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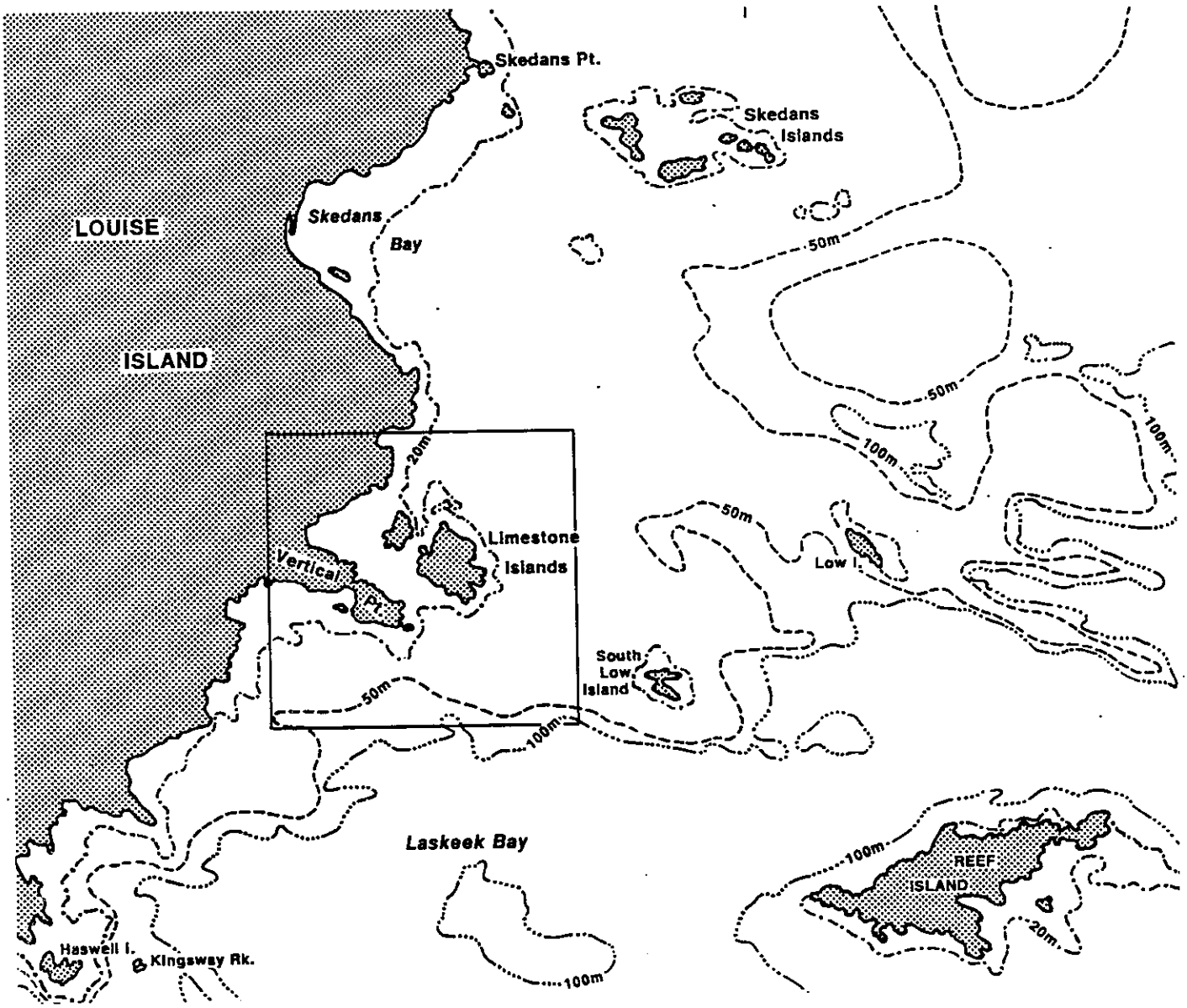
LASKEEK BAY CONSERVATION SOCIETY

REPORT ON SCIENTIFIC ACTIVITIES #3

1992

A. J. GASTON and A. LAWRENCE



January 1993

LASKEEK BAY CONSERVATION SOCIETY

The Laskeek Bay Conservation Society is a volunteer group based in the Queen Charlotte Islands. The society is committed to increasing the appreciation and understanding of the natural environment through:

sensitive biological research that is not harmful to wildlife or its natural habitat

interpretation and educational opportunities for residents of and visitors to the Queen Charlotte Islands

Established in 1990, the society is committed to a long-term seabird research programme in the Ancient Murrelet colony at Limestone Island. For further information, contact:

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BRIEF STATEMENT OF ACHIEVEMENTS

(1) The camp on East Limestone Island was occupied from 13 March to 3 July 1992

(2) Banding of Ancient Murrelets was carried out on East Limestone Island from 14 March to 24 June, with 675 chicks and 284 adults captured, including 49 adults retrapped from earlier years.

(3) Boat surveys in the Laskeek Bay - Skedans Bay area were repeated and confirmed evidence from earlier years that there is an important population of Marbled Murrelets summering in the area. Numbers this year appeared to be higher than in previous years.

(4) Incubation and breeding success of Ancient Murrelets were monitored at 25 burrows on East Limestone Island, from which 37 chicks departed; an average of 1.48 chicks/pair and normal for the Queen Charlotte Islands.

(5) Following the removal of raccoons from East Limestone Island, during the late summer and fall of 1991, evidence of predation on Ancient Murrelets recorded on transects fell sharply, with only 18 records, compared to 105 in 1991. This evidence supports the idea that raccoons were responsible for most of the predation seen in 1991.

(6) Sixty-one species of birds were recorded on or around the Limestone islands. In June, 128 forest birds of 16 species were trapped and banded to study their survival in future years.

(7) New projects initiated in 1992 included studies of Black Oystercatchers and Red-breasted Sapsuckers and putting in place 16 Cassin's Auklets nest boxes. These projects will be continued and expanded in coming years.

(8) In addition to activities at Limestone Island the Society provided volunteers to assist the Canadian Wildlife Service in censusing the Ancient Murrelet colony at Dodge Point, Lyell Island and surveying it for evidence of rat predation. Almost 50% of burrows showed evidence of predation by rats and the colony appears to have shrunk since the last census, in 1982. The same team resurveyed permanent seabird monitoring plots on Ramsay Island.

ACKNOWLEDGEMENTS

The research reported here could not have been carried out without the enthusiastic support of volunteers who took part in the work at Limestone Island, Dodge Point and Ramsay Island: Wendy Barker, Eric Bogren, Janet Brown, Virginia Collins, Michelle Deakin, Surya Forest, Leslie Foster, Joelle Fournier, Collin French, Mietka Gawlak, Celina Gold, Charlotte Husband, Jason Jones, Peter Jones, Rob Kelly, Julie Kimmel, Finn Larsen, Lisa Leduc, Nathalie MacFarlane, Keith Moore, Deane Nomura, Penny Richardson, Sylvia Scott, Duane Sept, Adrianna Spighi, Ilya Storm, Vernal Swift, Roy Tanami, Jeanette Theberge, Michelle Van den Brink, Sylvia von Schuckerman and Marcie Watkins.

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- Brian Leach for photo-finishing and a supply of chocolate bars to last the duration of the night chick-catching sessions.

- Dr Ted Miller of the Royal B.C. Museum for loan of recording equipment and advice on studying Red-breasted Sapsuckers.

- All those who donated money and bought t-shirts

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BACKGROUND

The Laskeek Bay Conservation Society was founded in 1990 by a group of conservationists and biologists mainly living in the Queen Charlotte Islands. The society organizes a volunteer programme to carry out educational activities based on biological monitoring and research in the Queen Charlotte Islands. The programme uses simple techniques, which cause a minimum of disturbance to the environment, while allowing as many people as possible to gain an appreciation for what is involved in ecological research. In addition, opportunities are provided for the interpretation of the local ecology to groups of interested visitors.

Since 1990 the society has maintained a field camp on East Limestone Island during March-June to act as a base for field studies in the area. The scientific work so far carried out continues and extends a programme that was initiated by the Canadian Wildlife Service in 1984, aimed at providing information on the biology and ecology of marine birds.

The main species of interest is the Ancient Murrelet, a small diving bird which is more common in the Queen Charlotte Islands than anywhere else in the world. Its population has decreased substantially over most of its range across the North Pacific, mainly because of predators introduced either deliberately (foxes, raccoons), or accidentally (rats), by people. Ancient Murrelets have become much scarcer, or disappeared altogether, on several of the Queen Charlotte Islands, in one case because of predation by rats. Raccoons have probably been responsible for the disappearance of Ancient Murrelets and other burrow nesting seabirds from other islands. Knowledge about what is happening to Ancient Murrelet populations is important for the conservation of the species, both in Canada, and worldwide.

The society is undertaking several other studies aimed at better understanding of the marine and terrestrial ecosystems of the Laskeek Bay area. These studies include the monitoring of sea lion haul-outs, gull colonies and Peregrine Falcon eyries. Studies of

forest bird populations, including songbirds and woodpeckers, were initiated in 1992. Documentation and study of rare plants and introduced mammal species on Limestone Island have also been initiated.

Surveys of Marbled Murrelets are also carried out by the society. This bird, which nests mainly in old-growth forest, has had its breeding habitat reduced by logging activities over much of its range. It has been declared a threatened species in Canada. In 1989 the Canadian Wildlife Service carried out boat surveys to determine the numbers of Marbled Murrelets feeding at sea around Louise Island, especially along those stretches of coast where the old growth forest is slated to be felled over the next few years. The society is continuing these surveys on an annual basis to provide an indication of the effects of logging on the Marbled Murrelet population.

A note on this report. Several of the tables and figures presented are identical to those shown in the 1991 report, except for the addition of the 1992 data point. This is deliberate. One of the main aims of our work in the Laskeek Bay area is to provide data that will tell us about long-term trends. It is therefore essential that the results for 1992 be seen in the context of earlier work in the same area.

ACTIVITIES IN 1992, OVERVIEW

The camp on East Limestone Island was occupied by Laskeek Bay Conservation Society personnel from 13 March to 3 July; the longest season yet. In 1992 wooden platforms were built for the sleeping tents to minimize their effect on the ground and to provide greater comfort for the occupants. In addition to regular volunteers, in June the camp hosted two students taking a field course under the Ontario Universities Field Courses programme.

Raccoons. During the summer and fall of 1991 the B.C. Ministry of Parks and Environment killed three raccoons on East Limestone Island and an additional five on adjacent Vertical Point. As a result, there was no evidence of raccoons on the island when camp was opened in mid-March. The only possible evidence of raccoons subsequently was the discovery of a fresh, headless Ancient Murrelet corpse on 11 June. As in previous year, systematic records of Ancient Murrelet predations were made by surveying fixed transects every six days; these were placed in the same places as in 1991. Methods used were described in the 1991 report (Gaston et al. 1992).

Boat surveys. Five sets of inshore and offshore boat surveys were carried out to estimate numbers of Marbled Murrelets and other marine birds, beginning in late April. Additional partial surveys were carried out on 16 March and 18 April. Boat surveys were conducted from a 4.5 m inflatable boat run at a constant speed. Sightings of seabirds were recorded on a hand-held tape recorder. Sightings of birds which were sitting on the water, or which flew up at the approach of the boat, were recorded as on the water, others were recorded as flying. A note was also made when birds were estimated to be more than 200 m from the boat's course. Other observations, of flight directions, or behaviour, were made where appropriate.

Observations from shore. In addition to the transects, daily observations were made from Cabin Cove of any marine bird activity visible from shore, and a regular log was kept of casual

observations of birds and mammals throughout the area. From 10 April to 26 June a ten minute count of Ancient Murrelets flying over the gathering ground, to the east of Cabin Cove, was carried out nightly at about one hour before sunset. The count was made through a 25x telescope, fixed so that the navigation beacon on Low Island was at the top edge of the field. This count provided an index of the numbers of Ancient Murrelets waiting to visit the colony that night, and hence provided a warning about how much activity to expect on the colony.

Burrow monitoring. Beginning on 10 April, burrows marked as occupied in 1990 or 1991 were inspected daily to discover whether eggs had been laid. We measured the first egg laid in each study burrow, as soon as it was laid, using calipers for the length and maximum diameter, and a spring balance for the weight. After the first egg was laid each burrow was fitted with a temperature probe which was used to observe the progress of incubation. Full details of the method are given in the 1991 report. After the clutch had been incubated for 30 days, the burrow was inspected, and after hatching, the chicks and adults were removed for weighing and banding.

Trapping adult murrelets. From 15 May onwards adult Ancient Murrelets were trapped in the latter part of the night by catching them on the ground with dip nets. Trapping was not initiated until late in the season in order to minimise disturbance to incubating birds. Some adults were also captured in the chick funnels as they accompanied their chicks. These birds were always released immediately to ensure that they reached the sea ahead of their chicks.

Chick trapping. Chick trapping, using the same plastic funnels as in earlier years, was carried out from 9 May to 5 June, with funnels operated from darkness to at least 1 a.m., if no chicks were seen, or to 1 h after the last chick was recorded. During the same period, adult birds were captured on the ground, banded, measured, weighed, and inspected for brood patches, and damage to feet and webs.

Banding Cassin's Auklets. On the night of 25 May a party visited "Cassin's Castle", on the south side of Reef Island to catch Cassin's Auklets. Adult Cassin's Auklets were trapped in a mist net as they arrived at their burrows. Banding at this colony has been carried out since 1985, the intention of the trapping effort being to obtain recoveries of birds banded previously in order to estimate the survival of the adult birds.

Forest bird studies. Several new initiatives aimed at studying forest birds on East Limestone Island and adjacent areas were begun in 1992. All sapsucker nests on East Limestone Island were located and mapped in late May, when the young nestlings are calling noisily from the nest cavity. A plan to record sapsucker drumming was unsuccessful due to weather and time constraints, but will be pursued next year. In June mist-netting of forest birds was conducted in Spring Valley to assess the feasibility of carrying out survival studies through banding. This will contribute to a North America-wide programme to monitor the survival of terrestrial birds.

Black Oystercatchers. Oystercatchers are a very prominent bird of the Laskeek Bay area, breeding on most of the smaller islands. Species of oystercatchers studied elsewhere in the world have proved to be very long-lived, but we know nothing of the longevity of local birds. This year we began a programme of locating nests and banding young oystercatchers, marking them with a year-specific colour-band. This will enable us to tell their age at a glance if we see them in future years. We hope that this project can be expanded in future years.

