LASKEEK BAY CONSERVATION SOCIETY

ANNUAL SCIENTIFIC REPORT, 1993

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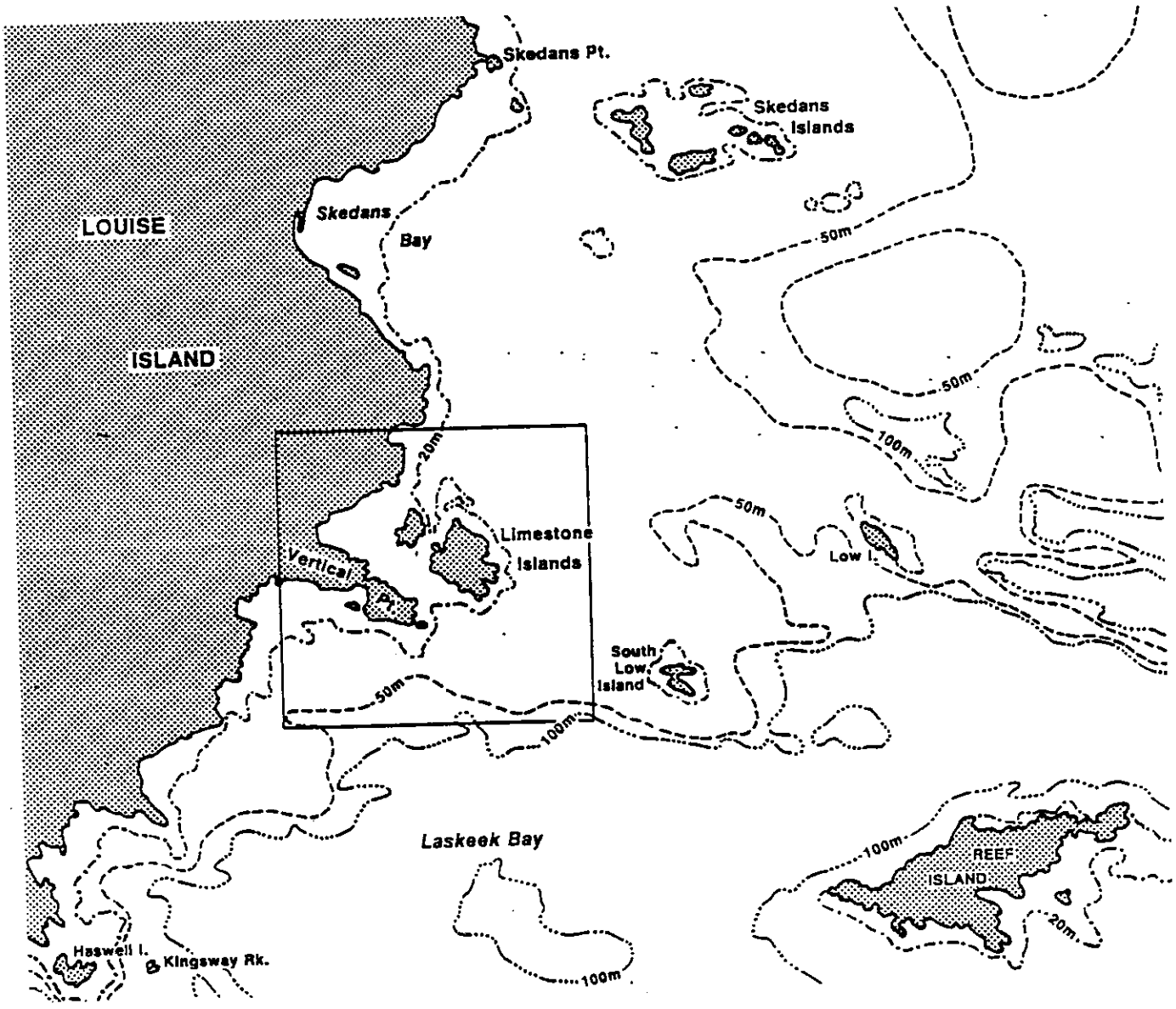

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Edited by

ANTHONY GASTON and KATHY HEISE

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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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BACKGROUND

The 1993 season was the fourth year of operations for the Laskeek Bay Conservation Society, a group founded by conservationists and biologists mainly living in Haida Gwaii. The goals and objectives of the Society are:

1. To undertake and support research and long term monitoring of wildlife populations, including nesting seabirds and other marine birds, forest birds, marine mammals and introduced species of the Laskeek Bay area (roughly coastal waters of Hecate Strait from Cumshewa Inlet to Lyell Island) of Haida Gwaii, the Queen Charlotte islands.

2. To provide information on all aspects of the biology of the Laskeek Bay area for residents of Haida Gwaii, the Queen Charlotte islands, and visitors to the area.

3. To encourage students and residents of the area to participate in field programs and to undertake and assist in presentations and other activities that promote better understanding and improved conservation of marine birds and forested and marine ecosystems throughout Haida Gwaii, the Queen Charlotte Islands.

The Laskeek Bay Conservation Society organizes a volunteer programme each summer to carry out educational activities based on biological monitoring and research. During the past four years, a camp at East Limestone Island has been operated for an increasing period each season and in 1993 it was run from early April to mid-July. In this report we present details of the 1993 field work and summarise the results of the research carried out to date.

The scientific work so far carried out continues and extends a programme that was initiated by the Canadian Wildlife Service in 1984. The aim of the work is to provide long term information on the biology and ecology of marine birds. Because they are top predators in marine food webs, marine birds are very sensitive indicators of environmental change. Things like the abundance of zooplankton, that may be difficult and expensive to measure directly over large areas, are reflected in changes to the behaviour and abundance of marine birds. By tracking a variety of species, with different habitat and diet needs, we can obtain an overall measure of the health of the marine ecosystem locally. Because marine waters may be subject to cyclical or directional changes operating at the scale of decades, such observations become most valuable when they are tracked consistently over many years.

In addition to the marine bird work, the society has undertaken 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.

Among seabirds, the main species of interest is the Ancient Murrelet, a small diving bird which is more common in Haida Gwaii 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. Knowledge about what is happening to Ancient Murrelet populations is important for the conservation of the species, both in Canada, and worldwide. In 1993, at the suggestion of the Laskeek Bay Conservation Society, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) commissioned a report on the status of the Ancient Murrelet. As a result it has been declared vulnerable in Canada. The surveys being conducted by the Society constitute the only long term study of Ancient Murrelets ongoing anywhere.

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. COSEWIC has declared it to be threatened 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 Laskeek Bay Conservation Society is continuing these surveys on an annual basis to provide an indication of the effects of logging on the Marbled Murrelet population. The sequence of boat surveys carried out to date is the longest run of replicated Marbled Murrelet surveys in Canada. However, given the year-to-year variation seen so far, we shall need many additional years of data to fully assess the effects of current logging.

A note on this report. Several of the tables and figures presented are identical to those shown in earlier reports, except for the addition of the 1993 data. This is deliberate. One of the main aims of our work is to provide information on long-term trends. With four years of work, and in some cases with comparable information from Reef Island for a further six years (1984-89), we are beginning to get a good idea of trends and inter-year variation. The value of the data obtained increases considerably as each year is added.

BRIEF STATEMENT OF ACHIEVEMENTS

1) Trapped 118 adult Ancient Murrelets, including 30 retraps from previous years, and 665 chicks at East Limestone Island. Estimates of adult survival rates suggest much higher mortality at East Limestone island than at Reef Island, presumably due to raccoons;

2) Monitored incubation activity and breeding success of 29 pairs of Ancient Murrelets that reared an average of 1.6 chicks each - normal for the species;

3) Carried out boat surveys of the Laskeek Bay area, covering approximately 600 km and seeing record numbers of Marbled Murrelets and Rhinoceros Auklets;

4) Censused Glaucous-winged Gulls and Black Oystercatchers in Laskeek Bay;

5) Participated in a study of artificial songbird nests at East Limestone island that indicated heavy predation by red squirrels;

6) Monitored impacts of raccoon predation on Ancient Murrelets, showing that mortality from raccoons was heavy in 1993;

7) Censused seal and sea lion haulouts and recorded 51 sightings of whales and dolphins. First sighting of California sea lion in Haida Gwaii recorded;

8) Trapped and banded 257 forest birds of 20 species at East Limestone Island. A total of 70 bird species were recorded in 1993.

ACKNOWLEDGEMENTS

The Laskeek Bay Conservation Society is non-profit volunteer-run organization, and could not operate without the generous support from a wide variety of groups and individuals. We gratefully acknowledge the financial and moral support of the following organizations.

- The Canadian Parks Service for their continuing strong financial and logistical support

- The Canadian Wildlife Service, Pacific and Yukon Region for financial support and for the loan of equipment.

- The Canadian Wildlife Service National Wildlife Research Centre, for financial support and the loan of equipment, including the first computer on Limestone Island.

- Wildlife Branch, Ministry of Environment, Lands and Parks for permission to conduct research in the Skedans, Limestone and Reef Island Wildlife Management Area.

- The Vancouver Aquarium for financial assistance and support in building hydrophone equipment.

- The World Wildlife Fund for financial support of the marine surveys of Marbled Murrelets and other waterbirds.

We are also very grateful to the following individuals:

- Barb, Keith and Amos Rowsell on the Anvil Cove, for providing their boat to transport people and all our gear for both the start-up trip in the storms of early April and the camp closure trip in the sunshine of July.

- Marvin and Sheila Boyd, and Dan Pick of South Moresby Air Charters for the safe and efficient weekly transport of volunteers, their gear and large orders of groceries, and to Marvin and Sheila for the timely donation of some black PVC pipe.

- Pat de Clark, Mary Morris, Michael Spencer and Linda Wilson for their generous donations.

- Terry and Charlotte Husband on Kingii for transporting people and supplies for the start-up strip in April and the school groups trip in May, and for transporting out an injured volunteer. Thanks also to Terry and Charlotte for the loan of a wood stove to replace the unsafe airtight.

- Janet and Michael Brown, who input much of the data onto a computer.

- Andrea Lawrence, for the excellent effort that she contributed in previous years, that made it possible to carry on LBCS work without her.

- Moira Lemon, for always being there to help out with boats, motors, generators and other equipment in Vancouver.

- Doug Burles for transporting volunteers to and from Limestone Island.

- Nathalie Macfarlane and the Queen Charlotte Islands Museum for continuing to provide us with meeting space and for storing all our gear.

- Peter Mylechreest for the loan of a tent and rain gear.

- Rick Nickerson on the Clipper II for delivering fuel.

- Colin French, for being Mr. Fix-it.

- Paul Prior for his patience and calm teaching in taking on the responsibility for the forest bird banding program.

- Sylvia Scott, for the loan of the popular Moosewood Cookbook.

-All of the in-town support people who bought groceries and picked up the garbage.

Finally, we thank each of the volunteers on Limestone, who gave and shared of themselves in the research effort. Special mention to our international visitors; two Australian, one British, one German, one Danish and one Swedish volunteer who imparted their own special flavour to island life. Limestone now supports a fascinating international cookbook. We hope to see you all next season.

CONTENTS

ACTIVITIES IN 1993, OVERVIEW

The field season, from April 9 to July 15, was two weeks longer than in 1992, and almost twice as long as the first season at Limestone Island, in 1990. A total of 469 person-days of work was performed over the 14 week period. Of these, 328 days were contributed by 34 volunteers who stayed on Limestone for periods of one to five weeks. Nineteen of these volunteers were Queen Charlotte Island residents, of which five had returned from previous years. An additional 52 days were contributed by 16 volunteers who stayed for less than a week.

Trapping of Ancient Murrelet chicks. Chick trapping, using the same plastic funnels (a system of plastic fences that guide chicks to the sea) as in earlier years, was carried out from 10 May to 13 June. Funnels were operated from darkness to at least 1 a.m., if no chicks were seen, or to 1 h after the last chick was recorded. Altogether, 665 chicks were caught, of which 653 were banded. This total was slightly lower than in 1992, when 674 chicks were caught within the same area.

The highest recorded number of chicks caught in an evening was 70, on 18 May. This is only slightly less than the May 21/22 1992 record of 76 chicks in one night. The peak number of chicks occurred earlier this year than in previous years. By the night of 20/21 May, 50% of the chicks had passed through the funnels. In 1990 and 1991 median dates were 23/24 May, and in 1992 the median date was 22/23 May.

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. Adult birds were banded, measured, weighed, and inspected for brood patches, and damage to feet and webs. Trapping was not initiated until late in the season in order to minimise disturbance to incubating

birds.

A total of 118 adult birds were captured, including 30 retraps, compared to 284 captures of which 66 were retraps in 1992. Six of the 1993 retraps were banded as chicks on Limestone Island, one in 1990 and five in 1991. Bands were also recovered from two dead birds, one banded as an adult in 1991 on Limestone Island, the other banded as an adult on Reef Island in 1987.

Ancient Murrelet breeding biology. Beginning on 10 April, burrows marked as occupied in previous years were inspected daily to discover whether eggs had been laid. We measured the first egg laid in each study burrow, 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.

Sixty-nine burrows were examined regularly to determine occupancy. Eggs were laid in 29 of these burrows. Sixteen of these 29 burrows were also occupied in 1992. In 25 burrows, incubation was successful. The four other nests were deserted, two without incubation ever beginning, and one possibly as a result of our activities. One other nest appeared to be incubated by a single adult which eventually abandoned it. Within the 25 burrows in which incubation was successful, we examined 44 chicks and 14 adults. Eight of the adults were banded as adults on Limestone Island in 1989, prior to the beginning of LBCS research activity in the area. Four occupied the same burrows in which they were found in 1992 and three of these birds were also in the same burrows in 1991. One bird that deserted a nest in 1991 returned to the same burrow in 1993 and successfully hatched two chicks.

Raccoons. Regular searches for raccoon sign were conducted in 1993. One raccoon was seen on East Limestone Island on 1 June. Fresh scat was found regularly, especially along shoreline areas and on West Limestone Island, where Ancient Murrelets also nest. In early June, B.C. Ministry of Environment and Parks staff killed four raccoons near Vertical Point. However, at least one raccoon continued to survive on East Limestone Island after June 10.

As in earlier years, we estimated predation rates by counting the number of Ancient Murrelets killed along seven 20m wide transects. Methods used were described in the 1991 report (Gaston et al. 1992). These transects cover 17% of the colony area. The predation rate on Ancient Murrelets was significantly higher in 1993 than in 1992, as 93 predations were found, compared to only 18 in 1992. The presence of at least one raccoon in 1993 appears to account for the large increase in predation over the 1992 levels.

Boat surveys. Boat transects covering the near shore and offshore waters of Laskeek Bay were conducted every two weeks, to census all birds at sea. The 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. Those birds that were sitting on the water, or which flew up at the approach of the boat, were recorded as on the water. A note was made when birds were estimated to be more than 200 m from the boat's course and interesting observations of birds in flight were also recorded.

A total of 58 km of transects was traversed bi-weekly between April 18 and July 10, and birds on the water within 200m of either side of the boat were noted. This is the fourth year that the LBCS has maintained coverage of these areas. Additional surveys were carried out in the waters east of Reef and the Skedans Islands, and three surveys in the area between Haswell Island and Lyell Island.

A minimum of seven surveys of each transect line were conducted. An unprecedented number of Marbled Murrelets were counted. In April, 248 Marbled Murrelets were seen, after which numbers generally increased in June to over 500 per survey. On 21 June, 1402 Marbled Murrelets were counted on inshore transect lines and 284 were counted on offshore transects, for a total of 1686 birds. This represents the highest count of Marbled Murrelets to date; more than double the previous maximum. Concentrations were greatest between Limestone Island and Haswell Island. Interestingly, the waters from Haswell Island south to Lyell Island, where high numbers were seen in 1992, did not have large concentrations of Marbled Murrelets in 1993.

Large numbers of Rhinoceros Auklets were noted in mid and late June, when they became one of the most abundant species in Laskeek Bay. During offshore transects and on surveys into the waters east of Reef Island, large numbers of Sooty Shearwaters and Black-legged Kittiwakes were noted, especially during May and June. Pacific Loons, Cassin's Auklets, Ancient Murrelets, Common Murres, Pelagic Cormorants and Glaucous- Winged Gulls were also seen regularly. Tufted Puffins were observed on several occasions, and a Long-tailed Jaeger was seen once.

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.

The highest number of birds seen to pass in a 10 minute interval was 185, on 23 April. The weather was particularly poor this spring, especially during April and early May, and counts were generally lower than in previous years.

Black Oystercatchers. Oystercatchers are a very prominent bird of the Laskeek Bay area, breeding on most of the smaller islands. A programme to study their dispersal and breeding was initiated in 1992. This year, 30 Black Oystercatcher nests, of which 28 were active, were surveyed in Laskeek Bay. The first eggs were noted May 25 and the first chicks were found June 18. Twenty-three chicks were weighed and given yellow colour bands. Food materials were also collected in the vicinity of nest sites to study chick diets. The highest number of nests found were in the Reef Island area (8 nests), in the Skedans Islands (7 nests) and on South Low Island (5 nests).

Glaucous-winged Gulls. In the lower mainland area of British Columbia and the Straits of Georgia Glaucous-winged Gulls are increasing rapidly. Consequently, the society is carrying out counts of nests, eggs and chicks at colonies in the Laskeek Bay area to determine whether populations are changing here. A total of 234 Glaucous-Winged Gull nests were censused in Laskeek Bay: Skedans Islands (20 nests, including one with 4 eggs); Low Island (4 nests); Lost Island (140 nests) and Kingsway Island (79 nests). Sixty Glaucous-Wing Gull chicks were banded on Kingsway Island, and were given brown colour bands.

Other bird studies. Daily records of all bird sightings were kept. Seventy species were recorded within Laskeek Bay, of which 68 were seen from Limestone Island. This year there were two first records for Limestone Island--one Horned Puffin on June 28 and one Pine Grosbeak on May 18. Up to 7 Rufous Hummingbirds (6 immature) at a time visited the feeder at the Limestone Island

cabin in mid to late May. Activity on the Peregrine Falcon eyrie on East Limestone was monitored through regular visits to a blind after 24 May. Initially three chicks were present, but only one juvenile successfully fledged on 25 June. A family of Common Ravens nested a short distance away from a nest site occupied in 1992. Three young fledged by 29 May and were frequently seen and heard in the area. Numbers of Northwestern Crows nesting in Crow Valley were lower than in previous years. A Bald Eagle nest was active again in 1993. One juvenile was still present in the nest on 10 July.

Under the direction of Paul Prior, a warden from the Long-Point Bird Observatory in Ontario, an intensive effort was made to band songbirds. Mist netting was carried out from 13 June to 13 July on East Limestone island and at nearby Vertical Point on Louise Island. A total of 257 birds, including 10 banded in 1992, were netted and banded. Twenty different species were caught, including four species not caught in 1992 (Red Crossbills, Red-Breasted Nuthatches, Song Sparrows and a Saw-Whet Owl). The most commonly netted species were Townsend's Warblers, Rufous Hummingbirds, and Chestnut-backed Chickadees.

The netting at Vertical Point was designed as a North American Monitoring Avian Productivity and Survival (MAPS) project. MAPS is designed to establish long-term monitoring of land bird population trends in North America. Mist net sites, located within a one hectare area, were operated by standard methods every tenth day. A total of 31 birds comprising 10 species were banded during 120 net hours.

As in previous years, 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. Since 1990, nineteen Red-breasted Sapsucker nest trees have been recorded on East Limestone Island, of which 10 were active this year, including one tree near the cabin that was occupied by Northern Flickers last year.

Marine Mammal Surveys. Special attention was taken of marine mammals this year and regular censuses were made of seal and sea lion haulouts. A stationary hydrophone was installed to acoustically monitor the area around E. Limestone, and in future years this should help to increase the frequency with which marine mammals are sighted. Eleven species of marine mammals, comprising four species of pinnipeds and seven species of whales, were recorded.

Steller sea lion numbers on the Skedans Islands declined from an initial count of 92 on 19 April to 0 from 31 May. On the Reef Island rocks, there were 544 Steller sea lions on 9 May, but the numbers gradually declined and remained constant at approximately 250-300 from mid-June onwards. California sea lions were recorded twice on Reef Island rocks, apparently the first records of this species in Haida Gwaii.

The first harbour seal pup was noted on 17 June. Counts on intertidal haul-outs were recorded regularly. A large male elephant seal was seen on 27 May, 6 km east of Lost Island. Killer whale pods were sighted seven times in 1993, all apparently transient (mammal-eating) groups. Minke whales were sighted on 11, gray whales on five and humpback whales on 12 occasions. Ten of the latter were photographed for identification. Harbour porpoises were seen on eight and Dall's porpoises on three occasions. Pacific white-sided dolphins were sighted 11 times in the near-shore waters of Laskeek Bay.

Impact of Introduced Predators. Under the direction of Dr. Jean-Louis Martin of the Centre National de Recherche Scientifique in Montpellier France, a study of predation on bird eggs by introduced species (raccoons and squirrels) was begun. Dummy nests, stocked with quail eggs, were placed along 3 km of transect lines across Limestone Island. Similar surveys on Ramsay Island (squirrel and rat free) and Murchison Island (no squirrels) ran concurrently. The predation rate on Limestone

Island was very high; 94 of 120 nests were predated within a 15 day period. Much of this predation was attributed to squirrels. The rate of predation observed was much higher than was seen at Ramsay or Murchison islands, where squirrels are absent.

ANCIENT MURRELET CHICK TRAPPING

Background

Trapping of Ancient Murrelet chicks en route from their burrows to the sea is carried out annually to provide information on numbers produced, and their condition (weight) at departure. They are banded to maintain a population of banded birds of known-age that can be retrapped subsequently when they return to breed. This retrapping tells us about rates of recruitment to the colony and the age at which birds return and can help us to deduce how age affects behaviour and breeding.

