

# **EAST LIMESTONE ISLAND ANCIENT MURRELET COLONY SURVEY, JUNE 2006**

Moira Lemon

*Canadian Wildlife Service, Pacific and Yukon Region, Delta, B.C. V4K 3N2*

## **SUMMARY**

Population estimates of breeding Ancient Murrelets on East Limestone Island have declined since the initial estimate of greater than 5000 pairs in 1971 (Summers 1974). After a detailed census by the Canadian Wildlife Service in 1983 estimated the population at less than 1500 pairs (Rodway et al 1988), two other surveys, conducted at six year intervals showed that the colony was certainly not increasing. Recent concern about the declining trend in the number of chicks captured in monitoring studies on East Limestone Island suggested that another colony survey was warranted. This report presents the results of that survey and compares those results to the previous three surveys.

## **METHODS**

The same methods were used to determine the nesting population of Ancient Murrelets in 2006 as were used in previous colony surveys on East Limestone Island in 1983, 1989 and 1995. A detailed description of survey methodology can be found in Rodway et al 1988. Fourteen transects, spaced approximately 100 meters apart around the island were established in 1983. Along these transects the number of burrows were counted within plots placed every 20 meters. A few modifications were made over the years which should not affect comparisons. Plot size was 5m x 5m in 1983 and 1989, but since the density of burrows on East Limestone Island is low, plots were enlarged to 7m x 7m in 1995 and 2006 to provide better coverage. In the 1995 survey, the number of burrows in the 5m x 5m portion of the larger plot was recorded separately for comparison to the larger 7m x 7m plot. Transect 8 was extended in 1989 and subsequent years to better cover this portion of the colony (Gaston et al 1989). Timing of the surveys differed somewhat between years. In 1983, the survey was

conducted in the beginning of May. In 1989 the survey was in late May to mid June, while in 1995 and 2006 the survey was carried out from mid to late June.

This most recent survey was carried out from 18 – 22 June; and 13 & 17 July, 2006. We surveyed the same fourteen transects established during the initial CWS survey in 1983. At that time, the start of each transect was plotted on an airphoto of the island and the beginning points described in relation to the topography and measured from coastline features. During the 1995 survey, wooden marker stakes were placed at the beginnings of the transects, all of which were relocated in 2006, with the exception of transect 4. There may be some small discrepancies in the transect start locations between 1983 and the other years, but not between 1995 and 2006. In the 2006 survey, we georeferenced the transects with a Garmin GPS unit, to further define the transect locations, and attached engraved metal tags to nearby trees labeling the particular transect. (Table 1).

Colony areas were defined as including all areas with burrows. If there were no burrows within a quadrat, the surrounding area was searched to determine if the quadrat fell within the colony boundaries. If burrows or signs of activity were found within a distance halfway to adjacent quadrats along the transects or half the distance laterally to adjacent transects, the area was considered part of the colony and the data obtained from the quadrat was included in calculations of burrow density. If no burrows were found within this range, the area was not considered to be part of the colony and the quadrat data was not used in density calculations. The mean density of burrows and its standard error for the colony was calculated as the mean of the burrow densities found within each quadrat within the colony boundaries.

We attempted to determine occupancy (breeding effort in the current year) of all burrows that fell within the quadrats. Since the 2006 survey was at the end of the Ancient Murrelet breeding season, recently hatched egg membranes were the main evidence of occupied burrows. Earlier in the season, adult birds with eggs or chicks, and cold eggs in burrows are evidence of occupied burrows. If no evidence was found in burrows that were completely explored, then these were

designated as empty (no nesting effort in 2006). Exploring burrows longer than an arm's reach required digging one or more small access holes until the end was encountered. Excavated holes were immediately patched with cedar shakes and soil. Very few burrows were accessible within the quadrats, so to increase the sample we explored every burrow encountered within a 10m expanding radius from three locations along transects in denser portions of the colony, until 5 or more burrows with known contents were found. A similar strategy was used in the 1989 survey, while in 1983 and 1995, occupancy rate was determined from the quadrats alone. Additionally, in 2006, we determined the current year breeding effort in most of the burrows within the Spring Valley and Cabin reproductive success plots. Occupancy rate (current year's breeding effort) was calculated as the number of occupied burrows/total burrows of known status for each quadrat or plot sample. Thus the mean occupancy rate and standard error for the colony is determined from the rates for each sample.

