

VANCOUVER ISLAND MARMOT
BONES FROM SUBALPINE CAVES:

ARCHAEOLOGICAL AND
BIOLOGICAL SIGNIFICANCE



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Ministry of
Environment,
Lands and Parks

VANCOUVER ISLAND MARMOT BONES FROM SUBALPINE CAVES: ARCHAEOLOGICAL AND BIOLOGICAL SIGNIFICANCE

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Abstract

Since 1985, faunal remains of the Vancouver Island marmot have been discovered in four high elevation cave sites: Clayoquot Plateau, Mariner Mountain, Limestone Mountain, and the Golden Hinde. Two sites are in Strathcona Provincial Park and a third is in Clayoquot Plateau Provincial Park. Cut marks on bones and artifacts recovered in Mariner Mountain cave indicate that the remains are the result of human hunting. Radiocarbon dating revealed that these sites are prehistoric ranging from 830-2630 years ago. The faunal remains provide additional evidence for a range decline in the Vancouver Island marmot. No marmots live in the vicinity of the cave sites today and three sites are peripheral to the present range. Although black bear, black-tailed deer, marten, and red squirrel are represented in the faunal remains, the predominance of Vancouver Island marmots suggests that aboriginal peoples travelled to these remote mountainous areas to hunt marmots. We summarize the analysis of faunal remains and review the implications for Vancouver Island marmot biogeography and conservation, and – aboriginal cultural history. Recommendations for future research in BC Parks and managing these cave sites are presented.

Executive Summary

The Vancouver Island marmot is a burrowing, colonial rodent confined to subalpine-alpine habitats on Vancouver Island. With population estimates ranging from 100-300 animals over the past two decades and a distribution localized to southeastern Vancouver Island, the species is listed nationally and provincially as endangered. It is the only endangered mammal endemic to Canada. Paleontological remains and historical records indicate that in the past the species was more widespread inhabiting northern and central Vancouver Island including Strathcona Provincial Park. The cause of this range decline is unknown.

Since 1985, ancient marmot bones have been found in four subalpine cave sites: Clayoquot Plateau, Mariner Mountain, Limestone Mountain, and the Golden Hinde. Two sites are in Strathcona Provincial Park and are the only archaeological sites known from the park. The Clayoquot Plateau site is in Clayoquot Plateau Provincial Park.

The purpose of our study was to analyze the bone deposits to determine the vertebrate species and their relative abundance in the sites, human processing techniques, and the significance of the sites for aboriginal peoples. We discuss the implications for marmot conservation. Recommendations are given for additional research needs and for managing cave bone deposits in BC Parks.

A total of 3981 bone specimens was recovered from the four sites. Except for single blue grouse and fish bones found at Mariner Mountain, all bones are mammalian. They represent five species: Vancouver Island marmot, black-tailed deer, black bear, marten, and red squirrel. The sites are dominated by Vancouver Island marmot with marmot accounting for 85-100% of the individual mammals represented at the sites.

Radiocarbon dates on 11 bones indicate that the sites are all prehistoric with dates ranging from 830-2630 BP (calibrated dates 990 AD to 807 BC).

The presence of numerous cut marks on the Vancouver Island marmot bones, and the representation of body parts in the sites indicate that the bones are the product of human hunting. Marmots were skinned for pelts and butchered for meat. The cuts on black bear, black-tailed deer, and marten remains also are consistent with human processing. Artifacts were also found in the Mariner Mountain site.

The four cave/rock shelters were seasonal hunting sites used in late summer or autumn. Although they were not used as habitation sites, the large bone deposits at Mariner Mountain and Limestone Mountain suggest that the middens accumulated from multiple hunting episodes. The few remains in the Golden Hinde and Clayoquot Plateau caves may be the result of single hunting episodes.

The four sites are significant from an archaeological perspective because they are the first subalpine sites with faunal remains from the Northwest Coast. Compared to typical coastal archaeological sites, the four subalpine caves have a low diversity of faunal remains and the dominant species is the Vancouver Island marmot. The few black-tailed deer, black bear, and marten represented in the sites suggest that they were taken opportunistically and it appears that aboriginal peoples travelled to these remote areas primarily to hunt marmots.

A review of the ethnographic literature indicates that the hoary marmot and Olympic marmot were important to aboriginal peoples on the Northwest Coast. Their fur was highly valued for clothing such as robes and blankets and the flesh was eaten. Information on aboriginal use of the Vancouver Island marmot is sketchy but some Nuu-chah-nulth peoples hunted marmots with deadfalls.

The Clayoquot Plateau, Mariner Mountain, and Golden Hinde sites provide additional evidence for a range decline in the Vancouver Island marmot. No marmots are living near these sites today and the Strathcona Provincial Park and Clayoquot Plateau Provincial Park sites are peripheral to extant colonies. The large number of marmots in the Mariner Mountain (74 animals) and Limestone Mountain (52 animals) caves is evidence that large colonies were once in the vicinity of the sites. Although overkill may have contributed to the disappearance of marmots from these areas, the impact of hunting on populations may have been minor because the large bone deposits appear to have accumulated from several hunting episodes over a period of time.

Environmental change during the Little Ice Age or in recent historical time is another possible explanation for the range decline of the Vancouver Island marmot in Strathcona and Clayoquot Plateau provincial parks. Severe winters, heavy snowfall, and delayed spring during the Little Ice Age 150-600 years ago could have impacted marmots. There is new evidence for a major glacial advance in Strathcona Provincial Park in the early 1700s. Recent historical vegetational changes also could have affected marmot habitat. In the Cascades and Olympic mountains of Washington, trees rapidly invaded the subalpine meadows between 1900 and the 1940s resulting in a loss of potential marmot habitat. The history of subalpine meadows on Vancouver Island needs to be studied and more dated sites are required to determine the chronology of marmot extinctions on Vancouver Island.

We recommend four areas for additional research in parks and ecological reserves:

- surveys for cave bones,
- surveys for living Vancouver Island marmots,
- meadow succession and fire history, and
- paleobotanical studies of long-term climate/vegetation changes.

BC Parks has a vital role to play in this research and Strathcona Provincial Park is of special interest. Despite the extensive subalpine-alpine habitat, no active marmot colonies exist in the park today. The Haley Lake Ecological Reserve is also an important research area because it provides an important baseline for comparison with subalpine habitats in other areas such as Strathcona Provincial Park.

Cave bone deposits have high scientific value and they can yield important information on the history of climate, animals, and humans in a park. Clearly they are an important heritage feature of any park. Successful management of these sites depends largely on education of BC Parks staff and park users. We recommend four important components to managing these cave sites:

- legal protection,
- documentation and scientific research,
- consultation with First Nations groups and the caving community, and
- education of BC Parks staff and park visitors.

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Introduction

The Vancouver Island marmot (*Marmota vancouverensis*) is a burrowing, colonial rodent that inhabits alpine and subalpine areas in the Mountain Hemlock and Alpine biogeoclimatic zones (Nagorsen 1987). Endemic to Vancouver Island, this mammal is listed nationally and provincially as endangered. During the past two decades, the population has fluctuated from 100-300 animals (Bryant 1995a; Bryant and Janz in press) and, except for an isolated colony at Mount Washington, all of the known extant colonies are confined to a localized area in the Nanaimo Lakes-Lake Cowichan area (Munro et al. 1985; Janz et al. 1994; Bryant and Janz in press). About 75% of the Vancouver Island marmot population is confined to a 40 km² core area in the Green Mountain-Haley Lake region, and in 1987 the Haley Lake Ecological Reserve was established to protect marmot habitat (BC Parks 1995).

Historical records suggest that this species was more widespread and the Vancouver Island marmot evidently has disappeared from Strathcona Provincial Park, the Beaufort Range, and Mount Arrowsmith in historical time (Bryant 1995b; Bryant and Janz in press). Ancient bones found in two north island caves (Nagorsen 1995a, 1995b, 1995c), demonstrate that the Vancouver Island marmot once inhabited low elevation sites that are forested today. The cause of these range declines is unknown. Most research (Bryant 1990) and inventories (Janz et al. 1994) have focused on the possible impact of high elevation logging, a recent phenomenon on Vancouver Island that has occurred in the past few decades. Although logging may have contributed to the range decline, the paleontological records and the disappearance of the Vancouver Island marmot from unlogged areas in Strathcona Provincial Park suggests that other factors have also contributed to the range decline.

Since 1985, ancient marmot bones have been found in four high-elevation archaeological cave/rockshelter sites (Figure 1). Three sites are peripheral to the known range of the Vancouver Island marmot. These discoveries are significant from a biological and archaeological perspective. They provide additional evidence for a range decline in the Vancouver Island marmot and suggest that historic or prehistoric factors such as climate change or early hunting played a role in this decline. The archaeological sites demonstrate that some aboriginal groups hunted Vancouver Island marmot, black bear (*Ursus americanus*), black-tailed deer (*Odocoileus hemionus columbianus*), and marten (*Martes americana*) in the remote subalpine areas of Vancouver Island. Until our study, faunal remains were known only from low elevation coastal sites and the only known archaeological site with