Glaucous-winged Gulls. In the lower mainland area of British Columbia and the Straits of Georgia Glaucous-winged Gulls are increasing rapidly. Gull colonies in the Queen Charlotte Islands were censused by the Canadian Wildlife Service in 1986. In June this year counts of nests, eggs and chicks were carried out at all colonies of Glaucous-winged Gulls in the Laskeek Bay area to determine whether populations have changed here in recent years.

CHICK BANDING AND WEIGHING

The first Ancient Murrelet chicks were captured on the night of 12 May, and the last on 4 June. The total caught was 674, an increase of 20% over 1991. Ninety percent of chicks were captured over a period of 14 nights, between 16 and 30 May. The peak of captures occurred on 21 May, when 76 were trapped, and the median date for all captures was 22 May; the earliest median date ever recorded at Limestone or Reef islands over 9 years (Table 1, Figure 1). Assuming an incubation period of 32 days, and two days between hatching and departure, the median date of clutch completion was 18 April. As the two eggs are laid 8 days apart, the median date of laying for first eggs was 10 April.

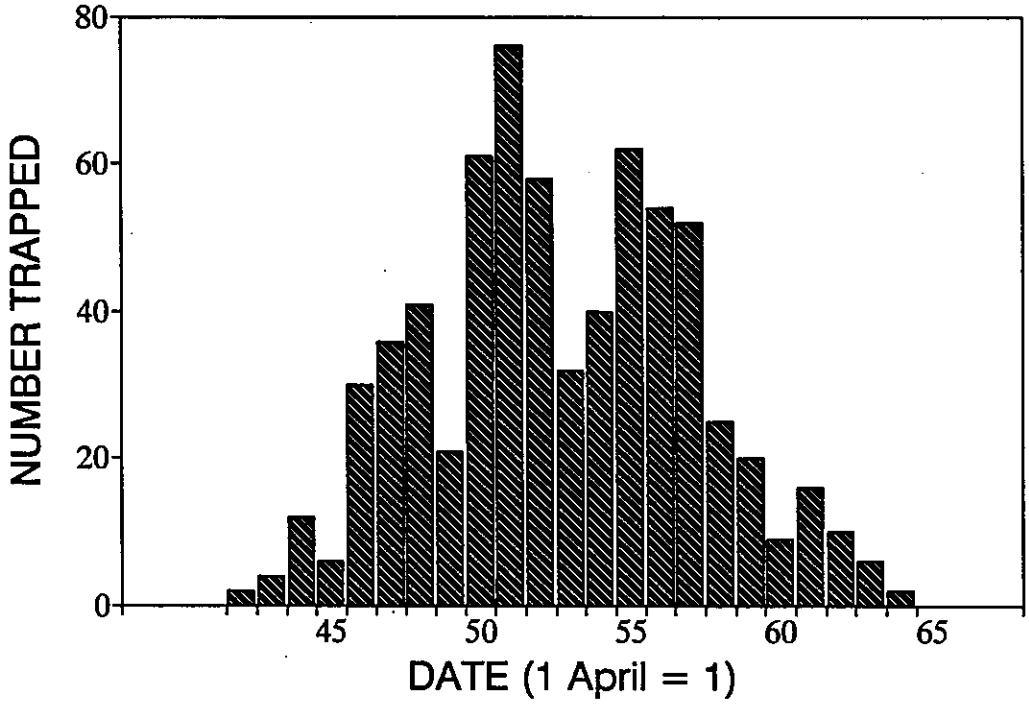
As in earlier years, funnel #1 caught the fewest chicks (42), and funnel #6 caught the most (155), although funnel #3 did almost as well, with 154. Funnels 1 and 2 showed the greatest increases over 1991 (62% and 41% respectively), while funnel 6 showed the least (8%). The elimination of raccoon predation may have caused some of the increase in chick production. However, numbers were still lower than we recorded in 1990, so we must hope that recovery continues next year.

Table 1. Numbers of chicks captured on East Limestone Island in 1992

DATE	FUNNEL						TOTAL	CUM. TOTAL
	1	2	3	4	5	6		
May 9-10	0	0	0	0	0	0	0	0
10-11	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0
12-13	2	0	0	0	0	0	2	2
13-14	0	2	0	0	0	2	4	6
14-15	0	0	4	3	1	4	12	18
15-16	1	2	0	1	2	0	6	24
16-17	2	2	4	6	8	8	30	54
17-18	1	12	9	4	5	5	36	90
18-19	2	5	9	7	6	12	41	131
19-20	0	2	5	6	5	3	21	152
20-21	8	6	14	17	2	14	61	213
21-22	2	8	20	17	7	22	76	289
22-23	5	4	15	10	11	13	58	347
23-24	2	6	5	4	5	10	32	379
24-25	5	6	9	7	6	7	40	419
25-26	3	7	13	11	10	18	62	481
26-27	4	10	8	7	10	15	54	535
27-28	1	12	22	3	6	8	52	587
28-29	2	3	8	1	3	8	25	612
29-30	2	0	2	8	6	2	20	632
30-31	0	3	0	0	5	1	9	641
Jun 31-1	0	4	3	3	5	1	16	657
1-2	0	3	4	1	0	2	10	667
2-3	0	0	0	6	0	0	6	673
3-4	0	0	0	1	1	0	2	675
4-5	0	0	0	0	0	0	0	675
Totals	42	97	154	123	104	155	675	
1991 totals	26	69	126	109	90	142	562	
1990 totals	37	137	192	146	163	198	873	
1991/1990	-30%	-50%	-35%	-25%	-45%	-28%	-36%	
1992/1991	+62%	+41%	+22%	+13%	+16%	+9%	+20%	

FIGURE 1

CHICKS TRAPPED, BY DATE, 1992



The mean weight of chicks captured at departure was 26.75 g, with 90% of chicks between 23-29 g (Figure 2). Unlike all earlier years, either at Reef or Limestone islands, chick weights showed no decline as the season progressed, except after 30 May (Figure 3). On average, chicks were lighter in 1992 than in earlier years. This is one of a number of pieces of evidence to suggest that 1992 was a rather exceptional year.

FIGURE 2

CHICK MASS AT DEPARTURE

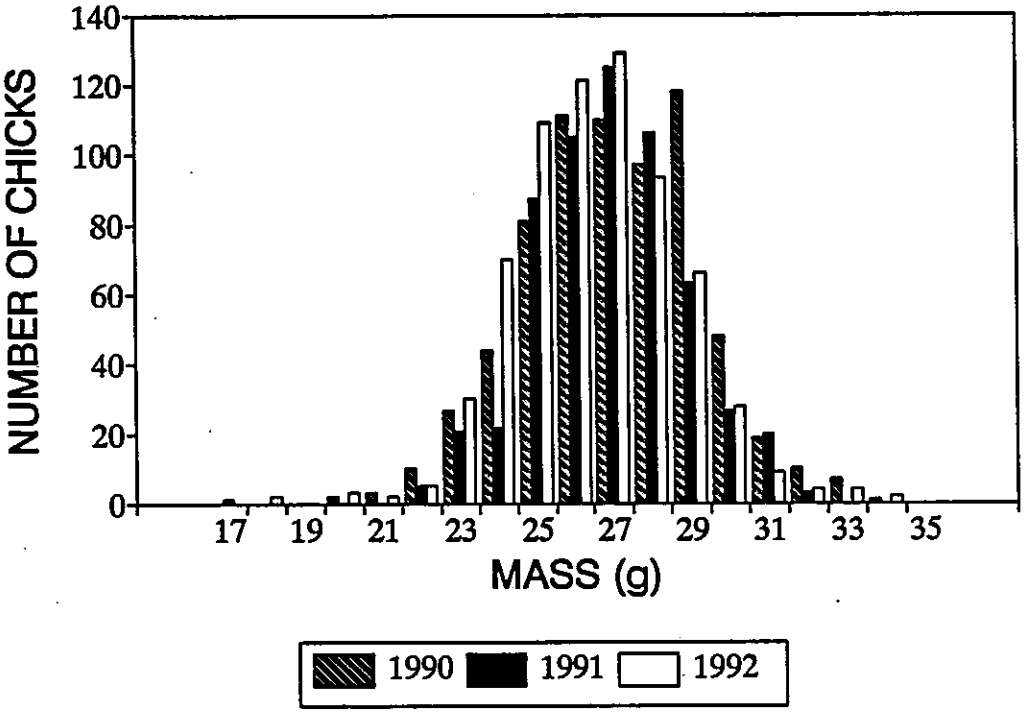
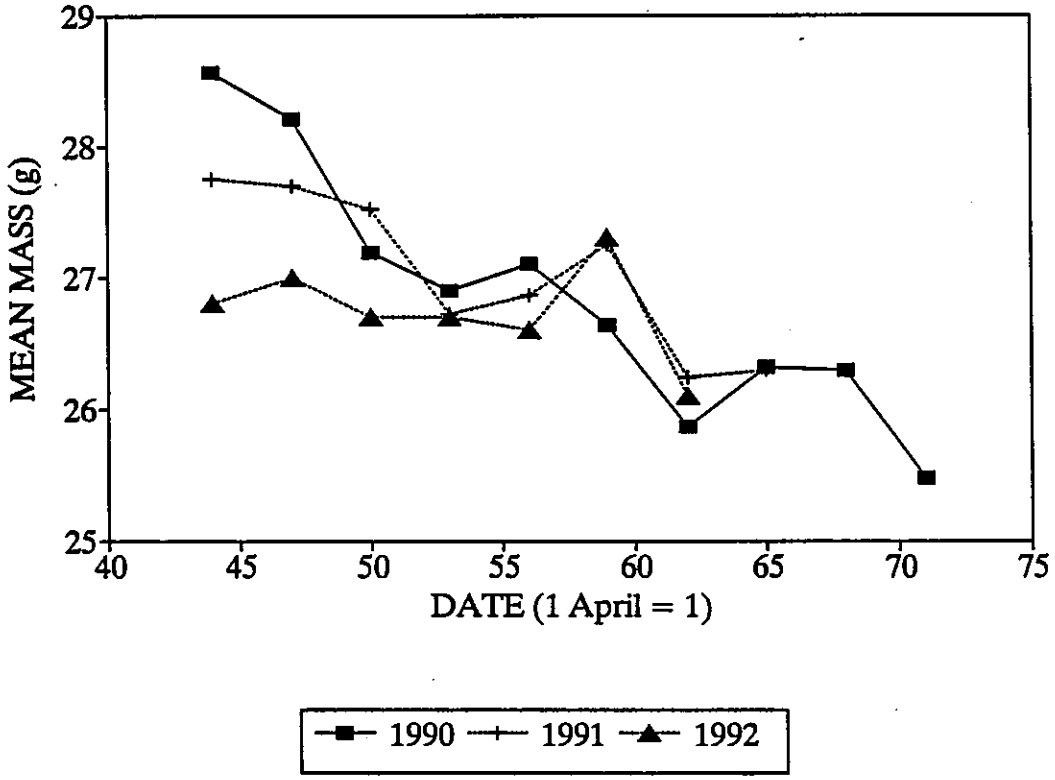


FIGURE 3

CHICK WEIGHT IN RELATION TO DATE



ADULT TRAPPING

Ancient Murrelets visited East Limestone Island on the night of 13 March, the first day that camp was occupied. Despite efforts to trap adults during the pre-laying period, only four were captured. A further 252 were trapped on the surface during 4 May to 21 June and 30 were removed from burrows for banding. The last bird trapped was caught on 21 June and the last heard on East Limestone Island was on 22 June.

Ancient Murrelets trapped on the surface included 29 banded as adults in earlier years and five banded as chicks at East Limestone Island in 1990. Another bird banded as a chick in 1990 was found killed by a predator. Those taken from burrows included 15 banded as adults in earlier years, 11 in the same burrows where they were found in 1991.

Of the 249 birds trapped in May and June, for which the brood patch was recorded, 18% had a full brood patch, and hence were presumably breeding, and 70% showed no sign of a brood patch, and were therefore non-breeding prospectors. The remainder had incomplete brood patches (<20 mm across), and were probably mainly non-breeders (Table 2). As in previous years, about half of the birds captured that had been banded in previous years were breeders.

The very high proportion of birds trapped without brood patches suggests that large numbers of prospecting birds visited East Limestone Island in 1992, a good sign for the future. However, some of the difference may have been due to the fact that trapping of adults usually began only after most chicks had passed through the funnels, about two hours after adults had started to arrive at the colony. Generally breeding birds arrive early in the night and most arrivals later on are of non-breeders (Gaston 1992). The late start to trapping may have biassed our sample towards non-breeding birds In addition, the very early departure of breeding birds consequent on the exceptionally early breeding season may also have had some effect.

Table 2. Proportions of birds trapped in May and June 1990, 1991 and 1992 with and without brood patches (excludes found dead)

YEAR	STATUS	BROOD PATCH STATE		
		0	>0<20	FULL(>19)
1990	New	117(39%)	19(6%)	162(55%)
	Retrap	4(27%)	3(20%)	8(53%)
1991	New	115(53%)	22(10%)	82(37%)
	Retrap	13(30%)	8(18%)	23(52%)
1992	New	168(71%)	24(11%)	31(18%)
	Retrap	7(27%)	5(19%)	14(54%)

The weights of both breeders and non-breeders trapped in 1991 were significantly lower than in 1990. In 1992 weights for both breeders and non-breeders were similar to those recorded in 1991 and the weights of birds taken from burrows at the time of hatching were almost identical (Table 3). As the weights of non-breeders recorded in 1991 and 1992 were similar to those recorded at Reef Island during 1984-89 (924 birds averaged 185 g), it seems that in 1990 conditions for non-breeders were exceptionally good. The situation in 1991 and 1992 is probably more typical.

Table 3. Weights of adult Ancient Murrelets captured on East Limestone Island in 1991. Dates given are for the night beginning. Birds with brood patches >19 mm in diameter probably bred.

