105	160	290	30-70	15					
12	70-205	70	180	7-30	12	0-50	0	50	4-5	20
13	-	-	-	-	-	0-25	0	25	2	3
14	115-295	205	385	40-60	4	0-115	0*	205	0*-40	13
15	295-430	205	340	37-50	4	0-340	0	250	3-42	14
16	70-205	35	170	6-30	18	0-115	0	80	3-15	14
17	70-205	70	205	23-40	19	0-70	0	70	5-23	18
18	115-205	115	205	18-32	12	0-115	0	115	4-18	12
19	70-115	70	90	10-15	0	0-205	0	90	5-20	3
	205-520	56	247	20-40	10					
20	250-430	160	340	8-32	4	0-250	0	160	2-8	4
21	70-320	70	225	15-35	10	0-115	0	115	5-25	5
22	70-205	70	165	28-35	11	0-70	0	70	10-28	41
23	50-205	25	205	20-45	9	0-70	0	70	10-28	11
24	25-160	25	160	3-32	14	0-25	0	25	1-3	7
25	25-250	25	250	10-40	23	0-70	0	70	10-30	45
26	70-295	70	295	6-42	15	0-70	0	70	5-6	6
27	70-610	48	250	7-40	5	0-70	0	48	3-7	1
28	70-295	25	160	10-13	10	0-70	0	70	2-8	4
						205-320	0	120	9-13	22

* - transect began ~80 m from shore but colony extended to shore edge.

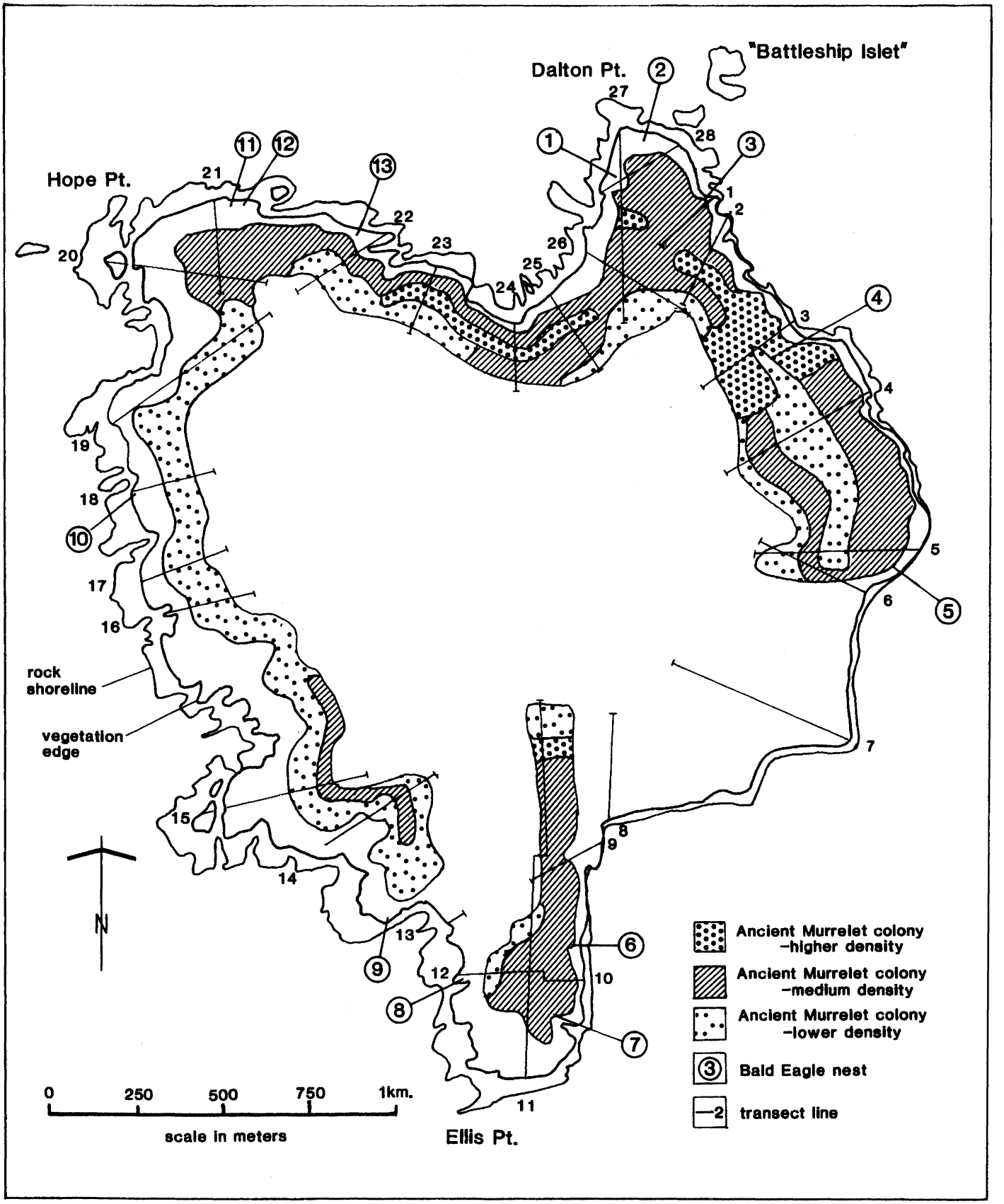

Fig. WG100-2. Ancient Murrelet colony and transect locations on Frederick Island in 1980.

Table WG100-3. Number of Ancient Murrelet burrows in 5x5 m plots along transects on Frederick Island in 1980. Numbers in bold print and underlined indicate plots within designated higher density areas. Bold print indicates plots within designated medium density areas. Plots in low density areas are in normal type. Plots considered outside the colony are indicated by a dash.

Plot	Transect 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	**3**	-	-	-	-	-	**2**	-	-	-	-
3	**5**	-	**7**	**3**	**4**	-	-	-	-	**4**	-	1	-	-
4	**6**	**5**	2	**4**	**3**	**3**	-	1	-	**0**	-	**0**	-	2
5	**3**	**10**	**14**	2	**6**	2	-	-	**5**		-	**6**	-	2
6	**0**	**5**	**8**	0	1	**3**	-	-	-		**4**		-	**4**
7		2	**7**	1	2	1	-	-	-		**0**			1
8		-	-	0	**3**	-	-	-			**4**			-
9				**4**	0	-	-				**4**			-
10				**3**	1		-				**3**			
11				0	1		-				1			
12				-	-		-				-			
13							-				-			
14							-				-			
15											-			
16											-			
17											**5**			
18											**0**			
19											**3**			
20											**6**			
21											**4**			
22											**1**			
23											**7**			
24											0			
25											1			
26											-			
27											-			

Plot	Transect 15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	**3**	**5**	**5**	-	-	-
3	-	1	2	-	1	-	**6**	**5**	**10**	**11**	**9**	**3**	**2**	**5**
4	-	0	0	1	-	-	**5**	2	1	**3**	**5**	**5**	**6**	**3**
5	-	1	1	2	-	-	**3**	1	2	-	**4**	2	**0**	**0**
6	-	-	-	-	-	-	**1**	-	-	-	2	2	**3**	**0**
7	-	-	-	-	1	**3**	**0**	-		-	-	1	**7**	**2**
8	1	-			2	**2**	0					-	**3**	-
9	2				1	**3**						-	**3**	
10	**5**				1	**5**							**2**	
11	-				1	-							**3**	
12	-				1	-							2	
13	-				-								1	
14					-								0	
15													-	

Table WG100-4. Habitat locations of Ancient Murrelet and Cassin's Auklet burrow entrances on Frederick Island in 1980.

Location	Ancient Murrelet		Cassin's Auklet	
	Number of burrows	% of total	Number of burrows	% of total
Tree roots	117	37	95	25
Fallen log	72	23	48	12
Stump	65	21	34	9
Under tree base	34	11	35	9
Open ground and moss tussock	22	7	32	8
Rock	3	1	15	4
Grass tussock	-	-	128	33
Total	313		387	

Table WG100-5. Occupancy of Ancient Murrelet burrows along transects on Frederick Island in 1980.

Date	Tran-plot	Contents: Empty	Adult only	1 cold egg	2 cold eggs	Deserted egg	2 eggs +?	Adult+ 2 eggs	Adult+ 2 chicks	Hatched eggshell	Occupied, contents not recorded	Total occup.	Total known
4/5	1-4	1	1									1	2
6/5	2-4	2				1[a]						1	3
6/5	2-5	3					1	2				3	6
6/5	2-6	3										0	3
7/5	2-7			1								1	1
8/5	25-3	3						2				2	5
8/5	25-4	1						2				2	3
8/5	25-5	2										0	2
10/5	3-3	2		1				1				2	4
10/5	3-5	3		1				1				2	5
10/5	3-6	2					1					1	3
10/5	3-7	2						1				1	3
22/5	9-5	1										0	1
24/5	23-2				1							1	1
24/5	23-3	2					3				1	4	6
24/5	23-4	1										0	1
24/5	23-5										1	1	1
26/5	5-3	1								1		1	2
26/5	5-4	1						1				1	2
26/5	5-5	1								1	2	3	4
29/5	24-2						1				1	2	2
29/5	24-3	1					1					1	2
7/6	5-6	1										0	1
7/6	5-7								1[b]			1	1
7/6	5-8	1									1	1	2
7/6	5-10									1		1	1
7/6	5-11	1										0	1
9/6	4-2	1									2	2	3
9/6	4-3						1				1	2	2
9/6	4-4				1						3	4	4
9/6	4-5										2	2	2
11/6	4-7									1		1	1
11/6	4-9	2									1	1	3
Totals		38	1	3	2	1	8	10	1	4	15	45	83

[a] partially incubated, rotten [b] one chick dead

Reproductive success and hatching chronology:

In the study plots, the majority of burrows contained two eggs in both years, with a small percentage of one, three and four egg clutches. Hatching success was highest in 1981 (84%). A greater portion of 2-egg clutches hatched than 1, 3 or 4-egg clutches in both years. Most unhatched eggs were from clutches that were deserted or not incubated (Table WG100-6). We determined the condition of the remaining eggs in 7 of the 15 2-egg clutches where only one chick hatched in 1980: 2 were infertile, 2 held advanced embryos, and 3 chicks hatched the night that the other chick departed the burrow, and were subsequently deserted. In both of the 3-egg clutches, 1 of the remaining eggs contained a chick which died in hatching. The remaining egg of the 2-egg clutch which hatched 1 chick in 1981, was infertile.

Hatching dates ranged from 17 May until 22 June in 1980 (n=87), and from 25 May until 19 June in 1981 (n=73) (Fig. WG100-3). Median hatch dates were the same in both years - 3 June (Mann-Whitney U test: Z=0.4077; p=0.6818). By 7 June in 1980, and 9 June in 1981, 80% of the sample clutches had hatched.

Outside our study plots, chicks were seen departing the colony as late as 28 June 1980 and 3 July 1981. By 6 July in both years, only a few Ancient Murrelet adults could be heard in the forest.

Of 119 burrows that had been occupied in 1980 and were relocated in 1981, 80 percent were again occupied by Ancient Murrelets, and 18 percent were unused in 1981 (Table WG100-7). A small percentage that had been occupied by Ancient Murrelets in 1980 contained Cassin's Auklets in 1981.

Measurements of Ancient Murrelet eggs and chicks from the study plots on Frederick Island in 1980 and 1981 are presented in Appendix II and III.

Nocturnal activity and chick departure:

Ancient Murrelets began to fly into the colony around 2320 h on most dark nights. If the night was clear with a bright moon, arrival was usually delayed by 30 to 45 minutes. On several occasions we heard Ancient Murrelets calling from their burrows 20 minutes before any birds flew in from the sea. Arrival of birds on the colony usually continued for about one hour, after which vocalizations reached a peak for about two hours (Table WG100-8).

During the hatching period, we observed several sets of chicks depart the colony. Initially the incoming adult bird remained at the entrance to its burrow, looked inside and called, while the incubating adult came out of the burrow, shepherding the two chicks in front of it. The chicks peeped continuously while emerging from the burrow. Once out of the burrow the adults stayed close to the chicks, and called repeatedly, generally with one adult ahead and one behind, as they led the chicks down through the forest. From our tents at night we could trace the progress of family parties as they passed by. We could hear the adult call, move on a few steps and call again while the chicks followed, peeping continuously. Our observations indicated that they travelled in this manner to the edge of the forest. From there the adults would fly out to the water and call once again. The chicks then travelled across the beach and into the water by themselves. Most chicks and attending adults had left the colony by 0230 though a few were still found crossing the beach at 0315.

Table WG100-6. Reproductive success of Ancient Murrelets on Frederick Island in 1980 and 1981 (adapted from Vermeer and Lemon 1986).

Parameters measured		1980 N	1980 %	1981 N	1981 %
1 egg clutches:	Total	6	5.6	4	4.6
	Unincubated	4	66.7	0	0
	Deserted	1	16.7	2	50
	Hatched	1	16.7	2	50
	Total eggs hatched	1	16.7	2	50.0
2 egg clutches:	Total	99	92.5	79	91.9
	Unincubated	5	5.0	2	2.5
	Deserted	9	9.1	4	5.0
	Predated	0	0	1	1.3
	1 egg hatched	15	15.2	1	1.3
	2 eggs hatched	70	70.7	71	89.8
	Total eggs hatched	155	78.3	143	90.5
3 egg clutches:	Total	2	1.9	2	2.3
	Deserted	0	0	2	100
	1 egg hatched	2	100	0	0
	Total eggs hatched	2	33.3	0	0
4 egg clutches	Total	0	0	1	1.2
	Deserted	0	0	1	100
	Total eggs hatched	0	0	0	0
Total no. of clutches		107		86	
Total no. of eggs laid		210		172	
Total no. of pairs which hatched eggs		88	82.2	74	86.0
Total no. of eggs hatched		158	75.2	145	84.3
Total no. of deserted clutches		12	11.2	9	10.5
Total no. of unincubated clutches		7	6.5	2	2.3
Total no. of clutches lost to predation		0	0	1	1.2

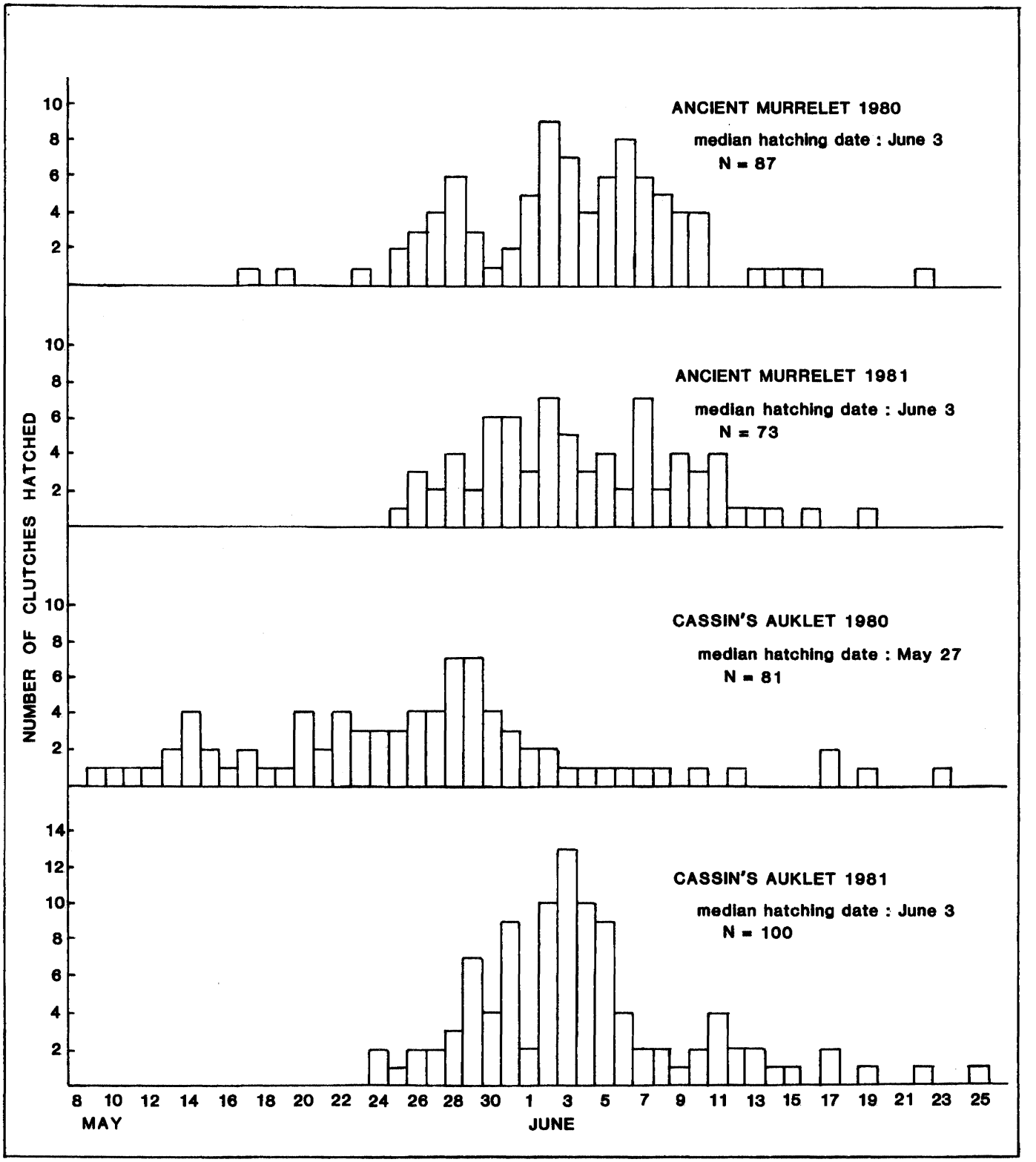

Fig. WG100-3. Hatching dates of Ancient Murrelets and Cassin's Auklets on Frederick Island in 1980 and 1981.