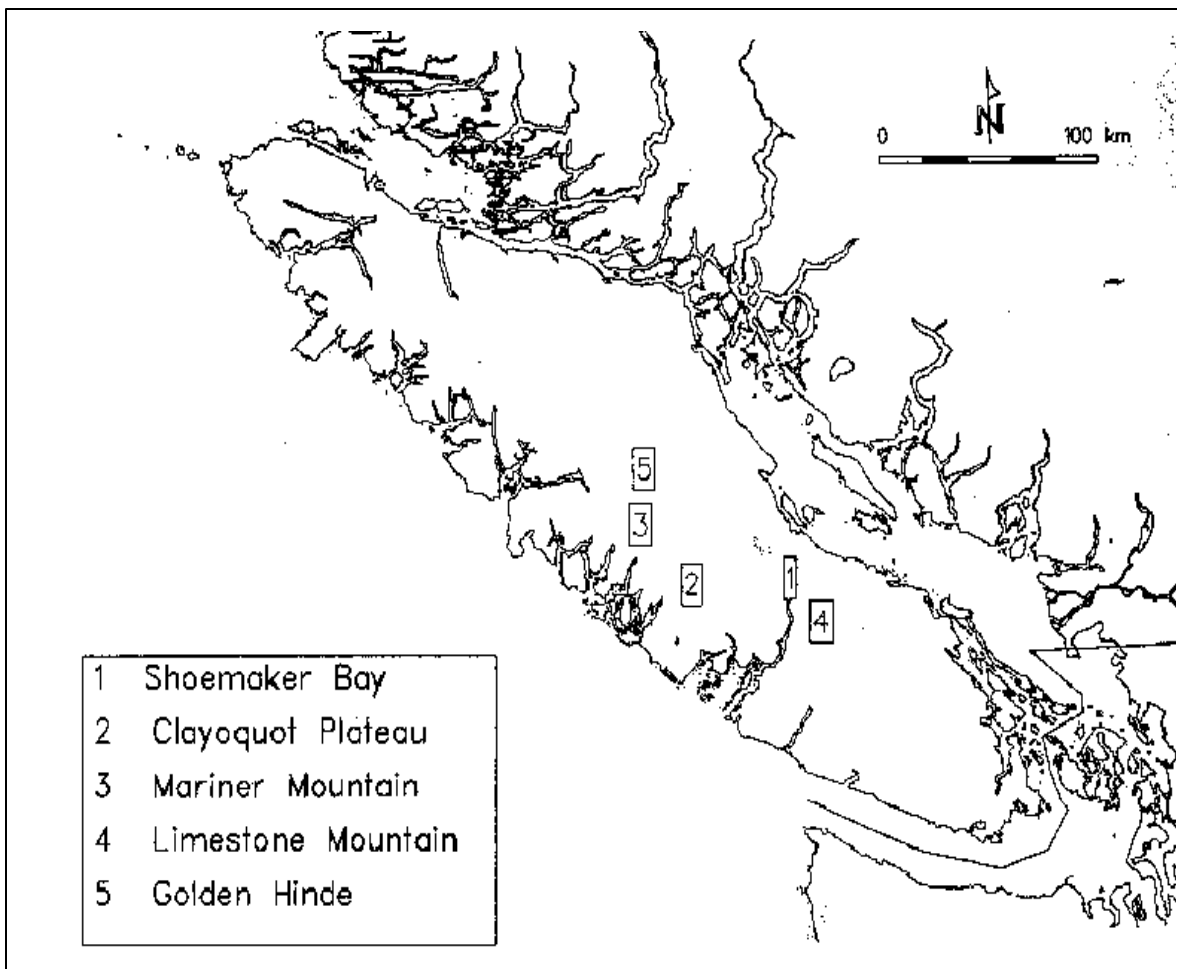


Figure 1. Locations of known archaeological sites with faunal remains of the Vancouver Island marmot

Vancouver Island marmot remains was a coastal shell midden on Alberni Inlet (Calvert and Crockford 1982). Because two cave sites are in Strathcona Provincial Park and a third is in Clayoquot Plateau Provincial Park, these subalpine archaeological sites need to be considered in the management of provincial parks.

In this report we summarize faunal analysis of the bone deposits and assess the biological and archaeological significance of the sites. Objectives of the faunal analysis were:

- a) determine the relative abundance and age structure of mammalian species in the sites,
- b) reconstruct skinning and butchering techniques,
- c) determine the seasonality of the sites, and
- d) compare the faunal remains from the four subalpine rock shelters with those typically found in coastal middens on Vancouver Island.

The importance of these data for the biogeography and conservation of the Vancouver Island marmot are discussed. Finally we recommend additional research needs in provincial parks and guidelines for managing faunal remains in caves.

Study Sites and Bone Deposits

Clayoquot Plateau

The Clayoquot Plateau cave site ("Marmot Cave") is 44 km west of Port Alberni at an elevation of 1220 m in an extensive karst area (Grundy 1986; Kozsan and Grundy 1989). Because it is an outstanding example of karst landforms and associated vegetational and geological features (Figure 2), the area was proposed as an ecological reserve in 1989 and included in Clayoquot Plateau Provincial Park established in 1995. "Marmot Cave" is a narrow cave extending about 12 m into a fractured rock. Marmot bones were discovered in the cave by Hans Roemer of BC Parks in 1985; a skull and selected long bones were sent to the Royal British Columbia Museum (RBCM) for identification. The site was subsequently explored by the University of Victoria caving club in 1988. In September 1988 David Nagorsen and Richard Hebda (RBCM) and Greg Allen (University of Victoria Caving Club), examined the site and collected 389 bones for analysis (Nagorsen 1989). The marmot bone elements were found in a scattered pile (Figures 3 and 4) at the far end of the cave in total darkness. They were exposed on rocks on the cave floor and under the rock debris. No artifacts or charcoal were present in the cave.



Figure 2. Numerous caves exist in the karst landforms of the Clayoquot Plateau



Figure 3. End of the Clayoquot Plateau cave where Vancouver Island marmot bones were found



Figure 4. Piles of Vancouver Island marmot bones on the floor of the Clayoquot Plateau cave

Mariner Mountain

"Mariner Cave" is a granite rock shelter situated on the east side of Mariner Mountain, Strathcona Provincial Park, at an elevation of 1220 m (Keddie and Nagorsen 1993). The triangular entrance is under a bedrock and large boulder formation above a talus slope. The floor is about 6 m in length by 3 to 5 m in width and averages about 2 m in height. The cave is dark except near the entrance. Marlene Smith and Steve Smith discovered the cave in 1992; David Nagorsen and Grant Keddie (RBCM), Ron Quilter (BC Parks), and Marlene Smith examined the site in November 1992. We collected 1937 bone specimens representing marmot, black-tailed deer, black bear, and marten in the cave. The bones were in nine distinct clusters within the cave. Single fish and bird bones were also found. In addition to bones, we recovered three artifacts in the cave: 1) a California mussel (*Mytilus californianus*) shell which could be a knife fragment, 2) a flaked stone with a naturally sharp edge (Figure 5), probably used for skinning, and 3) an abrading or sharpening stone most likely used to sharpen tools. A piece of burned wood was also collected on the cave floor.



Figure 5. Flaked stone tool from Mariner Mountain cave

After completing our analysis, we made a second trip to the cave in October 1994 to return the bones. Jack Little of the Nuu-chah-nulth Tribal Council and acting as a representative of the Ahousat Band, along with David Nagorsen, Mark Dickson, and Grant Keddie (RBCM), and Ron Quilter (BC Parks) returned the bone specimens and sealed the cave entrance to prevent human disturbance.

Limestone Mountain

The Limestone Mountain site is a small granite rock shelter located on the edge of a forested area on the north side of Limestone Mountain at an elevation of 1205 m. Limestone Mountain is about 1.5 km SW of Douglas Peak, the type locality where Harry Swarth collected a series of 11 museum specimens in 1910 (Swarth 1912). The rock shelter was about 3 m by 4 m and situated between two large boulders. Marmot bones were originally found by Mike Stini in 1991 and a mandible was sent to the RBCM for identification. David Nagorsen and Grant Keddie (RBCM), Doug Janz (Fish and Wildlife, Ministry of Environment), and Mike Stini examined the site in August 1993. We recovered 1561 bones representing Vancouver Island marmot, black-tailed deer, black bear, marten, and red squirrel (*Tamiasciurus hudsonicus*). All bones were on the surface or within a 10 cm litter mat of an alcove along the west wall of the shelter. We found no artifacts or charcoal at the site.

Golden Hinde

This is a small rockshelter below the summit of the Golden Hinde in Strathcona Provincial Park. It is at the base of a tarn at about 1420 m. The shelter consists of two compartments formed by several large boulders. Bones were in the first compartment which had a 3.5 x 3.5 m floor with a 1.9 m constricted area at the south end. In 1993, Lindsay Elms discovered the site and removed five bone specimens (all marmot); all were sent to the RBCM for identification. A mandible collected from a "rock cave at the tarn of the Golden Hinde" in 1979 by Shirley Duncan is presumed to have come from the same cave. The mandible was donated to the RBCM (BCPM 16691) in 1987. In October 1994, David Nagorsen and Grant Keddie (RBCM), Ron Quilter (BC Parks), and Jack Little (Nuu-chah-nulth Tribal Council and representative of Ahousat Band) examined the site; 99 bone specimens were found in the cave. Preservation was poor and the bones in this site were extremely fragmented and weathered. Most were on the floor of the first chamber but four were arranged on a rock near the entrance suggesting disturbance by human visitors. The presence of paper garbage in the first chamber of the cave was additional evidence for recent human disturbance. We found no charcoal or artifacts in the cave.

Material and Methods

Bone Samples

We attempted to collect the entire bone assemblages in the four sites. In Mariner Mountain and Limestone Mountain, two sites with large bone accumulations, a few bones were wedged between rocks and could not be collected. All bones were surface or littermat deposits and the faunal remains were not layered into different strata at any site. However, any groupings or clusters of bones on the floor of caves were noted. Bones from Clayoquot Plateau, Limestone Mountain, and Mariner Mountain were analysed at the RBCM. The faunal remains at the Golden Hinde were analysed *in situ* and left in the cave.

Analysis of Bone Elements

Each bone specimen from the Clayoquot Plateau, Mariner Mountain, and Limestone Mountain caves was catalogued and labelled with a unique code based on a two-letter acronym for the site and sequential numbers for each bone specimen (e.g., CL1 = Clayoquot Plateau specimen 1). We identified specimens to species and element using reference skeletons from the collections of the RBCM and standard reference manuals (Olsen 1964; Gilbert 1980; Schmid 1972).

Information recorded for each bone specimen included: site, species, cluster number, specimen number, element, description, age, side, condition, fragment and part descriptions, and descriptions of bone condition including the presence of butcher marks. We entered information into a database (dBASE IV software) that was modified from a database developed by Becky Wigen and Susan Crockford at the University of Victoria Anthropology Department.

We assigned Vancouver Island marmot skulls and mandibles to three age categories based on tooth eruption and crown wear: infants, young adults, old adults. Infants had deciduous premolars (i.e., milk teeth). Skulls or mandibles with fully erupted permanent premolars were classified as adult. Young adults had no crown wear on their cheek teeth; old adults had teeth with heavily worn crowns. Tooth wear was assessed with the aid of a dissecting microscope. Specimens lacking teeth were aged by size and skull development, or recorded as

unknown age. We aged the long bones (femur, fibula, humerus, radius, tibia, ulna) of Vancouver Island marmots by epiphyseal closure (Larson and Taber 1980). In immature animals the shaft of a long bone is separated from the bony cap (i.e., epiphysis) at each end by cartilage; in mature animals the cartilage is replaced by solid bone. We assigned marmot long bones to three age categories: epiphyses not fused, epiphyses fused with suture line visible, and epiphyses fused with suture line not visible. Distal and proximal epiphyses were treated separately.

We aged skulls and mandibles of black-tailed deer and black bear by tooth eruption and tooth wear (Robinette et al. 1957; Rausch 1961; Marks and Erickson 1966; Larson and Taber 1980). Because their long bones were fragmented we could not assess epiphyseal closure for black-tailed deer and black bear.

We examined bones for visible evidence of human modification from skinning, dismembering, filleting, or other activities intentionally altering bone, such as marrow extraction or fracturing bone, to obtain raw materials for tool manufacture. All observations were made with a microscope (10-25x magnification) except for the Golden Hinde bones which were examined in the field with a 10x hand lens. The position and orientation of all butcher marks were sketched on outline drawings. We also noted modification from natural, non-animal agents such as geochemical modification, root action, weathering, or rockfall abrasion.