BROOD PATCH	DATES	1990 (g)			1991 (g)			1992 (g)			t	
		Mean	s.d.	N	Mean	s.d	N	Mean	s.d.	N	90/91	91/92
All	29 Mar-4 Apr	214.5	10.54	31	207.9	15.55	25	-	-	-	1.88	-
>19mm	8-15 May	221.4	20.56	51	206.4	15.97	32	-	-	-	3.51**	-
	16-25 May	217.2	19.52	68	208.9	19.19	53	201.0	20.3	15	2.34*	1.39
	26 May-13 Jun	204.9	18.56	28	209.6	19.69	13	203.4	20.7	12	0.74	0.77
Nil	8-15 May	195.1	17.82	32	184.8	11.33	23	-	-	-	2.44*	-
	16-25 May	195.5	13.33	50	184.3	11.52	76	184.3	10.4	62	4.99**	0.0
	26 May-13 Jun	192.0	11.34	25	186.4	9.11	32	184.7	12.0	125	2.07	0.75
In burrows with chicks		-	-		212.3	13.43	32	212.5	9.7	30		0.0

* P<0.05 ** P<0.01

EGG SIZE

Eggs laid in 1992 were similar in measurements and mass to those laid in 1991. They were heavier relative to their length and breadth than those measured over 6 years at Reef Island (Table 4), suggesting some difference in shape between eggs laid at the two colonies. However, as many eggs were laid by the same birds each year, this difference could relate to a few individuals. The mass of the eggs weighed in 1992 corresponded closely to the general effect of laying date on egg size previously observed at Reef Island. With eight years of data on egg mass and date of laying we still find a strong correlation between these two variables (Figure 4).

The tendency seen in 1991, for eggs laid at the beginning of the season to be larger than those laid later, was less evident in 1992. As at Reef Island, those eggs laid late in the season tended to be a little smaller than others, but the trend was rather weak (Table 5).

FIGURE 4

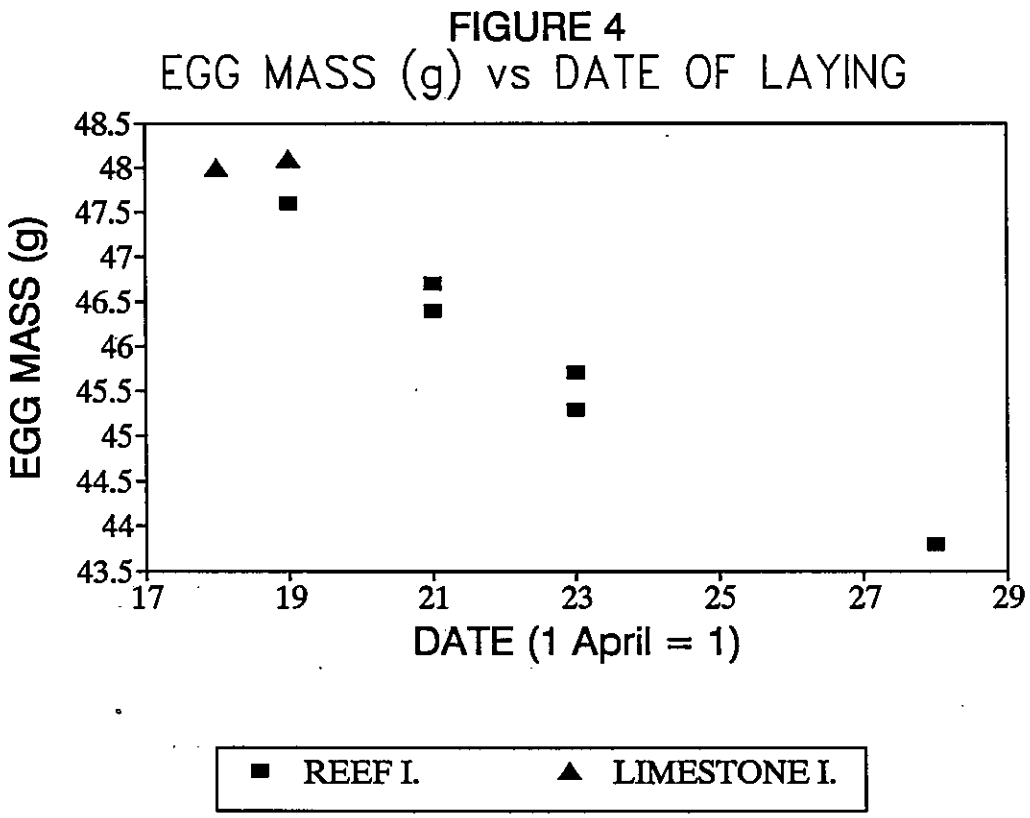

EGG MASS (g) vs DATE OF LAYING
EGG MASS (g)
48.5
48
47.5
47
46.5
46
45.5
45
44.5
44
43.5
17
19
21
23
25
27
29
DATE (1 April = 1)
REEF I.
LIMESTONE I.

Table 4. Measurements of Ancient Murrelet eggs from the Queen Charlotte Islands

Locality	Year	Weight(g)			Length(mm)			Breadth(mm)			Ref
		Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N	
Reef I.	1984	43.8	3.2	57	58.7	2.0	98	37.1	1.2	98	(1)
	1985	46.7	3.3	53	59.3	1.9	99	37.9	1.1	99	(1)
	1986	45.7	2.8	52	59.3	2.1	52	37.6	1.1	52	(1)
	1987	47.6	3.4	50	60.0	2.2	50	38.1	1.1	50	(1)
	1988	45.3	2.6	41	59.3	2.0	41	37.5	0.9	41	(1)
	1989	46.4	3.2	39	59.3	2.4	39	37.9	1.5	39	(1)
Limestone I.	1991	48.1	4.4	26	59.5	2.1	26	37.8	0.9	26	
	1992	**48.0**	**3.1**	**23**	**59.2**	**1.5**	**23**	**37.4**	**2.0**	**23**	

(1) Gaston (1992)

Table 5. Fresh weights of Ancient Murrelet eggs from Reef and Limestone islands, relative to date of laying.

Year	Regression of weight on date (weight=A-(date*B)	Estimated weights 15 April	15 May
1984	45.04-(date*0.066)	44.05	42.07
1985	47.57-(date*0.056)	46.73	45.05
1986	48.74-(date*0.122)	46.91	43.25
1987	48.49-(date*0.044)	47.84	46.52
1988	45.90-(date*0.036)	45.36	44.28
1989	47.36-(date*0.047)	46.65	45.24
1991	53.17-(date*0.464)	49.92	36.00
1992	**50.43-(date*0.170)**	**47.88**	**42.78**

INCUBATION

We monitored incubation in 21 burrows by means of temperature probes. The eggs in several burrows had already been laid when we began to inspect them, so dates of first eggs were obtained for only 16 nests; these ranged from 11-24 April. Incubation began on average 9.75 days later (range 8-12, s.d. 1.14, N=12). We were able to follow the entire incubation period for 20 nests, and at 6 of these incubation was interrupted for 1 or 2 days. All these interruptions occurred within 3 days of the start of incubation.

Incubation periods (from start of incubation to hatching) ranged from 30-33 days (N=17). The number of days of actual incubation had a similar range with 13/17 clutches hatching after 30 or 31 days of incubation (Table 6). At burrows where we knew the number of days that the chicks spent before leaving for the sea, no broods left after one day, eleven after 2 days and three after 3 days.

Table 6. Incubation periods and number of days for which eggs were actually incubated.

Year	Incubation period									Days incubated					
	29	30	31	32	33	34	35	36	37	28	29	30	31	32	33
Reef Island															
1984		1	2	1			2			1	2	2	1		
1985	1	1	3	2	1	2	1	2	1	1	1	6	5		1
1988											4	15	7		
1989											10	44	9	3	
Reef Island															
Totals	1	2	5	3	1	2	3	2	1	2	17	67	22	3	1
Limestone I.															
1991		3	7	4	1	2					1	12	6		
1992		**3**	**5**	**7**	**2**							**4**	**9**	**3**	**1**

PREDATION BY RACCOONS ON SEABIRDS

Events in 1992

Although there was no evidence of any raccoons present on East Limestone Island at the start of the Ancient Murrelet breeding season, we repeated the seven strip transects surveyed in 1991 to determine the effect of removing the raccoons. These transects were searched for predation remains at six day intervals throughout the season. Signs of predations were classified as follows;

(1) Feather piles. These consisted of large numbers of contour feathers (breast, back, scapulars) scattered over an area up to 5 m in diameter, but normally concentrated in a clump. Complete single or paired wings were sometimes associated with these piles, and occasionally feet. Wings found without associated contour feathers, either single, or attached in pairs to the pectoral girdle, were also included in this category.

(2) Burrow digging. In 1991 some burrows were enlarged through the entrance tunnel, while in other cases the predator dug down from above. Several holes within a radius of 5 m were treated as a single predation event, unless other evidence suggested that more than one occupied burrow had been entered.

(3) Carcasses or inverted skins. Carcasses found in 1991 were sometimes practically intact, often with the head severed from the body. This appears to be characteristic of raccoon predation. At the other extreme, some whole skins were everted and completely cleaned inside.

Twelve transect surveys were carried out between 20 April and 24 June, yielding 14 feather piles, of which 2 contained wings and three carcasses or inverted skins (none complete). This compares with 78 feather piles, 17 burrow diggings and 10 carcasses on transects carried out between 3 April and 8 June 1991. The highest number of predation remains (7) was found on Transect #7, and the lowest (0) on transects #1 and #6. Six feather piles were found after 7 June and a complete headless

carcass was found on 11 June, although not within the transects. The possibility that a raccoon arrived on the island in early June and remained for a period cannot be discounted, although no fresh latrines or other signs were found.

As in 1991, the length of wings collected in May resembled those of non-breeders, rather than breeders (Mean = 138.2 $\pm$ 2.93 mm, N = 12). Only two wings were found in April, measuring 139 and 140 mm; typical of breeders.

Table 7. Predation remains found on transects in 1992

DATE	FEATHER PILES	BURROW DIGGING	CARCASSES
31 Mar - 30 Apr	2	0	1
1 - 15 May	2	0	1
16 May - 8 June	8	0	1
> 8 June	2	0	0
Totals	14	0	3

The results of the transect surveys suggest that the number of breeding Ancient Murrelets killed in 1992 was only about 20% of the numbers killed in 1991. In addition, a greater proportion of the birds killed in 1992 died after 15 May (11/17 in 1992, compared to 31/88 in 1991, Chi^2 with Yates' correction = 4.0, $P<0.05$). Evidence from the length of wings collected suggested that the majority killed were non-breeders, as would be expected in the second half of the season.

The very sharp decrease in the evidence of predation on Ancient Murrelets at East Limestone Island seems unlikely to have

been related to a decrease in the number of birds. Numbers of chicks trapped suggested that similar numbers of breeders were present in 1991 and 1992. In addition, the large proportion of non-breeders among birds trapped in 1992 suggests that there was no reduction in numbers of prospecting birds visiting the colony.

Previous studies of predation at East Limestone Island.

Surveys of East Limestone Island for predation remains were carried out in 1988-90. In 1988 parties of three people visited the island for a few hours on 7 and 13 June, covering the colony area systematically and counting 123 feather piles and 2 inverted skins, as well as four burrows that had been excavated. In 1989 we counted predation remains between 24 May and 10 June on 115 5x5 m plots evenly distributed throughout the colony area, and also on two larger plots, #1 0.8 ha and #2 0.25 ha. The density of predation remains recorded was 66/ha in the 5x5 plots, 56/ha in plot 1 and 60/ha in plot 2. Extrapolating to the total area of the colony (14 ha) gave estimates of 924, 784 and 840 predation remains (Gaston et al. 1989). A comparison of the relative frequency of predation remains at East Limestone and Reef islands suggested that predation was about ten times higher at East Limestone.

In 1990, transects 1-6 were surveyed as in 1991 and 1992, although transect 6 was not begun until 18 May. Eighty-five feather piles or carcasses were found on transects 1-6, giving a mean density of 38.3/ha; 536 over the entire colony (Gaston 1991). In 1991, 88 feather piles or carcasses were found on transects 1-7, a density of 34.4/ha extrapolating to 481 for the entire colony (Gaston et al. 1992). A similar calculation for 1992 yields a density of predations of 6.6/ha, extrapolating to 93 for the entire colony.

In 1988 and 1989 we obtained no definite evidence of the presence of raccoons on the island, although burrows that had been dug into were found in both years and raccoon scats were found on West Limestone Island in 1989. No intensive surveys for

raccoon latrines and no spotlight surveys of the inter-tidal zone were carried out in either year. In 1990 radio-tracking informed us that at least one male raccoon was present on East Limestone Island throughout the season. A second animal, with kits, was seen in July during spotlight surveys of the inter-tidal zone. This animal was probably present throughout the season as it seems unlikely that it would have swum to the island with small kits. We found evidence of raccoons in the form of decapitated carcasses from the start of the season. In 1991 intensive studies by spotlighting from a boat showed that three raccoons were present on East Limestone Island for most or all of the season.

In the light of the dramatic reduction in numbers of predations at East Limestone Island, following the elimination of raccoons prior to the 1992 breeding season, it seems probable that raccoons were present on the island at least from 1988. In 1983, Rodway et al. (1988) reported 16 feather piles/ha during surveys carried out during 2-7 May. In 1991 and 1992 less than half of predations had occurred by that date, so Rodway et al.'s estimate indicates that more than 30 predations/ha probably occurred over the entire season, a level similar to those seen in 1990 and 1991. Raccoons were common at nearby Vertical Point in 1983 (Rodway et al. 1988) and may well have been visiting the Limestone islands at that time.

The absence of decapitated carcasses on surveys in 1988 and 1989 was probably due to most surveys being conducted in the afternoon. Observations of corpses in 1991 showed that they were usually scavenged by crows or eagles within a few hours, which converted them rapidly to typical feather piles.

Summary

Evidence collected over the past three years strongly suggests that most of the predation of Ancient Murrelets that has been observed at East Limestone Island in the course of surveys carried out since 1983 was the result of raccoons. This contradicts assumptions made by Gaston (1990), on the basis of

preliminary results. The evidence for this conclusion was only accumulated as a result of painstaking efforts by many people, with the most critical ingredient being the removal of raccoons before the 1992 breeding season.

Summers and Rodway (1988) and Rodway (1991) correctly predicted the effects of raccoons on Ancient Murrelets, on the basis of their behaviour elsewhere. Now, through intensive research efforts, it has been possible to demonstrate their effect unequivocally. The difficulty of the task emphasizes the fact that very major changes in ecosystems can go undetected, or even where suspected, can remain unproven, unless we are prepared to take a rigorous approach to the problem.

