THE EFFECTS OF MAMMALIAN PREDATORS ON A SOUTHERN OREGON COLONY OF LEACH'S STORM-PETRELS (*OCEANODROMA LEUCORHOA*)

by

ANNE MARIE POLLARD

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Dr. Alan Shanks, Chair of the Examining Committee

1 Dec 2008

Date

Committee in Charge:	Dr. Alan Shanks, Chair Dr. Jan Hodder Dr. Rob Suryan

Accepted by:

Dean of the Graduate School

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Approved: ______________________________
Alan Shanks

Saddle Rock, with an estimated 86,300 birds, was the third largest colony of Leach's Storm-petrels (*Oceanodroma leucorhoa*) in Oregon in 1988. This colony is uniquely vulnerable to terrestrial predation due to its contiguity with the mainland during low tides. In recent years, an increase in visitation of raccoons and river otters to Saddle Rock has resulted in increased bird mortality. In 2007 I estimated predation rates ranging from 0 to 59 birds per night, with predation occurring on 7 of 11 nights checked. 48% of marked burrows were depredated throughout the season. In 2007 and 2008, I monitored nesting density and burrow occupancy rates on Saddle Rock and compared these data with those from nearby Hunters Island, a similarly sized colony. Saddle Rock now hosts significantly lower densities than Hunters Island. Comparisons of recent Saddle Rock data with those from 1979-1995 show a steep population decline.

CURRICULUM VITAE

NAME OF AUTHOR: Anne M. Pollard

PLACE OF BIRTH: Denver, Colorado

DATE OF BIRTH: 25-April 1984

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon

DEGREES AWARDED:

Master of Science in Biology, December 2008, University of Oregon

Bachelor of Science in Biology, 2005, University of Oregon

AREAS OF SPECIAL INTEREST:

Community Ecology
Marine Education

PROFESSIONAL EXPERIENCE:

Museum Preparation Technician, Oregon Institute of Marine Biology, University of Oregon, 2008

Palila Project Intern, U. S. Geological Survey, Pacific Island Ecosystems Research Center, Volcano, Hawaii, 2006

Seabird Banding Intern, Oregon Institute of Marine Biology,
Charleston, Oregon 2006

Biological Technician, South Slough National Estuarine Research Center,
Charleston, Oregon 2004

GRANTS, AWARDS AND HONORS:

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This thesis is dedicated to my parents

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CHAPTER I

GENERAL INTRODUCTION: A BRIEF HISTORY OF THE SADDLE ROCK LEACH'S STORM-PETREL (*OCEANODROMA LEUCORHOA*) RESEARCH

Few people are granted the experience of being on a Leach's Storm-petrel (*Oceanodroma leucorhoa,* LHSP) colony in the darkest part of the night. I consider myself extremely fortunate to know the wonder of lying under a mist net looking up at a swarm of thousands of vocalizing storm-petrels, silhouetted against a starry sky. This nocturnal, planktivorous procellariiform, with an estimated worldwide breeding population of 8 million (Huntington *et al.* 1996), is among the most numerous seabirds in the northern hemisphere, yet, due to the difficulties in accessing both their island breeding colonies and their winter foraging grounds, it is largely unstudied. I had the good fortune to study breeding Leach's storm-petrels on the Saddle Rock colony, part of the Eastern Pacific population, where researchers with the U. S. Fish and Wildlife Service have been monitoring LHSP since 1979. In this chapter I summarize the Saddle Rock seabird research between 1979 and 2008.

Like all LHSP, those of the Eastern Pacific population breed on islands with soil coverage suitable for burrow construction, with their breeding range extending from islands off Baja California to Buldir Island in the Aleutian Island chain (Huntington *et al.* 1996). Oregon LHSP breed on seven major colonies, with over 20 000 birds each (Table 1), and at least six minor colonies (between 100 and 10 000 birds, Naughton *et al.* 2007).

All colonies are part of the Oregon Islands National Wildlife Refuge or the Three Arch Rocks National Wildlife Refuge. 95% of Oregon LHSP are concentrated in colonies on the southern coast (Figure 1, Naughton *et al.* 2007). In the 1988 U.S. Fish and Wildlife survey, Saddle Rock (N 42.250 W -124.414) was the third largest colony, with an estimated 87 520 breeding birds.

Table 1: All Oregon colonies containing over 20 000 breeding LHSP. U.S. Fish and Wildlife colony numbers, colony names, and the survey dates are included (Naughton *et al.* 2007).

