LASKEEK BAY RESEARCH

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ANNUAL SCIENTIFIC REPORT, 1997

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Edited by

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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

Since 1990, the Society has operated a field research station at East Limestone Island and is carrying out a diverse long-term monitoring, research and interpretation programme in the surrounding islands and waters of Laskeek Bay. We actively involve volunteers from our island communities, many other locations in British Columbia, as well as from overseas. For further information contact:

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BACKGROUND

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.*

INTRODUCTION

The Laskeek Bay Conservation Society organizes a volunteer programme each summer to carry out biological monitoring and research, to provide interpretation for visitors, and learning opportunities for students and volunteers. During the past eight years, a camp at East Limestone Island has been operated during the spring and early summer.

The scientific work of the Society is carried out in collaboration with several researchers who have ongoing interests in the ecology of Haida Gwaii, especially the islands of the Laskeek Bay area. The research programme is directed by a Scientific Advisory Committee that works closely with the Society's board of directors to develop research that is relevant to the conservation needs of Haida Gwaii and consistent with the goals of the Society. Beginning with a programme of marine bird monitoring (an extension to a programme that was initiated by the Canadian Wildlife Service in 1984) the research activities have now been expanded to include marine mammals, intertidal invertebrates, plants, forest birds, and issues relating to the impact of introduced mammals, including the impacts of deer, raccoons and squirrels on island ecosystems. The aim of the work is to provide long term information on the biology and ecology of Laskeek Bay ecosystems. Ongoing monitoring, using simple standardized techniques that allow year-to-year comparisons to be made, and allowing the direct participation of volunteers, is the cornerstone of the Society's activities. By monitoring a variety of indicator species in ocean, intertidal and terrestrial ecosystems, we can obtain an overall measure of their health. 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.

ACKNOWLEDGEMENTS

The Laskeek Bay Conservation Society is a 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 contributions of all our supporters and apologize to any we may have inadvertently omitted from this list:

We received generous contributions from the following supporters:

I. W.Alton Jones Foundation for financial assistance to our education and interpretive program and administration costs;

II. Canadian Wildlife Service National Research Centre, Ottawa and Pacific and Yukon Region, Delta, B.C., for financial assistance and long-term equipment loans;

III. Ministry of Environment, Lands and Parks, Skeena Region, for permission to conduct research in Laskeek Bay Wildlife Management Area and undertake conservation measures to protect the breeding Ancient Murrelets;

IV. South Moresby Forest Renewal Account (SMFRA) for financial assistance to our core program;

V. Gwaii Trust for assistance with Project Limestone, our program for Haida Gwaii students;

VI. Gwaii Haanas Archipelago Management Board for permission to conduct surveys in the southern Laskeek Bay area.

We also thank the following individuals for their generous assistance and/or donations, all of which made a difference to the quality of the information collected and our camp life:

VII. Greg Wiggins (SMFRA) for helping us to secure funding for our core operations;

VIII. South Moresby Air Charters, for friendly and safe transportation of volunteers and for tolerating large volumes of gear each week;

IX. Parks Canada for a fuel donation and for his collaborative scientific efforts;

X. Crew, and guests of the 'Maple Leaf' and 'Island Roamer' for welcoming us aboard to enjoy gourmet dinners and their for wonderful company;

XI. Nathalie Macfarlane, Haida Gwaii Museum, for storage for a roomful of gear in her basement, public relations on our behalf, and for providing a venue for a public talk regarding deer ecology and research in Laskeek Bay;

XII. Graeme Ellis for black and white film and camera for orca photos;

XIII. Chris Bowman for countless hours of help to computerize the 1997 finances;

XIV. Greg Martin for his assistance above and beyond the call of duty;

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XVI. Joelle Fournier for her cheerful and efficient assistance in the office at the end of the season;

XVII. the Volunteer Directors for their continual commitment and support, without which we would be unable to have such a program;

XVIII. all those who volunteered their time in town to collect groceries and run errands, particularly Catherine Allen; and

XIX. all of the in-town support people who bought groceries, met volunteers, and picked up the garbage;

XX. all of the volunteers who participated in the Limestone Island camp, purchased t-shirts or made donations, thank-you and please join us again next year.

