EFFECTS OF INTRODUCED RATS ON NESTING SEABIRDS OF HAIDA GWAII

Anne Harfenist

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ABSTRACT

In 1993, I conducted studies on two islands in Haida Gwaii (Queen Charlotte Islands) to determine effects of introduced rats on breeding seabirds. The breeding population of ancient murrelets (*Synthliboramphus antiquus*) on Langara Island declined by approximately 40% between 1988 and 1993 to a level less than 10% of its historical size. The colony covered only about 50% of the area used by murrelets in 1988. Predation on ancient murrelet eggs and adults by Norway rats (*Rattus norvegicus*) appears to be the primary cause of the colony decline.

By 1993, the main ancient murrelet colony on Kunghit Island covered approximately one third of the area used by breeding murrelets in 1986. A secondary colony decreased from 800 pairs to 11 pairs during the same time period. As on Langara, depredated eggs and adults were abundant throughout both the abandoned and active sections of the colony and Norway rats are probably responsible for the declines. I did not find signs of rats in the rhinoceros auklet (*Cerorhinca monocerata*) colony on Kunghit and was unable to detect changes in the auklet population.

Rats do not appear to have emigrated to the smaller seabird islands surrounding Kunghit. I found no evidence of extensive changes in breeding seabird populations on those islands.

RESUME

En 1993, j'ai effectué des études sur deux îles à Haida Gwaii (îles de la Reine-Charlotte) afin de déterminer les effets de l'introduction de rats sur des oiseaux marins nicheurs. Entre 1988 et 1993, les populations reproductrices d'alques à cou blanc (*Synthliboramphus antiquus*) de l'île Langara ont diminué d'environ 40 %, soit à un niveau inférieur à 10 % de sa taille historique. La colonie ne couvrait plus qu'environ 50 % de l'aire occupée par les alques en 1988. Les ravages causés cheq les oeufs et les adultes d'alques par les surmulots (*Rattus norvegicus*) semblent être la raison première de ce déclin.

En 1993, la principale colonie d'alques à cou blanc sur l'île Kunghit occupait environ un tiers de la zone utilisée par les alques nicheurs en 1986. Une colonie moins importante est passé de 800 à 11 paires pendant la même période. Comme sur Langara, les ravages chez les oeufs et les adultes étaient importants aussi bien dans la section abandonnée que dans l'aire active de la colonie, et ce sont probablement les rats qui sont là encore les principaux responsables du déclin. Je n'ai pas trouvé de signes d'activités des rats dans la colonie de maraceux rhinocéros (*Cerorhinca monocerata*) sur Kunghit et il m'a été impossible de déceler un quelconque changement dans la population de ces maraceux.

Les rats ne semblent pas avoir émigré vers les îles plus petites autour de Kunghit. Je n'ai observé aucune variation importante chez les populations d'oiseaux marins nicheurs de ces îles.

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ACKNOWLEDGEMENTS

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I thank the Old Masset Village Council for giving me permission to work on Langara Island in Duu Guusd Tribal Park. The Archipelago Management Board kindly gave me permission to work on Kunghit in Gwaii Haanas.

By offering us the use of his facilities in case of emergency, John McCulloch of Langara Lodge added to our safety net and I thank him also.

Rowley Taylor generously shared with me the expertise that he has developed during many years of dealing with introduced predators on islands in New Zealand. Doug Bertram, Gary Kaiser and Rhonda Millikin reviewed an earlier draft of the report and provided many helpful comments. Pam Whitehead drafted the figures.

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1. GENERAL INTRODUCTION

Predation by non-native mammals has been a major cause of the decline, and in some cases extirpation, of breeding seabirds throughout the world (Moors and Atkinson 1984). Historically, rats (*Rattus* spp.) have posed one of the most serious threats to seabirds. In Haida Gwaii (Queen Charlotte Islands), rats have been found on five islands that support breeding populations of seabirds: Kunghit, Langara, Lyell, Murchison and St. James (Fig. 1). All of the affected islands have supported some type of intensive human activity (eg. light and weather stations, whaling port, World War 2 installations, logging activity) and the introduction of rats was probably the result of accidental transport during those operations. The present studies were designed to examine the detrimental effects of introduced rats on seabirds nesting on Langara and Kunghit Islands.

2. LANGARA ISLAND

2.1. Introduction

Historical records indicate that Langara Island (also known as Kiis Gwaii and North Island) once supported breeding populations of Cassin's and rhinoceros auklets, fork-tailed and Leach's storm petrels, as well as ancient murrelets and tufted puffins (Campbell *et al.* 1990). Surveys conducted in 1981 found only the latter two species (Rodway *et al.* in prep.). The 1981 survey also documented the abandonment of large portions of the island that had previously been used by ancient murrelets. Rodway and co-workers (in prep.) estimated that approximately 25,000 pairs of ancient murrelets nested on Langara Island in 1981. This is a considerable decline from an estimated 200,000 pairs that historically may have bred at the colony (Gaston 1992).

By 1988, the ancient murrelet colony had contracted further and rats had been identified as an important cause of this decline (Bertram 1989). In light of those findings, the restoration of habitat for ancient murrelets and other seabirds through the eradication of the rats from Langara Island was identified in the Nestucca oil spill litigation settlement as an important method of ensuring the long-term survival of seabirds in Haida Gwaii.

The study reported here was planned as a first step in evaluating the feasibility of a rat eradication program for Langara Island. The main objective of the research was to reassess the status of the ancient murrelet on the island in relation to rat predation. The secondary objective was to describe the diversity of native forest birds and mammals on the island both to insure their consideration during planning for rat eradication and to provide baseline estimates against which populations post rat eradication could be measured.

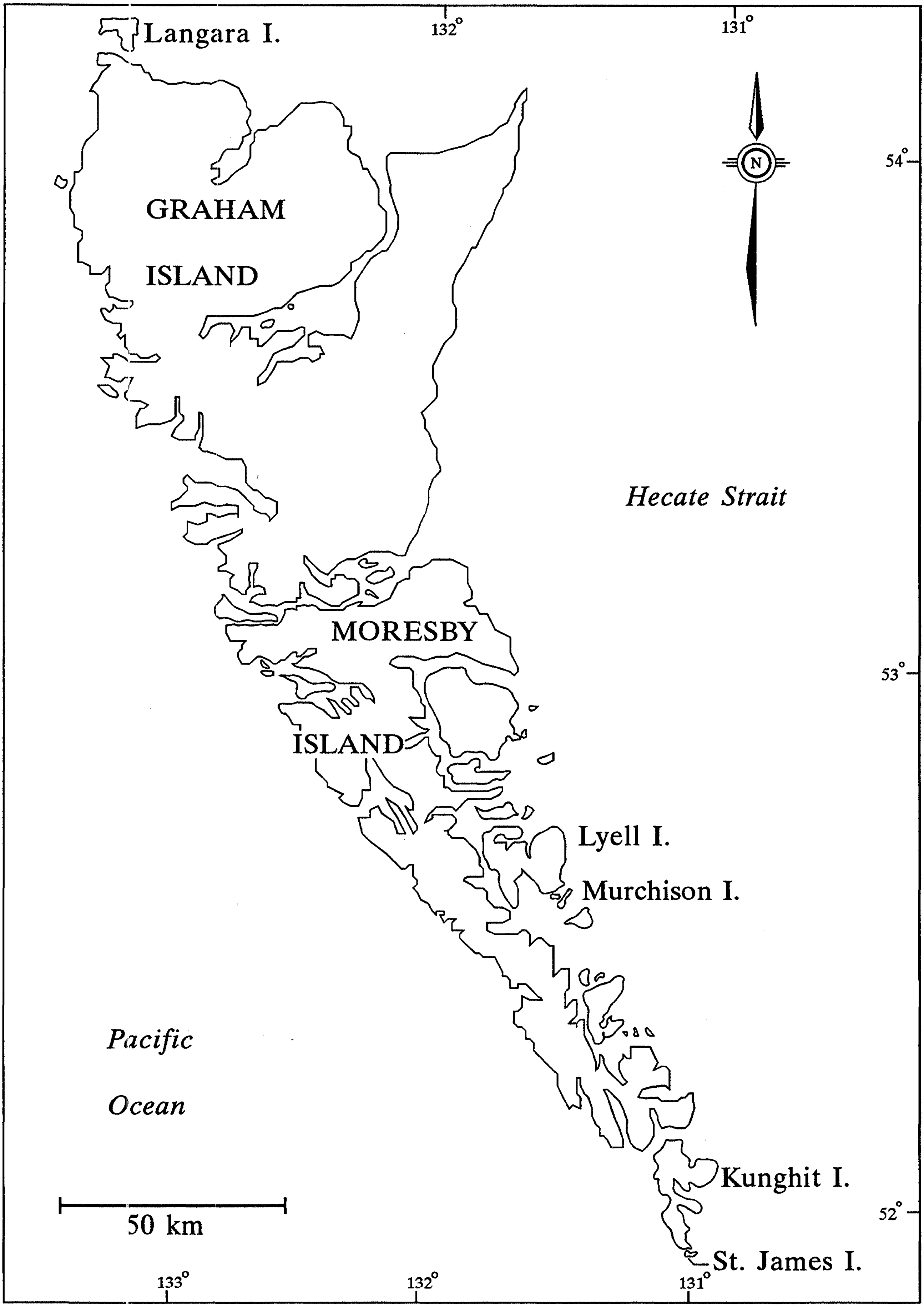

Fig. 1. Map of Haida Gwaii showing location of seabird islands with introduced rats.

2.2. Study Site

Langara Island (54° 14'N, 133°W) is a 3100 ha island off the northwest corner of Graham Island (Aau Gwaii). Most of the edge of the island is covered by a Sitka spruce (*Picea sitchensis*) forest with some areas of very thick regeneration. Grass meadows are found along the shore at sites of past human settlements. A western redcedar (*Thuja plicata*) forest covers most of the interior of the island and is the dominant vegetation zone on Langara. Salal (*Gaultheria shallon*) or moss is the main ground cover in the cedar forest. Between the spruce and cedar zones, and overlapping both, is a western hemlock (*Tsuga heterophylla*) forest, usually with moss ground cover. Elevated bogs cover much of the centre of the north end of the island. A more complete description and map of the vegetation can be found in Rodway *et al.* (in prep.).

2.3. Methods

2.3.1. Ancient Murrelets

2.3.1.1. Colony Survey

We surveyed most of the ancient murrelet colony using line transects, but did total counts of burrows in the small remnant colonies at Cohoe Point and Fury Bay. Fifteen of the 16 transects censused in 1988 (Fig. 2) were resurveyed. We were unable to locate transect #6, but replaced it with a new transect. Eighteen new transects (A-R) were added in order to calculate the breeding population size and define the colony boundaries more accurately than had been done during previous surveys. On new transects and those that were in the active colony in 1988, we attempted to determine the status of all burrows within 5 x 5 m plots placed every 40 m along the transect. This involved burrow excavation in some cases. Burrows were considered active if they contained pieces of eggshell or shell membrane from the 1993 breeding season. Occupancy rate was calculated as # active burrows/total # burrows for each plot. A transect was considered finished when no burrows were found inland of the last plot.

On transects in areas that had been abandoned by 1988, we checked for signs of activity approximately 5 m to each side of the line. Those checks were done between 19 and 22 May. The rest of the transects were surveyed between 6 and 18 June, after most murrelets had left the island, in order to minimize disturbance and prevent desertion.

On all transects we counted depredated eggshells, feather piles, carcasses and chewed spruce cones found within a 5 m swath along the line. 'New' eggshells from the 1993 breeding season and 'old' eggshells from prior breeding seasons were tallied separately.

We searched Cohoe Pt. (May 9) and Fury Bay (June 12) for active burrows. All burrows that had any evidence at their entrances of use by ancient murrelets during the 1993 season were counted. We did not excavate any burrows in those two areas.

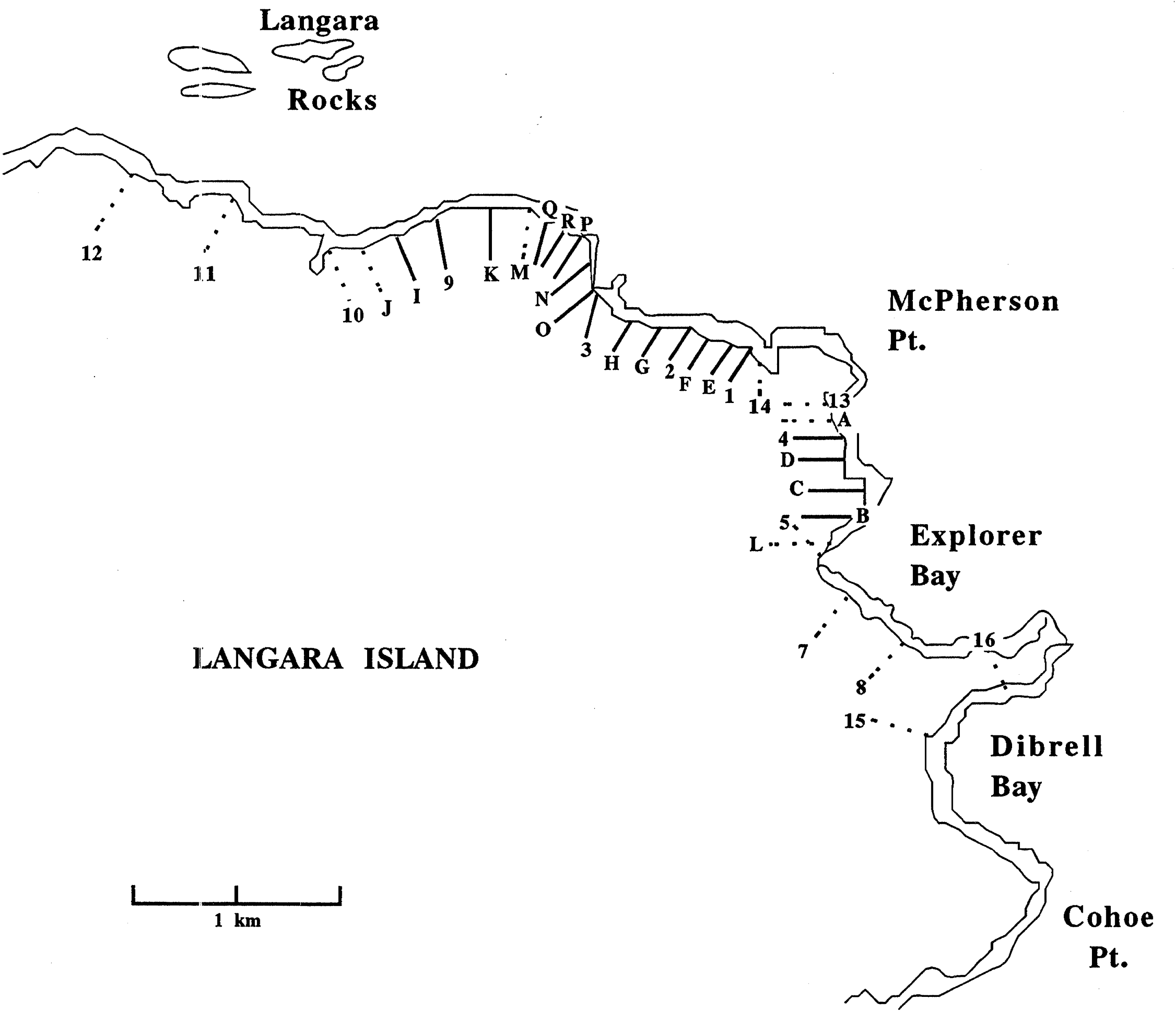

Fig.2. Location of transects used to survey the main ancient murrelet colony, Langara Island, 1993. Transects denoted with solid lines were wthin the active colony; those denoted with dotted lines were outside the active colony.