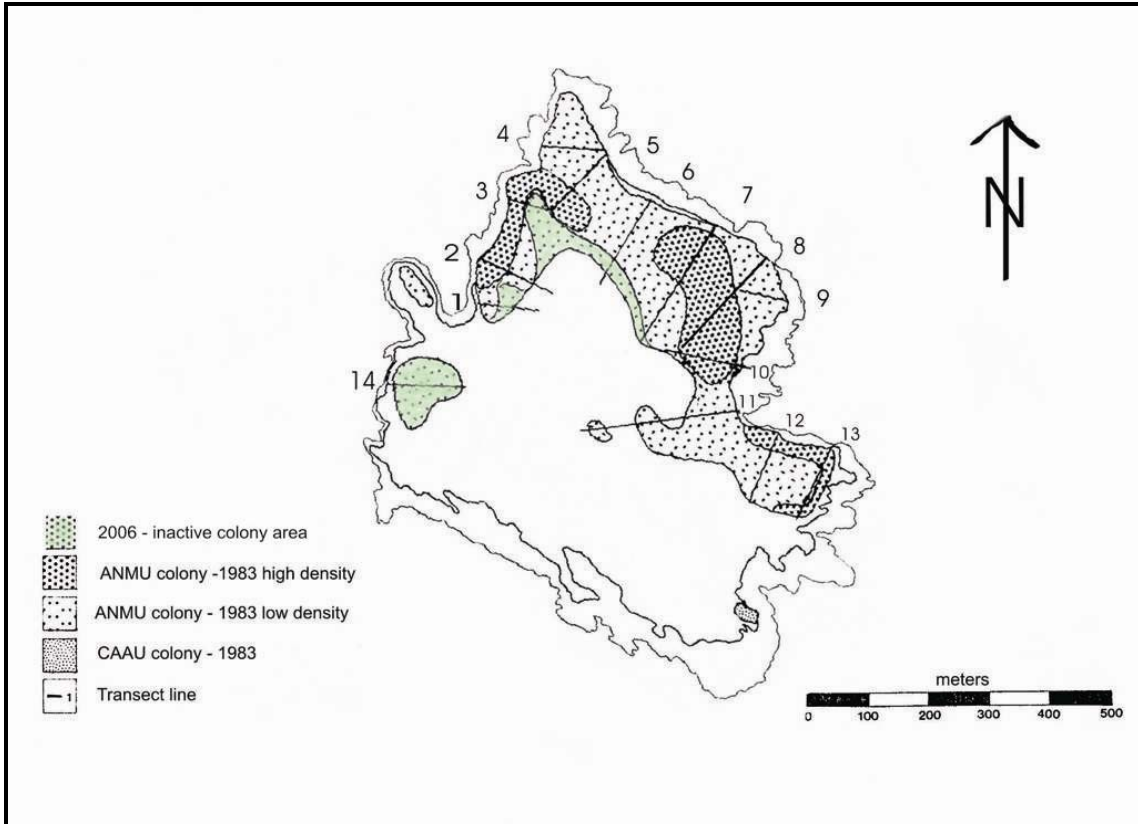
In addition to the burrow counts, we recorded evidence of predation (number of depredated eggshells, feather piles, wings and carcasses) within the quadrats and as a continuous 5m strip along the transect.

## RESULTS

### Colony area changes

The total area of the Ancient Murrelet colony on East Limestone Island was estimated to be 12.55 hectares in 2006, about 15% smaller than it was in 1983. (Fig. 1). It is difficult to define colony boundaries where burrow density is very low. However, there are several areas of the colony that have definitely contracted since 1983. In the area of transect 14, south of the Boat Cove, there was no sign of recently used burrows from 1989 to 2006. A concentrated search of the area in 2006 found one or two old burrows, but these held no recent sign.

There may be a few birds nesting in the area, but since it would be very minimal, this portion of the original colony extent was excluded from the delineation of the 2006 colony boundaries. We searched a small cove to the south of Transect 14 area where a small pocket of burrowing had been previously described in 1989. Two burrows were found there, but since the area is so small, it is not included in the estimated size of the colony.



**Figure 1**  
**Comparison of the 2006 Ancient Murrelet colony boundaries to the 1983 colony extent on East Limestone Island**

The 2006 colony extent is narrower on the west side of the island north of Boat Cove, where there is now no sign of burrows beyond the edge of the slope in the vicinity of transect 1 and 3. As well, the colony does not extend as far inland in the North Cove area in the region of transects 5 and 6. Burrows were very sparse along these two transects making colony boundary delineation very difficult, and it could actually be less than indicated.

In the inland part of transect 9 and the mid part of transect 8, there is a pocket of regenerating spruce where no burrows were found. The size of the area is such that it is too difficult to delineate on the map, and since similar small pockets likely occur elsewhere within the colony, it is not excluded.

Although the colony appears to extend further along transect 11 in 1983 than in 2006, this transect cuts through a low wet area beyond camp, and may have run in a slightly different location each year, making it hard to judge any apparent changes in colony boundaries. Pockets of burrows occur on raised forest ridges on the north side of the inland end of the transect, which likely fell along the transect in 1983 and 1995, while in 1989 and 2006 the transect at this point ended up in the flat wet area. Therefore, the boundaries of the colony in 2006 are depicted the same as in 1983 for this area.