Table WG100-7. Status of burrows in 1981 that had been occupied in 1980 in study plots on Frederick Island.

	Ancient Murrelet		Cassin's Auklet	
	N	%	N	%
No. of 1980 burrows	146	-	165	-
No. of 1980 burrows not found in 1981	22	15.1	19	11.5
No. of 1980 burrows found in 1981	124	84.9	146	88.5
No. of occupied 1980 burrows with unknown contents in 1981	5	4.0	15	10.3
No. of occupied 1980 burrows with known contents in 1981	119	96.0	131	89.7
Occupied burrows from 1980 that were empty in 1981	21	17.6	40	30.5
Occupied burrows from 1980 that were occupied in 1981	95	79.8	89	67.9
Burrows that held CAAU in 1980 and ANMU in 1981	-	-	2	1.5
Burrows that held ANMU in 1980 and CAAU in 1981	2	1.7	-	-
Burrows that held CAAU adult and 1 egg and 2 ANMU eggs in 1980; and a CAAU in 1981	1	0.9	-	-

Table WG100-8. Observations of Ancient Murrelets and Cassin's Auklets on nesting slopes on Frederick Island in 1981.

Location	Date	Time	Notes
Ancient Gully	18 May	2330	Ancient Murrelets calling in the forest
		0010-0400	Cassin's Auklets in chorus Storm-petrel aerial displays
		0315-0431	72+ birds flying out of forest
Ancient Gully	31 May	2200-2250	Bald Eagles calling
		2300	Ancient Murrelet called from forest Bald Eagle called
		2322	Ancient Murrelets flying in
		2345-0140	Ancient Murrelet chicks heard
North Bay Plateau	6 June	2240-2307	Bald Eagle and Peregrine Falcon active
		2335-0005	Ancient Murrelets flying in
		0015-0030	Ancient Murrelet chicks coming out led by both adults. 10 sets seen.
North Bay Plateau	22 June	0010-0100	100 Ancient Murrelets flew in
		0100-0215	much Ancient Murrelet vocalizing in forest
		0100-0345	Cassin's Auklets in full chorus
		0350	all Ancient Murrelets have flown out
		0355-0410	many Cassin's Auklets flying out
Ancient Gully	7 July	0023-0130	main movement of birds into colony mainly Cassin's Auklets
		0146-0207	few Cassin's Auklet calls, some Ancient Murrelets calling
		0222-0340	Cassin's Auklet chorusing
		0350-0430	birds flying out.

Staging:

During the first week in June 1980, Ancient Murrelets gathered in Peril Bay offshore of the northeast coast of Frederick Island. Twenty-four were seen there at 2000 h and over 130 birds, in groups of 10 to 20 were counted at 2200 on 4 June. Dense fog settled over the area on 7 and 8 June and during this time Ancient Murrelets could be heard chorusing continuously throughout the day and night. We counted a minimum of 500 birds in Peril Bay Passage during a short boat trip between camp and the area of transect 3 at 0330 on 8 June. Most birds seen were adults but there were several family groups of adults and chicks.

During the boat survey on 17 June 1981, Ancient Murrelets were concentrated about 1 km off the north coast of the island where an estimated 25,000 birds were staging. An additional 5000 Ancient Murrelets were gathered along the west coast towards the southwest end of the island (Fig. WG100-4).

We observed no aggregations of Ancient Murrelets near the island once the majority of chicks had departed the colony. On 1 August 1981, a three-quarters grown Ancient Murrelet chick was feeding on a school of fish offshore from camp.

Cassin's Auklets: On Frederick Island, the Cassin's Auklet colony extended in a nearly continuous band around the perimeter of the island, broken only at the lowland on the southeast coast of the island and in the low wet area behind the bay south of Hope Point (Fig. WG100-5). Burrows occurred throughout the spruce-*Calamagrostis* zone up to the break in slope where spruce gives way to hemlock. They began at the vegetation edge and extended inland a mean distance of 87 m (Table WG100-2). The colony extended further inland on grassy knolls on the west coast. Burrows were most abundant at the vegetation edge (Table WG100-9). Assigned low and high density areas had 0-6 and 7-27 burrows per plot, respectively. Cassin's Auklet colony overlapped Ancient Murrelet colony at the edge of the hemlock forest where the forest is more open.

A large proportion of Cassin's Auklet burrows occurred under grass tussocks (Table WG100-4), reflecting the habitat of the majority of the colony. The mean length of a sample of 57 burrows was 99 ± 4 cm.

1980 population estimate:

Number of sample plots:	Higher density:	34
	Lower density:	42
	Total:	76 (1900m² = 0.36% of colony)
Average density:	Higher density:	4847 ± 405 burrows/ha
	Lower density:	724 ± 132 burrows/ha
	Overall:	2568 ± 305 burrows/ha
Colony area:	Higher density:	20.8 ha
	Lower density:	32.7 ha
	Total:	53.5 ha
Total burrows:	137,388 ± 16,318	
1980 Occupancy rate:	65.4 ± 5.7% (68 of 104 known - Table WG100-10)	
1980 Nesting population:	89,852 ± 13,169 pairs	

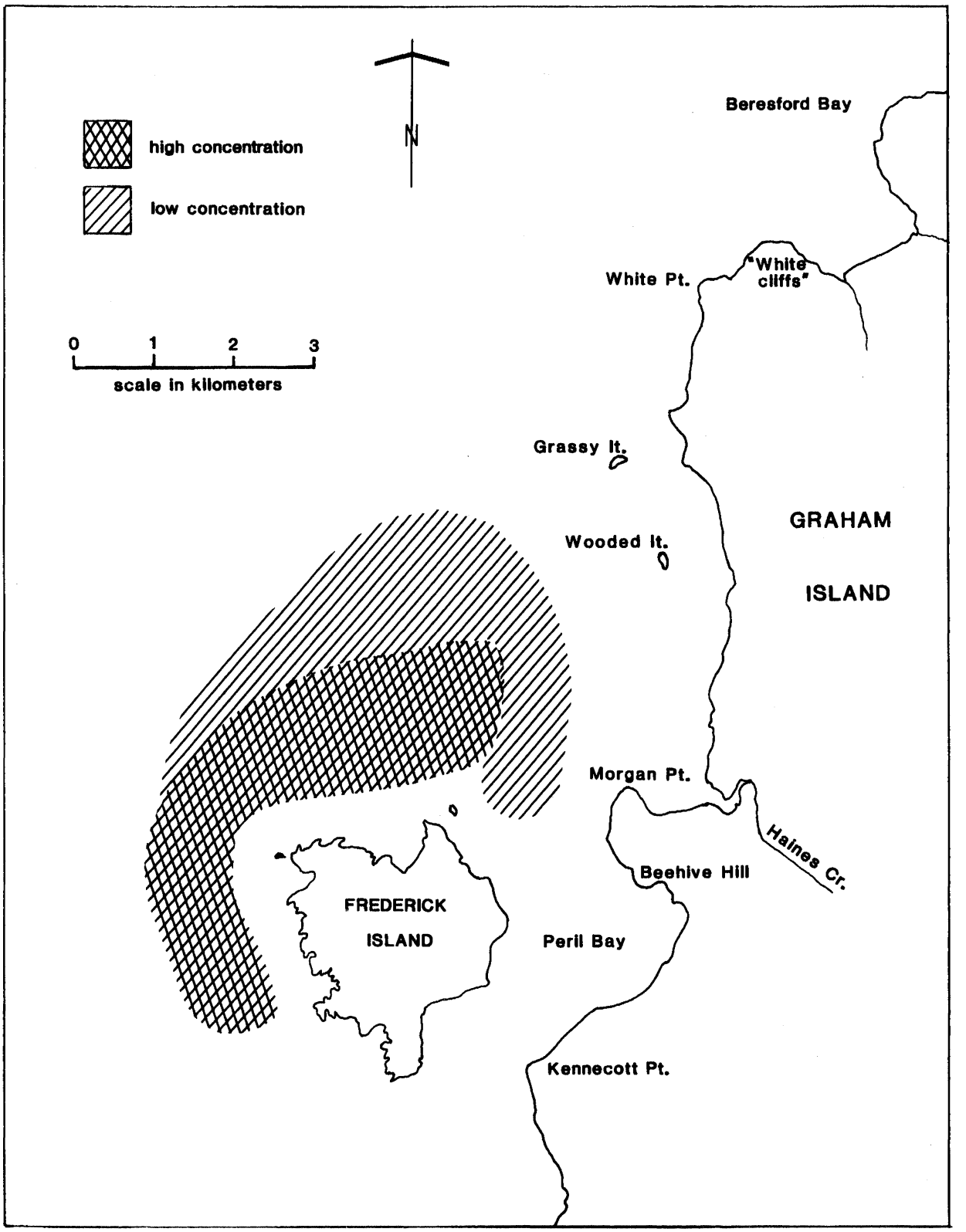

Fig. WG100-4. Ancient Murrelet staging areas around Frederick Island in 1981.

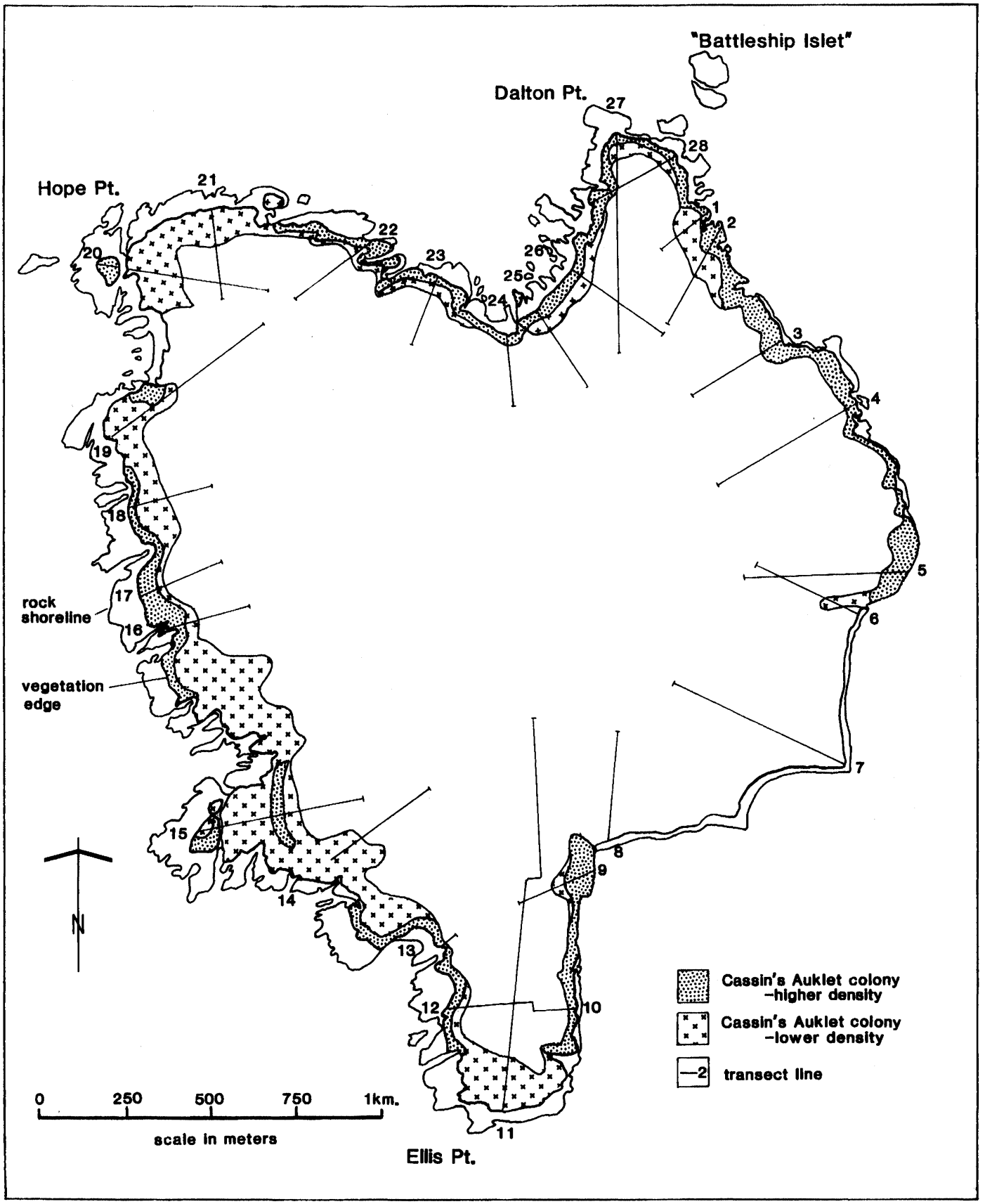

Fig. WG100-5. Cassin's Auklet colony and transect locations on Frederick Island in 1980.

Table WG100-9. Number of Cassin's Auklet burrows in 5x5 m plots along transects on Frederick Island in 1980. Bold print indicates plots within designated higher density areas. Plots considered outside the colony are indicated by a dash.