Colony Number	**Colony Name**	**Survey Date**	**Estimated Number of Breeding Birds**
219-052C	Three Arch Rocks Complex	12-Jun-1979	25 000
270-071	Hunters Island	19-Jul-1988	39 480
270-076	"North Crook Point Rock"	15-Jun-1988	99 090
270-079	Saddle Rock	1-Aug-1988	87 520
270-106	"Unnamed Colony"	3-Aug-1988	44 736
270-109	"Whaleshead Cove" (East Rock)	3-Aug-1988	73 268
270-123	Goat Island	14-Jul-1988	102 060
	All Other Islands	1979 or 1988	10 656
		Oregon Coast Total	**481 810**

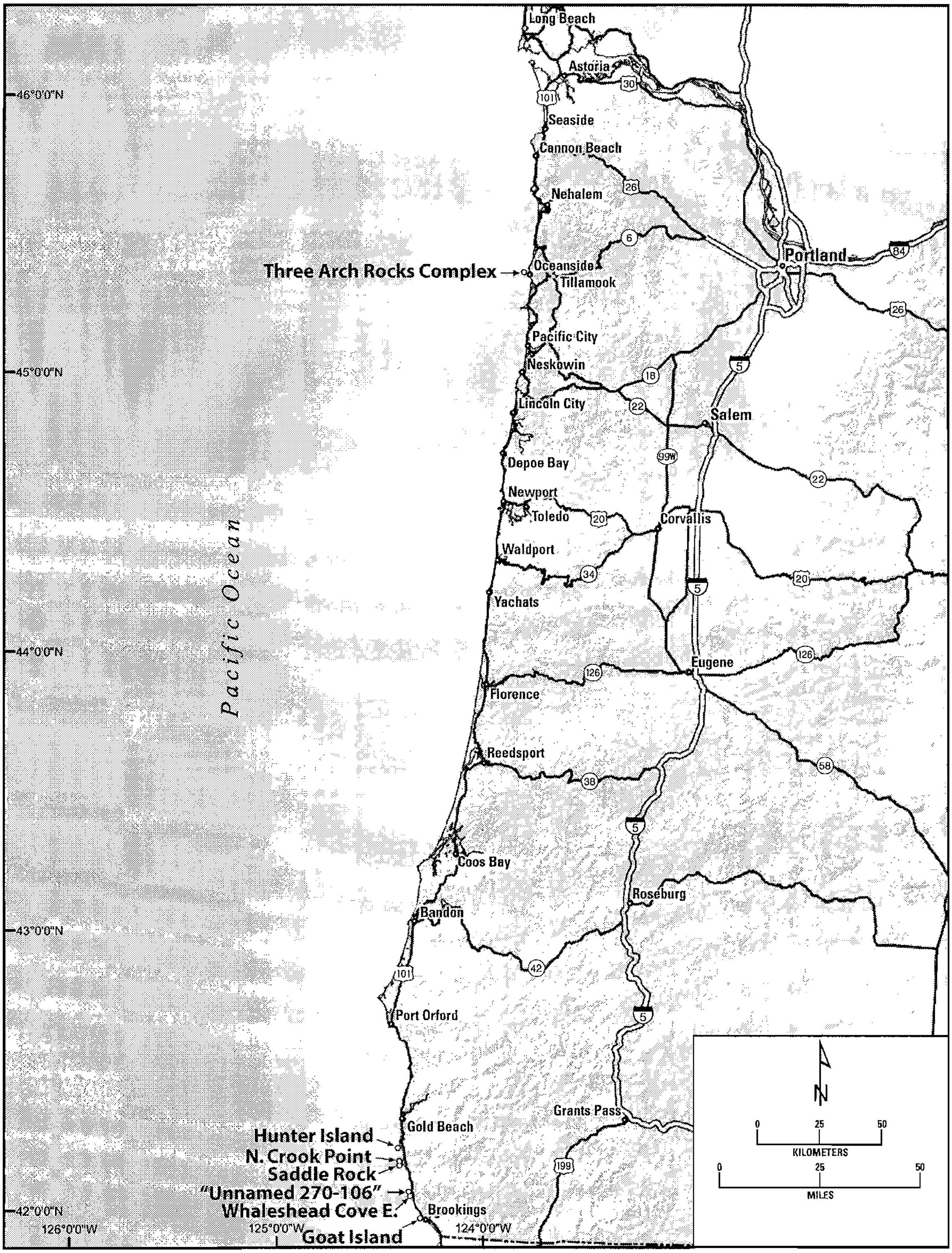

Figure 1: The locations of the seven largest colonies of Leach's Storm-petrels in Oregon.