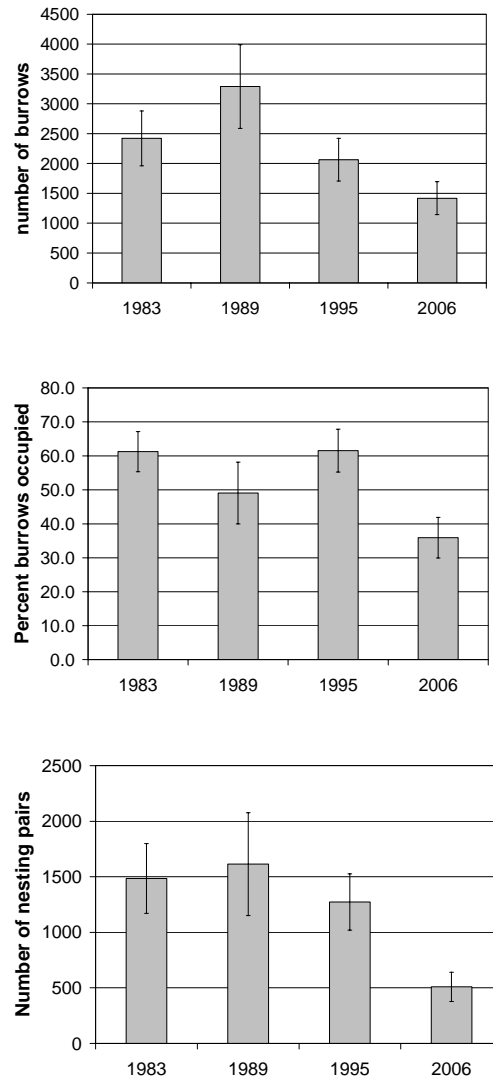
**Estimated number of burrows, occupancy and breeding population**

On re-examination of the previous surveys, a few errors were found in the table presenting counts of burrows in the 1989 report (Gaston et al 1989), so the revised table is presented here – table 2. Similarly, the burrow occupancy rate is revised from the one that appears in the 1989 report. The report for the 1995 survey did not contain the raw data on burrow counts, so it is presented here as well, in table 3. Because of the refinement of the colony boundaries, and the above amendments, the estimates of total burrows presented in this report differ slightly from those presented in Gaston and Lemon 1996 and Lemon and Gaston 1999.

During the 2006 survey, we searched for burrows in 106 quadrats which fell within the boundaries of the colony as it was outlined in 1983. The larger plot size (49 m<sup>2</sup>) increased the proportion of the colony covered from about 1.6 percent (with 25 m<sup>2</sup> plots) to 3.3 percent. We counted 47 burrows within the 85 quadrats that fell within the current colony boundaries (Table 4), giving a mean density of 113 +/- 22 burrows per hectare in 2006, less than the density of 150 +/- 26 bur/ha determined in 1995, and the lowest density found during the four colony surveys. Based on the revised figure of 12.55 hectares for the colony (omitting portions of the 1983 colony that no longer have evidence of nesting birds), the estimate of the total number of burrows is 1418 +/- 276. (Table 5). (The 1995 estimates of burrow density from 25m<sup>2</sup> and 49m<sup>2</sup> plots were virtually the same. However, since the coverage in the larger plots was greater, the standard error of the resultant estimate was reduced, and therefore it was better to use the larger plot).

Out of 64 burrows that could be completely examined, 23 showed signs of breeding effort in 2006, nineteen with hatched egg-membranes and four burrows containing cold abandoned eggs (Table 6). Occupancy rates in the other three survey years were all significantly higher, with the rate in both

1983 and 1995 about 61%, (Table 7 for 1995, see Rodway et al 1988 for 1983) while in 1989 the occupancy rate was 49.1 +/- 9.1% (Table 8). Applying the 2006 burrow occupancy rate of 35.9 +/- 6 % to the total number of burrows on the island, gives an estimate of 509 +/- 132 breeding pairs of Ancient Murrelets on East Limestone Island in 2006. (Table 5; Fig. 2).



**Figure 2**  
**Estimates of total number of burrows, occupancy rate and number of nesting pairs of Ancient Murrelets on East Limestone Island in 1983, 1989, 1995 and 2006**

### **Predation**

Evidence of predation on Ancient Murrelets within the quadrats was recorded during each of the four surveys. (Tables 9, 10, 11 for 2006, 1995, 1989 respectively; 1983 data is presented in Rodway et al 1988). Feather piles from Ancient Murrelets were found scattered throughout the colony. Using these as an indicator of depredation on adult birds, I calculated a mean density of 48 feather piles/ha from data collected within all the quadrats along the transects in 2006. This is similar to the estimate of 45 feather piles/ha determined in the 1995 survey, but less than the 78 feather piles/ha determined in 1989 (Table 12). There was a much lower estimate of 16 feather piles/ha in 1983, but

this might be due to the survey occurring early in the breeding season, while the other three surveys were at or after the end of the breeding season, when the counts of feather piles would represent the accumulated predation evidence from the whole nesting season. There was a notable absence of depredated eggshells through the colony in 2006, unlike what is often observed in other Ancient Murrelet colonies. Only one depredated egg was found in the surveyed plots in 2006, and although not abundant, more were found in quadrats during the surveys in the other three years, when estimates ranged from 9 to 32 depredated eggs/ha.(Table 12).