Plot	Transect 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**23**	**27**	**10**	**2**	**7**	-	-	-	**15**	**11**	3	**16**	**10**	3
2	2	**15**	**8**	-	**11**	-	-	-	**0**	-	4	0	-	0
3	6	0	-	-	-	3	-	-	**13**	-	0	-	-	7
4	6	5	-	-	-	-	-	-	1	-	0	-	-	-
5	-	-	-	-	-	-	-	-	-		-	-	-	-
6	-	-	-	-	-	-	-	-	-		-		-	-
7		-	-	-	-	-	-	-	-		-			-
8		-	-	-	-	-	-	-			-			-
9				-	-	-	-				-			-
10				-	-		-				-			
11				-	-		-				-			
12				-	-		-				-			
13							-				-			
14							-				-			
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18											-			
19											-			
20											-			
21											-			
22											-			
23											-			
24											-			
25											-			
26											-			
27											-			

Plot	Transect 15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	1	**12**	**16**	**19**	4	**11**	0	**20**	**17**	**9**	**21**	**16**	**10**	**10**
2	1	**9**	**13**	2	0	**10**	4	0	6	-	4	0	0	0
3	**13**	1	-	0	1	3	1	-	-	-	-	-	-	-
4	2	-	-	-	0	0	-	-	-	-	-	-	-	-
5	0	-	-	-	**13**	0	-	-	-	-	-	-	-	-
6	5	-	-	-	0	0	-	-	-	-	-	-	-	**8**
7	**11**	-	-	-	-	-	-	-		-	-	-	-	**1**
8	1	-			-	-	-					-	-	**5**
9	-				-	-						-	-	
10	-				-	-							-	
11	-				-	-							-	
12	-				-	-							-	
13	-				-								-	
14					-								-	
15													-	

Table WG100-10. Occupancy of Cassin's Auklet burrows along transects on Frederick Island in 1980.

		Contents								
Date	Tran Plot	Empty	1 cold egg	Egg +?	Adult + egg	Chick	Chick latrine	Occupied contents not recorded	Total occupied	Total known
4/5	1-1	1						4	4	5
4/5	1-3	1							0	1
4/5	1-4	2							0	2
6/5	2-1	4		2				1	3	7
6/5	2-2	3			2				2	5
6/5	2-4	3			2				2	5
8/5	25-1	4			2			3	5	9
8/5	25-2	1							0	1
10/5	3-1		1					1	2	2
10/5	3-2	4							0	4
22/5	9-1	1		3		3		4	10	11
22/5	9-3	3		1		2		3	6	9
22/5	9-4		1						1	1
24/5	23-1	4		3		3	1	1	8	12
24/5	23-2			2					2	2
26/5	5-1	1		1				3	4	5
26/5	5-2	2		2		3		2	7	9
29/5	24-1		1	4		1			6	6
2/6	13-1	1						5	5	6
9/6	4-1	1						1	1	2
TOTALS		36	3	18	6	12	1	28	68	104

Reproductive success and hatching chronology:

Hatching success was highest in 1980 (73%). Fledging success of hatched chicks was 90% in 1980 and 95% in 1981 (Table WG100-11). In 1980 the first chick hatched on 9 May and the last hatched on 23 June, with a median hatch date of 27 May. The hatching period was more compressed in 1981 from 24 May until 25 June, with a median hatch date of 3 June (Fig. WG100-3). Hatching was significantly earlier in 1980 (Mann-Whitney U test: $Z = 7.36$, $p \ll 0.01$). By 31 May 1980 and 7 June 1981, 80% of the clutches had hatched. Similar to hatching, fledging was earlier for the sample of birds in 1980 than in 1981. Median date of fledging in 1980 was 9 July and 18 July in 1981 (Fig. WG100-6).

Table WG100-11. Reproductive success of Cassin's Auklets on Frederick Island in 1980 and 1981 (from Vermeer and Lemon 1986).

Parameters measured	1980		1981	
	N	%	N	%
No. of clutches (1 egg)	111	-	160	
No. of eggs hatched	81	73.0	109	68.1
Deserted clutches	24	21.6	47	29.4
Unincubated clutches	2	1.8	1	0.6
Infertile clutches	4	3.6	3	1.9
No. of chicks fledged	72	88.9	104	95.4

With only one exception, all Cassin's Auklets were incubating one egg. In 1981, one adult bird was incubating 2 eggs, but eventually deserted the burrow. In two burrows in 1980 Cassin's Auklets were attending clutches that included Ancient Murrelet eggs as well as their own. Both of those birds subsequently deserted their burrows.

In both years towards the end of the season, we reexamined burrows where birds had deserted their nests earlier in the season, either through natural causes or as a result of our presence. In one of these burrows in 1980 we found a small chick that had hatched on 16 July. In 1981, two burrows contained 1 week old chicks on 24 July, and one burrow held an adult incubating an egg on 10 July. All three of these burrows had previously contained adults incubating eggs, which had deserted their burrows by 1 June. These may represent birds that had relayed later in the season, after a failed nesting attempt, or were late nesting birds taking over a vacated burrow.

Thirty percent of burrows that had been occupied in 1980, were empty and unused in 1981 (n=131). Sixty-eight percent were again occupied by Cassin's Auklets, while 2 burrows that had been used by Cassin's Auklets in 1980, contained Ancient Murrelets in 1981 (Table WG100-7).

Measurements of Cassin's Auklet eggs and adult birds from study plots on Frederick Island in 1980 and 1981 are presented in Appendix IV and V.

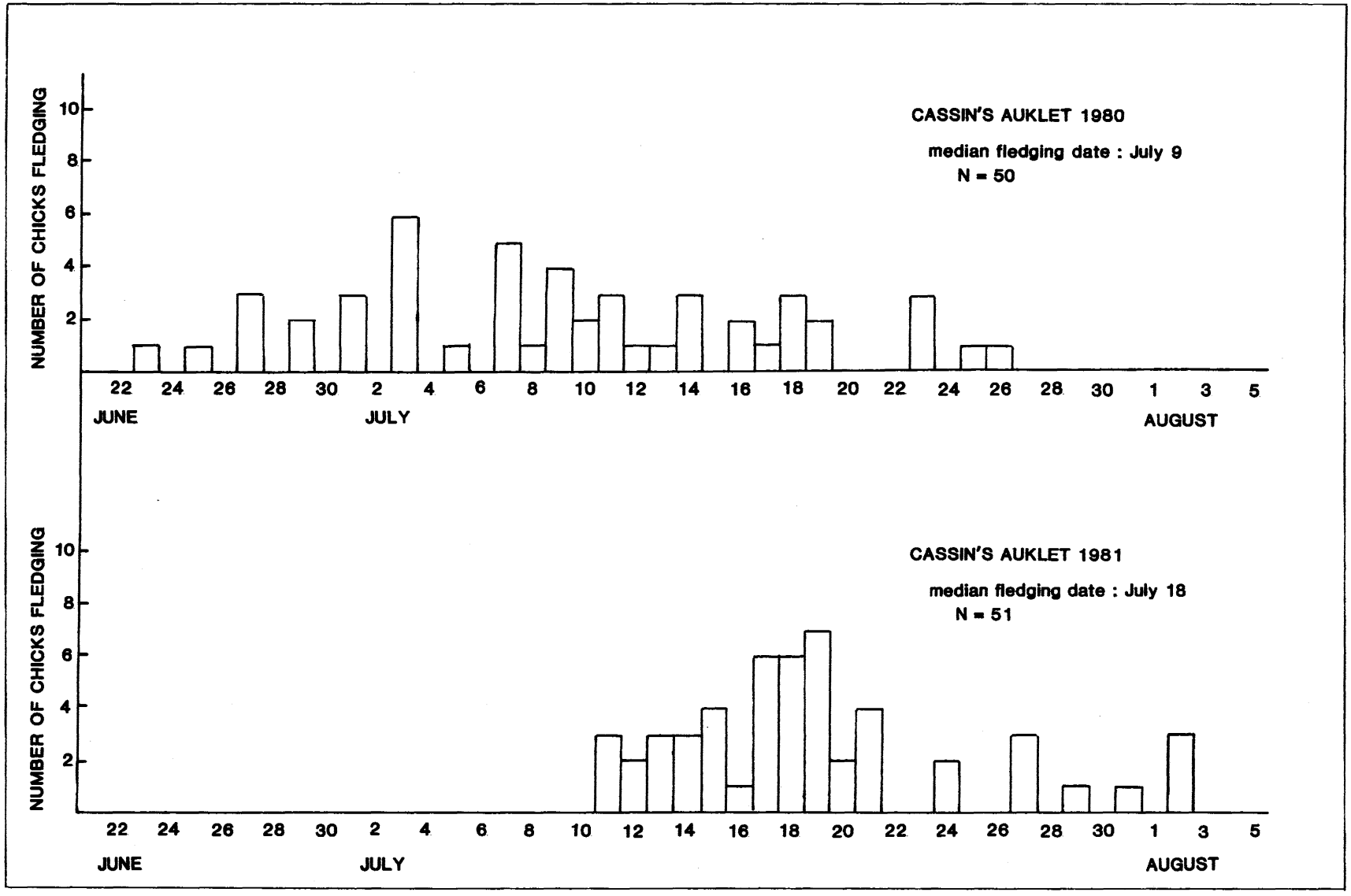

Fig. WG100–6. Fledging dates of Cassin's Auklets on Frederick Island in 1980 and 1981.

Offshore sightings of Cassin's Auklets:

During our occasional boat trips in the vicinity of Frederick Island, no Cassin's Auklets were seen until late in the field season. Sightings of birds near shore were frequent in the latter half of July. In the late afternoon of 21 July 1981, about ¼ mile to the north northeast of "Battleship Islet" we saw about 25 Cassin's Auklets in one small area. These birds were probably fledglings, their attempts at flying and diving did not always meet with success. Cassin's Auklets were also seen in front of camp and between Frederick Island and Grassy Island to the north on 26 and 28 July and 1 August 1981.

Predation:

We recorded 141 separate incidents of predation in the 10.7 hectares searched along transects in 1980 (Table WG100-12). Most kill sites were found in hemlock forest in Ancient Murrelet colony. Remains were found in the spruce-*Calamagrostis* shore zone, but searching was more difficult there through grass tussocks up to 1 meter in height. Depredated remains of Ancient Murrelets were encountered throughout the colony. The highest incidence of predation occurred along the north and northeast coasts of the island where the nesting density of Ancient Murrelets was greatest. Along the west coast where densities of Ancient Murrelets were low, depredated remains were also scarce. No evidence of predation was found in the large, low wetland on the southeast side of Frederick Island where no burrowing occurred.

Using the area searched along sections of transects within Ancient Murrelet colony boundaries (5.69 ha-5.3% of colony) and the number of feather piles found there (64), we calculated the density of remains to be 11.25 ± 2.27 feather piles per hectare. Extrapolating over the 109.4 ha of Ancient Murrelet colony yields an estimate of 1231 ± 248 birds killed in 1980.

Fewer remains of Cassin's Auklets were encountered in the area searched along the transects. Within the delineated Cassin's Auklet colony we searched 2.88 ha (5.4% of the colony) finding only 3 pairs of wings and 3 carcasses. Using these as an estimate for the total number of birds killed, yielded 2.1 ± 1.7 birds per hectare or 111 ± 91 Cassin's Auklets over the whole colony.

Ancient Murrelet chicks accounted for a small proportion of the predation remains found (Tables WG100-12 and WG100-13). In one location near our camp, over a three night period, we found a total of nine dead chicks that had been lacerated around the head. By morning, all had been scavenged (one by a crow).

The four predation plots set up in the Ancient Murrelet colony in 1981 were in selected areas of heavy predation and are not representative of predation over the whole colony. The density of depredated birds ranged from 12 to 380 per hectare (Table WG100-13). Most predation occurred prior to the first week of June, and few additional signs of predation were found in mid-June.

Avian predators of Ancient Murrelets and Cassin's Auklets on Frederick Island include Bald Eagles, Peregrine Falcons, Common Ravens and Northwestern Crows. We saw Bald Eagles and Peregrine Falcons calling, flying and perched in tall trees along the shoreline at dusk before the seabirds arrived. We encountered a Bald Eagle perched only 1½ m above the ground in a tree within the Ancient Murrelet colony at night on 9 June 1980 and 6 July 1981. Both times the eagle flew off on our approach. Prey remains found at two Peregrine Falcon eyrie sites in 1980 were predominantly of Ancient Murrelets (69% of the 92 remains found, Table WG100-14). Cassin's Auklet remains formed a smaller but still substantial portion (26%). Cassin's Auklets were a larger proportion of the prey remains towards the end of the collection time in July.

Table WG100-12. Depredated remains found in a 10 meter strip along transects on Frederick Island in 1980.

Tran	Plot	Date	AMMU feather pile	ANMU single wing	ANMU pair of wings	ANMU chick	CAAU pair of wings	CAAU carcass	Depredated burrow	BAEA pellet	Other
1	3	4/05								3	
1	3-4	4/05	1								
2	1-2	6/05								2	
2	4-5	6/05	4								
3	3	10/05	1								
3	3-4	10/05	2								
3	4-5	10/05	2								
3	5-6	10/05	2							2	
3	7-8	10/05	2								
4	1-2	9/06	3								
4	2-3	9/06	1								
4	4	9/06	1		1						
4	5	9/06	1								
4	9	11/06		1							
4	10	11/06	2								
5	3-4	26/05								15	
5	4-5	26/05			1						
5	5-6	7/06							2		
5	7-8	7/06	1								
5	9	7/06		1							
5	11	7/06	1	1							
6	6-7	20/06	1								
6	8	20/06	1								
9	2	30/06					1				
9	4-5	30/06	1							1	
10	3-4	30/06	2						1	1	
11	2	6/07								1	
11	16-17	8/07	1								
11	23	8/07	1								
11	24-25	8/07		1							
11	25-26	8/07			1						
13	2-3	30/06	1								
13	3-4	30/06	2							1	
13	4-5	30/06	1								
14	4	12/07						1			
14	7	12/07								1	
15	1	4/07	1								
15	2	4/07	1								
15	4	4/07	1								
15	10-11	4/07	1								
16	3	10/07	1								1 Leach's Petrel
16	5	10/07	1								
16	6	10/07	1								
17	4	2/07	1								
17	6-7	2/07	1								
18	1	28/06	1								
18	5	28/06			1						
19	4-5	28/06						1			
19	6-7	28/06	2								
19	9-10	28/06	1								Crow pellet ANMU chick down
19	10-11	28/06	4								
20	4-5	22/06	2		1						
20	8	22/06	1								
20	10	22/06	1								
20	10-11	22/06				1					
21	2-3	22/06	1			1					

Table WG100-12. (continued)

Tran	Plot	Date	AMMU feather pile	ANMU single wing	ANMU pair of wings	ANMU chick	CAAU pair of wings	CAAU carcass	Depredated burrow	BAEA pellet	Other
21	5-6	22/06	1								
21	7-8	22/06			1						
22	2	18/06						1			
22	3	18/06									1 Red Phalarope
22	3-4	18/06	2							3	
24	1-2	29/05	1		1				1		
24	4-5	29/05	1								
25	1	29/05								1	
25	3-4	8/05	2								
25	4	8/05	1						1		
25	5-6	8/05	1								
26	1-2	11/07	2								
26	3-4	11/07	4								
26	4-5	11/07							1		
27	9-10	24/06	1		1						
28	2	3/07					1				
28	2-3	3/07	3		2		1				
28	4-5	3/07	1								
28	6-7	3/07	1								
28	7	3/07	1								
Totals			79	4	10	2	3	3	6	31	3

Table WG100-13. Predation evidence found in four plots in the Frederick Island Ancient Murrelet colony in 1981. Each survey date lists the new remains since the previous date.

Date	Plot #	Size (m^2)	Adult ANMU feather pile	Chick ANMU feather pile	ANMU pair of wings	Raptor pellet	Excavated burrow	Density of remains depredated birds per hectare
4/06	1				1	1		
11/06	1							
8/07	1							
Totals	1	840	0	0	1	1	0	12
4/06	2		17			2		
11/06	2		8	3		1		
8/07	2		5			1		
Totals	2	1373	30	3	0	4	0	219
20/05	3		35				4	
8/06	3		18				4	
18/06	3		5	1				
25/07	3		3			1	1	
Totals	3	5088	61	1	0	1	9	120
8/06	4		16			1		
18/06	4							
25/07	4		2					
Totals	4	468	18	0	0	1	0	380

Table WG100-14. Seabird remains found in the vicinity of two Peregrine Falcon eyries on Frederick Island in 1980.