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REPORT ON SCIENTIFIC ACTIVITIES BASED AT THE LASKEEK bAY CONSERVATION SOCIETY FIELD CAMP IN 1997

Joanna Smith, *Laskeek Bay Conservation Society, Box 867, Queen Charlotte B.C. V0T 1S0*

Ancient Murrelets

Ancient Murrelets *Synthliboramphus antiquus* are provincially BLUE-listed primarily due to threats from introduced predators and oil spills. The Council on the Status of Endangered Wildlife in Canada (COSEWIC) has designated the Ancient Murrelet as VULNERABLE indicating that declining populations may become endangered unless the factors responsible for the decline are addressed. Our long-term monitoring will aid in answering questions related to lifetime reproductive success and adult and chick survival.

Adult Banding

A large net was used to catch Ancient Murrelets in flight and three net locations were used in 1997: Spring Valley, Cabin Cove and North Cove. Our efforts began on 22 March and continued until 10 April, at which time we stopped to prevent disturbance during egg-laying. We resumed on 11 May and stopped on 9 June, when colony attendance declined rapidly. Nets were erected for an aggregate of 34 h. The total numbers of murrelets caught over the season was 411 (377 in the net, 13 on the ground and 21 in burrows). However, this included 71 recaptures of birds already trapped in 1997 and excluding these recaptures, our total sample of birds was 340 (Table 1). Adults recaptured from previous years can give us information on survivorship and breeding status. Also, we recaptured 13 adults that were banded as chicks in 1990-1992 and 1994-1995; no chicks banded in 1993 were trapped this year (Table 2). Among adults banded as chicks, one third of those 2-3 years old and all those five or older were breeding.

Table 1. Distribution of 340 Ancient Murrelets caught March 22 - June 9, 1997, East Limestone Island. All birds trapped before 15 April were classified as breeders, as were those trapped in May or June with a >19 mm brood patch, or with chicks. Birds trapped after 30 April with brood patches measuring < 10 mm were classified as non-breeders. Those caught between 15 -30 April, or after 30 April with a brood patch 10-19mm were treated as "status unknown".

Status	Method	<15April	mid-season	After May 1			TOTAL
		Breeder	Unknown	non Breeder	Unknown	Breeder	
NEW	Net / ground	79	2	92	11	17	209
	Burrow	0	0	0	0	8	
RECAPTURED	Net / ground	63	6	14	4	31	131
	Burrow	0	0	0	0	13	
		135	8	106	15	69	340

Table 2. Ancient Murrelet adults recaptured in 1997 that were banded in previous years as either adults or chicks; numbers in parentheses indicate how many were breeders this year.

Year Banded	No. recaptured 1997	Banded as ADULTS	Banded as CHICKS
1989	7 (6)	7 (6)	none banded
1990	14 (14)	12 (12)	2 (2)
1991	13 (13)	12 (12)	1 (1)
1992	13 (12)	12 (11)	1 (1)
1993	7 (7)	7 (7)	0
1994	14 (8)	7 (5)	7 (3)
1995	9 (5)	7 (5)	2 (0)
1996	54 (51)	54 (51)	0
TOTAL	*131 (116)*	*119 (109)*	*13 (7)*

Chick Banding

A system of clear, plastic funnels was used again to capture murrelet chicks as they made their way to sea. The protocol was changed slightly this year to monitor funnels between 2300 and 0230 hrs instead of one hour after last chick was banded (1990-1995) or until 0200 (1996). Funnels were monitored for 36 nights, between 8 May and 12 June, and both the start and end of chick departures was determined. The first chick departed on 11 May and peak departure was on 24 May, when 41 downy murrelets headed through the funnels. This year, 583 chicks were banded: 527 from funnels, 29 caught outside funnels and 27 found in burrows.

To compare between years, the average percent (± SD) of chicks banded before and after 0200 hrs was calculated for 1990-1995. It was found that 87.5% of chicks were banded before 0200 hrs so, in 1996, chick numbers were 'corrected' by 12.5% to account for fewer hours capturing chicks (see protocol above). The seven year average (±SD) for chicks caught before 0200 hrs is 583 ± 88 and this year 456 were caught in the numbers have averaged 667± 99, compared to 527 caught in 1997.