## **DISCUSSION**

The results from the 2006 survey showed a considerable decline in the estimated total number of Ancient Murrelet burrows on the East Limestone Island colony from values determined in 1983. (Figure 2 and table 5). The 1989 estimate appears to be the highest of all years, but not significantly different than 1983 and 1995. The higher burrow density in that year is mainly driven by three plots which have 6 burrows each (table 2) and particularly in two of those plots, on transect 8 and 11, where there were no burrows recorded in the other three survey years.

Burrow occupancy rates were highest in 1983 and 1995, and at just over 61% were similar to the approximated median occupancy rate of 63% for Ancient Murrelets in B.C. (Rodway et al 1988). Although lower, the occupancy rate in 1989 was not significantly different from those values (table 5). However, the 2006 survey showed the lowest burrow occupancy rate of all survey years (36%), and consequently that combined with the lower total number of burrows yields an estimated breeding population that is about one third of the

1983 population, and a marked decline since 1995.

Other observations providing supporting evidence for a decline in the breeding population of Ancient Murrelets on East Limestone Island was the lack of hatched eggshell membranes seen on the surface of the colony in 2006. At the end of the nesting season on other Ancient Murrelet colonies in Haida Gwaii, the leathery white hatched membranes are frequently seen at the mouths of burrows and scattered about below burrows on steeper slopes. Notes from the surveys conducted on East Limestone Island in 1989 and 1995, which occurred late in the nesting season, indicated that it was not uncommon to see these hatched membranes scattered through the colony. Short burrows, with a concentric ring of twigs around the entrance, seem to occur on colonies where new burrows are being constructed and the colony is perhaps increasing. These are quite obvious, and are recorded when encountered during the transect surveys. We saw none in 2006, whereas in 1983 there were 5 of these “twiggy entrance” burrows recorded, 4 in

1989 and 1 in 1995 on East Limestone Island.

The similar depredation rate on adult birds estimated in the 2006 survey and in the previous survey in 1995 is disturbing, since compared to the estimated breeding population, it suggests increased predation pressure on the remaining birds. Predation on adult birds expressed as the estimate of the number of feather piles per hectare, was highest in the 1989 survey, almost double that of the subsequent surveys.

Extensive squirrel cone scale caches and middens are present throughout the colony now. They were recorded along all transects in 2006, though they were less frequently encountered along the west side of the island. Squirrel sign was also abundant in 1995 and was noted frequently in 1989. Some anecdotal notes of squirrel caches near the east coast of the island in 1983 confirm that squirrels were present on the island then. Partway through the survey in 2006, we attempted to quantify the occurrence of squirrel sign in the Ancient Murrelet burrows. Although we collected no direct evidence of squirrels negatively impacting the breeding murrelets, of fifty-three Ancient Murrelet burrows investigated, 10% had a continuous layer of chewed cone scales throughout the tunnel, 33% had scattered cone scales in the tunnel and nest cup, while the remainder didn't contain any

chewed cone scales. Along the transects we did find some cavities and tunnels under tree roots and stumps that were completely filled with chewed cone scales. Some of these held small fragments of very old murrelet eggshells, suggesting that squirrels are likely opportunistically taking over Ancient Murrelet burrows.

We explored Crow Valley on the southeast shore of the island, but found no burrows or evidence of Ancient Murrelets nesting there. We found no indication that the colony had shifted to anywhere else on the island. The majority of the Ancient Murrelet colony in 2006 was mostly close to shore near transects 2 -4 on the west side of the island and around the east coast from transect 7 through 12 (from the east end of North Cove to Lookout Point and on the slopes above Camp Cove). Higher densities of burrows were also found at the inland sections of transects 7 & 8, which is close to the area of the old Spring Valley reproductive success plots.

This decline in the estimated nesting population of Ancient Murrelets on East Limestone Island contrasts with the increasing trend in burrow densities in plots on George and Ramsay islands and the stable trend on Rankine Island, three of the Ancient Murrelet colonies in Gwaii Haanas that are monitored regularly. (Hipfner 2004; Lemon 2003; 2005).

## ACKNOWLEDGEMENTS

Many thanks to those, in addition to the author, who took part in the colony census on East Limestone Island: 1983 – Michael Rodway, Doug Bertram, Dave Powell, Yves Turcotte, Randy Reusch; 1989 - Sue

Johnson, Andrea Lawrence, Kathy Heise; 1995 –Ginny Collins, Delphine Boussilier, Mitchel Davis, Keith Moore; 2006 - Les Loewen, Michiko Nishimura, Jen Rock, Jake Pattison, Fran Fowler, Kate Pierce.