Date	Ancient Murrelet	Cassin's Auklet	Fork-tailed Storm-Petrel	Red-necked Phalarope	Unid. bird
East coast site					
7/06	16	2			
20/06	8	4	1		
5/07	1				
24/07	4	4			
Totals	29	10	1		
North coast site					
18/06	10	2		1	
27/06	13	7			
7/07	11	5			3
Totals	34	14		1	3

Ravens and crows were commonly seen throughout the Ancient Murrelet colony perched in trees and on the ground. In 1981 we saw a raven on the ground peering into the entrance of an Ancient Murrelet burrow. We also saw a raven fly out of the forest with an egg in its bill. Northwestern Crows were seen three times in 1980 with Ancient Murrelet eggs, and once in 1980 we surprised a group of five crows on the ground in the colony. On our arrival they flew off leaving behind a freshly killed Ancient Murrelet. Throughout the colony we found Ancient Murrelet burrows that had been excavated to expose the nest cavity. In all cases the eggs had been removed and eaten. In most cases the adult bird had been killed and only a pile of feathers remained where the bird had been plucked in the disturbed area in front of the burrow. Generally only thin root hairs were shredded and no large roots severed to expose the burrow. At a few of these excavations were the unmistakeable signs of a bird's bill probing into the ground, suggesting that ravens or crows were responsible. Excavations of burrows occurred in both years, with some areas of the colony harder hit than others. In the last week of July in 1981 there were at least 31 excavations of Cassin's Auklet burrows, both in the spruce-*Calamagrostis* covered knolls around the shore and in hemlock forest in one area on the east coast. Some of those appeared to have been more forcefully dug up, with earth scattered further around and roots broken. Often the remains of well feathered chicks were found at the site. River Otters may have been responsible for some of those depredations.

In 1981, we witnessed three crows working together to dig up a burrow from our Cassin's Auklet study plots. They succeeded in dislodging a rock cover we had placed over a hatchway into the burrow, and proceeded to remove the plug of earth, moss and wood. The crows subsequently associated our coloured marking tags with the burrows, and began to excavate our study plots. Replacing the tags with inconspicuous markers and weighing down the hatchways with rocks prevented further disruptions.

Associated species:

Fork-tailed Storm-Petrel - A few birds were commonly heard at night in 1980 and 1981, from the beginning of May until mid-July. One storm-petrel egg was found on the ground on the north coast on 12 May 1981, but no burrows were found in either 1980 or 1981.

Leach's Storm-Petrel - Seen at night on 21 July 1980 and heard at night near camp on 27 June 1981.

Pelagic Cormorant - Non-breeding birds seen on "Battleship Islet" on 22 and 26 May 1980, and 3 July 1981.

Bald Eagle - A maximum of 5 immatures were seen on 22 May 1980. There were 5 immatures on "Battleship Islet" in 1986. We located 13 Bald Eagle nests around the island (Fig. WG100-2) of which 10 were active in 1980:

1. On west side of Dalton Point; 20 m up in spruce; nest of sticks about 1 meter wide. Two adults present on 4 May 1980.
2. North end of Dalton Point in an area of blowdown and topped trees near shore. Adults perched nearby in 1980. Adult perched in tree beside nest tree on 4 July 1981.
3. Between camp and transect 1; 35m up in 50 m spruce, 15 meters from shore, positioned where a cluster of branches split from trunk. Adult on nest on 4 May 1980; adult at nest on 9 May 1981.
4. North side of major gully near transect 3 at an elevation of about 60 m; 18 m up in spruce tree. Adult present on 17 May 1980.
5. East coast, near transect 6, 28 m up in spruce tree, 20 m from the edge of the vegetation and at 10 m elevation. Two adults flew off nest and perched in nearby tree; at least two young birds heard calling from the nest on 26 May 1980. Two adults attending nest on 24 May 1981.
6. East side of Ellis Point near transect 9. One "excited" adult perched nearby in 1980.
7. East side of Ellis Point, south of transect 10; 25 m up in 38 m hemlock. Two adults present and calling in 1980.
8. West side of Ellis Point near transect 12.
9. On steep slope north of transect 13, 28 m up in tree. No activity in 1980.
10. On west coast, just north of transect 18 in the area of surge channels. 20 m up in a gnarled spruce with four forking branches. Appeared inactive in 1980. Two adults present at nest on 19 May 1981. Adult from nest chased immature Bald Eagle from vicinity on 5 July 1981.
11. On north coast near transect 21, 28 m up in tree. Nest was almost 1 m across. Two adults present in 1980.
12. On north coast, 25 m up in snag, near shore. Two adult eagles present in 1980. Two adults perched above nest on 15 May 1981.
13. On north coast near transect 22, 35 m up in spruce tree near the edge of the forest on a point. Nest was 2 m across with salmonberry growing on edges. Two adult eagles present on 20 May 1980.

Peregrine Falcon - Falcons were active daily around the island. They engaged in typical territorial disputes with Bald Eagles, chased Red Crossbills on 30 May and 25 July 1980, and one was sighted giving chase to a Belted Kingfisher through the forest at Dalton Point on 15 July 1980. Three active eyries were located in 1980 and 1981.

Common Murre - 5 sighted north of Frederick Island on 9 July 1980.

Marbled Murrelet - Frequently seen in the passage between Frederick Island and Graham Island throughout our stay in 1980 and 1981. Two to 4 birds were seen through May to mid-July. Maximum of 10 birds seen on 20 July 1980. North of Frederick Island, 12 Marbled Murrelets were seen on 4 July 1980 and 5 were seen on 9 July 1980.

Rhinoceros Auklet - Frequently seen in the passage between Frederick Island and Graham Island in 1980 and 1981. Generally seen in mixed feeding flocks with Glaucous-winged Gulls and Pigeon Guillemots. High numbers recorded were 120 on 27 June 1980; 40 on 20 July 1980. Several rafts of Rhinoceros Auklets, totalling approximately 250 birds, were seen north of Frederick Island on 9 July 1980. "Many" were seen north of Frederick Island on 26 July and 3 August 1981. No Rhinoceros Auklets were found nesting on Frederick Island, but burrows along transect 20, were noted to have much larger entrances than normal Cassin's Auklet burrows. We were unable to determine contents of these burrows.

Tufted Puffin - One on 9 July 1980, north of Frederick Island.

Northwestern Crow - Seen daily through 1980 and 1981 field seasons, singly and in small groups within the forest and along the shore. Often gathering in flocks of 20 to 40 birds on the shore. Largest flock recorded was 80 birds on 30 June 1980. In 1986, 25 were foraging in tidal areas adjacent to "Battleship islet". Ground nests of crows were found in both 1980 and 1981.

1. On the west side of Dalton Point, under a *Calamagrostis* tussock on a steep slope. 4 eggs in a nest lined with dry grass on 8 May 1980.
2. On east coast south of transect 2, in forest under a root cavity of a large hemlock. The nest was formed of twigs and grasses. On 4 June 1980, there were 3 young fledglings beside the nest.
3. On the Ellis Point peninsula, under beach logs. One well-feathered chick in the nest on 24 May 1981.
4. Under a small spruce seedling near the shore edge at camp. We monitored the nest in 1981:

7 May	- 2 eggs in nest
8 May	- 3 eggs
9 May	- 4 eggs
24 May	- 4 eggs
26 May	- 1 chick, 3 eggs
27 May	- 2 chicks, 2 eggs
5 June	- 2 chicks
26 June	- nest empty - 1 fledgling nearby

Common Raven - 2 to 4 birds seen regularly in 1980 and 1981 throughout the field season. Fledgling flying with adults on 16 July 1981. In 1986, three ravens were on "Battleship islet" and surrounding tidal areas.

Northern Sea Lion - One swimming north through passage between Frederick Island and Graham Island on 21 May 1980. One near "Battleship islet" on 18 July 1981.

Hair Seal - Regular haulouts at Dalton Point on "Battleship islet", at Hope Point and Ellis Point. Three adults with pups on 16 June 1980 at "Battleship islet". 10 adults and 4 pups on tidal shelves of "Battleship islet" on 4 July 1981. 7 hauled out near Hope Point on 4 June 1981.

River Otter - Occasional signs of otters seen around the island in both 1980 and 1981: scats on the north coast; runs along the forest fringe on the east coast near transect 5, and an otter "bath" and lots of scats in the shoreline spruce and grass forest south of Hope Point. Otter tracks were seen on the beach below transects 1 and 2 on 23 July 1980, and in front of camp on 13 July 1981. Six otters swam in front of camp on 6 August 1981.

Sitka Deer - Seen regularly in 1980 and 1981, all around the island. Frequently seen feeding along the tide line. Two fawns seen 10 July 1980. Doe and fawn on 16 July 1981.

Peromyscus sp. - Seen regularly at camp in 1980 and 1981. "Many" by the end of June in each year.

Shrew - One or two animals were regular visitors at camp in 1980.

Killer Whales - 4 swam south down the channel between Frederick Island and Graham Island on 20 July 1980.

Bat - Occasionally seen at dusk around camp.

Other sightings:

Red-throated Loon - One on 12 May, 30 June 1980 and 9 May 1981.
Common Loon - One or two birds frequently seen in 1980 and 1981 between Frederick Island and Graham Island. Maximum of four on 17 May 1980.
Red-necked Grebe - Seen regularly until 17 May 1980.
Great Blue Heron - One seen on southeastern beach on 30 June 1980.
Sandhill Crane - two flew past "Battleship islet" towards the north bay on 31 May 1981.
Harlequin Duck - One in front of camp on 2 July 1981.
White-winged Scoter - Four flying by on 8 July 1980.
Band-tailed Pigeon - One seen during a foggy day, 26 June 1980.
Blue Grouse - Occasionally seen and heard in both 1980 and 1981. One adult with 4 chicks on 20 June 1980.
Semi-palmated Plover - Seen on 22 May and 4 July 1980.
Greater Yellowlegs - Seen occasionally from 1 - 24 July 1980.
Spotted Sandpiper - Two on east side of island on 4 June 1980.
Whimbrel - Heard on 15 May 1980; two seen on 2 June 1980, and two on 12 May 1981.
Belted Kingfisher - Single bird seen frequently in both 1980 and 1981; two seen on 10 July 1980.
Rufous Hummingbird - One or two seen frequently in both 1980 and 1981.
Red-breasted Sapsucker - Seen in 1980 and 1981. Young heard calling from a nest hole 18 m up a snag in the blow down south of Hope Point on 22 June 1980.
Hairy Woodpecker - Seen regularly in 1980 and 1981. Two unconfirmed nest sites found in 1980, one on Ellis Point peninsula and the other near transect 5.
Northern Flicker - Seen on 22 May 1980 and 20 July 1981.
Western Flycatcher - Regular in both 1980 and 1981.
Tree Swallow - One seen on 30 June 1980.
Chestnut-backed Chickadee - Regularly seen and heard throughout 1980 and 1981, frequently in flocks of 10-20 birds.
Red-breasted Nuthatch - Seen occasionally in 1980 and 1981.
Brown Creeper - Seen on 7 May, 30 June and 22 July 1980, and occasionally in 1981.
Winter Wren - Seen regularly 1980 and 1981. Nest building observed on 10 May 1981, and young fledglings out with adults seen on 6 July 1980.
Golden-crowned Kinglet - Seen frequently in 1980 and 1981; flocks of 10 birds noted on 1 and 3 June 1980.
Swainson's Thrush - First heard on 2 June 1980 and 31 May 1981, then regularly thereafter in both years.
Hermit Thrush - Seen and heard regularly throughout 1980 and 1981. Nest found on Dalton Point on 23 June 1980.
American Robin - Seen in the flat grassland area on the southeast shore of the island on 2 and 30 June 1980, and in the forest along the north coast on 18 May 1981.
Varied Thrush - Seen and heard regularly throughout 1980 and 1981.
Orange-crowned Warbler - Regular in 1980 and 1981.
Yellow-rumped Warbler - Seen on 11 July 1981.
Yellow Warbler - Seen on 13 May 1981.
Fox Sparrow - Regular in 1980 and 1981 around shore. Young fledglings seen on 9 June 1981 near camp.

Song Sparrow - regular in 1980 and 1981. Five nests were found from casual observations in 1980.
1 - 16 June - nest with 2 eggs
2 - 22 June - nest in grasses at Hope Point
3 - 23 June - nest in grasses at Dalton Point
4 - 28 June - nest with 3 eggs in grass south of Hope Point
5 - 3 July - nest with 3 chicks in grass behind camp
6 July - 4 chicks present
8 July - 4 chicks present
12 July - chicks have fledged

Dark-eyed Junco - Occasional sightings in 1980 and 1981. Maximum of 10 recorded on 28 June 1980.

Rufous-sided Towhee - Seen on 12 May 1980.

Red Crossbill - Regular in 1980 and 1981; commonly seen in several flocks of more than 80 birds in each.

Pine Siskin - Regular in 1980 and 1981, in small numbers and flocks of 40 birds or more.

Incidental Observations in areas near Frederick Island

Grassy Islet WG-080

Black Oystercatcher - "Many" seen 26 July 1981.
Glaucous-winged Gull - 4 nests with eggs on 9 June 1981.
Hair Seal - 60 hauled out on intertidal rocks 26 July 1981.

Wooded Islet WG-090

Loon sp. - 4 July 1980.

Fork-tailed Storm-Petrel - Nesting on islet amidst *Maianthemum* and tree roots. 9 July 1980 - two burrows excavated, one containing a chick, the other an adult and egg.

Pelagic Cormorant - At least 20 birds roosting on rock shelves on 9 July 1980.
Bald Eagle - 9 July 1980 - nest 12 m up in spruce. Adult present.
Ancient Murrelet - A few birds on water near the islet on 26 July 1981.
Northwestern Crow - Four seen on 9 July 1980.
Song Sparrow - Seen on 9 July 1980.

West Coast Graham Island

Sooty Shearwater - 6 May 1981 - "thousands" near Marble Island.

Great Blue Heron - 5 July 1980 - flying from the forest behind Beehive Hill-Peril Bay beach.

Sandhill Crane - 9 July 1980 - three seen feeding on tidal shelf on section of coast between Haines Creek and White Cliffs.

Merganser sp. - 5 July 1980 - female flying out from Haines Creek.

Bald Eagle - 9 July 1980 - five adults and 2 nests seen on section of coast between Haines Creek and White Cliffs:
1. 20 m up 30 m spruce tree on Graham Island shore just around point north of Grassy Islet.
2. 18 m up spruce tree on shore edge, opposite Bousel Rocks. Two adults present.
20 July 1980 - two at Kennecott Point.

Peregrine Falcon - 9 July 1980 - one seen near "White" Cliff and White Point.
Semipalmated Plover - 3 August 1981 - six along the Beehive Peril Bay beach.
Sanderling - 20 July 1980 - three on Beehive-Peril Bay beach.
Least Sandpiper - 3 August 1981 - seven on Beehive-Peril Bay beach.
Ancient Murrelet - 6 May 1981 - seen on water near Marble Island.
Rhinoceros Auklet - 6 May 1981 - seen on water near Marble Island.

Belted Kingfisher - 20 July 1980 - two along Beehive-Peril Bay beach.
Hairy Woodpecker - 4 June 1980 - nest about 10 m up in snag in Peril Bay Indian Reserve - two adults nearby.
Common Raven - 9 July 1980 - two adults and young on section of coast between Haines Creek and "White Cliffs".
Fox Sparrow - 9 July 1980 - seen on section of coast between Haines Creek and "White Cliffs".
Song Sparrow - 9 July 1980 - seen on section of coast between Haines Creek and "White cliffs".
Northern Sea Lion - 15 June 1980 - about 100 hauled out on Joseph Rocks. 6 May 1981 - hauled out on Joseph Rocks.
River Otter - 9 July 1981 - tracks along Beehive - Peril Bay beach.
Sitka Deer - 9 July 1981 - tracks along Beehive-Peril Bay beach.
Raccoon - 9 July 1980 - tracks in sand near "White cliffs" north of Haines Creek.
Black Bear - 5 July 1980 - tracks at Haines Creek. 9 July 1981 - tracks on Beehive-Peril Bay beach.
Red Squirrel - 9 July; 3 August 1981 - Beehive-Peril Bay beach.