Chicks leave the burrow at 1-2 days old and run through the forest to the sea. During this journey, they are captured by means of plastic fences ("funnels", because of their V-shape) that guide them to trapping stations near the beach where they are weighed and banded before being taken to the sea and released. The interruption to their journey takes only a few minutes and appears to have no effect on their ability to rendezvous with their parents and make a successful transition to life at sea. There are six funnels, four on the north-east coast (N1-N4), one at the Cabin (C5) and one in Spring Valley (S6). They are kept in exactly the same place from year to year, to ensure that numbers trapped are comparable.

Results in 1993

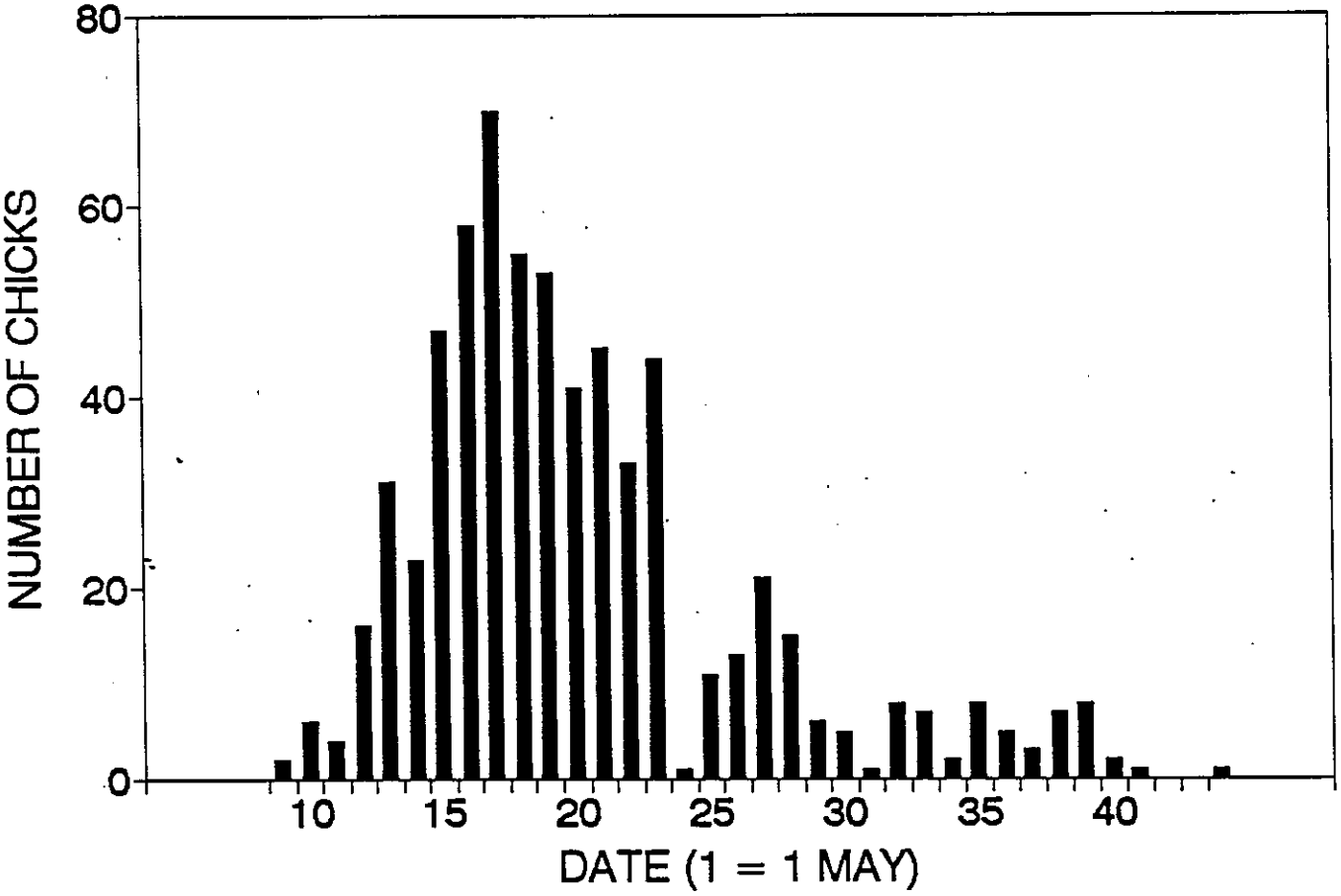
In 1993, the first Ancient Murrelet chicks were captured on the night of 10 May and the last on 15 June. The total caught was 653, very similar to the number trapped in 1992. A maximum of 70 was trapped on the night of 18 May, 80% were trapped between 13-26 May and 90% between 13 May and 2 June. The median date (date by which 50% of chicks had left) for all captures was 19 May; the earliest median date ever recorded at Limestone or Reef islands over 10 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 15 April. As the two eggs are laid 8 days apart, the median date of laying for first eggs was 7 April.

Table 1. Chicks captured on East Limestone Island in 1993

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	2	0	0	0	0	2	2
11-12	2	0	2	1	0	1	6	8
12-13	0	1	2	0	1	0	4	12
13-14	1	2	2	4	6	1	16	28
14-15	1	8	7	3	1	11	31	59
15-16	4	0	5	9	5	0	23	82
16-17	5	9	6	4	11	12	47	129
17-18	3	4	6	10	17	18	58	187
18-19	4	9	10	16	11	20	70	257
19-20	3	4	14	3	10	21	55	312
20-21	7	13	7	6	0	20	53	365
21-22	2	4	9	6	10	10	41	406
22-23	2	5	2	16	10	10	45	451
23-24	3	8	5	10	6	1	33	484
24-25	6	2	9	9	11	7	44	528
25-26	0	0	0	0	0	1	1	529
26-27	0	3	2	2	4	0	11	540
27-28	0	1	0	0	7	5	13	553
28-29	4	3	5	4	0	5	21	574
29-30	1	0	5	3	0	6	15	589
30-31	0	0	2	2	1	1	6	595
Jun 31-1	0	2	0	3	0	0	5	600
1-2	0	0	1	0	0	0	1	601
2-3	0	2	0	2	0	4	8	609
3-4	0	0	1	4	0	2	7	616
4-5	0	2	0	0	0	0	2	618
5-6	0	1	4	0	0	3	8	626
6-7	0	1	0	0	1	3	5	631
7-8	0	0	1	1	1	0	3	634
8-9	0	4	0	0	2	1	7	641
9-10	0	1	3	0	1	3	8	649
10-11	0	0	0	0	0	2	2	651
11-12	0	1	0	0	0	0	1	652
12-13	0	0	0	0	0	0	0	652
13-14	no trapping							
14-15	0	0	0	0	1	0	1	653
Totals	48	92	110	118	117	168	653	

FIGURE 1
DATES OF CHICK DEPARTURES, 1993

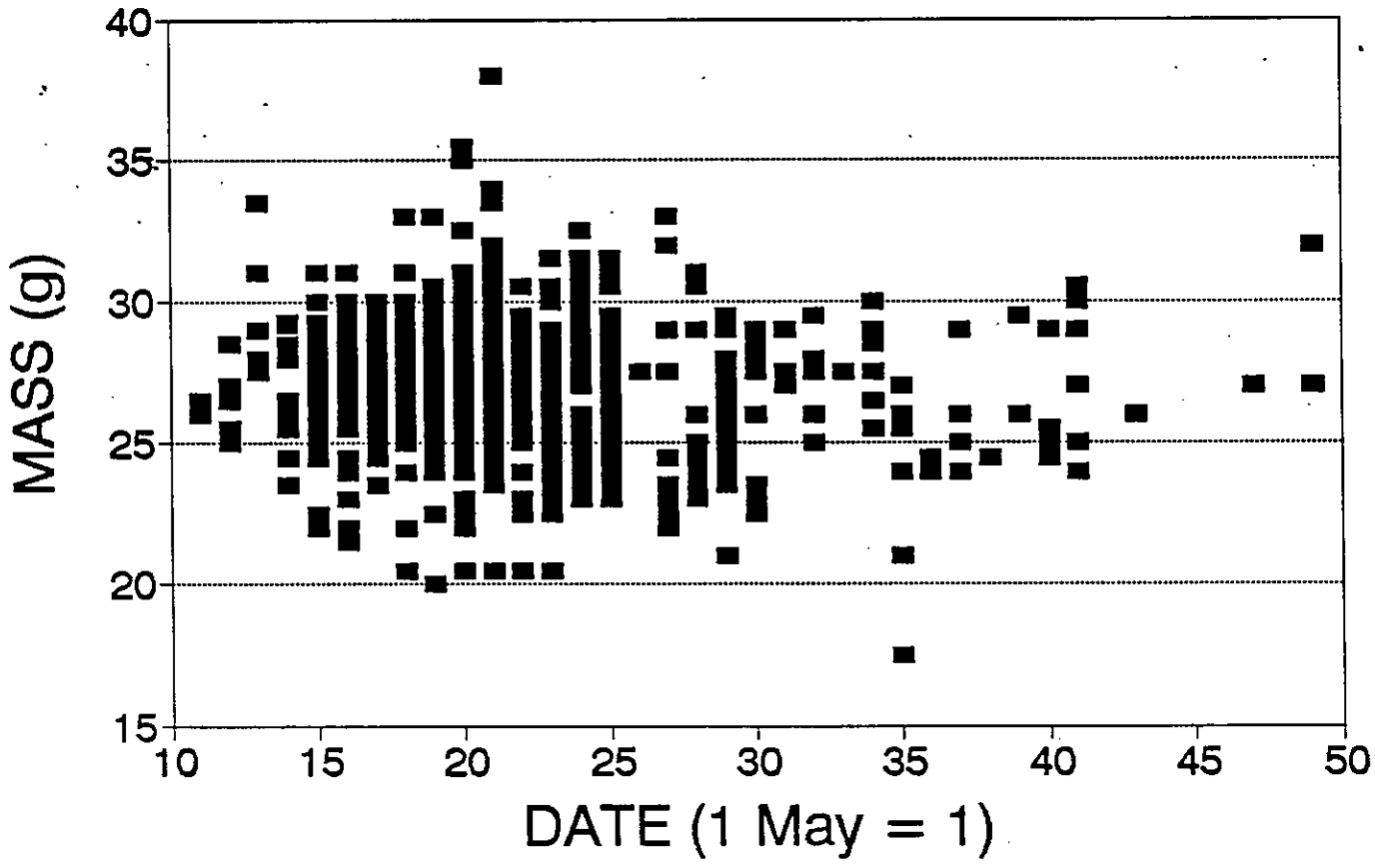


Chick weights

Chicks weighed in their burrows immediately after hatching averaged 31.0 g (s.d. 3.9, N=48). Those trapped in the funnels during departure averaged 27.0 g (s.d. 2.4, N=642), so they lost at least 4 g in weight during their stay in the burrow. Unlike

earlier years, there was a significant difference in the mean weight of chicks captured at different funnels, with those in N4 and C5 being the heaviest, averaging 27.45 and 27.4 g, respectively. The significance of this variation is unknown, but may relate to date of departure, because chicks that left before 15 May or after 26 May were significantly lighter than those trapped at the peak of departures (Figure 2). There was no difference in weight among chicks leaving at different times of the night.

FIGURE 2
CHICK WEIGHT vs DATE, 1993



Inter-year comparisons

In the four years of operations at East Limestone Island we have trapped 2763 chicks, most of which, but not all, have been banded and weighed. Overall, the Spring Valley funnel has caught the most chicks (24%), followed by #3 on the NE shore (Figure 3). Changes in numbers from year to year appear fairly consistent at different funnels. All showed a decrease between 1990 and 1991, most showed a slight increase from 1991 to 1992 and similar numbers were caught in 1992 and 1993 (Figure 4).

The mean date of chick departures has become progressively earlier over the four years; 25 May in 1990, 24 May in 1991 and 1992 and 22 May in 1993 (Table 2). There was no difference among funnels in dates of departure, although chicks captured at funnel N1 have tended to be a little in advance of other funnels (Figure 5). This indicates that there is no tendency for birds nesting in different parts of the colony to be synchronized with their neighbours; an effect often seen at colonies of seabirds active in daylight (gulls, murres, etc.).

FIGURE 3
CHICK TOTALS BY FUNNEL, 1990-93

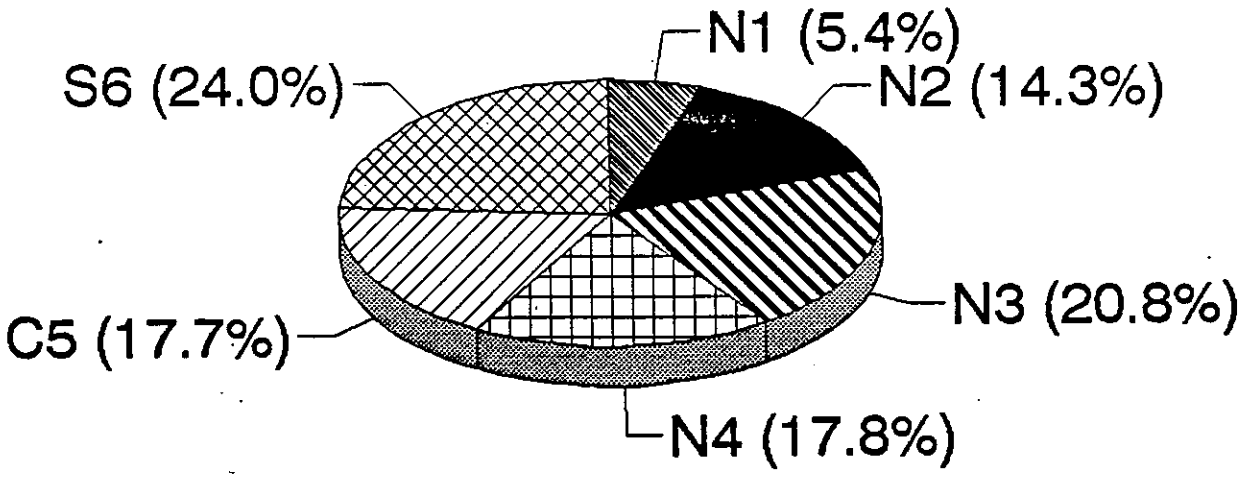


FIGURE 4
CHANGES IN CHICK CAPTURES, 1990-93

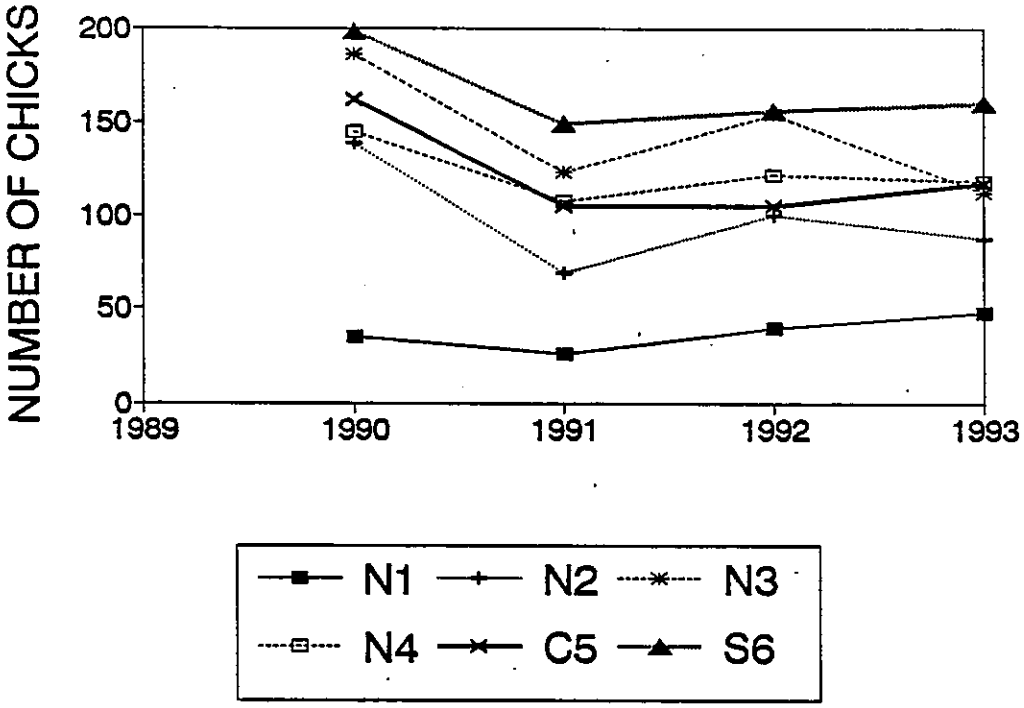


FIGURE 5
DEPARTURE DATES BY FUNNEL

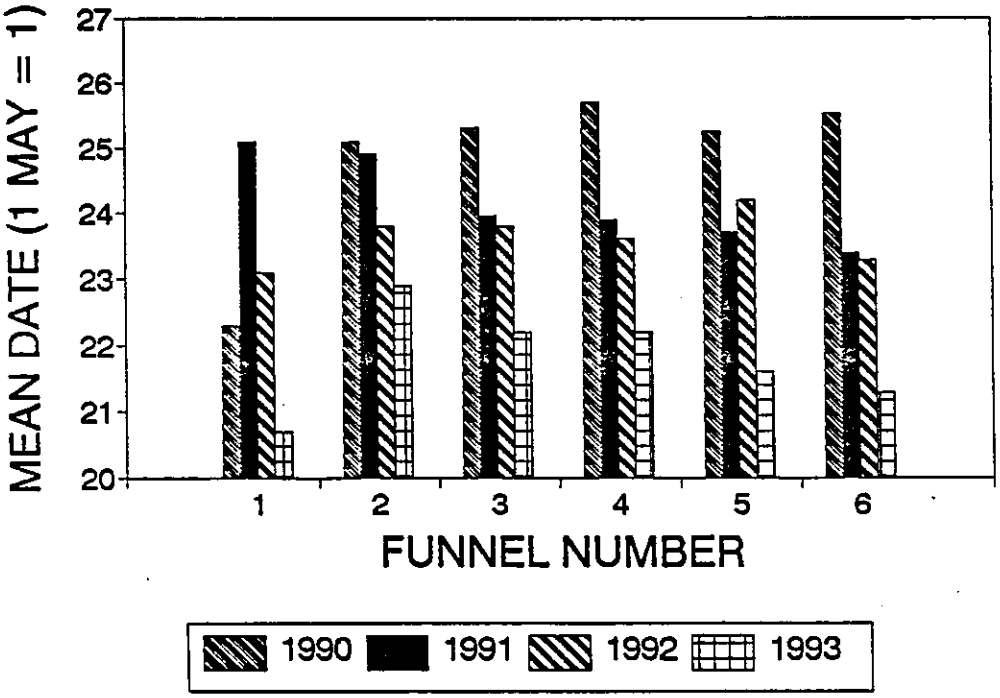


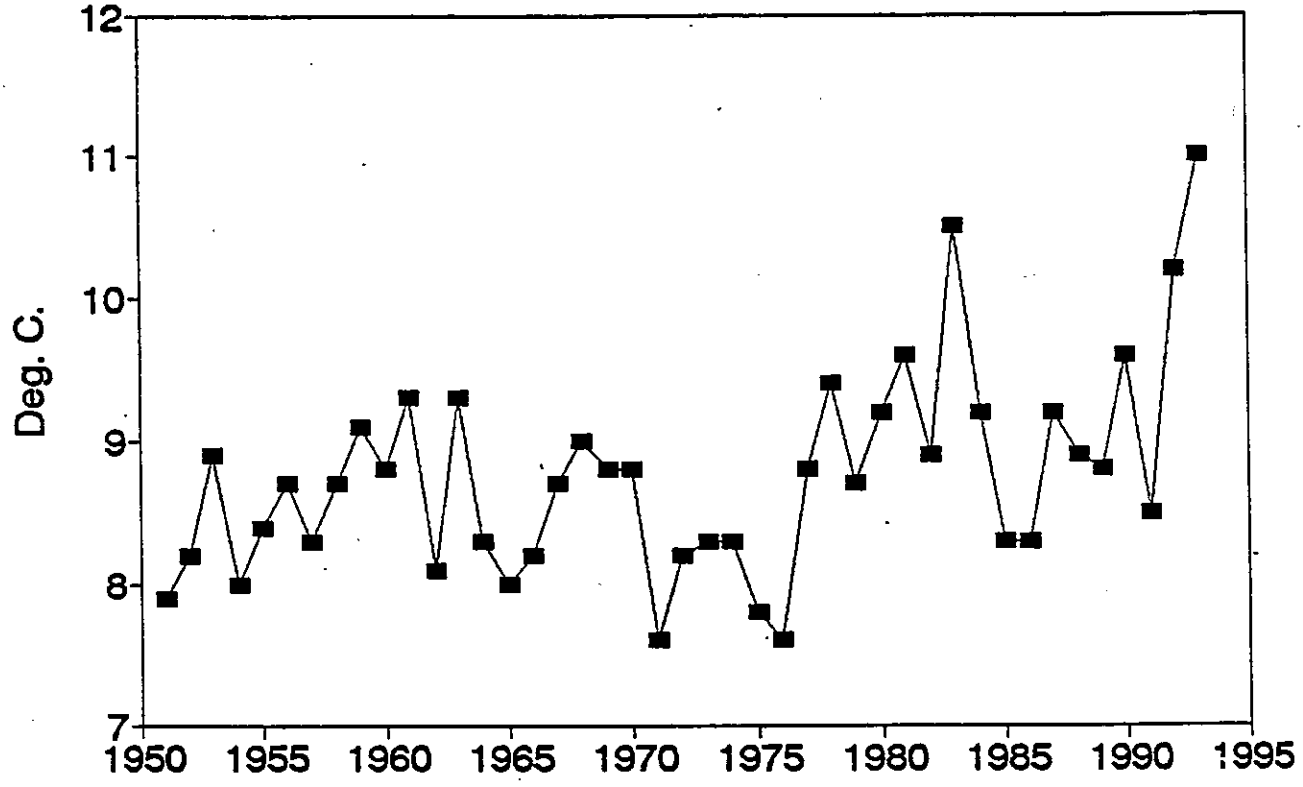
Table 2. Mean and median dates of chicks captured in the funnels at East Limestone Island, 1990-93

YEAR	MEAN	S.D.	MEDIAN	N
1990	25.2	6.7	23	865
1991	23.9	5.6	23	579
1992	23.6	4.4	22	671
1993	21.8	6.1	19	643

The year to year fluctuations in numbers of chicks may have been caused by raccoon predation. In 1990, one raccoon was present on East Limestone Island and the presence of a second, with kits, was discovered after the end of the breeding season. In 1991 there were at least two raccoons resident throughout the season on the island. In 1992, we saw little sign of typical raccoon predation, such as burrow digging or headless corpses, and concluded that raccoons were absent, at least during the main part of the breeding season. In 1993 at least one raccoon was present during the breeding season. Heavy raccoon predation may have caused the reduction in chick production in 1991, compared to 1990, whereas the absence of raccoons in 1992 may have allowed the partial recovery that year. It appears that numbers of Ancient Murrelets are unlikely to increase unless raccoons can be permanently excluded from the island.