Burrow Monitoring

Burrow checks were started on April 7 with the placement of knock-down sticks in the entrance of 72 burrows in two plots: Spring Valley and Cabin. This year, occupancy was the same as last year, 38%, but the number of birds that laid eggs in burrows was lower, 21 vs. 28 pairs, and the mean number departing per pair was also lower (Table 3).

Table 3. Occupancy and fledging success of monitored Ancient Murrelet burrows, East Limestone Island.

	1996	1997
Original burrows	89	72
New burrows	2	16
Useable burrows	74	56
Burrows occupied	28	21
Proportion (%)	38	38
Burrows with 2 chicks	2	6
Burrows with 1 chick	4	1
Burrows abandoned	2	6
Total chikcs produced	48	29
Chicks reared per pair	1.71	1.38

Each year we band or record the band of adult murrelets occupying burrows in the two monitored plots. It's exciting to see the same individuals returning to the same burrows year after year (i.e. site fidelity) and more exciting still when an adult returns to a plot that was banded as a chick (i.e. philopatry). In 1997, we banded 8 new birds, for a total of 21 marked murrelets in burrows. Eight murrelets were found using the same burrow that they used last year and one pair has used the same burrow for four consecutive years. One bird banded in 1992, has occupied the same burrow for the last six years.

In previous years, Ancient Murrelet departure vocalisations have been recorded as adults and chicks leave the burrow. This year, we

successfully recorded departing vocalisations at six of the 15 occupied burrows, slightly fewer than last year.

Gathering Ground Counts

During the breeding season, Ancient Murrelets congregate in the water surrounded by Low, Reef and East Limestone Islands, with numbers greatest several hours before sunset. Between March 16 - June 15, a spotting scope was used by staff and 31 volunteers to count murrelets between Low and Limestone Islands, two hours before sunset. The highest single count was 302 on April 26 but there were several peak periods where > 100 birds were counted each night: April 22-29, May 20-26 and June 7-8. On eighteen evenings, fog, storms or a heat shimmer over the water prevented the daily count.

Marine surveys

The waters and islands of Laskeek Bay are in a Ministry of Environment Wildlife Management Area. Each year, we survey the waters of Laskeek Bay for mammals and birds along the same transects, particularly focusing on marine birds and pinniped haul-outs. During these surveys, volunteers have the opportunity to view whales, seals, sea lions and seabirds, learning how to distinguish the different species, and note foraging behaviour and seasonal movement patterns.

Seabird Surveys

In 1997, four seabird surveys were conducted between 13 May and 28 June at 10-18 day intervals. In other years, surveys have also been done in April but because of workload considerations and frequent storms, we concentrated our efforts over just two months.

Fifteen bird species were counted this year, including six alcids, two species each of gulls, loons, and ducks and one species of shearwater, grebe and cormorant. Steller's Sea Lions *Eumetopias jubata* and Harbour Seals *Phoca vitulina* were the most common mammal seen during each survey but Minke whales *Balaenoptera acutorostrata* and Harbour Porpoises *Phocoena phocoena* were seen on half of the surveys.

Marbled Murrelets *Brachyramphus marmoratus* have been analysed specifically in previous years, primarily because of conservation concerns. In British Columbia this species is Red-listed primarily because of the loss of nesting habitat in old-growth forests. Peak counts were taken on 18-19 June with 183 birds, but this is fewer than have been found in other years (492 - 1996; 275 - 1995; 635 - 1994; and 1686 - 1993).

Marine Mammal Surveys

Marine mammal watches of Laskeek Bay were conducted from a point close to the cabin ("Lookout Point"). Over the course of the season, 25 watches involving staff and 21 volunteers, resulted in 15 h of observation. Pinnipeds were seen on 14 of the watches and while cetaceans were infrequent; two

Grey Whales *Eschrichtius robustus*, one Minke Whale and a pod of 20 Killer Whales *Orcinus orca* were counted.

Including all observations between March and July, ten species and 1452 individuals were counted. In order of abundance, our list includes Steller's Sea Lions, Harbour Seals, Orcas, Harbour Porpoises, Pacific White-sided Dolphins *Lagenorhynchus obliquidens* , Dall's Porpoises *Phocoenoides dalli*, Minke Whales, Grey Whales, Humpback Whales *Magaptera novaeangliae*, and Northern Elephant Seals *Mirounga angustirostris*.