SURVEYS AT SEA

Seven coastal and five offshore surveys of marine birds at sea were carried out between 16 March and 27 June. Generally, there was a higher diversity of species seen on coastal surveys, especially those carried out before the end of April. Eighteen species were recorded on coastal surveys, whereas only 11 were seen on offshore surveys (Tables 9, 10). The diversity of species was greatest in March, when the wintering sea ducks were present. Few passage visitors were recorded, the only clear examples being Pacific Loons and Red-necked Phalaropes. Pelagic Cormorants were numerous throughout, while Marbled Murrelets became the most common species on the non-coastal surveys after mid-May (Table 10).

Numbers of Marbled Murrelets seen in the Skedans Bay - Laskeek Bay area were somewhat higher than those seen in previous years (Table 11). As in earlier years, numbers of Marbled Murrelets increased to a peak in May. The highest count, of 310 on 28 May, was the maximum recorded in four years of surveys. In addition, numbers remained high in June, unlike 1990 and 1991, when numbers counted in June were only half of the peak counts (Figures 5, 6).

In March, large numbers of Marbled Murrelets were present in Cumshewa Inlet. On 13 March 72 were counted close to Nedden Island and a further 120 off the north shore of Louise Island, between Mathers Creek and Girard Point. On 16 March 248 were counted between Louise Narrows and Moresby Camp. All were in winter plumage. Large numbers were also present north of Louise Narrows on 3 April.

On 17 and 27 June surveys were extended from Louise Island south to the north and east coasts of Lyell Island. Aside from a few Pigeon Guillemots and Rhinoceros Auklets, practically all the birds recorded on these surveys were Marbled Murrelets. On 17 June these occurred in two concentrations; 168 birds were in a loose flock off Heming Head, Talunkwan Island and another 118 off Fuller Point and south of there as far as Gogit Point, Lyell

Island, roughly the area adjacent to Windy Bay. These two aggregations made up 85% of Marbled Murrelets seen that day. The concentration off Talunkwan Island was again present on 27 June when 174 were counted south of Heming Head within a single stationary scan. The survey on that date did not extend as far as Windy Bay. Moderate numbers (23) were seen offshore on a transect from Titul Island to Vertical Point on 10 June, but only 1 was seen on the same transect on 27 June, although sea conditions on that date were less suitable. Additional surveys in this area are needed to determine whether the concentrations seen in 1992 are a normal phenomenon.

At 0730 hrs on 28 June 500-600 Marbled Murrelets were estimated present to the north and east of Limestone Island within about 2 km, counted from the boat 400 m off Limestone Island in flat calm conditions.

On 5 May, in very calm conditions, a survey was made to the East of Reef Island, about 7 km out into Hecate Strait. Several flocks of about 100 Sooty Shearwaters were seen feeding, with smaller numbers of Rhinoceros Auklets, Common Murres and Herring and Glaucous-winged Gulls in attendance. Small numbers of Ancient Murrelets were also present, but did not feed with the shearwaters.

FIGURE 5

MARBLED MURRELETS, OFFSHORE TRANSECTS

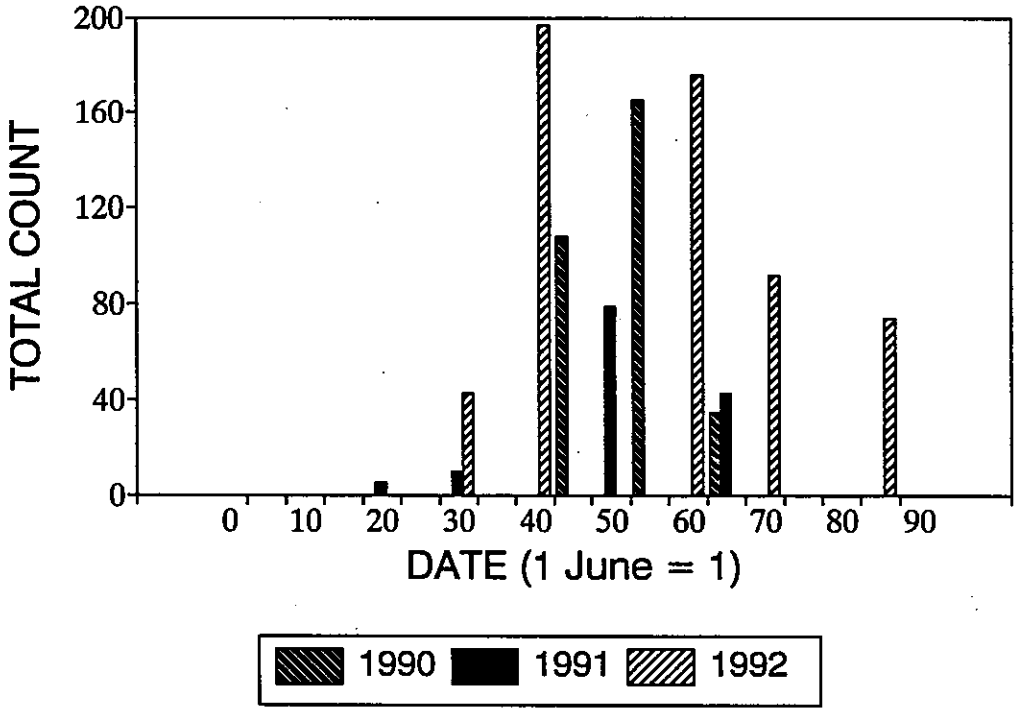


FIGURE 6

MARBLED MURRELETS, COASTAL TRANSECTS

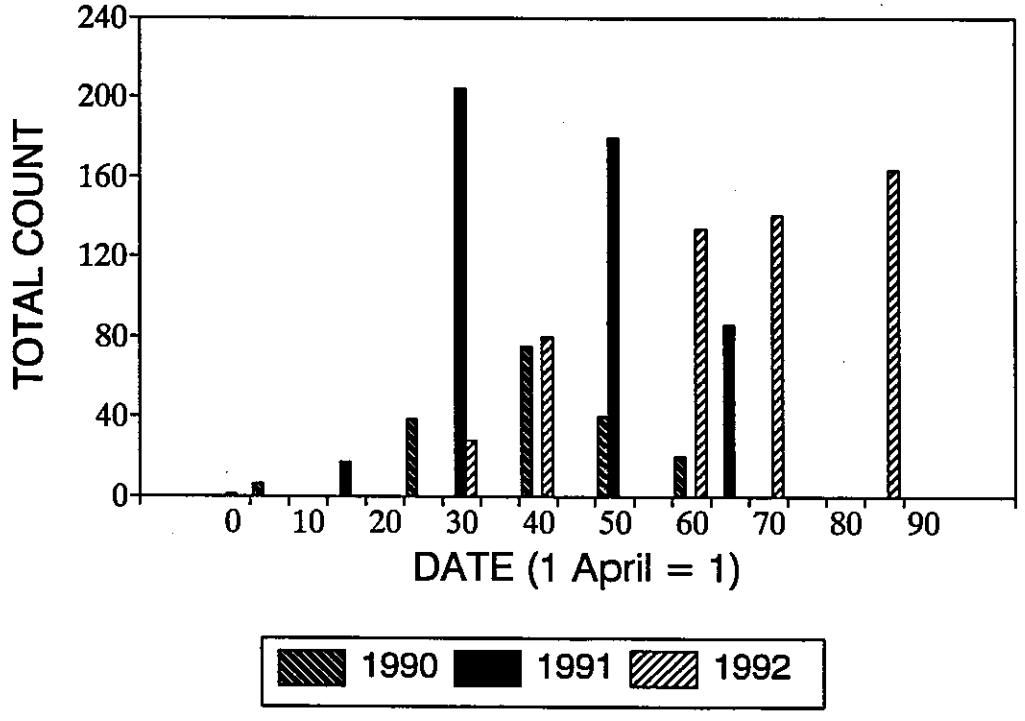


Table 9. Birds seen on coastal boat transects (400 m from shore) in the Skedans Bay - Laskeek Bay area, 1992

SPECIES	16 Mar	18 Apr	28 Apr	11 May	28 May	9 Jun	27 Jun
Common Loon	5	0	3	14	1	0	0
Pacific Loon	0	0	1	0	1	0	3
Red-necked Grebe	2	1	0	0	0	0	0
Pelagic Cormorant	14	3	5	10	0	0	1
D-crested Cormorant	15	6	0	0	0	0	0
Bufflehead	7	0	8	9	0	0	0
Barrow's Goldeneye	4	0	0	0	0	0	0
W-winged Scoter	42	22	9	11	3	5	1
Black Scoter	15	0	0	0	0	0	0
Oldsquaw	10	0	3	0	0	0	0
Harlequin Duck	2	4	0	0	0	0	0
Common Merganser	6	0	3	0	0	0	0
G-winged Gull	5	4	3	2	0	1	2
Herring Gull	0	0	0	0	0	1	0
Pigeon Guillemot	19	26	50	34	16	10	11
Marbled Murrelet	**2**	**3**	**28**	**80**	**134**	**141**	**163**
Ancient Murrelet	8	0	0	0	4	0	0
Rhinoceros Auklet	0	0	1	0	0	0	1
Transects	D-J		D-J	D-M	D-M	D-J	D-M
Species recorded	15	8	10	6	5	5	7

Table 10. Birds seen on open water transects in Skedans Bay in 1992.
Inshore = transects 1, 7, 8, K and L; Offshore = transects 3-5, 7 & 9

Species	28 April		11 May		28 May		9 June		27 June	
	Insh	Off	Insh	Off	Insh	Off	Insh	Off	Insh	Off
Pacific Loon	0	0	0	0	33	0	6	0	12	3
Common Loon	1	0	0	1	0	0	0	0	0	0
Sooty Shearwater	0	0	0	0	0	0	0	0	0	1
Pelagic Cormorant	1	0	2	0	5	0	1	1	0	0
D-crested Cormorant	2	0	0	0	0	0	0	0	0	0
Brandt's Cormorant	1	0	0	0	0	0	0	0	0	0
G-winged Gull	0	12	0	0	0	2	1	0	0	171
Black-legged Kittiwake	0	0	0	0	0	0	0	0	0	12
Parasitic Jaeger	0	0	0	0	0	0	0	0	0	1
Common Murre	0	0	0	1	0	0	0	0	0	0
Pigeon Guillemot	2	1	0	0	3	0	10	1	0	3
Marbled Murrelet	0	0	5	0	9	1	70	9	35	8
Ancient Murrelet	0	5	0	4	0	349	8	650	26	86
Cassin's Auklet	0	0	0	0	0	0	0	0	1	0
Rhinoceros Auklet	0	0	3	0	0	0	0	4	1	58

Table 11. Comparison of numbers of Marbled Murrelets seen in the Skedans Bay - Laskeek Bay area in 1989, 1990 and 1991

DATE	1989		1990		1991		1992	
	Coast[1]	Offsh[2]	Coast	Offsh	Coast	Offsh	Coast	Offsh
Up to 9 April	-	-	6	-	1	0	2	-
10-19 April	-	-	-	-	17	-	-	-
20-29 April	-	-	38	-	-	5	28	43
30 Apr - 9 May	-	-	-	-	205	16	-	-
10-19 May	-	-	50	104	144	85	80	197
20-29 May	74	-	25	165	-	-	134	176
30 May - 9 Jun	68	-	14	35	86	52	141	92
After 10 June	-	-	-	-	-	-	163	70

1; transects D-J

2; transects 1,3,5 and 7

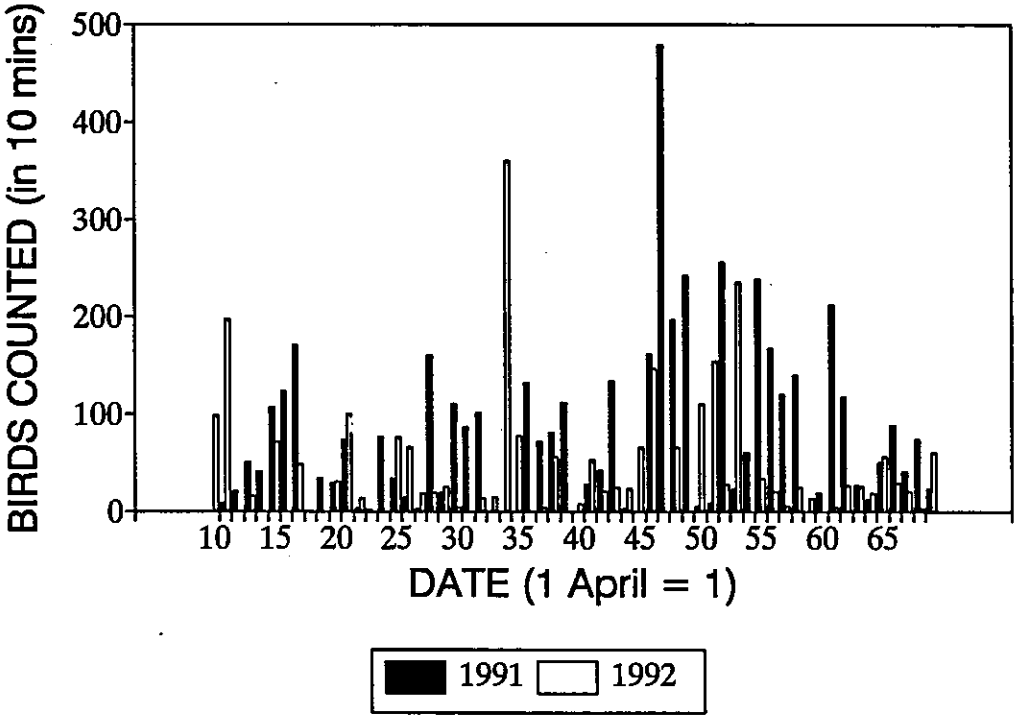
COUNTS OF ANCIENT MURRELETS ON THE GATHERING GROUND

Evening counts of birds flying over the gathering ground to the east of Limestone Island were made from Cabin Cove between 1900-2030 hrs from 10 April - 26 June, using the same methods as in previous years. Numbers seen in a ten minute watch ranged up to 359. Counts of over 100 occurred on six nights up to 23 May, but thereafter the highest count was 59. Numbers did not reach double figures after 16 June, emphasizing that most birds must have departed from the breeding area by that date (Figure 7).