## LITERATURE CITED

Gaston, A.J., K. Heise, A. Lawrence, and M.J.F. Lemon, 1989. Studies of Ancient Murrelets on the Limestone

Islands, May-June 1989. unpublished Canadian Wildlife Service report.

- Gaston, A.J. and M.J.F. Lemon. 1996. A tale of two islands: Comparison of population dynamics of Ancient Murrelets at two colonies in Haida Gwaii, Canada. Pp. 29 - 38 in Gaston A. J. (ed.) 1996. Laskeek Bay Research 6. Laskeek Bay Conservation Society, Queen Charlotte City, B.C.
- Hipfner, J.M. 2004. Surveys of permanent seabird monitoring plots on Ramsay Island, Gwaii Haanas, in June 2002. Pp. 35 - 39 in Gaston, A.J. (ed.) 2004. Laskeek Bay Research 13. Laskeek Bay Conservation Society, Queen Charlotte City, B.C.
- Lemon, M.J.F. and A.J. Gaston, 1999. Trends in Ancient Murrelet populations since 1980. in Bird Trends, Canadian Wildlife Service, Environment Canada. No. 7, Spring 1999 : 22 – 25
- Lemon, M.J.F. 2003. Surveys of permanent Seabird Monitoring Plots on George Island and East Copper Island, Gwaii Haanas National Park, June 2003. unpublished CWS report to Parks Canada, Dec. 2003.
- Lemon, M.J.F. 2005. Surveys of permanent Seabird Monitoring Plots on Rankine Island, Gwaii Haanas National Park, June 2005. unpublished CWS report to Parks Canada, Feb. 2006.
- Rodway, M.S., M.J.F. Lemon, and G.W. Kaiser. 1988. British Columbia Seabird Colony Inventory: Report #1 - East Coast Moresby Island. Technical Report Series, No. 50. Canadian Wildlife Service, Pacific and Yukon Region, B.C.
- Summers, Kenneth R. 1974. Seabirds breeding along the east coast of Moresby Island, Queen Charlotte Islands, British Columbia. Syesis 7:1-12

**Table 1**  
**Descriptions and locations of start and end points for transects on East Limestone Island, June 2006**

<b>Tran. #</b>	<b>Bearing (°)</b>	<b>GPS location</b>	<b>GPS Accuracy</b>	<b>Location of transect point from GPS position</b>	<b>Description</b>	<b>markers</b>
1 - start	95	N 52.90880 ° W 131.61689 °	13.6 m	7m at 122° to tran start	west side of island in Boat Cove on north side of trail - starts at 70cm dbh cedar tree	wooden stake in front of cedar; metal tag on north
end		N 52.90893 ° W 131.61564 °	9.2 m	at end (plot 6)	at edge of drop into a transverse valley;	
2 - start	114	N 52.90967 ° W 131.61639 °	5.5 m	7m to transect start	west side of island approx 75m north of	wooden stake with tag at
end					plot 6 on east side of gully heading down into broad valley	
3 - start	100	N 52.91046 ° W 131.61582 °	6.9 m	5m at 280° to tran start	approximately 120m north of Tran 2, on	wooden stake 5m from start
end		N 52.91055 ° W 131.61443 °	8.9 m		plot 5 at higher end of North Cove area	
4 - start	90	N 52.91161 ° W 131.61510 °	9.4 m	10 m east to tran start. GPS on beach	approx. 105m N of tran 3. Small beach with large Alder just S of trans begin. In level area between 2 rock ribs.	No wooden stake. Tag on cedar 3m along tran line.
end		N 52.91172 ° W 131.61363 °	8.6 m		at transect end 97m (just before plot 6)	
5 - start	221	N 52.91128 ° W 131.61325 °	7.4 m	GPS position at transect start	West end of North Cove, shorewards of Funnel # 4	wooden stake on edge of veg. Metal tag on 60cm dbh Spruce 2m along trans.
		N 52.91040 ° W 131.61442 °	11.5 m	7m at 90° to transect end	Transect end at plot 8, at top end of North Cove forest	
6 - start	210	N 52.91039 ° W 131.61206 °	8.4 m	GPS position at transect start	approx. 105m SE of tran 5 in North Cove.	wooden stake at transect start; metal tag on Spruce beside stake