There are two sea lion haul-outs in Laskeek Bay, one at the eastern end of the Skedans Islands and one on the offshore rocks of Reef Island. From March through May, as many as 180 Steller's Sea Lion were seen on the Skedans Islands. By late May, sea lions had disappeared from Skedans and more than 300 were found on the eastern rocks Reef Island. Harbour Seal counts were done during seabird surveys and the greatest count was 115 on Skedans Islands, in mid-June. Orcas were seen during the day four times and heard once at night during Ancient Murrelet chick banding. Both residents and transients were seen (including T-70). In all, 36 Orcas were counted, some individuals twice; photos that were taken from the Zodiak will aid in identifying these individuals.

Black Oystercatchers

Black Oystercatchers *Haematopus bachmani* continue to nest along the rocky shorelines of many of the islands in Laskeek Bay and this year we surveyed 35 nesting locations. During our initial surveys in May, 16 nests had between 1 and 3 eggs. By late June, seven chicks were present at four nests. Several weeks later, we banded six chicks but time did not permit us to return to the other nests before we closed the station for the season thus the final counts of chicks and eggs are unknown. Predation of nests appeared to be the most obvious reason for nest failure and, if the pair on East Limestone Island is any indication, this shorebird spends a great deal of time defending its territory.

Glaucous-winged Gulls

Glaucous-winged Gulls *Larus glaucescens* have been censused since 1993 in order to provide a gross estimate of population trends. Five islands were censused June 15-23 and 276 nests contained 1-3 eggs. In general, there appears to be a progressive shift from Kingsway Rock to Lost Islands, with more gulls nesting on the Lost Islands (Table 4).

Table 4. Glaucous - winged Gull colony census in Laskeek Bay 1993-97. Cumshewa Island was added in 1994 and totals are given for nest counts without the Cumshewa colony.

Colony	1993	1994	1995	1996	1997
Lost Islands	140	165	145	175	226
Kingsway Rock	79	82	56	46	36
Skedans Islands	20	12	11	1	8
Low Island	4	2	1	6	0
Cumshewa Island		7	4	2	6
Total	234	261	213	228	270

Terrestrial fauna and flora

Red-Breasted Sapsuckers

Red-Breasted Sapsuckers *Sphyrapicus ruber* continue to nest on the island at high densities. Cavity excavation began in early April, and chicks were first heard calling in late May - early June. Fledgling sapsuckers appeared during the second week of June and many were seen learning to feed with one or both parents. We now have 53 wildlife trees in our sample. Trees were photographed and mapped, and nest cavities identified for future reference. Two new birds were banded this year and as a result of a determined effort by one of our directors, Seana Burke, we learned that sapsuckers are difficult to capture as they fly into or out of their cavity!

Bird Checklist and Field Notes

Daily checklists were completed throughout the field season, resulting in 63 species tallied for Limestone Island and Laskeek Bay; 32 was the greatest number of species counted on a single day (April 16 and 27).

In years prior, two raptors were known to breed on Limestone Island: Bald Eagles *Halaeetus leucocephalus* and Peale's Peregrine Falcons *Falco peregrinus pealei*. No eagles bred this year but the pair of falcons on the south facing-cliffs successfully reared at least one fledgling in a new location. For the first time, we noted a pair of Sharp-Shinned Hawks *Accipiter striatus* along the main trail and observed two fledglings with parents feeding in early July.

Shorebirds such as Whimbrels *Numenius phaeopus*, Wandering Tattlers *Heteroscalus incanum* and Black Turnstones *Arenaria melanocephala* made frequent visits to the islands in the spring. Belted Kingfishers *Megaceryle alcyon* were added to our list of known breeders on the island, when a nest was found on the south facing slopes. Fork-tailed Storm Petrels *Oceanodroma furcata* returned to the small colony in the cabin cove, calling late at night in May and early June. Lastly,

Cassin's Auklets *Ptychoramphus aleuticus* were heard on several occasions in the evenings of chick banding, but burrows were not monitored this year on Cassin's Tower.