The advance in mean date of laying may also be affected by raccoon predation. Individual Ancient Murrelet pairs tend to lay earlier in successive years, presumably as they get older and more experienced (Gaston 1992). If relatively few young birds are recruiting to East Limestone the average age and experience of breeders may be increasing, leading to earlier average laying. However, it is also possible that early laying in 1993 was the result of exceptionally warm water temperatures which prevailed in Hecate Strait throughout the year (Figure 6).

FIGURE 6
MAY SEA TEMPERATURES, CAPE ST JAMES



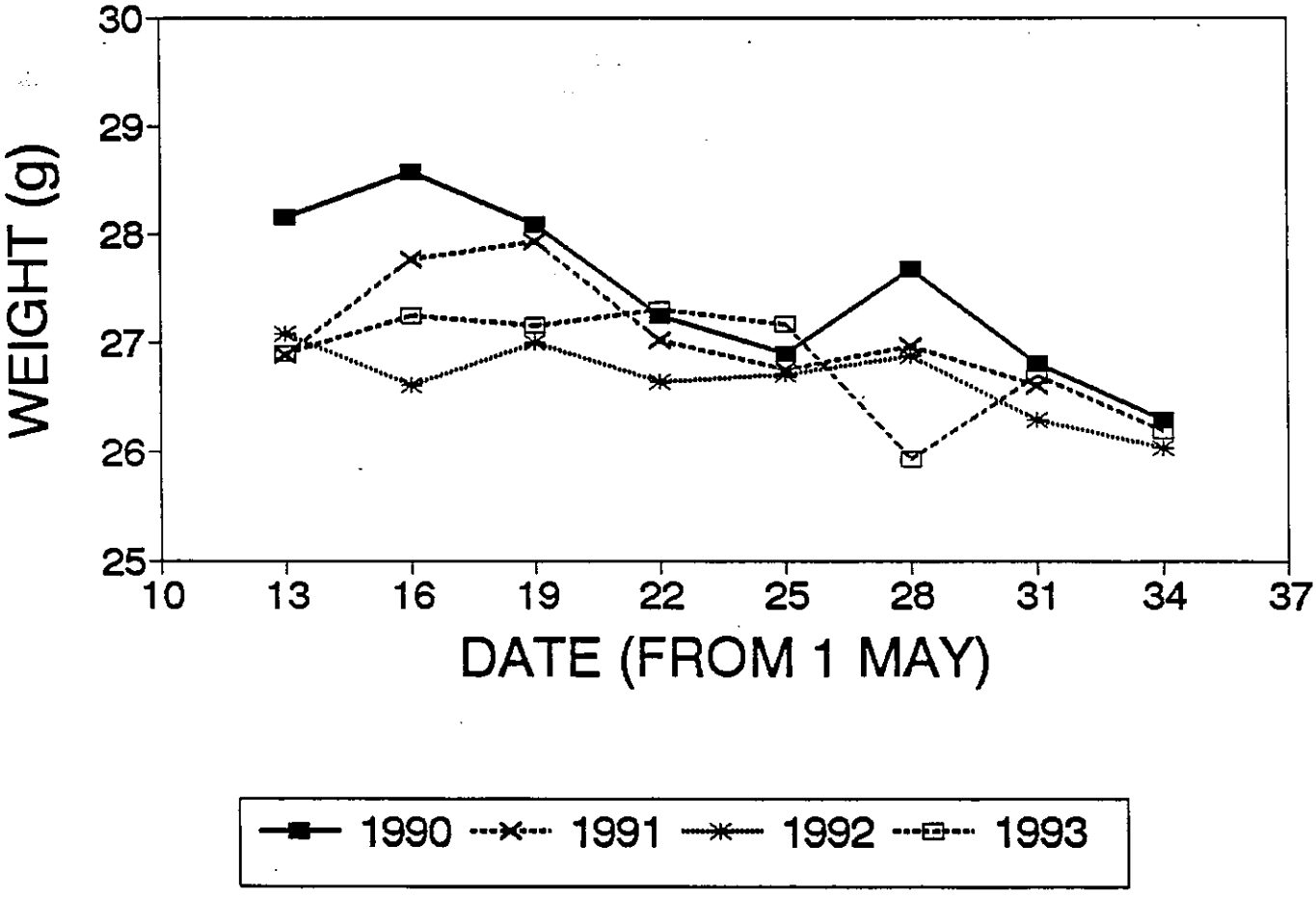
The weight of chicks captured in burrows has not varied among years, although we have data for only three years, as this information was not collected in 1990. However, the much larger sample of chicks trapped in funnels has shown small, but significant, inter-year variation, with the chicks being heaviest in 1990 and lightest in 1992 (Table 3).

Table 3. Chick weights by year

YEAR	MEAN	S.D.	N
1990	27.7	2.5	865
1991	27.1	2.0	579
1992	26.7	2.1	671
1993	27.0	2.4	643
Combined	27.2	2.3	2758

In all years there has been a tendency for chicks departing at the peak for the colony to be slightly heavier than those leaving before or after. This pattern was most marked in 1990, when early chicks were much heavier than later chicks. In 1992 the pattern was only discernable right at the end of the season (Figure 7). It is likely that this effect is caused by later laying birds producing slightly smaller eggs; an effect seen in most years (see below). This, in turn, is a result of a high proportion of the late layers being young birds, which typically produce smaller eggs than more experienced breeders. The effect was generally much more striking at Reef Island, where the pattern seen in 1990 at Limestone Island was typical of all years (Gaston 1992: Figure 13.4). Like the timing of breeding, this could indicate a reduction in the number of new recruits entering the Limestone Island population.

FIGURE 7
CHICK WEIGHTS BY DATE



Retrapping of birds banded as chicks

Ancient Murrelets rarely visit their breeding colonies in the first year after hatching, so with our banding effort beginning in 1990, we could not expect returns of chicks banded at Limestone Island before 1992. However, one chick banded in 1990 was retrapped in 1991. In 1992, we captured six birds banded as chicks at Limestone Island in 1990 and in 1993 another one banded as a chick in 1990 and five banded as chicks in 1991. Hence we have so far retrapped 13 of our banded chicks, one as a first year, eleven as second years and one as a third year. In addition, in 1989, the Canadian Wildlife Service trapped two birds banded as chicks at Reef Island in 1987 and in 1991 we found a dead bird banded as a chick at Reef Island in 1989. Two birds banded as adults at Reef Island have been recorded at Limestone Island; a bird trapped in 1990 (banded as a non-breeder in 1989) and a bird found dead in 1993. The latter recovery, involving a bird banded in 1987 and hence certainly of breeding age when recovered, strongly suggests that it had been breeding at Limestone Island, but the possibility that it was transported there after death by an eagle or peregrine cannot be discounted.

The numbers of chicks retrapped, relative to numbers banded (0.8%), is similar to what was observed at Reef Island, where 1% of second year chicks were retrapped. In relation to the number of adults trapped, the proportion is higher, but this is probably because we band a higher proportion of the chicks reared on Limestone island than was the case at Reef Island. Our results confirm that the majority of non-breeding birds trapped are in their second year.

There is no evidence, either from our work at Limestone Island, or from the earlier studies at Reef Island, that chicks that are heavy at departure are more likely to survive to return than lighter ones. The mean weight at departure of the 1990 chicks retrapped was 27.6 g (s.d. 2.1, N=8), compared to 27.7 for all chicks weighed that year. The corresponding figures for 1991 are

26.4 g (s.d. 1.3, N=5) and 27.1 g. Nor is there evidence that early chicks are more likely to return than those leaving later. The dates of departure of our retrapped sample range from 15 May to 4 June, with 8/13 coming after the median date of departure for their year.

ADULT ANCIENT MURRELET TRAPPING

Numbers trapped and retrapped

Ancient Murrelets were already visiting East Limestone Island on the night of 15 March, when a spotlight survey was carried out for raccoons. Camp was not occupied until 9 April, by which time there were already eggs in several of the study burrows. No trapping of adults was attempted until the beginning of the chick departure period, after which 119 were captured, including 24 retraps of birds banded as adults in earlier years. Of the latter, nine were removed from burrows after hatching. Five of them had been banded in the same burrows in earlier years (2 in 1991, 3 in 1992), while one had been banded in 1991 in a different burrow. The other three retraps had been banded in 1989 as breeders, after being caught on the surface.

Breeding status was judged on the basis of the size of the brood patches (>19 mm across = breeder). Of the 106 birds caught on the surface for which the brood patch was recorded, 70% showed no sign of a brood patch, and were therefore non-breeding prospectors and another 20% had a full brood patch, and hence were presumably breeding. The other birds (10%) had incomplete brood patches and were presumably non-breeders or failed breeders. These proportions are very similar to those seen in 1992 (Table 4). The preponderance of birds without brood patches is presumably due to the bulk of trapping being carried out at the end of the season and late in the night, by which time most breeders had departed. Unlike previous years, only 20% of the birds captured that had been banded in previous years were breeders (4/20).

Table 4. Proportions of birds trapped in May and June 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%)
1993	New	59(69%)	10(12%)	17(20%)
	Retrap	15(75%)	1(5%)	4(20%)

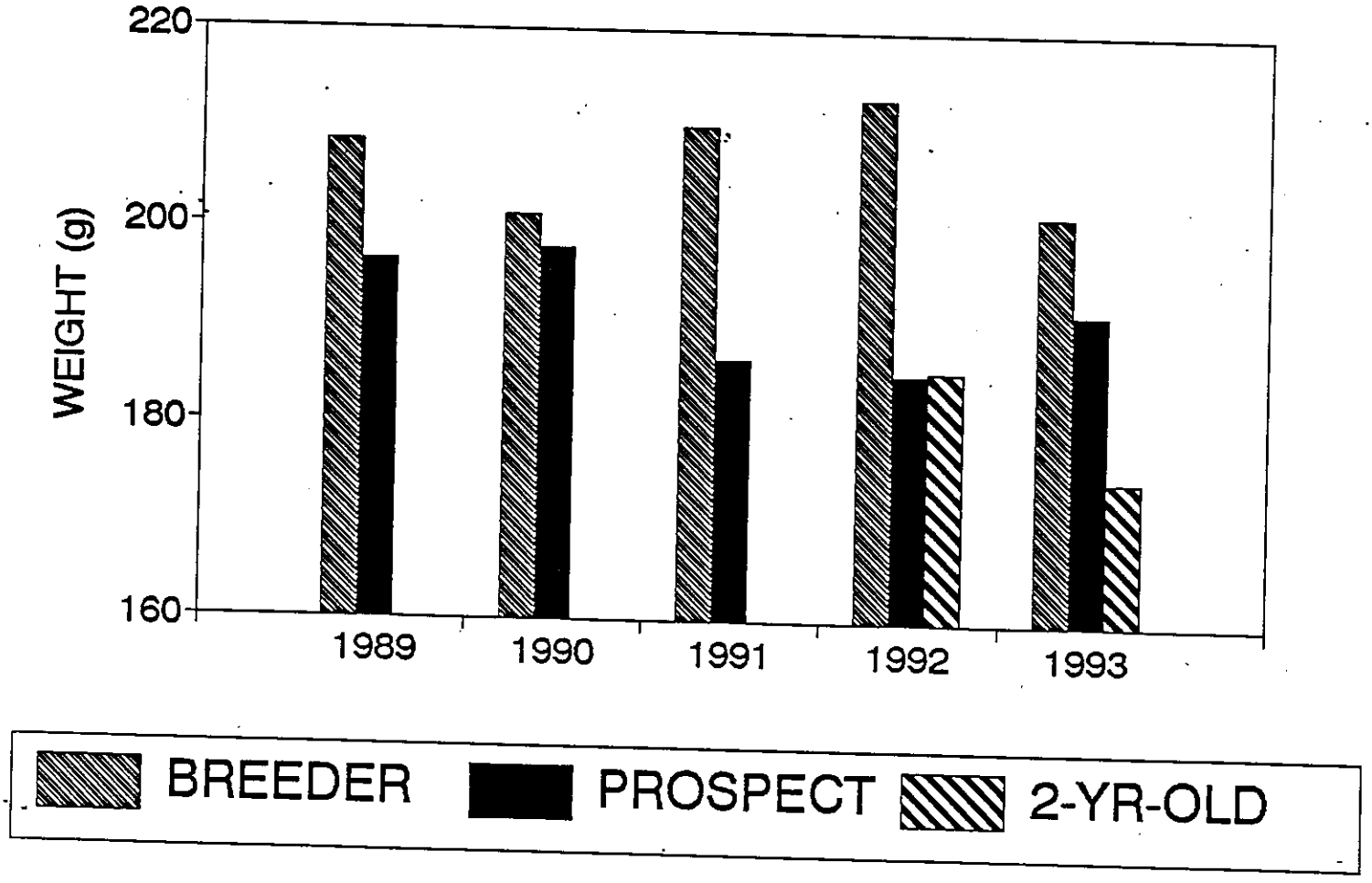
Adult weights

The mean weight of birds trapped as non-breeders (brood patch small or absent) was 191.4 g (s.d. 15.7, N=85). Breeders taken from burrows at the time of hatching averaged 206.7 g (s.d. 15.6, N=15); significantly heavier. The mean weight of the the five two-year-olds trapped was 174.5 g (s.d. 7.0), significantly lighter than the weight of all non-breeders. If we add the weight of the five two-year-olds captured in 1992, the mean weight at that age rises to 180.0 g (s.d. 7.6, N=10), still lower than the average for all non-breeders (189.5 g, s.d. 14.7, N=620).

Comparing the data on weights obtained over the past five years, we find that the weight of non-breeders has fluctuated considerably, being highest in 1989 and 1990 and lowest in 1991 and 1992 (Figure 8). Weights of breeders trapped in the burrow has

fluctuated in an opposite fashion, with birds being heaviest in 1991 and 1992 (data for breeders in 1989 is taken from Reef Island).

FIGURE 8
ADULT WEIGHTS



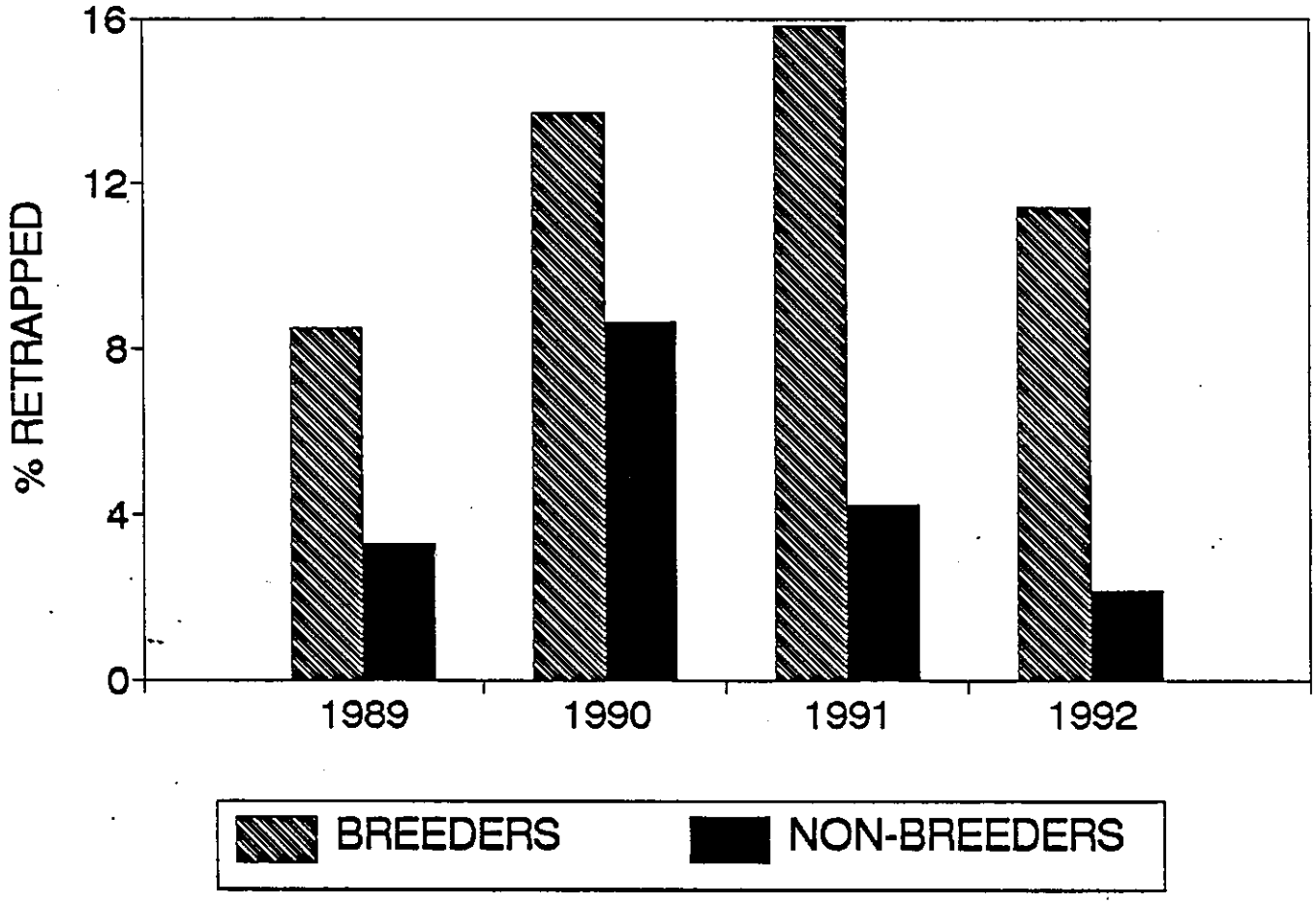
The average weight of two years olds recorded at Limestone Island (180 g) is almost identical with weights for birds of the same age captured at Reef Island (180 ± 7.4 g, N=20). However, the weights of all non-breeders recorded at Limestone Island, which average 189.5 g, are significantly heavier than those recorded at Reef Island, where the average over six years was 184.6 g (s.d. 11.6, N=924). Because most non-breeders are caught after 15 May and because trapping at both colonies was carried out fairly continuously from that date to the end of the season, these results should be comparable. The difference suggests that there may be a higher proportion of three-year-olds (mean weight at Reef Island, 197 g) among the prospectors visiting Limestone Island than was the case at Reef Island.

Rates of retrapping and estimates of survival

The proportion of birds banded as adults that were retrapped at East Limestone Island varied from 3.6% in 1993 to 11.6% in 1991, depending on the amount of effort expended. In all years, the rate of retrapping of birds banded as breeders was about three times that of birds banded as prospectors (Figure 9). Among those banded as prospectors, 25% (N=28) were breeding when retrapped one year later, 54% (N=13) were breeding two years later and 80% (N=5) after three years.

Several methods are available to compute survival rates from banding data where birds are being retrapped. One of the main intentions of the adult trapping programme is to estimate survival rates using these methods. Because some banding was carried out by the C.W.S. in 1989 we now have four years of retrap data available and this provides a suitable sample for preliminary analysis. The data on numbers banded and retrapped are given in Appendix 1.

FIGURE 9
PROPORTION OF BIRDS RETRAPPED



I have used the capture-recapture programme SURGE (Lebreton and Clobert 1986) to estimate survival rates from our data. To do so, I combined data from birds banded in burrows and those caught on the surface, but analysed breeders and non-breeders separately. The resulting estimates suggest that, on average, 73% of non-breeders trapped at Limestone Island survive from one year to the next, but only 42% of breeders. The confidence limits on these estimates are very large, but the mean values for both estimates fall outside the confidence limits for the other, suggesting that

the difference is probably significant (Table 5). Moreover, the survival rate for breeders is far below that estimated for breeders at Reef Island during 1984-89 (Table 5, Gaston 1990), an estimate based on exactly the same type of data.

Table 5. Annual survival rates estimated by SURGE

	Mean	95% confidence interval Minimum	Maximum
East Limestone I.			
Breeders	42%	31%	53%
Non-breeders	73%	43%	91%
Reef I.			
Breeders	69%	65%	78%

Given the very high level of predation by raccoons found at Limestone Island throughout the period of the study (except for 1992), the low survival rate of breeders is not surprising. No raccoons were present at Reef Island during the work there. Raccoons take both breeders and non-breeders, especially the latter (see below), so the difference between the two groups is probably not explained by predation. However, the 95% confidence limits on the estimate for non-breeders are very large and the true survival rate could be considerably lower than the mean value estimated.

Two pieces of information suggest that there may be a difference between Limestone and Reef islands in the age structure of the non-breeding population:

(1) the fact that many birds at Limestone Island continue as non-breeders for two or more years, and

(2) the higher average weights of non-breeders recorded at Limestone Island.

It is possible that disturbance to prospecting birds by raccoons has prevented the prospectors from initiating breeding as

soon as they do at colonies without raccoons. However, it is also possible that feeding conditions in the past four years have been different from those prevailing during the Reef Island study, affecting the nutritional status of the birds. The evidence from the weight of two-year-olds suggests that conditions have not changed, but the samples involved are very small.