In general, LHSP return to their colonies from their tropical winter foraging grounds in April and May to begin burrow excavation or renovation and nest building (Huntington *et al.* 1996). I have seen evidence of LHSP activity on Saddle Rock as early as late February. Although synchrony and phenology is variable between populations and even between closely situated colonies (Huntington *et al.* 1996), LHSP generally lay between mid-May and mid-June on temperate, east Pacific colonies (Ainley *et al.* 1974), and the incubation period lasts 43 days (Huntington *et al.* 1996). The mean hatching date on Petrel Island in British Columbia was August 9 in 1983 (Vermeer *et al.* 1988). On Hunters Island in 2008, I observed that 23% of eggs had hatched by June 21 (N=26) and by July 2, 76% of eggs had hatched (N=25), indicating an average hatch date slightly before July 2, over a month earlier than that found in British Columbia. LHSP chicks fledge at roughly 63 days on Petrel Island (Vermeer *et al.* 1988), but fledging age differs between different colonies and years. I have seen chicks without fully developed primary feathers on Saddle Rock on October 8 in 2007, and I expect there were birds fledging as late as November.

LHSP generally nest on islands that are inaccessible to terrestrial predators, which makes their colonies difficult for humans to access as well. Saddle Rock is a fairly unique colony in that it is contiguous with the mainland during very low tides. It is separated from the mainland (Crook Point) by a 65 m channel, which drains completely during tides lower than mean low tide (Figure 2). The island has a steep rocky face on the north, east, and south sides, with a sea cave running underneath from east to west bisecting a second sea cave running from north to south. The top of the island consists of about 9100m^2 of vegetation-covered soil, which is suitable LHSP nesting habitat. This is composed of two steep, vegetated ‘knolls’ with a flat area in between (referred to as the saddle area). The west side of the island is composed of roughly 3000m^2 of flat, rocky ledges, which is suitable for gull nesting habitat. These ledges gradually descend to the intertidal zone.