On the afternoon of May 26, songbird banding took place near the cabin, with Tony Gaston and his students from eastern universities. Five birds were caught over the six hours, including a Red-Breasted Sapsucker and four retraps (two Winter Wrens *Troglodytes troglodytes* and two Hermit Thrushes *Hylocichla guttata*).

Introduced Mammal Surveys

Limestone Island is affected by the introduction of three mammals: Sitka Black-tailed Deer *Odocoileus hemionus* , Red Squirrels *Tamasciurus hudsonicus* and Raccoons *Procyon lotor*. Deer browse severely limits most of the understory vegetation below 1.5m. This reduces the abundance of flowering plants and shrubs from the rocky shoreline to the forested interior. This year, an island-wide deer census was not conducted but 10 deer were counted (mostly on the north side) by Gwenaël Vourc'h (University of Montpellier, France). Considering the islands small size and its proximity to larger populations of deer, research questions will be restricted to ones of a monitoring nature, for example, the results from the creation of deer exclosures.

Red Squirrels were surveyed again this year to describe distribution or movement throughout the islands diverse habitat types. This is part of a collaborative project to assess the impact on songbird populations now that the shrub layer has been greatly reduced. Ten surveys were done between April 21 and June 9, involving 20 of the volunteers. There were fifty squirrel detections (only nine of them inside the 20m station radius) resulting in 0.9 squirrels per survey. Squirrels were most often detected on the main and look-out trails.

The presence of raccoons on nearby Louise Island continues to threaten the Ancient Murrelet colonies on East and West Limestone Islands. Two spotlight surveys were done during low tide on May 10 and June 28 and six raccoons were observed foraging at Vertical Point, which is an easy swim to the murrelet colony. With the permission of the Ministry of Environment, Lands and Parks, we killed five of the raccoons, but were unable to remove the sixth. To protect the Ancient Murrelet colony from this introduced predator, we must maintain pressure on nearby populations in order to prevent their access to the seabird colonies.

Plant Inventory

A list of plants found on East Limestone Island was begun in 1994 and was compiled from published authorities and field observations. This year, efforts were made to create a comprehensive floral species list and to engage the volunteers in looking for rare or less common species, usually on cliffs which are out of reach of deer. The list is now complete, except for mosses, lichens and grasses, and will be finalised over the winter to include abundance notes and a locality map. This list, if updated at regular intervals, may serve as a way to monitor population changes over time. For example, species may become more or less abundant as a result of grazing from introduced herbivores.

THE OCCURRENCE OF TICKS AMONG NESTLING ANCIENT MURRELETS AT REEF ISLAND, BRITISH COLUMBIA

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The occurrence of ticks (*Ixodes* spp.) on colonial seabirds and their nestlings is well documented (King et al. 1977, Duffey 1980) and may cause significant harm to nestlings under some circumstances (Morbey 1995). During intensive studies of Ancient Murrelet *Synthliboramphus antiquus* chicks at Reef Island, British Columbia during 1984-89 and in 1995, we noticed no sign of ticks, either on chicks or adults. However, in 1997, ticks were detected on the webs or toes of 19% (186 of 985) chicks captured while departing from the colony.

The number of ticks counted per individual varied up to 11, with most chicks affected by only one or two (76%). The proportion of chicks parasitized declined over the season (Figure 1) from 22% among the first 30% of chicks departing (<23 May) to 9% among the last 10% (>31 May). In addition, there appeared to be some correlation with the time of departure during the night, the proportion of chicks parasitized being highest in the middle of the departure window, between 01.00-02.00 h Pacific Daylight Time (Figure 2).

Chicks departing late in the season may be the offspring of first-time breeders, many of which use newly-excavated burrows (Gaston 1992). As most Ancient Murrelet burrows are more than 1 m from one another, ticks could be spread from burrow to burrow by prospecting birds that enter several burrows in a single night: deer mice *Peromyscus maniculatus*, are another possible vector. Newly-excavated burrows may be less likely to be infested than those that have been in use for several years. The time of night effect may also be related to the timing of departure of experienced and inexperienced birds, with the more experienced, presumably those using older burrows, being more likely to depart between 01.00-02.00 PDT: the darkest period of the night at Reef Island.