Distinguishing cut marks from animal tooth marks or natural damage is largely a subjective exercise based on the experience and comparative observational skills of the examiner. According to Binford (1981) human-induced butchering and skinning marks would be expected to show two characteristics: 1) repetitive cut marks on many examples of the same bone element, 2) some anatomically dictated reason why a particular cut mark should occur at a given location on the bone. Cuts from tools are characteristically deeper on the parts of the short curvature and shallow on the flatter or long curvature surfaces. This is different from scoring by carnivore teeth which tend to follow the contour of the bone. Carnivore scoring is often transverse to the long axis of bones since it results from turning the bones against the teeth. Rodent gnaw marks are often in parallel groups and have flat to concave bases. As there was a high incidence of rodent gnawing on bones from all assemblages, the structure of these markings was examined carefully to distinguish them from butcher marks.

We used two standard quantitative measures in our faunal analyses: number of identified specimens (NISP), and minimum number of individuals (MNI) (Grayson 1984). Number of identified specimens are simply total counts of the identified bone specimens for each species. The minimum number of individuals for a species represented in a sample is determined from the minimum number of individuals represented by the most abundant body part. Bones are identified to element and side; the number of individuals is given by the most abundant element.

The relative abundance of different mammal species in sites was expressed as %NISP and %MNI. We calculated the relative abundance of the three age categories (infant, adult, old adult) for Vancouver Island marmot mandibles in the Limestone Mountain, Mariner Mountain, and Clayoquot Plateau sites based on total minimum numbers of individuals that could be aged. A sample of only four individual Vancouver Island marmots prohibited a quantitative age analysis for the Golden Hinde cave. To assess the representation of different body parts for Vancouver Island marmots in sites, we calculated the relative frequency of skeletal elements. Frequency was based on the proportion of expected bones for each element found (i.e., %MNI).

Radiocarbon Dating

We submitted eleven bones to the Isotrace Radiocarbon Laboratory, University of Toronto for ^{14}C analysis by accelerator mass spectrometry. Dates were corrected for $\delta^{13}\text{C}$. Ages are uncalibrated radiocarbon years (± 1 standard deviation) given in years before present (BP), and calibrated ages (with 95.5% confidence intervals) derived from dendro calibration data. All dates are based on single bones. Sample sizes for dating ranged from one (Golden Hinde) to six bones (Mariner Mountain).

The six bones from Mariner Mountain cave were selected from different areas on the floor of the cave. We tested for contemporaneity among the six dates using the Chi-square test statistic described by Bowman (1990):

$$\chi^2 = \sum (t - T)^2 / \sigma^2$$

where t = an individual radiocarbon date with a standard deviation σ and, T is the pooled mean of the individual radiocarbon dates, $T = \sum t / \sigma^2 / (\sum 1 / \sigma^2)$. The null hypothesis is that the dates are from a single statistical sample.

Results

Radiocarbon Dating

Bones from all of the sites are prehistoric dating from 830-2630 BP (uncalibrated) and 990 AD to 807 BC (calibrated) (Table 1). The six bones from Mariner Mountain span 141 calendar years. However, the Chi-square test was not significant ($\chi^2=9.045$, $0.10 < P < 0.05$) supporting the null hypothesis that the dates are from a single statistical sample.

Table 1. Radiocarbon dates for Vancouver Island marmot bones from four cave sites. Uncalibrated radiocarbon years are years before present (BP).

Site	Element	Lab Number	Radiocarbon Years	Calibrated Age
Clayoquot Plateau	Femur	TO-1224	2630 \pm 50 ^a	807 BC (899-775 BC) ^b
	Tibia	TO-692	2490 \pm 50	680 BC (800-406 BC)
Mariner Mountain	Femur	TO-3562	890 \pm 50	1163 AD (1021-1255 AD)
	Femur	TO-3563	920 \pm 50	1047 AD (1011-1226 AD)
	Femur	TO-3564	990 \pm 50	1022 AD (1000-1038 AD)
	Femur	TO-3565	850 \pm 50	1211 AD (1033-1268 AD)
	Femur	TO-3566	890 \pm 50	1163 AD (1021-1255 AD)
	Femur	TO-3567	970 \pm 90	1027 AD (888-1252 AD)
Limestone Mountain	Femur	TO-4266	1030 \pm 60	1015 AD (890-1165 AD)
	Femur	TO-4267	1070 \pm 60	990 AD (880-1040 AD)
Golden Hinde	Mandible	TO-4265	830 \pm 60	1225 AD (1040-1290 AD)

^a \pm 1 standard deviation.

^b Range is 95.5% confidence interval.

Faunal Analysis

Relative Abundance of Species in Sites

A total of 3981 bone specimens was recovered in the four sites. Except for a blue grouse (*Dendragapus obscurus*) tibia and a small fish vertebra found in Mariner Mountain cave, all faunal remains were mammalian. Of the 3979 mammalian bone specimens, 3807 could be identified to species. Only five mammal species were represented in the faunal remains: Vancouver Island Marmot, black bear, black-tailed deer, marten, and red squirrel. Counts of identified bone specimens (NISP) and estimates of minimum numbers of individuals (MNI) demonstrate the predominance of Vancouver Island marmots in the four cave sites (Table 2). At least 143 individual marmots were represented in the faunal remains; the large

Table 2. Relative abundance of mammal species in faunal remains from four cave sites

Site and Species	NISP ^a	% NISP	MNI ^b	% MNI	Most Common Element
Clayoquot Plateau					
Vancouver Island marmot	389	100	13	100	humerus
Mariner Mountain					
Vancouver Island marmot	1335	72.4	74	87.1	mandible
Black-tailed deer	419	22.7	7	8.2	astragalus
Black bear	89	4.8	3	3.5	mandible
Marten	2	0.1	1	1.2	-
Limestone Mountain					
Vancouver Island marmot	1321	89.7	52	85.3	tibia
Black-tailed deer	99	6.7	3	4.9	mandible
Black bear	45	3.1	3	4.9	mandible
Marten	6	0.4	2	3.3	scapula
Red squirrel	1	0.1	1	1.6	-
Golden Hinde					
Vancouver Island marmot	99	100	4	100	mandible

^a Number of identified bone specimens.

^b Minimum number of individuals.

number in the Mariner Mountain and Limestone Mountain sites is particularly noteworthy. The discrepancy in relative abundance of black-tailed deer at Mariner Mountain using NISP and MNI can be attributed to inflated bones counts. The skulls and long bones of this species were broken into numerous individual pieces and fragments. In contrast to the four subalpine rock shelters, mammalian faunal remains in the coastal midden at Shoemaker Bay (Calvert and Crockford 1982) were mostly marine mammal, black-tailed deer, furbearers, and black bear; Vancouver Island marmots were incidental (Figure 6).

Figure 6. Relative abundance (% MNI) of mammals in the faunal remains from four subalpine cave sites and the Shoemaker Bay coastal midden

Age Composition of Faunal Remains

Vancouver Island Marmot

Biological age of marmot samples as revealed by mandibular teeth varied among sites (Figure 7). The Clayoquot Plateau remains were mostly infants and young adults with unworn teeth; a large proportion of the Mariner Mountain remains were old adults with worn teeth. Because there have been no studies on known age animals, the age when Vancouver Island marmots acquire their permanent dentition is unknown. However, individuals with deciduous premolars are probably young-of-the-year. According to Mashkin and Kolesnikov (1990), the deciduous premolars of Old World marmots are replaced by the permanent teeth before animals enter hibernation in their first winter. The chronology of tooth wear has not been studied in Vancouver Island marmot but we assume that Vancouver Island marmots with worn cheekteeth are individuals two years or older. Van Vuren and Salsbury (1992) observed increasing wear on the lower premolars of yellow-bellied marmots (*Marmota flaviventris*) with age and their measure of premolar gap was most effective for discriminating one year-olds from older animals. Similarly, in Old World marmots, the cheekteeth become worn in animals that are two years or older (Mashkin and Kolesnikov 1990).

Figure 7. Relative abundance (% MNI) of three age categories of Vancouver Island marmot mandibles from three cave sites

In all sites epiphyseal fusion of the long bones (Tables 3-5) generally supports the age differences demonstrated by mandibles. Most long bones from the Clayoquot Plateau site were immature with the sutures unfused; more mature bones (i.e., those with fused sutures) were present in the Mariner Mountain and Limestone Mountain sites. Unfortunately, epiphyseal fusion has not been studied in known age individuals for any marmot species and we cannot relate the stage of fusion to chronological age.

Table 3. Epiphyseal closure in Vancouver Island marmot long bones from Clayoquot Plateau site

Element	Unfused	Fused	
		Suture Visible	Suture Not Visible
Proximal Femur	15	0	3
Distal Femur	15	1	3
Proximal Fibula	12	1	4
Distal Fibula	11	0	6
Proximal Humerus	16	4	6
Distal Humerus	9	0	13
Proximal Radius	16	0	6
Distal Radius	20	0	2
Proximal Tibia	18	2	4
Distal Tibia	16	0	6
Proximal Ulna	11	0	8
Distal Ulna	15	1	3

Table 4. Epiphyseal closure in Vancouver island marmot long bones from Mariner Mountain site

Element	Unfused	Fused	
		Suture Visible	Suture Not Visible
Proximal Femur	14	0	41
Distal Femur	25	10	28
Proximal Fibula	11	0	3
Distal Fibula	7	1	6
Proximal Humerus	36	21	36
Distal Humerus	3	0	83
Proximal Radius	11	15	61
Distal Radius	44	5	11
Proximal Tibia	36	11	28
Distal Tibia	6	7	56
Proximal Ulna	22	11	41
Distal Ulna	37	5	11

Table 5. Epiphyseal closure in Vancouver island marmot long bones from Limestone Mountain site

Element	Unfused	Fused	
		Suture Visible	Suture Not Visible
Proximal Femur	26	1	15
Distal Femur	23	1	6
Proximal Fibula	8	1	8
Distal Fibula	9	0	14
Proximal Humerus	18	0	4
Distal Humerus	20	2	34
Proximal Radius	34	1	36
Distal Radius	55	1	11
Proximal Tibia	21	5	12
Distal Tibia	28	4	33
Proximal Ulna	34	5	42
Distal Ulna	42	1	5

Black Bear

The mandibles and maxilla in the Mariner Mountain site appear to represent two individual bears. One was an adult with permanent dentition; the other was a cub with the second upper molar (M²) erupting. According to Rausch (1961) and Marks and Erickson (1966), M² erupts August to September and is usually fully erupted by late autumn. Mandibles in the Limestone Mountain site represented three bears. Two were old adults with worn molars. Based on size (the teeth are missing) the third mandible was from an immature animal.

Black-tailed Deer

Ages of five mandibles and three maxilla with teeth recovered at Mariner Mountain were all two to three years old (Appendix 1). No fawns, yearlings or old deer were represented. Because there were no skulls or mandibles and the long bones were highly fragmented, we could not evaluate age in the black-tailed deer from Limestone Mountain.