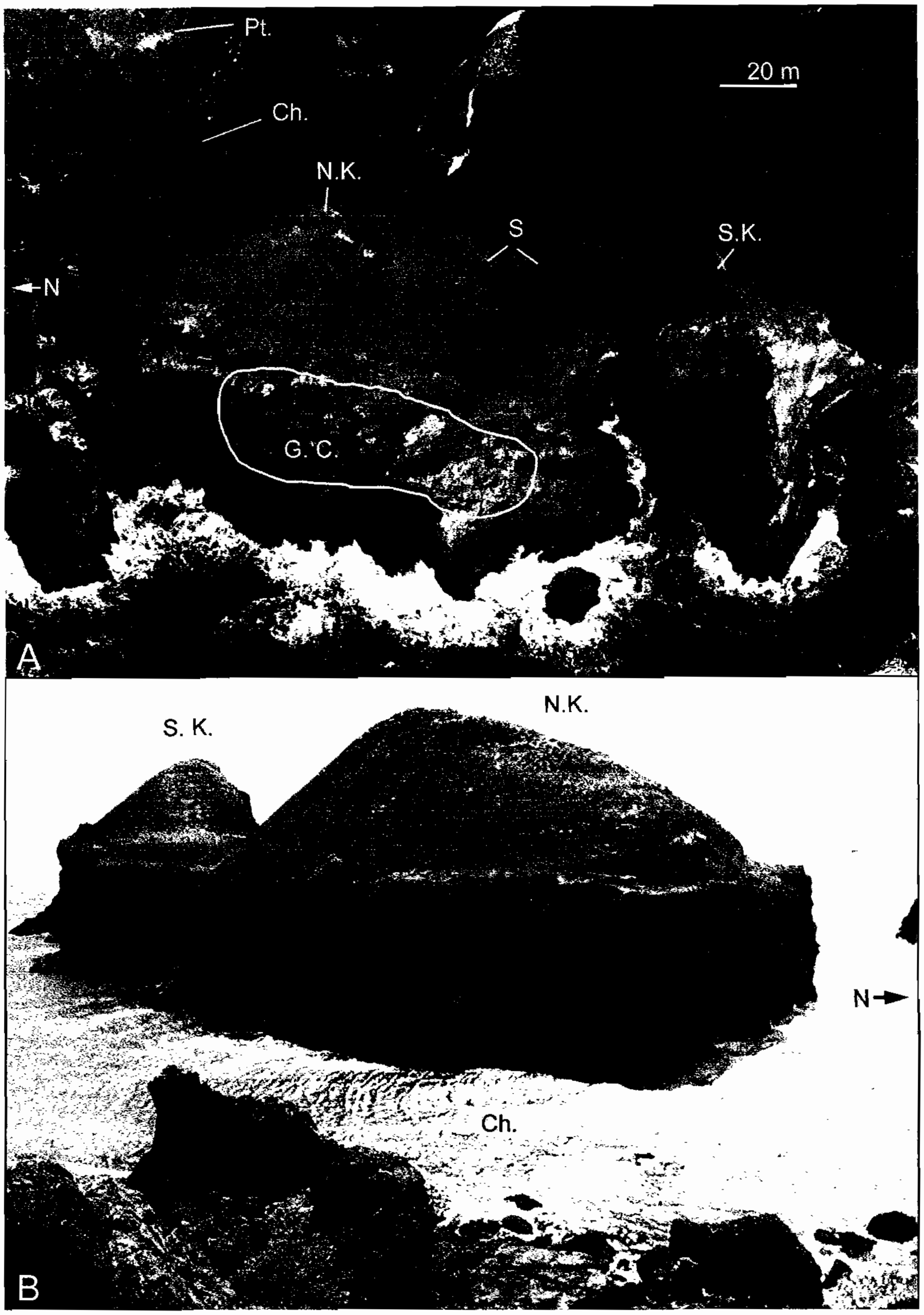

Figure 2: Photographs of Saddle Rock; A) Aerial view of Saddle Rock; B) View of Saddle Rock from the north east at high tide, when the channel (Ch.) is flooded; (G. C.) Gull colony, (N. K.) North knoll, (S. K.) South knoll, (Pt.) Crook Point, and (S) Saddle area.

Because the channel between the island and Crook Point is exposed during very low tides, Saddle Rock is the most accessible LHSP colony on the Oregon Coast, and has been the site of most of the LHSP research in Oregon. In 1979, Robert Pitman, in cooperation with the U. S. Fish and Wildlife Service (USFWS), began documenting the breeding biology of LHSP and other breeding birds on Saddle Rock, and continued visiting the colony almost yearly until 1993. USFWS made population estimates in 1979 and 1988, and began making almost yearly visits to Saddle Rock in 1987 to measure burrow occupancy and to band birds for a mark-release-recapture study. Occupancy surveys ended in 1997, and work on Saddle Rock ceased until 2004 and 2005, when the Point Reyes Bird Observatory (PRBO) and University of Oregon M. S. student Michelle Schuiteman carried out a mark-release-recapture and a diet study on LHSP (Schuiteman 2006). Varying numbers of both adult birds and chicks were banded by USFWS, PRBO, and Schuiteman between the years of 1979 and 2005 (Roy Lowe, USFWS, Julie Thayer, PRBO, and Michelle Schuiteman, pers. comm.). In 2007 and 2008, I studied mammalian predation on LHSP on Saddle Rock and the use of call playbacks to monitor nesting attendance of LHSP. These studies are explained in detail in Chapters II and III of this thesis, respectively. All work was completed under a Special Use Permit issued by USFWS.

In 1979, Pitman began banding adult LHSP captured in mist nets, and chicks removed from burrows, in an attempt to estimate the Saddle Rock population size based on recapture rates. He banded 3000 adults and chicks between 1979 and 1987. USFWS banded an additional 6000 birds between the years of 1987 and 1997, and PRBO and Schuiteman banded another 2000 in 2004 and 2005. At that time, recapture rates were still too low and variable to make an accurate estimation of the Saddle Rock colony size. A summary of bands used on Saddle Rock can be found in Appendix A.

Population estimates were made in 1979 and 1988 by USFWS. In both years, several one m^2 plots were randomly chosen from three areas of the colony: the north knoll, the south knoll, and the saddle area (Table 2). Active burrows within each plot were counted, counts were averaged across plots within an area, and multiplied by the acreage of each area. These values were added together for an estimate of the breeding population (Table 2). Burrows were investigated by excavation in 1979 and by a process called grubbing (where the researcher reaches into the burrow and feels for an adult, a chick, or an egg) in 1988. Areas used for each section on the colony were roughly estimated by sight as 1 acre for both the south knoll and the saddle area and 1.1 acres for the north knoll (raw data for these estimates, and for the 2007 and 2008 estimates, are listed in Appendix B).