		N 52.90941 ° W 131.61267 °	11.3 m		plot 9	
7 - start	210	N 52.91038 ° W 131.61080 °	7.5 m	GPS position at transect start	North Cove approx 115m SE of tran 6 on mossy knoll at shore	wooden stake at trans start; metal tag on Cedar 3m along trans.
		N 52.90803 ° W 131.61174 °	12.3 m	GPS approx 20m along tran line from plot 12		wooden stake 7m beyond plot 12
8 - start	220	N 52.90998 ° W 131.60943 °	9.8 m	GPS position at transect start	approx. 105m SE of tran 7 around onto east coast from North Cove. Approx 20m W of channel in rock shelf	wooden stake 2m along line. Metal tag on Spruce, 3m W of Tran
		N 52.90849 ° W 131.61077 °	8.6 m	at end (plot 11)	Plot 11 in valley floor	
9 - start	280	N 52.90958 ° W 131.60876 °	6.7 m	GPS position at transect start	east coast of island in small CAAU area, above vertical cliff; 15m north of odd limestone rock arches in moss	wooden stake at tran start; metal tag on Spruce 4m along line
		N 52.90941 ° W 131.60981 °	7.2 m	GPS position 4m before plot 5	end of transect at plot 5	
10 - start	280	N 52.90853 ° W 131.60914 °	4.6 m	GPS position at transect start	east side of island on rock knoll to N of beach (N side of biffy gully)	wooden stake at start; metal tag on small spruce
10 - end		N 52.90823 ° W 131.61130 °	9.8 m	GPS position 6m S of 130m trail peg	167m along tran line (end of plot 9) is 5m at 50° from 130m trail peg	
11 - start	260	N 52.90778 ° W 131.60981 °	10.8 m	GPS position 8m at 80° from trans start	east side of island at S end of camp beach at large spruce	metal tag on tree; wooded post had been removed
end		N 52.90695 ° W 131.61319 °	16.0 m	GPS position at plot 13	plot 13 is 10 m at 260° from snag # 19	
12 - start	200	N 52.90716 ° W 131.60864 °	8.8 m	GPS position 8m at 20° from tran start	80m east of east corner of camp bay (heading out toward Lookout Point)	Wooden stake at start; metal tag on large 90cm dbh cedar

end		N 52.90630 ° W 131.60898 °	7.7 m	GPS position at plot 6	plot just before drop down steep slope	
13 - start	200	N 52° 54.417' W 131° 36.443'		GPS position at transect start	approx 105m east of transect 12; 30m from end of vegetation on LookOut Point	
end		N 52° 54.356' W 131° 36.472'		GPS taken at 120m; plot 7	near edge of cliff	
14 - start	90	N 52.90736 ° W 131.61849 °	10.7 m	GPS position 8m at 90° from tran start	70m south of chasm on south side of boat bay peninsula.	wooden stake at start; metal tag on cedar 1m south of stake

**Table 2**  
**Number of Ancient Murrelet burrows in 5 x 5m quadrats along transects on East Limestone Island in June 1989. (-) = plots considered outside the colony**

Transect	PLOT NUMBER														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	0	-	-									
2	1	0	1	0	1	0	-								
3	1	0	6	1	0										
4	0	0	0	0	1	1									
5		0	0	0	0	0	0	0							
6	-	0	0	2	1	0	0	0	-	-					
7	0	2	0	0	0	0	1	1	2	0	0				
8	1	0	0	0	0	0	1	2	0	0	6	-	-		
9	0	1	4	0	0										
10	0	0	1	0	1	0	0	0	0						
11	6	1	0	2	0	2	0	1	-	-	-	-	-	-	-
12	1	0	0	1	0	0									
13	2	0	0	0	0	0	0								
14	-	-	-	-	-										

**Note :** Transect 9, plot 1 - 2 CAAU burrows

**Table 3**  
**Number of Ancient Murrelet burrows in 7m x 7m quadrats along transects on East Limestone Island in June 1995. (-) = plots considered outside the colony**

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

**Note :** Transect 9, Plot 1 - 3 CAAU burrows; Transect 14, Plot 4 - 1 old ANMU burrow

**Table 4**  
**Number of Ancient Murrelet burrows in 7m x 7m quadrats along transects on East Limestone Island in June 2006. (-) = plots considered outside the colony**

Transect	PLOT NUMBER												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	0	-	-	-	-							
2	4	0	0	0	0	0							
3	0	0	-	-	-								
4	1	0	2	0	2								
5		0	0	1	0	0	0	0					
6	-	1	0	0	1	0	0	-	-				
7	0	3	0	0	0	0	2	1	3	0	0	-	
8	4	0	1	0	0	0	0	1	3	0	0		
9	0	2	0	0	0								
10	0	3	0	0	0	0	0	0	0				
11	0	1	0	0	1	2	1	1	-	-	-	-	-
12	2	0	0	2	0	0							
13	0	0	0	0	1	1	0						
14	-	-	-	-	-								