WG-230 HIPPA ISLAND 103 F/10,11

Location: North of Skelu Bay. 53°32'N 132°58'W

Land status: Part of Port Chanal Provincial Ecological Reserve.

Date of visit: 27 May to 17 October 1983 (transects of all areas and reproductive study on storm-petrels - see Vermeer and Devito 1988 and Vermeer *et al.* 1988). Transects through Ancient Murrelet and Cassin's Auklet colony on the main island were conducted between 27 May and 25 June; transects for storm-petrels on the northern islet, "Petrel Islet", were surveyed between 5 July and 25 August. Total counts of oystercatcher and gull nests on the northwest rock were made on 8 July 1986.

Colony access: Boat landings can be made on beaches along the northeast side and in the mid-west bays.

Base camp: There is good camping in the bay half way along the northeast side. Water is available from a stream here. Camping is also possible in the mid-west bays, but the ground is often very wet. On the northern "Petrel Islet", camping is possible on the high gravel beach lining the channel that separates the islet into two portions. The boat can be landed on the small beach on the northeast corner.

Observers: 1983: M. Lemon, M. Rodway, D. Bertram, A.J. Gaston, G. Kaiser, D. Powell, L. Rankine, R. Reusch, Y. Turcotte, K. Vermeer. 1986: M. Rodway, J.A. Rodway, C. Rodway.

Census method: Line transects: On the main island, 256 quadrats, 5x5 m, were surveyed at 30 m intervals along 31 transects spaced 200 m apart (Table WG230-1). Along transects 1E,1W,2E,2W,7E,8E and 9W an additional plot was placed midway between the 30 m points to further sample the narrower band of Cassin's Auklet colony. On the northern islet, 59 quadrats, 2.5x2.5 m, were surveyed at 15 m intervals along 7 transects spaced 50 m apart. Transects were run at a bearing of 103°, and were 115, 135, 195, 255, 135, 105 and 22 m long, respectively.

Transects on the main island were placed in all accessible slopes. Spacing measurements began from the extreme north end of the island and continued along the shoreline on the northeast side to south of the sand dune on the eastern side of the island. From this point southwards, slopes are frequently disrupted by bands of cliffs and were considered too precipitous for line transects. The western side of the island was sampled south from the north end of the island to the protected bay, as a continuation and extension of transects 1-10 begun on the east side.

Table WG230-1. Transect parameters on Hippa Island in 1983.

Transect #	Bearing (°)	Total length (m)	Elevation Beg. (m)	Elevation End (m)	Elevation Max. (m)	Average slope (°)	Range of slope (°)
1E	210	114	1	25	25	6	2-20
1W	30	160	2	25	25	6	6-8
2E	210	210	1	11	26	27	3-52
2W	30	120	1	28	28	16	7-33
3E	210	240	8	10	25	13	5-30
3W	30	120	1	10	10	4	1-7
4E	210	290	3	27	29	11	1-42
4W	30	215	2	17	17	6	3-11
5E	210	305	1	25	30	9	3-37
5W	30	215	1	35	35	12	4-37
6E	210	270	5	55	55	15	3-42
6W	30	100	50	55	55	16	2-25
7E	210	275	3	74	88	24	6-45
7W	30	320	2	74	74	13	0-29
8E	210	245	3	65	65	27	2-50
8W	30	275	1	60	60	24	2-61
9E	210	155	1	24	28	6	1-13
9W	65	155	5	45	45	22	3-58
10E	210	215	1	24	30	16	3-45
10W	30	60	1	6	6	7	0-12
11	168	305	5	90	100	21	0-37
12	200	335	1	99	104	17	4-40
13	195	545	2	220	220	26	1-62
14	190	425	2	220	220	33	3-50
15	219	390	25	225	225	27	10-40
16	220	455	2	271	282	32	2-55
17	220	215	130	235	235	33	20-40
18	195	95	8	25	25	15	8-25
18A	220	5	170	170	170	33	
19	230	125	2	50	50	14	7-30
20	286	35	1	25	25	31	21-40

A large portion of Hippa Island could not be sampled with line transects due to the steepness and irregularity of the terrain. Accessible areas were explored. On the west side of the island from the protected bay south to the southwest point of the island, the forested ridges above the cliffs were explored for signs of nesting. The shoreline was walked and accessible areas spot checked for signs of burrowing from the protected bay southwards to a point midway along the south shore, after which the shore was impassable. The south and east sides (south of the sand dune) of the island were mostly inaccessible. One spot check from the beach of a steep forested rib on the mid south side was done. An attempt was made to delineate boundaries of burrowing areas, but no burrow density estimates were made for those sections of the island.

A composite 1:10,300 scale airphoto was used as a base map for delineating colony areas. Contour lines were drawn on this airphoto by enlargement from those found on a 1:50,000 scale topographic map. Significant distortion exists around the sides of the airphoto particularly in the southeast part of the island, due to the location of the flight path used for the airphoto. Ground measurements, slope and elevations taken along transects were used to correct contour lines on the map. Boundaries of the colony were drawn to the appropriate elevational extent on the map, and the area measured using a compensating polar planimeter then corrected for the slope of the land obtained in the field, as described in the main methods section.

To supplement occupancy data for Cassin's Auklets obtained within quadrats along transects, an occupancy plot was established on the west coast, north of the protected bay.

The occupancy rate for storm-petrels on the northern islet ("Petrel Islet") was determined from burrows with known contents in plots along transect lines until the end of July. After this time, Fork-tailed Storm-petrels were fledging (Vermeer *et al.* 1988) and their absence would affect the occupancy rate.

To obtain an estimate of predation throughout the colony we searched an area with a radius of 10 m around each plot along the transects and recorded all depredated remains found within those areas.

Hippa Island was circumnavigated to locate Ancient Murrelet staging areas. Estimates of the numbers of Ancient Murrelets in the major staging ground of Hippa Passage were made from shore with the aid of binoculars and a 20x spotting scope. Several observers made estimates and these were averaged.

Description: Including "Petrel Islet", Hippa Island has an area of 676 ha. of which 556 ha. are vegetated. Hippa Island consists of a dramatic variety of topographic features. The south and east sides of the island are very steep, rising rapidly to a peak elevation of 486 m. Those slopes are rift with numerous slides, which appear to be frequent occurrences, two new ones were observed in 1983, and other sections were in various stages of regeneration. Considerable rock and cliff are exposed, interspersed with bands of more mature forest where slides have not occurred. Those slopes are difficult to access and the habitat is very disrupted.

The west side of the island is a rugged conglomerate of cliffs, rocky and grassy knolls, dissected rocky shoreline, low level forest behind recessed beaches, and steep forested slopes. The southern end is the steeper area with larger cliffs rising toward the higher south end. The northern end is lower with more moderately undulating forested and regenerating slopes.

The northeast side of Hippa is of more uniform habitat and topography. As on the west, the north end is lower undulating forest while towards the southern peak the slopes are steeper and more uniform. At the east end of that side is

a sand dune surrounded by a small level area of intact forest. Above this, the slope rises steeply and the forest has been levelled by a large swath of windfall.

A shallow lake sits perched above the northwest arm of the island, lying in a cirque-like depression on the west side of the peak. Mature forested slopes rise from around the lake toward the peak.

As has been suggested above, the forests on Hippa Island have suffered from numerous slides and blowdowns. The large windfall swath above the sand dune is at present vegetated mostly with grass under the overturned trees with some patches of small regenerating spruce. Another large blowdown area cuts across the lower slopes south from the large protected bay on the west side. It is also covered mainly with grass and patches of small regenerating spruce with some deciduous shrubs such as elderberry and salmonberry. Areas of older blowdowns with thick, sometimes almost impenetrable, regenerating spruce occurred along most transects on the north end of the island (transects 1-8; Fig. WG230-1).

Where the forests have not been devastated by slides or windfall, their composition follows the pattern of Sitka Spruce (*Picea sitchensis*) dominating along the shore, Western Hemlock (*Tsuga heterophylla*) mixing with the spruce and then becoming dominant within 150 m from shore, and Western Red Cedar (*Thuja plicata*) becoming more abundant further from shore and at higher elevations. At elevations above 200 m along the east side, in areas where the slope becomes moderate and the drainage is poor, the hemlock and red cedar become stunted and covered with clumps of moss.

Ground cover in the mature stands of forest is predominantly moss with grass occurring along the shore edges and on the more open knolls, especially along the north and west sides.

The small northern islet, which we have named "Petrel Islet", is 20 ha in extent, of which 4.2 ha is vegetated. It is separated from Hippa Island by a narrow channel of water. The vegetated portion of the islet is divided by a shallow channel which fills with water only on the highest tides of the month. Sitka Spruce forms the forest cover on the islet and the understory consists of moss, bare litter, and thick regenerating spruce seedlings when the forest canopy is more open. Grass (*Calamagrostis nutkaensis* and *Elymus molis*) fringes the islet and occurs in a few more open patches. An expansive rock shelf extends out from the southwest part of the islet.

Nesting species:

Storm-petrel: Storm-petrels were nesting only on "Petrel Islet", where they were the predominant species (Fig. WG230-2). They were burrowing in all available habitat under tree roots, logs, grass tussocks and into open ground (Table WG230-2). Particularly at the beginning of the season, we frequently found an incubating bird in the nest chamber behind a tunnel that was completely choked with spruce cones. It appeared as if the bird had pulled all these in to completely enclose itself in the burrow.

Density ranged from 0 to 16 burrows per 2.5x2.5 m plot (Table WG230-3). Population and density figures differ slightly from that presented in Vermeer *et al.* 1988, because data from transects 6 and 7 were not available for their analysis.

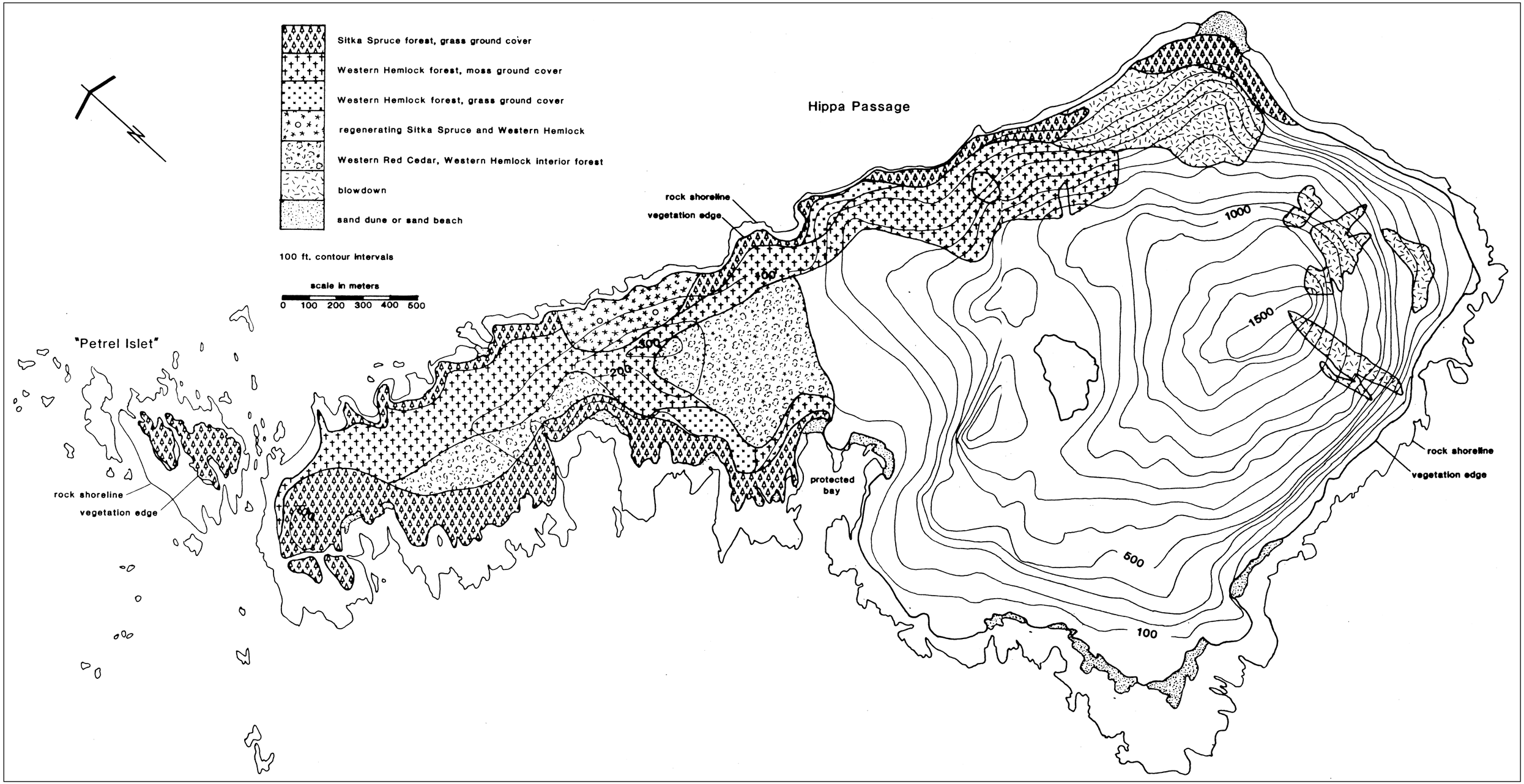

Fig. WG230-1. Vegetation map of seabird colony areas on Hippa Island in 1983.

Table WG230-2. Habitat locations of storm-petrel burrows on the northern islet of Hippa Island ("Petrel Islet") in 1983.

	Number of storm-petrel burrows	Percent of total
Grass tussock	64	26
Open ground	64	26
Log	49	20
Live tree roots	43	18
Dead tree roots	7	3
Rock	6	2
Tree base	5	2
Stump	3	1
Shrubbery	2	1

Table WG230-3. Number of storm-petrel burrows in 2.5x2.5 m plots along transects on the northern islet of Hippa Island ("Petrel Islet") in 1983. Plots considered outside the colony are indicated by a dash. Plot marked by a star was only 4.7 m^2.

	Transect						
Plot	1	2	3	4	5	6	7
1	2	3	2	0	4	9	2
2	3	0	4	2	1	4	14
3	9	5	12	7	0	5	
4	16	0	12	0	0	6	
5	1	0	0	3	6	9	
6		7	0	6	12	5	
7		4	1	3	14	11	
8		-	8	4	0	5	
9			0	6	2		
10			1	11	3		
11			6*	7			
12				1			
13				8			
14				0			
15				-			

1983 Population estimate:

Number of sample plots:	57 (355 m^2 - 0.93% of colony)
Average density:	7521 ± 912 burrows/ha
Colony area:	3.8 ha
Total burrows:	28,881 ± 3502
1983 Occupancy rate:	82.4 ± 3.9% (75 of 91 known- Table WG230-4)
Species ratio:	32 (46%) Fork-tailed to 37 (54%) Leach's storm-petrels
1983 Nesting population:	
Forked-tailed Storm-Petrels:	10,894 ± 1419 pairs
Leach's Storm-Petrels:	12,788 ± 1666 pairs

Pelagic Cormorant: Pelagic Cormorants were suspected to be nesting on the south coast of Hippa Island on the landward faces of separated rock pinnacles, which were not thoroughly examined. On 29 August, 12 birds were roosting on nearby cliffs, 3 in breeding plumage. One bird was sighted on 14 September, still with breeding patches. Small numbers of immatures and adults were frequently sighted in other areas.

In 1986, we boated as close as possible to the previous nest site on the south end of the island (Rodway *et al.* in prep). No cormorants were seen, but past nest sites were only visible from shore.