Representation of Body Parts in Faunal Remains

Vancouver Island Marmot

Although the relative abundance of different skeletal elements differed among the Clayoquot Plateau, Mariner Mountain, and Limestone Mountain sites (Figures 8-10; Appendix 2), there were some consistent patterns in the marmot bones recovered. Ribs and vertebrae were under represented in the three sites. The scarcity of vertebrae is especially striking given the large number that would be expected for the number of marmots estimated to be represented in the sites. For example, no vertebrae were found in the Clayoquot Plateau and Mariner Mountain caves. Few foot bones were recovered from the three sites and the pelvic bones were under represented in the Clayoquot Plateau and Limestone Mountain remains. Noteworthy differences among the sites include few complete skulls in the Limestone Mountain marmot remains and the under representation of marmot limb bones in the Mariner Mountain faunal remains. Although the sample size is small (only four individual Vancouver Island marmots), noteworthy differences in the Golden Hinde cave remains were the absence of complete skulls and disproportionately more ribs and vertebrae (Appendix 2). However, the frequency of bone elements in this site should be interpreted with caution because the faunal remains were disturbed by recent park visitors. Conspicuous elements such as skulls could have been removed from the cave.

Figure 8. Relative abundance (% MNI) of Vancouver Island marmot bone elements in the Clayoquot Plateau faunal remains

Figure 9. Relative abundance (% MNI) of Vancouver Island marmot bone elements in the Mariner Mountain faunal remains

Figure 10. Relative abundance (% MNI) of Vancouver Island marmot bone elements in the Limestone Mountain faunal remains

Black Bear and Black-tailed Deer

Black bear skeletal remains were highly fragmented and incomplete (Appendix 3). No vertebrae, ribs or complete skulls were found in the Mariner Mountain cave. A similar pattern was evident for Limestone Mountain with only one vertebra and a single rib fragment. The most abundant elements of the appendicular skeleton were the foot bones. Although black-tailed deer faunal remains were also highly fragmented, they demonstrated some differences from the bears (Appendix 3). Ribs and vertebrae were well represented at both sites and there was better representation of various long bone elements.

Among-site differences were also evident for both species. In contrast to Mariner Mountain, skull remains were few at Limestone Mountain: black bears were represented only by mandibles and molar teeth, and the only cranial material for black-tailed deer consisted of two antler tines. Innominate bones of black bear and deer were also missing from Limestone Mountain.

Evidence for Human Processing Activities

Cuts marks on Vancouver Island marmot specimens are summarized in Table 6. In general, cut marks were most frequent on the head, jaws, upper limb bones, and the clavicles; cuts were rarely seen on the innominate bones, lower limb bones, and foot bones. Differences in cut patterns evident among sites suggest differences in skinning and butchering.

Table 6. Summary of cut marks on Vancouver Island marmot bones from three archaeological sites

Element	Clayoquot Plateau			Mariner Mountain			Limestone Mountain		
	# Cut	NISP ^a	% Cut	# Cut	NISP	% Cut	# Cut	NISP	% Cut
Skull	9	11	81.8	23	58	39.7	12	41 ^b	29.3
Mandible	7	24	29.1	80	149	53.7	27	74	36.5
Clavicle	8	11	72.7	0	17	0.0	19	56	33.9
Rib	1	3	33.3	3	170	1.8	10	358	2.8
Innominate	0	2	0.0	1	63	1.6	0	13	0.0
Vertebra	0	0	-	0	2	0.0	0	19	0.0
Scapula	0	23	0.0	0	91	0.0	0	66	0.0
Humerus	5	22	22.7	4	107	3.7	12	67	17.9
Radius	0	22	0.0	0	79	0.0	2	95	2.1
Ulna	0	19	0.0	0	85	0.0	0	97	0.0
Femur	10	20	50.0	22	95	23.1	14	67	20.8
Tibia	1	23	4.3	6	99	6.1	4	98	4.1
Fibula	0	17	0	0	29	0.0	0	36	0.0
Metatarsus	2	24	8.3	0	6	0.0	4	34	11.8

^a Number of identified specimens.

^b Includes skull pieces from Limestone Mountain.

Clayoquot Plateau

There were no carnivore tooth marks and the bone assemblage was remarkably undamaged given its age of 2600 BP (Figure 11). Of the 11 skulls, 9 showed work marks on the anterior region only. Most cuts were on the premaxillary (Figure 12). Two nasal bones were cut and one specimen had a long cut on the top of the frontal in addition to premaxillary cuts. The damage is consistent with the head of the animal being snapped forward to remove it rather than being severed near the base. All skulls were broken close to the occipital suture line. The occipitals were present on only six skulls. Seven auditory bullae had puncture marks consistent with being punctured by the pterygoid at the base of the skull when the cranium was snapped forward.



Figure 11. Entire assemblage of 389 Vancouver Island marmot bones from the Clayoquot Plateau site



Figure 12. Cut marks on the rostrum of a Vancouver Island marmot skull from the Clayoquot Plateau site

Six left mandibles had skinning cut marks on the anterior portion of the ramus; one right mandible had three cuts under the base of the posterior ramus which likely resulted from skinning or cutting of the throat area before the head was snapped back.

Ten femurs had skinning cut marks on or just above the distal end on the posterior side. We also identified butcher marks on the neck of femurs. Five right humeri had cuts near their distal ends. Two were cut across the bone bridge above the lateral epicondyle and three had cuts angled to the long axis of the bone near the distal end of the shaft.

Eight clavicles had cuts mostly in mid shaft or toward the distal end. These would result from cutting the shoulder muscles.

Two right metatarsi had two cuts each across the surface of the bone. There were only three ribs from the site. All had broken distal ends and one had two sharp cuts across its midsection.

Mariner Mountain

a) Human Modification to Marmot Bones

No carnivore chew marks were present on bones. Cuts were on skulls of 23 individual marmots, as well as on an additional 28 separate skull parts. All cuts on the skull were on the upper anterior of the maxilla and the ventral occipital in various combinations, and the anterior portions of the nasal bones. All maxillae cuts are indicative of cutting the skin around the nose. Cuts were present across the articular surfaces of seven occipital condyles and, in five specimens, across the small ridge extending from the anterior of the condyle to the basio-occipital. The cut angles on the condyles show that the cutting was directly from the side of the skull posterior to the bullae, typical of those produced by pulling back the head and severing from the neck. Cuts, small crushed points, and combinations of these were present on 33 auditory bullae. Their position suggest that a knife blade point was jabbed into this area to sever the muscles which connect the back of the tongue to the skull.

For the 80 mandibles with butcher marks, cuts were confined to the region across the ascending ramus. As the skin in the ramus area is loose and easy to cut it is unlikely that they would be made during the skinning process. Only when cutting deep to remove the jaw by severing the muscle below the zygomatic arch would these kinds of marks be produced. In some mandibles, cuts occurred only near the edge at the base of the coronoid crest or front of the ramus (17 specimens); only near the edge on the posterior base of the condyloid process or back of the ascending ramus (11); across the centre of the ramus (4); or, more commonly, in combinations which include the first two cuts mentioned on both sides of the ascending ramus (22); and the latter combination plus other cuts near the centre of the ramus (15). In most specimens, cuts were made straight across the ascending ramus. The combination cuts across the ramus were often parallel, suggesting single knife movements across the ramus. Others indicate separate cutting movements near each edge of the ramus in the same horizontal plane. Two mandibles had only single cuts on the base of the horizontal ramus curving under the masseteric line. These are likely the result of skinning the facial fur.

There were 22 femurs with cut marks. All but two had cuts on the neck of the femur where the iliofemoral and ischiofemoral ligaments are located.

Four humeri had cuts on their distal ends. Three had one or two cuts across the small bone bridge above the lateral epicondyle on the anterior surface of the bone.

There were six cut tibias. Two had dubious cuts on the inside surface of the proximal shaft and four had single cuts on the distal shaft, three on the posterior surface and one on the anterior surface. They are probably cuts from skinning, but their infrequency does not suggest any regular pattern.

Three ribs had single cut marks; only one fortuitous cut occurred on the inside surface of an ischium. The innominates were evidently removed without cutting the muscles attached to them suggesting that the abdominal area was snapped and pulled off the sacrum and then discarded.

b) Bone Clusters on Cave Floor

The way the marmot remains were aggregated into nine areas of the cave gives some clues as to the nature of the marmot processing activities. The vast majority of bone elements were located in Area 8 (MNI 44). Skulls, however, were relatively less common in this area in comparison with the other areas.

The composition of some of the smaller piles is revealing. Areas 1 and 3 were similar with mostly skull parts and long bones. In Area 1 (MNI 10) the complete skulls (cranium with mandibles) of about ten marmots were removed at the same time and dumped. Ten well preserved skulls and fragments with eight right and left mandibles were found close together. The postcranial bones in Area 1 represent only small portions of a maximum of four individuals. In Area 3 (MNI 10) there are ten right and eight left mandibles with a minimum of four animals based on skull sections.

Area 4 (MNI 9) is similar to Areas 1 and 3 in having nine individuals based on cranium and fragmentary non-matching cranial parts, but it had only one mandible. Postcranial bones included 20 ribs. Area 5 (MNI 5) had some similarities with five skulls and six left and three right mandibles. Other bones included about 30 longbones and, significantly, about 30 ribs. Area 7 (MNI 3) is a small pile which includes two skulls and three mandibles with miscellaneous postcranial material.

The other areas were small with proportionally more postcranial material. Area 2 (MNI 3) had only some postcranial remains of three marmots. Area 6 (MNI 7) included mainly long bone portions (44) of seven individuals. Only three skulls and two sets of mandibles were present. Six innominates were present. Area 9 (MNI 2) with 21 loosely scattered bones did not form as distinct a cluster as the other area samples. It included two left and right tibia and the same for mandibles.

The skulls in all areas except Area 8 may represent as many as 33 individuals, but it is uncertain how much overlap there is between clusters. Even given some overlap there is still a minimum of about 25 skulls that would be exclusive of Area 8. This clearly shows that a large number of the 62 skulls from the site were located in six of the smaller areas of bone concentrations. If each of the nine areas were given a separate MNI count it would add up to 93 with 44 in Area 8. This figure would suggest that skulls are under-represented in Area 8.

c) **Human Modification to Other Mammals**

The limited evidence indicates some black bear and black-tailed deer remains were chewed. The chew marks were made by either wild animals or aboriginal dogs.

Bear skulls showed definite evidence of skinning and butchering. Two right posterior skull fragments have cuts across the posterior end of the zygomatic process and one left maxilla fragment had an upward cut forward of the infraorbital foramen. Five mandibles had cuts on one or both sides across the base of the ascending ramus. In a matching pair, the left showed cuts on the posterior and anterior surface of the ascending ramus but the right was only cut at the anterior side. Only two postcranial bones showed evidence of human modification. A left scapula had three cut marks on one edge and a right radius had a series of very fine cut marks just below the distal end. Gnaw and tooth pressure marks were also found on the latter bone.