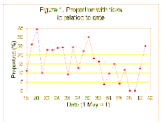
Figure 1. Proportion with tick
in relation to time
Proportion (%)
Date (1 May = 1)

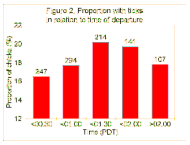
Figure 2. Proportion with ticks
in relation to time of departure
Proportion of ticks (%)
22
20
18
16
14
12
247
284
214
227
167
<00.00
<01.00
<01.30
<02.00
>02.00
Time (PDT)

This appears to be the first record of ticks on Ancient Murrelets (Gaston 1994). The rapidity with which the infestation appears to have spread is remarkable. From a total absence within our study area (about 15% of the colony area) in 1995, a minimum of 19 % of burrows appear to have been affected by 1997. In addition to about 7000 pairs of Ancient Murrelets, the island also supports about 2000 pairs of Cassin's Auklets *Ptychoramphus aleuticus* (Rodway 1991), the nestlings of which are heavily parasitized by ticks at some colonies in British Columbia (Morbey 1995, R. Kelly, pers. comm.). Although we have not recorded ticks on Cassin's Auklet chicks at Reef Island, it seems that contact with auklets, whose burrows are interspersed among Ancient Murrelet burrows in some areas, is a possible means by which ticks began to parasitize the murrelets.

We saw no sign of any damage to the chicks resulting from tick parasitism: all webs appeared intact. This is in contrast to Cassin's Auklet chicks which show frequent signs of web damage and grow more slowly when heavily parasitized (Morbey 1995). Because Ancient Murrelet chicks spend only 2 days in the burrow, the ticks presumably have insufficient time to cause tissue damage. Reduced effects of parasitism may be an additional benefit accruing to Ancient Murrelets as a result of their precocial departure strategy.

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INTER-COLONY MOVEMENTS OF ANCIENT MURRELETS *Synthliboramphus antiquus* AT TWO ADJACENT ISLANDS

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ABSTRACT

Trapping and banding of adult Ancient Murrelets and of chicks departing the colony were carried out at Reef Island in 1984-89, 1995 and 1997, and at East Limestone Island in 1989-97. These two colonies are separated by about 6 km of open water. Censuses, and estimates of chick production agree in suggesting that the population of Reef Island has increased since the mid-1980s, while that of East Limestone Island has remained stable or fallen, presumably because of persistent predation by introduced raccoons. Recapture probabilities were estimated for chicks banded at the two colonies. The probability of recapturing a chick banded at Reef Island was generally lower than for an East Limestone Island chick, corresponding to the lower proportion of total chick production that was banded at Reef Island. The likelihood of recapturing birds banded as chicks as pre-breeding prospectors on the non-natal colony, rather than the one where they were reared, was about 1 in 5 for those reared at Reef Island and 1 in 7 for those reared at East Limestone Island. For birds of breeding age (>3 years old), recruitment was observed from East Limestone to Reef Island, but not in the reverse direction. These data suggest that prospectors visit either island indiscriminately, but that, in recent years, they have been more likely to settle at Reef Island. The potential asymmetry demonstrated by these results may have implications for the population dynamics of the two colonies.

Introduction

Understanding the dynamics of a wild population requires knowledge of fecundity, survival rates, immigration and emigration. While fecundity and survival are generally fairly well known, information relating to the frequency and significance of dispersal is very scarce (Harris 1991, Coulson and Mevergnies 1992, Halley and Harris 1993, Halley et al. 1995). Direct evidence of dispersal (as opposed to genetic evidence) can be most easily obtained where colonies are close together, enabling simultaneous study, and small enough that a significant proportion of the population can be marked and examined. This combination of circumstances is not available everywhere, which probably accounts for the paucity of dispersal studies, relative to those on other demographic parameters. In this paper, we focus on the population dynamics of two adjacent colonies of Ancient Murrelets *Synthliboramphus antiquus* and attempt to measure the frequency of population interchange between them on the basis of recapture data. In doing so, we present a simple approach to recapture analysis that has not been presented previously. Because Harris (1991) and Harris et al. (1994) showed that some seabirds are more likely to be seen at colonies other than their natal colony as pre-breeding prospectors, rather than as breeders, we consider breeding and non-breeding birds separately.