2.3.1.2. Knock-down Plots

We monitored burrow visitation rates using knock-down tags (Gaston *et al.* 1988) in plots established for this purpose in 1988 (Bertram 1989). Mean knock-down frequencies provide an index of occupancy that can be compared for the same areas in different years (Gaston *et al.* 1988). Very thin twigs were placed across the entrance(s) of all burrows in six 20 m^2 plots and checked daily for knock-downs for 15 days between 11 and 26 May. Any twigs that had been moved by the birds were replaced each day. At the end of the monitoring period, we probed the burrows with long sticks to determine which tunnels were not really burrows and which burrows had multiple entrances. The former were excluded from the totals for each plot. The results from multiple entrances of a single burrow were combined.

We determined the proportion of tags knocked down/night for each plot. The data was transformed using an arcsin square root transformation and compared between plots using a Tukey HSD multiple comparisons test. Plots were compared between years using a Bonferroni paired t-test.

2.3.1.3. Chick Mass at Departure from Colony

In order to determine if the presence of rats at the colony affected chick mass, we weighed chicks as they departed from the colony. We set up a chick funnel (Gaston *et al.* 1988) to direct departing chicks to a weighing station near the shore. The funnel consisted of a plastic wall along one side of a valley northwest of McPherson Point; the steep hill on the other side of the valley acted as a natural wall. We monitored the station for nine nights between 27 May and 7 June. Monitoring began just after dark (23:00 - 23:30) and finished when no chicks had passed through for 1/2 hour (01:35 - 02:30).

All chicks passing through the station were weighed to the nearest 0.5 g on a Pesola balance and banded with a USFWS stainless steel bird band. Any adults that crashed into the station were also banded and were checked for the presence of a brood patch. Adults were not weighed.

2.3.2. Songbird Surveys

As a baseline for future comparisons, we censused songbirds in the cedar forest using the fixed-radius (50 m) point count census technique (Manuwal and Carey 1991). Thirty plots along six transects (Fig. 3) were surveyed between 9-14 May by counting all birds seen or heard for 20 minutes within each plot. Surveys were conducted between 05:55 and 09:55 on mornings with little or no wind. The centres of the plots were no closer than 400 m apart, at least 150 m from the nearest clearing (bog, lake) and at least 200 m from the forest edge. Those criteria precluded the use of this method along the shore or in the spruce or hemlock forests because each of those zones is less than 200 m wide. We did, however, record the presence and evidence of breeding for all species seen or heard in all vegetation zones on the island.

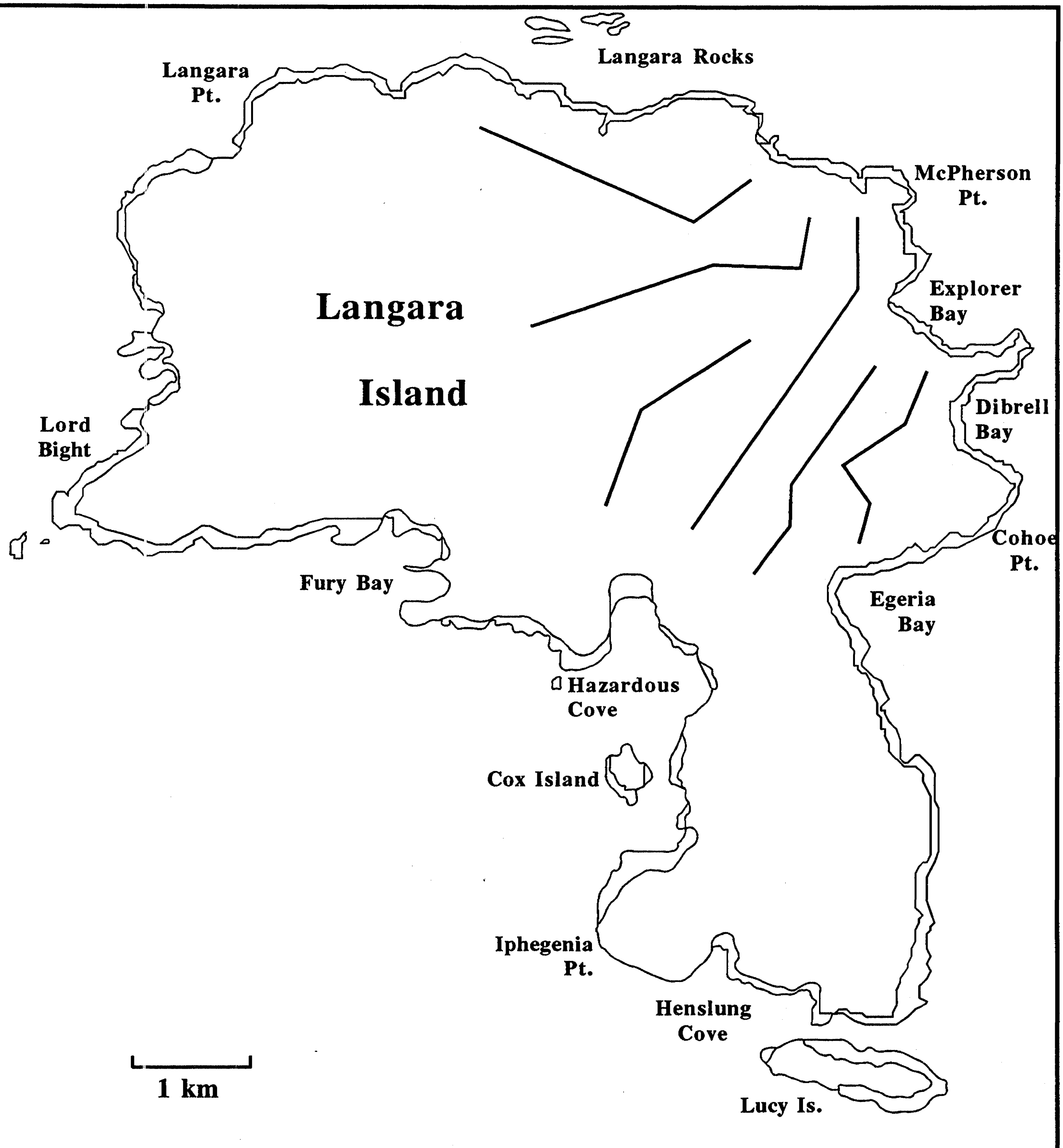

Fig. 3. Location of songbird survey (———) transects, Langara Island, 1993.

2.3.3. Rat Activity

We set live traps for a total of 37 trap-nights to try to identify the species of rat living on Langara Island. Traps were baited with a mixture of peanut butter and oatmeal and set along the shore, in a meadow, in the spruce forest and in our camp. We also set live traps on Lucy Island for a total of 9 trap-nights. Rats caught were drowned and photographed, and the skulls were submitted to the vertebrate collection of the Royal British Columbia Museum.

2.3.4. Native Small Mammals

We used pitfall and Sherman live traps to determine the presence/absence of native small mammals on Langara Island. Trap lines were run in all major habitat types in the northeast part of the island for a total of 428 trap-nights. Traps were baited with a mixture of oatmeal and peanut butter and checked daily. Any live animals were released.

2.3.5. Associated Species

In the course of our work, we kept records of species of birds and mammals that we noticed on Langara and in the surrounding waters.

2.4. Results and Discussion

2.4.1. Ancient Murrelets

2.4.1.1. Colony Survey

In 1993, the majority of ancient murrelets on Langara Island nested in two distinct areas. The main colony ran west from McPherson Pt. and covered the northeast corner of the island (Fig. 4). A smaller colony existed south of McPherson Pt. The total area of these two colonies was approximately 22.9 ha. Most of the colony was in the hemlock/moss forest, but active burrows were also found in the spruce forest, usually along the edge of the island.

An estimated 14,600 pairs of ancient murrelets nested in the two colonies near McPherson Pt. (Table 1). The detailed survey results are presented in Appendix 1. We found only a very small remnant (25-50 pairs) of the Cohoe Pt. colony (Fig. 4) and we found no evidence of nesting activity at the colony west of Fury Bay.

The results of the 1993 ancient murrelet survey clearly indicate that both the breeding population of birds and the area of the colony have declined since 1988 (Table 2). The 1993 breeding population was approximately 60% of the population in 1988. The colony now covers only about 50% of the area that it covered in 1988, and only about 20% of the area covered in 1981. The apparent colony expansion by 1993 into an area south of McPherson Pt. not used in 1988 (see Fig. 4) is actually a reflection of more accurate definition of the colony boundaries

Table 1. Estimation of the nesting population of ancient murrelets on Langara Island in 1993.

<u>Main Colony</u>

Length of Colony (m): 1900

Mean Width of Colony (m): 120.5

∴ Area of Colony = 229,000 m^2
= 22.9 ha

Burrow Density (burrows/m^2): 0.18 ± 0.016

∴ Total Number of Burrows = 41,220 ± 3646

Occupany Rate: 0.36 ± 0.039

∴ Estimated nesting population = 14,633 ± 2059

<u>Cohoe Point Colony:</u>

Estimated nesting population = 50

<u>TOTAL NESTING POPULATIONS:</u>

14,680 ± 2059

Table 2. Comparison of the results of ancient murrelet surveys conducted on the main colony of Langara Island in 1981, 1988 and 1993.

Year	Colony Area (ha)	No. Quadrats Sampled	Mean Burrow Density (burrows/ha)[a]	Total No. Burrows[a]	Occupany Rate (%)[a]	Nesting Population (pairs)[a,b]
1981[c]	100.8	39	820±139	82,650±14,010	26.3±8.0	21,740±3570
1988[d]	46.3	31	1358±225	63,150±10,420	38.4±7.7	24,250±6250
1993[e]	22.9	59	1800±160	41,220±3646	35.5±3.9	14,630±2060

a ± S.E.

b In 1981, an additional 500 pairs estimated at Iphegenia Pt. and 50 pairs at Fury Bay.

In 1988, an additional 280 pairs estimated at Cohoe Pt.

In 1993, an additional 50 pairs estimated at Cohoe Pt.

c From Rodway *et al.* (in prep.), recalculated in Bertram (in press).

d From Bertram (1989).

e This study.

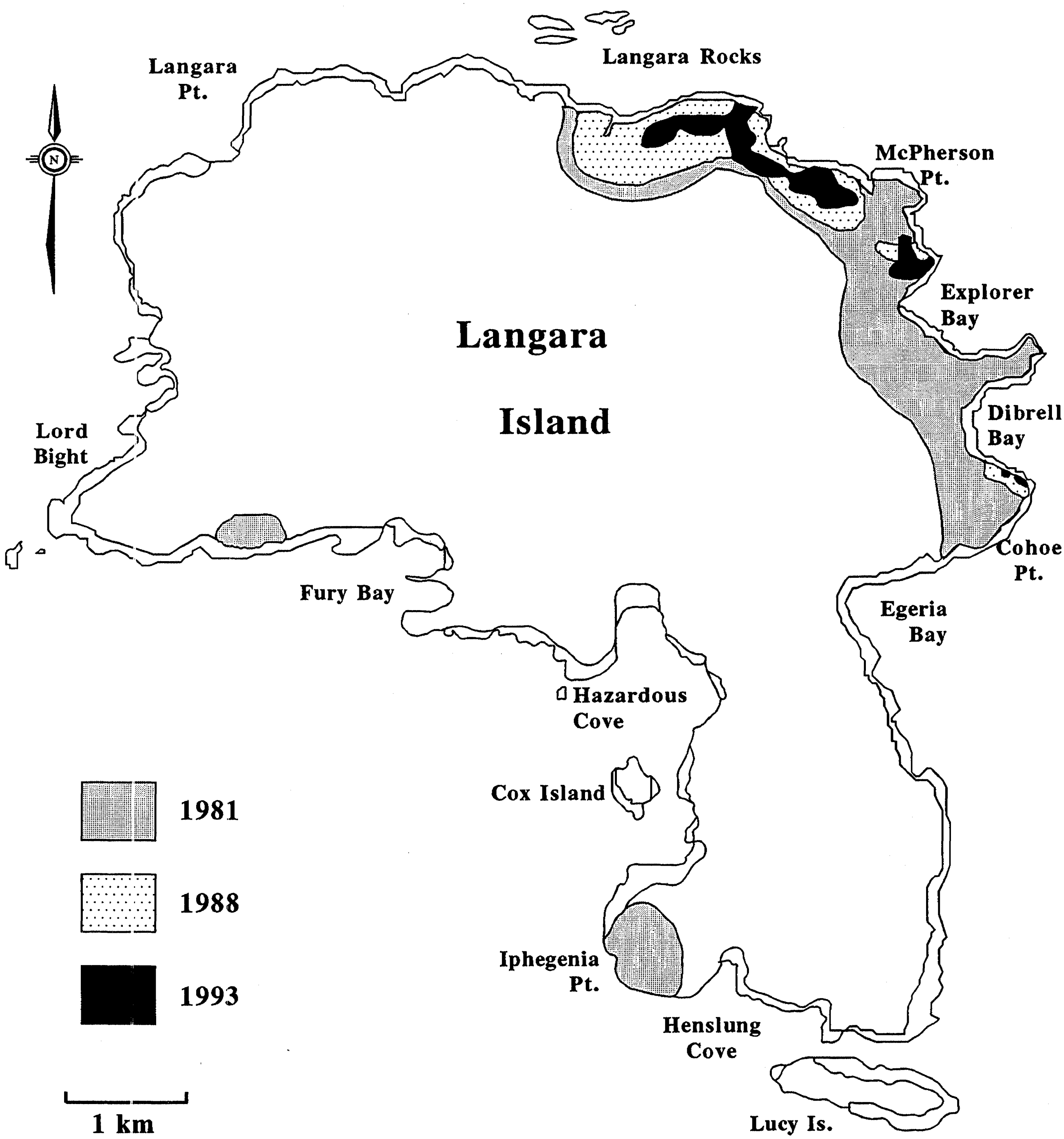

Fig. 4. The extent of the ancient murrelet colony on Langara Island in 1981, 1988 and 1993. The colony west of Fury Bay was not surveyed in 1988, but was presumed to be at least partially active because dead, fresh chicks were found in the vicinity (see Bertram 1988).

in the later survey. We found old depredated eggshells and carcasses in the 'new' area, indicating past activity.