Table 2: Leach's Storm-petrel population estimates on Saddle Rock for 1979 and 1988. The number of one m^2 plots surveyed for each area is given. Burrows/area gives the estimated burrows for the north knoll, the south knoll, and the saddle areas, and adults/area is that value multiplied by two for the overall breeding population estimate.

Year	Area	N	Average Burrows/m^2	Burrows/Area	Adults/Area
1979	N. Knoll	8	4.1	21 372	42 745
	Saddle	5	0.2	332	664
	S. Knoll	3	1.0	2226	4452
	Total			**23 930**	**47 860**
1988	N. Knoll	3	6.8	35 950	71 899
	Saddle	3	0.3	548	1095
	S. Knoll	2	3.0	6677	13 355
	Total			**43 174**	**86 349**

Between 1979 and 1997, varying numbers of burrows (usually around 100) were checked for occupancy in an attempt to monitor LHSP breeding effort on Saddle Rock (Table 3). The average occupancy rate from occupancy surveys performed between 15-July and 15-August was 79.5% (95% confidence interval +/- 6.2%), and the occupancy rates remained relatively stable. My 2007 and 2008 occupancy rates were much lower than the historical average. A more detailed description of burrow occupancy between 1979 and 2008 can be found in Appendix C, which includes the number of adults, eggs, and chicks found.

Table 3: Occupancy rates between 1979 and 2008 including the date, the number of burrows checked, and the number of burrows occupied (i. e. containing an adult, a chick or an egg) for each survey

Year	Date	# Burrows	# Occupied	% Occupancy
1979	23-Jul	163	108	66.3
1979	28-Jul	53	46	86.8
1980	18-Jul	107	76	67.4
1980	13-Aug	168	100	59.5
1981	5-May	23	3	13.0
1981	31-Jul	265	237	89.4
1982	28-Apr	35	1	2.9
1983	9-Aug	105	101	96.2
1984	5-Sep	319	94	29.5
1985	7-Apr	20	13	65.0
1985	15-Aug	74	68	91.9
1986	17-Jul	154	135	86.8
1987	11-Jun	39	35	89.7
1987	25-Jul	277	175	63.2
1988	1-Aug	100	83	83.0
1989	15-Jul	134	114	85.1
1990	23-Jun	100	91	91.0
1990	31-Jul	122	106	84.5
1992	14-Aug	100	69	69.0
1993	6-Jul	100	69	69.0
1993	18-Aug	100	57	57.0
1994	9-Aug	100	82	82.0
1995	14-Aug	100	86	86.0
1997	19-Aug	100	70	70.0
2007	29-Jul	114	48	42.1
2008	1-Jul	25	2	8.0
2008	1-Aug	100	19	19.0

The 1979 USFWS Oregon Seabird Survey (Varoujean and Pitman 1979) paints a relatively diverse picture of the composition of nesting seabirds on Saddle Rock with 65 Western Gull nests, 11 Pelagic Cormorant nests, 12 Pigeon Guillemot nests, 5 Tufted Puffin nests, and 53,000 breeding LHSP adults. In 1981, Pitman noted at least one pair of breeding Black Oystercatchers, several pairs of Fork-tailed Storm-petrels, and a group of about 10 Double-crested Cormorants. Pitman's field notes (summarized in Appendix D) indicate this species composition remained relatively consistent until at least 1990, with the exception of the group of Double-crested Cormorants, which was ephemeral, and only bred again in 1981, 1987, 1989, and 1990. The 1990 field notes are the last containing accounts of Tufted Puffins breeding on the island, which disappeared sometime before 2007. In the Saddle Rock trip summaries written to Pitman (summarized in Appendix D), Lowe (USFWS) mentions high mortality of gull chicks in 1993, but still records the colony as present in 1997. By 2005, the gull colony had disappeared entirely, with the exception of one or two nests on a ledge on the cliff on the northwest side of the island (pers. obs.). In 2008, I observed very few nesting Leach's storm-petrels (<5000 individuals), two Western Gull nests that produced offspring, and an unknown number of nesting Pelagic Cormorants and Pigeon Guillemots.

Little can be found in the early field notes to explain this decline in both seabird diversity and biomass between the years of 1990 and 2007, with the exception of one mention of the odor of skunk on Saddle Rock by Pitman in 1984, and a brief description in 1997 by Lowe of a mammalian scat (either raccoon or river otter) found in the gull colony in the vicinity of over 100 severed LHSP wings. The identity of the mammals present on the island was not discovered until 2007, when my motion sensing cameras caught images of both raccoons and a river otter on the colony (described in Chapter II). I found raccoon and river otter to be significant sources of LHSP mortality, and they may also have been responsible for the disappearance of the gull colony, the Tufted Puffins, the Fork-tailed Storm-petrels, and the oystercatchers.