**NB:** Transect 9, plot 1 - 3 Cassin's Auklet burr; Transect 9, plot 2 - 1 Cassin's Auklet burr.

**Table 5**  
**Population estimates of Ancient Murrelets on East Limestone I. from 1983, 1989, 1995 and 2006**

Variable		1983	1989	1995	1995	2006
<b>Plot size</b> m <sup>2</sup>		25	25	25	49	49
<b>Burrows/m<sup>2</sup></b>	mean	0.0163	0.0239	0.0152	0.015	0.0113
	s.e.	0.0031	0.0051	0.0031	0.0026	0.0022
	N	98	92	95	95	85
<b>Occupancy</b>	mean	0.613	0.491	0.615	0.615	0.359
	s.e.	0.059	0.091	0.063	0.063	0.0603
	N*	44	11	22	22	10
nest status	occupied	49	26	24	24	23
nest status	known	80	53	39	39	64
<b>Colony area</b>	(ha)	14.85	13.76	13.76	13.76	12.55
<b>Total</b>	mean	2421	3289	2092	2064	1418
	s.e.	460	702	427	358	276
<b>Nesting Pop.</b> (pairs)	mean	1485	1614	1284	1273	509
	s.e.	314	463	296	254	132

N\* - N is the number of quadrats or plots where an occupancy rate was investigated, and from which the mean occupancy rate of the colony was determined.

**nest status occupied** - total number of burrows that were occupied

**nest status known** - total number of burrows with known occupancy status (occupied or empty)

**Table 6**  
**Occupancy (current years' breeding effort) of Ancient Murrelet burrows on East Limestone**  
**Island June 2006**

Transect	Quad. or plot	Date	empty	1 cold egg	2 cold eggs	hatched membrane	Total Occup	Total Known
2	1-2	21-Jun	1			1	1	2
4	3	20-Jun				1	1	1
7	2 (OccupPlot)	19-Jun	5		1	4	5	10
8	1-2 (OccupPlot)	20-Jun	2			2	2	4
8	8 (OccupPlot)	20-Jun	3			1	1	4
8	9	20-Jun				1	1	1
11	5	18-Jun		1			1	1
12	4	22-Jun	1				0	1
11	CabinPlot	13-Jul	21			7	7	28
8	SV Plot	17-Jul	8		2	2	4	12
<b>Totals</b>			41	1	3	19	23	64

**Table 7**  
**Occupancy (current years' breeding effort) of Ancient Murrelet burrows on East Limestone**  
**Island June 1995**

Trans	Quad.	Date	empty	1 cold egg	1 cold E, 1 pred E	2 cold egg	hatched membr.	pred burr	Total Occ.	Total Known
2	2	17-	2						0	2
3	2	18-	1						0	1
4	1	21-		1					1	1
4	4	21-	1						0	1
6	4	20-			1				1	1
6	6	20-					1		1	1
7	2	20-	2				4		4	6
8	1	22-	1	1			2		3	4
8	4	22-	1						0	1
8	5	22-	1				1		1	2
8	8	22-	1				1		1	2
10	3	21-					1		1	1
10	9	21-					1		1	1
11	2	18-	1				1		1	2
11	3	18-	1			1	1		2	3
11	4	18-	1						0	1
11	5	18-	1				1	1	2	3
11	6	18-					1		1	1
12	1	19-					1		1	1
12	4	19-					2		2	2
13	6	19-					1		1	1
14	4	23-	1						0	1
<b>Totals</b>			15	2	1	1	19	1	24	39

**Table 8**  
**Occupancy (current years' breeding effort) of Ancient Murrelet burrows on East Limestone Island June 1989**

Trans	Quad.	Date	empty	1 cold egg	Adult + 2 eggs	hatched membrane	pred . burr	Total Occup	Total Known
3	3	9-Jun	1			5		5	6
4	4	10-Jun	4			1		1	5
6	4	9-Jun	3			1	1	2	5
7	3	1-Jun	3			2		2	5
7	6	1-Jun	3			2		2	5
7	9	1-Jun			2	1		3	3
8	8	10-Jun	5					0	5
8	11	10-Jun	4			1		1	5
9	3	9-Jun	2	1	1	1		3	5
11	1	8-Jun				3		3	3
12	4	8-Jun	2			2*	2	4	6
<b>Totals</b>			27	1	3	19	3	26	53

<b>Incidental evidence of Current Years Breeding effort along transect lines 1989.</b>									
Trans	Quad.	Date	empty	1 cold egg	Adult + 2 eggs	hatched membrane	pred . burr	Total Occup	Total Known
2	3	25-May	1					0	1
2	line	25-May	1					0	1
4	5	10-Jun	1					0	1
4	6	10-Jun	1					0	1
7	7	1-Jun			1			1	1
7	8	1-Jun	1					0	1
10	5	26-May			1			1	1
10	7	26-May			1**			1	1
11	6	8-Jun				1		1	1
11	8	8-Jun	1					0	1
<b>Totals</b>			6	0	3	1	0	4	10

\* one of these had the nest cup dug up

\*\*eggs not reached

**Table 9**  
**Depredated remains of Ancient Murrelets within 7m x 7m quadrats and in 5m strips**  
**between quadrats along transect lines on Limestone Island in 2006**