The Ancient Murrelet is a small auk breeding across the temperate and sub-arctic North Pacific. About half of the world population breeds in Haida Gwaii (Queen Charlotte Islands), British Columbia. Because of recent population declines, the species is listed as 'vulnerable' by the Committee on the Status of Endangered Wildlife in Canada (Gaston 1994). As monitoring population numbers and understanding their demography are major features of any conservation strategy, the Canadian Wildlife Service has been conducting research on Ancient Murrelet population ecology since 1983 at two colonies: Reef Island and East Limestone Island (Gaston et al. 1988, Gaston 1990, 1992).

Raccoons *Procyon lotor,* an introduced species in the archipelago, were known to have killed many Ancient Murrelets at East Limestone Island during the period prior to 1993 (Gaston 1994, Hartman *et al.* 1997). No raccoons have been reported from Reef Island. Population trends at the two colonies, based on censuses carried out at East Limestone Island in 1983 and at Reef Island in 1985, and repeated at both colonies in 1995, indicated that numbers increased at Reef Island (by about 3% annually), but were stable at East Limestone Island. The survival rate estimated for breeding adults at East Limestone Island in the 1990s was significantly lower than that estimated at Reef Island during 1984-89 (Gaston 1990, Gaston and Lemon 1996). These differences presumably relate to predation by raccoons, which are known to have caused severe population declines at some seabird colonies in Haida Gwaii (Gaston and Masselink 1997). The annual mortality of breeding birds caused by raccoon predation at East Limestone Island was estimated as 15% during 1990-91: an increase of about 60% over mortality measured at Reef Island (23%, Gaston 1990, Hartman et al. 1997).

Study area and methods

Reef Island and East Limestone Island are 6 km apart and support relatively small (<10,000 breeding pairs)

colonies of Ancient Murrelets (Rodway 1991). Both colonies were censused in the 1980s and again in 1995 (Gaston and Lemon 1996). In addition, mass-trapping of departing chicks was carried out at Reef Island in 1985-89, 1995, and 1997 and at East Limestone Island in 1990-97.

Chicks leave the colony at 2-3 days old and make their way from the natal burrow to the sea under cover of darkness. Most do so without guidance by their parents, which rendezvous with them once they reach the sea (Jones et al. 1989). Chicks were trapped using plastic funnels to direct them to banding stations close to the shore. They were released directly to the sea, usually within a few minutes of capture (Gaston *et al.*

x(i j), the probability of recapturing, at colony j, a bird of known age x initially banded at colony i (i,j {R,L}, where R = Reef Island and L = Limestone Island), we used the following formula:

$$RT_{x(i\,j)} = R_{t+x(i\,j)} / (E_{t+x(j)}\ N_{t(i)}).$$

The summations are over all years for which both banding of chicks at colony i in year t *and* t+x(i j) t+x(j) t(i) 6

2 with 1 degree of freedom, using Yates' correction for small samples.

Results

2 = 5.08, *P* 2 = 9.66, *P* i+2(L) i+2(R)

2(R>L) 2(L>R)

3(R>L) 3(L>R)

4to6(L>R) 2 = 3.76, P = 0.05). In addition, two 7Y birds banded as chicks at East Limestone Island were recaptured as breeders at Reef Island, making a total of six breeding age recruits.

Figure 1. Numbers of birds recaptured at the natal and non-natal colony in relation to age.

Table 1. Numbers of Ancient murrelet chicks banded (N) and non-breeding adults trapped (R, E for recaptures and total effort, respectively) used in estimating recapture probabilities (RT) for 2Y birds.

		t(i)	t+2(i)	t+2(i i)	2(i i)	t+2(j)	t+2(i j)	2(i j)
Reef								
	1985	**328**	**283**	**4**	**43.1**			
(i=R; j=L)	**1986**	**720**	**310**	**5**	**22.4**			
	1987	**1070**	**464**	**12**	**24.2**	**183**	**2**	**10.2**
	1988	**1256**	**0**	**0**	**-**	**132**	**1**	**6.0**
	1989	**984**	**0**	**0**	**-**	**158**	**1**	**6.4**
	1995	**1223**	**209**	**7**	**27.4**	**104**	**0**	**0**
	Totals	**3341**	**1266**	**28**	**26.2**	**577**	**4**	**6.2**
Limestone								
	1990	**865**	**204**	**6**	**34.0**			
(i=L;j=R)	**1991**	**619**	**81**	**5**	**99.7**			
	1992	**723**	**93**	**3**	**44.6**			
	1993	**691**	**66**	**5**	**109.6**	**339**	**2**	**8.5**
	1994	**673**	**6**	**0**	**-**			
	1995	**587**	**104**	**2**	**32.8**	**209**	**1**	**8.1**
	Totals	**4158**	**554**	**21**	**51.9**	**548**	**3**	**8.4**