Summary of data from adult trapping

Catching adult murrelets in the forest at night causes undeniable disturbance to the birds involved and hence requires substantial justification. The following information has been obtained from this technique thus far:-

(1) Survival rates of birds breeding at Limestone island are lower than those reported from Reef Island during 1984-89;

(2) Survival rates of breeders are lower than those of non-breeders;

(3) Non-breeders at Limestone Island contain a higher proportion of birds more than 2 years old than was found at Reef Island;

(4) The weight of non-breeders varies from year to year and is unrelated to variation in the weight of breeding birds.

In addition, the following information obtained previously at Reef Island has been confirmed:

(5) Most prospecting birds are second years

(6) Second year non-breeders weigh about 10% less than breeders

BREEDING STUDIES OF ANCIENT MURRELETS

Eggs

Eggs laid in 1993 were similar in measurements and mass to those laid in earlier years (Table 6, Figure 10). It seems to be a characteristic of Ancient Murrelets that egg size is relatively constant from year to year. However, a comparison of egg size with date of laying shows that at Limestone Island there is a tendency for egg size to decrease as the season progresses (Figure 11). This effect was much less marked at Reef Island (Table 7).

Although the variation from year to year is very slight, it may nevertheless carry subtle information about feeding conditions for the females in the period running up to laying. When we look at the years in which eggs were relatively small (1984, 1986, 1988, 1992) we find that these correspond to years in which Black-legged Kittiwakes were either not recorded, or only seen in very small numbers around Laskeek Bay. Conversely, in the odd years (1985, 87, 89, 91 and 93) Black-legged Kittiwakes were comparatively abundant, and Sooty Shearwaters and humpback whales were common. The apparent correlation between egg size and the abundance of certain offshore-feeding birds and marine mammals may indicate some common factor in local feeding conditions, making egg size a useful potential tool for monitoring changes in the marine ecosystem.

FIGURE 10
EGG VOLUME INDEX BY YEAR

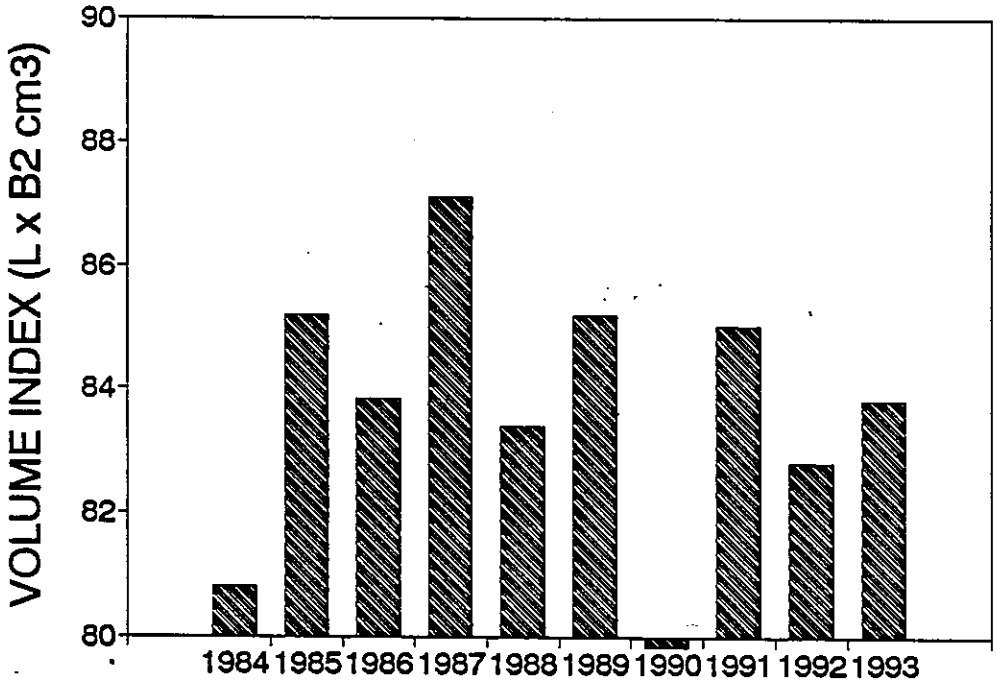


FIGURE 11
EGG VOLUME INDEX vs TIMING OF BREEDING

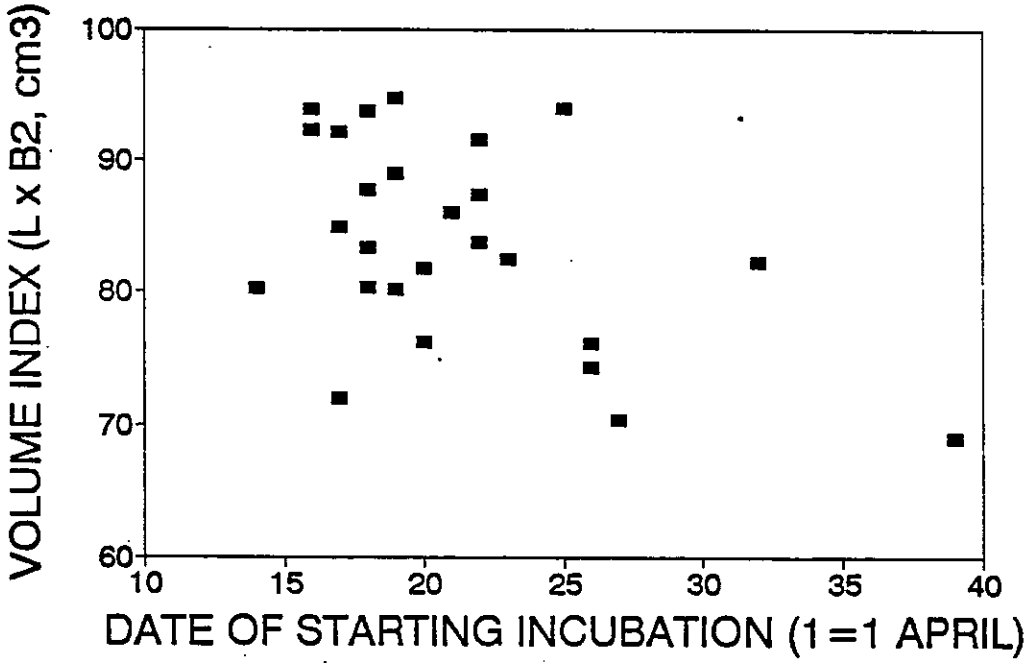


Table 6. Measurements of Ancient Murrelet eggs from the Queen Charlotte Islands

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	
	1993	45.2	3.9	26	59.6	2.0	26	37.5	1.3	26	

(1) Gaston (1992)

Table 7. 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
1993	53.23-(date*0.378)	47.56	36.22

Breeding success and incubation

Breeding by Ancient Murrelets was attempted in 29 of the study burrows at East Limestone Island in 1993. Of these, 25 succeeded in producing chicks and four were deserted, of which only one desertion could have been caused by our activities; the others were deserted without any intrusion on the nest. A total of 47 chicks were reared for an average productivity of 1.62 chicks per pair.

Eggs were present in 14 burrows when first inspected on 10 April, but only one bird was incubating. All but two pairs began incubation by the end of April. The median departure date for the study burrows was 23 May, exactly the same as the chicks trapped in funnels.

We were able to follow the entire incubation period for 23 nests, but we were able to measure the length of time between laying of the first egg and the beginning of incubation at only 13 nests. This averaged 8.5 days (s.d. 3.1). At seven sites, incubation was interrupted for 1-3 days. All but one of these interruptions occurred within 3 days of the start of incubation. The duration of the combined incubation and brooding period (from the start of incubation to departure) averaged 33.5 days (s.d. 1.5, N=23).

Out of 39 burrows that have been monitored in all four years at Limestone Island, only one has failed to produce a chick in any year, and that was only occupied once. Ten burrows have succeeded in rearing chicks in all years and another eight did so in three out of the four years. The largest year on year change occurred between 1990 and 1991, when 13/36 (36%) successful burrows were not occupied the next year. The corresponding proportions for 1992 and 1993 were 20% (N=25) and 23% (N=22). In 1990, none of the burrows was inspected until after the chicks had departed, so disturbance could not have been involved in the amount of abandonment. The rate of turn-over of burrows is similar to that seen at Reef Island in 1987-89, when similar

methods were used and suggests that it is normal to have approximately 20% of burrows abandoned each year.

PREDATION BY RACCOONS ON SEABIRDS

This topic was dealt with at some length in the 1992 report (Gaston and Lawrence 1993). Hence, it will be only briefly summarized for this year. In 1993, there was no evidence of any raccoons present on East Limestone Island during spotlight surveys carried out on two nights in March (Terry and Charlotte Husband). However, from the start of the season, there was evidence of heavy predation. Later, digging of burrows and headless carcasses, both usually associated with raccoon predation, were found. Raccoon scats were found on both West and East Limestone islands. On 1 June a raccoon was seen on the cliffs south of Cabin Bay and further raccoon sign (hairs, diggings, and scats) continued to be found until the end of the season. Whether the raccoon was present throughout the season, or arrived some time in April is not known. There is a possibility that more than one could have been present, but we have no definite evidence.

We repeated the strip transects surveyed in previous years to monitor the level of predation. They 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. 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 previous years 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.

In 1993, we found 88 predations within our transects, of which 84 consisted of feather piles only (Table 8). Only two burrows were found excavated and only two carcasses were found. Three other excavated burrows were located by casual observations elsewhere, all freshly dug in June. The small number of carcasses probably relates to the fact that most transect inspections were made several hours after dawn, by which time any raccoon kills could have been scavenged. However, the scarcity of burrow excavations until June suggests that the raccoon present in 1993 did not bother to do as much digging as animals present in earlier years.

Comparing the period up to 13 June for the 4 years for which we have comparable data, shows that predation rates have been fairly similar, except in 1992, when we believe that no raccoon was present (Figure 12). This result confirms that raccoons are a principal cause of the high predation observed at Limestone Island.

As in other years, we measured the length of any wings found on predation surveys (Figure 13). The mean length of wings found up to 15 May was 143.6 mm (sd 3.2, N=30), of those found between 15 May and 8 June 140.8 mm (sd 3.8, N=13) and of those found later, 140.0 (sd 2.7, N=18). These measurements confirm the pattern, found in earlier years, that suggests the majority of birds killed after mid-May are two-year-old prospectors, that have shorter wings than older birds.

FIGURE 12
PREDATIONS ON TRANSECT, UP TO 13 JUNE

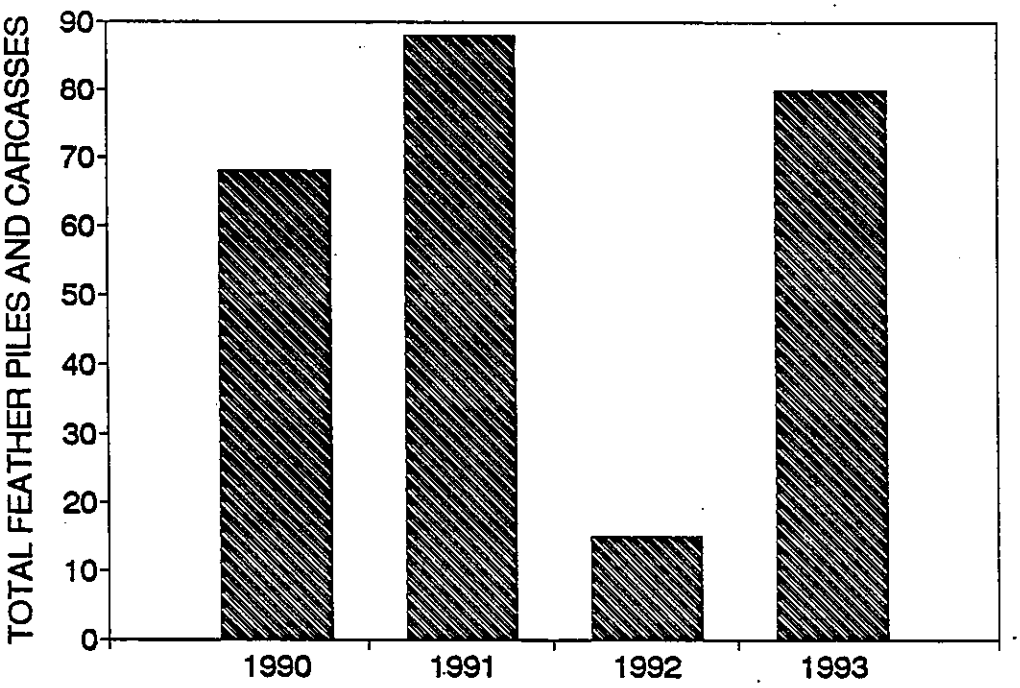


FIGURE 13
WING LENGTH OF BIRDS KILLED, 1993

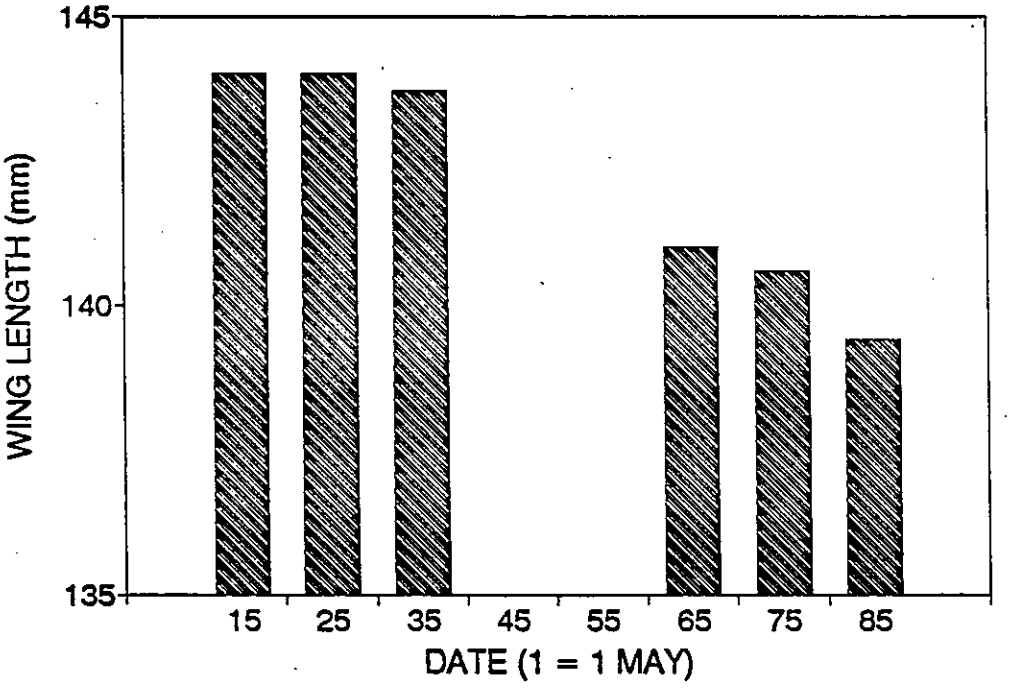


Table 8. Predation remains found on transects in 1993

DATE	FEATHER PILES	BURROW DIGGING	CARCASSES
10 - 30 Apr	26	0	1
1 - 15 May	19	1	0
16 May - 8 June	27	0	0
> 8 June	12	1	1
Totals	84	2	2

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 - 24 June, using the same methods as in previous years. Numbers seen in a ten minute watch ranged up to 185. Counts of over 100 occurred on only 4 nights; 23 April, 17 May and 13 and 15 June. Numbers did not reach double figures after 16 June, the same date as in 1992, emphasizing that most birds must have departed from the breeding area by that date (Figure 14).

Numbers of birds seen on the gathering ground were generally lower than those recorded in earlier years (Figure 15). Taking the period from 15 May onwards, in 1990 there were five counts of more than 100 birds. In 1991, there were eleven, including five of more than 200. In 1992, there were four counts above 100, including one over 200. In 1993 no count exceeded 200 and only 3 reached 100 during the same period. The mean counts for the period 16 May - 15 June were 55, 131, 53 and 29, respectively.

The low numbers recorded in 1993 do not seem to have been related to weather conditions, as wind speeds in that period (mean 8 km/h) were similar to those in 1991 (8 km/h) and 1992 (9 km/h). More importantly, there were many days of complete calm (8 in May alone) that should attract large numbers to the gathering grounds. As most birds attending the gathering grounds after mid-May are thought to be non-breeding prospectors, the decline in numbers counted is worrying, as it may imply a reduction in recruitment to the colony in future. However, the very large inter-year variation could relate to other factors, such as food supply, and may not indicate a change in population.

FIGURE 14
GATHERING GROUND COUNTS, 1993

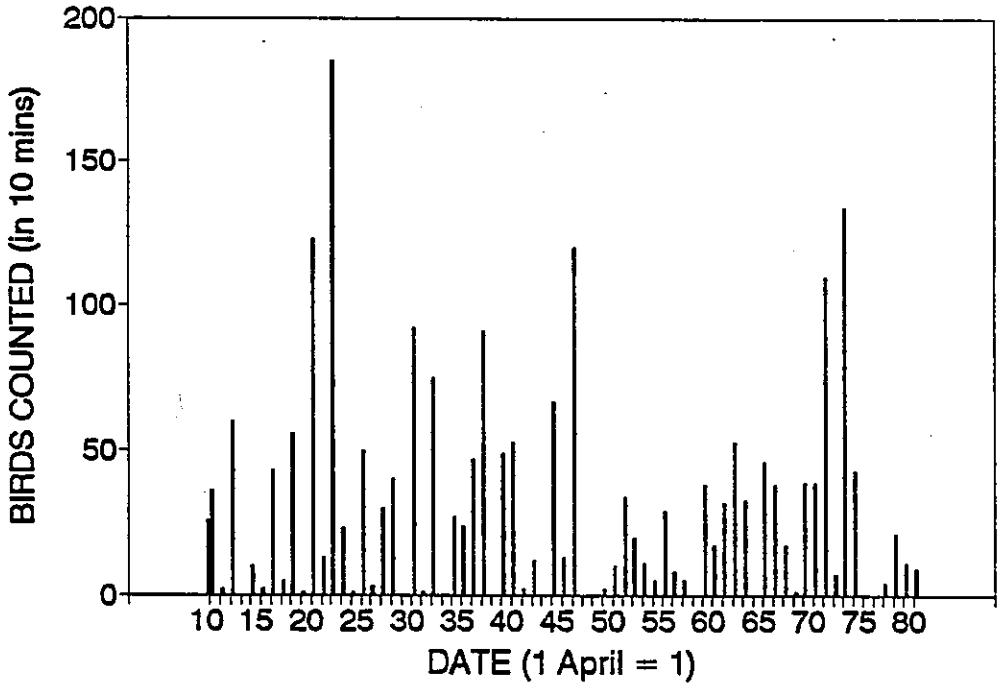
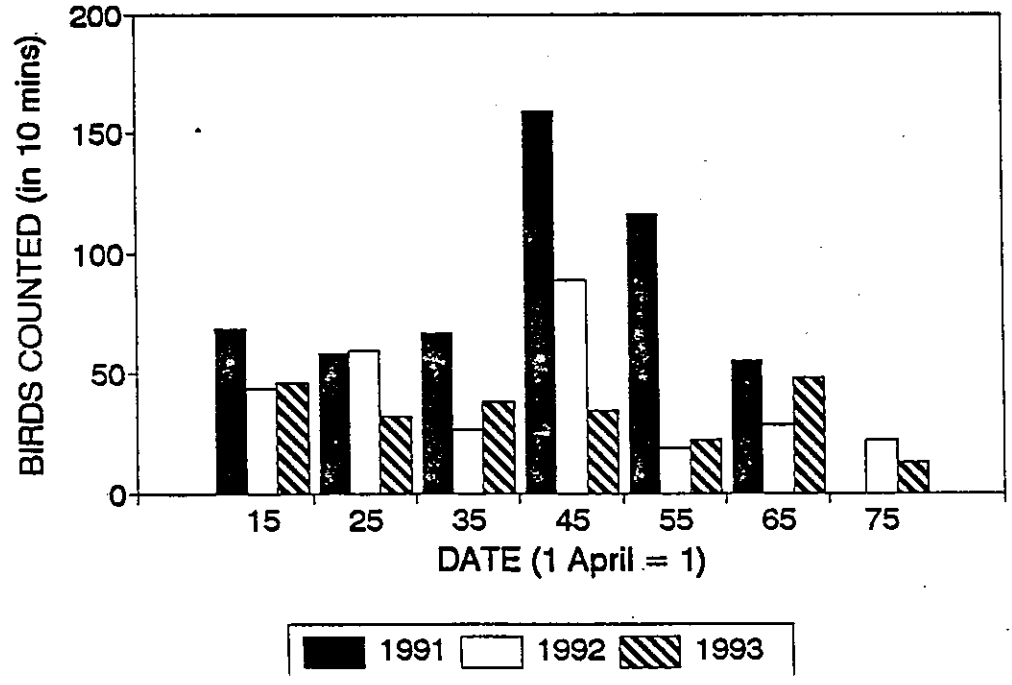


FIGURE 15
GATHERING GROUND COUNTS



SURVEYS AT SEA

Methods

In 1993, boat surveys to census seabirds were conducted in Laskeek Bay between 9 April and 15 July. Figure 16 shows the location of the most commonly surveyed transect lines. Seven complete *coastal* and *offshore* surveys were conducted during the 14 week season. In addition, transects of waters from Haswell Island south to Lyell Island were undertaken on 27 May, 27 June and 11 July. In 1992 this area provided high counts of Marbled Murrelets. In addition five surveys were carried out to the east of Reef Island into Hecate Strait.

Surveys were carried out with a 4.5 m inflatable boat powered by a 25 hp outboard. Most surveys were done in the morning when sea conditions were calmest, with two observers and one boat driver present. The species and number were recorded for all birds on the water within 200 m of either side of the boat.