Numbers of birds seen on the gathering ground were generally similar to those seen in 1991 during April, but after mid-May counts were generally lower than in 1991. In the earlier year there were five counts of more than 200 and a further six of more than 100 after 15 May, compared to only one and three in 1992. This difference does not seem to have been related to weather conditions, as wind speeds in 1991 (mean 8 km/h) were similar to those in 1992 (mean 9 km/h).

FIGURE 7

GATHERING GROUND COUNTS



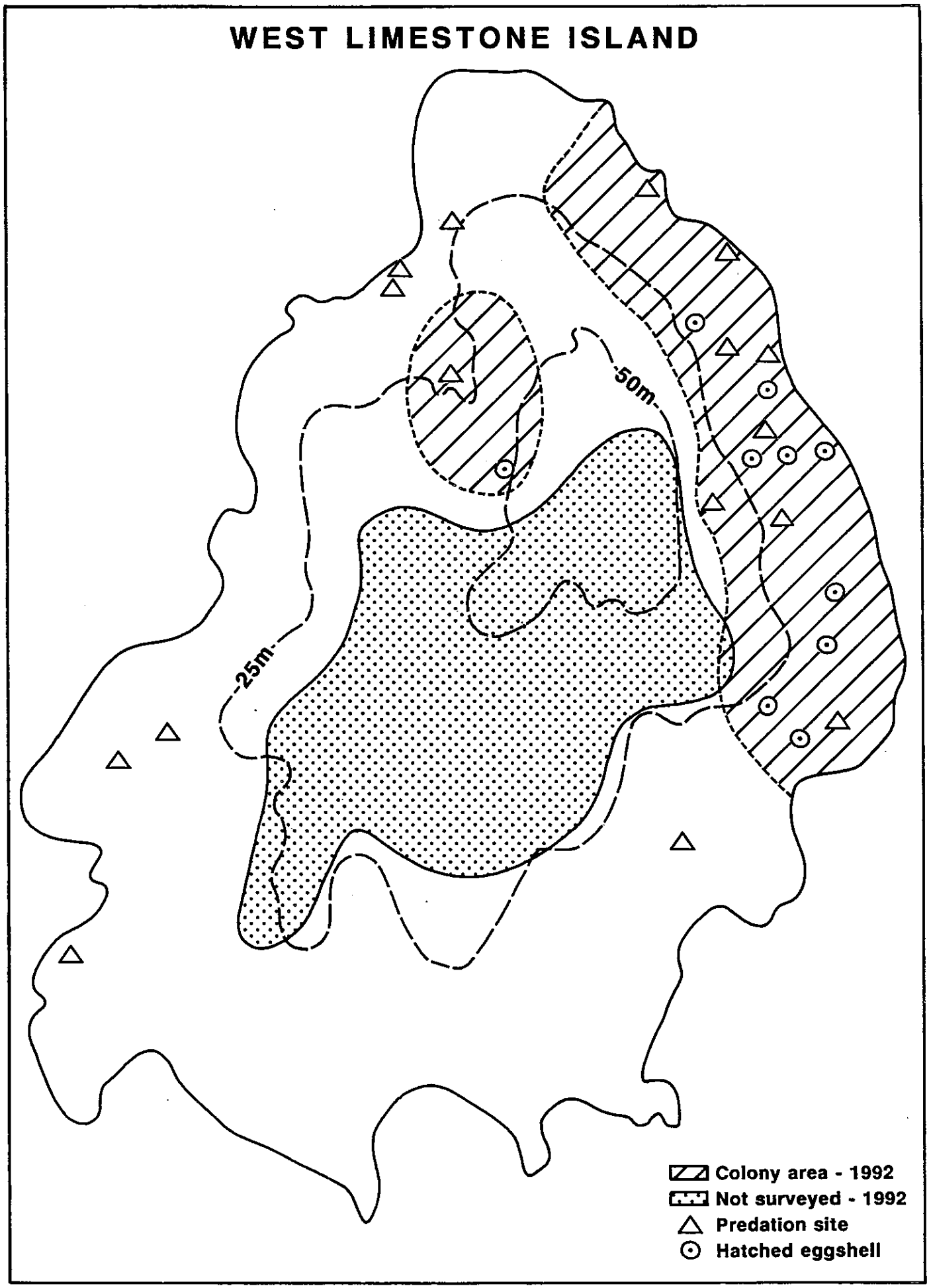
A SURVEY OF WEST LIMESTONE ISLAND

Practically all of the observations of Ancient Murrelets carried out in 1990 and 1991 were confined to East Limestone Island. Ancient Murrelets were reported breeding on West Limestone Island in 1983 in small numbers by Rodway et al. (1988). Brief surveys in 1988 and 1989 confirmed the presence of burrows, but suggested that very few birds were using the west island at that time (Gaston et al. 1989).

On 9 June six people visited West Limestone Island to survey for signs of Ancient Murrelet and raccoon activity. Walking roughly in line abreast and spaced at 20 m intervals they walked the entire circumference of the island, mapping the position of any signs indicating Ancient Murrelet breeding activity or predations. All but the central 20% of the area was inspected. Because ground cover is lacking over most of the island we believe that most or all of the predation remains present in the area covered were located.

Sixteen feather piles were found, of which six contained wings. Nine eggshells or egg membranes suggesting recent chick departures were also found, all in an area on the northeast side of the island where many active burrows were also seen. Half of the predations were found in the vicinity of the occupied burrows, the rest being scattered down the west coast (Figure 8). It appears that a viable population of Ancient Murrelets still persists on West Limestone Island, although no estimate of total numbers could be obtained.

The area of the colony appears to have decreased since 1983 (Cf Rodway et al. Figure EM720-1). The number of predations recorded was also lower in 1992, with only 8 found in the approximately 2 ha of the colony area (4/ha), compared to 44/ha in 1983. Part of the reduction is presumably due to a decrease in the number of Ancient Murrelets visiting the colony and perhaps part due to the eradication of raccoons on East Limestone Island. No signs of raccoons were found during the survey.


WEST LIMESTONE ISLAND
50m
25m
Colony area - 1992
Not surveyed - 1992
Predation site
Hatched eggshell

GLAUCOUS-WINGED GULLS

In previous years the closing of camp by mid-June has precluded carrying out a complete inventory of gulls breeding in the Laskeek Bay area, because egg laying does not usually begin until late May. This year, because of the longer season, we were able to carry out counts of nests and clutch sizes at all breeding sites in Laskeek Bay (except Cumshewa Islet) between 10 and 15 June.

The largest breeding aggregation was found on Lost Islands, where there were 120 nests, 118 with eggs and chicks, on 14 June (Table 12). The total number of breeding pairs for the entire area was 235, slightly more than the 213 recorded at the same colonies in 1986 by Rodway (1988). Compared with Rodway's survey, the colony at Lost Islands had increased by 60%, from 75 pairs, and the one on Kingsway Rock by 119%, from 43 pairs, while those on Low and Skedans islands, which supported 39 and 49 pairs, respectively in 1986, had decreased by 97% and 63%. We have noticed large numbers of Bald Eagles roosting on Low and Skedans islands in May and June and their presence may inhibit breeding at those sites in some years. If we continue our counts annually we can determine the extent to which gulls move among the various colonies in Laskeek Bay from year to year.

Most clutches were of three eggs (184/220=84%). Two nests at Lost Islands on 14 June contained small chicks. Assuming an incubation period of 27 days from clutch completion and an interval of two days between each egg of a three egg clutch, first eggs were probably laid about 15 May.

Table 12. Counts of Glaucous-winged Gull nests in the Laskeek Bay area in 1992.

Location	Date (June)	Nests							Total
		Empty	1E	2E	3E	1E+1C	1E+2C	2C	
Kingsway Rock	10	4	4	9	77	-	-	-	94
Lost Islands	14	2	7	10	96	3	1	1	120
Skedans Islands	15	7	1	2	8	-	-	-	18
Low Island	15	-	-	1	-	-	-	-	1
Reef Island	14	-	-	-	-	-	-	-	2*

* pairs present, but nests not inspected

BLACK OYSTERCATCHERS IN SKEDANS BAY

During June we explored all likely breeding sites for Black Oystercatchers in the Skedans Bay area, as far south as Reef Island and also on the Lost Islands. At least 22 pairs were present in this area; 10 on the Skedans Islands, 3 on East Limestone Island, 5 on Reef Island and adjacent islets, 2 on Low Island, 2 on South Low Island and 2 on the Lost Islands. Active nests were found associated with all pairs except for 5 on the Skedans Islands and 1 on East Limestone Island. Raccoons were not thought to have been present on any of these islands in 1992.

Clutches consisted of 1 (1), 2 (8), or 3 (9) eggs. Some pairs apparently lost their first clutch and laid replacements, as eggs were present on visits more than 26 days apart. Because we made only a few visits to each nest we could not determine exact dates of hatching, but these probably ranged from 5-31 June, with some clutches still being incubated on 1 July. All five clutches on Reef Island hatched by 15 June, whereas the first of five clutches on the Skedans Islands hatched about 25 June. It appears that the peak of hatching for first clutches was probably mid-June. The earliest eggs, assuming two days between each laying and an incubation period of 26 days, were laid about 5 May, comparatively early for British Columbia (Campbell et al. 1990).

BIRD AND MAMMAL RECORDS

Minke Whale. Two seen feeding for about 1 h off the south coast of East Limestone Island on 14 March. One passed southwards on 29 June.

Humpback Whale. One adult and one juvenile were seen from the East Limestone Island cabin passing northwards on 4 June.

Orca. Not seen in 1992.

Harbour Porpoise. One north of Reef Island on 11 May.

Steller's Sealion. Counts at the haul-outs were as follows:
(1) Sealion Rocks, off Reef Island; 15 March 260, 5 May and 25 June 400-500
(2) Skedans Islands; 3 April 140, 28 April 55, 6 May 28, 1 June 28.

Harbour Seal. About 25 at Low Island on 11 May and 12 on 28 June. Often seen and heard in Cabin Cove on East Limestone Island, young heard after 12 June.

River Otter. Seen often on East Limestone Island, especially in Cabin Cove.

Raccoon. No definite evidence of raccoons was found on East or West Limestone islands, although one raccoon style predation was found in June (see above). Five were seen at Vertical Point, Louise Island during a spotlight count on 2 July.

Red Squirrel. Common on East Limestone Island.

Black-tailed Deer. Several present on East Limestone Island, with up to 5 adults counted. One new fawn was seen on 7 June.

Pacific Loon. Maximum numbers on boat surveys (33) were recorded on coastal transects on 28 May. About 100 were present in small flocks between the Limestone and Low islands on 5 and 6 May and 75 were seen around the Skedans islands on 8 May.

Red-necked Grebe. Single birds off East Limestone island on most days in March.

Sooty Shearwater. Several feeding flocks of up to 100 were present 3-9 km east of Reef island on 5 May. About 20 were seen south of Reef island on 15 June.

Fork-tailed Storm Petrel. Heard calling often at night and seen flying near Cassin's Tower on 2 July.

Pelagic Cormorant. Up to several hundred roosted on Kingsway Rock, Vertical Point and East Limestone Island during March-July. About 400 were present at Sealion Rocks, off Reef Island on 15 March. In June most were in non-breeding plumage. There were eight occupied nests at the east end of Reef Island on 25 June.

Double-crested Cormorant. Seen frequently in March and early April, with a maximum count of 21 at Skedans Islands on 15 March. Last recorded on 9 May.

Canada Goose. A flock flew north on 11 April.

Pacific Brant. Flocks of 15->100 were seen between 24 April and 13 May.

Green-winged Teal. Twelve near Vertical Point on 15 May.

Black Scoter. One off East Limestone Island on 14-15 March.

Bald Eagle. One pair nested on East Limestone Island, rearing one young hich was still in the nest on 3 July. Between 75-100 were present on the Skedans islands on 21 May and 13 were soaring over Limestone Island on 28 May.

Peregrine Falcon. Although a pair was present irregularly near the breeding site on East Limestone Island there was no evidence of nesting. At Reef island one pair reared 1 young at the western eyrie, but no birds were seen at the eastern site.

Sharp-shinned Hawk. One seen near the cabin on 30 June.

Blue Grouse. Heard drumming on East Limestone Island almost daily between 15 April and 24 May.

Black Oystercatcher. Three pairs were present on East Limestone Island, but no young were hatched before mid-June. Pairs were also present on West Limestone I. (1), Low I. (1), South Low I. (2), Kingsway Rock (1) and Reef I. (at least 4, including 2 with chicks in early June).

Whimbrel. Sixty flew north and 7 were present at Skedans on 11 May.

Wandering Tattler. One seen on East Limestone island on four dates between 17-29 May.

Red-necked Phalarope. Twelve were seen on boat surveys on 9 June.

Glaucous-winged Gull. At Kingsway Rock on 10 June there were 64 occupied nests; 54 with three eggs, 8 with two eggs and 2 with 1 egg. Eight empty cups were also present. At Low Island on 11 June there were 7 empty nests, 3 nests with one egg and one with two eggs and on the islets at the east end of Reef Island there were 3 nests with three eggs and one with two eggs.

Herring Gull. About 200 east of Reef Island on 15 March.

Black-legged Kittiwake. Not recorded in 1992

Marbled Murrelet. See section on boat surveys.

Cassin's Auklet. Sixteen nest boxes were placed on East Limestone Island in mid-March, 14 of them on "Cassin's Tower", where a presumed raccoon dug up most of the burrows in 1991. There was no sign that any of the boxes were used in 1992, but one eggshell was found on the tower, so presumably some birds returned to the site. Calling was heard frequently in the Cabin Cove area.

Tufted Puffin. Two flew north off Cabin Cove on 26 June and 1 was seen near Skedans on 1 July.

Rhinoceros Auklet. Heard several times at night on East Limestone Island. Seen frequently during the gathering ground count and common on boat surveys in June.

Saw-whet Owl. Heard calling on East Limestone Island on several nights in June.

Belted Kingfisher. Often seen on the west coast of East Limestone Island.

Hairy Woodpecker. Two pairs were present on East Limestone Island, and a pair with 2 young was seen on 26 June.

Flicker. A nest was active in a dead snag close to the cabin on East Limestone Island. Birds were first seen at the hole on 25 April and the young fledged on 24 June.

Red-breasted Sapsucker. At least ten nests with chicks were present on East Limestone Island. Chicks were first heard calling on 26 May and the first fledged on 15 June.