Vegetation on Saddle Rock has not been well documented, but it is evident that there are at least two non-native species that have colonized the island: iceplant (*Carpobrotus edulis*) and tansey ragwort (*Senecio jacobaea*). Iceplant was first recorded on the colony in 1990 on the south knoll. Pitman hypothesized that the Double-crested Cormorants seen nesting on the south knoll in 1987 and 1989 may have transported the plant onto the island as nesting material. Since then, iceplant has spread to most of the south and east sides of the south knoll and can be found along the perimeter of the east side of the island (Figure 3). It creates a monoculture that out-competes native vegetation. It is unclear when tansey ragwort first made its appearance on Saddle Rock, though it is now prevalent and patchy on most of the north knoll and in the saddle area. There was no mention of it in Pitman's description of vegetation from 1979. In July 2007, USFWS and myself made an ArcGIS survey of iceplant and tansey ragwort coverage on Saddle Rock (Figure 3). My data, detailed in Chapter II, indicate mammalian predators are slightly more likely to disturb burrows in iceplant-dominated areas than those in native vegetation-dominated areas. It is not immediately evident that these plant species inhibit seabird breeding efforts directly on Saddle Rock and no attempt has been made to remove either species.

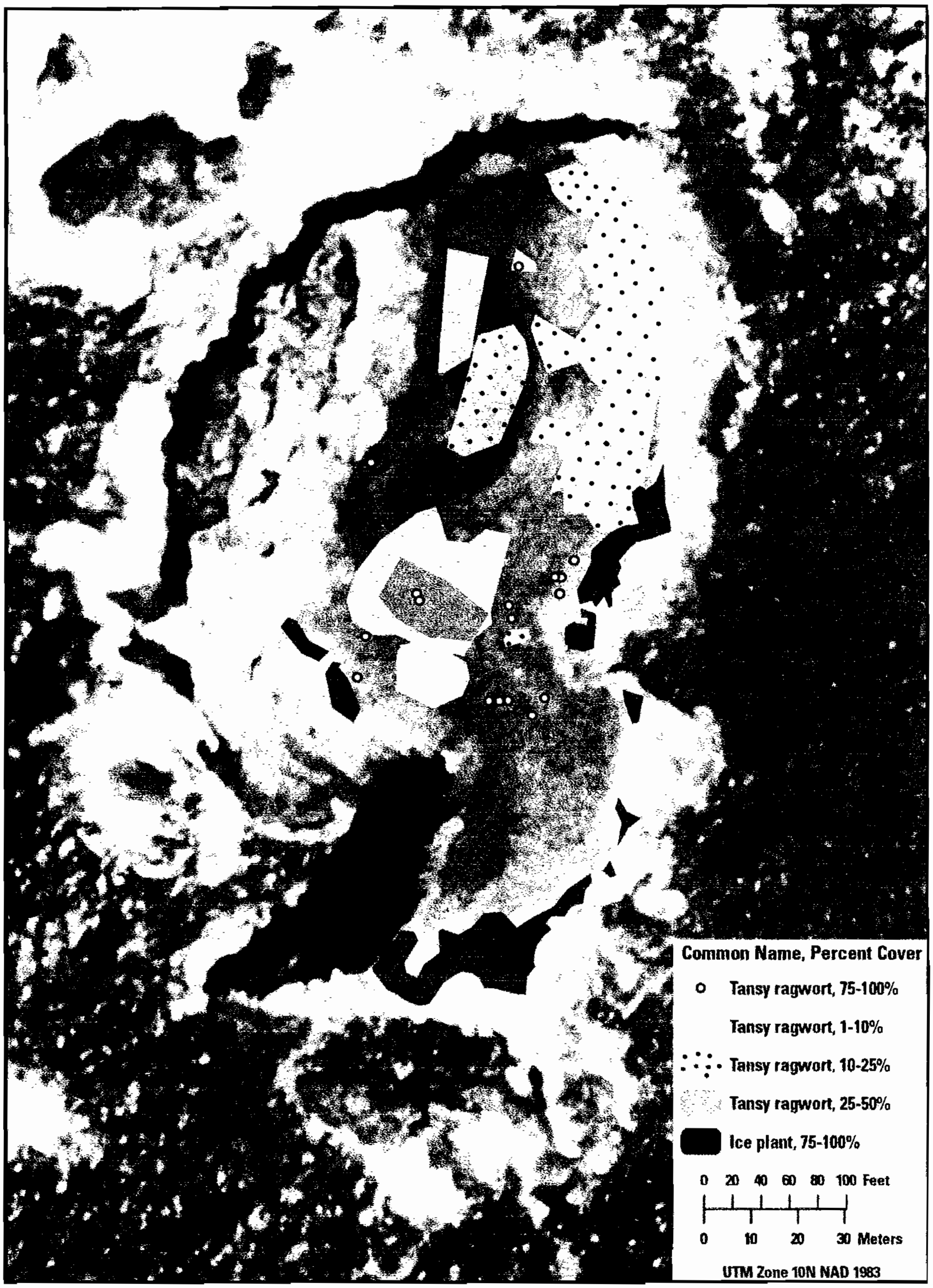

Figure 3: Invasive iceplant and tansey ragwort coverage on Saddle Rock. GIS polygons indicate areas with invasive coverage. White dots represent individual plants in areas dominated by native vegetation (Photo courtesy of Khem So, USFWS).

In Summer 2008, USFWS made extensive efforts to remove raccoons from Saddle Rock and the Crook Point area in hopes of restoring the LHSP colony. Although eleven animals were removed by late summer, much LHSP depredation occurred on the colony and motion sensing cameras revealed raccoons to be the cause. By fall 2008, tracks from only one raccoon were found, intermittently, on the mainland, indicating all permanent residents had been removed.