It should be noted that although the first ancient murrelet survey of Langara Island, conducted in 1981, reported only 25,000 breeding pairs (Rodway *et al.* in prep.), there is evidence that the colony had already contracted considerably by then. Subjective population estimates from the 1970's ranged from 50,000 (Nelson and Myers 1976) to 90,000 (Vermeer *et al.* 1984). Gaston (1992) estimated that the original population was approximately 200,000 pairs. Thus, the present breeding population of ancient murrelets probably is less than 10% of the original population.

We found old shells of murrelet eggs throughout the abandoned areas of the colony in 1993 (see Appendix 2). Square tooth marks, diagnostic of rat predation (R. Taylor, pers. comm.), were easily discernible on many of these shells. This suggests that rats were a cause of the abandonment. We also found 142 new depredated eggshells along transects within the active colony. Again, many of those shells had signs of rat predation. Assuming average density of occupied burrows within the 1.56 ha surveyed along the transects, seven percent of the eggs from a total of 995 active burrows were lost to predation in a single breeding season.

Predation intensity was not uniform throughout the colony. Predation was especially heavy along transects R, P and N. All three of those transects were in the northeast corner of the main colony and were among the most densely burrowed (active and inactive burrows) transects. They were close to transect M which no longer contains any active breeding areas and transect Q which had only 40 m of active colony remaining. It appears that rats are presently causing the abandonment of regions of the colony with the highest density of burrows.

We also found ancient murrelet carcasses with the backs of the head gnawed open, which is indicative of rat predation (R. Taylor, pers. comm.). In some cases, those carcasses were later scavenged by raptors (bald eagles, peregrine falcons) or corvids (ravens, crows) leaving feather piles (pers. obs.). Thus, it is unclear whether the murrelet feather piles and wings found throughout both the active and abandoned colony (Appendix 2) represent birds that were depredated or scavenged by these species. Raptor predation is common on ancient murrelet colonies along the coast of British Columbia (eg. Rodway *et al.* 1988, Gaston 1992). River otters may have been responsible for a small percentage of the predation on adult murrelets. We found two murrelet burrows that had been dug out and found otter signs nearby in both cases.

2.4.1.2. Knock-down Plots

The proportion of burrows that were entered varied significantly between plots. The mean proportion of knock-downs per night for each plot ranged from 0.21 to 0.54, with plots 4 and 5 visited, on average, less frequently than the other plots (Table 3; Tukey HSD Multiple Comparisons Test, P values < 0.05). Plots 4 and 5 also had the lowest mean visitation rates in 1988 (Table 3).

Table 3. Comparison of results from knock-down plots in 1988[a] and 1993[b], Langara Island.

Plot	No. of Burrows		Proportion knock-downs/Night (x ± S.D.)	
	1988	1993	1988	1993
1	68	75	0.33 ± 0.02	0.45 ± 0.02
2	40	42	0.39 ± 0.03	0.54 ± 0.02
3	72	45	0.38 ± 0.02	0.48 ± 0.01
4	64	51	0.21 ± 0.02	0.30 ± 0.01
5	51	42	0.27 ± 0.02	0.20 ± 0.01
6	43	67	0.32 ± 0.02	0.51 ± 0.03

[a] From Bertram 1989.

[b] This study.

Visitation rates calculated from knock-down plots are not directly translatable into occupancy rates (Gaston *et al.* 1988). Rather, the mean frequencies can be used as an index to compare occupancy rates between years. The 1993 knock-down rates for each plot do not differ significantly ($P > 0.05$) from the rates recorded in 1988; occupancy rates measured during the colony surveys were also similar (see Table 2). The occasional inclusion by Bertram (1989) of tunnels that were not burrows and multiple entrances to a single burrow as multiple burrows may explain the minor differences in knockdown rates found between years.

No obvious daily pattern of visitations between plots is evident from Fig. 5. However, the pairs of plots, located within 50 m of each other, seem to show a higher degree of synchronization. This suggests that activity is synchronized in localized sections of the colony, but not necessarily for the colony overall. In contrast, Bertram (1989) found that the day-to-day pattern of knock-downs was similar among plots.

It is interesting to note that, although the same plot boundaries were used in 1993 and 1988, the number of burrows in five of the six plots changed between the years. The encroachment of regenerating spruce has decreased the amount of suitable habitat in plot 5 and the collapse of a huge tree has increased the availability of nesting habitat in plot 1. Major habitat changes were not evident in plots 3 and 4, but burrows have disappeared. The loss of nearby habitat to spruce regeneration may have caused the increase in burrow density in plot 6.

2.4.1.3. Mass of Chicks at Departure from Colony

We caught a total of 170 chicks and 22 adults at the weighing station. The mean chick mass for each night of measuring is given in Table 4. Those means were similar to those found at Langara in 1988 (Bertram 1989) and by researchers at Reef Island over several years (Gaston 1992).

The chick masses presented in Table 4 may be biased because we did not begin weighing and banding chicks until approximately one week after finding chicks on the colony. Thus, we do not know the masses of early-departing chicks. Gaston (1992) noted a seasonal decline in chick mass at departure in most years. A similar trend was not evident at Langara Island in either 1988 (Bertram 1989) or 1993.

2.4.2. Songbird Surveys

We recorded 19 species of forest birds during the songbird surveys in the cedar forest on Langara Island (Table 5). An additional 10 species were noted in other habitats on the island.

At least some of the ground-nesting species successfully fledged young on Langara Island. Fledgling blue grouse, orange-crowned warblers, fox sparrows and song sparrows were observed (Appendix 4). Thus, rats have not eliminated such potentially vulnerable species from the island. The results of an artificial nest experiment run on Langara suggest that eggs of ground-nesting species are depredated by rats (Martin 1994). However, in the experiment, only those nests near the shore were destroyed and most predation occurred in June (Martin *et al.* 1994). Thus, blue grouse may reproduce successfully in interior bogs because they never encounter rats in that habitat. Birds that fledge their young before June may also not encounter rats.

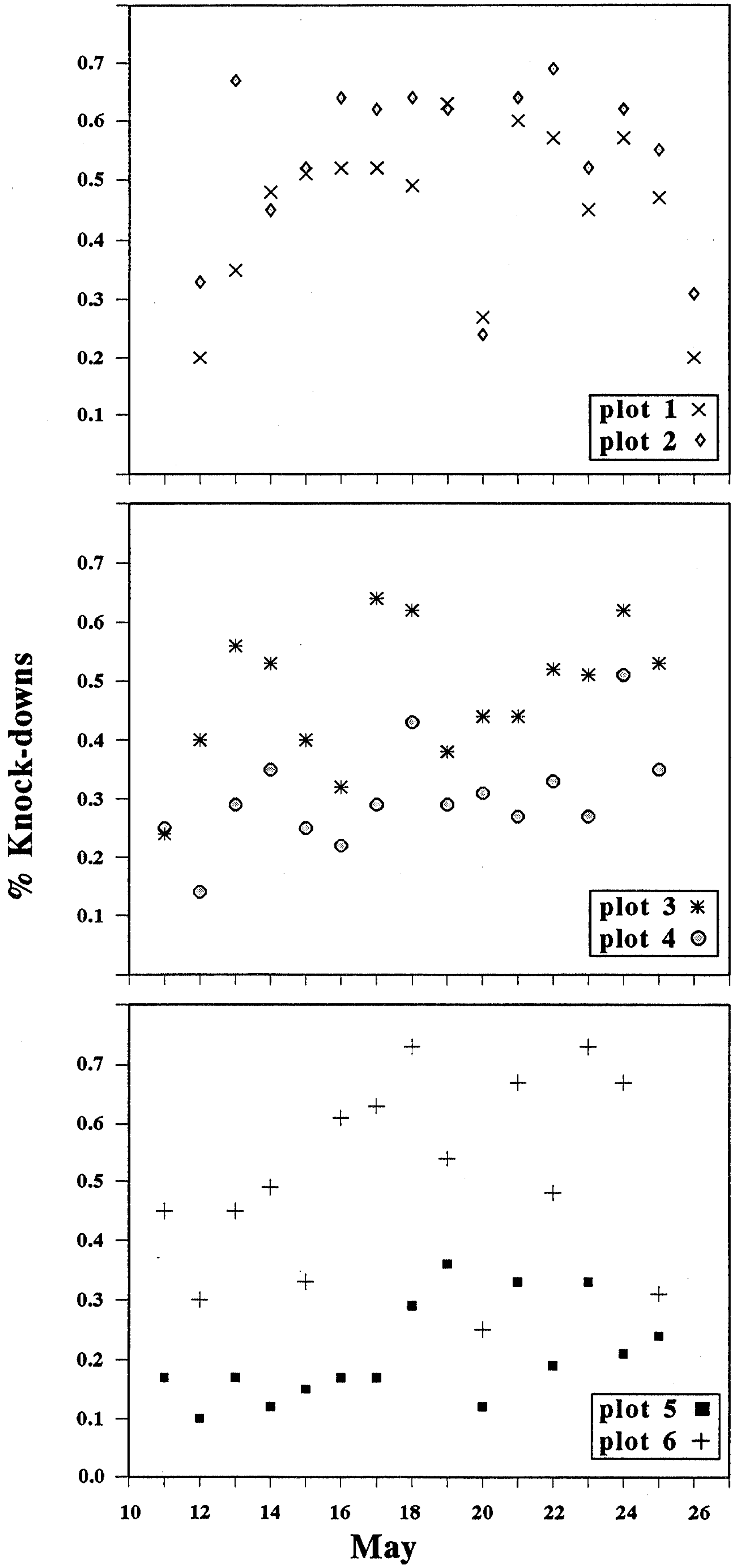

Fig.5. Percent knock-downs per night on six plots, Langara Island, 1993.

Table 4. Ancient murrelet chick mass at departure from colony, Langara Island, 1993.

Date	N	Mean Mass (g)	S.D.	Min.	Max.
27 May	42	27.3	2.13	23.0	33.0
28 May	32	26.8	1.58	24.0	30.5
29 May	22	26.6	2.26	21.0	30.5
30 May	21	27.2	1.97	24.0	30.0
31 May	23	26.2	1.95	23.0	29.0
01 June	10	27.3	2.25	22.0	30.0
03 June	8	27.0	1.29	25.0	29.0
05 June	5	27.5	1.22	26.0	29.0
07 June	6	26.4	2.29	23.0	29.5

Table 5. Results of songbird point count surveys[a] conducted in cedar forest, Langara Island, May 1993.

Species	Plots in which Observed No.	%	No./Plot ($\bar{x}$ ± S.D.)
Hairy Woodpecker	1	3	1.0 ± 0.00
Pacific Slope Flycatcher	12	40	1.2 ± 0.37
Tree Swallow	1	3	2.0 ± 0.00
Common Raven	1	3	1.0 ± 0.00
Chestnut-backed Chickadee	15	50	1.7 ± 0.60
Winter Wren	19	63	1.1 ± 0.31
Golden-crowned Kinglet	13	43	1.4 ± 0.49
Hermit Thrush	8	27	1.3 ± 0.43
Varied Thrush	10	33	1.7 ± 0.90
Orange-crowned Warbler	2	7	1.0 ± 0.00
Townsend's Warbler	11	37	1.2 ± 0.39
Wilson's Warbler	1	3	1.0 ± 0.00
Dark-eyed Junco	4	13	4.0 ± 0.00
Red Crossbill	10	33	6.2 ± 5.21
Pine Siskin	2	7	10.5 ± 9.5

[a] The following bird species were heard vocalizing from outside the plots: Red-throated Loon, Common Loon, White-fronted Goose, Bald Eagle, Peregrine Falcon, Blue Grouse, Black Oystercatcher, Glaucous-winged Gull, Hairy Woodpecker, Pacific Slope Flycatcher, Northern Crow, Common Raven, Tree Swallow, Winter Wren, Golden-crowned Kinglet, Hermit Thrush, Varied Thrush, Townsend's Warbler, Fox Sparrow, Golden-crowned Sparrow, Red Crossbill, and Pine Siskin.

Incidental observations of fledglings of seven other species (Appendix 4) indicate that at least some shrub- and tree-nesting species also reproduce successfully in the presence of rats. This conclusion is supported by the results of the artificial nest experiment: no shrub nests were disturbed (Martin *et al.* 1994).

It is difficult to compare the songbird survey results from Langara with those from other islands in Haida Gwaii. Differences in the number of species or abundance of some species may reflect ecological differences in the forest habitat which is dominated by cedar on Langara Island and by spruce and hemlock on other islands that have been surveyed (J.-L. Martin, pers. comm.). The Langara survey results do provide a baseline, however, for comparison with future surveys to be conducted after the rats are eradicated from the island.

2.4.3. Rat Activity

Although we found rat-chewed ancient murrelet eggshells in the murrelet colony throughout May and June, we rarely saw the rats in May. In June, however, rats were frequently observed in the hemlock/moss and spruce forests, meadows and on beaches. We found no signs of rat activity in either the cedar forest or the bogs.

We trapped one rat on Langara and two on Lucy Island. All were Norway rats (*Rattus norvegicus*). In addition, the Langara Island lightkeepers photographed a rat killed at the light station at Langara Point; it also was a Norway rat.

The specimens of rats collected from Langara Island up to 1960 were black rats (*Rattus rattus*; also called ship or Alexandrian rats). The specimens collected during the 1988 census on Langara, which had previously been described as *R. rattus* (Bertram 1989), have now been re-examined and have been identified as *R. norvegicus* (D. Nagorsen, pers. comm.). The latter species will out-compete and eventually replace black rats when the two species come in contact (Taylor 1975). Thus, it seems likely that at some time in the 1950's or 1960's a new introduction of rats occurred.