The first routine survey of Laskeek Bay was carried out between 18-21 April, and the last survey of the season was carried out on 10 July. Because of changes in sea conditions, it was not always possible to complete surveys within a one or two day period. We did not carry out surveys when sea condition was greater than Beaufort 2 (small wavelets).

Marbled Murrelets

On 15 March, 375 Marbled Murrelets were sighted in Cumshewa Inlet. There were also high numbers of murrelets in mid March 1992 in this area. The largest concentration of birds in March 1993 was between Nedden Island and Chadsey Creek (Moresby Island), along the 37 fathom line.

In May and early June, numbers were similar to those seen in earlier years, but in the second half of June there was a dramatic increase in the number of Marbled Murrelets (Table 9).

Almost 1700 birds were counted on June 21, the majority of which were concentrated close to shore between Vertical Point and Haswell Island. Counts were also higher than normal in Skedans Bay (Table 10), also close inshore. High numbers persisted in the same areas until early July. The sharp increase in Marbled Murrelets occurred concurrently with the presence of large numbers of Rhinoceros Auklets. For example, at 18:00 on 30 June we counted 460 Rhinoceros Auklets and 367 Marbled Murrelets from Limestone Island.

The number of Marbled Murrelets declined quickly in July, and only 178 were counted during a boat survey on July 10, despite ideal conditions. On 4 July a bird in transitional plumage from summer to winter was seen in the bay, and on 9 July a marbled murrelet in full winter plumage was noted.

The surveys south of Kingsway Rock, first carried out in 1992, were repeated in 1993 to determine whether relatively high concentrations seen in 1992 were normal. On 27 June 1992, 286 birds were counted in this area. However, the highest count in 1993 was of 121 birds, also on 27 June. On the same date 549 Marbled Murrelets were counted on the inshore transects between Kingsway Rock and Vertical Point.

Table 9 Results of line transect surveys for marbled murrelets within Laskeek Bay during 1993.

Date	Transect		Total
	Coastal	Offshore	
18-21 April	183	65	248
3, 6 May	9	19	35
27, 31 May	114	163	277
15-16 June	208	146	354
21 June	1402	284	1686
29 June-2 July	591	184	775
July 10	144	34	178

Table 10. Comparison of numbers of Marbled Murrelets seen in the Skedans Bay - Laskeek Bay area in 1989-93

DATE	1989		1990		1991		1992		1993	
	Coast[1]	Offsh[2]	Coast	Offsh	Coast	Offsh	Coast	Offsh	Coast	Offsh
Up to 9 April	-	-	6	-	1	0	2	-	-	-
10-19 April	-	-	-	-	17	-	-	-	178	15
20-29 April	-	-	38	-	-	5	28	43	-	-
30 Apr - 9 May	-	-	-	-	205	16	-	-	9	1
10-19 May	-	-	50	104	144	85	80	197	-	-
20-29 May	74	-	25	165	-	-	134	176	114	96
30 May - 9 Jun	68	-	14	35	86	52	141	92	-	-
10-19 June	-	-	-	-	-	-	-	-	208	27
20-29 June	-	-	-	-	-	-	163	70	538	92

1; transects D-J

2; transects 1,3,5 and 7

Other seabirds

After Marbled Murrelet, the most numerous species recorded on transects was the Ancient Murrelet, with a maximum count of 1577 (Table 11). All of these were recorded on offshore transects. The high counts on surveys 1, 3 and 5 probably involved birds on the gathering grounds, rather than feeding aggregations, as surveys were carried out in the afternoon and maximum numbers were seen north of South Low Island, the usual gathering area for Limestone Island. Numbers of Rhinoceros Auklets seen were much higher than in previous years, with a total of 744 counted, mostly on offshore transects in June and July (Tables 11 and 12). They were concentrated especially between the Skedans Islands and South Low Island, and at the beginning of July, when numbers peaked, they were also common in Skedans Bay. As in the case of Marbled Murrelets, numbers appeared to diminish after the first week in July.

The most numerous bird recorded on surveys into the waters of Hecate Strait, beyond Reef Island, was Sooty Shearwater. More than 1000 were counted. Other common species were Ancient Murrelet, Rhinoceros and Cassin's auklets and Glaucous-winged Gulls (Table 13). The numbers of Cassin's Auklets recorded were much higher than were seen on similar surveys in previous years.

In addition to the birds recorded on transect on 9 May, there were approximately 300 Black-legged Kittiwakes and 450 Sooty Shearwaters within 0.8 km of the north tip of Reef Island and three humpback whales feeding 2.5 km north of the east end of Reef Island. On 3 June, there were approximately 350 Ancient Murrelets, 250 Sooty Shearwaters and 50 Cassin's Auklets sitting on the water less than 0.8 km from the east tip of Reef, just beyond the transect line. On 12 June, the transect ended abruptly when we encountered three humpback whales approximately 10 km east of the east tip of Reef Island. On the return trip back to East Limestone, 2 Marbled Murrelets were seen 5 km east-northeast from the east end of Reef Island.

Figure 16 Map of Laskeek Bay showing coastal and offshore transects.

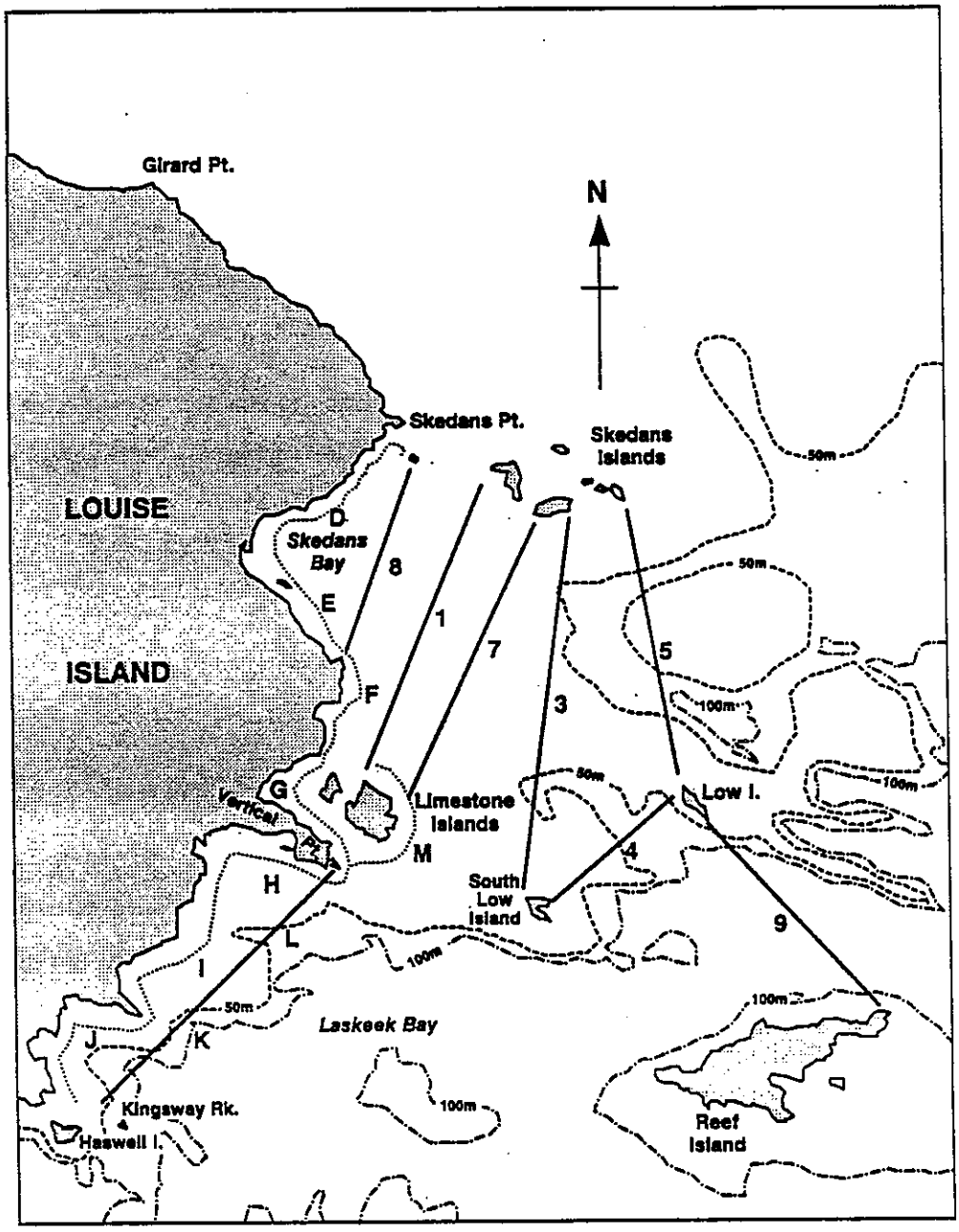


Table 11 Summary of birds seen on offshore transects in the Laskeek Bay area in 1993.

Species	Survey Dates							Totals
	April	May			June	July		
	18-21	3-6	11-15	27-30	12-16	1-2	10	
Common Loon	9	2	0	0	0	0	0	11
Pacific Loon	0	0	0	4	0	0	0	4
Pelagic Cormorant	18	6	1	1	2	1	0	29
Double-crested Cormorant	1	5	1	1	0	0	0	8
Harlequin Duck	4	0	0	0	0	8	0	4
Glaucous-winged Gull	5	8	32	4	1	20	0	70
Herring Gull	1	0	0	0	0	0	0	1
Black-legged Kittiwake	0	0	14	0	0	0	0	14
Common Murre	0	0	0	0	0	0	1	1
Pigeon Guillemot	47	4	25	5	23	0	32	136
Marbled Murrelet	65	19	39	163	149	184	34	653
Ancient Murrelet	659	35	360	118	405	0	0	1577
Cassin's Auklet	0	0	0	0	9	8	1	18
Rhinoceros Auklet	12	18	5	19	178	417	26	675
Species Recorded	10	8	8	8	7	6	5	

Table 12 Summary of birds seen on inshore transects in the Laskeek Bay area in 1993.

Species	Survey Dates							Totals
	Apr 18	May 6	May 31	Jun 15	Jun 21	Jul 1	Jul 10	
Common Loon	2	3	0	0	0	0	0	5
Pacific Loon	0	2	0	0	0	0	0	2
Western Grebe	1	0	0	0	0	0	0	1
Pelagic Cormorant	18	11	12	0	0	0	0	41
Goldeneye	12	0	0	0	0	0	0	12
Harlequin Duck	2	0	0	0	0	0	0	2
Glaucous-winged Gull	2	2	5	0	0	1	0	10
Common Murre	0	0	0	0	0	1	0	1
Pigeon Guillemot	30	21	16	69	44	60	32	272
Marbled Murrelet	183	9	114	208	1402[1]	591	144	2651
Rhinoceros Auklet	5	1	0	0	36	22	5	69
Species Recorded	9	7	4	2	3	5	3	11

[1] An additional 284 Marbled Murrelets were counted on offshore transects K, L and 8 on this date (total 1686).

Table 13. Summary of birds seen on transects running east of the east tip of Reef Island in 1993.

Date	Time	Distance(km)	SOSH	BLKI	ANMU	RHAU	CAAU	COMU	GWGU
9 May	1250	8	385	2	52	1	2	64	1
27 May	0715	8	3	1	0	5	0	0	0
3 June	1100	13	314	0	449	41	133	5	2
12 June	1400	10	379	0	53	60	101	3	105
4 July	0835	6	0	0	0	2	0	0	0
Totals		45	1081	3	554	109	236	69	108

GLAUCOUS-WINGED GULLS

Counts of nests and clutch sizes were undertaken on five breeding sites in Laskeek Bay between 23-29 June, 1993. This was the second annual census of breeding gulls in the area by the volunteers of the Society. Annual counts will help to determine whether Glaucous-winged Gulls move among the colonies in Laskeek Bay. A total of 244 nests were counted in five colonies: Skedans Islands (20 nests); Low Island (4 nests); Lost Island (140 nests); Kingsway Island (79 nests); and Reef Island (1 nest). Table 14 shows the number of nests censused in 1986, 1992 and 1993 for comparison, as well as the percent change in number of nests since the previous census. Overall the number of nests increased slightly from 1992 (3.8%).

Most clutches were of three eggs (178 of 228 nests with eggs = 78%), although one was found on Skedans Island with four eggs. This is slightly lower than in 1992 when 84 percent of all nests with eggs contained three eggs. Table 15 shows the number of nests found and their contents at each of the five sites.

On 23 June on Kingsway Island, in a census of 38 nests, no eggs had hatched, although 10 nests contained eggs that were either pipped or cracked. On 27 June, 22 of 41 nests contained chicks or cracked or pipped eggs (54%). At Lost Islands on 26 June, one still-damp chick was found. This suggests that first hatching at both colonies occurred about 25 June, suggesting that first eggs were laid about 26 May in 1993 (assuming an incubation period of 27 days (Erlich et al. 1988) from clutch completion, and an interval of two days between each egg). This is 11 days later than first egg date estimated by the same method in 1992 (15 May, in Gaston and Lawrence 1993). Sixty Glaucous-winged Gull chicks were metal and colour banded (brown) on Kingsway Rock on 8 and 13 July. We hope to resight some of these birds in future. Little is known of Glaucous-winged Gull dispersal patterns in northern British Columbia.

Table 14. Counts of Glaucous-winged gull nests in the Laskeek Bay area in 1986, 1992 and 1993.

Location	1986	1992	(% change)	1993	(% change)
Kingsway Rock	43	94	(+119%)	79	(-16%)
Lost Islands	75	120	(+60%)	140	(+17%)
Skedans Island	49	18	(-63%)	20	(+11%)
Low Island	39	1	(-97%)	4	(+300%)
Reef Island	?	2[1]		1	
Total	213	235	(+10.3%)	244	(+3.8%)

[1] Reef Island, 1992 2 pairs present but nests not inspected. In 1993, there were 2 pairs of gulls present, but only one pair defended an active nest, which contained 2 chicks.
Source: 1986 data--Rodway 1988; 1992 data-- Gaston and Lawrence 1993

Table 15. Contents of Glaucous-winged gull nests in the Laskeek Bay area in 1993 (E = egg, C = chick)

Location (# nests)	Date	Contents				
		0	1E/C	2E/C	3E/C	4E
Kingsway Rk (79)	Jun 23,29	0	1	11	67	0
Lost Isl. (140)	Jun 26	6	11	20	103	0
Skedans Isl. (20)	Jun 29	8	1	2	8	1
Low Isl. (4)	Jun 29	2	1	1	0	0
Reef Island (1)	Jul 4	0	0	1	0	0
Total (244)		16	14	35	178	1

BLACK OYSTERCATCHERS

A survey of potential breeding sites for Black Oystercatchers was conducted in Laskeek Bay in 1993. This was the second consecutive year the area was surveyed for nests (see Gaston and Lawrence 1993). Thirty sites were found, including two that were identified in 1992 but inactive in 1993. Table 16 lists the location of these sites, and the content of the nests, including chick weights, where available.

Breeding sites were found by scanning the shoreline from a boat, looking for adult birds. If found, an observer was placed on shore to look more closely for nest sites. We found that the behaviour of the birds was an excellent guide to whether or not they had a nest. Nests were always found when adults behaved defensively. In those cases where adults were not defensive, no active nests were located. Nests were visited on average once every two weeks. We were always careful when approaching the nest and handling the chicks so as not to reveal the chicks location to avian predators.

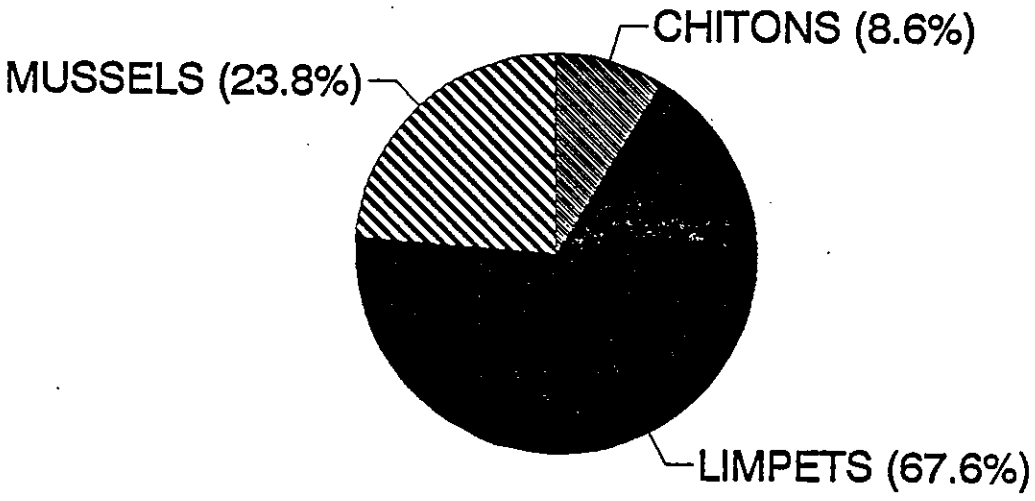
Our objectives were to determine the location and breeding success of each nest and to metal and colour band any chicks in excess of 70 to 100 grams (bands would not stay on smaller chicks). Yellow colour bands were placed on the left leg. In future, this will provide life history data, such as survival and dispersal information and will give an instant indication of the birds age if it is resighted, since the year of banding is known. Oystercatchers are reported to live for more than 20 years, but no studies have been conducted in this area.

Clutches consisted of one (13 nests), two (11 nests) or three eggs (4 nests). Seven of the 28 nests were abandoned sometime after the first egg was laid. The first chicks were found on 18 June and were estimated to be approximately 2 days old (Table 16). Assuming an incubation period of 24 days (Ehrlich et al. 1988), the earliest eggs were probably laid

about 23 May. Two eggs were found on 25 May at site I on East Limestone Island. In total 23 chicks were banded before the camp was disbanded on 15 July. As can be seen from Table 16, chicks that were too small to band at 30-35 g. had gained enough weight within two weeks to be large enough to band.

We collected food remains from the vicinity of nest sites, as Lisa Leduc did in 1992 (Leduc 1993). This method provides an indication of hard-bodied food brought to the nest by the adults, but any soft bodied prey would be consumed by the chicks without a trace. In total, 2200 remains were collected, identified and measured. Limpets (Superfamilies Fissurellacea and Patellacea) were the predominant food item (Figure 17), of which 91% were 12-33 mm in length. Leduc (1993) obtained similar results in 1992. The second most common food item was mussels (*Mytilus sp.*), followed by chitons (Class Polyplacophora). Small shore crabs (*Hemigraspus* sp.), a kelp crab (*Pugettia producta*) and small abalone (*Haliotis kamchatkana*) were occasionally found in the vicinity of the feeding areas.

FIGURE 17
DIET OF OYSTERCATCHER CHICKS, 1992



DIET OF OYSTERCATCHER CHICKS, 1993

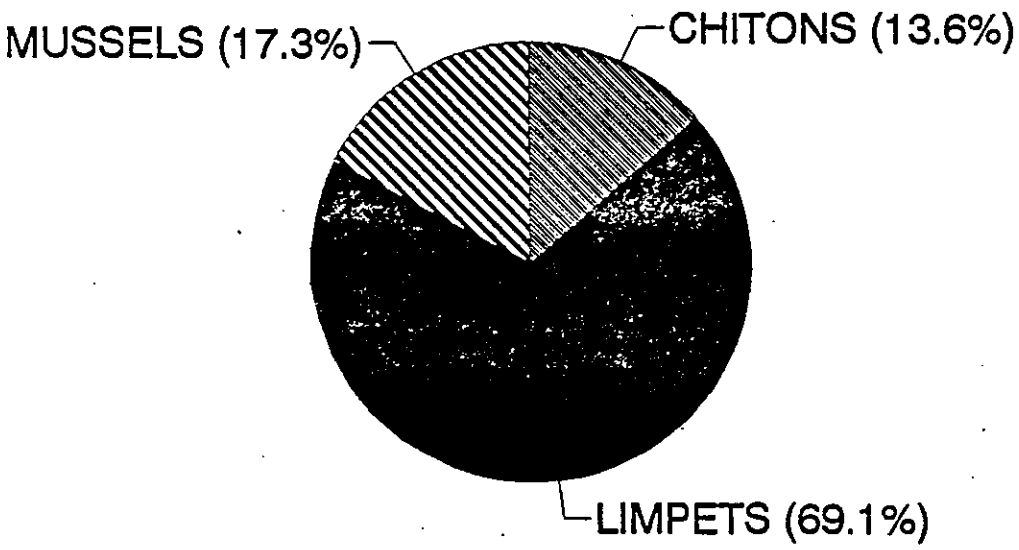


Table 16 Location and contents of Black Oystercatcher breeding sites in Laskeek Bay in 1993.