Black Oystercatcher: A thorough survey for nesting oystercatchers was not conducted, but four nests were recorded around Hippa Island in 1983:

1. On the west coast on a rocky promontory just north of the protected bay. The nest was made of rock chips and 2 limpet shells. One egg and 2 adults were present on 28 May.

2. At the west end of "Petrel Islet". The nest was made of rock chips and mussel shell fragments. Two downy chicks and 2 adults were present on 7 June.

3. On the west side of "Petrel Islet". The nest was composed of rock chips. Two eggs and 2 adults were present on 7 June.

4. On the northeast side of "Petrel Islet". Nest was composed of rock chips with shells. Two eggs and 1 silent, flying adult on 11 June. Two chicks and 2 attending adults on 21 June.

Small groups of oystercatchers were regularly seen on "Petrel Islet": 4 on the tidal shelf at the southwest end throughout August and September; 12 on 4 September and 18 on 12 September on the reefs off the northeast end of the islet.

In 1986, 3 empty scrapes, with suspected young, were found on the gull rock at the northwest corner of the main island (Fig. WG230-3). Five protective adults were present.

Table WG230-4. Occupancy of storm-petrel burrows along transects on the northern islet of Hippa Island ("Petrel Islet") in 1983.

Date	Tran	Plot	Empty	Cold egg	Unid. petrel	Fork-tailed Storm-petrel				Leach's Storm-Petrel			Total occupied	Total known
						Adult	Adult + egg	Adult + chick	Chick	Adult	Adult + egg	Chick		
5/7	2	1			3								3	3
5/7	2	3						1			2		3	3
7/7	2	6	1				1						1	2
11/7	2	7	1						2				2	3
12/7	3	1								1[a]			1	1
12/7	3	2	1								3		3	4
12/7	3	3	2			1			2	1	2		6	8
13/7	3	4					2	2			3		7	7
16/7	3	7									1		1	1
20/7	3	8	1				1		3		2		6	7
20/7	3	10									1		1	1
20/7	3	11	1								2		2	3
21/7	4	2	1								1		1	2
21/7	4	3						1	3				4	4
21/7	4	5									1		1	1
21/7	4	6							1		2		3	3
21/7	4	7							2				2	2
23/7	4	8									3		3	3
23/7	4	9					1	1	1		1		4	4
23/7	4	10	2		1				1		2		4	6
23/7	4	11	3		1						2		3	6
23/7	4	12									1		1	1
23/7	4	13	2		1				1	1	1		4	6
27/7	1	1									1		1	1
27/7	1	2							1		1		2	2
27/7	1	3							3		1		4	4
27/7	1	4	1						1				1	2
29/7	5	2									1		1	1
8/8	5	5	2	1			1						2	4
8/8	5	6		1					3		2	1	7	7
8/8	5	7	1	1					1		1		3	4
8/8	5	9							1			1	2	2
8/8	5	10		1									1	1
14/8	6	1	1									2	2	3
14/8	6	2	2									2	2	4
14/8	6	3	1						3			1	4	5
14/8	6	4										2	2	2
14/8	6	5	1										0	1
14/8	6	6	1						1[b]			1	2	3
14/8	6	7	1										0	1
25/8	7	1	1						1				1	2
25/8	7	2	1						1[b]				1	2
Total			28	4	6	1	6	5	32	3	37	10	104	132
Total to end July			16	0	6	1	5	5	21	3	34	0	75	91

a: 2 adults in burrow
b: chick fledged

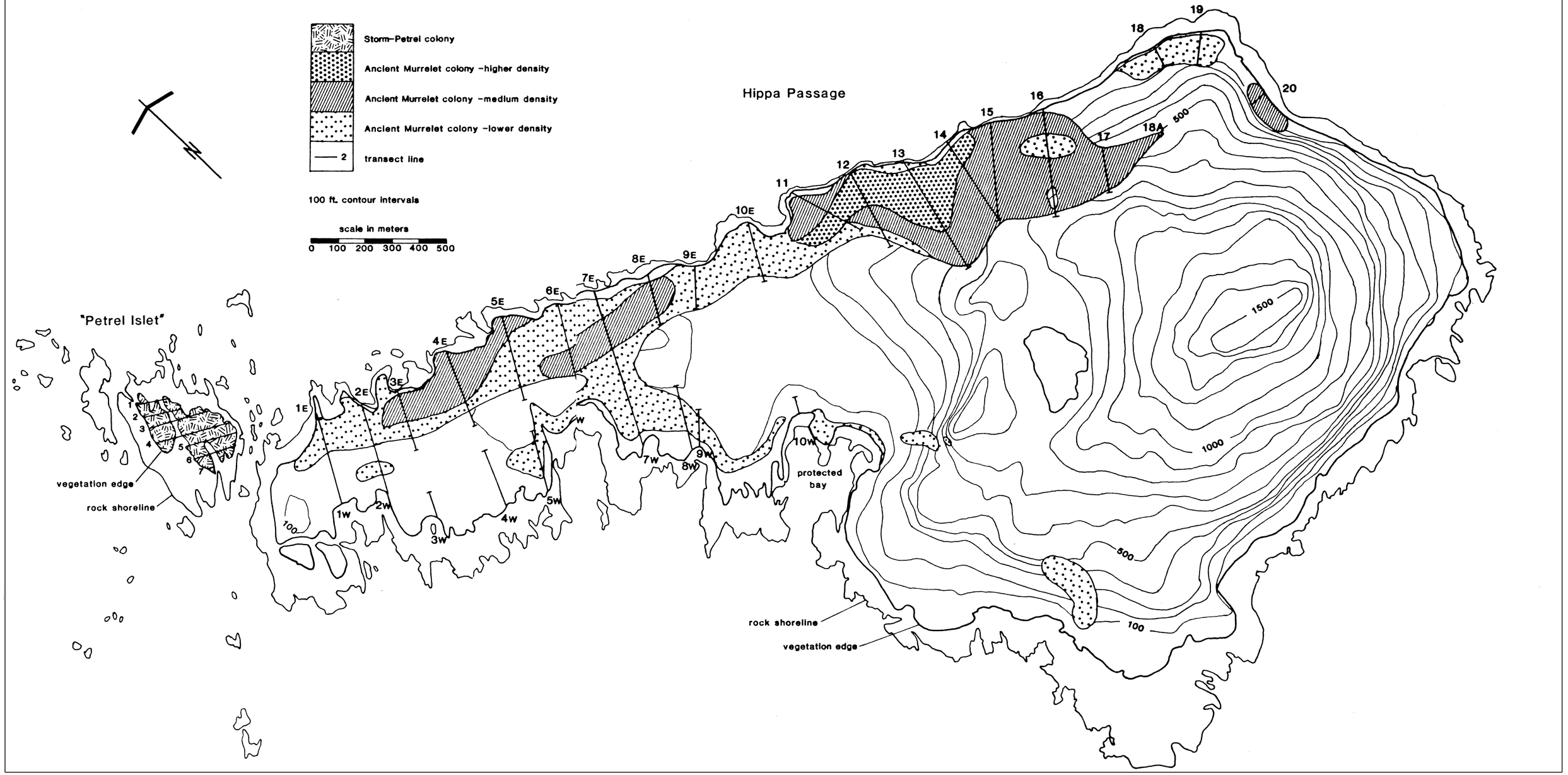

Fig. WG230-2. Ancient Murrelet and Storm-Petrel colony areas on Hippa Island in 1983.

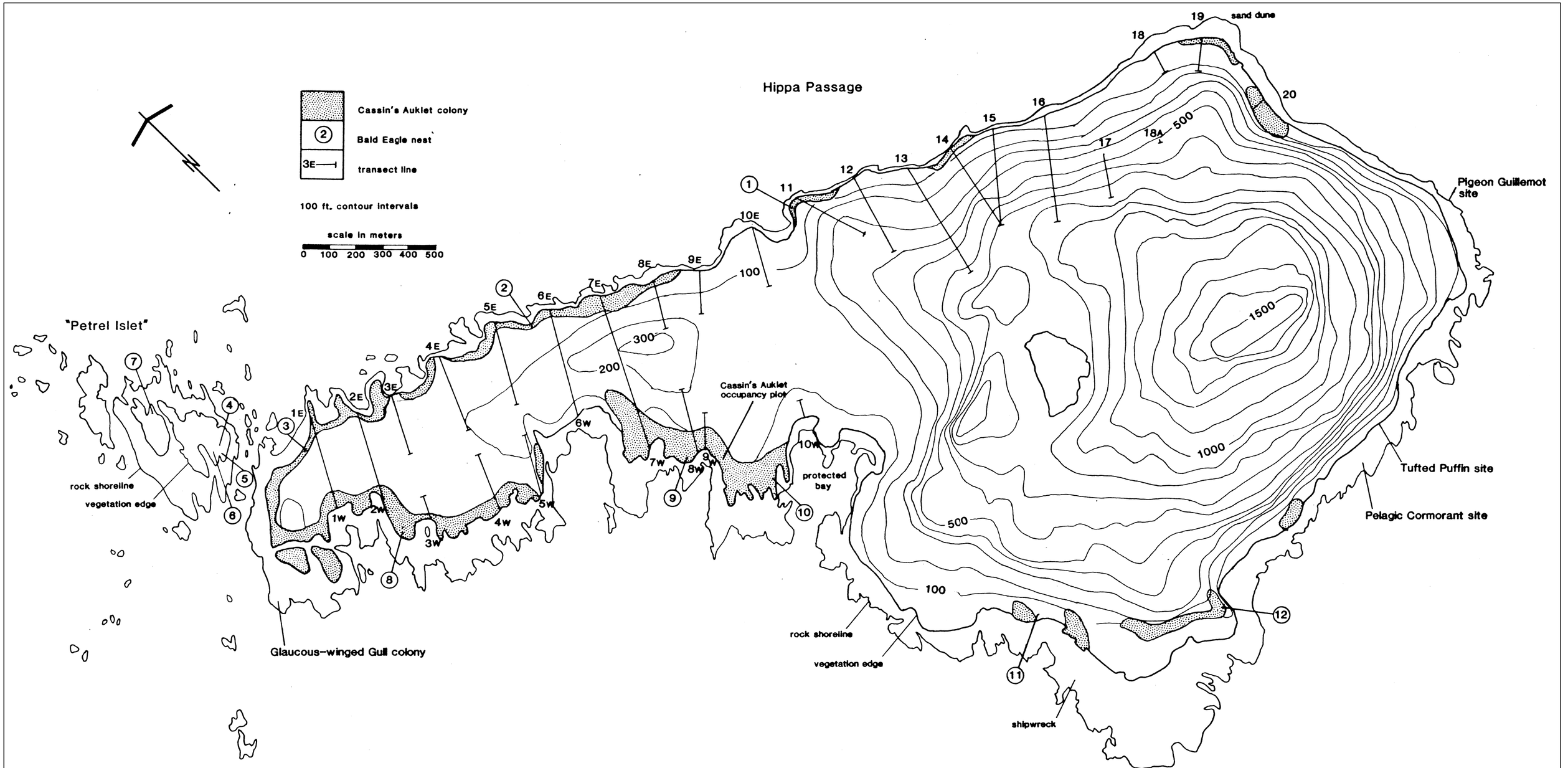

Fig. WG230-3. Cassin's Auklet colony area on Hippa Island in 1983.

Glaucous-winged Gull: A single nest containing 2 eggs was located on the west side of "Petrel Islet" on 7 June 1983.

No survey was conducted in 1983 of the main gull colony on the rocks at the northwest end of Hippa Island. Twenty adults standing on territories, and 100+ roosting on the rocks below, were counted from "Petrel Islet" on 7 June. Fledged young of the year were flying around the gull colony on 9 August. After 24 August, no large groups of gulls were seen around the nesting rocks.

Through August and September, small numbers of Glaucous-winged Gulls were seen alone or with feeding flocks of Black-legged Kittiwakes on the northeast end of Hippa Island.

In 1986, we tallied 68 nests on the northwest rocks (Table WG230-5).

Table WG230-5. Glaucous-winged Gull nests on the northwest rocks of Hippa Island in 1986.

Start	Empty	1E	2E	3E	1E2Y	1E1Y	1Y	2Y	3Y	Total
1	5	3	3	16	1	2	23	10	4	68

Pigeon Guillemot: Small numbers were seen regularly in 1983. A maximum of 43 were counted on the southeast coast of the main island where they were suspected to be nesting.

Ancient Murrelet: Ancient Murrelets were found nesting in suitable habitat along the entire northeast coast of the main island from the sand dune to the north end (Fig. WG230-2). Major concentrations of burrows occurred in that area, ranging from shoreline to as much as 495 m inland and from sea level to a maximum elevation of 282 m (Table WG230-6). An area of low density burrowing was found along the mid-west coast from the protected bay northward. Those areas were sampled along transects and their total was calculated to be 98.3 ha. Isolated pockets of burrowing were found above the steep cliffs south of the protected bay and above the shipwreck. We estimated that the isolated pockets located on the west side comprised an additional 3.8 ha of colony. We suspected that other disjunct patches of burrowing occurred in suitable habitat along the more inaccessible south and east slopes. One spot check from the beach on the mid-south side (Fig. WG230-2) showed some evidence of burrowing by Ancient Murrelets on a steep forested ridge. It is likely that nesting occurred where habitat permitted in these inaccessible south and east slopes. No attempt was made to estimate either density or colony area for this part of the island. As those areas were not sampled along transects, and because other similar areas were probable but not located, we did not include them in the overall population calculation. They would add a marginal proportion to the population. A few Ancient Murrelet burrows were encountered on "Petrel Islet".

Ancient Murrelets were found nesting primarily in open, mossy areas under mature forest on seaward facing slopes. However, it was not unusual to find them nesting in grassy areas under mature forest, under spruce regeneration, or in windfall areas. Burrows were predominantly located around live trees and roots, stumps and dead roots, or mossy deadfall lying on the ground (Table WG230-7). The mean length of a sample of 83 burrows was 51 ± 2 cm.

Table WG230-6. Extent of Ancient Murrelet and Cassin's Auklet colonies along transects on Hippa Island in 1983.

	Extent of burrowing			
	Distance along transect (m)		Elevation (m)	
Transect #	ANMU	CAAU	ANMU	CAAU
1E	23-114	0-38	3-25	1-4
1W	--	0-53	--	2-15
2E	8-165	0-23	2-22	0-5
2W	52-105	0-23	11-28	1-24
3E	0-165	--	8-25	8-12
3W	--	0-15	--	0-4
4E	0-225	--	3-25	3-7
4W	--	0-45	--	2-10
5E	0-255	0-15	1-30	2-5
5W	45-165	--	5-30	--
6E	0-255	0-15	5-55	5-8
6W	15-45	--	52-55	--
7E	23-270	0-53	7-88	3-17
7W	75-325	0-195	20-60	2-46
8E	23-225	0-23	10-62	3-12
8W	75-225	0-75	30-60	0-35
9E	0-165	--	0-28	--
9W	23-105	0-82	8-40	5-35
10E	0-195	--	0-30	--
10W	--	--	--	--
11	15-300+	0-15	13-100	5-13
12	0-285	--	0-104	--
13	0-495	--	2-205	--
14	15-405	0-15	13-220	2-13
15	0-390	--	25-225	--
16	15-435	--	6-282	--
17	--	--	--	--
17A	*15-195	--	138-230	--
18	15-95	--	12-27	--
18A	* 0-15	--	170	--
19	15-135	0-15	4-50	2-4
20	0-50	0-50	1-25	1-25

* Above blowdown.

Table WG230-7. Habitat locations of Ancient Murrelet and Cassin's Auklet burrows on Hippa Island in 1983.