2.4.4. Small Mammal Survey

The only native small mammal that we trapped on Langara Island in 1993 was the dusky shrew. The shrews were trapped along the beach and in the meadow near McPherson Pt. and in the spruce regeneration just south of the McPherson Pt.; none were trapped inland of the spruce forest (Table 6). We frequently observed shrews along beaches and in meadows, but never interior to the spruce forest.

Table 6. Results of native small mammal surveys on Langara Island, 1993.

Habitat	No. Trap Nights: Live Traps	No. Trap Nights: Pit Fall Traps	Species Trapped
Beach	30		2 dusky shrew
Grass/hummock meadow	38		1 dusky shrew
Spruce forest (shoreline)	57	15	-
Spruce regeneration	39	15	1 dusky shrew
Hemlock/moss forest	110	15	-
Cedar forest	73	15	-
Bog	21		-

Our trapping technique was designed only to determine presence/absence of small mammals and the results can not be used to calculate a population estimate. If shrew numbers are being depressed by the presence of rats, either through predation or competition for food, a change in the shrew population following rat eradication may show up through the trapping success per trap-night or an expansion of the habitats in which shrews are found.

Dusky shrews were the only species of native small mammal reported on Langara during previous seabird studies (Bertram 1989, Rodway *et al.* in prep.).

2.4.5. Associated Species

A list of bird and mammals observed during the course of our other activities appears in Appendix 4.

2.5. Conclusions

The breeding population of ancient murrelets on Langara Island has declined by approximately 40% between 1988 and 1993. The population is now probably less than 10% of its historical size. In addition, the colony boundaries continue to contract. The evidence available suggests that the primary cause of the decline is predation on eggs and adults by Norway rats, an introduced predator. It seems likely that if rats are not controlled on the island, the ancient murrelet population will continue to decline and the species will eventually become extirpated at this location.

Rats have not extirpated ground nesting songbirds from Langara, but may be predating some of their nests. If the rats are eradicated from Langara Island, comparisons of songbird and small mammal populations pre- and post-eradication should permit a better understanding of the effects of the introduced predators on those parts of the island ecosystem.

3. KUNGHIT ISLAND AND SURROUNDING ISLANDS

3.1. Introduction

Declines in the breeding population of burrow-nesting alcids have been reported from three of the five seabird colonies with rats in the Haida Gwaii archipelago (Rodway *et al.* 1988, Bertram 1989, Gaston and Lawrence 1993, this report). The status of nesting seabirds on the remaining two islands is unknown. The present study was designed to examine the effects of rats on seabirds nesting on a fourth island, Kunghit Island. We also wanted to determine if rats have spread to any of the small seabird islands surrounding Kunghit Island. Rats are able to disperse by swimming short distances of up to 300 m in cold marine waters (Taylor 1984). Thus, any islands within several hundred metres of an affected island are potentially at risk.

3.2. Study Site

Kunghit Island is a 12,330 ha island at the southern end of Gwaii Haanas. The steep edges of the island are covered with Sitka spruce often with grass or moss ground cover. Western hemlock and western redcedar cover much of the interior of the island.

High, Charles and Gordon Islands all lie within a few hundred metres of the shore of Kunghit Island (Fig. 6). High Island is 42 ha with similar vegetation to Kunghit. Charles Island is actually two islands connected by a gravel beach, totalling 2.6 ha. The two islands are covered by a mixed Sitka spruce/western hemlock forest with a very thick salal understorey. The Gordon Islands are covered with a sparse Sitka spruce forest with a thick salal understorey.

More detailed descriptions of the vegetation and topography of those islands can be found in Rodway *et al.* (1988, 1990).

3.3. Methods

3.3.1. Kunghit Island Seabird Surveys

We re-surveyed only those areas of Kunghit Island where breeding colonies had previously been reported (see Rodway *et al.* 1988). We used two types of census methods: total counts of burrows and line transects.

Total counts of the burrows in the rhinoceros auklet colony (17-19, 24 July) and the Jenkins Point ancient murrelet colony (12 July) were conducted. The counts involved exploring all safely accessible parts of each sub-colony and counting all burrows encountered. We attempted to determine the status of every tenth burrow in order to calculate an occupancy rate for each colony. We also counted all carcasses, feather piles and depredated eggshells found during the surveys.

The ancient murrelet colony at Luxana Bay was surveyed using line transects (25-28 July). We set up transects approximately every 150 m along the southern shore of Luxana Bay with the first and last transects outside the area of active burrowing (Fig. 7). Transects were run on a bearing of 230°. We attempted to determine the status of all burrows within 7 x 7 m plots placed every 40 m along each transect. We also counted all carcasses, feather piles and depredated eggshells found within a 7 m swath along the transects between the plots. 'New' eggshells from the 1993 breeding season were tallied separately from 'old' eggshells from prior breeding seasons. A transect was considered finished when no burrows were found inland of the last plot.

During both the total counts and the line transects, a burrow was considered active if it contained a bird, pieces of new eggshell or shell membrane and/or regurgitated food. A burrow was considered inactive if all tunnels were thoroughly explored without encountering any of the above signs. Any burrows with unreachable tunnels were categorized as inaccessible if no obvious signs of activity were noted. Occupancy rate was calculated as # active burrows/total # burrows.

We did not attempt to census the tufted puffin colonies because of the inaccessible location of the burrows. Birds entering burrows at two locations and birds on the water were counted.

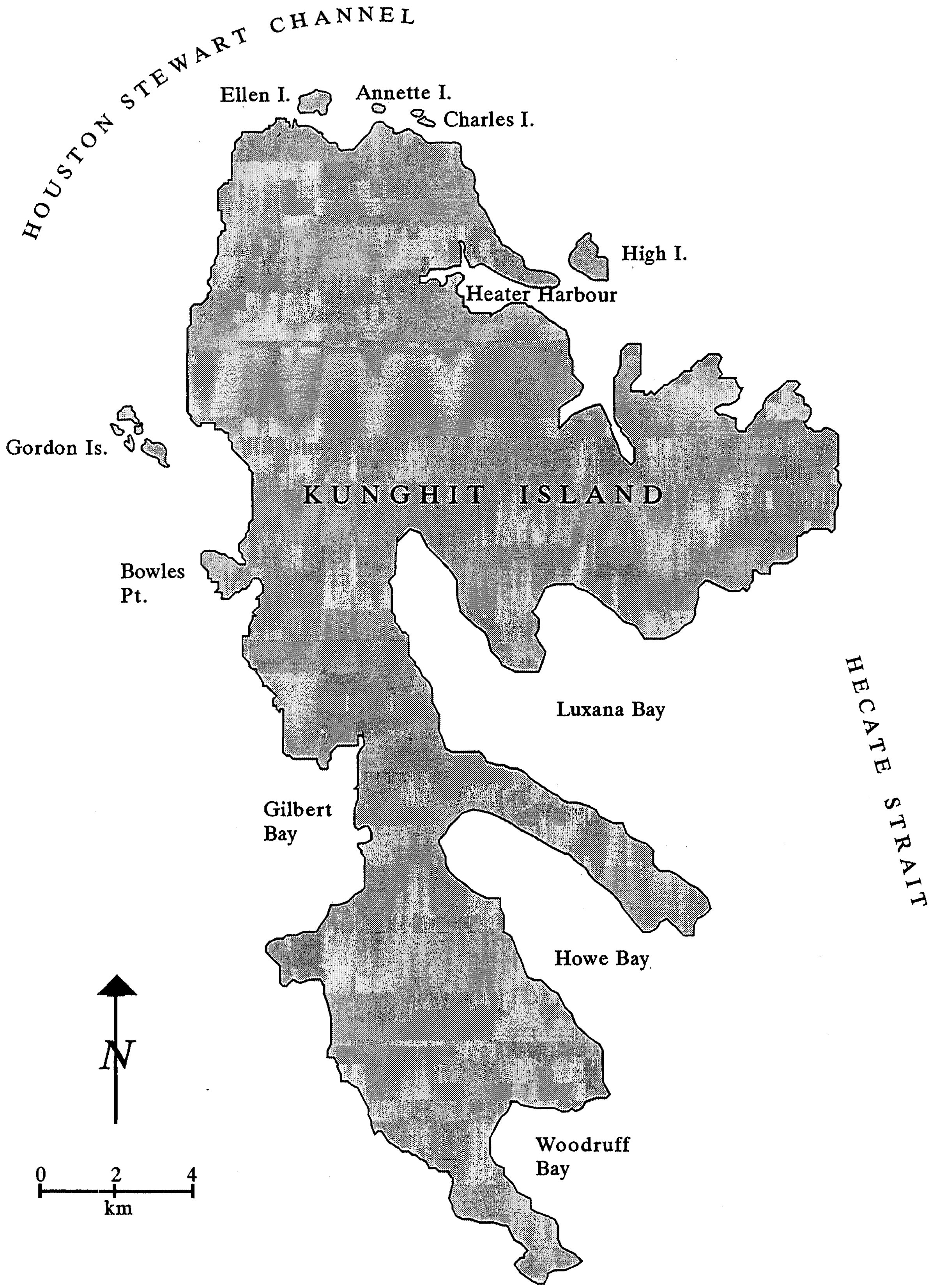

Figure 6. Kunghit Island and surrounding islands.

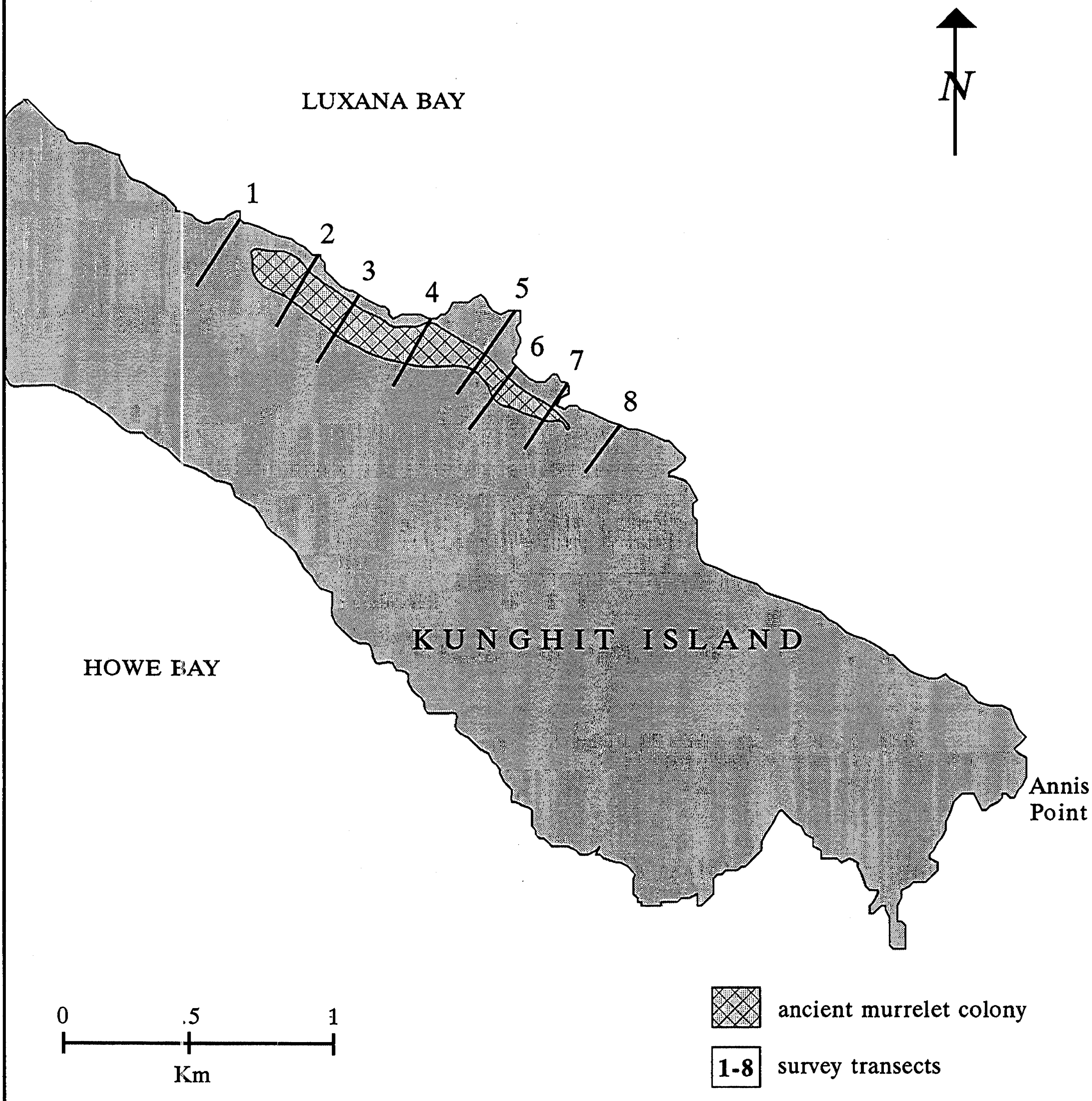

Figure 7. Location of survey transects and extent of ancient murrelet colony at Luxana Bay on Kunghit Island in 1993.

3.3.2. Seabird Surveys on Surrounding Islands

We explored all safely accessible parts of High (11 July), Charles (14-15 July) and Gordon (2-5 August) Islands and counted all burrows encountered. Burrows of different species were distinguished by size of entrance, droppings around the entrance, regurgitated food, feathers, eggshells, and/or odour (see Rodway *et al.* 1988 for details). We attempted to determine the status of every tenth burrow encountered in order to calculate an occupancy rate for each colony. Burrows were considered active if they contained birds, pieces of eggshell and/or regurgitated food.

3.3.3. Rat Activity

We used live traps to determine the presence/absence of rats on High, Charles and Gordon Islands. Ten traps were set along the shore and at the edge of the vegetation for a total of 30, 100 and 41 trap-nights, respectively. We also set live traps at Heater Harbour, Rose Harbour and Luxana Bay (Fig. 6) in order to confirm the species of rat on Kunghit Island. The traps were baited with a mixture of peanut butter and oatmeal. Rats caught were drowned and photographed; skulls were submitted to the Royal British Columbia Museum collection.

We also searched the islands for signs of rat activity. We looked for rat dens, faeces, runways, and chewed spruce cones.