<b>Transect</b>	<b>Plot</b>	<b>Pred. egg</b>	<b>feather pile</b>	<b>single wing</b>	<b>pair wings</b>	<b>BAEA pellet</b>
1	2		1			
1	3-4		1			
2	1		2	1		
2	1-2			1		
2	3		1			
4	2		1			
5	3		1			
6	1-2		1			
6	5		1	1		
7	2		1			
8	2-3					1
8	3		1	1		
9	1-2			1		
9	2		2			
10	1		1			
10	1-2		1			
10	4			1		
10	4-5			1		
10	5-6		1			
11	1		1			
11	4		1	1		
11	5		1			1
11	5-6		1			
11	6		1			
11	7		1			
11	8		1	1		
12	1		1	2	1	
12	1-2		2	1		
12	4	1				
12	4-5		1			
12	5		1			
13	1			1	1	
13	2			1		
13	4-5		1	1		
14	4					1
<b>TOTAL</b>	in quads.	1	20	10	2	2
<b>TOTAL</b>	along transects	1	29	15	2	3

**Table 10**  
**Depredated remains of Ancient Murrelets within 7m x 7m quadrats and in 5m strips between quadrats along transect lines on Limestone Island in 1995**

<b>Transect</b>	<b>Plot</b>	<b>Pred. egg</b>	<b>feather pile</b>	<b>single wing</b>	<b>pair wings</b>	<b>BAEA pellet</b>	<b>dug up burrow</b>
1	1-2		1				
1	3					1	
2	1		1	1			
2	1-2	1		1			
2	2		1	2			
3	1		1				
3	1-2	2	1	1			1
3	2-3		1				
3	4-5	1					
4	1		2				
4	1-2		2				
4	2		2				
4	2-3			1			
4	5	1				1	
5	3-4		1				
5	6					2	
6	1		1				
6	1-2		1				
6	4		1				
7	1		1				
7	1-2		1				
7	2		1				
7	2-3		1				
7	10		1	2			
7	10-11		1				
7	11		1				
8	1-2		1				
8	3-4		1	2			
9	1-2		1				
9	2-3		1				1
10	1	1					
10	1-2	1		1			
10	3		1				
10	4-5		1				
10	6		1				
10	7-8		1				
11	3		1				
11	4-5		1				
11	5						1
11	5-6						1

11	6		1				
11	6-7	1					
11	7	1					
11	7-8	1	3	1			
11	8-9	2	1				
11	13		1				
12	1		2	1	1	2	
12	3		1	1			
12	5		1	1			
12	5-6		1				
13	1		1				
13	1-2		1				
13	6	1					
13	6-7		1				
14	3-4		1				
14	4-5					1	
<b>TOTALS</b>	Colony	4	21	8	1	6	1
<b>TOTALS</b>	along trans	13	48	15	1	7	4

**Table 11**  
**Depredated remains of Ancient Murrelets within 5m x 5m quadrats and incidental records of remains in 5m strips between quadrats along transect lines on Limestone Island in 1989**

Transect	Plot	Pred. egg	feather pile	single wing	pair wings	BAEA pellet	invert carcass
1	1-2		1				
1	2-3		2		2		
2	2-3		1				
2	3		1	1			
2	6-7		1				
4	3					1	
4	3-4		1				
5	8		1	1			
6	4	1					
6	7		1				
8	2		1				
8	5		1				
8	10-11		1				
8	11		1				1
8	12		1		1		
9	1		2				
9	3	1					
10	3		1	1			
10	4-5		2		1		
11	1		1				
11	4		1				
11	6		1		1		
11	7		1				
11	8		1				
11	14		1				
11	14-15		1		1		
12	3-4	1					
12	4	1	1				
12	5	1	1				
13	1		2				
13	5-6	1					
13	7	1					
TOTALS	in quads	5	18	3	1	1	1
TOTALS	with incidentals	7	30	3	6	1	1

**Table 12**  
**Results of predation estimates of Ancient Murrelets on East Limestone Island in 1983, 1989, 1995 and 2006**

<b>Variable</b>		<b>1983</b>	<b>1989</b>	<b>1995</b>	<b>2006</b>
<b>Plot size</b>	m <sup>2</sup>	25	25	49	49
<b>Colony area</b>	(ha)	14.85	13.76	13.76	12.55
<b>feather piles/ha</b>	mean	16	78	45	48
	s.e.	8	19	10	11
	N	99	92	95	85
	# plots with fp	4	16	18	18
	# fp in plots	4	18	21	20
<b># of depredated birds in colony</b>	mean	238	1073	619	602
	s.e.	119	261	138	138
<b>depred eggs/ha</b>	mean	32	22	9	2
	s.e.	11	10	4	
	N	99	92	95	85
	# plots with ep	8	5	4	1
	# ep in plots	8	5	4	1
<b># of depredated eggs in colony</b>	mean	475	303	124	25
	s.e.	163	138	55	

N\* - N is the number of quadrats surveyed within the colony area  
**fp** - feather piles (representing depredated Ancient Murrelets)  
**ep** - depredated Ancient Murrelet eggs