A deer skull had a series of parallel skinning cut marks on the left side above the tooth row on the maxillae. No cuts were found on the corresponding right side. Five deer mandibles had cut marks across the posterior base of the ascending ramus. We found cut marks only on two scapulae; one on the outer and one on the inner edge of the constricted area below the articular end. Two cuts were located on the neck of a femur but none were found on the other five proximal ends, the four distal ends, or the many shaft fragments. Most ulnae were not cut; only a single cut was observed between the articular surfaces of one. Of four humeri fragments a cut was seen on the distal shaft; at the junction of the shaft; and two cuts on the inside of the

greater tubercle. Five ribs had cut marks; two were cut across the middle of the ribs; one near the proximal end and one cut at a broken edge. Six vertebrae had butchering cuts; three thoracic were cut across the base of the spine; a 6th sternal was cut on two edges of the centrum; and two atlas vertebrae had multiple cuts across the upper ventral edge and with the latter also across the upper and lower dorsal edge. No cut marks were observed on innominates.

Of the two marten bones, the ulna had no cut marks and the humerus had two end cuts.

d) Tools Associated with Bones

Four artifacts were found in the Mariner Mountain cave site. A sharpening or abrading stone made of a coarse sandstone was found in the middle of Area 4 in a pile of marmot bones. This 11.5 cm long rectangular stone tapers from 3.5 cm in width (1.5 cm from one end) to 2.6 cm at the other end. Its thickness varies from 1.37 to 1.15 cm. The stone has a quartz groundmass with magnetite and mica present. It is ground on both flat sides but is extremely smoothly ground on one side. The rougher surface has black organic material adhering to it in parts. The tool could have been used to re-sharpen a ground mussel or slate knife. It is too smooth to have been used for primary sharpening of stone, bone or wooden projectile points.

A partially burnt knot of wood, possibly used as a torch, and chunks of associated charcoal were found on top of the Area 5 bones. A burnt deer scapula, heavily covered in charcoal soot, lay immediately below it.

Fragments of a California mussel shell were found together in Area 8, against the back of the west wall, in a pile of marmot bones. This is probably part of a shell knife but does not include the distal end which usually forms a sharp cutting edge. The tool could have been used in the skinning process.

A green siltstone flake (4.42 x 3.54 x 1.55 cm), with several possible working edges, was found in a pile of marmot bones in Area 8 (Figure 5). It may have been used as a cutting tool for skinning and butchering. The flake has one long straight distal edge (2.85 cm long) that continues in a curve to one side. This edge has slight rounding that may be natural weathering or use polish. There is no retouching on this edge. One side has step fracturing from earlier removal of smaller flakes as well as possible retouch at the bottom edge. Another short straight edge is slightly rounded with no obvious retouch. Two other short sections of the flake have what appears to be unifacial use retouch. The finest edge of this flake fits the larger cuts on some bones, when both are observed together under a microscope. Other bone cuts were much finer and could not have been cut with this tool.

Limestone Mountain

a) Human Modification to Marmot Bones

Skulls were highly fragmented and no complete skulls were found. Of the three partial skulls, two had cut marks; another ten skull parts had cut marks. The cuts are consistent with skinning. The cutting of the tongue muscles is suggested by cuts on a left auditory bulla that also had a punctured right bulla, and cuts on an individual left bulla. Three other right bullae had puncture marks. Three specimens had cuts across the edge of the foramen magnum indicative of severing of the head.

Of 74 mandibles, 27 had cuts and 16 were missing parts where cut marks usually occurred or were too weathered for analysis. Most common cuts appeared on the ascending ramus as a result of cutting the masseter muscle. Fourteen had cuts on both sides of the ramus, with half having more cuts across the centre of the ramus. Eight had cuts only on the edges of the ramus and two had cuts on the underside of the posterior part of the ramus. Other specimens differed in having additional downward cuts on parts of the ramus. Two had cuts on the inner or labial side of the main ramus which are likely secondary to the cutting involved in the removal of the tongue.

There were 14 femurs with cuts near the proximal end. One was also cut just above the distal end. Eleven had the cuts only on the neck of the femur; two had cuts on the neck and across the upper greater trochanter and one was cut just below the outer trochanteric crest. The proximal cuts are consistent with the severing of the proximal ligaments of the leg. The one distal cut may be related to removal of the fur from the leg area.

Only four tibiae had cut marks that do not clearly represent a pattern. Two had single angled cuts near the distal end and one was cut across the side of the distal end. One had a single long cut on the inside of the proximal shaft. These cuts seem more likely to be related to skinning than butchering.

Twelve humeri were cut on the distal end. Seven had cuts on one edge of the dorsal surface across or near the small bone ridge above the lateral epicondyle on the anterior surface. One had cuts in a similar location on the ventral side. The cuts are the result of cutting muscles and suggest the removal of the front paws during the skinning process. Three humeri had single cuts angling down on the distal end of the shaft and one has cuts across the same area. They seem consistent with removal of the skin from the lower forelegs.

Ten ribs had cut marks which are atypical given the general absence of ribs from the site. Four were cut near the proximal end, three near the distal end and three near the middle. The distal end cuts may have been made during the separating of the belly fur but the others are suggestive of the filleting of the ribs.

Nineteen clavicles had cuts mostly toward the distal or proximal ends and on both anterior and posterior sides. Four had cuts near both ends. They are consistent with the removal of the front limbs. The scapulae (which have no cut marks) would have been removed at this time.

Two radii had poorly defined distal end cut marks. They may be related to skinning during removal of the forearms but should be considered inconclusive for establishing a butchering pattern.

Three metatarsi had single cuts near their distal ends and one specimen had several random cuts on the shaft. They are related to skinning and not butchering.

b) Human Modification to Other Mammals

Other mammal bones were highly fragmented. Cuts were observed on two black bear and two black-tailed deer bones. One bear mandible had three cuts on the lower base of the posterior of the condyloid process and several cuts on the posterior and mid-surface of the coronoid process of the ascending ramus. Three long, fine cuts were found on the dorsal surface of a left bear scapula parallel to the spinous process.

A deer rib mid-section had three cuts on its dorsal surface and a deer cervical vertebra fragment had nine short close together cuts and one near by cut on the edge of one side.

No cuts were present on the single red squirrel bone; two marten femurs had cuts on the neck.

Golden Hinde

Only two marmot bones had cut marks: a left mandible with cuts on each side of the base of the ascending ramus, and a partial rib with three cut marks. The limited evidence from this site suggests that at least some butchering occurred here, but the presence of a vertebral column and ribs suggests that at least one animal was skinned and no parts taken away for food consumption.

Discussion

Interpretation of the Faunal Assemblages

The faunal remains in the four subalpine sites are clearly the product of human hunting. Because the cave/rockshelters are shallow with no vertical shafts, they are not natural trap sites where mammals would fall to their death. Although carnivore tooth marks were found on a few bones, the largely intact marmot long bones (Figure 11) are inconsistent with a carnivore kill. There are only four wild carnivores on Vancouver Island that would be capable of killing and transporting an adult marmot to a cave: black bear, gray wolf (*Canis lupus*), cougar (*Felis concolor*), and wolverine (*Gulo gulo*). Predation from these species would result in extensive damage to the skeleton of a small mammal such as a marmot.

The numerous cut marks identified on bone specimens and the presence of artifacts in one cave are convincing evidence for human predation. The peculiar biases in marmot body parts represented at the four sites are also consistent with human processing. Differences in the relative abundance of various body parts in faunal remains can result from preservation, recovery and sampling bias, human butchering, and disturbance from scavengers (Behrensmeier and Hill 1980). Small rodent (Townsend's vole, *Microtus townsendii*, or deer mouse *Peromyscus* sp.) gnaw marks were found on many bones and it is possible that some small bone elements such as ribs or vertebrae were transported from the caves by small rodents. No marmot bones showed evidence of carnivore chewing and scavenging probably had little impact on the faunal assemblages. Because they are fragile and small, poor preservation could also contribute to the scarcity of marmot ribs in our sites. The few foot bones recovered may be the result of sampling bias. Small and few in number, they could be overlooked. However, we attribute most of the differences in relative abundance of body parts to processing associated with butchering and skinning.

The cut marks on bones and body parts recovered in the sites suggest that Vancouver Island marmots were skinned for pelts and butchered for meat. The use of marmot pelts and meat by aboriginal peoples has been well documented (see Ethnographic Evidence for Native Use of Marmots section). The numerous cuts on the rostral area of skulls and on the mandibles are consistent with skinning. The cuts on the neck of the femurs is consistent with cutting and removing the thigh muscles for meat. The absence of cut marks on the pelvis

suggests that the softer tissue may have been cut and the abdominal area snapped back and pulled off. In some marmots, the front lower legs were cut to facilitate skinning. Leaving tails and feet on the skins would explain the general absence of foot bones and tail vertebrae. The paucity of ribs and vertebrae suggests that meat and fat may have been left attached to back bone and ribs and transported to another location.

Throughout the province, aboriginal peoples captured marmots with deadfall traps (Drucker 1950, 1955) and snares (Preble 1910). The faunal remains provide no indication as to how the Vancouver Island marmots were killed or captured. The broken skulls at Clayoquot Plateau appear to be the result of snapping the head forward to facilitate the processing of the carcass rather than crushing damage associated with a deadfall trap. Crushed vertebrae would indicate damage from a deadfall trap but vertebrae are absent from the sites.

Cut marks and the body parts represented in the sites indicate that black-tailed deer, black bear, and marten were also at least partially skinned and butchered at Mariner Mountain and Limestone Mountain. The physical remains provide no evidence how they were killed. It is conceivable that some bones are the result of animals being dragged into caves by carnivores. However, the presence of both carnivore chewing and butchering on a few bones would suggest that parts of these larger animals were either given to dogs or scavenged by carnivores after processing by hunters. There are too few cut bones to interpret processing techniques. But the scanty data indicate that deer and bear were heavily butchered and most of their parts removed from the cave sites.

In the subalpine areas of Vancouver Island permanent snow cover usually persists from late November to June depending on snowfall, aspect, and elevation. The four caves would be filled with snow during those months and they would be accessible only after snow melt. According to cavers, the Clayoquot Plateau cave is filled with snow until early August some years. The faunal remains at the four sites are certainly consistent with hunting in late summer or early autumn. The Vancouver Island marmot hibernates from October to late April or early May (Nagorsen 1987) and this species would be available for only a brief period from late spring to early autumn. Young-of-the-year usually emerge from their natal burrow in late June or July (Nagorsen 1987). The presence of infant marmots with milk teeth in the faunal remains supports a late summer or early autumn date for the sites. The age of the black bear cub is also consistent with this season.

Aboriginal peoples who hunted the subalpine-alpine areas probably lived with larger groups in villages on the ocean shore. Hunters ventured into the subalpine areas for the main purpose of hunting the Vancouver Island marmot or were part of a larger task force that came to these regions during the deer and bear hunting season. We interpret the subalpine archaeological sites as temporary hunting sites used only in late summer or early autumn. Although the existence of permanent camps near the subalpine sites cannot be ruled out without further survey work, it would appear that the cave/rockshelter sites were not habitation sites. These sites probably served as temporary shelters for processing animals in inclement weather. No fire pits were found in the caves and the only evidence for fire was a piece of burned wood found in the Mariner Mountain cave. Curiously no evidence of fire was found in the Clayoquot Plateau site, although the bones were deposited in a dark area at the back of the cave. Animals may have been processed inside the entrance and then thrown to the back of the cave. The lack of artifacts in the sites indicates that most artifacts used at these sites were taken back to the main village. The few artifacts found at Mariner Mountain cave probably represent the rare tool lost or discarded.