3.3.4. Associated Species

In the course of our work, we kept records of species of birds and mammals that we noticed on Kunghit and in the surrounding waters.

3.4. Results and Discussion

3.4.1. Kunghit Island Seabird Surveys

3.4.1.1. Ancient Murrelet Colony

The majority of ancient murrelets nested in a colony that stretched along the southern shore of Luxana Bay (Fig. 7). The detailed survey results are presented in Appendix 3. We estimated that 3550 pairs of ancient murrelets nested in that area in 1993 (Table 7). The colony at Jenkins Point had an estimated 11 pairs of murrelets.

Unfortunately, the lack of a previous census of ancient murrelets at Luxana Bay precludes a quantification of any trends in the breeding population at the site. The 1986 total of 8000 pairs was actually a guess based on colony size (Rodway *et al.* 1988). Thus, a comparison between the two population estimates is meaningless. However, the colony boundaries at Luxana Bay

Table 7. Estimation of the nesting population of ancient murrelets on Kunghit Island in 1993.

Luxana Bay Colony:

Length of Colony (m): 1340

Mean Width of Colony (m): 83

∴ Area of Colony = 111,220 m^2

= 11.1 ha

Burrow Density (burrows/m^2): 0.06 ± 0.012

∴ Total Number of Burrows = 6673 ± 1334.6

Occupany Rate: 0.53 ± 0.106

∴ **Estimated nesting population = 3537 ± 970.1**

Jenkins Point Colony:

Number of Burrows: 57

Occupany Rate: 1 of 5

∴ **Estimated nesting population = 11**

TOTAL NESTING POPULATIONS:

3550 ± 970

have contracted between 1986 and 1993. In 1986, the colony covered about 35.3 ha (Rodway *et al.* 1988); by 1993 the birds were nesting in only about 11.1 ha. Part of the difference between the two area measurements may be due to differences in the accuracy with which the area was calculated. The decrease of 24 ha of active colony, however, cannot be explained by measuring errors. Comparable population counts do exist for the Jenkins Point colony. The 11 pairs present in 1993 represent a major decline from the 800 pairs estimated to breed in the area in 1986 (Rodway *et al.* 1988).

We observed evidence of rat activity throughout the two ancient murrelet colonies. We counted 33 depredated eggshells (23 new and 10 old) and three rat-chewed carcasses along the transects in the Luxana Bay colony (Appendix 3). A rat den with ten ancient murrelet eggshells at the entrance was found along transect #4. We also found rat faeces throughout both colonies and one of the eight burrows checked for occupancy in the Jenkins Point colony contained chewed spruce cones, an indicator of rats. In addition, 19 and 3 feather piles were counted at Luxana Bay and Jenkins Point, respectively. Those piles may represent either raptor kills or raptor scavenging of rat kills.

The extensive evidence of rat predation throughout the two ancient murrelet colonies suggest that the large colony contractions between 1986 and 1993 were caused by rats.

3.4.1.2. Rhinoceros Auklet Colony

An active rhinoceros auklet colony occurred in disjunct patches extending along the north shore of Luxana Bay to north of Lyman Point (Fig. 8). The sub-colonies corresponded to those found in 1986 with the exception of area A. We found no burrows in that area where surveyors counted only 3 burrows in 1986 (Rodway *et al.* 1988). Our counts for sub-colonies B, C and E were similar to those of 1986 (Table 8). We did not count all of sub-colony D because we lacked the necessary safety equipment to work on the steep and unstable slopes. From the size of the sub-colony and the density of the burrows in the sections that were explored, we guessed that sub-colony D had about 2000 burrows. Thus, the colony total was approximately 3750 burrows.

Because our count was not complete, we can provide only a general estimate of the breeding population. The occupancy rate for sub-colonies B, C and E was 68% (59 of 87 burrows). The estimated breeding population for 1993 is, therefore, 2500 pairs. This estimate is identical to that from the 1986 survey (Rodway *et al.* 1988). Although we estimated a higher number of total burrows, we used the occupancy rate measured for the colony which was lower than the B.C. median used by Rodway and co-workers.

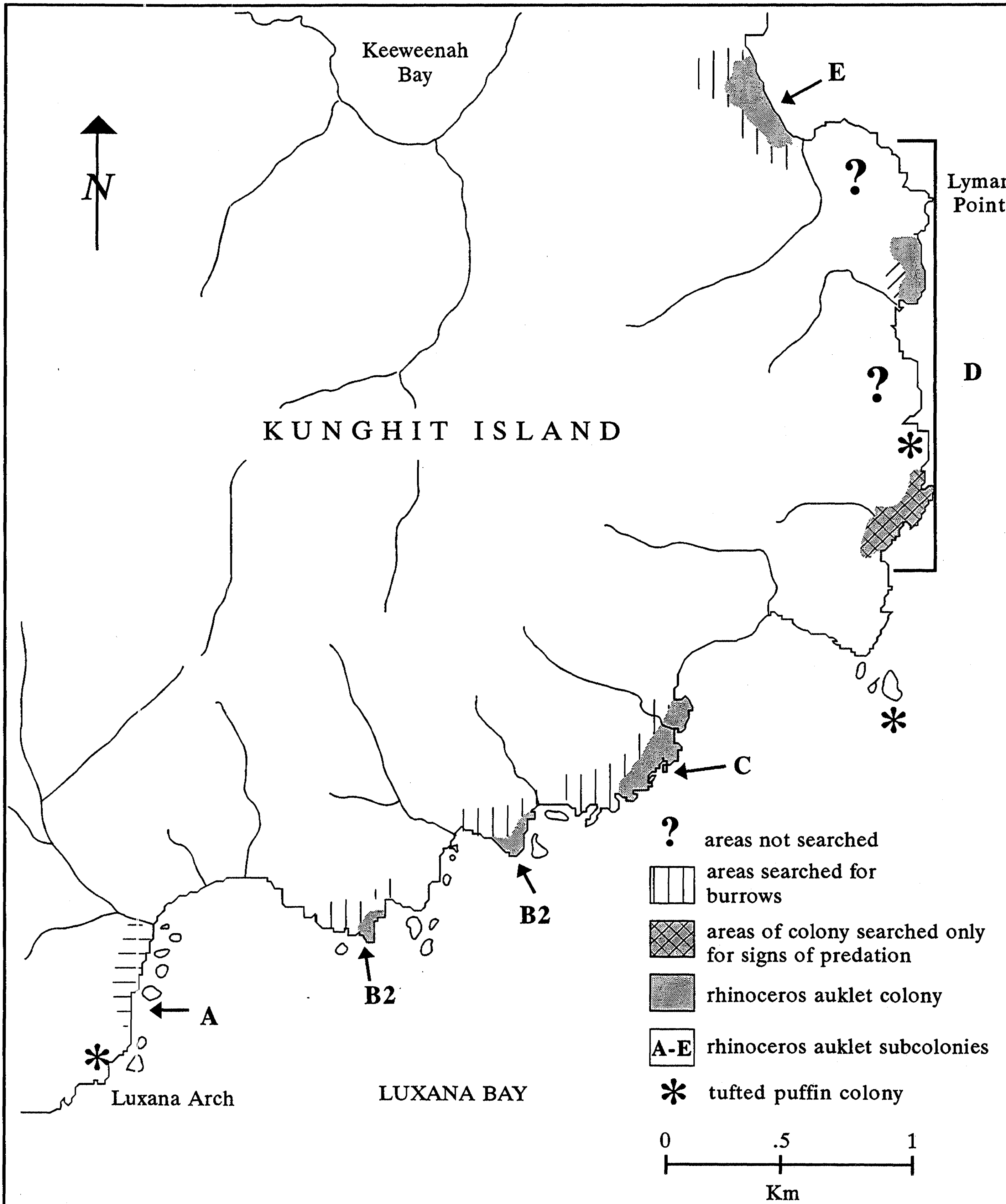

Figure 8. Rhinoceros auklet colony areas on Kunghit Island in 1993.

Table 8. Comparison of the results of rhinoceros auklet surveys conducted on Kunghit Island in 1986[a] and 1993[b].

Sub-colony[c]	Year	Total No. of Burrows
A	1986	3
	1993	0
B	1986	96
	1993	120
C	1986	1200
	1993	1337
D	1986	1742
	1003	nc[d]
E	1986	255
	1993	304

a From Rodway *et al.* 1988.

b This study.

c See Fig. 8 for locations.

d nc - not counted, estimated as 2000.

We found only two depredated eggshells in the rhinoceros auklet colony and neither had teeth marks of rats on them. If rats were present, they apparently did not remove and eat the birds' eggs. It is possible that rhinoceros auklet adults, which are approximately twice as heavy as ancient murrelet adults, are able to defend their eggs against rats. We found only very limited evidence of possible rat predation on the auklets themselves: two adult carcasses had the backs of their skulls chewed out, diagnostic of rat predation (R. Taylor, pers. comm.). We also found two adult and three chick carcasses without heads and eight adult heads without bodies. The removal of heads is characteristic of, but not diagnostic of, rat predation. However, many rhinoceros auklet carcasses on the colony were intact (one adult and eight chicks). Thus, the evidence visible on the surface of the colony suggests that rats have little impact on the rhinoceros auklets. However, it is possible that rats kill chicks in the burrows. The chicks are left unattended by their parents after about four days post-hatching and may be vulnerable until they are large enough to defend themselves. Because we were unable to access the nest chambers of most of the auklet burrows on Kunghit, it may have been difficult to detect such mortality if chicks were killed in the nest chamber.

Other than the two rat-chewed carcasses mentioned above, we did not find any signs of rat activity such as piles of faeces, dens or hoards of chewed spruce cones. This suggests that the density of rats was much lower in the rhinoceros auklet colony than in the ancient murrelet colony.

Most of the depredated rhinoceros auklets on Kunghit appeared to have been eaten by raptors. We found 103 feather piles, most of which were located at bald eagle plucking posts. Eight of the 12 raptor pellets containing auklet feathers were also found at the plucking posts. In addition, we found 13 sets of paired wings. In all cases the wings were attached to an intact sternum with no signs of rat tooth marks and were probably evidence of raptor predation. High levels of predation by bald eagles and peregrine falcons is common on alcid colonies throughout Haida Gwaii (eg. Rodway *et al.* 1988, Gaston 1992).

3.4.1.3. Cassin's Auklet Colony

While counting burrows in the northern portion of rhinoceros auklet sub-colony D (Fig. 8), we found four active Cassin's auklet burrows among 400 rhinoceros auklet burrows. We also found one dead Cassin's auklet adult in the area. The carcass was relatively intact with just the breast muscle torn away. We cannot extrapolate accurately to a breeding population total for this sub-colony. We did not see evidence of Cassin's auklet burrows in the other sub-colonies.

3.4.1.4. Tufted Puffin Colony

We observed tufted puffins on cliffs at the four locations reported in the 1986 survey: Luxana Arch, Lyman Islet, rhinoceros auklet sub-colony D and Bowles Point (Rodway *et al.* 1988). Puffins were seen entering and exiting burrows at the first three of those sites. No estimate of the breeding population of Kunghit Island is possible from this limited information.

3.4.2. Seabird Surveys on Surrounding Islands

3.4.2.1. High Island

Burrows on High Island were confined to a small area on the southwest side of the island. We found eight rhinoceros auklet burrows, six of which were active (Table 9). This total is similar to the six rhinoceros auklet burrows found in 1985 (Rodway *et al.* 1988). The earlier survey did not find any evidence of occupation; this may be because signs of occupancy for rhinoceros auklets are less obvious in early June, when those surveys were done, than in July, when we did our surveys.

3.4.2.2. Charles Island

Most of the 194 alcid burrows found were located along the vegetation edge of the two islands (Table 9). The majority were rhinoceros auklet burrows. We were unsure of the identity of about 10 - 20 burrows on the south island, because there is overlap in the size of burrow entrance between rhinoceros and Cassin's auklets. All of the alcid burrows checked for occupancy were rhinoceros auklet burrows, and so we included the unknown burrows in the total for rhinoceros auklets. There may, however, be a very small Cassin's auklet colony on Charles Island. We estimate that 90 pairs of rhinoceros auklets nest on the islands.

Our total for alcid burrows is almost identical to that reported for 1986 (Rodway *et al.* 1988). Rodway and co-workers counted 171 rhinoceros auklet burrows and 12 Cassin's auklet burrows. Their 1985 count was considerably lower but was conducted in only one half hour and was certainly less than complete. Our estimated breeding population is lower than that of Rodway and co-workers, but this is because of differences in the occupancy rate used in the calculations. We used the occupancy rate measured on Charles Island whereas Rodway *et al.* used the higher median occupancy rate for all colonies in British Columbia. We have no reason to believe that the breeding population of alcids on Charles Island has changed.

The largest concentration of storm petrel burrows were found at the east end of the north island (Table 9). The area of active petrel burrows extended into very thick salal across the island at that point. Our counts were higher than those in 1986 (50 and 33 burrows on the north and south islands, respectively) (Rodway *et al.* 1988), suggesting that the storm petrel colony has increased. An estimated 120 pairs of storm petrels nested on the islands in 1993.

Most of the active storm petrel burrows that were checked for occupancy contained chicks. This suggests, based on the nesting chronology of the two storm petrel species (Vermeer *et al.* 1988), that they were fork-tailed storm petrels. In addition, the only petrel vocalisations that we heard at night were those of fork-tailed storm petrels. One burrow contained a Leach's storm petrel incubating an egg. Thus, the colony supports a mixture of the two species, but the majority are fork-tailed storm petrels.

Table 9. Breeding seabird survey results for High, Charles and Gordon Islands, 1993.

		Cassin's Auklets	Rhinoceros Auklet	Storm Petrel spp.
High Island:				
	Total # burrows		8	
	Occupancy		6 of 8	
	Breeding population (prs)		6	
Charles Island (north):				
	Total # burrows		108	49
	Occupancy		6 of 10	5 of 7
	Breeding population (prs)		65	35
Charles Island (south):				
	Total # burrows		86	127
	Occupancy		4 of 13	17 of 25
	Breeding population (prs)		26	86
Gordon Island (north):				
	Total # burrows	59	44	1
	Occupancy	3 of 3	3 of 4	0
	Breeding population (prs)	59	33	0+[a]
Gordon Island (south):				
	Total # burrows	723[b]	113[b]	9
	Occupancy	26 of 36	5 of 6	1 of 1
	Breeding population (prs)	522	94	9

a A small number of storm petrels was probably nesting on an inaccessible stack.

b This total includes 250 Cassin's auklet burrows and 30 rhinoceros auklet burrows estimated on inaccessible areas of the colony.