Location	Site	First Visit	Contents	Final Visit	Contents
E. Limestone	I	May 25:	2 eggs	July 7:	1 chick (>134 g.)
	II	June 21:	1 newly hatched chick	July 14:	1 chick (>300 g.)
	III	May 15:	nest scrape	July 2:	3 chicks (212, 182, 199g.)
W. Limestone	I	May 30:	2 eggs	July 7:	abandoned
S. Low Island	I	June 20:	2 chicks (32,33 g.)	July 3:	2 chicks (107,130g.)
	II	June 20:	1 chick (73 g.)	July 3:	1 chick (219 g.)
	III	June 20:	2 chicks (36,37 g.)	July 3:	1 chick (157 g.)
	IV	June 20:	2 eggs	July 9:	2 chicks (142, 149 g.)
	V	June 20:	3 chicks (34,34,31 g.)	July 10:	1 chick (99 g.)
Skedans Is.	I	May 30:	3 eggs, 3 empty scr.	June 29:	2 chicks (70, 89g.)
	II	May 30:	Not active[1]	June 29:	not active
	III	May 30:	1 nest scrape	July 7:	abandoned
	IV	May 30:	2 eggs	July 7:	abandoned
	V	June 29:	1 egg	July 7:	1 egg pipped/ possibly dead
	VI	June 29:	2 chicks (39,43 g.)	July 7:	1 chick (100 g.)
	VII	June 29:	1 egg	July 7:	abandoned
Low Island	I	June 29:	2 chicks (104,115 g.)		NA
	II	June 29:	2 chicks (77,86 g.)		NA

Table 16 (continued)

Location	Site	First Visit	Contents	Final Visit	Contents
Reef Island	I	June 26:	2 eggs	NA	
	II	June 26:	1 chick, dead	NA	
	III	July 4:	1 chick (165 g.), 1 egg, dead	NA	
	IV	July 4:	Not active[2]	NA	
	V	July 4:	1 chick (188 g.)	NA	
	VI	July 1:	1 chick (163 g.)	July 4:	1 chick (did not weigh)
	VII	July 4:	shell fragments, 4 adults[3]	NA	
	VIII	July 4:	shell fragments, chicks concealed	NA	
Lost Island	I	June 26:	1 egg	NA	
	II	June 26:	1 egg	NA	
	III	June 26:	3 eggs	NA	
Kingsway Rocks	I	June 27:	1 egg	NA	

[1] Birds present in 1992 but no active nest found.

[2] Nest active in 1992.

[3] Adults not defensive, chick(s) probably dead.

FOREST BIRD BANDING

Over 30 species of landbirds have been seen or heard on East Limestone Island since the Laskeek Bay Conservation Society first began its studies in 1990. In 1992, a preliminary effort was made to catch and band forest birds, and a mist net site was established in Spring Valley. This resulted in the banding of 125 birds, comprising 17 species. In 1993 the level of mist netting and banding effort was increased. Four mist net sites were established on the island and a fifth at Vertical Point, on Louise Island. These sites ran from 13 June to 13 July, 1993.

Two hundred and forty birds were banded in the course of 860 net hours, yielding a catch rate of 0.44 birds per net hour. Table 17 shows the location and catch from all five sites in 1993. Ten of the birds caught were retraps from 1992, including a Winter Wren and a Hermit Thrush banded in Spring Valley in 1992 that were retrapped in Crow Valley in 1993. We also had returns of Townsend's Warbler, Orange-Crowned Warbler, Red-breasted Sapsucker, Western Flycatcher, Song Sparrow and Oregon Junco. This indicates that the migrant species, as well as the island residents, will return to breed on Limestone Island.

The Vertical Point site was established to assess the feasibility of participating in a continent-wide monitoring program known as the North American Monitoring Avian Productivity and Survival (MAPS) project. The purpose of MAPS is to establish permanent mist net sites that are operated at the same time during the calendar year for an extended period of time. By using uniform methods each year, it is hoped that long-term trends in population abundance and recruitment of songbirds can be detected. As can be seen from Table 17, the MAPS site yielded only 31 banded birds in 120 net-hours of operations, too few birds to be of utility to the MAPS project. The overall rate (0.26 birds/net-hour) was somewhat lower than the catch rate on Limestone Island (0.34 and 0.44 birds per net hour respectively).

We intend to reevaluate this effort and test other possible MAPS sites, perhaps using one of those on East Limestone Island.

Table 18 summarizes the species caught and banded in 1993 on East Limestone and Vertical Point. The most commonly netted species were Townsend's Warbler, Rufous Hummingbird and Chestnut-backed Chickadee. Rufous Hummingbirds were not banded, as their legs were too small for the band sizes available. In addition to the species listed, a Northern Saw Whet Owl was caught in one of the mist nets at Vertical Point and was released without banding. Table 18 also lists the number of each species caught in 1992 for comparison. We caught fewer Pine Siskins and Brown Creepers in 1993 than in 1992, but many more Red-breasted Sapsuckers, Chestnut-backed Chickadees and Hermit Thrushes.

Table 17 Number of birds caught in five mist net sites on East Limestone Island and at Vertical Point in 1993.

Location	Birds Banded	Retraps from '92	Birds Caught	Total Spp.	No. Nets	Total Net hrs	Bird Net h
Spring Valley (5 nets)	160	7	232	17	5	530.4	0.4
North Plateau (2 nets)	2	0	7	3	2	47	0.1
Crow Valley (3 nets)	22	2	35	10	3	81.5	0.4
Boat Cove (5 nets)	25	1	35	12	5	82.3	0.4
Vertical Pt. Louise Is.[1] (5 nets)	31	0	41	10	5	120	0.3
Total in 1993	240	10	350	20	20	861.2	0.4
Total in 1992 (all Spring V.)	125	NA	141	17	3	unknown	

[1] MAPS site on Louise Island.

Table 18 Species caught and banded in mist nets on East Limestone Island and Vertical Point, in 1993.

Species	EL	VP	93 Total	92 Total	92 Retraps
Northern Flicker	0	0	0	2	0
R-B Sapsucker	18	3	21	9	3
Hairy Woodpecker	2	0	2	1	0
Rufous Hummingbird	27	4	0	0	0
Red-breasted Nuthatch	2	0	2	0	0
Western Flycatcher	5	1	6	5	1
C-B Chickadee	34	0	34	6	0
Brown Creeper	4	0	4	14	0
Winter Wren	18	2	20	13	1
G-C Kinglet	24	0	24	20	0
Swainson's Thrush	5	2	7	2	0
Hermit Thrush	23	16	39	4	2
Varied Thrush	4	3	7	3	0
O-C Warbler	12	1	13	6	1
Townsend's Warbler	44	0	44	25	1
Fox Sparrow	3	0	3	2	0
Song Sparrow	3	0	3	0	3
Oregon Junco	9	3	12	4	1
Pine Siskin	1	0	9	1	0
Red Crossbill	5	0	5	0	0
Total	216	31	247[1]	125	10

[1] This total includes 3 Hermit Thrushes, 3 Orange-crowned Warblers and 1 Song Sparrow, all banded as nestlings.

BIRD NOTES

As in previous years, we kept a daily species list of all sightings of birds and mammals. Seventy species of birds were recorded within the Laskeek Bay area, of which 68 were seen from Limestone, including 1 new record (Horned Puffin) for the area. Sixteen species of mammals were recorded, including one new record (California Sea Lion) for the area, and a second species which had not been seen from camp prior to this year.

SEA AND SHORE BIRDS

Pacific Loon

Seen in all months.

Common Loon

Often seen in April and until the middle of May, but infrequently after that.

Red-throated Loon

One seen on 15 May.

Western Grebe

Seen on 12 April and on 17 May.

Sooty Shearwater

First sighted on 9 May. Commonly seen on boat surveys in May and June, especially to the east of Reef Island.

Storm-petrel

Not seen in 1993, but heard calling occasionally at East Limestone Island.

Double-crested Cormorant

Commonly seen flying by Cabin Cove in April and May. Last seen June 15.

Pelagic Cormorant

Seen daily, typically flying north by Cabin Cove in the morning and heading south in the evening.

Brandt's Cormorant

Seen on four occasions between 15-27 May.

Pacific Brant

Seen and heard flying overhead regularly in April and until mid-May.

Canada Goose

Seen flying northbound on 14, 15 and 17 April, including a flock of 350-400 on 14 April.

American Widgeon

Two seen on 14 May.

Harlequin Duck

Seen regularly from 10 April to 18 May, especially in the vicinity of the Boat Cove.

Black Scoter

Seen on 12 April only.

Surf Scoter

Seen on 2 and 10 June and 1 seen on 14 July.

White-winged Scoter

Seen infrequently from April through June, but seen four times in small groups (2-7 birds) in July.

Common Merganser

Seen occasionally in April in pairs, and a single male was present in the bay at Vertical Point on 31 May. Also seen on 17 and 21 June.

Black Turnstone

Infrequently seen.

Whimbrel

On 11 May, 11 were seen flying near South Low Island in the morning and 54 flew by camp in the afternoon.

Wandering Tattler

Two were seen on 14 May and again 15 May. Seen again on 24 May.

Spotted Sandpiper

One was seen on 17 May and two on 18 May.

Red-necked Phalarope

On 27 June, three were seen during boat surveys. On 9 May, a small flock (<10) of phalaropes was seen flying north near South Low Island (species uncertain).

Black Oystercatcher

There were three active nests on East Limestone Island. See the section on oystercatchers for more information.

Glaucous-winged Gull

Seen almost daily. See the section on Glaucous-wing Gulls for more information.

Herring Gull

Seen frequently in June in Laskeek Bay, but not in large numbers.

California Gull

Infrequently sighted. One on 15 May and two on 16 May were seen from camp. A second-year bird was seen from camp on 3 July. On June 27 two were seen on Kingsway Rock.

Black-legged Kittiwake

First seen on 2 May, and seen often in May and June. On 1 and 2 June, feeding flocks were visible from East Limestone Island.

Long-tailed Jaeger

One seen approximately 8 km east of Reef Island during offshore transects.

Parasitic Jaeger

From 19-30 June, one to two were regularly seen from East Limestone, frequently harassing Black-Legged Kittiwakes.

Pomarine Jaeger

One was seen from camp on 6 June.

Common Murre

First recorded on 27 April and seen frequently throughout the season in small numbers, especially during boat transects. One bird was still in winter plumage on 9 May.

Pigeon Guillemot

One of the most commonly sighted birds in Laskeek Bay. Several pairs nested on the cliffs at the SEA corner of East Limestone Island. An adult was seen flying to the nest carrying a fish on 13 July. No inventory has been done on this species.

Marbled Murrelet

See section on boat surveys.

Cassin's Auklet

First reported April 10. The nest boxes installed at Cassin's Tower in 1992 were inspected periodically. Some were entered regularly, but no eggs were laid in them, although there were signs of active nesting elsewhere on the tower. A few burrows on the north side of Cabin Cove were dug out, presumably by a raccoon.

Tufted Puffin

Two were seen on 9 May and two on 12 June, during transects east of Reef Island. One was seen near the Skedans Islands on 2 June.

Horned Puffin

A single bird spent most of the daylight hours on 28 June within 200 m of shore in the bay at the SW tip of the island.

Rhinoceros Auklet

First seen 20 April and increasingly common in May. In June they were often the most abundant bird seen on the water. On 22 June, over 500 were counted during a morning scan out to sea from the East Limestone Island cabin, and similar numbers of birds were still visible from camp on 30 June.

LANDBIRDS

Sharp-shinned Hawk

One was seen on 24 May at East Limestone Island.

Red-tailed Hawk

Seen once, on 10 April.

Peregrine Falcon

The eyrie was first checked from the blind on 24 May, when 3 chicks were present. One chick fledged successfully, about 6 July.

Bald Eagle

One nest was used in the middle of East Limestone Island. A young bird was still present in nest on 10 July. Another tree, near sapsucker tree #14, showed signs of nesting activity by eagles in April, but the site was not used.

Osprey

Two were seen flying northbound by Cabin Cove on 26 April.

Blue Grouse

Was heard drumming regularly until 11 May, but not heard subsequently.

Saw-whet Owl

First heard on 10 April and heard regularly after 12 May.

Rufous Hummingbird

Present from 9 April to 15 July, regularly using the feeder by the cabin on East Limestone Island. Numerous young were seen. Less abundant after 10 July.

Belted-Kingfisher

Seen frequently perched in the limbs of cedar trees in Boat Cove.

Red-breasted Sapsucker

Sapsuckers were seen regularly from 9 April on East Limestone Island. However, no nests were found during surveys of West Limestone Island. Nests have been censused on East Limestone Island since 1991. At least 8 nests were located in 1991, 10 in 1992 and 11 in 1993. Nineteen different nesting trees have been found, and although the same tree may have a nest a second year, nest holes do not appear to be reused. We will attempt to confirm this by conducting another census in 1994. Juveniles birds were first heard on 29 May, and young from tree #12 were probably the first to fledge on 24 June.

Hairy Woodpecker

Often seen in Spring Valley/ C-plot area and in Boat Cove. No nests were located but young were present on the island in July.

Northern Flicker

Seen regularly until predation remains were found on 20 April, after which none was seen.

Western Flycatcher

Often heard calling at night, especially near Funnel 2.

North-western Crow

No active nests were located this year, but crows were commonly seen around island.

Common Raven

A nest was located near the site used for the last two years. Young fledged 26-29 May.

Tree Swallow

A pair was seen flying over the sea near Haswell Island on 13 June. Also seen on 7 and 13 July.

Chestnut-backed Chickadee

Commonly seen and heard. The first young were caught in mist nets on 17 June. An adult was feeding nestlings in a Red-breasted Sapsucker hole in tree #8, on 27 June.

Red-breasted Nuthatch

First heard on 20 April. Family parties were first seen on 28 June.

Brown Creeper

Seen and heard regularly. One was seen carrying nesting material up sapsucker tree #5.

Winter Wren

Common. Young were first heard on 17 June.

Golden-crowned Kinglet

Often heard but not abundant. The first young were caught in mist-nets on 28 June.

Swainson's Thrush

First heard on 31 May. Less common than the Hermit Thrush.

Hermit Thrush

First heard on 17 April. Common. The first young caught on 17 June. Two nests were found: one near mist net site A1 in Crow

Valley with four eggs on 25 June and a second nest near funnel #4, with an adult still incubating on 2 July. This could have been a second brood.

Varied Thrush

Present from 9 April onwards, often heard, but not often seen.

Robin

Seen and heard on Louise Island, but not on East Limestone Island.

Orange-crowned Warbler

First heard on 25 April and most commonly heard in Crow Valley. A nest in a crevice in a rock wall hatched 3 chicks on 21 June, which were banded 28 June.

Fox Sparrow

First observed 27 April, then 21 May and then every few days in June and July.

Song Sparrow

One often near the biffy and the water-hole on East Limestone island. Often present in Boat Cove.

Savannah Sparrow

One seen on 14 May and two on 15 May.

Dark-eyed Junco

Commonly seen in the area between Cassin's burrows N1-N5.

Red Crossbill

Present daily but did not begin to travel in large groups until 14 June.

Pine Siskin

Heard often from 9 May-4 July, and occasionally thereafter.

Pine Grosbeak

One seen on East Limestone Island on 18 May.

MAMMALS

Eleven species of marine mammals, comprising four species of seals and sea lions (pinnipeds) and seven species of whales (cetaceans) were observed in 1993 in the Laskeek Bay area.

SEALS AND SEA LIONS

Steller (Northern) sea lion

On the Skedans Islands counts of Steller sea lions declined from an initial count of 92 on 19 April to nil on 31 May 31 and thereafter. On the Reef Island Rocks there were 544 Steller sea lions on 9 May, but the numbers gradually declined and remained constant at approximately 250-300 from mid-June onwards (Table 19).

California Sea Lion

At least two California sea lions were recorded on the Reef Island rocks on 9 May and one on 1 July. These appear to be the first records of this species reported on the Queen Charlotte Islands.

Northern Elephant Seal

One adult male elephant seal was seen approximately 4 miles east of Lost Island on 27 May.

Harbour Seal

Harbour seals were often seen swimming and feeding in Cabin Cove. They were also commonly seen hauled out on shorelines within the Laskeek Bay area. Table 20 lists counts of harbour seals made at some of the larger haul-out sites in the area. The counts suggest a population of about 200 seals in Laskeek Bay in June. A small pup was present in Cabin Cove on 17 June.

Table 19 Steller sea lion counts on Skedans and Reef Islands.

Location	Date	Count	Location	Date	Count
Skedans Is.	Apr 19	92	Reef Is.	May 9	544
	May 2	94		May 25	348
	May 11	35*		Jun 12	405
	May 25	12		Jun 26	252
	May 28	2		Jul 1	305
	May 31	0		Jul 10	251

* more animals in water, not included in the count

Table 20 Harbour seal counts in Laskeek Bay in 1993.

Location	Date	Count
Skedans Is.: SW tip of westernmost islet	Apr 18	25
	Jun 16	19[1]
	Jul 10	20
All of the Skedans Is.	Jun 29	150+
South Low Island	Apr 18	27
	May 3	40
	May 25	18
	Jun 16	25
	Jul 9	23
Low Island	May 25	8 (E.side)
	May 28	17 (W.side)
	Jun 16	15 (W.side)
	Jul 10	21 (W.side)

[1] more in kelp beds around the islands.

WHALES

Baleen whales. Three species of baleen whales were seen in Laskeek Bay in 1993: humpback, gray and minke whales.

Humpback Whale

Humpback whales were seen on eight occasions, mostly in Hecate Strait, as shown in Table 21.

Minke Whale

Minke whales were seen on 9 occasions (Table 22).

Gray Whale

Gray whales were seen on 5 occasions in Laskeek Bay in 1993, as listed in Table 23.

Table 22 Humpback whales sightings in the vicinity of Laskeek Bay in 1993.

Date	No. seen	Location	Activity
May 2	1	4.8 km E of Low Island	travelling
May 9	3	N. end Reef Island	including cow/calf feeding
	1	4.4 km E of Reef Island	swimming with 25 Pacific WS dolphins
May 11	1	South Low Island	feeding
Jun 3	1	16 km E of Reef Island	travelling
Jun 12	3	10 km E of Reef Island	including cow/calf feeding
	1	9 km E of Reef Island	
	1	16 km SEA of Reef Island	

Table 23 Gray whale sightings in Laskeek Bay in 1993.

Date	No. seen	Location	Activity
Apr 24	1	Cabin Cove	travelling north
May 19	2	between Low and S. Low	
May 25	1	1.6 km N of Skedans	travelling north
May 31	2	SEA tip of E Limestone	cow/calf, feeding
Jun 4	1	North Cove (E. Limestone)	travelling north

Table 24 Minke whale sightings in Laskeek Bay

Date	No. seen	Location	Activity
May 2	1	.4 km NW of E Limestone	travelling north
Jun 3	1	Vertical Point	
Jun 12	1	2 km E of E Limestone	
Jun 15	1	SEA tip E Limestone	
Jun 18	1	1.2 km NE of Cabin Cove	feeding
Jun 26	1	Vertical Point	travelling north
Jun 28	1	E. Limestone Skedans, Low I.	seen at 0650, 0815 and 0900
Jul 1	1	Cabin Cove	travelling south
July 11	1	1.5 mi. E of Porter Head	travelling SW

Toothed Whales. Four species of toothed whales and dolphins were seen in Laskeek Bay in 1993: Dall's porpoises, harbour porpoises, Pacific white-sided dolphins and killer whales.

Dall's Porpoise

Dall's porpoises were seen on 3 occasions: one was seen on 7 May, .8 km East of Cabin Cove; 2 were seen on 3 June, .8 km West of S. Low Island; and 10-20 were seen on 12 June, 3.2 km East of Low Island.

Harbour Porpoises

Harbour porpoises were seen on 8 occasions as listed in Table 25.

Pacific white-sided dolphins

Pacific white-sided dolphins were seen and/or heard on 11 occasions, as listed in Table 26. This is the first year that Pacific white-sided dolphins have been seen from East Limestone Island (1 July).

Killer Whales

Killer whales were seen on 7 occasions (Table 27).

Table 25 Harbour porpoise sightings in Laskeek Bay in 1993.

Date	No. seen	Location	Activity
May 26	1	1.6 km SEA of Hemming Head	feeding
Jun 3	1	.4 km SEA of E Limestone	
Jun 16	3	between Skedans & S. Low I.	including 1 calf
	1	.8 km S of Skedans Is.	
Jun 26	1	Vertical Point	
Jun 27	1	SEA tip E Limestone	
Jul 10	1	.5 km S of Skedans Is	
Jul 13	1?	.8 km E of Limestone	

Table 26 Pacific White-sided dolphin sightings in Laskeek Bay in 1993.

Date	No. seen	Location	Activity
Apr 21	?	near Skedans Islands	heard on hydrophone
May 4	?	near Cabin Cove	heard on hydrophone
May 9	25	4 km E of Reef Island	with humpback whale
May 27	?	6 km E of Lost Island	heard on hydrophone
Jun 26	20-25	1.6 km E of Nelson Pt.	travelling east
Jun 29	200	S Low to E of Nelson Pt	milling
	4	1.2 km N of Low Is.	eastbound
Jul 1	6	north of Limestone	
	50+/-	3.2 km SEA of E Limestone	
	12-15	between Reef and Low Island	
Jul 10	20-25	E Limestone to Reef Is.	feeding, widely scattered

Table 27 Killer whale sightings in Laskeek Bay in 1993.

Date	No. seen	Location	Activity
May 2	1	.3 km E of Low Island	travelling north
May 18	3-4	S. Low Island	southbound
Jun 26	1	Vertical Point	surfaced twice
Jul 6	2	Cabin Cove	southbound
Jul 7	3	Cabin Cove	circled E. Limestone
Jul 11	2	Cabin Cove	southbound
Jul 14	3	Cabin Cove to Skedans	killed seal(s) in Skedans Is.

LAND MAMMALS

River Otter

There was regular sign of otter activity on East Limestone Island, including a 'slide' used frequently in the North Cove, and an otter was seen occasionally in the Boat Cove and in the Cabin Cove. However, there was no evidence of an active otter den on the island.

Raccoon

The first confirmation of a raccoon on East Limestone Island in 1993 was a scat found in the Boat Cove on 28 April. A scat was found on West Limestone on the same date and several others were found throughout the field season. One raccoon was seen on 1 June, near the hydrophone site. None was killed on East Limestone in 1993, although four were killed around Vertical Point, in early June (BC Ministry of Parks and Environment).

Red squirrel

Red squirrels were common in all areas of the island. There was a population explosion around 31 May. On 29 June a squirrel was observed feeding on sap after a Red-breasted Sapsucker had apparently been feeding on a small hemlock.

Deer mouse

Deer mice were not often seen on East Limestone Island, except in the vicinity of the cabin. There appeared to be a sharp increase in population in the area of Funnel #2 around 9 June.

Black-tailed deer

Black-tailed deer were commonly seen in all parts of the island. The first fawn was noted on 7 June.

Bats

Lone bats were seen flying on the nights of 20 and 25 June.