The faunal remains at Clayoquot Plateau and Golden Hinde may represent a single episode of marmot hunting and these caves may have been used only once. The large bone deposits found at Mariner Mountain and Limestone Mountain probably accumulated from multiple hunting episodes over a period of time. Although the radiocarbon dates were not significantly different, our sample was small. If funds for radiocarbon dating were unlimited, a sample of six dates from each cluster would be a more effective approach to assess for contemporaneity. However, the archaeological context with a number of distinct clusters on the cave floor is consistent with several hunting events. The most compelling evidence for multiple hunting episodes, however, comes from the numbers of animals harvested. The numbers of marmots found in these sites exceed the average colony size known today. For example, of the 51 individual marmots represented by mandibles at Mariner Mountain cave, 41 are from adults. Based on an analysis of 35 reproductive colonies, Bryant and Janz (in press) reported that the mean number of adults/colony was 4.2; their maximum mean count for adult Vancouver Island marmots in a single colony was 15.7. It is possible that aboriginal hunters foraged over a vast area harvesting marmots from colonies far beyond the Mariner Mountain site and then transported animals to the cave site for processing. However, given the rugged inaccessible terrain this seems unlikely and we attribute the large number of marmot remains to several hunting episodes.

Which aboriginal groups hunted marmots at the four archaeological sites is unknown. The evidence left in the caves is scanty. Uncertainty regarding some territorial boundaries and historical territorial changes and extinctions of local aboriginal populations also hinder any attempts to determine the aboriginal groups involved.

Archaeological significance

The four cave sites are significant because they are the first subalpine archaeological sites with faunal material described for the Northwest Coast. The Mariner Mountain and Golden Hinde rockshelters represent the only archaeological sites known from Strathcona Provincial Park. Numerous archaeological sites with faunal remains have been described from the Olympic Peninsula and southern coast of British Columbia. However, they are all coastal sites situated near sea-level with long-term continuous occupancy (Bergland 1983; Mitchell 1990). Because of the diverse food resources available, their middens contain a variety of faunal remains including mollusks, fish, birds, and marine and terrestrial mammals. On Vancouver Island, black-tailed deer is consistently the dominant terrestrial mammal found in coastal middens (Calvert 1980; Calvert and Crockford 1982; Mitchell 1981; Bernick 1983).

In contrast, the four subalpine caves are specialized seasonal sites with short-term use and their faunal remains demonstrate some striking differences from coastal sites. With no marine resources available and a depauperate avian fauna compared with coastal sites, terrestrial mammals are the major resource in these subalpine areas. The high incidence of Vancouver Island marmot in the faunal remains demonstrates that it was the major species hunted in subalpine areas. The low numbers of black-tailed deer, black bear, marten, and red squirrel in the Limestone Mountain and Mariner Mountain sites suggest that these animals were taken opportunistically. The few mammal species represented in the sites clearly reflect the low mammalian species diversity in the subalpine areas of Vancouver Island (Cowan and Guiguet 1965). Nevertheless, several mammals that range into subalpine-alpine areas of Vancouver Island are conspicuously absent from the archaeological sites: gray wolf, cougar, elk (*Cervus elaphus*), wolverine, and ermine (*Mustela erminea*). Wolf, cougar, and elk have all been found in coastal middens (Mitchell 1981; Calvert and Crockford 1982; Bernick 1983) and their absence from the subalpine sites is curious.

The only other Vancouver Island marmot bones recovered from an archaeological site are from the Shoemaker Bay site (DhSe 2), a shell midden located on Alberni Inlet west of Port Alberni (Figure 1) (Field and Laquer 1975; Calvert and Crockford 1982). This is a typical coastal site with a diversity of faunal material including mollusks, fish, bird, and mammals. Vancouver Island marmot was incidental with only 24 bone specimens. The site is stratified into two major components or zones with all of the marmot bones found in the upper Component II or Zone A, although four are from an uncertain zone A/B. Zone A has two radiocarbon dates that range from 1341 BP (AD 609) and 1056 BP (AD 894).

The available archaeological evidence suggests that Vancouver Island marmots were being hunted in two general time periods: about 2600 BP, and a later period from 800 to 1070 BP. The dates from Shoemaker Bay push the latter period back to about 1300 BP. There is no archaeological evidence for hunting marmots from about 700 BP until the period of European contact. Ethnographic documentation is limited but suggests at least some hunting by some aboriginal groups in the areas south of the Clayoquot Plateau. However, with only five dated archaeological sites with marmot remains these gaps are probably the result of sampling bias. More dated subalpine sites will probably demonstrate continuous marmot hunting throughout the past few thousand years.

Given that humans have occupied Vancouver Island for at least 8000 years (Carlson 1979), Vancouver Island marmots were probably hunted earlier than 2600 BP. However, because of extreme weathering and acidic conditions associated with granite rock, conditions for bone preservation in most subalpine caves or rockshelters on the island would be poor. Preservation beyond a few thousand years is unlikely. The only caves likely to support ancient archaeological bones are those situated in karst landforms which are alkaline. It is noteworthy that 9400 year old Vancouver Island marmot bones recovered from a karst trap cave at Nimpkish Lake (Nagorsen 1995a, 1995b) were better preserved than the 800-1000 year old bones found at Limestone Mountain, Mariner Mountain, and the Golden Hinde.

Ethnographic Evidence for Native Use of Marmots

The importance of marmots to the aboriginal peoples along the Northwest Coast of North America has not been fully recognized and ethnographic and historical information on their use is poorly documented in contrast to the British Columbia interior. Information on the Vancouver Island marmot is particularly sparse.

During the visits of fur trader John Meares to the Northwest Coast of America between 1786 and 1788, he observed that the skins of marmots [presumably hoary marmot] occurred in "great quantities" (Meares 1790). Ethnographer Philip Drucker, in speaking of the Northwest Coast in general, noted that: "The marmot [presumably hoary marmot] ... furnished a light but finely furred pelt, prized throughout the area for clothing. In days before European blankets, these hides were one of the chief articles used in potlatches. Marmot were plentiful in many localities in the higher mountains. The grounds were usually privately owned, and huts or cabins were built on them. The hunters with their families went up in the fall when the fur had set but before time for the marmot to hibernate. The season was a short but rich one, for the animals were easy to catch, and the hunting parties came out with quantities of valuable furs" (Drucker 1950: 246).

The primary technique for catching the hoary marmot was deadfall traps set directly in front of the burrows. The deadfalls were a smaller version of those used for bear, with a log weight supported by a lever arm held by a trigger (Drucker 1950). The Tlingit had a special carved trigger for the traps (Drucker 1950, 1955) which had "magically effective designs or figures, not considered necessary in trapping other animals" (Emmons 1991). Among the Sekani peoples the hoary marmot was killed with "sticks, after smoking them out of their holes or flooding them out by diverting a stream; and if the ground hogs retreated into crannies among the rocks they twisted long sticks in their fur and pulled them out into the open" (Jenness 1937). Snares were evidently also used, although snares may be a recent technique adopted after the introduction of wire. In 1910, on an alpine meadow near Klappan Mountain on the upper Stikine drainage, Edward Preble observed that "every slight elevation was occupied by a family of marmots and a party of Indians near had hundreds of snares set at the burrows and were catching large numbers. The skins are stretched and traded and the flesh dried for winter use" (Preble 1910).

On the northern coast of British Columbia, wealth was directly measured in hoary marmot skins among the Tlingit and the Gitksan of the upper Skeena River (Drucker 1950). Drucker noted that the: "Skins of the whistling marmot were regarded as very valuable, particularly among Tlingit, Haida, Tsimshian, and the northern Kwakiutl divisions. It seems that anciently a robe made by sewing together many of the small soft-furred hides was about equal in value to the sea-otter robe". The significance of marmots is reflected in the naming of the new moons. The Yakutat Tlingit of southern Alaska refer to September as the "digging moon" when marmots "put up food for the winter" (de Laguna 1972). To the Kispiox Gitksan, September was the "marmot hunting moon" when marmots were hunted on the upper Skeena River (Drucker 1950).

On the southern coast the use of marmot furs was documented by Peter Puget in 1792 while visiting a village on Eld Inlet, northwest of Olympia, Washington (Bern 1939), and in 1825 by John Scouler while at Baker's Bay near the Columbia River when he referred to "a robe made of the skins of a species of marmot" (Blackwood 1826). These first documents probably refer to the Olympic marmot (*Marmota olympus*) of the Olympic Peninsula which were hunted by the Quinault and Queets from June to September (Singh 1966). Quinault elders, on the west side of the Olympic Peninsula, said that of all the furs sewn to make robes, the marmot was the "favorite" (Olson 1936). The marmot or kwukwu'k were "usually sought during the season of elk hunting in the mountains. They were easy to kill. Their skins were much used in the manufacture of bed blankets. A small shoulder robe of four to six skins of the animal was sometimes made. A single skin made a handy seat when one had to sit in a cold or damp spot. The flesh of the marmot was regarded as excellent and well-flavoured meat because they eat grass" (Olson 1936).

Fur trade documents also indicate that marmots were trapped for fur. Marmot furs were not traded on the northern and central coast at Hudson's Bay Company forts from 1828 to 1855. A change occurred in 1856 when 575 marmot furs [species not given] were taken at Fort Simpson and another 1337 the following year. The steamer, *Beaver*, trading along the coast collected 1032 marmot furs in 1856 and 2188 marmot furs in 1857.

Information on the Vancouver Island marmot is scanty. This species was recognized by Alexander C. Anderson of the Hudson's Bay Company in his notes written between 1834 and 1867: "The skins of the marmot sewed together make a light warm robe. The rocky mountain marmot [= hoary marmot] of the mainland are generally grey in colour whilst the marmot of Vancouver Island and some of the Northern mountains are black or very dark brown. Robes made of alternate grey and black skins are very effective and valued accordingly" (Anderson 1920). While in Kyuquot territory at Nootka Sound in 1786, Alexander Walker observed marmot skins, but these may not necessarily be the products of Vancouver Island. Furs of mainland animals such as fox and rabbits were also observed (Fisher 1982). Fur trade documents indicate that 166 marmot furs were acquired in 1857 at Fort Rupert on the northeast coast of Vancouver Island. However, the furs were only recorded as "marmot" and the species identification is not known. They could have been Vancouver Island marmots or hoary marmots from the mainland coast.