3.4.2.3. Gordon Islands

We found 103 alcid burrows along the northern edge of north Gordon Island and counted 586 alcid burrows on south Gordon Island (Table 9). The latter count was not complete, however, because we considered one area unsafe to explore without safety equipment. The edges of this stack were covered with alcid burrows. Based on the number of burrows on a similar land form of similar area, an estimated 250 and 30 burrows of Cassin's and rhinoceros auklets, respectively, nested on that stack. Our final totals of 520 breeding pairs of Cassin's auklets and 94 pairs of breeding pairs of rhinoceros auklets should be used only as general estimates.

In a 1985 survey, Rodway *et al.* (1988) estimated 700 and 80 breeding pairs of Cassin's and rhinoceros auklets, respectively. That survey encountered the same problems of stack inaccessibility as we did and, thus, no conclusions about alcid population trends for the Gordon Islands should be made as a result of these two surveys.

Although we only found one unoccupied storm petrel burrow on the north island, we did find a storm petrel eggshell at the base of a nearby inaccessible stack which smelled strongly of storm petrel. Thus, there is probably a small storm petrel colony on the northern end of the north island. The 1985 survey did not note any nesting storm petrels, but the discrepancy in results does not indicate a change in populations.

3.4.3. Rat Activity

3.4.3.1. Kunghit Island

We trapped two rats at Heater Harbour and one at Rose Harbour; all three specimens were Norway rats. The most recent previous collection of rats from the island was done in 1946. The eight specimens collected at that time were all identified as black rats (*Rattus rattus*). Thus, at some time, probably in the 1950's - 1970's, Norway rats were introduced to Kunghit Island. Norway rats are larger than black rats and tend to out-compete them when the two species come in contact, eventually driving the smaller species to local extinction (Taylor 1975).

Such a displacement could have important implications for nesting seabirds. If, as suggested above, rhinoceros auklets have been able to defend themselves and their eggs against black rats, they may be less successful against the larger Norway rat. The absence of significant rat predation on the rhinoceros auklet colony may reflect the failure of Norway rats to have yet reached that section of the island rather than the invulnerability of the auklets to rats.

3.4.3.2. Surrounding Islands

We saw no evidence of rat activity and did not capture any rats on High, Charles or Gordon Islands. The crossing distances between Kunghit and these surrounding islands (300-950 m) seems to have precluded the dispersion of Norway rats to the smaller islands.

3.4.4. Associated Observations

A list of the birds and marine mammals observed during the course of our other activities appears in Appendix 5.

3.5. Conclusions

It seems evident that the introduced Norway rat is in the process of extirpating ancient murrelets from Kunghit Island. The Jenkins Point colony has almost completely disappeared and the boundaries of the Luxana Bay colony have contracted substantially since 1986. The signs of heavy rat predation on the Luxana Bay colony are essentially identical to those found at the Langara Island colony where the breeding population has declined approximately 40% in 5 years.

The fate of the rhinoceros auklets is less clear. We found few signs of rat activity in the rhinoceros auklet colony, but are unsure if less predation is occurring or if the evidence is less visible. A re-survey of the rhinoceros auklet colony in five years may provide more clues as to its ultimate fate.

Many of the breeding tufted puffins may survive due to the inaccessibility of their burrows.

Although rats have successfully been eradicated from small islands in New Zealand using the anti-coagulant brodifacoum, a similar program on Kunghit Island would be logistically complicated and prohibitively expensive. Kunghit is approximately four times as large as Langara Island where rat eradication using the New Zealand methodology will cost $1.3 million. Elimination of the rats on Kunghit would probably cost more than $5 million. Unless alternative control methods are found for Kunghit, I expect the gradual extirpation of the ancient murrelet and possibly rhinoceros auklet colonies.

Norway rats do not seem to have spread to the surrounding islands that support breeding seabirds. This is important because as breeding seabirds are displaced from Kunghit, nearby islands may act as refuges. It should be noted that Charles and Gordon Islands are covered with a very thick salal understorey and, thus, are probably unsuitable for nesting ancient murrelets. It will be interesting to see if the small ancient murrelet colony on Sgan Gwaii (Anthony Island) expands.

We do not know how Norway rats arrived at Kunghit Island. The route of introduction should be considered if rat eradication is considered for nearby St. James Island. Although it seems unlikely that Norway rats dispersed across the turbulent waters separating the two islands, if the Kunghit rats did swim across from St. James then the ultimate success of an eradication effort is questionable. An attempt should be made to determine whether the rats on St. James and Kunghit are from the same population or are the result of separate introductions.

4. GENERAL CONCLUSIONS

The devastating effects that introduced rats can have on a seabird colony and the difficulty in removing them once they have arrived on an island make it essential that steps be developed to insure that future introductions do not occur. Increasing boat traffic in Gwaii Haanas brings with it an increasing risk of damaging rat introductions and this risk should be considered in managing Gwaii Haanas. Similarly, barges, draggers and other work boats are a potential source of future introductions to seabird colonies throughout the archipelago. Steps should be taken to insure that boats working around seabird colonies are free of rats.

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Appendix 1. Ancient murrelet survey results for the main colony, Langara Island, 1993. Asterisk (*) indicates plots considered to be part of the active colony.

Transect	Plot[a]	No. Active Burrows	No. Inactive Burrows	No. Inaccessible Burrows	Depredated Eggshells[b]		FeatherPiles/ Carcasses[b,c]	
					old	new	old	new
1	40	-	4	-	-	-	-	-
	*80	-	2	-	-	2	-	rc
	*120	1	9	-	-	-	rc	2fp
	*160	-	8	-	-	-	rc	-
	200	-	1	-	-	-	rc	-
	240	-	1	-	-	-	-	-
	280	-	-	-	-	-	-	-
2	*40	2	2	1	-	-	-	-
	*80	2	2	1	-	-	-	rp
	*120	-	1	-	-	-	-	fp
	*160	2	3	1	5	-	-	fp
	*200	1	1	-	-	-	-	-
	240	-	-	-	-	-	-	-
	280	-	-	-	-	-	-	-
3	40	-	-	-	-	-	-	-
	80	-	-	-	-	-	-	-
	*120	1	2	-	2	-	-	rp
	*160	1	-	-	1	1	-	-
	*200	-	-	-	-	-	-	-
	*240	3	2	-	-	-	-	-
4	40	-	-	-	-	-	-	-
	80	-	-	-	-	-	-	-
	120	-	3	-	-	-	b	-
	*160	4	4	-	-	1	-	rc
	*200	3	3	-	-	-	-	-
	240	-	-	-	-	-	-	-
9	40	-	-	-	-	-	-	-
	80	-	2	-	-	-	-	-
	*120	1	2	3	-	-	-	-
	160	-	2	-	-	1	-	-
	200	-	3	-	-	-	-	-
	240	-	-	-	-	-	-	-
	280	-	-	-	-	-	-	-
10	40	-	-	-	-	-	-	-
	80	-	2	1	-	-	-	-
	120	-	-	-	-	-	-	-
	160	-	-	-	-	-	-	-
A	40	-	2	-	-	-	-	-
	80	-	-	1	-	-	-	-
	120	-	-	1	-	-	-	-
	160	-	-	-	-	-	-	-

Appendix 1 (cont.).

Transect	Plot[a]	No. Active Burrows	No. Inactive Burrows	No. Inaccessible Burrows	Depredated Eggshells[b]		FeatherPiles/ Carasses[b,c]	
					old	new	old	new
B	*40	-	-	-	-	-	-	-
	*80	1	7	2	2	-	-	-
	*120	-	3	-	-	-	-	-
	*160	1	4	-	-	-	-	-
	*200	2	5	1	-	-	-	-
	240	-	2	-	-	-	-	-
	280	-	-	-	-	-	-	-
C	40	-	-	-	-	-	-	-
	80	-	3	-	-	-	-	-
	*120	1	3	-	1	-	rc	-
	*160	2	4	1	-	-	-	-
	200	-	-	-	-	-	-	-
D	40	-	2	1	-	-	-	-
	*80	1	5	1	-	1	-	-
	120	-	2	-	-	-	-	-
	160	-	3	-	-	-	-	-
	200	-	-	-	-	-	-	-
E	40	-	1	-	-	-	b,rp	fp
	*80	-	3	1	-	-	-	-
	*120	-	1	1	-	-	-	-
	*160	-	3	2	-	3	-	4rp
	*200	1	3	-	-	-	-	-
	240	-	-	1	-	-	-	fp
	280	-	-	-	-	-	-	-
F	*40	1	3	-	-	-	-	-
	*80	-	-	-	-	1	-	-
	*120	2	4	-	-	-	-	-
	160	-	1	-	1	-	-	-
	200	-	-	-	-	-	-	-
G	40	-	-	-	-	-	-	-
	*80	3	2	1	-	1	-	fp
	*120	3	3	1	-	-	-	-
	160	-	-	-	-	-	-	-
H	40	-	1	-	-	-	-	-
	*80	2	1	-	2	-	-	-
	*120	-	1	-	2	-	-	-
	*160	-	-	-	-	-	-	-
	200	-	4	-	-	-	rc	-
	240	-	1	-	-	-	-	-
I	40	-	2	-	-	-	-	-
	*80	1	-	1	-	-	-	-
	*120	-	4	-	-	-	-	-
	*160	1	2	-	-	-	-	-
	200	-	-	-	-	-	-	fp
	240	-	-	-	-	-	-	-

Appendix 1 (cont.).

Transect	Plot[a]	No. Active Burrows	No. Inactive Burrows	No. Inaccessible Burrows	Depredated Eggshells[b]		FeatherPiles/ Carasses[b,c]	
					old	new	old	new
J	40	-	-	-	-	-	-	-
	80	-	1	-	-	-	b	-
	120	-	-	-	-	-	-	-
	160	-	3	-	-	-	rc	-
	200	-	-	-	-	-	-	-
	240	-	-	-	-	-	-	-
K	40	-	1	-	-	-	-	-
	80	-	1	-	-	-	-	-
	120	-	1	-	-	-	-	-
	*160	1	1	-	-	-	-	2rp
	*200	2	2	3	2	-	-	fp
	*240	3	2	1	-	-	-	-
	280	-	3	-	-	-	-	-
	320	-	-	-	-	-	-	-
M	40	-	-	-	-	-	rp	-
	80	-	-	-	-	-	-	-
	120	-	-	1	-	-	-	fp
	160	-	3	-	-	-	-	-
	200	-	4	1	-	-	-	-
	240	-	1	-	1	-	b	-
	280	-	1	-	1	-	-	-
	320	-	-	-	-	-	-	-
N	*40	-	-	-	-	-	-	2fp
	*80	-	2	-	2	4	-	-
	*120	-	2	-	-	-	-	-
	*160	-	-	-	-	1	-	rp
	*200	5	3	-	-	-	-	-
	240	-	1	-	-	-	-	-
	280	-	-	-	-	-	-	-
	320	-	-	-	-	-	-	-
O	40	-	-	-	-	-	-	-
	80	-	5	-	-	-	-	fp
	120	-	-	-	-	-	-	fp
	160	-	-	-	-	-	-	-
	200	-	-	-	-	-	-	-
	*240	3	6	-	-	-	-	rc,2fp
	*280	2	3	2	-	-	-	fp
	320	-	2	-	-	-	-	-
	360	-	-	-	-	-	-	-
P	*40	4	7	3	1	2	rp	-
	*80	1	2	1	4	2	-	-
	*120	3	4	3	1	2	-	-
	*160	-	-	1	-	3	-	4fp
	*200	1	4	-	-	-	-	-
	240	-	-	-	-	-	-	-

Appendix 1 (cont.).

Transect	Plot[a]	No. Active Burrows	No. Inactive Burrows	No. Inaccessible Burrows	Depredated Eggshells[b]		FeatherPiles/ Carasses[b,c]	
					old	new	old	new
Q	40	-	2	1	-	1	-	-
	80	-	2	1	-	-	-	fp
	120	-	1	-	-	-	-	-
	*160	1	3	1	-	1	-	-
	200	-	-	-	-	-	-	-
	240	-	2	-	-	-	-	-
	280	-	-	-	-	-	-	-
R	*40	1	2	1	1	-	b	-
	*80	1	1	-	1	-	b	-
	*120	1	3	2	2	-	rc,b	2fp
	*160	3	-	-	1	1	-	2fp
	*200	2	-	3	-	-	-	-
	240	-	-	-	-	-	-	-
	280	-	-	-	-	-	-	-

a Plot designations indicate distance from shore (m) along transect.
b 'new' = from 1993 breeding season, 'old' = from pre-1993 breeding season.
c 'fp' = feather pile; 'b' = bones; 'rp' = raptor pellet; 'rc' = rat-chewed carcass/bones.

Appendix 2. Numbers of depredated eggshells, feather piles, raptor pellets, and carcasses found along transects[a] during ancient murrelet surveys on the main colony, Langara Island, 1993.

Transect	Depredated Eggshells[b]		Feather Piles	Raptor Pellets	Carcasses/Bones[b,c]	
	old	new			old	new
1	5	4	14	0	3 rc	rc
2	12	4	12	1	0	0
3	26	3	9	2	0	0
4	3	4	8	1	b	rc
9	6	0	1	1	0	0
10	0	0	1	0	0	0
A	0	0	1	0	0	0
B	22	6	5	0	0	5 fp
C	20	1	8	0	b,rc	0
D	3	2	1	0	0	0
E	4	7	7	5	3 b	0
F	3	2	6	0	rc	0
G	11	4	7	0	0	0
H	10	1	2	0	b,rc	0
I	11	2	4	1	0	0
J	1	0	5	1	2 b,rc	0
K	15	9	31	7	3 b,rc	b
L	6	5	15	2	12 b, 3 rc	0
M	11	3	4	1	b	0
N	4	17	15	11	0	0
O	19	2	16	0	b,rc	rc
P	78	31	14	0	4 rc	0
Q	2	6	34	0	b	a
R	23	32	32	2	3 b,rc	0

[a] A swath of approximately 5 m along each transect was checked for signs of predation.
[b] 'new' = from 1993 breeding season; 'old' = from pre-1993 breeding season.
[c] 'b' = bones; 'rc' = rat-chewed carcass; 'a' = dead adult, cause of death unknown.

Appendix 3. Ancient murrelet survey results, Luxana Bay, Kunghit Island, 1993. Asterisk (*) indicates plots considered to be part of the active colony.