Rufous Hummingbird. First recorded on 20 April.

Western Flycatcher. First recorded on 1 May.

Northwestern Crow. No nests were found in "Crow Valley" this year, despite a thorough inspection in early June. Nor were the flocks of 10-30 crows seen in 1991 a regular feature of East Limestone Island this year.

Winter Wren. Fledged young seen on East Limestone Island on 22 May.

Yellow-rumped Warbler. One on East Limestone island on 30 June.

Orange-crowned Warbler. First recorded on 22 April.

Townsend's Warbler. First recorded on 14 April.

Yellow Warbler. One seen on East Limestone Island on 27 May.

Golden-crowned Kinglet. Heard singing on 15 March. First juveniles seen on 6 June.

Swainson's Thrush. First recorded on 2 June.

Hermit Thrush. Not recorded until 10 April.

Varied Thrush. Heard singing from 15 March.

American Robin. One on East Limestone Island on 12 April.

Tree Swallow. Two at Kingsway Rock on 10 June.

Dark-eyed Junco. Family party seen on East Limestone Island on 27 May.

Song Sparrow. First recorded on East Limestone island on 15 March.

Fox Sparrow. One pair seen regularly in Spring Valley.

Other species recorded (other than those listed in Table 9)

Raven	Red Crossbill
Chestnut-backed Chickadee	Pine Siskin
Brown Creeper	

SURVEY OF ANCIENT MURRELET COLONY AT DODGE POINT ON LYELL ISLAND, IN 1992.

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Background and methods

The Ancient Murrelet colony at Dodge Point, Lyell Island, was censused by the Canadian Wildlife Service in May and June 1982 (Rodway et al. 1988). At that time, rats were present throughout the colony and thought to be depredating the eggs of Ancient Murrelets. Rats are also present on the Ancient Murrelet colony on Langara Island where they have been implicated in the decline of the nesting population of Ancient Murrelets (Bertram 1989).

To evaluate the effects of rats on the population at Lyell Island we decided to repeat the colony census in 1992, using methods similar to those employed in 1982. The task was carried out between 5-19 June 1992 and involved, in addition to myself, seven volunteers from the Laskeek Bay Conservation Society. As one of the original 1982 field crew, I was able to ensure that the methods adopted were very similar to those used earlier.

The 1982 census consisted of counts of burrows in 5m x 5m quadrats spaced at 20m intervals along 22 transects run perpendicular to the shore throughout the colony area and placed 200 to 300m apart. A sample of burrows along the transects, and within a large plot in the core area of the colony, were examined to determine occupancy.

We resurveyed ten of the original 22 transects, selecting alternate transects to ensure that we covered the whole extent of the original colony area. The beginning points of transects were located from detailed maps, written descriptions and metal markers placed on trees in 1982.

Some modifications were made to the methods used in 1982. We increased the plot size to 7m x 7m, a size better suited to low density colonies, such as Lyell Island. However, we also recorded

the number of burrows within a 5m x 5m area of each quadrat to enable us to make better comparisons with the previous survey. In addition to data on occupancy obtained from within the quadrats, we determined the contents of burrows in six selected plots: (1) along transect 14 around quadrats 8 and 9; (2) on transect 20 in the vicinity of quadrats 4 and 5 and (3-6) in the vicinity of Dodge Point, near transect 12.

As we conducted our survey after the end of the breeding season, we recorded a burrow as occupied if it contained hatched egg membranes, depredated eggs or fresh carcasses. If no evidence was found in burrows that were completely explored, then these were designated as empty (no nesting effort in 1992).

Burrows are very sparse over much of the area occupied by Ancient Murrelets on Lyell Island. Consequently, defining the boundaries of the colony was difficult. As in 1982, the colony area was taken to include all areas where burrows showed recent signs of activity. Where burrows were located, but no signs of recent activity were observed, those parts of the colony were considered abandoned. If there were no burrows within a quadrat, the surrounding area was searched to determine if the plot fell within the colony boundaries. If signs of activity were found within a distance halfway to adjacent quadrats along the transects or half the distance laterally to adjacent transects, the area was considered part of the colony and the data obtained from the quadrat was included in calculations of burrow density. If no burrows were found within this range, the area was not considered to be part of the colony and the quadrat data was not used in density calculations.

As we were unable to repeat all of the 1982 transects, the delineation of the extent of the colony in 1992 was not as precise. For those areas that we were unable to survey this year, we assumed that the colony boundaries had remained unchanged, unless there was any evidence to the contrary. In addition to the census, we kept note of any evidence of predation on Ancient Murrelets, either in the burrows, or on the surface.

Results

As in 1982, the Ancient Murrelet colony on Lyell Island was found to extend along the coast south of Dodge Point to within 750m of Fuller Point and westward along the north coast for 1100m. An isolated patch of burrows further west (1600-2200 m west) of Dodge Point was still present. Although the length of the colony was substantially unchanged, it appeared to have contracted in width, beginning further from shore, and extending a shorter distance upslope in some areas, than it did in 1982 (Table 1, Figure 1). Areas at the two extreme ends (transects 2-4; 18-22) showed very little nesting activity this year compared to 1982. These areas were included in the current colony boundaries, giving a total area of 94.95 hectares, compared to 125.8 ha in 1982. The core area remains concentrated around Dodge Point (transects 8-16). Pockets at the two extreme ends of the colony that were moderately dense in 1982 (transects 2, 18 and 20) are now very sparse.

Of the 169 plots surveyed along the 10 transects, 101 fell within the colony boundaries. Within the 7m x7m plots, we found 76 burrows, with 32 burrows in the 5m x 5m portions (Tables 2 & 3) Using only data from transects surveyed in both years, 47 burrows were counted in 5m x 5m plots in 1982 (Table 4). Burrow densities appear lower overall at 127 $\pm$ 26 burrows/ha in 1992 compared to 172 $\pm$ 36 burrows/ha in 1982 (derived from data in 5m x 5m plots along transects run in both years) (Table 5).

The density of burrows varied, with the highest density found around Dodge Point. I categorised the colony into two density classes (higher and lower, Figure 1). Higher density areas had continuous burrows along transects, with burrows present in most plots. In lower density areas burrows were infrequent and rarely occurred in plots (these classes are equivalent to the high and medium density areas designated in the 1982 survey). Within the 38.1 ha of the high density area, mean burrow density based on the 7m x 7m plots was 276$\pm$48 burrows/ha (N=48), while in the lower density area (56.9 ha) it was 42$\pm$20 burrows/ha (N=53). The

corresponding figures for the 5m x 5m plots were 208±45 and 53±24 burrows/ha.

Seventy burrows were excavated to determine occupancy (Table 6). Of these, 57.1 ± 8% had been occupied this year, slightly higher than, but not significantly different from, the occupancy rate of 52 ± 3% in 1982. However, only half (20 of the occupied burrows) successfully hatched young this year. The remainder, 50 ± 13%, held depredated adult birds or eggs, a much higher percentage of predation within the burrows than observed in 1982 (Table 5). We found no dead adult birds in burrows at that time.

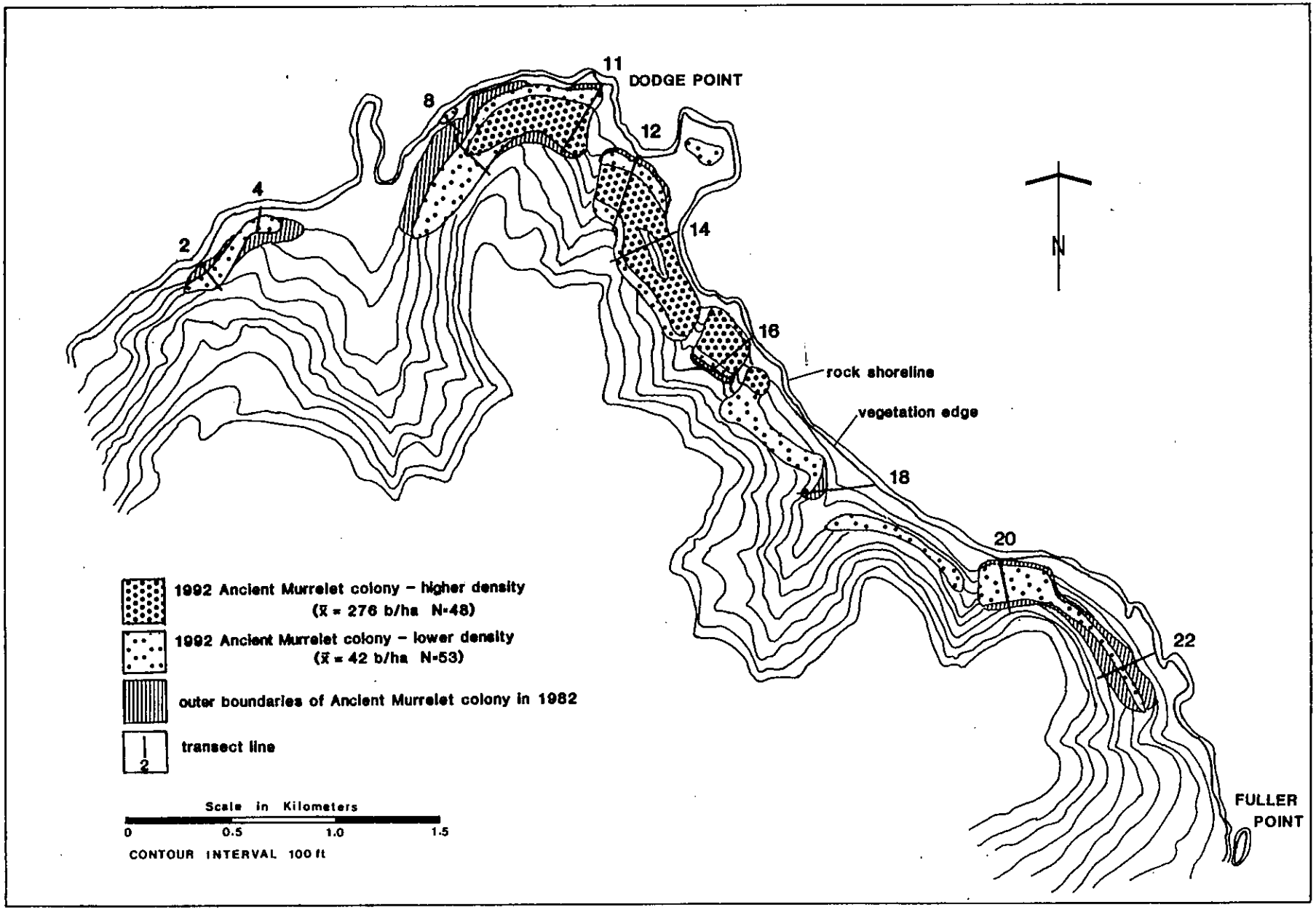

Figure 1. Ancient Murrelet colony area and transect locations on Lyell Island in 1992 and 1982.

Table 1. Extent of Ancient Murrelet colony along transects on Lyell Island in 1982 and 1992.

Transect	1982			Transect	1992		
	Distance along transect (m)	Range of elevation (m)	Average slope (°)		Distance along transect (m)	Range of elevation (m)	Average slope (°)
1	No colony						
2	20-140	22-112	33	2	50-190		30
3	120-200	60-88	21				
4	80-160	24-62	27	4	70-150		29
5	No colony						
6	320-540	43-162	20				
7	140-500	38-221	32				
8	80-400	35-235	35	8	0-30; 170-390	82-200	34
9	60-420	18-211	32				
10	10-290	12-190	34				
11	10-400	5-170	26	11	30-390	5-160	27
12	22-382	6-201	30	12	50-390	20-207	29
13	100-300	43-50	18				
14*	50-270	16-250	35	14	50-290	20-240	35
15	60-330	20-185	32				
16	30-330	14-139	28	16	30-310	25-145	31
17	150-290	93-187	38				
18**	250-350	74-121	21	18	330-390	100-120	22
19	120-210	77-141	37				
20	10-290	11-208	41	20	30-270	20-185	42
21	180-290	116-187	39				
22	120-270	70-176	39	22	190-230	115-145	38
23	No colony						
24	No colony						
25	No colony						

* 80 m of cliff excluded from ground measurement.
** location of tran 18 may be in different location in 1992 than in 1982.

Table 2. Number of Ancient Murrelet burrows in 7mx7m plots on Lyell Island in 1992. Plots considered outside the colony are indicated by a dash.

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

Table 3. Number of Ancient Murrelet burrows in 5mx5m plots along transects on Lyell Island in 1992. Plots considered outside the colony are indicated by a dash.

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

Table 4. Number of Ancient Murrelet burrows in 5mx5m plots along transects on Lyell Island in the original 1982 survey. Plots considered outside the colony are indicated by a dash. Only transects that were surveyed in the 1992 census are shown.

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

* Plots not surveyed in 1982, when the spacing of the plots along transect 12 was every 45m.

Table 5. Population estimates for Ancient Murrelets at Dodge Point in 1982 and 1992

Variable	1982		1992	
	All trans.	1992 trans*	5 x 5 qu.	7 x 7 qu.
Plot size (m^2)	25	25	25	25
Burrows/m^2: mean	0.0163	0.0172	0.0127	0.0154
s.e.	0.0028	0.0036	0.0026	0.0028
N	221	109	101	101
Occupancy: mean	0.52		0.57	
s.e.	0.03		0.08	
N	10		16	
Nest predation:				
mean	0.51		0.50	
s.e.	0.008		0.126	
N	10		16	
Colony area (ha)	125.8		94.9	
Total burrows:				
mean	20505	21638	12059	14622
s.e.	3522	4529	2469	2659
Occupied nests:				
mean	10656	11283	6876	8332
s.e.	1927	2456	1690	1899

* using only data from transects 2, 4, 8, 11, 12, 14, 16, 18, 20 & 22

Dead birds found in the burrows were located well within the tunnel, often close to the nest cup. They had been chewed about the neck, shoulder, and breast, and in most cases, the cranium had been chewed open. Depredated eggs were found within the nest chamber or the tunnel leading to the nest. In almost all cases the membrane was well thickened, making it seem likely that the eggs had been at an advanced stage of development when depredated. In some, bits of down were stuck to the inside of the membrane. Of the 20 burrows that had been depredated, five held dead adult birds. This represents 12.5% of the occupied burrows in 1992.