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EFFECTS OF INTRODUCED MAMMALS IN HAIDA GWAII

The Laskeek Bay Conservation Society is keen to study and publicize the impact of introduced organisms on native ecosystems. In 1993, the Society participated in a programme designed by Dr Jean-Louis Martin, of the Centre National de Recherche Scientifique, Montpellier, France to analyse the effects of introduced rats and squirrels on the reproduction of forest birds. The following article is a preliminary analysis of the data obtained in what was a pilot project. Some of the findings may be modified in the light of future investigations. It also includes a description of work carried out by Jean-Louis and his associates on the effects of deer browse on forest vegetation. We hope to continue studies of many of these impacts in future years.

THE IMPACT OF INTRODUCED MAMMALS ON THE VEGETATION AND LAND BIRDS OF OLD GROWTH FORESTS IN HAIDA GWAII (QUEEN CHARLOTTE ISLANDS): PRELIMINARY RESULTS

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INTRODUCTION

The introduction of alien species is a global threat on the diversity of life, especially on isolated islands. Accidental or intentional species introductions generally have adverse effects on the distribution and abundance of the native faunas and floras (ICBP 1985, Drake et al. 1989). They have led many species to disappear and brought others to the verge of extinction. Haida Gwaii (Queen Charlotte islands) is no exception.

They were nine species of terrestrial mammals and four species of bats native to Haida Gwaii. During the past century one species, the Caribou *Rangifer tarandus dawsoni*, has become extinct. However, 11 species of terrestrial mammals have been introduced to the islands (Cowan 1989, Foster 1989): The Black tailed deer *Odocoileus hemionus*, the Wapiti *Cervus americanus*, the European red deer *Cervus elaphus*, the Red squirrel *Sciurus hudsonicus*, the American beaver *Castor canadensis*, the European

black rat *Rattus rattus*, the Norway rat *Rattus norvegicus*, the House mouse *Mus musculus musculus*, the Muskrat *Ondatra zibethica oyoyooensis*, the Racoon *Procyon lotor vancouverensis* and the Domestic cat *Felis domesticus* that has become feral on Langara Island.

Among the introduced deer, the Black tailed deer, released on Graham Island, at the end of last century (Osgood 1901) has now successfully colonized the entire archipelago, including the smallest offshore islands which the species visits periodically. The absence of predators and, on most of the islands, of hunting, leaves these deer populations totally unchecked. The impact of deer on the native vegetation can be dramatic and is one of the main changes pressed upon the natural features of the islands by European settlers (Foster 1989). Deer affect forest regeneration (Pojar et al. 1980, Pojar and Banner 1984, Foster 1989) and can influence seed dispersal and the establishment of native and introduced plants (modification of plant community composition; modification of habitat structure).

The Red squirrel was also very successful in colonizing the archipelago. It was introduced on Graham Island in 1950 by the Game Commission to help provide Sitka spruce seeds to seed gatherers (Foster 1989). It has spread across the main islands and to the less isolated smaller islands. However, it is absent from most of the average and small sized islands that are sufficiently isolated (pers. obs.). This pattern of distribution provides a good situation for ecological field experiments.

By affecting the seed production and dispersal of some plants, such as Sitka spruce, red squirrels could alter forest regeneration patterns. Squirrels are also efficient bird nest raiders. The latter effect may interact with modifications of the understory vegetation cover by deer browsing. The impact of squirrels in Haida Gwaii has not been studied so far.

The Raccoon, introduced in the 1940s (Foster 1989) was also extremely successful in spreading across the archipelago and has

had a strong impact on breeding sea birds (Masselink and Van der Brink 1992, Gaston 1992, Bailey and Kaiser 1993). Their effect on ground nesting land birds has not been studied.

Rats occur on several islands (main islands, Langara, Murchison, Lyell etc...), but do not seem to spread easily from the islands on which they were accidentally introduced. They have had a dramatic impact on seabird populations on some islands (Gaston 1992).

Concerns about the impact of these introductions on the biological diversity of old growth forest communities on Haida Gwaii prompted us to investigate the effect of predation by squirrels and rats and of browsing of the understorey by Black tailed deer on the nesting of native land birds. Deer browse may affect potential nesting sites as well as the visibility of nests to predators, by affecting the distribution and abundance of understorey plant species, as well as growth and survival of tree seedlings used by birds for nesting or foraging.

We studied the predation of artificial nests baited with Japanese Quail (*Coturnix coturnix*) eggs on three islands with different sets of introduced predators and compared it to the predation of artificial nests observed on another island without introduced predators.

We also documented the impact of Black tailed deer on the understorey vegetation and on the regeneration of the dominant tree species of old growth forests on islands of different sizes. Variation in the impact of deer from island to island can help us to assess present and future impacts of deer on the vegetation and possible mitigating techniques.

MATERIALS AND METHODS

1. Predation on artificial nests

a. Study localities

The study took place between 12 May and 25 June 1993 on Ramsay Island (4,557 ha), which had no introduced mammalian nest predators, Limestone Island (48 ha), which had an abundant population of squirrels and one Raccoon, Langara Island (3,103 ha), with introduced Norway rats (D. Nagorsen, Royal B.C. Museum, pers. comm.) and Murchison Island (425 ha, introduced ship rats, A.J. Gaston, pers. comm.).

On Ramsay, Limestone and Murchison Islands, the only potential native mammalian nest predator is the deer mouse *Peromyscus maniculatus*. The deer mouse has been often observed on Ramsay and Limestone islands. Deer mice have not been observed on Murchison Island. Langara Island supports a population of dusky shrews *Sorex monticolus*, but has no deer mice (AH pers. obs.). The dusky shrew has also been observed on Ramsay Island.

b. Methods

Transects of artificial wicker nests were established on each island (nest diameter, 8 cm). Wicker nests were placed on or above the ground (between 0.5 and 2 m usually in a small tree or shrub) in order to mimic both ground nesting and shrub nesting birds. The interior of the nests was lined with moss. Each nest was baited with two Japanese Quail eggs. Their size, although still small enough to mimic passerine eggs, was large enough to make it difficult for deer mice to break them.

Individual transects were 1 km long on all islands except Murchison where the transect was only 600 m long. Three transects, each comprising 42 ground and 42 shrub nests were set up on 26 May on Ramsay and Limestone islands. Ramsay Island was our control island. Three transects of 40 nests were set up on

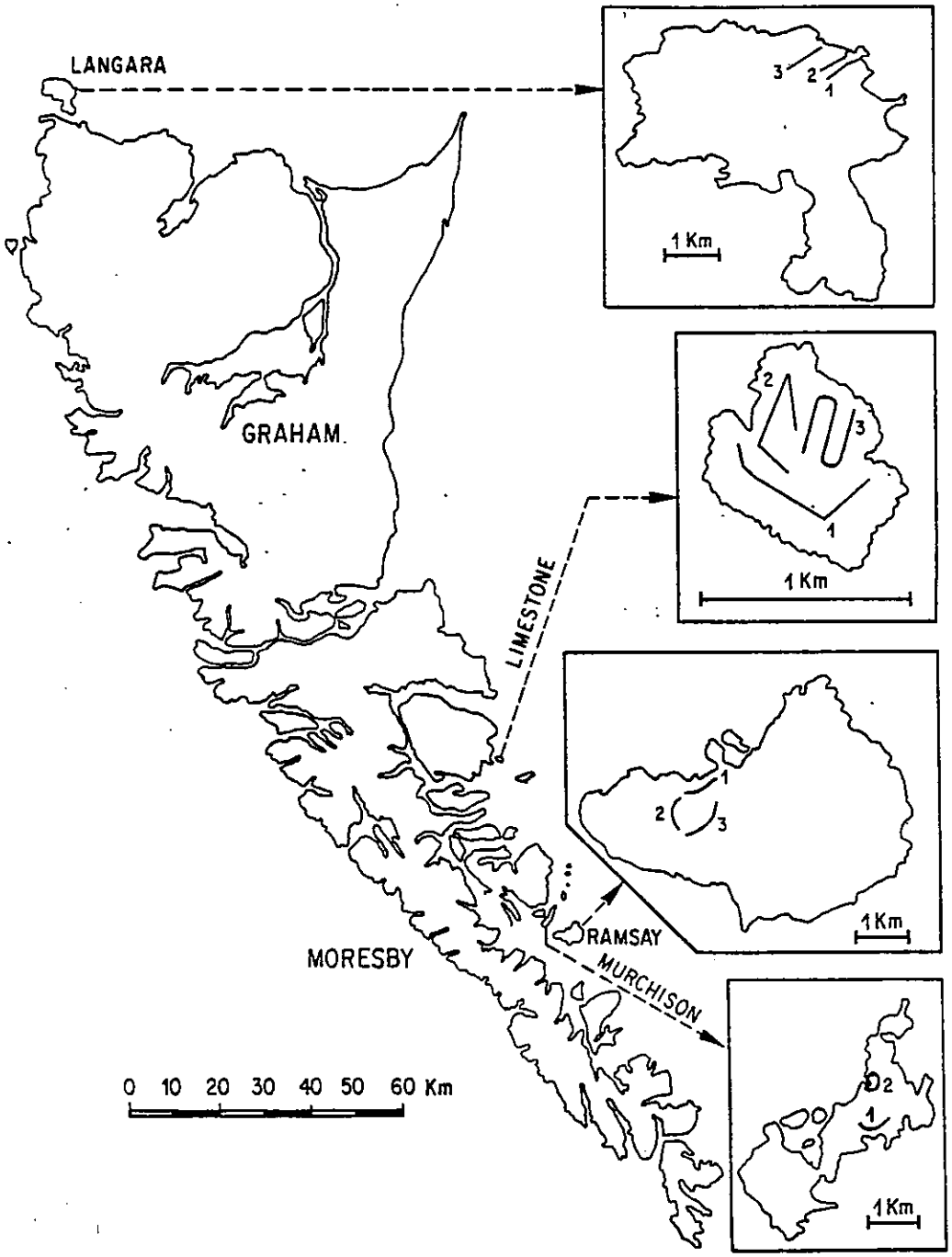
May 12-14 on Langara Island. On Murchison Island one transect of 13 ground nests and a plot of 35 nests were set up in two different localities on 28 May and 12 June, respectively. The location of the transects on the islands are shown in Figure 1

On the transects of Ramsay, Limestone and Langara Islands one ground nest and one shrub nest were placed every 50 m, one on each side of the transect, on alternating sides and at a minimum of about 10 m from the marked transect. The transects were first run for 7 days in order to allow potential predators to discover and get used to this new food resource. After this initiation period the nests were relocated within a 15 m radius on Ramsay and Limestone and moved 25 m along the transect on Langara, nest types being switched side and predated eggs replaced. The transects were checked again on days 4, 8, 12, and 15 on Ramsay and Limestone and on days 3, 6, 9, 12, and 15 on Langara Island. Fifteen days corresponds to the approximate length of the period from laying to hatching for small passerine birds.

On Murchison Island, one ground nest was placed every 50 m on alternate sides of the transect. This transect was checked after 7 and 15 days. The plot of 35 ground nests had higher nest density with distance between nests varying from 5 to 25 m. It was situated within a small area surrounding an abandoned cabin close to the shore. These nests were checked after 7 days.

The results of these experiments were analyzed by the Mayfield method for estimating nest survival rates (Mayfield 1961, 1975). Equality of nest survival estimators were tested according to the method proposed by Hensler and Nichols (1981).

Figure 1. The study areas and the localisation of the transects of artificial nests on Langara, Limestone, Ramsay and Murchison.



2. The impact of Black tailed deer on the understorey

a. Sampling localities

Four different islands were selected as representative samples of the range of conditions encountered in isolated islands within the archipelago. Tar and Agglomerate islands are small (6 and 20 ha, respectively) and well isolated from the main islands, Ramsay Island is a large island (4,557 ha), well isolated from the main islands, and Moresby Island (the De la Beche inlet area) is one of the main islands. The first three islands were selected for their isolation from the main island, to maximize the difficulty for deer to reach them or to use several islands for foraging. No replicates were sampled, but our direct knowledge of the habitat conditions on most of the islands in the area suggests that the islands sampled were representative of islands of similar size and isolation.

b. Impact on shrubs

We focused on the two commonest shrubs: Salal *Gaultheria shallon* and Huckleberry *Vaccinium* sp.. We defined two categories: well developed shrubs (height equal or greater than 0.5 m and several stems or main branches) and shoots (height less than 0.5 m and only one stem).

Well developed shrubs were sampled along transects within 10 m to the left or to the right. When shrub cover was very dense only one or two plants were studied at regular intervals (10 to 20 m) in order to avoid biases due to locality. When shrub cover was low (individual shrubs spread out), all plants found along the transect were studied. For each shrub we measured height, the distance from the base of the shrub to the ground (e.g. growing on a stump, a snag etc.), the type of support on which the shrub was growing, the distance from the ground to the lowest foliage on the shrub (foliage and buds were the target of deer browsing), and finally the amount of browsing that the shrub had suffered, scored from 1 (no browsing) to 6 (very heavy browsing).

Shoots were sampled like shrubs. All shoots studied were accessible to deer and were found growing on the ground or on other supports. For each shoot the impact of browsing was measured by counting the number of times the shoot had been clipped (deer having no upper incisors will rip off the tip of the shoot leaving a jagged edge). Assuming that each spring the seedling grows a new shoot, the number of clipped old shoots per plant can be used to estimate the number of years this individual was "trying" to get started. Differences in the browsing patterns were compared using the Kolmogorov Smirnov test for samples from different localities.

c. Impact on tree seedlings

Seedlings (young trees >10 cm and <0.5 m high) of Sitka spruce *Picea sitchensis*, western hemlock *Tsuga heterophylla* and cedar sp. (western red cedar *Thuja plicata* or yellow cedar *Chamaecyparis nootkatensis*) were identified along transects and scored from 0 (no browsing) to 5 (shape very heavily affected by browsing). Seedlings were usually found in small patches of regeneration. Ten plants were sampled in each patch and additional individuals were only recorded at least 25 m away in order to limit locality effects.

RESULTS

1. Predation on artificial nests

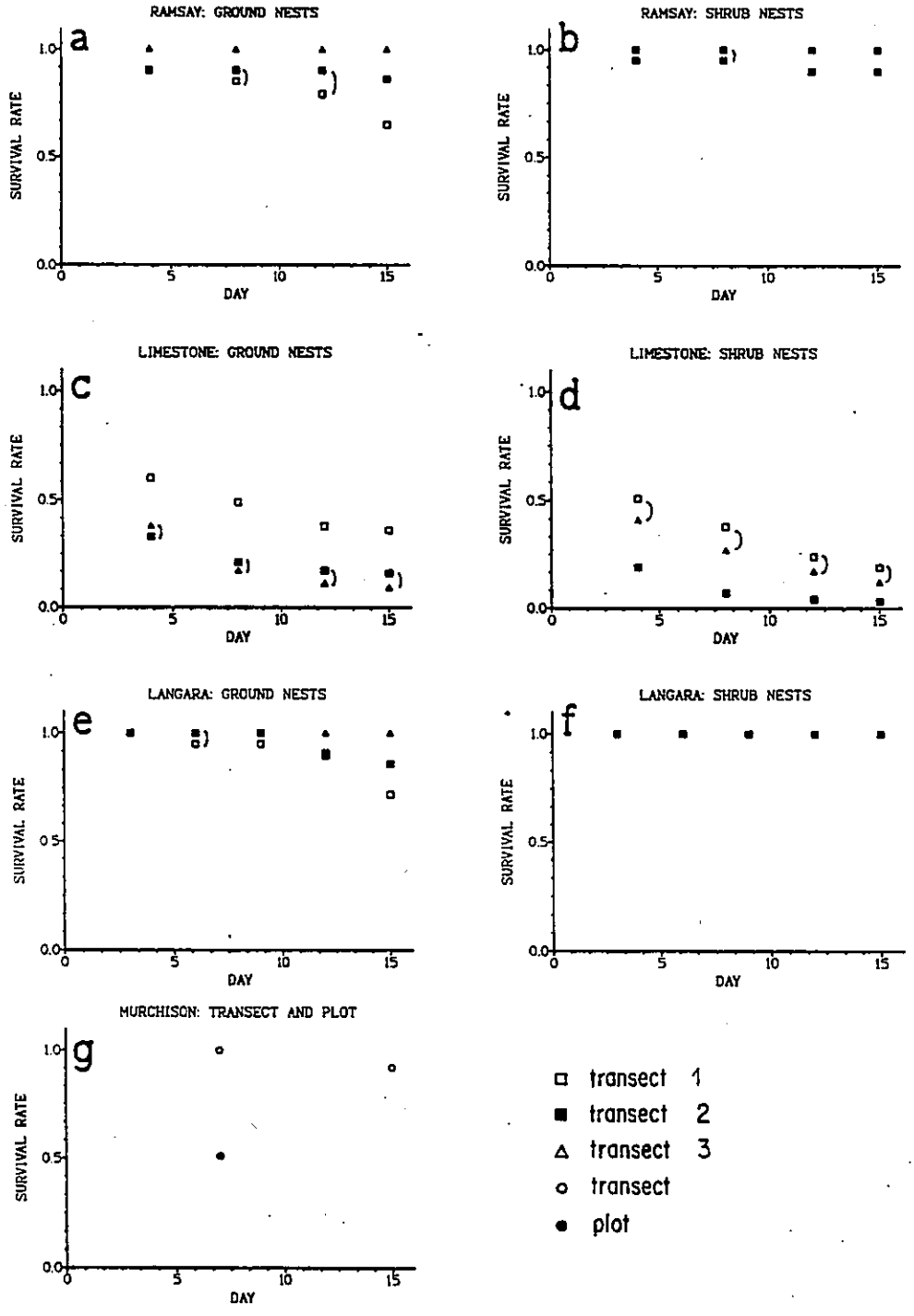
On Ramsay Island predation rates at the end of the experiment varied among transects from 0 to 35 % (Figure 2a and b). For ground nests, the highest predation rate was observed on transect 1, the closest to the shore (between 150 and 300 m). Six out of the seven predations were attributed to Deer mice (egg shells were heavily and finely scratched, typical of deer mouse, JLM pers. obs.). In only one case was the shell broken and chewed and the interior eaten. One of the scratched eggs eventually disappeared.

On the second transect, predation on ground nests (3 nests) was exclusively attributed to small birds (egg shells pierced and emptied or egg shell pushed in, no scratches). For the first two transects the rate of predation increased with time (increasing negative slope of survival curve with time, Figure 2a). No predation was observed on transect 3, the furthest from the shore and the one with the densest understorey.

Predation of shrub nests on Ramsay only occurred on transect 2 (Figure 2b). All predations in these 3 nests were attributed to birds. Two of these shrub nests were located at the same point on the transect as the ground nests that had eggs predated by small birds.

On Limestone Island, the level of predation along nest transects was dramatically and significantly higher than on Ramsay Island (Figure 2b and c). On transects 2 and 3, 40-60 % of nests had been depredated by the first check (day 4) and 90% of the ground nests had been depredated by the end of the experiment. The predation rate between successive checks decreased with time. Nest predation rates for ground nests were significantly lower on transect 1 on Limestone Island, which had the densest understorey, than on transects 2 and 3.

Figure 2. Pattern of predation of artificial nests on islands with different sets of introduced mammalian nest predators. Three transects were set up on each island. Half of the nests were placed on the ground (ground nests, graphs a, c and e) half above the ground at heights ranging from 0.5 to 2 m (shrub nests, graphs b, d and f). Ramsay Island: no introduced predator (graphs a and b); Limestone island: introduced Red squirrel and one Raccoon (graphs c and d); Langara (graphs e and f) and Murchison (graph g): introduced Norway rat. On graph b open triangles and open squares overlap, on graph f all 3 symbols overlap. For overlapping values and values linked by a parenthesis the hypothesis of equality of survival rate cannot be rejected. All other differences are statistically significant.



The predation rate of shrub nests for transects 1 and 3 was significantly higher at each check than the values observed for transect 2. When ground and shrub nest were compared, predation rates were higher for shrub nests than for ground nests (compare Figures 2c and 2d).

Nests which had been depredated were often disturbed, dragged away, or turned over. All tooth marks found on the shell fragments suggest predation by red squirrels. Scratches on the shells were much broader than those made by deer mice and less regular. The higher predation for shrub nests also suggests predation by squirrels rather than by raccoon. However, the exact impact of raccoon on the artificial nests, was difficult to assess without further data.

On Langara Island, all of the shrub nests survived until the end of the experiment (Figure 2f). For the ground nests, survival was high until day 9 (Figure 2e). Thereafter, predation increased with time on transects 1 and 2. Predation occurred predominantly at nests close to the shore. All nests survived on transect 3. Six eggs disappeared. Of the remaining 12 depredated eggs, eight were attributed to rats, based on the pattern of incisor marks on the eggshell; four were crushed too badly for the predator to be determined, but each of these was in a nest where the second egg showed signs of rat predation.

On Murchison Island, only one of 13 nests from the transect was preyed on (open circles on Figure 2e), probably by a bird. No eggs were scratched. In contrast, of the 35 ground nests placed at high density near the shore, 50% of the nests had been depredated after only 7 days, with clear evidence of rat predation in all cases (fresh rat droppings near or inside the broken shells, scratches that were regular but intermediate in size between those of squirrel and deer mouse).

2. The impact of Black tailed deer

Shrub densities were lowest on Ramsay Island (Table 1) and highest on Tar Island (Table 1 and pers. obs.). Agglomerate Island and Moresby Island had intermediate shrub densities (pers. obs.).

Table 1. Number of shrubs and shoots sampled per meter of transects on each island. * refers to samples for which the transect run through dense stands of the plants measured and for which individuals were sampled at regular intervals. In all other instances plant densities were so low that all the individuals situated within 10 m of the transect where censused.