I would like to conclude Chapter I with a few recommendations for future work on Saddle Rock. The removal of raccoons from Saddle Rock will provide an excellent opportunity to study colony dynamics of Leach's Storm-petrels. Though LHSP are widely believed to be very philopatric, I predict Saddle Rock will see re-colonization from LHSP that were not born on Saddle Rock. The extremely high densities on colonies of LHSP on the southern Oregon coast along with reports of a very high number of non-breeding adults in the wintering areas of the eastern tropical Pacific (Spear and Ainley 2007), indicate nest habitat may be a limitation in this population. Saddle Rock, if the predators are removed, will have ample suitable nesting habitat. Regular monitoring may show the population rebounding faster than expected if recruitment is limited to those birds that were fledged from Saddle Rock, due to the influx of adults whose natal colonies are too crowded. We may also see the return of the gull colony and other species of seabirds to Saddle Rock, and any monitoring should include an account of all species.

Saddle Rock hosts populations of Oregon Voles (*Microtus oregoni*) and salamanders (*Ensatina sp.*). A nearby colony, Hunters Island, is further offshore and hosts a population of Clouded Salamanders (*Aneides sp.,* pers. obs.). A study of the biogeography of Saddle Rock and similar islands, using genetic analysis, may reveal interesting histories of these subpopulations.

In the past, researchers have spent a significant amount of time on the colony for banding, diet studies, and, myself included, predation assessment. Although I am an advocate the aforementioned research, I think it is important to acknowledge the possibility that human presence resulted in raccoon and river otter use of Saddle Rock. Human scent is known to attract meso-carnivores to nesting birds (Whelan *et al.* 1994). Colony monitoring, without banding, can be done in a few hours. Also, collecting specimens for genetic analysis can be accomplished quickly, and during the non-breeding season. Limiting human activity on Saddle Rock and other near shore colonies may be important for maintaining healthy colonies.

Bridge I

Chapter I discusses the importance of the Saddle Rock colony as a significant population of Leach's Storm-petrels, and an accessible site for storm-petrel research. It gives a brief history of the seabird research done on Saddle Rock between 1979 and 2008, complete with the first observations of mammalian predation on breeding storm-petrels on Saddle Rock. Evidence from the 2005 field work suggested that the Saddle Rock colony was experiencing very high levels of mammal predation. Chapter II of this thesis describes and quantifies the predation and its impact on the Saddle Rock population of Leach's Storm-petrels.