Location	Ancient Murrelet Burrows	%	Cassin's Auklet Burrows	%
Tree base and roots	102	42	17	30
Stumps and dead roots	55	23	15	26
Fallen logs	46	19	9	16
Open ground	29	12	7	12
Rock	9	4	2	4
Grass	2	0.8	7	12
TOTAL	243	100	57	100

In the quadrats sampled along transects, the density of burrows ranged from 0 to 16 burrows/25m^2 quadrat (Table WG230-8). Three density categories were defined: low - < 0.5 burrows per quadrat; medium - 0.5-4.0 burrows per quadrat; and high - > 4.0 burrows per quadrat. Higher density burrowing was found along the northeast side, with the major high density area occurring on steeper slopes toward the east end (Fig. WG230-2).

1983 Population estimate:

Number of sample plots:
Higher density: 19
Medium density: 75
Lower density: 94
Total: 188 (4700 m^2 - 0.5 % of colony)

Average density:
Higher density: 2253 ± 362 burrows/ha
Medium density: 640 ± 77 burrows/ha
Lower density: 68 ± 19 burrows/ha
Overall: 520 ± 66 burrows/ha

Colony area:
Higher density: 10.1 ha
Medium density: 38.9 ha
Lower density: 49.3 ha
Total: 98.3 ha

Total burrows: 51,140 ± 6491

1983 Occupancy rate: 78.4 ± 3.9% (91 of 116 known) (Table WG230-9)

1983 Nesting population: 40,094 ± 5455 pairs

Table WG230-8. Number of Ancient Murrelet burrows in 5x5 m plots along transects on Hippa Island in 1983. Numbers in bold print and underlined indicate plots within designated higher density areas. Bold print indicates plots within designated medium density areas. Plots in low density areas are in normal type. Plots considered outside the colony are indicated by a dash.

Plot #	Transect #															
	1E	1W	2(E)	2(W)	3(E)	3W	4(E)	4W	5(E)	5(W)	6(E)	6(W)	7(E)	7(W)	8(E)	8(W)
1	-	-	-	-	0	-	**2**	-	**2**	-	0	-	-	-	-	-
2	-	-	-	-	**2**	-	**1**	-	**0**	-	0	0	-	-	-	-
3	0	-	0	-	**1**	-	**0**	-	**1**	0	1	-	0	-	**5**	-
4	0	-	0	-	**8**	-	**1**	-	0	0	1		0	0	**0**	0
5	0	-	0	0	0		**2**	-	1	0	0		0	2	**0**	0
6	1		0	0	0		**3**	-	0	0	0		0	0	**2**	0
7			0		-		**2**	-	0	-	**4**		**3**	0	**1**	0
8			1		-		0		0	-	**4**		**3**	1	**1**	1
9			-				-		0		**1**		**3**	0	0	-
10			-				-		-		-		**0**	0	0	-
11									-				0	0		
12													0			

Table WG230-8 (continued)

Plot #	Transect #														
	9(E)	9(W)	10(E)	10W	11	12	13	14	15	16	17	18	18A	19	20
1	0	-	0	-	-	**8**	1	-	**2**	-	-	-	0	-	**1**
2	0	-	0	-	**2**	**16**	0	**4**	**0**	**0**	**3**	0		0	**1**
3	2	0	0	-	**0**	**0**	0	**1**	**4**	**2**	**1**	0		0	
4	0	0	0		**5**	**7**	**5**	**6**	**0**	**5**	0	0		0	
5	0	0	0		**1**	**4**	**7**	**1**	**3**	0	0			0	
6	0	0	1		**5**	**0**	**1**	**0**	**3**	0	0				
7		2	1		**3**	**1**	**6**	**0**	**1**	0	0				
8		-	-		**6**	**1**	**6**	**0**	**3**	**4**	-				
9		-			**14**	0	**5**	**1**	**0**	**2**					
10					0	0	**4**	**0**	**1**	**1**					
11					0	-	**4**	**1**	**3**	**0**					
12						-	**0**	**0**	**0**	slide					
13							**0**	**1**	**1**	slide					
14							**3**	**0**		slide					
15							**0**	-		**4**					
16							**1**			-					
17							**0**								
18							-								
19							-								

Table WG230-9. Occupancy of Ancient Murrelet burrows along transects on Hippa Island in 1983.

Date	Transect #	Plot #	Empty	Cold egg	Adult+ 1 egg	Adult +2 eggs	Adult + 2 chicks	Hatched eggshell membranes	Total occupied	Total known
27/5	2E	8				1			1	1
28/5	9E	1				1			1	1
		3				1			1	1
28/5	9W	7	1						0	1
28/5	10E	6	1						0	1
30/5	8E	3	2			4[a]			4	6
		4	1				1		1	2
		6				3	1		4	4
		7				1			1	1
		8	1			1			1	2
		9			1				1	1
31/5	7E	7	2			1			1	3
		8	1						0	1
		9				1			1	1
		10		1[b]					1	1
		12				1			1	1
31/5	7W	8					1		1	1
31/5	8W	5				1			1	1
		6	1						0	1
1/6	11	2		1		1			2	2
		3			1	1			2	2
		5	1						0	1
	11	6				1	1	1	3	3
		7	1				1		1	2
		8				1			1	1
		9	2		2			1	3	5
		11				1			1	1
1/6	12	1				2			2	2
		2	1	1		5			6	7
		4				2			2	2
		5	2			1			1	3
		7	1						0	1
2/6	13	3				1			1	1
		4			2	2			4	4
		5	1		1	3			4	5
		7	1						0	1
		9				5			5	5
		11				3			3	3
3/6	14	2				1			1	1
		3						1	1	1
		9						1	1	1
		10				1			1	1
		13					1		1	1
5/6	15	1				1			1	1
		2				1			1	1
		3					2		2	2
		5	1						0	1
		6		1				1	2	2
9/6	16	2						1	1	1
		3	1				1		1	2
		4						1	1	1
		7						2	2	2
		8				1			1	1
		9						1	1	1
		10						1	1	1
		11	1						0	1

Table WG230-9. (continued)

Date	Transect #	Plot #	Empty	Cold egg	Adult+ 1 egg	Adult+ 2 eggs	Adult + 2 chicks	Hatched eggshell membranes	Total occupied	Total known
10/6	18	2	1						0	1
		3	1						0	1
		4						1	1	1
10/6	19	2					1		1	1
		5					1		1	1
10/6	20	1				1			1	1
		2						1	1	1
20/6	3E	2						1	1	1
	3E	4						1	1	1
		5						1	1	1
		6						1	1	1
22/6	4E	2						1	1	1
Total			25	4	7	51	11	18	91	116

a - 1 clutch with 3 eggs
b - 2 egg clutch.

Hatching and chick departure:

In this study no individual nests were monitored to determine hatching chronology, but from the contents of burrows found along transects an estimate of hatching and chick departure dates can be made (Table WG230-9). The first pipping eggs and chicks were found on 30 May. After 3 June the majority of known burrows explored contained chicks or had been recently departed by chicks. Some adults were still incubating eggs on 10 June.

Staging:

The only staging area of Ancient Murrelets observed around Hippa Island was in Hippa Passage from the north end of the island east to the mouth of Nesto Inlet. Large concentrations of Ancient Murrelets were repeatedly seen in that area. Since the water in Hippa Passage was choppy most of the time, it was often difficult to estimate numbers of birds. However on two calm days, careful estimates were made from the shore on the mid-northeast side of Hippa Island. On 28 May, between 0700 and 0900 h, with a 20X scope, 3 observers made an average estimate of 40,000 birds. On 10 June, at 0800 h, with binoculars, 2 observers made an average estimate of 53,000 birds. It was assumed that similar concentrations occurred on other days when the weather made it difficult to discern birds on the water. On most days from 20 May to 10 June flocks could be seen flying off the water for short distances, but birds on the water were not distinguishable. Regular observations ceased after 10 June. On 18 June, some flocks were seen flying and landing, but again it was too rough to determine numbers. On calm mornings, the chorusing multitude could be seen stretching in a continuous mass down the middle of Hippa Passage. Their chorus was readily audible from shore when one awoke. The birds were mostly milling about, different groups swimming back and forth, or getting up and flying for short distances. Numerous birds were diving.

We assumed that the birds were rafting in Hippa Passage throughout the day. We encountered a large concentration of Ancient Murrelets while boating across Hippa Passage on 6 June at 2130 h. We speculated that these large groups could include subadults and nonbreeders as well as breeding birds.

Cassin's Auklet: The major concentrations of Cassin's Auklet burrows were found along grassy slopes and knolls on the northern section of the west coast (Table WG230-6, Fig. WG230-3). Burrowing was generally absent from the lowland sections between knolls and behind beaches. Burrowing usually began at or near the shore and extended inland no more than 60 m. Along transect 7 burrowing extended as much as 195 m, but this transect parallelled the shore of the large bay north of it and the actual distance of the burrowing to the nearest shore was considerably less than suggested. The maximum elevation at which Cassin's Auklets were found burrowing in this area was 46 m, with most burrows occurring below 30 m.

Along the northern section of the northeast coast, burrowing was confined to a narrower band of habitat than on the west side, usually extending not more than 20 m from shore. Other isolated strips of burrowing were found further east on the northeast side, and pockets of burrowing were found along the southwest coast on separate knolls and along the tops of some of the cliffs. One area on the southwest corner was located along the cliff top at 70 m elevation. A small patch of burrowing was encountered east above the cliffs above the protected bay on the west coast at an elevation of 250 m (Fig. WG230-3). A few Cassin's Auklet burrows were found on "Petrel Islet".

The total burrowing area sampled by transects was 27.4 hectares. Other isolated areas of burrowing probably occurred on the unexplored south and east slopes in appropriate habitat. Cassin's Auklet burrows were found on a grassy promontory near sea level in one area spot-checked on the mid-south side (Fig. WG230-3). We suspected that nesting occurred where habitat permitted on inaccessible south and east slopes, but no attempt was made to quantify it.

Burrows located there would not appreciably alter the overall population estimate.

Cassin's Auklets were nesting primarily in open grassy areas under mature forest. Smaller numbers were found in open mossy habitat under mature forest, under spruce regeneration, and in windfall areas. Burrows were mainly located around the bases of trees and live tree roots, stumps and dead tree roots, and around mossy deadfall. A smaller proportion were located around grass tussocks and in open ground (Table WG230-7). The mean length of a sample of 29 burrows was 84 ± 5 cm.

Numbers of burrows within quadrats ranged from 0 to 9 (Table WG230-10).

Table WG230-10. Number of Cassin's Auklet burrows in 5x5 m plots along transects on Hippa Island in 1983.

	Plot #						
Transect #	1	2	3	4	5	6	7
1(E)	0	0	0				
1(W)	0	0	0	0			
2(E)	0	0					
2(W)	0	3					
3(W)	0						
4(W)	0	0					
5(E)	3						
6(E)	6						
7(E)	3	1	1	1			
7(W)	4	0	0	0	1	0	1
8(E)	9	1					
8(W)	0	8	4				
9(W)	5	1	0	0	0	0	
11	1						
14	4						
19	0						
20	2	0					

1983 Population estimate:

Number of sample plots: 43 (1075 m^2 - 0.4 % of colony)

Average density: 550 ± 137 burrows/ha

Colony area: 27.4 ha

Total burrows: 15,054 ± 3750

1983 Occupancy rate: 83.3 ± 3.2% (50 of 60 known - Table WG230-11)

1983 Nesting population: 12,540 ± 3157 pairs

Offshore sightings of Cassin's Auklets: Cassin's Auklets were rarely seen on the water around Hippa Island. Only one sighting was recorded: on 7 June, 1 bird was seen on the water off the west bay.

Table WG230-11. Occupancy of Cassin's Auklet burrows along transects on Hippa Island in 1983.

Date	Transect #	Plot #	Empty	Adult + egg	Adult + chick	Chick	Chick latrine or hatched egg	Fledged chick	Total occupied	Total known
7/5	1E	1		1					1	1
28/5	9W	1	1	1					1	2
	9W	2			1				1	1
	9W	4	1						0	1
29/5	2W	2		1					1	1
30/5	8E	1	1			1			1	2
31/5	7W	7		1					1	1
10/6	19	1					1		1	1
24/6	6E	1					1		1	1
3/7	Occupancy plot		7	2		7	24	9	42	49
Totals			10	6	1	8	26	9	50	60

Tufted Puffin: Puffins were thought to be nesting on steep grassy ridges on the mid-south side. A maximum of 45 were seen flying to and from grass slopes on 7 June 1983. Smaller numbers were seen into September. Forty were counted off the south side in 1986.

Predation:

Considerable evidence of predation on Ancient Murrelets and Cassin's Auklets was found along transects on the main island. In a total area of 8.17 ha searched for prey remains, 155 remains were located (Table WG230-12). Most remains were of Ancient Murrelets, but the majority of the area searched was within Ancient Murrelet colony. Concentrations of remains were found within denser parts of the colony. A total area of 5.91 ha (6% of colony) was searched within delineated Ancient Murrelet colony and 1.35 ha (4.9% of colony) in Cassin's Auklet colony. Within this area, predation evidence represented a minimum of 55 Ancient Murrelets, 53 Ancient Murrelet eggs and 5 Cassin's Auklets, giving estimates per hectare of 9.4 ± 1.6 Ancient Murrelets, 3.7 ± 2.2 Cassin's Auklets, and 9.0 ± 1.4 Ancient Murrelet eggs. Extrapolating over colony areas indicated that 924 ± 157 Ancient Murrelets, 885 ± 138 Ancient Murrelet eggs and 101 ± 60 Cassin's Auklets were preyed upon on the colony at the time of our surveys.

Major predators on the main island were assumed to be Bald Eagles and Peregrine Falcons. Eyrie sites were not checked for prey remains, but pellets containing feathers were found throughout the colony. Crows, ravens and river otters were potential predators of birds and eggs. Most river otter scats found on the main island contained fish remains, but 4 contained feathers. On "Petrel Islet" river otters were preying on storm-petrels. We found tracks of river otters in the soil around the excavated entrances of storm-petrel burrows, particularly in the latter part of the nesting season. The remains of near fledging age chicks were scattered about at most of these sites.

Table WG230-12. Predation evidence in a 10 m radius around plots along transects on Hippa Island in 1983.

Transect	Plot	ANMU eggshells	ANMU feather piles	ANMU wing sets	ANMU carcass	CAAU feather pile	CAAU wing sets	CAAU carcass	BAEA pellet	Raptor pellet	River Otter scat
1E	4	1	2		1						
1E	6	1	1	1							
2E	2	1									
2E	3	1						1			
2E	5	1									
2E	9	1									
2E	10									25	
2W	6				1				5		
3E	3		1								
3E	5		1								
3E	7		1								
3E	8			3							
4E	4		1								
4E	6	1									
4E	7		1								
4E	10						1				
4W	2						1	1			
4W	4			1							
4W	6		2								
5E	1	1	1								
5E	3		1	1							
5E	5	2									
5E	10		1								
5E	11						1				
5W	2				1		1				
5W	3		4		1						
5W	4		1								
6E	1			1							
6E	4	1								1	
6E	5	1			1						
6E	7	1									
6E	10			1							
7E	3	1									
7E	4		1								
7E	5				1						
7E	6	3									
7E	8	3									
7E	9		2								
7W	4										1
7W	5				1			2			
7W	9								1		
7W	10							1			
7W	11				1						
8E	2	1									
8E	4			1	1						
8E	5	2									
8E	6			1							
8E	10				1						
8W	2		1					1			
8W	4		1								
8W	5		1								
8W	6	1	1								
8W	10		1								
9E	6		1								
9W	5	1									
9W	7		1								
9W	9		1								

Table WG230-12. (continued)

Transect	Plot	ANMU eggshells	ANMU feather piles	ANMU wing sets	ANMU carcass	CAAU feather pile	CAAU wing sets	CAAU carcass	BAEA pellet	Raptor pellet	River Otter scat
10E	4	1									
11	1		1								
11	2				1						
11	4	1	2								
11	5		1	1						1	
11	9			1							
11	11	3	1 adult 1 chick	1							1
12	1		1								
12	2		1								
12	7	1									
12	9	1		1							
12	10	1	1								
12	11	2	1		1						2
12	12	2			1				2		
13	1	1	1								
13	2		2								
13	3	1							1		
13	5		2								
13	9	1	1	1							
13	11		1								
13	12	1									
13	17	1									
13	18	1									
14	3	1									
14	7	1									
14	8	1	1								
14	12	1		1	1						
14	13	1									
15	1	1									
15	3	1									
15	4	1									
15	5	2									
15	6		1								
15	7	1									
15	9	1									
15	10	3									
15	11	1			4						
16	8		1						1		
17A	2	1									
17A	7	1									
18	4		1								
19	3					1					
Totals in area searched		61	49	16	18	1	4	6	10	27	4
Totals in colony area		53	40	11	15	0	1	4			

Associated species:

Bald Eagles - Twelve Bald Eagle nests were located on Hippa Island and "Petrel Islet" in 1983 (Fig. WG230-3):

1. 15 m high in 20 m spruce tree, 5 m from shore near transect 11; nest of sticks; no adults seen on 10 June.