Transect	Plot[a]	No. Active Burrows	No. Inactive Burrows	No. Inaccessible Burrows	Depredated Eggshells[b]		Feather Piles/ Carcasses[b,c]	
					old	new	old	new
1	40	-	-	-	-	-	-	-
	80	-	2	-	-	-	-	-
	120	-	1	-	-	-	-	-
	160	-	-	-	-	-	-	-
	200	-	-	-	-	-	-	-
	240	-	-	-	-	-	-	-
2	40	-	-	-	-	-	-	-
	*80	2	-	2	-	1	-	-
	*120	-	1	1	-	-	-	-
	160	-	-	-	-	-	-	-
3	*40	2	3	3	-	1	-	-
	*80	-	-	-	-	1	-	b
	*120	1	-	-	-	-	-	fp
	160	-	-	-	-	-	-	-
	180	-	-	-	-	-	-	-
4	*40	-	1	-	-	-	-	-
	*80	3	3	-	-	-	-	-
	*120	2	2	-	-	4	-	-
	*160	2	-	-	1	4	-	-
	200	-	-	-	-	-	-	-
5	40	-	-	-	-	-	-	-
	80	-	-	-	-	-	-	-
	120	-	-	-	-	-	-	-
	160	-	-	-	-	-	-	-
	*200	1	1	-	-	-	-	-
	*240	1	-	-	-	-	-	fp
	280	-	-	-	-	-	-	-
6	40	-	-	-	-	-	-	-
	*80	1	1	-	-	2	-	rp
	*120	1	1	2	-	-	-	-
	160	-	-	-	-	-	-	-
	200	-	1	-	-	-	-	-
	240	-	-	1	-	-	-	-
	280	-	-	-	-	-	-	-
7	40	-	-	-	-	-	-	-
	80	-	2	3	-	-	b,rc	-
	*120	-	1	1	1	-	-	-
	160	-	-	-	-	-	-	-
	200	-	2	1	-	-	-	-
8	40	-	-	-	-	-	-	-
	80	-	-	-	-	-	-	-
	120	-	-	-	-	-	-	-
	160	-	-	-	-	-	-	-
	200	-	-	-	-	-	-	-

[a] Plot designations indicate distance from shore (m) along transect.
[b] 'new' = from 1993 breeding season; 'old' = from pre-1993 breeding season.
[c] 'fp' = feather pile; 'b' = bones; 'rp' = raptor pellet; 'rc' = rat-chewed carcass.

Appendix 4. Casual bird and mammal observations, Langara Island, May-June, 1993.

The following list includes observations of species made incidentally to our study. It includes any evidence collected of successful nesting by forest birds. Also included are numbers of marbled murrelets and other species counted during two boat trips that we made around Langara on 18 May and 12 June (Fig. 9) in a 16' inflatable boat.

BIRDS:

RTLO: 3 pairs seen on larger lakes in interior of island; courtship displays seen on 1 lake (12 May). Observed at sea (see Fig. 5).
PALO: Observed at sea (see Fig. 5).
COLO: 1 heard (13 May). Observed at sea (see Fig. 5).
RNGR: 1 seen off McPherson Pt. (13 May).
SOSH: Approximately 1500 seen off Lord Bight (3 June); possibly mixed with Short-tailed Shearwaters (*Puffinus tenuirostris*).
FTSP: Heard once in mid-May and sporadically through June.
LESP: Heard once in mid-May and sporadically through June.
PECO: Commonly seen flying by; 20-50 observed on rocks at Langara Pt. (see also Fig. 5).
GWFG: Several flocks flew over island in mid-late May.
CAGO: 5 flew over island (3 June).
MALL: 1 seen flying over McPherson Pt. (28 May).
CITE: 1 seen on large bog on northern end of island (22-23 June).
HADU: 1 male and 3 females seen on Langara Rocks; 3 males and 1 female seen at Hazardous Cove (3 June).
WWSC: Seen occasionally on the water in May (see also Fig. 5).
COME: Occasionally heard/seen flying over.
BAEA: Very common with many nests around periphery of island.
SSHA: 1 seen early May.
RTHA: 1 seen in large bog on north side of island (11 June).
PEFA: Commonly seen/heard; 8 active eyries produced 21 chicks (W. Nelson, pers. comm.).
BLGR: Commonly heard drumming; 2 females observed giving distraction displays in 2 different bogs; 1 chick approximately 1 week old seen (11 June).
SACR: Tracks seen in bogs on northern end of island throughout May-June; nest on northern bog near lightstation (G. Schweers, pers. comm.).
BLOY: Heard sporadically; 2 seen on Langara Rocks (3 May); 4 seen along Fury Bay (12 June).
WATA: 1 seen at McPherson Pt. (12-13 May).
SPSA: Several seen near McPherson Pt. (13-20 May).
COSN: 1 seen at head of creek near small lake (15 May).
GWGU: Commonly seen; 50 seen on and around Langara Pt. (18 May) (see also Fig. 5).

Appendix 4 (cont'd)

PIGU: Commonly seen on water and on rocks; concentrations at NE corner of island (up to 55 birds), at Langara Rocks (up to 24), near Cox I. (up to 65) and in Henslung Cove (up to 32) (see also Fig. 5).

MAMU: Keer calls heard most mornings and evenings 28 May - 4 June; also heard 16 and 18 June. Observed 11 (18 May) and 16 (12 June) feeding in Pillar Bay (see also Fig. 5).

ANMU: Raft off the colony most evenings during breeding season; concentration (approximately 200 birds) also seen at Lord Bight (3 June) (see also Fig. 5).

RHAU: More than 1000 birds seen between McPherson Pt. and Masset Inlet (28 June); 75 observed at Langara Pt (18 May) (see also Fig. 5).

TUPU: 3-5 consistently observed around Cox Island; 10 seen at Langara Pt. (18 May) and 10 seen near Lord Bight (3 June) (see Fig. 5).

NSWO: 1 heard calling near camp (6-7 May).

BEKI: 1 seen at Henslung Cove (21 June).

RUHU: Occasionally seen in meadows, hemlock and cedar forests.

RBSA: 1 seen at Dibrell Bay (early June).

HAWO: Commonly seen/heard; nest with young found (2 June).

PSFL: Commonly seen/heard; dead fledgling found (24 May).

TRSW: 2 heard near large northern bog (10 May); 2 seen flying south of McPherson Pt. (15 May).

BASW: 1 seen in northern bog (25 May).

NOCR: Commonly seen/heard; young seen/heard in June.

CORA: Commonly seen/heard; active nest found at Dibrell Bay (19 May); nest near McPherson Pt. fledged 3 young (1 June).

CBCH: Commonly seen/heard; at 2 locations, adults seen feeding young (mid-late May).

RBNU: 1 heard near McPherson Pt. (15 May).

BRCR: Commonly seen/heard; first seen 22 May.

WIWR: Commonly seen/heard; adults seen feeding young (16 June).

GCKI: Commonly seen/heard; adults seen feeding young (15 June).

RCKI: 1 seen near McPherson Pt. (20 May).

SWTH: Commonly seen/heard; first noted 21 May; adults seen feeding 2 fledglings (10 June).

HETH: Commonly seen/heard.

VATH: Commonly seen/heard; adults seen feeding young (13 June).

AMPI: 1 seen in bog at north end of island (24 May).

OCWA: Commonly seen/heard; fledglings seen (20 June).

TOWA: Commonly seen/heard; adults seen feeding young (16 June).

WIWA: Uncommon; first noted 13 May.

SASP: 1 seen near McPherson Pt. (13 May); 1 seen near large bog (17 May).

FOSP: At least 11 pairs seen/heard, primarily along north end of island; fledglings seen (20 June).

SOSP: At least 4 pairs observed along beaches; adults seen carrying food near McPherson Pt. (23 May).

Appendix 4 (cont'd)

GCSP: 13 seen/heard for several days in mid May.
WCSP: 1 seen near McPherson Pt. (13 May).
DEJU: Several pairs observed defending territories in bogs.
RECR: Flocks commonly seen/heard in cedar forest.
PISI: Large flocks occasionally seen feeding in tall spruce trees.

MAMMALS:

EUJU: Up to 75 observed on or near Langara Rocks 9 - 22 May; less than 20 seen after 22 May. 1-10 individuals frequently observed swimming by McPherson Pt. throughout May-June.
PHDA: 3-4 seen off Cohoe Pt. (12 June).
LAOB: Large schools observed off McPherson Pt.: 1000 (7 May), 100 (27 May), 200 (16 June).
OROR: Observed on 3 occasions: 6 (1 male, 2-3 females, 2-3 young) swam by Langara Rocks (18 May); 5 (1 male, 4 females?) swam by Langara Rocks (24 May); 2 seen in Lord Bight (3 June).
MENO: 10 seen about 2 km off shore along west side of island (3 June); 2 (1 adult and 1 young) seen off McPherson Pt. (5,15,16 June); 4 seen off McPherson Pt. (13 June).
LUCA: Commonly seen in the water; occasionally seen on island.
ODLE: Deer sign and paths seen all over island; commonly seen in meadow south of McPherson Pt.
SOMO: Trapped in several habitats (see Table 3); frequently seen in meadows and on beaches.

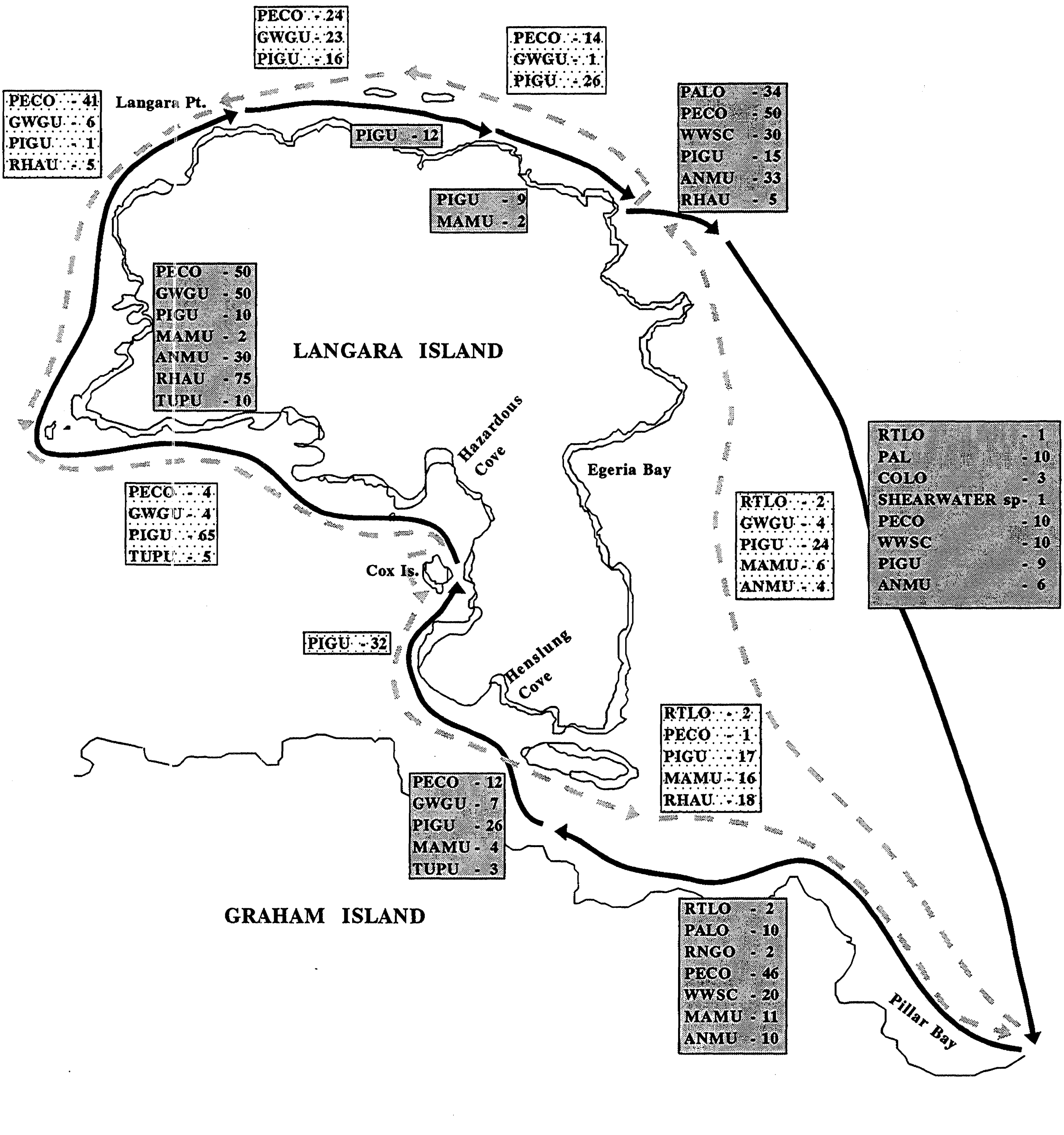

Fig. 9. Seabirds observed during boat surveys around Langara Island on May 19 (⟶ ; shaded boxes) and June 12 (- - ⇢ ; dotted boxes), 1993. Limits of survey zones are denoted by arrow lengths. Specific locations of large concentration of birds are noted in Appendix 3.

Appendix 5. Casual bird and mammal observations, Kunghit and surrounding islands, July-August, 1993.

KUNGHIT ISLAND (HEATER HARBOUR CAMP): 8 July - 13 August

COLO: 1 seen 14 July and 11 August
CAGO: 1 flew over on 10 August
GWTE: 4 seen 11 August
WWSC: 1 seen 13 July
COME: Maximum of 4 females with 16 chicks observed throughout period
BAEA: Maximum of 3 adults and 1 immature observed throughout period; active nest on north side of harbour
SSHA: 2 seen on 12 August
SACR 1 flew over on 11 August
SEPL: 1 seen sporadically throughout July
GRYE: 1 seen occasionally in July and August
LEYE: 1 seen 11 August
SPSA: 1 seen 10 August
LESA: 5 seen 9 August; 17 seen 11 August
GWGU: Maximum of 10 observed throughout period
COMU: 1 seen 10 August
PIGU: Maximum of 5 observed throughout period
MAMU: Maximum of 69 adults + 4 juvs. observed throughout period; 2 flew out of valley in evening keer calling on 31 July; 2 flew very low over campsite in morning of 10 August
CAAU: Juveniles occasionally observed in late July and August
RHAU: Maximum of 250 observed throughout period
TUPU: 2 seen 10 August
RUHU: 1 female observed almost daily throughout period
BEKI: 1-2 frequently observed throughout period
RBSA: 1 heard/seen sporadically throughout period; 1 juv. seen 13 August
HAWO: 1 heard 11-14 July
PSFL Maximum of 6 heard/seen throughout period
NOCR: Maximum of 15 seen/heard throughout period
CORA: Maximum of 6 observed throughout period
CBCH: Maximum of 10 heard/seen throughout period
RBNU: 1 heard sporadically in July
BRCR: 1 heard/seen sporadically throughout period
WIWR: Maximum of 6 heard/seen throughout period
GCKI: Maximum of 10 heard/seen throughout period
HETH: Maximum of 10 heard/seen throughout period; nest fledged 4 chicks
VATH: Maximum of 10 heard/seen throughout period
TOWA: Maximum of 6 + 2 fledglings seen/heard throughout July
WIWA: 1 heard 22 July

Appendix 5 (cont'd).