An estimate of the nesting population of Ancient Murrelets on Lyell Island using data from the 7m x 7m plots is 8332 $\pm$ 1899 pairs. Derived from the 5m x 5m plots the estimate is lower at 6876 $\pm$ 1690 pairs. Both these estimates are lower than the estimated nesting population of 10656 $\pm$ 1927 obtained in 1982 (Table 5).

Occupancy rates in the plots near Dodge Point (3-6) were higher than those for plots along transects 14 and 20 near the southern end of the colony (1 and 2) (table 6 and 7). This supports our observation that there was little sign of nesting activity in peripheral areas.

Evidence of predation on Ancient Murrelets was found on the surface throughout the colony, especially in the higher density areas. We recorded 37 feather piles, 27 pairs of wings, 61 single wings, 2 carcasses and 131 depredated eggs while carrying out our transects. Within the 7m x 7m quadrats we found the remains of 3 adult birds and 22 depredated eggs (Table 8). Extrapolating to the entire colony area yields an estimate of predation remains on the surface of 568$\pm$285 birds and 4216$\pm$1329 eggs.

The presence of bones in some burrows suggests that predation has been going on for some time. We were unable to reach the ends of most burrows so estimate are probably minimal. Overall, we found bones in 15% of the burrows that we inspected completely (Table 7).

Table 6. Occupancy of Ancient Murrelet burrows on Lyell Island in 1992.

Location	Empty 1992	Hatched eggshell 1992	Depredated Egg 1992	Adult Carcass	Total Known Nest Attempts 1992	Total Known Status 1992
Tran. 8-10			1		1	1
Tran. 11-19	1				0	1
Tran. 12-8		1			1	1
Tran. 12-12		1			1	1
Tran. 12-14	1				0	1
Tran. 12-15	1				0	1
Tran. 14-4		1			1	1
Tran. 14-14	1				0	1
Tran. 16-5		1			1	1
Tran. 16-9		1	1		2	2
Occupancy Plots						
1	9	1	3		4	13
2	2		1		1	3
3	7	4	1	2	7	14
4	2	8		2	10	12
5	4	2	2		4	8
6	2		6	1	7	9
TOTALS	30	20	15	5	40	70

Table 7. Burrow occupancy rate and proportion of burrows containing bones along transects and in occupancy plots on Lyell Island in 1992.

Transect	Total Number of Burrows	Burrows ends reached	Occupancy rate	Proportion of burrows with bones	
				All Burrows	Ends reached
2	3	0		0.00	
4	1	0		0.00	
8	6	1	100.00	0.17	0.00
11	15	1	0.00	0.00	0.00
12	14	4	0.50	0.00	0.00
14	25	7	0.43	0.08	0.00
16	10	3	100.00	0.00	0.00
18	0	0			
20	2	0		0.00	
22	0	0			
Totals:	76	16	0.56*	0.04*	0.00*
Occupancy Plots					
1	33	13	0.31	0.03	0.08
2	14	3	0.33	0.43	0.33
3	31	14	0.50	0.10	0.14
4	18	12	0.83	0.22	0.25
5	15	8	0.50	0.00	0.00
6	18	9	0.78	0.22	0.22
Totals:	129	59	0.56*	0.14*	0.15*

* Average values

Table 8. Depredated remains of Ancient Murrelets in 7mx7m plots on Lyell Island in 1992.

Trans	Plot	egg	chick	feather pile	pair wings	adult carcass	dug out burrow
2	9				1		
8	12			1			
8	19	1					
8	20	1					
11	8	2					
11	11	5					
11	18	1					
12	9	1					
12	12		1				
12	17			1			
14	4	2					
14	5	2					
14	6	1		1			
14	7					1	
14	8	1					
14	12						1
14	14						1
16	9	2					
16	12	2			1		
20	10	1					

Discussion

Our survey this year suggested that the density of burrows on Lyell Island declined between 1982 and 1992. Although the colony boundaries were similar to those found in 1982, the estimate of the number of breeding pairs is lower. The bulk of the colony is now concentrated around Dodge Point, with no other areas of dense burrowing, such as had been found in 1982. This suggests that the colony is indeed contracting. Burrow occupancy rates were similar in both years with 1992 rate slightly higher, but it seems almost certain that breeding success was lower this year than in 1982, when 72% of 25 study burrows produced chicks (Rodway et al. 1988) and signs of rat predation were found in only 8% of burrows inspected.

At Langara Island in 1988, Bertram (1989) found that the Ancient Murrelet colony had contracted considerably in area, but burrow occupancy had remained unchanged. Evidence of rat predation was found in 29% of burrows inspected. The similarity to the situation at Dodge Point is striking and suggests that a contraction in the occupied area, rather than a uniform reduction in density over the whole colony, is a typical reaction to predation by rats.

The decline in numbers of about 25% since 1982 is not, in itself, catastrophic. However, no evidence of predation on adult murrelets was found in 1982, whereas in 1992 12.5% of occupied burrows contained depredated adults. This suggests that predation by rats is probably becoming more severe on this colony and this seems almost certain to accelerate the present decline. Unfortunately, because of the size of Lyell Island, eradication of rats seems unlikely. It is possible that we shall have to accept the extirpation of Ancient Murrelets from Lyell Island; an ironic outcome, considering that protection of the murrelets was a major issue in the fight to save Lyell Island from logging a few years ago.

SURVEY OF PERMANENT SEABIRD MONITORING PLOTS ON RAMSAY ISLAND

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Introduction

In 1984, the Canadian Wildlife Service established twelve 20 x 20m plots within the Ancient Murrelet colony, and eight 15 x 15m plots and one 20 x 24m plot within the Cassin's Auklet colony on Ramsay Island (Table 1, Figure 1). The corners of the plots were marked with colour-coded flat aluminum stakes and labeled with engraved aluminum tags nailed on the tree closest to the lower left corner of the plot (when facing the interior of the island). The Cassin's Auklet plots were all located at the shoreline, and their aluminum tags were placed on white plastic backings. The Ancient Murrelet plots were set back in the forest, and the distance from shore and bearing to the plots were measured. This information was engraved on a metal tag with a red plastic backing and nailed onto conspicuous tree trunks along the shore. There were eight of these bearing points established on the shore.

Each plot was mapped and the positions of trees, stumps, logs and other features were recorded. The locations of burrows were mapped in relation to these features and a detailed description of each burrow was recorded. Burrows were examined by feeling through the entrance; no excavations were performed. All signs of occupation by birds (eggshells ,membranes, feathers and regurgitated food etc) were recorded.

On June 16,17, and 18 1992, five observers resurveyed eleven of the twelve Ancient Murrelet and one of the Cassin's Auklet monitoring plots on Ramsay Island. Two additional Cassin's Auklet monitoring plots were resurveyed by one of the volunteers (Jason Jones) on August 1, 1992. Plots were relocated and examined in the same way as during the original survey. The

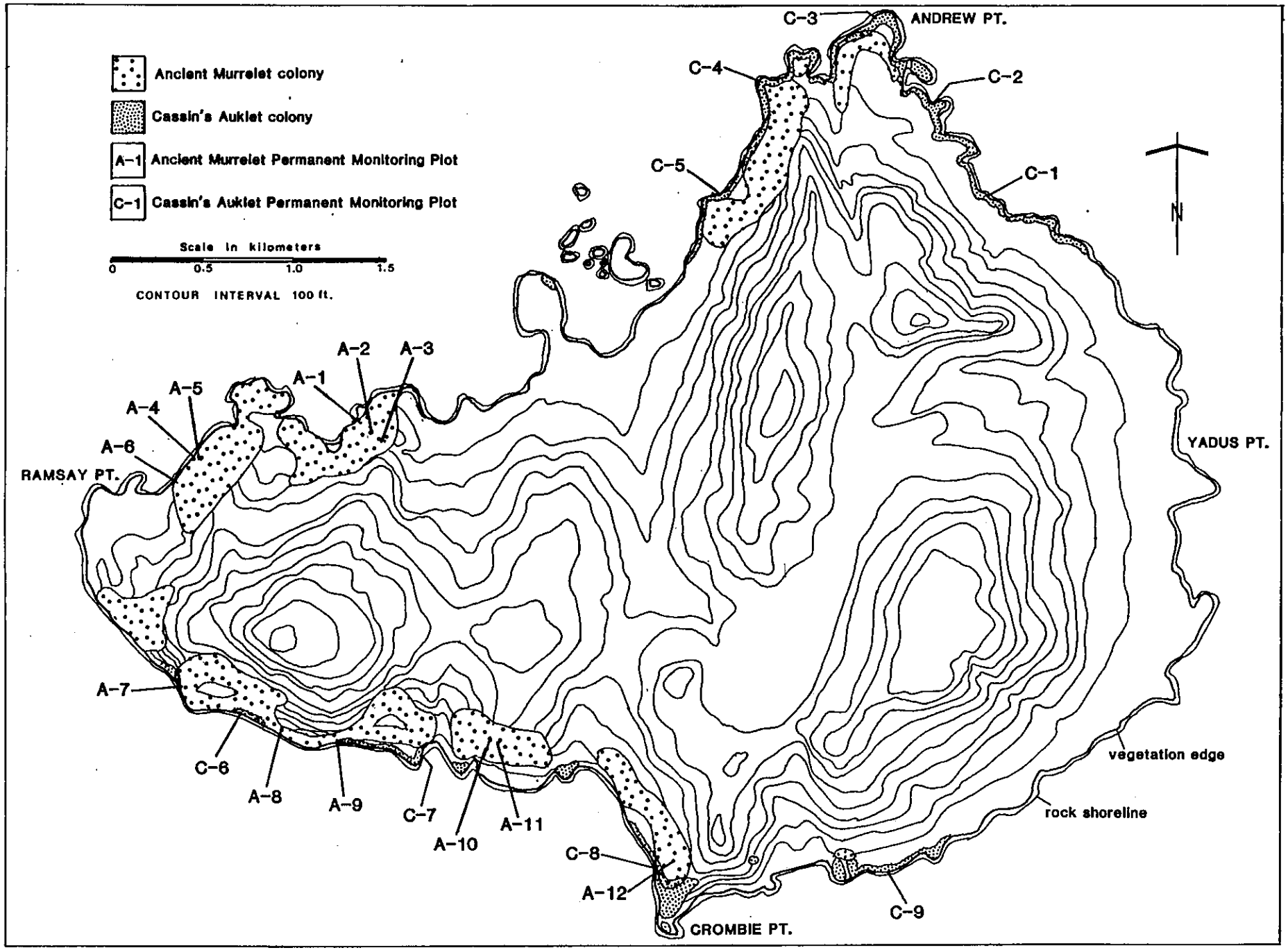

Figure 1. Permanent Seabird Monitoring Plot locations on Ramsay Island.

positions of new burrows were added to the original maps. Burrows less than 30cm deep and without nest chambers were recorded as "starts"; these were mapped, but not counted in the total number of burrows.

Results

The numbers of Ancient Murrelet burrows increased in 10 of the 11 plots that we surveyed, ranging from 5 to 64% increase in burrow numbers (Table 2). One plot showed a decrease of 36%. The total of all plots rose from 206 burrows in 1984 to 252 burrows in 1992, an increase of 22%. This increase in burrow numbers is a little less than the 27% increase in burrow numbers in plots resurveyed on George Island in 1991. A small number of burrows present in 1984 had filled in and were no longer visible when we resurveyed them this summer. Plots which showed the smallest increase were located near the colony boundaries. In plot 12, which showed a decrease in burrow numbers, a tree had fallen across part of the plot destroying a few burrows.

Although we were not able to resurvey all of the Cassin's Auklet permanent plots, all three plots examined showed a decrease in burrow numbers between 1984 and 1992 (Table 3). The total burrows in the three plots decreased from 100 burrows in 1984 to 92 burrows in 1992 a decrease of 8%.

Discussion

Ancient Murrelets often dig new burrows when they begin to breed, even when burrows dug previously are available (Gaston 1992). Changes in numbers of Ancient Murrelet burrows on the monitoring plots presumably reflect a continuing recruitment of new breeders to the area. The effect on total population is uncertain, as we do not know the proportion of occupied burrows, but a decrease appears unlikely. Cassin's Auklets, on the other hand, do not appear to dig new burrows where existing burrows are available; occupancy rates are usually uniformly high. The decrease in burrow numbers on the study plots may therefore

indicate a modest population decline. However, any conclusions will have to await examination of the remaining monitoring plots, hopefully in 1993.

Table 1. Details of monitoring plots set up for seabirds on Ramsay Island in 1984 by the Canadian Wildlife Service.

	Plots	Size mxm	Burrows/plot (range)	Total Burrows		
				In Plots	In Colony	% Colony in Plots
Ancient Murrelet	12	20 x 20	18 (7-35)	218	28156	0.8
Cassin's Auklet	8 1	15 x 15 20 x 24	36 (18-58) 57	346	18049	1.9

Table 2. Numbers of Ancient Murrelet burrows recorded in permanent monitoring plots on Ramsay Island in 1984 and 1992.

STATUS	PLOT											
	1	2	3	4	5	6	7	8	9	10	11	12
1984	20	7	11	35	22	28	7	24	12	14	24	14
1992												
"OLD" Burrows	18	7	11	31	16	23	5	23		14	24	9
"NEW" Burrows	3	3	2	11	13	7	3	11		9	9	0
TOTAL 1992*	21	10	13	42	29	30	8	34	not done	23	33	9
% INCREASE/ DECREASE	5	43	18	20	32	7	13	42	not done	64	38	-36

* These numbers do not include new "starts"; short tunnels without any nest chamber, apparently in the process of construction.

Table 3. Numbers of Cassin's Auklet burrows recorded in permanent monitoring plots on Ramsay Island in 1984 and 1992.

STATUS	PLOT								
	1	2	3	4	5	6	7	8	9
1984	40	45	34	40	58	28	18	26	57
1992									
"OLD" Burrows			32	34				22	
"NEW" Burrows			0	1				3	
TOTAL 1992**	*	*	32	35	*	*	*	25	*
% DECREASE			6	13				4	

* Plots not resurveyed in 1992
* These numbers do not include new "starts"; short tunnels without any nest chamber, apparently in the process of construction.