	SALAL		HUCKLEBERRY	
	Shrubs	Shoots	Shrubs	Shoots
Tar	>>0.30 *	>>0.20*	0.14	0.10
Agglomerate	>>0.25*	>>0.25*	0.08	0.13
Ramsay	0.08	0.06	0.09	0.09
Moresby	>>0.25*	>>0.30*	>0.17	>0.04

a. Impact of browsing on salal

The amount of browsing varied with island size (Fig. 3, row 1). On the smallest island (Tar) few of the shrubs sampled showed signs of browsing. The impact of browsing increased with island area (Table 2, Figure 3, row 1). It was highest on Ramsay Island and significantly lower on Moresby Island. The pattern observed on Moresby was similar to that seen at Agglomerate Island.

The distribution of shrub size was similar in most samples (Figure 3, row 2, Table 2), although on Moresby Island, the size distribution was skewed towards the lower sizes. In contrast, significant differences were found among islands in the distribution of the height of the lowest foliage (Figure 3, row 3, Table 2). On Tar Island, foliage started below 1.5 m in most cases. On Agglomerate Island, the situation was similar, but more shrubs only had foliage more than 1.5 m above ground. This

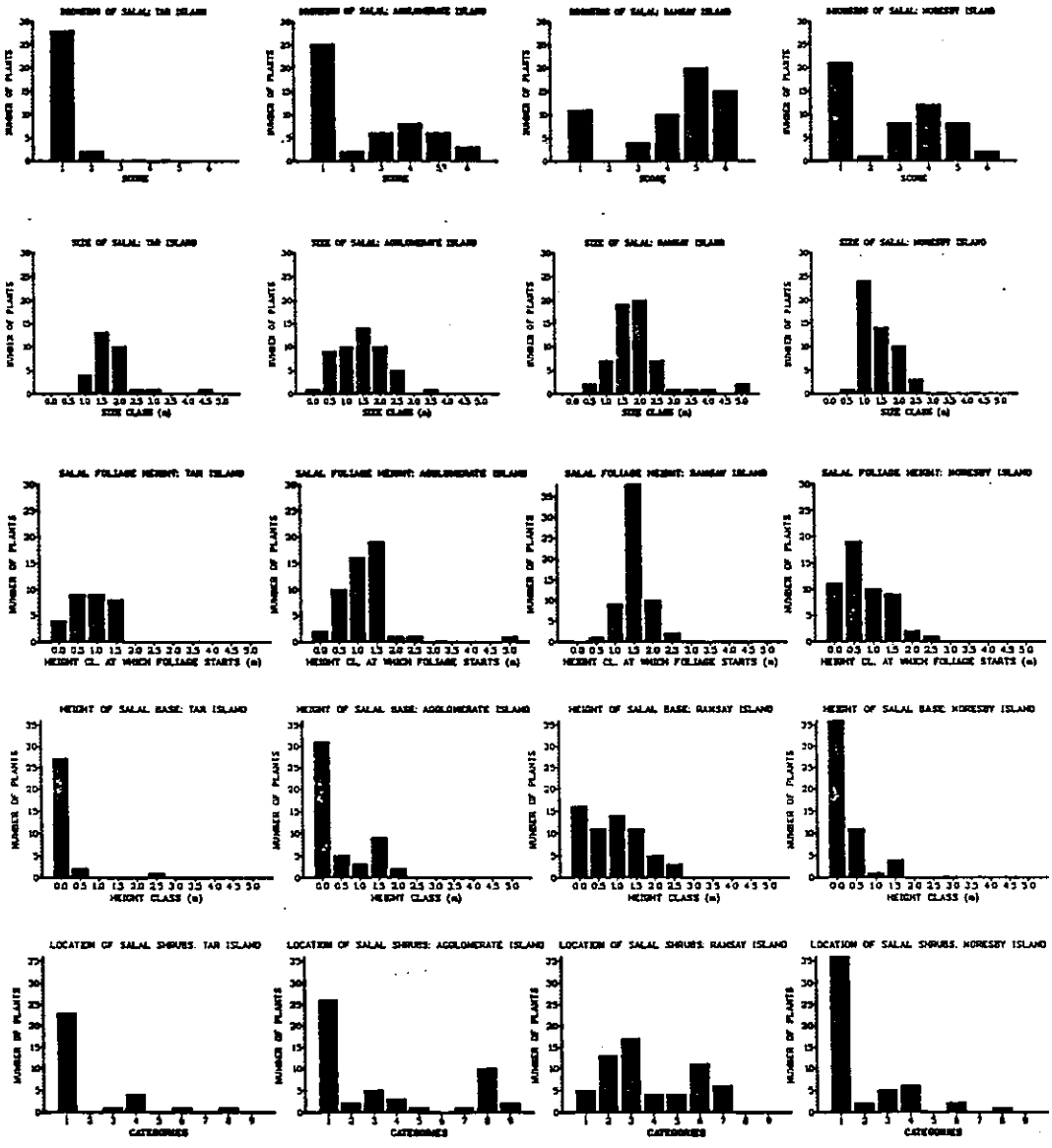
trend was most marked on Ramsay Island, where most of the shrubs had foliage only more than 1.5 m above ground. Moresby Island was similar to Tar Island in this character.

Table 2. Results of Kolmogorov Smirnov tests of similarity of character distributions among ordered categories for Salal. n.s. = the similarity hypothesis cannot be rejected. *, **, *** = the similarity hypothesis is rejected at the 0.05, 0.01 and 0.001 probability level respectively.

		Tar	Agglomerate	Ramsay
	Agglomerate	***		
Browsing	Ramsay	***	***	
	Moresby	***	n.s.	***
	Agglomerate	n.s.		
Shrub size	Ramsay	n.s.	n.s.	
	Moresby	*	n.s.	**
	Agglomerate	n.s.		
Foliage height	Ramsay	***	***	
	Moresby	n.s.	**	***
	Agglomerate	n.s.		
Height of base	Ramsay	n.s.	**	
	Moresby	n.s.	n.s.	***
	Agglomerate	n.s.		
Location	Ramsay	***	***	
	Moresby	n.s.	n.s	***

On Tar Island, most shrubs were growing on the ground (Figure 3, row 4). The proportion of shrubs growing on some other support was higher in the other samples, but only Ramsay Island differed statistically from the other islands (Table 2). Most of the shrubs on Ramsay Island were rooted more than 1 m above the ground. Similarly, on Ramsay more shrubs grew on supports that rendered them more difficult to reach from the ground, especially the sides of stumps, snags, trees and rocks and the tops of stumps (2, 6, 7, 8 and 3, respectively, Figure 3, row 5, Table 2).

Figure 3. Impact of browsing by Black tailed deer (Odocoileus hemionus) on Salal (Gaultheria shallon). Sample sizes equal 30, 50, 60 and 52 respectively for each row. Islands are ranked according to increasing size along rows. Tar = very small isolated island (6 ha); Agglomerate = small isolated island (20 ha); Ramsay = large isolated island (4,557 ha), Moresby = main island. Each row refers to one of the characters studied: row 1 = amount of browsing; row 2 = size distribution of the shrubs; row 3 = height from the ground at which foliage starts; row 4 = height of shrub base from the ground; row 5 = location of the shrubs (on what support they did germinate). Score: 1 = no browsing; 2 = very little browsing; 3 = little browsing; 4 = medium browsing; 5 = heavy browsing; 6 = very heavy browsing. Categories: 1 = on the ground; 2 = on the side of a stump; 3 = on the top of a stump; 4 = on the side of a fallen root system; 5 = on the top of a fallen root system; 6 = on the side of a snag; 7 = on the side of a tree; 8 on a rock; 9 on the top of a snag.



b. Impact of browsing on Huckleberry shrubs

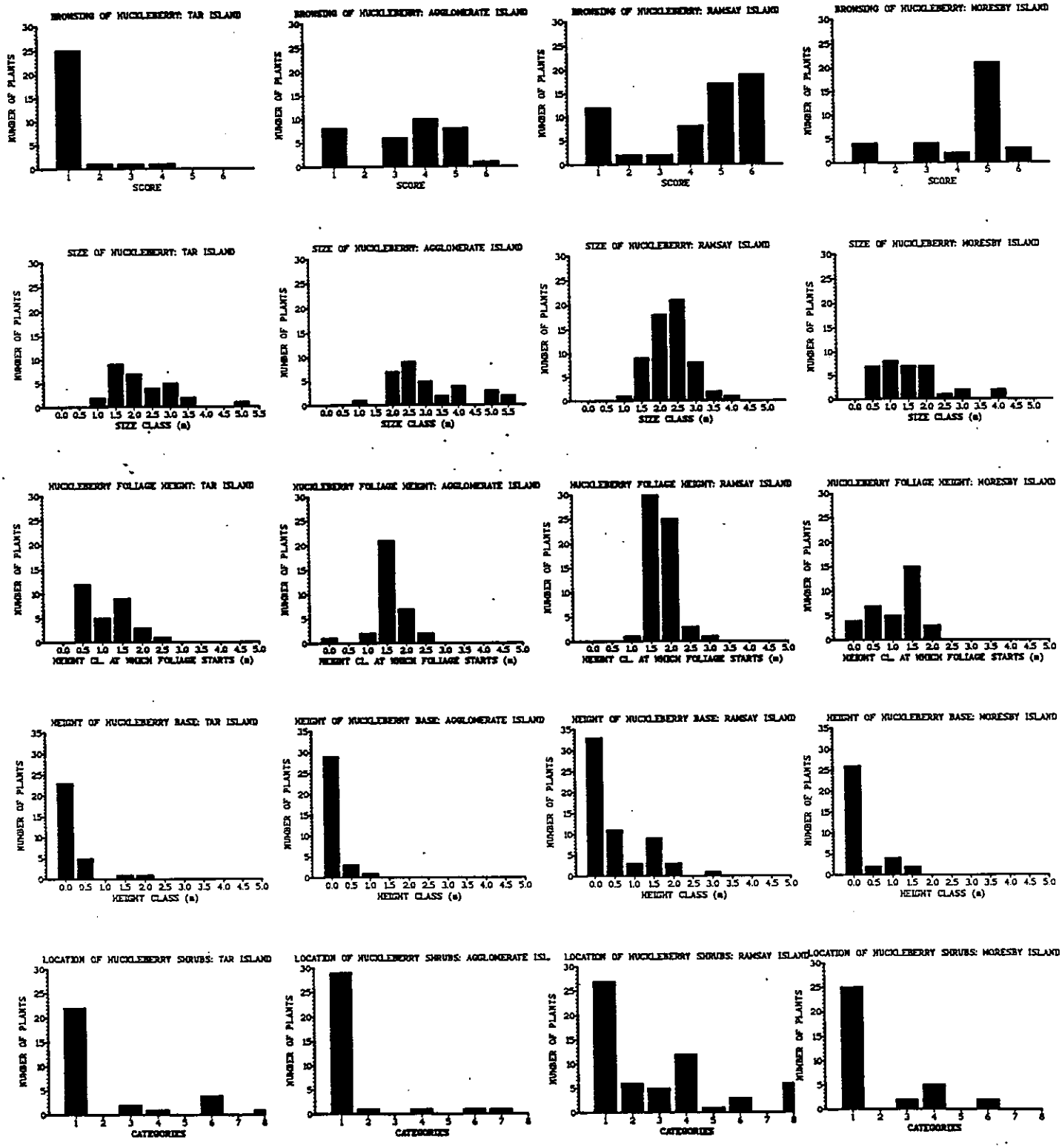
The results obtained for huckleberry confirmed those observed for salal (Figure 4, Table 3). On Moresby Island, however, a higher proportion of huckleberry than salal was heavily browsed (Figure 5), a pattern consistent with the preference deer have for huckleberry when it is available (Pojar et al. 1980).

Table 3. Results of Kolmogorov Smirnov tests of similarity of character distributions among ordered categories for Huckleberry. n.s. = the similarity hypothesis cannot be rejected. *, **, *** = the similarity hypothesis is rejected at the 0.05, 0.01 and 0.001 probability level respectively.

		Tar	Agglomerate	Ramsay
Browsing	Agglomerate	***		
	Ramsay	***	*	
	Moresby	***	**	n.s.
Shrub size	Agglomerate	n.s.		
	Ramsay	n.s.	n.s.	
	Moresby	*	**	***
Foliage height	Agglomerate	**		
	Ramsay	***	n.s.	
	Moresby	n.s.	*	***
Height of base	Agglomerate	n.s.		
	Ramsay	n.s.	*	
	Moresby	n.s.	n.s.	n.s.
Location	Agglomerate	n.s.		
	Ramsay	n.s.	***	
	Moresby	n.s.	n.s	*

As for salal, huckleberry shrubs tended to be significantly smaller on Moresby Island than on the smaller islands. On Agglomerate and Ramsay islands we observed significantly more shrubs with foliage starting only at 1.5 m from the ground than on Moresby or Tar islands (Figure 4, row 3). Huckleberry was mostly recorded as growing on the ground on all islands, but the proportion of shrubs growing on supports that put them out of reach of deer was highest on Ramsay Island.

Figure 4. Impact of browsing by Black tailed deer (Odocoileus hemionus) on Huckleberry (Vaccinium sp.). Sample sizes are 30, 33, 60 and 34 respectively along each row. For row, score and categories definitions see Fig. 3.



c. Impact of deer on salal and huckleberry shoots

For salal, the average number of clips observed per shoot was lowest on Tar Island and highest on Ramsay Island and increased with island size for Huckleberry (Table 4).

Table 4. Impact of Black tailed deer on Salal and Huckleberry shoots on the 4 islands studied. Impact is measured as the average number of times a shoot had been clipped by deer over the past years. s.d. = standard deviation; N = sample size.

	SALAL			HUCKLEBERRY		
	Clips/shoot	s.d.	N	Clips/shoot	s.d.	N
Tar	0.83	1.34	30	1.40	3.10	5
Agglomerate	1.20	1.18	50	4.05	2.61	19
Ramsay	3.98	3.04	60	5.90	6.64	60
Moresby	1.56	1.83	60	6.37	8.15	8

d. Impact of deer on tree seedlings

For spruce and hemlock, the impact of deer on seedlings was again highest on Ramsay Island, where the average score for both species was above 3. The lowest average score was observed on Tar Island (Spruce only). No cedar seedling were found, except on Moresby Island (probably all yellow cedar) (Table 5).

Table 5. Impact of Black tailed deer on tree seedlings (very young trees over 10 cm in height) on the 4 islands studied. Seedlings were scored 0 to 5 with 0 = no sign of browsing and 5 = seedling shape heavily affected by browsing. The Table gives average scores (the sum of the N scores divided by N (sample size). In bold values for which sample size is above 10. no = not observed.

	Spruce	N	Hemlock	N	Cedar	N
Tar	**0.01**	10	no		no	
Agglomerate	0.66	3	**0.95**	60	no	
Ramsay	**3.50**	100	**3.60**	100	no	
Moresby	0.67	6	**0.37**	73	1.55	69

DISCUSSION

a. Predation on artificial nests

The experiments indicate that the Red squirrel is a predator which can have a dramatic impact on the breeding success of forest passerines in Haida Gwaii. Levels of predation by squirrels were easily the highest observed. The shape of the survival curves (Figure 2c and d) suggests that squirrels found the nests quickly and easily. The predation rate decreased with time, as the remaining nests became harder to find (in some cases individual squirrels observed workers placing nests, making the initial discoveries immediate).

The lower rate of predation seen on transect 1 at Limestone Island may have been caused by the denser understorey present on this transect which made nests harder for the predators to find. If confirmed, this result suggests that the impact of black-tailed deer on the understorey may increase the vulnerability of songbird nests to predation on many islands. In the long run deer and squirrels could, therefore, interact in reducing the abundance of forest birds in Haida Gwaii.

The impact of rats is more difficult to assess. Results obtained from the studies at Murchison and Langara islands indicate that predation of artificial nests by rats may vary with distance from the shore line and with the timing of alternative food sources. Rat predation was highest at nests closest to shore on both Langara and Murchison Islands. At Langara Island, the distribution of depredated nests mirrored the distribution of the rats on the island; no rats or their signs were observed interior to the Hemlock/moss zone and no nests interior to that zone were depredated (AH pers. obs.). Similarly, the incidence of deer mice was highest near the shore on Ramsay Island. The presence of high rodent densities near the shores may be explained by the regular and abundant food source provided by the intertidal zone, compared to the forest interior.

The results from Langara Island also suggest an influence of the timing of alternative food resources. The onset of nest predation by rats coincided with rat sightings in camp and the hatching of Ancient Murrelets (AH pers. obs.). Possibly, rats concentrated on murrelet eggs while they were available and only began searching for other resources after many of the eggs had hatched and the nestlings were gone.

Finally, the low rates of nest predation observed for both ground and shrub nests on Ramsay Island, and for above ground nests on Langara Island, suggest that predation on artificial nests by native predators is unusually low in Haida Gwaii forests, compared with figures published for other forest bird communities (Martin 1987, Andren and Angelstam 1988, Santos and Telleria 1992, Telleria and Santos 1992). Elsewhere, predation rates range from 30-90% and are usually higher than 50%. Corvids, which are often listed among the main nest predators (especially along forest edges), were not identified as predators in our experiments, although both ravens and crows were present at all study sites. Again the bounty of resources found along the shore may be the reason that corvids do not search for nests. If unusually low levels of nest predation are characteristic of the Haida Gwaii islands where there are no introduced predators, then local songbirds may not have maintained levels of antipredator behaviour similar to those of their mainland counterparts. In that case, local birds may be unusually vulnerable to an introduced predator, such as the squirrel. As a corollary, one can also ask: are forest bird populations on small islands with large squirrel populations (such as Limestone Island) still self sustaining?

b. The impact of browsing by deer

We found differences among islands in all of the variables studied. Deer had an influence on the abundance of shrubs, and on their distribution in the landscape, and on the regeneration

of both shrubs and trees (we did not study the chances tree seedlings have to eventually outgrow deer predation, but see studies of Pojar and Banner 1984).

On the smallest island (Tar) signs of browsing were minimal and shrub cover (mainly salal) was close to 100% over most of the island. When island size increased, fresh and old signs of deer also increased (unpubl. obs.) and shrub cover decreased. Salal patches are eroded by browsing at the edges. The proportion of shrubs with foliage starting only at a height inaccessible to deer (about 1.5 m) increased with island size as did the proportion of shrubs growing out of reach of deer (on stumps, snags or trees). The impact of deer was greatest on Ramsay Island, the largest isolated island, and decreased on the main island. This was true for most characters studied.

We could find no suitable explanation for the smaller size of shrubs growing on the main island. However, there are differences in vegetation structure between the area sampled on Moresby Island, which belongs to the coastal cedar-pine-hemlock vegetation zone and the other islands, all of which fall in the coastal western hemlock vegetation zone (Banner et. al. 1989).

We suggest two reasons why deer browsing is heavier on Ramsay Island than on the larger and smaller islands. The first supposes that the smallest islands are too small to support a resident deer population (deer don't stay) and that the main island is so large that the impact of deer is mitigated by higher diversity of resources (a consequence of larger area) or higher rates of juvenile dispersion. Ramsay Island may be large enough to harbour a resident deer populations but too small for easy dispersal. Agglomerate Island may not be large enough for a permanent deer population, so that deer are only periodically resident, reducing the damage to vegetation. Our observations support this idea. Deer impact was obvious (dense network of old deer trails), but there were no fresh signs or deer sightings. Only two piles of deer droppings were located and both were very

old. During a similar search on Ramsay Island, fresh droppings were regularly observed (unpubl. results).

The second explanation for inter-island differences in deer impact uses the same rationale for the smaller islands, but supposes that the lower impact of deer on the main island is caused primarily by differences in climate. The drier conditions (see ref. in Banner et al. 1989) that prevail in summer (and probably also in winter) on islands such as Ramsay may be more favourable to deer (improved juvenile survival ?) than those on the main island. Hence deer density may be higher on Ramsay than on Moresby Island.

Whatever the underlying mechanisms are, the impact of deer on the vegetation varies with island size in our samples (isolation being kept constant for all except the main island). The small isolated islands were the least affected, the larger islands off the east coast the most affected. Indeed other large islands, such as Murchison or Reef, show vegetation patterns very similar to those observed for Ramsay. Furthermore, the trend of decreasing vegetation cover in the understorey (largely due to variation in the cover of salal) with increasing island area has been shown by Martin, Gaston and Hitier (submitted) in their study of bird distribution in relation to changes in island area and vegetation. In that study most of the islands along the east coast of Gwaii Haanas were censused.

Although many factors may play a role in vegetation changes in relation to island area, our results suggest that deer distribution are an essential component. On the basis of these results, islands such as Ramsay, Murchison or Reef would be among the most sensitive to invasion by squirrels. Indeed on these islands most of the understorey has vanished or is threatened by deer. The nest predation rates observed on Limestone island, where deer are common and their impact comparable to that seen on Ramsay Island, speak for themselves. If management choices such as deer eradication or deer control have to be made these islands

might be priorities.

The preliminary results presented here confirm the large scale impact of deer on the vegetation pattern of Haida Gwaii and reveal that squirrel have the potential to have a significant impact on land bird reproduction, an impact that may be amplified by the vegetation changes resulting from deer browsing.

Acknowledgements: We would like to thank Doug Burles from Parks Canada for his time and support, Tony Gaston for his commitment and help behind the scene, Gavin Cadzow, Susan Cohen, Shannon Gibson, Susan Pinkus, Heron Weir, Reuben Wier, and Kathy and David Wilford all volunteers for the Laskeek Bay Conservation Society, Phred Collins, Yolanda Morbey and Chris Naugler who helped on Langara, for their enthusiasm in the field. Sylvie Blangy, Soline and our Haida neighbours for their company and support. We thank Christophe Thebaud and T.E. Martin for their insights in planning the project, the Gwaii Haanas Joint Management Board for issuing a permit for this research and the Old Masset Village Council for permission to work on Langara. Logistic and financial support was granted by the Canadian Wildlife Service, the Laskeek Bay Conservation Society, Parks Canada and, last but not least, by the Centre National de la Recherche Scientifique.

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