Table 2. Numbers of Ancient murrelet chicks banded (N) and non-breeding adults trapped (R, E for recaptures and effort, respectively) used in estimating recapture probabilities (RT) for 3Y birds.

		t(i)	t+3(i)	t+3(i i)	3(i i)	t+3(j)	t+3(i j)	3(i j)
Reef								
	1985	**328**	**310**	**3**	**29.5**			
(i=R; j=L)	**1986**	**720**	**464**	**3**	**9.5**	**183**	**1**	**7.6**
	1987	**1070**	**-**	**12**	**-**	**132**	**0**	**-**
	1988	**1256**	**-**	**-**	**-**	**158**	**0**	**-**

	1989	**984**	**0**	**0**	**-**	**204**	**0**	**-**
	Totals	**1048**	**774**	**6**	**13.8**	**677**	**1**	**1.8**
Limestone								
	1990	**865**	**81**	**1**	**14.3**			
(i=L;j=R)	**1991**	**619**	**93**	**5**	**86.9**			
	1992	**723**	**66**	**2**	**41.9**	**339**	**0**	**-**
	1993	**691**	**6**	**0**	**-**	**-**	**-**	**-**
	1994	**673**	**104**	**7**	**100.0**	**209**	**2**	**14.2**
	Totals	**3571**	**350**	**15**	**51.9**	**548**	**2**	**5.2**

Table 3. Numbers of Ancient murrelet chicks banded (N) and non-breeding adults trapped (R, E for recaptures and effort, respectively) used in estimating recapture probabilities (RT) for 4-6Y birds.

		t(i)	t+4'(i)	t+4'(i i)	4'(i i)	t+4'(j)	t+4'(i j)	4'(i j)
Reef								
	1985	**328**	**349**	**1**	**8.7**	**449**	**0**	**-**
(i=R; j=L)	**1986**	**720**	**-**	**-**	**-**	**378**	**0**	
	1987	**1070**	**-**	**-**	**-**	**200**	**0**	**-**
	1988	**1256**	**-**	**-**	**-**	**143**	**0**	**-**
	1989	**984**	**208**	**4**	**19.5**	**192**	**0**	**-**
	Totals*	**1312**	**557**	**5**	**15.7**	**1362**	**0**	**-**
Limestone								
	1990	**865**	**354**	**5**	**16.3**	**208**	**2**	**11.1**
(i=L;j=R)	**1991**	**619**	**399**	**3**	**12.1**	**385**	**0**	**-**
	1992	**723**	**333**	**2**	**8.3**	**177**	**1**	**7.8**
	1993	**691**	**248**	**1**	**5.8**	**177**	**1**	**8.2**
	Totals*	**3571**	**348**	**15**	**11.4**	**548**	**4**	**6.0**

*** Years with A > 0**

Discussion

2(R>R) 2(L>L)

(R>L) (L>R) as evidence of preferential recruitment to the Reef Island colony. Predation by raccoons and the disturbance to the colony consequent on the presence of these alien predators seems to be the most likely explanation for the difference in recruitment between the two colonies. The role of differential recruitment in determining the difference in population trends between the two islands remains to be explored.

Our conclusions are necessarily tentative, being based on small samples collected over several years and with little replication at the two colonies. However, this type of data is not uncommon in seabird studies (e.g. sample sizes given by Hudson 1985). We believe that our approach can shed light on relative probabilities of dispersal or recruitment in situations where a lack of serial recapture data makes capture-recapture analysis

inappropriate. Further development of methods for analysing dispersal is urgently required in order to complete our understanding of demography for species where philopatry is not complete.

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