2. In spruce tree near shore near transect 6E; nest of sticks; two adults circling, perching and calling from trees nearby on 24 June.

3. 25 m high, in 30 m dead spruce tree, 5 m from shore near transect 1E; one adult flew into nest, one adult perched in adjacent tree on 27 May.

4-6. On southern part of "Petrel Islet", all in close proximity; all nests in spruce trees with grassy understory; nests of sticks, 10 to 15 m off the ground; 2 adult and 1 immature seen around these 3 nests on 7 June.

7. On northern part of "Petrel Islet"; nest in spruce tree with grassy understory, 15 m above ground; 2 adults present on 11 June.

8. Nest of sticks, 20 m high in a 25 m spruce tree, situated on the edge of a 12 m high bluff on headland near transect 3W; no eagles seen nearby on 20 June.

9. In a tree on headland above cliff near transect 8W; adult Bald Eagle being chased by Peregrine Falcons (male and female) around nest site on 31 May.

10. On headland on north side of protected bay near transect 10W in a spruce tree 20 m from the rock shore; 2 Bald Eagles flying above on 28 May.

11. On cliff set back 30 m from shore just north of shipwreck; nest 20 m high in 30 m spruce tree, 15 m inland from cliff top; adult on nest on 4 June.

12. 16 m high in dead spruce tree in middle of ridge, 40 m from cliff edges on SW point of Hippa; salmonberry growing around edges of nest; no eagles seen around nest on 17 Sept.

Small numbers of adults and immatures (maximum 4) were regularly sighted around Hippa Island. They also were sighted on the ridge on the north side of Nesto Inlet, at Hosu cove, at the Mace Creek estuary (3 adults on 20 Aug) and on the alpine ridges south of Mace Creek estuary (2 immature on 15 Sept). On 14 September, 7 adult and 3 immature Bald Eagles were seen perching and flying at the outlet to Mercer Lake. Chum salmon were spawning up the creek.

Peregrine Falcon - Although no eyries were located, 5 territories were identified along the west coast of Hippa Island in 1983:

1. 1 adult chasing immature eagle on 27 May; a pair chasing Wandering Tattler and perching in trees.

2. At a high recessed cliff on the west side of Hippa at the large bay north of the protected bay. One pair chasing eagles and soaring around cliffs on 28 and 30 May, and 25 June.

3. Around high cliffs on the headland forming the north side of the protected bay on the west coast of Hippa. A pair was present on 28 May, 4 June and 17 September.

4. Around cliffs and bluffs on the south side of the protected bay, a suspected eyrie site, though it may be an alternate site to the one on the north side of the bay. One bird was heard calling on 29 August.

5. West coast around the recessed cliffs and bluffs just north of the shipwreck. A pair, though particularly the female, were diving and screaming at an adult Bald Eagle.

Peregrine Falcons were regularly seen through June, August and September at "Petrel Islet". One bird was often seen perched in the trees, soaring above the islet, or chasing eagles. A pair was sighted on 2 and 21 September.

Common Murre - 1 off south end on 9 Aug. 1983.

Marbled Murrelet - 1 or 2 seen on 6 & 7 June and 20 & 28 Aug. 1983.

Rhinoceros Auklet - Small numbers seen regularly. Maximum of 41 on 25 Aug. 1983.

Northern Saw-whet Owl - Around petrel colony on "Petrel Islet" 10-17 Sept. 1983.

Northwestern Crow - Regularly seen. Maximum of 40 on 13 August 1983 on "Petrel Islet".

Common Raven - 1 to 4 seen regularly.

River Otter - River Otters were frequently seen, especially around "Petrel Islet" where the field camp was located. Otter dens were located on the northeast coast of Hippa Island; one 800 m northwest of the sand dune and one 800 m southeast of the north point; and on the north side of "Petrel Islet". Otters were major predators on the petrels (see Predation), but, judging from the scats found, appeared to be feeding primarily on fish and crustaceans on the main island.

Sitka Deer - Deer were common on Hippa Island. They were occasionally sighted on "Petrel Islet".

Other birds and mammals sighted:

The following is an annotated list of species sighted on or in the vicinity of Hippa Island and "Petrel Islet" (within map grids 103F/10 and 103F/11) from 25 May to 30 June and from 1 August to 25 September 1983.

Pacific Loon - 4-5 offshore on 7 & 10 June.
Common Loon - 1 in Hippa Passage on 10 June.
Red-necked Grebe - 1 in Port Chanal on 14 September.
Sooty Shearwater - Frequently seen offshore.
Great Blue Heron - One frequented the tidal chute bisecting "Petrel Islet" from 1 August through September.
Brant - One flock of 57 seen flying south on 28 Aug.
Canada Goose - 22 in Empire Anchorage on 14 Sept.
Green-winged Teal - 165 in Hippa Passage on 4 Sept. and small numbers (1-12) in Hippa Passage from 6-16 Sept.
Blue-winged Teal - 30 in Mace Creek estuary on 15 Sept.
Pintail - 2 with Green-winged Teal in Hippa Passage on 14 Sept.
Surf Scoter - 18 off SE coast of Hippa on 11 Sept.
White-winged Scoter - 1 off N end of Hippa on 12 Aug.
Common Merganser - 1 female in Mercer Creek on 14 Sept.
Red-breasted Merganser - 8 in female plumage in Mace Creek Estuary on 14 Sept.
Sharp-shinned Hawk - One frequented "Petrel Islet" from 1 Aug. through Sept.
Blue Grouse - Heard above Nesto Inlet on 6 June.
Semipalmated Plover - 3 on "Petrel Islet" on 7 Aug.; 1 on "Petrel Islet" from 3-6 Sept.

Black Oystercatcher - A group of 14 were seen in the Mace Creek estuary on 20 August.
Greater Yellowlegs - 1 on "Petrel Islet" on 10 & 11 Sept.
Lesser Yellowlegs - 1 lame bird on "Petrel Islet" from 6-13 Aug.
Wandering Tattler - 1 or 2 seen frequently from 20 Aug. to 12 Sept.
Spotted Sandpiper - 3 on "Petrel Islet" on 29 & 30 Aug.
Whimbrel - 1 on "Petrel Islet" on 29 June.
Black Turnstone - 2-4 on "Petrel Islet" from 17 Aug. to 6 Sept.
Sanderling - 1 on "Petrel Islet" on 8 Aug.
Western Sandpiper - 9 on "Petrel Islet" on 12 Aug.
Least Sandpiper - 3 on "Petrel Islet" on 14 & 24 Aug.
Northern Phalarope - 1 on "Petrel Islet" on 19 Aug.
Long-billed Dowitcher - 1 on "Petrel Islet" on 3 Sept.
Franklin's Gull - 1 adult on "Petrel Islet" from 7-12 June.
Herring/Thayer's Gull - Small numbers seen from 25 Aug.-6 Sept. and 23 immature and 2 adults on "Petrel Islet" on 8 June.
Black-legged Kittiwake - Seen 2 Aug. through 16 Sept. Largest flock was 110 on 25 Aug.
Belted Kingfisher - 1 or 2 seen regularly.
Rufous Hummingbird - 1 seen periodically - 28 May and 7 June-16 Aug.
Red-breasted Sapsucker - 1 on SW corner of Hippa I. on 17 Sept.
Hairy Woodpecker - Regularly sighted.
Northern Flicker - Sighted periodically - 29 May; and 16 Aug.-1 Sept.
Western Flycatcher - Heard singing in forests from 20 May-10 June.
Chestnut-backed Chickadee - Small numbers (1-8) seen regularly.
Brown Creeper - 3 sighted in forest and 1 climbing sea stack on 13 and 17 Sept.
Winter Wren - 1 to 4 seen regularly. Adults were seen feeding young on the main island and on "Petrel Islet" in June.
Dipper - 2 on Mace Creek on 20 Aug. and 2 on Mercer Creek on 14 Sept.
Golden-crowned Kinglet - Flocks of 1-15 seen regularly from 1 Aug. through Sept.
Swainson's Thrush - Heard singing periodically from 4-25 June.
Hermit Thrush - Heard singing from 30 May-24 June.
Varied Thrush - Periodically heard singing.
Orange-crowned Warbler- Recorded singing on 28 and 31 May, 12 June, and 9 Aug. A nest of woven grasses was found in a grass tussock on the edge of a small rock face on the south side of "Petrel Islet". Observations on contents were as follows:

7 June - 5 eggs, 1 adult was scared off nest, and both adults were scolding us.
21 June - 5 young in nest - mostly naked with tufts of down. Adult very agitated.
26 June - 5 downy young with some feathers emerging from sheaths; eyes open, wide beak. Adult present and feigning injury.

Townsend's Warbler - Seen and heard singing regularly until mid June. Heard singing 13 Aug. and 7 Sept.
Wilson's Warbler - Seen and heard singing on 3, 31 May and 9 June.
Savannah Sparrow - 12 seen on Gillam Pt. on 12 Sept.
Fox Sparrow - Seen and heard singing regularly; 1 downy young being fed on 29 May.
Song Sparrow - Seen and heard singing regularly.
Dark-eyed Junco - Seen periodically in different areas.
Red Crossbill - Flocks of up to 45 seen frequently.
Pine Siskin - 15 seen on 17 Sept.

Hair Seal - Hair seals were frequently seen around the coast of Hippa Island particularly on the east side of "Petrel Islet" from 25 August to 4 September. Groups of 14 to 24 individuals were hauled out on the tidal reefs.

Sei Whale - One was sighted in Hippa Passage close to the sand dune on 10 June.

Black Bear - No Black Bears were sighted around Hippa Island, but one was seen fishing up Mercer Creek on 14 September, and one was foraging along the north shore of Port Chanal on 20 August.

Small rodents - There was some evidence of small rodent activity on Hippa Island and almost none observed on "Petrel Islet". In the field camps that were located on the mid northeast side of Hippa and then on "Petrel Islet", there were no signs of small rodents.

SUMMARY AND CONCLUSIONS

The three major colonies on the west coast of Graham Island support over half a million breeding seabirds, including 264,000 Ancient Murrelets, 205,000 Cassin's Auklets and 47,400 storm-petrels, representing 92% of the total population estimated breeding in the region (Rodway *et al.* in prep.). Surveys of smaller colonies are required to complete baseline population estimates for the region.

Historical populations on Langara, Cox and Lucy islands were much larger and more diverse than at present (Rodway *et al.* in prep.). Introduced rats, marten, and possibly raccoons have likely decimated breeding populations at those colonies. The rat eradication program on Langara Island should help rehabilitate what once was one of British Columbia's largest seabird colonies.

METHODOLOGICAL CONSIDERATIONS AND RECOMMENDATIONS

The goal of the inventory program was to establish baseline estimates of breeding seabird populations using replicable survey techniques. On the west coast of Graham Island, recent, total counts of surface nesting species have been conducted at most colonies and are readily compared to both past and future census results (Rodway 1988). For burrow nesting species, only colonies on Langara, Frederick and Hippa islands have been surveyed with replicable methodology.

Changes in population estimates for burrow nesting species are more difficult to interpret than changes in counts of surface nesters. The level of precision of estimates derived from systematic sampling along transects depends on the precision of three components which enter into their calculation: colony area, burrow density, and burrow occupancy rate. Each component has its own sources of error.

In the methods presented in this report, there is no measure of error for colony area calculations, and its level of precision is unknown. Distance, slope and elevation measurements taken along transects help delineate nesting areas, but precise identification of colony boundaries depends on thorough exploration, careful observations and detailed and explicit note-taking. Sources of error arise whenever observations or field notes are not comprehensive enough to allow unequivocal definitions of colony limits. Training of observers in what evidence to look for, and how to record it unambiguously, is an essential element of an inventory program and directly influences the quality of data obtained. Having an experienced corps of surveyors from year to year maintained a consistent standard for defining colony limits. Large scale, accurate, topographic maps are required to reliably map and measure colony areas.

The standard error of the average burrow density has been calculated for each colony surveyed. The level of precision and accuracy depends on burrow distribution, sampling intensity and appropriate selection of quadrat size and spacing. Compromises were made between the level of precision desired and the time required to obtain that level. Observer bias in indentifying burrows may create an unmeasured subjective error especially for Ancient Murrelet burrows,

some of which require careful examination to distinguish from holes in the ground (see discussion of knock-down plots in Bertram 1989). Consistent criteria, experienced observers and mutual consultation minimized discrepancies. Studies are required to evaluate the importance of this bias.

Occupancy was determined in a replicable manner though sampling schemes varied. Digging alcid burrows to determine occupancy is a laborious and time-consuming task. Often half or more of the attempts are unsuccessful. As a result, it was generally not feasible (nor desireable due to the potential disturbance to incubating birds) to determine the occupancy of burrows within all quadrats, and occupancy was determined in only some of the quadrats. Selection of quadrats was not systematic or random, but typically resulted from the delegation of an amount of work to be accomplished in one day. We recommend not attempting to explore burrows in all quadrats. On storm-petrel and alcid colonies in other regions of the coast, we selected quadrats randomly and set a fixed sample size of five burrows per plot chosen (see Rodway *et al.* 1990a&b, Rodway and Lemon 1990, Rodway and Lemon 1991). This method facilitates statistical analysis and comparison and we recommend it for future surveys. Research on the variation in occupancy rates within and between colonies, and over time, is required to assess and improve sampling methodology (see Gaston and Jones 1984; Gaston and Collins 1988).

There may be an advantage to sampling burrow occupancy separately from burrow density. Effort spent exploring burrows was more productive when determining occupancy was the sole objective of the activity. Excavating burrows within plots along transects was generally less efficient due to the continual switching of activities from recording and measuring to digging.

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Appendix I. Summary of seabird breeding populations on the west coast of Graham Island.

The west coast of Graham region supports over half a million breeding seabirds including 266,000 Ancient Murrelets, 218,300 Cassin's Auklets, and 75,800 Storm-petrels. The largest concentrations are on Frederick, Hippa and Langara islands, described in this report. The following table includes data for the smaller island colonies in the region, many of which were surveyed for the surface nesting Pelagic Cormorants, Black Oystercatchers, Glaucous-winged Gulls and Pigeon Guillemots in a separate survey in 1986 (see Rodway 1988). Some small colonies have not been surveyed since 1977, and population estimates from that time (Campbell and Garrioch 1979; British Columbia Nest Record Scheme) are included to present total estimates for the region.

The following codes have been used to indicate the type of population estimates presented.

S: breeding suspected but not directly observed

x: breeding confirmed but population not estimated

e: population estimated without systematic sampling or total counts

t: population estimated from systematic sampling along transects

26: a number without a code indicates a total count

E: extinct

(): number of birds in breeding plumage on or near the colony

Acronyms for species names follow Campbell and Harcombe (1985) (see Appendix VI).