The only ethnographic information on the Vancouver Island marmot refers to Nuu-chah-nulth peoples. George Hamilton of Port Alberni reported to ethnologist Philip Drucker that the Opetchesaht of the Port Alberni area hunted marmots with deadfalls (Drucker 1950). Luke Swan of Hotspring Cove and Ahousat, who was born in 1893, recorded information in his native language on the ownership of resources in Manhousat territory. The Manhousat lived to the north and west of the Ahousat before merging with them. A tape (translated by George Louie) notes that only one chief owned the high forested areas along the mountains which included the homes of the fur bearing animals such as the wolf, bear, and elk but implied that "no one" had ownership rights over the marmots. This statement shows a recognition of the presence of marmots but may reflect knowledge from a time period in which marmots were no longer hunted.

Anglicized versions of the local southern Nuu-chah-nulth name for the Vancouver Island marmot include Sit-si-tehl (Sproat 1868) and Shee-shee teelh or Shishitulh. The late George Louie suggested that the "shi shi" component refers to "cleaning-like pulling the leaves off berries". This may refer to a marmot cleaning its face. It is also possible that the "shi shi" part is an onomatopoeia for the species' alarm call.

Results from the radiocarbon dating demonstrate that marmots disappeared from these areas sometime within the past 800-2600 years. Unfortunately, with only three dated prehistoric sites available and rather vague anecdotal historical records, we cannot reconstruct the chronology of marmot extinctions in the Clayoquot Plateau and Strathcona Provincial Park. Vancouver Island marmots may have disappeared from the Golden Hinde in recent historical time. Old burrows have been found at Marble Meadows, Greig Ridge, and Phillips Ridge (Bryant 1993). The Greig Ridge burrows are only about two km from the Golden Hinde site. The persistence of abandoned burrows has not been measured but presumably they were occupied in this century. Anecdotal reports of Vancouver Island marmot whistles from the Golden Hinde, Phillips Ridge, and Greig Ridge in 1979 (Bryant 1993) come from a single observer and are insufficient evidence for living marmots. The mandible found at the Golden Hinde (RBCM 16691) by Shirley Duncan in 1979 and cited by Bryant (1993) is from the prehistoric archaeological site that we studied.

There are no historical sightings or observations of abandoned burrows from Mariner Mountain or Clayoquot Plateau Provincial Park (Bryant 1993). The nearest Vancouver Island marmot record to Mariner Mountain site is a mandible found at Drinkwater Creek in 1940 (Cowan Vertebrate Museum, University of British Columbia UBC 4540). Because the mandible has not been dated by radiocarbon analysis, the geological age of this specimen is unknown. Except for an anecdotal report of whistles heard on Nahmint Mountain in 1988, Clayoquot Plateau Provincial Park is far beyond the historical records summarized by Bryant (1993). More sites with dated marmot remains would assist in determining the most recent occupancy dates for Vancouver Island marmot in these peripheral areas.

Two plausible explanations for the disappearance of marmots from Strathcona and Clayoquot Plateau provincial parks are climatic change and overkill from prehistoric hunting. According to the prehistoric overkill hypothesis (Martin 1984), vulnerable animals such as large mammals and flightless birds were hunted to extinction when early human hunters colonized new areas. The most compelling evidence is for some of the oceanic islands such as New Zealand where large flightless birds were exterminated in as little as 500 years after humans arrived. In North America, overkill involved the large herbivores and carnivores (so called megafauna) and smaller North American mammals were largely not impacted (Martin 1984). Marmot remains have been found in number of archaeological sites across North America. Bones of the yellow-bellied marmot for example, occur in various archaeological sites associated with caves and rockshelter sites in the Great Basin and southwestern United States (Lange 1956; Thomas 1985; Grayson 1988) but local extinctions and range changes for this marmot have been attributed to climatic changes rather than prehistoric overkill.

The scenario of rapid extinction from prehistoric overhunting does not apply to the Vancouver Island marmot. Although humans have been on Vancouver Island for at least 8000 years (Carlson 1979), the Vancouver Island marmot has not been extirpated, and marmots and humans have evidently coexisted on Vancouver Island for thousands of years. Nevertheless, the large number of marmots and predominance of older, breeding age animals represented in the Mariner Mountain and Limestone Mountain faunal remains suggest that early hunting could have contributed to the decline of local marmot colonies. Because the time frame is unknown, it is difficult to assess the impact of human predation. If the marmot remains in the four archaeological sites are the product of single events, then the impact would be significant. However, if the bones accumulated from hunting activities over a period of time, then the hunting may be sustainable. The physical evidence from Mariner Mountain cave suggests that the large bone deposits accumulated from more than one hunting episode.

Long-term climatic and vegetational changes also could account for the marmot's decline. Grayson (1987) and Harris (1990) documented local extinctions of the yellow-bellied marmot in the Great Basin and southwestern United States that in part are correlated with late Pleistocene and early Holocene climate changes. However, data on marmot extinctions within the past few thousand years are scanty. Grayson (1987) reported the extirpation of a yellow-bellied marmot population in western Nevada that occurred within the past 1500 years, but he was unable to relate this to climatic events or human activities.

Climatic and vegetational changes that followed the ice-age on Vancouver Island (Hebda 1995) probably had a major influence on the distribution of the Vancouver Island marmot. The cool environment in the early post-glacial resulted in an open parkland environment across much of the island. Palaeontological records from Nimpkish Lake (Nagorsen 1995a, 1995b) and Weymer Creek near Tahsis (Nagorsen 1995c) demonstrate that during this period the Vancouver Island marmot inhabited low elevation sites that are now forested. With a shift to warm, dry climates and forest expansion in the early Holocene 10 000-7500 years ago (Hebda 1995), Vancouver Island marmots presumably disappeared from low elevations and their distribution was restricted to subalpine-alpine areas. These climatic changes in the early Holocene resulted in the fragmented distributional pattern and metapopulation lifestyle described by Bryant and Janz (in press).

The most pronounced late Holocene climatic changes on Vancouver Island occurred during the Little Ice Age, a period about 150-700 years ago characterized by cold temperatures and glacier expansion (Grove 1988). Although well-studied in the Rocky Mountains (Luckman 1986), climatic fluctuations on Vancouver Island during this period have received little attention. A preliminary study of tree-ring chronology of mountain hemlock (*Suga mertensiana*) and yellow cedar (*Chamaecyparis nootkatensis*) in subalpine areas of the Forbidden Plateau and Comox Glacier Nature Conservancy Area of Strathcona Provincial Park by Smith (1994, 1995) revealed significant fluctuations in tree growth through the last 300 years that presumably parallel climatic changes. Dates from subfossil trees found at Moving Glacier, Milla Lake indicate that this glacier reached its maximum Little Ice Age position in the 1700s following a century of reduced tree growth. The effect of these climatic fluctuations on marmot habitat is not clear but periods of heavy snow fall, delayed springs, and cold wet summers would reduce reproduction and survival of marmots (Van Vuren and Armitage 1991). Such climatic effects would be most pronounced on colonies in central or northern Vancouver Island where winter climate is more severe than southeastern Vancouver Island.

The tree line and the extent of alpine-subalpine meadows in the mountains of the Pacific Northwest is highly dynamic and historical successional changes that have occurred in the past century in response to climatic fluctuations and fire history may also have implications for marmot habitat. In the southern Coast Mountains (Brink 1959), Cascade Range (Franklin et al. 1971), and Olympic Mountains (Fonda and Bliss 1969), coniferous trees such as subalpine fir (*Abies lasiocarpa*) and mountain hemlock rapidly invaded subalpine-alpine meadows from the early 1900s to 1940s. This conifer invasion evidently coincides with a period of warm dry climate and reduced snow cover. Fire may also assist in maintaining subalpine meadows in these mountains (Brooke et al. 1970; Kuramoto and Bliss 1970). Milko (1984) attributed the historical range decline of the Vancouver Island marmot to habitat loss from forest succession. He noted that the meadows at Gemini Peak near the Haley Bowl, which are evidently maintained by fire were being invaded by subalpine fir. Unfortunately, forest succession and fire history in the subalpine meadows of Vancouver Island especially the Strathcona Provincial Park region have not been studied and the effects of succession on marmot habitat is speculative.

Whatever the cause and timing for the disappearance of the Vancouver Island marmot from northern and central Vancouver Island, it is significant that marmots have not recolonized most sites that once supported prehistoric or historic colonies. As is typical of most marmot species, two or three year old Vancouver Island marmots may leave their natal dens and disperse. Bryant (in press) reported movements up to 7 km for ear-tagged animals and low elevation records of solitary animals (Bryant 1993) suggest that some Vancouver Island marmots may disperse 25-30 km. Some of the prehistoric and historic locations may be too isolated to be reached from extant colonies. The nearest active colony to Strathcona Provincial Park for example, is at Mount Washington. Mariner Mountain cave is 48 km from Mount Washington and Golden Hinde is 33 km from Mount Washington. Similarly, the Clayoquot Plateau site is about 58 km from Mount Washington and 69 km from P Mountain, the nearest known extant colony in the core area to the south. Although transplants could be used to re-establish colonies in these areas (Janz et al. 1994), it is essential that comprehensive habitat studies are done to determine that these sites are still suitable for marmots.

Recommendations

Future Research

Any attempt to understand the range decline of the Vancouver Island marmot is hindered by insufficient data. Marmot remains are known from only seven prehistoric sites: Shoemaker Bay, the four archaeological sites described herein, and paleontological sites at Nimpkish Lake and Weymer Creek. More sites have to be found before we can reconstruct the chronology of marmot colony extinctions and determine the impacts of climatic change or early hunting. Research on long term paleobotanical changes and recent succession in the subalpine meadows of Vancouver Island is required before we can assess the impact of climatic or habitat changes.

BC Parks has a vital role to play in this research. Strathcona Provincial Park is of special interest. Despite the extensive subalpine-alpine habitat and evidence for prehistoric and historic colonies, no active marmot colonies exist in the park today. Although Strathcona Provincial Park has been suggested as a possible area for reintroducing the Vancouver Island marmot (Janz et al. 1994), it is essential to determine the cause for the disappearance of marmots before any reintroductions are made. Haley Lake Ecological Reserve is also an important research area because it supports one of the largest populations of the Vancouver Island marmot and the extensive subalpine meadows in the Haley Bowl are unique for Vancouver Island. The site provides an important baseline for comparison with subalpine habitats in other areas such as Strathcona Provincial Park and Clayoquot Plateau Provincial Park.

We recommend four areas for additional research in parks and ecological reserves:

- surveys for bones,
- surveys for living marmots,
- meadow succession and fire history, and
- paleobotanical studies of long term climate/vegetation changes.

Surveys for bones

Sources for mammal bones include faunal remains associated archaeological middens and natural sites such as cave trap sites and carnivore dens. The most important archaeological sites for documenting the historic and prehistoric range of the Vancouver Island marmot are subalpine rock shelters or caves because they are presumed to be in close proximity to former marmot colonies. Given that thousands of potential rockshelters exist in the subalpine areas of Vancouver Island, systematic inventories for high elevation archaeological sites are not practical. However, in Strathcona Provincial Park intensive surveys for rockshelters could be done in some of the historical marmot sites such as Greig Ridge, Phillips Ridge, and the Forbidden Plateau.