SOSP:	Maximum of 2 + 1 juvenile seen/heard in late July
DEJU:	1 observed 9 August
RECR:	Maximum of 25 seen/heard throughout period
PHVT:	Up to 3 seen daily

LUCA - den

ODLE: sign

KUNGHIT ISLAND (BOWLES POINT AND BAY): 5 August

BAEA - 2	GWGU - 50	RHAU - 200
SEPL - 3	PIGU - 20	TUPU - 2
BLOY - 1	MAMU - 1 + 2 juvs.	WIWR - 2
LESA - 8	CAAU - 40 juvs.	

KUNGHIT ISLAND (WOODRUFF BAY): 12 August

SUSC - 2	WESA - 3	TUPU - 4
WWSC - 8	LESA - 8	CORA - 2
BAEA - 2	BASA - 1	WIWR - 2
PEFA - 3	MAMU - 1	SOSP - 2 + 2 juvs.
SPSA - 2	RHAU - 30	RECR - 8

KUNGHIT ISLAND (RHAU SUB-COLONIES A + B): 17 July

BAEA - 16	PSFL - 1 + 2 fldgs.	CORA - 1
PEFA - 1	NOCR - 3	SOSP - 2

OROR - 4 (1 male, 1 young, 2 females?)
ODLE - sign

KUNGHIT ISLAND (RHAU SUB-COLONY C): 19 and 24 July

SOSH - 1	RHAU - 20	GCKI - 6
shearwater sp. - 100		SWTH - 1
PECO - 10	RUHU - 2	HETH - 3 + 3 juvs.
BAEA - 4 + nest w/ 1 chick	HAWO - 2 + 3 juvs.	TOWA - 1
	PSFL - 5	WIWA - 1
PEFA - 5	NOCR - 2	SOSP - 1
GWGU - 45	CBCH - 12	RECR - 6
PIGU - 15	WIWR - 14	

Appendix 5 (cont'd).

ODLE - sign

KUNGHIT ISLAND (RHAU SUB-COLONY D): 10 August

shearwater sp. - 20	TUPU - 28	PECO - 15
BLOY - 2	BEKI - 1	BLSC - 3
GWGU - 30	NOFL - 1	WWSC - 4
COMU - 2	HAWO - 1	BAEA - 6
PIGU - 45	CORA - 2	RTHA - 1 juv.
CAAU - 20 juvs.	HETH - 2	PEFA - 1
RHAU - 100	WIWR - 6	SOSP - 2
PHDA - 2	SOMO - 1	ODLE - sign

KUNGHIT ISLAND (RHAU SUB-COLONY E): 18 July

PIGU - 4	RBSA - 1 + 1 juv.	HETH - 2
MAMU - 2 + 2 juvs.	PSFL - 3 fldgs.	TOWA - 6
ANMU - 1	CBCH - 4	SOSP - 2

ODLE - sign

BOAT TRIP - HEATER HARBOUR to LUXANA BAY:

17-19, 24 July (maximum counts)	25-28 July (maximum counts)
SOSH - 5	PECO - 30
PECO - 40 + 6 nests at arch	BAEA - 16
BAEA - 10	PEFA - 1 male, 1 female
BLOY - 3	BLOY - 2
GWGU - 80	RNPH - 2
COMU - 5	CAGU - 1
PIGU - 65	GWGU - 60
MAMU - 30	COMU - 3
ANMU - 1	TBMU - 1
CAAU - 2 juvs.	PIGU - 40
RHAU - 300	MAMU - 19 + 1 juv.
PHVT - 2	ANMU - 1
	CAAU - 4 juv.
	RHAU - 500
	TUPU - 100

Appendix 5 (cont'd).

HIGH ISLAND: 11 July

PECO - 3	TUPU - 1	GCKI - 8 juvs.
COME - 1	RUHU - 2	HETH - 5
BAEA - 1 imm.	RBSA - 1 + 2 juvs.	VATH - 2
BLOY - 5	HAWO - 1	TOWA - 5
GWGU - 11	PSFL - 3	FOSP - 3
PIGU - 32	NOCR - 32	SOSP - 5
MAMU - 14	CBCH - 12	RECR - 14
RHAU - 150	WIWR - 7 + 1 juv.	

LUCA - den　　ODLE - sign

BOAT TRIP - HEATER HARBOUR to HIGH ISLAND:

11 July	29 July	9 August	13 August
PECO - 3	BAEA - 2	BAEA - 2	RNGR - 1
COME - 4	HEGU - 1	SEPL - 3	PECO - 8
BAEA - 2 imm.	GWGU - 20	BASA - 2	BAEA - 1
BLOY - 3	COMU - 1	GWGU - 10	GWGU - 20
GRYE - 1	PIGU - 10	PIGU - 10	PIGU - 10
GWGU - 10	MAMU - 5	CAAU - 2	MAMU - 2
PIGU - 20	RHAU - 170	RHAU - 100	RHAU - 350
MAMU - 35	TUPU - 1	TUPU - 1	TUPU - 8
RHAU - 220	NOCR - 25	BEKI - 1	CORA - 2
TUPU - 1	CORA - 2	EUJU - 1	

CHARLES ISLAND: 14-15 July

PECO - 2	PIGU - 25	CORA - 2
HADU - 3	MAMU - 5 + 1 juv.	TOWA - family
BAEA - 20	RHAU - 500	FOSP - 1
BLOY - 4	TUPU - 1	SOSP - 4 + 1 nest w/ 3 eggs
GWGU - 45	alcid sp. - 700	
COMU - 5	RUHU - 1	

LUCA - den　　ODLE - sign

Appendix 5 (cont'd).

GORDON ISLANDS: 1-8 August

loon sp. - 3	COMU - 5	CORA - 3
PECO - 15	PIGU - 25	CBCH - 8
WWSC - 2	MAMU - 2	SWTH - 2 + 1 juv.
BAEA - 40	CAAU - 45 juvs.	HETH - 1
PEFA - 3	RHAU - 500	OCWA - 1
GBHE - 2	TUPU - 3	FOSP - 7 + 3 juv.
BLOY - 2	BEKI - 3	SOSP - 9 + 3 juv.
GRYE - 1	RUHU - 2	RECR - 4
WESA - 4	NOFL - 1	HEGU - 1
PSFL - 2 + 1 juv.	GWGU - 120	NOCR - 45
EUJU - 1	PHDA - 1	BAAC - 1
PHVT - 1	ODLE - sign	

BOAT TRIP - HOUSTON STEWART CHANNEL:

23/24 July	1 August	8 August
HADU - 8	PECO - 10	PECO - 25
BAEA - 2	BAEA - 4	GWTE - 6
BLOY - 2	BLOY - 2	HADU - 2
CAGU - 10	WESA - 1	BAEA - 4
HEGU - 1	MEGU - 1 juv.	BLOY - 6
GWGU - 60	CAGU - 8	CAGU - 10
BLKI - 35	GWGU - 100	HEGU - 2
PIGU - 35	COMU - 2	GWGU - 100
MAMU - 30	PIGU - 30	COMU - 1
CAAU - 3 juvs.	MAMU - 10	PIGU - 20
RHAU - 75	CAAU - 7 juvs.	MAMU - 10
CORA - 2	RHAU - 800	CAAU - 2 juvs.
	BEKI - 1	RHAU - 800
		TUPU - 2
		BEKI - 4
		NOCR - 30

BOAT TRIP - GORDON IS. to SGAN GWAII to ADAM ROCKS to LOUSCOONE PT. to SMALL COVE to FANNY PT. to FLATROCK I.: 7 August

PECO - 275 (200 at Adam Rk.)		CAAU - 60 juvs.
HADU - 5	HEGU - 2	RHAU - 450
WWSC - 1	GWGU - 300	TUPU - 9
BAEA - 10	COMU - 2	HOPU - 1
BLOY - 2	PIGU - 40	BEKI - 2
SPSA - 1 + 4 juvs.	MAMU - 22 + 2 juvs.	

Appendix 6. Index to species names and acronyms used in this report.

BIRDS:

Red-throated Loon	*Gavia stellata*	RTLO
Pacific Loon	*G. pacifica*	PALO
Common Loon	*G. immer*	COLO
Red-necked Grebe	*Podiceps grisegena*	RNGR
Sooty Shearwater	*Puffinus griseus*	SOSH
Fork-tailed Storm Petrel	*Oceanodroma furcata*	FTSP
Leach's Storm Petrel	*O. leucorhoa*	LESP
Pelagic Cormorant	*Phalacrocorax pelagicus*	PECO
Great Blue Heron	*Ardea herodias*	GBHE
Greater White-fronted Goose	*Anser albifrons*	GWFG
Canada Goose	*Branta canadensis*	CAGO
Green-winged Teal	*Anas crecca*	GWTE
Mallard	*A. platyrhynchos*	MALL
Cinnamon Teal	*A. cyanoptera*	CITE
Harlequin Duck	*Histrionicus histrionicus*	HADU
Black Scoter	*Melanitta nigra*	BLSC
Surf Scoter	*M. perspicillata*	SUSC
White-winged Scoter	*M. fusca*	WWSC
Common Merganser	*Mergus merganser*	COME
Bald Eagle	*Haliaeetus leucocephalus*	BAEA
Sharp-shinned Hawk	*Accipiter striatus*	SSHA
Red-tailed Hawk	*Buteo jamaicensis*	RTHA
Peregrine Falcon	*Falco peregrinus*	PEFA
Blue Grouse	*Dendragapus obscurus*	BLGR
Sandhill Crane	*Grus canadensis*	SACR
Semipalmated Plover	*Charadrius semipalmatus*	SEPL
Black Oystercatcher	*Haematopus bachmani*	BLOY
Greater Yellowlegs	*Tringa melanoleuca*	GRYE
Lesser Yellowlegs	*T. flavipes*	LEYE
Wandering Tattler	*Heteroscelus incanus*	WATA
Spotted Sandpiper	*Actitis macularia*	SPSA
Western Sandpiper	*Calidris mauri*	WESA
Least Sandpiper	*C. minutilla*	LESA
Baird's Sandpiper	*C. bairdii*	BASA
Common Snipe	*Gallinago gallinago*	COSN
Red-necked Phalarope	*Phalaropus lobatus*	RNPH
Mew Gull	*Larus canus*	MEGU
California Gull	*L. californicus*	CAGU
Herring Gull	*L. argentatus*	HEGU
Glaucous-winged Gull	*L. glaucescens*	GWGU

Appendix 6 (cont'd).

Common Murre	*Uria aalge*	COMU
Thick-billed Murre	*U. lomvia*	TBMU
Pigeon Guillemot	*Cepphus columba*	PIGU
Marbled Murrelet	*Brachyramphus marmoratus*	MAMU
Ancient Murrelet	*Synthliboramphus antiquus*	ANMU
Cassin's Auklet	*Ptychoramphus aleuticus*	CAAU
Rhinoceros Auklet	*Cerorhinca monocerata*	RHAU
Tufted Puffin	*Fratercula cirrhata*	TUPU
Horned Puffin	*F. corniculata*	HOPU
Northern Saw-whet Owl	*Aegolius acadicus*	NSWO
Belted Kingfisher	*Ceryle alcyon*	BEKI
Rufous Hummingbird	*Selasphorus rufus*	RUHU
Red-breasted Sapsucker	*Sphyrapicus ruber*	RBSA
Hairy Woodpecker	*Picoides villosus*	HAWO
Northern Flicker	*Colaptes auratus*	NOFL
Pacific-slope Flycatcher	*Empidonax difficilis*	PSFL
Tree Swallow	*Tachycineta bicolor*	TRSW
Barn Swallow	*Hirundo rustica*	BASW
Northwestern Crow	*Corvus caurinus*	NOCR
Common Raven	*C. corax*	CORA
Chestnut-backed Chickadee	*Parus rufescens*	CBCH
Red-breasted Nuthatch	*Sitta canadensis*	RBNU
Brown Creeper	*Certhia americana*	BRCR
Winter Wren	*Troglodytes troglodytes*	WIWR
Golden-crowned Kinglet	*Regulus satrapa*	GCKI
Ruby-crowned Kinglet	*R. calendula*	RCKI
Swainson's Thrush	*Catharus ustulatus*	SWTH
Hermit Thrush	*C. guttatus*	HETH
Varied Thrush	*Ixoreus naevius*	VATH
American Pipit	*Anthus rubescens*	AMPI
Orange-crowned Warbler	*Vermivora celata*	OCWA
Townsend's Warbler	*Dendroica townsendi*	TOWA
Wilson's Warbler	*Wilsonia pusilla*	WIWA
Savannah Sparrow	*Passerculus sandwichensis*	SASP
Fox Sparrow	*Passerella iliaca*	FOSP
Song Sparrow	*Melospiza melodia*	SOSP
Golden-crowned Sparrow	*Zonotrichia atricapilla*	GCSP
White-crowned Sparrow	*Z. leucophrys*	WCSP
Dark-eyed Junco	*Junco hyemalis*	DEJU
Red Crossbill	*Loxia curvirostra*	RECR
Pine Siskin	*Carduelis pinus*	PISI

Appendix 6 (cont'd).

MAMMALS:

Harbour Seal	*Phoca vitulina*	PHVT
Northern Sea Lion	*Eumetopias jubatus*	EUJU
Dall's Porpoise	*Phocoenoides dalli*	PHDA
Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	LAOB
Orca	*Orcinus orca*	OROR
Minke Whale	*Balaenoptera acutorostrata*	BAAC
Humpback Whale	*Megaptera novaeangliae*	MENO
River Otter	*Lutra canadensis*	LUCA
Sitka Deer	*Odocoileus lemionus*	ODLE
Dusky Shrew	*Sorex monticolus*	SOMO