ECOLOGY OF BLACK OYSTERCATCHERS AT EAST LIMESTONE ISLAND

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Abstract

Observations were made on a pair of Black Oystercatchers feeding chicks at East Limestone Island. Chicks were fed more frequently in the interval from high tide to mid tide than from mid tide to low tide. Transects lines were used to determine the size ranges of food available and food remains were collected at the nest to determine food selected. An ANOVA showed that there was selective foraging with respect to individual organisms of limpets. A chi-squared test showed that there was a significant difference with respect to size of limpets and mussels that were available and those that were taken to the nest. In conclusion, the Black Oystercatcher forages preferentially to feed its chicks during certain tidal conditions and is selective in its foraging with respect to some species and sizes.

Introduction

Black Oystercatchers are common birds in the Laskeek Bay area, breeding on the rocky coasts of the smaller islets. The female lays 1-3 eggs in a scrape nest located above high tide, usually on gravel or in a depression in the rocks. Incubation takes about 29 days and the chicks are fed by their parents for another 35 days until fledging (Ehrlich et al., 1988). Most of the foraging during this period takes place in the inter-tidal zone adjacent to the nest site, or within about 100 m of it.

Because the state of the tide determines how much of the inter-tidal zone is available to Oystercatchers for foraging, we might expect the tidal cycle to have a marked effect on the rate of provisioning of the chicks. I observed a pair of

Oystercatchers feeding their chicks to determine whether foraging was affected by the state of the tide, and if so, how. In addition I sampled the remains of food items fed to chicks and compared these remains to those available by systematically sampling the inter-tidal zone.

Methods

I observed the pair of Black Oystercatchers located on Oystercatcher Point, East Limestone Island from the adjacent peninsula (approximately 80 m from the nest site) on three days (27, 28 and 29 June). Observations were carried out for five and one half hours each day during the ebb tide. Using binoculars and a stop watch, I recorded the time when the adults left the nest, when they returned and whether or not the chicks were fed.

Five transect lines were fixed at different locations on Oystercatcher Point and the adjacent peninsula during low tide, all in areas where the oystercatchers foraged frequently. The lines were run from the water's edge to the top of the barnacle zone. Their total length depended on the slope (8.8m, 12m, 6.25m, 7.5m and 16.25m), but each was divided into 8 equal segments. Starting at the bottom of the transect line, a 0.5 m square quadrat was placed in a checker board fashion up the transect line so that the bottom of the quadrat was placed level with the bottom of each segment. I counted the numbers of chitons, mussels and limpets in each quadrat and classified them into three size classes (A, B, C), by comparing them with a small board on which the designated size ranges were marked. At the same time, I collected all food remains (shells) from the feeding area (usually a relatively flat, sheltered area about 2 m^2 in extent. I also collected food remains from chick feeding sites at Reef Island (4), South Low Island (1), Low Island (1) and Skedans Island (1). The maximum length of all the shells collected were measured with calipers.

Results

One parent oystercatcher remained with the chicks at all times. During the 16 hours of observations, the oystercatcher chicks were left alone for no more than 4 minutes at a time and for only 9 minutes in total. The chicks received an average of 5.8 feeds/h during watches. However, there were 22 feeds during the last half hour period of the watch on day 2; more than three times as many as in any other half-hour period. This outlier has consequently been omitted from further analyses. Without it, the chicks received 4.5 feed/hour. On all three days chicks were fed more frequently during the first 2.5 h after high tide than during the subsequent 2.5 h period (Table 1). Summing results for the three days, 71% of feeds occurred during the first 2.5 h (N=69), a significant difference from the second 2.5 h (Chi^2 = 12.2, $P<0.01$).

Limpets made up 65% (N=276) of food items found at the study nest, with 96% of them being between 40-70 mm in maximum diameter. This differed significantly from the proportion found in the quadrats, where the preferred size range made up only 44% of those found (chi^2=1251, df=2, $p<0.0001$, Table 2). Mussels, which made up another 20% of food items collected, were also taken selectively, with 98% of those found at the feeding site being 12-33 mm in length, compared to only 1% of those found on transects (chi^2= 56.2, df=2, $p<0.005$). However, there was no significant difference found in the sizes of chitons, which made up the rest of the prey remains found at the nest (chi^2= 0.26, df=2, $p<0.05$).

Table 1: Numbers of times that chicks were fed in relation to the state of the tide

Time after high tide (h)	Number of times chicks fed		
	Day 1	Day 2	Day 3
0.0-0.5	1	1	4
0.5-1.0	4	1	3
1.0-1.5	5	4	4
1.5-2.0	4	4	7
2.0-2.5	4	1	2
2.5-3.0	1	4	3
3.0-3.5	2	1	1
3.5-4.0	2	0	0
4.0-4.5	2	0	1
4.5-5.0	1	1	1
5.0-5.5	NA	22	1

Table 2. Availability of food in relation to size

Organism	Mussel			Limpet			Chiton		
Trans #	A <40mm	B 40mm-70mm	C >70mm	A <12mm	B 12mm-33mm	C >33mm	A <20mm	B 20mm-35mm	C >35mm
1	31	6	1	168	4	0	0	6	10
2	14	1	1	207	1	0	0	0	1
3	37	32	11	204	0	1	0	1	5
4	173	58	8	322	5	0	0	4	4
5	270	396	77	284	3	0	0	0	11
Totals	525	494	98	1185	13	1	0	11	31
%	47	44.2	8.8	98.9	1.1	0	0	26.2	73.8

Table 3. Food selected in relation to size

Organism	Mussel			Limpet			Chiton		
Size Range	A <40mm	B 40mm-70mm	C >70mm	A <12mm	B 12mm-33mm	C >33mm	A <20mm	B 20mm-35mm	C >35mm
Nest #1	1	52	1	1	177	2	0	9	33
%	2	96	2	0.6	98.3	1.1	0	21.4	78.6

Table 4. Differences among nest sites in the proportions of different prey remains found

Nest site	Total # of organisms	Limpets	Mussels	Chitons
1	276	180	54	42
2	367	291	59	17
3	193	147	43	3
4	87	16	52	19
5	102	81	11	10
6	21	1	11	9
7	56	49	5	2
8	228	168	56	4

There was a significant difference among sites in the proportions of different organisms selected ($F=6.84, df=2, p<0.05$).

Discussion

As I watched only one pair of oystercatchers, and on only three days, it was not possible to generalize about the results. However, they suggest that the tidal cycle may affect foraging in this species, and that the oystercatchers are selective in their feeding. The half hour on day 2 when 22 feedings were observed was omitted from the statistical analysis because during this period the one adult remaining with the chicks was foraging at the barnacle zone, three feet below the nest, and delivering very small fragments to the chicks. This behaviour had nothing to do with the tidal conditions because barnacles are always available. Another factor that affected the foraging habits of the adults was any sign of danger. Eagles, gulls or ravens flying nearby, and especially overhead, elicited loud warning calls from the adult at the nest, causing the foraging adult to return.

The Black Oystercatcher pair on Limestone Island was found to be selective in feeding their chicks mainly on limpets and mussels at the large end of the spectrum of those available. Perhaps their predation accounts for the lack of large limpets in the transect samples. Comparing the nests sampled, six of the eight had more limpets than any other type of food (Figure 9).

The part of the study comparing food remains at different nests in the Laskeek Bay area included only hard-bodied animals that would leave remains after they were eaten; other species that may have been fed to chicks could not be detected. On one occasion I observed an oystercatcher chisel the meat out of a limpet and

deliver only the meat to the chicks and this may occur fairly frequently, possibly biasing the sample collected, compared to the actual size distribution and frequency of prey collected. However, the collections analysed show that there is a lot of variation in the food fed to chicks at different nests. It would be interesting to see how this variation relates to the availability of prey.

FOREST BIRDS AND FOREST TYPES ON THE LIMESTONE ISLANDS

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Introduction

A recent study of land birds on the islands around Laskeek Bay concluded that variation in vegetation structure and composition could affect the distribution of forest birds (Martin and Gaston, LBCS Scientific Report for 1991). As a follow up to their study I investigated the relationship between vegetation and the occurrence of different bird species on East and West Limestone Islands.

I defined five priciple vegetation types: mature spruce-hemlock (SH), mature cedar-spruce (CS), regenerating spruce (SR), regenerating alder (AR) and mature spruce-cedar (SC). Using a point count method similar to Martin and Gaston, I recorded birds at 35 stations distributed randomly in the five forest types. At each station I spent 20 minutes and recorded all the birds seen or heard within an estimated radius of 50 m. All points were selected to be at least 100 m from any point previously sampled on the same day and at least 50 m from the boundary of the chosen vegetation type. However, the last criterion was not always met because of the shape of certain vegetation types. Each vegetation type was sampled at least six times between 26 and 29 June 1992 in conditions ranging from sunny to overcast and slight to moderate winds. Most counts were performed in the early morning, afternoon or evening, but those on West Limestone Island were conducted in mid-morning and early afternoon. Species commonly encountered in flocks (Golden-crowned Kinglet, Chestnut-backed Chickadee, Red Crossbill and Pine

Siskin) were recorded by flocks, rather than by individuals.

At each station I recorded the amount of cover present in five layers of vegetation: ground (0-5 cm), upper ground (5-30 cm), shrub (30 cm-5 m), subcanopy (5-20 m) and canopy (>20 m). I also recorded the frequency of dead snags and the slope and aspect. Vegetation cover was greater in the regenerating than in the mature vegetation types in all layers except the canopy. In mature vegetation types canopy cover was similar, but ground and shrub cover was lower in cedar-spruce than in the other two types.

Results

To compare the total numbers of species in each vegetation type I used only the first six stations sampled in each type. The total species recorded varied from 12 in mature spruce-cedar to 16 in regenerating spruce. Variation in the average number of species recorded per station was greater in the regenerating vegetation types and ranged from 5.3 in regenerating alder to 10.2 in regenerating spruce (Table 1).

Table 1. Total numbers of species recorded and average numbers recorded per station in relation to vegetation type

Vegetation type	Total species recorded	Average species per station
SC	13	7.2
SR	17	10.2
CS	16	6.4
AR	13	5.3
SH	15	9.0

Only six species were recorded in all 5 vegetation types: Chestnut-backed Chickadee, Western Flycatcher, Golden-crowned Kinglet, Winter Wren, Varied Thrush and Red Crossbill. The ubiquity of these birds may be related more to their tendency to vocalize frequently, rather than to their abundance. Among the small birds (Northern Flicker or smaller) that are most likely to be specific to a particular vegetation type, Wilson's Warbler and Song Sparrow were found only in one vegetation type, regenerating alder. Brown Creeper, a specialist on large tree trunks, was absent from the two regenerating vegetation types.

To compare the similarity among the birds of different vegetation types I calculated an index of similarity (S) from the formula:

$$S = 2C/(A+B)$$

where A and B are the numbers of species recorded in two vegetation types and C is the number found in both. This index ranges from 0 (no species in common) to 1 (all species found in both vegetation types). The average similarity between the birds of regenerating alder and those of other vegetation types was 0.68. The average similarity between other vegetation types was 0.77 (Table 2). This suggests that alder, the only broad-leaved vegetation type, may support a slightly different bird community from that of the coniferous vegetation types.

Table 2. Similarity indices among the five vegetation types

Vegetation type	Vegetation type				
	SC	CS	SR	SH	AR
SC		0.69	0.80	0.71	0.74
CS			0.73	0.82	0.60
SR				0.86	0.77
SH					0.62
Mean S			0.77		0.68

I compared numbers of individuals recorded per count to determine the extent to which density varied with vegetation type. These numbers are clearly influenced by the conspicuousness of the species involved. The highest density recorded was for Townsend's Warbler in mature spruce-cedar (Table 3), but this species was absent from mature cedar-spruce, suggesting that it may avoid cedar, to some extent. Golden-crowned Kinglet was the most evenly distributed species with an average of more than one record per station in four of the five vegetation types.

Discussion

I found little variation in the numbers of bird species occurring in different vegetation types on the Limestone Islands. This may be because either many species are equally at home in different habitats, or my stations, being close to vegetation boundaries, picked up birds from adjoining vegetation types. However, some differences that I detected, such as the presence of Wilson's Warbler in regenerating alder, the absence of Brown Creepers from regenerating alder and spruce, and the absence of Townsend's Warbler from mature cedar-spruce, may reflect habitat

preferences.

As my study was carried out over a short time it provides only a brief "snapshot" of vegetation preferences at a certain stage of the season. Preferences for individual species may change over the course of the year. Moreover, turnover of the island avifauna may alter species composition from year to year. Further understanding of rates of turnover, as well as habitat preferences, may be important as habitat continues to be eroded by logging on nearby Louise Island.

The vegetation of Limestone Island, especially the ground and shrub layers, has been much alterred by the browsing of introduced Black-tailed Deer. The species composition and density of the bird fauna may have been significantly affected by these changes. A better understanding of habitat requirements by birds may allow us to reconstruct the impact of the deer on bird communities in the Queen Charlotte Islands.

Table 3. Average numbers of individuals recorded per station in each vegetation type

Species	Vegetation type				
	SC	CS	SR	AR	SH
Bald Eagle	1.0	1.0	1.5	-	1.0
Glaucous-winged Gull	-	1.0	-	-	1.0
Hairy Woodpecker	-	1.0	-	-	1.0
Northern Flicker	-	-	1.0	-	1.0
Red-breasted Sapsucker	1.0	-	2.0	-	1.3
Northwestern Crow	-	1.0	2.0	1.0	-
Common Raven	-	1.0	-	-	-
Chestnut-backed Chickadee	1.0	1.1	1.0	2.0	1.2
Dark-eyed Junco	1.0	-	2.0	1.0	1.0
Western Flycatcher	1.4	1.0	1.0	1.2	1.3
Brown Creeper	1.0	1.0	-	-	1.0
Red-breasted Nuthach	-	1.0	1.4	-	1.0
Golden-crowned Kinglet	1.5	1.6	1.5	1.0	1.4
Winter Wren	1.0	1.0	1.3	1.0	2.0
Swainson's Thrush	-	-	1.3	1.3	1.0
Hermit Thrush	-	1.5	1.3	-	1.0
Varied Thrush	1.0	1.8	1.0	1.0	1.6
Red Crossbill	1.6	1.7	2.4	1.0	1.0
Pine Siskin	1.0	-	2.0	-	2.0
Orange-crowned Warbler	1.0	1.8	1.0	1.2	-
Townsend's Warbler	3.2	-	1.0	1.7	2.3
Wilson's Warbler	-	-	-	1.0	-
Song Sparrow	-	-	-	1.0	-

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