Another potential area is the Haley Lake-Green Mountain area. It is noteworthy that an artifact (arrow or spear point made from chert; RBCM accession #

A 1982-12; DgSc-Y:1) was found near the old, upper ski lodge on Green Mountain in June 1980. The subalpine meadows associated with Green and Gemini mountains and the Haley Bowl may have been a traditional area for hunting marmots and elk. Nevertheless, no archaeological sites were found during a preliminary survey of the Haley Lake-Green Mountain area July 27-28, 1995.

Sites with the greatest potential for yielding ancient bones are caves associated with karst landforms because these environments provide ideal bone preservation. The 2600 year-old marmot bones from the Clayoquot Plateau (the oldest archaeological remains of the Vancouver Island marmot), 9400 year-old marmot and 12 200 year-old mountain goat *Oreamnos americanus* bones recently found in a cave at Nimpkish Lake (Nagorsen 1995a, 1995b), and 9800 year-old black bear bones found in a cave in White Ridge Provincial Park (Nagorsen et al. 1995d) demonstrate the enormous potential of caves in karst landforms. Several major karst areas occur in Strathcona Provincial Park, including Marble Meadows, that potentially could support ancient bone deposits.

Surveys for living marmots

Since 1972, much of Strathcona Provincial Park has been inventoried for marmots and all sites with historical colonies have been searched on the ground at least once (Bryant 1993, 1995b). Some sites, for example, Greig Ridge, are particularly well inventoried with more than five ground searches since 1972. Inventories in Strathcona Provincial Park should be focused on the rugged Mariner Mountain area. Although there have been no reports of Vancouver Island marmots from mountain climbers who occasionally access this region, the remains of 74 marmots in Mariner Mountain cave indicate that this area must have supported a large population of Vancouver Island marmots 900-1000 years ago. Potential habitat also exists to the southwest along an extensive ridge system that extends from Mariner Mountain to Abco Mountain. Schoen Lake Provincial Park and the Clayoquot Plateau Provincial Park are two areas outside of Strathcona Provincial Park where BC Parks' inventories also could be concentrated.

Succession in subalpine meadows

The rapid invasion by subalpine fir and mountain hemlock trees in the subalpine meadows of the Cascade Range and Olympic Mountains during this century is striking (Fonda and Bliss 1969; Franklin et al. 1971). Extensive marmot habitat potentially could have been lost as a result of forest succession. An evaluation of tree-rings and fire history would be invaluable to determine if subalpine meadows on Vancouver Island are also being lost to tree invasion. An analysis of the Haley Bowl-Gemini Mountain area would provide a useful baseline for assessing habitats in Strathcona and Clayoquot Plateau provincial parks. Tree-ring chronology could be used to test Milko's (1984) hypothesis of recent forest succession at Gemini Mountain and determine if the meadows at Haley Lake are stable. In Strathcona Provincial Park, meadow succession should be evaluated in sites where historical marmot colonies are known (e.g., Greig Ridge, Forbidden Plateau). In Mount Rainier (Franklin et al. 1971) and Olympic national parks (Schreiner and Burger 1994), historical photographs have been used successfully to reconstruct vegetational changes in subalpine-alpine sites. We suggest that BC Parks collect available historical photographs from Strathcona Provincial Park and the Haley Bowl area.

Paleobotanical studies

Data on long term vegetation and climatic changes are also required to interpret Vancouver Island marmot habitat and range declines. Tree-ring chronologies may be particularly useful for evaluating climatic fluctuations during the Little Ice Age (150-700 years ago). Because Smith (1994, 1995) sampled subalpine habitats (1200-1450 m), his tree-ring research in Strathcona Provincial Park has major implications for Vancouver Island marmot habitat. We encourage BC Parks to

support this important work and broaden the sampling to include tree-ring samples from the Haley Lake Ecological Reserve and prehistoric marmot sites in Strathcona Provincial Park (Golden Hinde and Mariner Mountain) and Clayoquot Plateau Provincial Park.

Any research on climate history should be integrated with pollen studies to reconstruct late Pleistocene and Holocene environments. During the past 12 000 years, major climatic and vegetation changes have occurred on Vancouver Island (Hebda 1995). Nonetheless, most pollen core samples are from low elevation wetlands. Core samples from representative subalpine wetlands in Strathcona Provincial Park, Clayoquot Plateau Provincial Park, and the Haley Lake area would be invaluable for interpreting long term trends in marmot habitat.

Managing Cave Bone Sites in Provincial Parks

Cave bone deposits may be archaeological sites resulting from aboriginal activities or natural deposits from carnivore dens or trap sites where animals have fallen and been killed. Their age can range from recent historical time to ancient bones thousands of years old. All of these remains have high scientific value and they can yield important information on the past climate, animal and human history of a park. Clearly, they are an important heritage feature of any park. Successful management of these sites depends largely on education of BC Parks staff and park users. Cave deposits are most likely to be found by BC Parks staff or park users. Many of these sites are located in remote, inaccessible areas and it is impossible for BC Parks to continuously monitor the sites to protect them from human disturbance and vandalism. Cave entrances could be gated or sealed but this will detract from the natural features and it contravenes the general philosophy of BC Parks. Gating also may 'flag' sites and encourage vandalism. There are four important components to managing these cave sites:

- legal protection,
- documentation and scientific research,
- consultation, and
- education.

Legal protection

Any archaeological site in a provincial park or recreation area is protected under the *Heritage Conservation Act* and the *Park Act* (section 13). Additional protection can be given to sites by having them designated as provincial heritage sites (see section 6(1)(c) and (2) of the *Park Act*).

Natural bone sites can be deemed of a paleontological nature and protected under the *Heritage Conservation Act*. However, there is no precise definition of 'paleontological' and distinguishing the ancient prehistoric from the historical is arbitrary. The 9800 year old black bear and black-tailed deer bones found in Windy Link Pot Cave on White Ridge (Nagorsen et al. 1995), for example, are technically 'subfossils' and it may be inappropriate to refer to this site as paleontological. Yet, this is an important cave deposit with high scientific value and it should be protected.

Documentation and scientific research

When these sites are discovered it is imperative that they are left intact and reported to BC Parks staff. The first stage of documentation should involve a brief description and mapping of the location by BC Parks staff. It is essential that sites are then evaluated by biologists and archaeologists trained in faunal analysis and bone identification. They can identify the vertebrate species represented and the general context of the site. A qualified archaeologist is essential to assess human modification on bones and the presence of artifacts. Some sites (e.g., black-tailed deer bones from a recent carnivore kill) may require little more than documentation. Other sites (e.g., caves with Vancouver Island marmot remains or potentially ancient bones) have enormous scientific value and they may warrant extensive research. Some material may have to be temporarily removed from the site for examination. A research permit will be drawn up with researchers and BC Parks to formalize schedules and research conditions.

Consultation

Aboriginal groups should be informed by BC Parks of any archaeological sites. Management and research plans for these sites should be discussed in consultation with the appropriate aboriginal groups. If they are recorded on the Provincial Archaeological Sites Inventory, then a policy may have to be developed to control access to this information.

BC Parks should maintain close links with the Vancouver Island caving community. Cavers played a major role in recovering mammal bones from the Clayoquot Plateau site, the White Ridge, and the Nimpkish Lake cave. Also the caving community may assist in the management of sensitive cave sites.

Both aboriginal groups and the caving community could assist BC Parks in developing appropriate educational programs.

Education

We recommend training programs such as workshops for backcountry rangers working in Strathcona Provincial Park to familiarize BC Parks staff with caves and faunal remains and increase their awareness of the sensitivity and significance of these sites.

Public education is also essential. However, any educational program will be a fine balance between discouraging park visitors to search for cave bones yet ensuring that any fortuitous discoveries are reported and not disturbed. General information (without giving specific locations) on the nature and sensitivity of these sites could be provided on signage located at park entrance areas or trailheads. Information could also be given in BC Parks brochures and interpretation programs.

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Appendix 1. Age of black-tailed deer mandibles and maxillae from Mariner Mountain site

Element	Side	Age
Mandible	Left	2 years
Mandible	Right	2 years
Mandible	Left	2.5 years
Mandible	Right	2.5 years
Mandible	Right	3 years
Maxilla	Left	2 years
Maxilla	Left	2.5 years
Maxilla	Right	2.5 years

Appendix 2. Representation of Vancouver Island marmot skeletal parts in four archaeological sites

Element	Clayoquot Plateau	Mariner Mountain	Limestone Mountain	Golden Hinde
Cranium				
complete skulls	11 ^a	58	3	0
mandibles	24	149	74	8
other pieces	39	129	50	6
isolated teeth	6	10	64	7
Vertebra	0	2	19	17
Rib	3	170	358	20
Clavicle	11	17	56	1
Scapula	23	91	66	2
Innominate	6	89	74	12
Humerus	33	113	73	5
Radius	23	78	95	4
Ulna	19	85	97	3
Metacarpus	24	0	2	0
Carpus	4	0	1	0
Femur	28	101	0	2
Tibia	30	103	106	6
Fibula	20	29	36	3
Long bone fragments	3	2	18	5
Metatarsus	29	6	34	0
Tarsus	2	0	0	0
Calcaneum	9	0	3	0
Astragalus	7	0	2	0
Phalanges	33	0	9	0

^a Counts are number of individual specimens (NISP).

Appendix 3. Representation of black bear (Bb), marten (Ma), red squirrel (Rs), and black-tailed deer (Btd) skeletal parts in the Mariner Mountain and Limestone Mountain sites

Element	Mariner Mountain				Limestone Mountain			
	Bb	Ma	Rs	Btd	Bb	Ma	Rs	Btd
Cranium								
complete skull	0 ^a	0	0	0	0	0	0	0
mandible	7	0	0	9	3	1	0	0
other pieces	15	0	0	15	0	0	0	0
isolated teeth	15	0	0	10	3	0	0	0
antler	-	-	-	0	-	-	-	2
Vertebra								
atlas	0	0	0	3	0	0	0	0
axis	0	0	0	5	0	0	0	0
cervical	0	0	0	15	0	0	0	7
thoracic	0	0	0	22	0	0	0	3
lumbar	0	0	0	2	0	0	0	1
sacral	0	0	0	6	0	0	0	0
caudal	0	0	0	0	0	0	0	0
unidentified	0	0	0	2	1	0	0	14
Rib	0	0	0	99	2	0	0	31
Scapula	7	0	0	13	1	2	0	0
Innominate	4	0	0	8	0	0	0	0
Humerus	3	1	0	17	1	0	1	5
Radius and Ulna	6	1	0	21	2	0	0	10
Carpus and Metacarpus	13	0	0	3	2	0	0	5
Femur	2	0	0	21	0	3	0	2
Tibia	1	0	0	28	0	0	0	0
Long bone fragments	0	0	0	28	1	0	0	2
Tarsus and Metatarsus	0	0	0	13	7	0	0	4
Calcaneum	2	0	0	10	0	0	0	0
Astragalus	0	0	0	11	0	0	0	0
Phalanges	6	0	0	13	20	0	0	10

^a Counts are number of identified specimens (NISP).