CHAPTER II

THE EFFECTS OF MAMMALIAN PREDATORS ON A SOUTHERN OREGON COLONY OF LEACH'S STORM-PETRELS (*OCEANODROMA LEUCORHOA)*

INTRODUCTION

Leach's Storm-petrels (LHSP), like most seabirds, nest on offshore islands, protecting them from terrestrial predators. They avoid avian predation by digging nest burrows and only visiting the colonies nocturnally. They require islands with enough soil or cobble for burrow construction. Spear and Ainley (2007) calculated that 49% of LHSP are non-breeding each year, presumably in part due to extreme nest habitat limitation. Historically, the degree of habitat limitation changes as sea level fluctuates due to periods of glaciation (Spear and Ainley 2007). Rising sea levels may submerge some colonies, while others may be formed as erosion forms haystacks out of capes. Similarly, sinking sea levels will expose seamounts, forming new potential colonies, while near-shore colonies may become contiguous with the mainland. Changes in erosion and sand deposition patterns due to changing sea level can have unpredictable effects on nest habitat. Severe nest habitat limitation may force LHSP and other habitat limited seabirds to utilize marginal colonies that may be at risk of exposure to the mainland and its predators or submersion. This paper presents an example of what may happen when a near-shore storm-petrel colony becomes accessible to mainland predators.

As burrow nesting on islands is their primary defense, storm-petrel colonies are extremely susceptible to extirpation due to human introductions of domesticated dogs, cats, pigs, rats, mice, and red foxes (Ainley *et al.* 1990; Erskine 1992; Sowls *et al.* 1978).

One would expect the same kind of vulnerability to native terrestrial predators on islands that, due to geologic processes, have become contiguous with the mainland. Mink were found to be the cause of petrel deaths on a colony in California that is 200 m away from the mainland (Harris 1974). In British Columbia, river otters consumed 24% of nesting adults on a near-shore colony (Vermeer *et al.* 1988) and black bears and mink have extirpated colonies (Rodway 1991). The native black vole preys on eggs of burrow nesting auklets on St. Lawrence Island in the Bering Sea (Sealy 1982). At Fish Island, Alaska, river otters consumed high percentages of nesting Leach's and Fork-tailed Storm-petrels (Quinlan 1983). This paper documents the near extirpation of a large LHSP colony in a short period of time due to depredation by native raccoons and river otters, and investigates the possibility of native rodent predation on LHSP eggs.

The Saddle Rock colony in southern Oregon is a site of a recent onset of native mammalian depredation of LHSP. The colony is part of the Oregon Islands Wildlife Refuge, and was regularly monitored by the U.S. Fish and Wildlife Service (USFWS) between the years of 1979 and 1997 (See Chapter I of this thesis). Burrow occupancy rates were determined almost yearly and the population size was estimated in 1979 and 1988, providing an opportunity to assess the effects of native mammalian predation. Varying numbers of adult and chicks were banded during occupancy surveys. Burrow occupancy rates were high and relatively stable.

USFWS records of LHSP predation on the Saddle Rock were minimal and appeared to be the result of avian predation between the years of 1979 and 1995. The first mention of mammalian presence on the colony was in 1997 when either a river otter or raccoon scat was found containing LHSP and over 100 severed wings were found in the vicinity. In 2004, large numbers of LHSP remains were found on the colony. Most were wings severed at the humerus, indicating mammalian predation (D. Ledig, pers. comm.). A similar level of predation was noticed in 2005. River otters were common in the area and were assumed to be the source of the predation. During the 2007 and 2008 breeding seasons, under a special use permit issued by USFWS, I studied the source and the degree of predation on this colony in contrast to a nearby island colony that is inaccessible to mammalian predators (the “control” site).

METHODS

Study Sites

Saddle Rock (N 42.250 W -124.414, Fig. 1), Curry County, Oregon, the primary field site, is separated from the mainland by a 65m channel of water (Figure 2). This is almost exclusively a LHSP colony, with a few breeding Western Gulls, although, historically, there was more species diversity (Robert Pitman, see also Chapter I). During tides lower than mean low tide it is possible to walk across this channel. This exposes the island to non-swimming, terrestrial mammals for short intervals each month. Saddle Rock storm-petrel nesting habitat consists of an area of approximately 9100 m^2 of vegetation covered soil, encompassing two steep ‘knolls’ and a flat place separating the two. A raised boardwalk in the center of the island provides access to researchers without damaging petrel burrows. Vegetation consisted of mostly native rushes, ferns, and cow parsnip, with areas of invasive ice plant monoculture and patchy tansey ragwort. The predator-free “control” site, Hunters Island (N 42.324 W -124.425, Figure 1) is 7 km north of Saddle Rock and is separated from the mainland by 600 m of water at high tide

(Figure 2). It is never accessible by foot during low tides and we found no evidence of mammalian predation of LHSP on Hunter Island. Here the nesting habitat is approximately 13 800 m^2 of vegetation covered soil along a ridge with a flat area along the top and sloping sides. Vegetation was composed of mostly native grasses. Hunters Island hosts colonies of Double-Crested Cormorants and Western Gulls, in addition to LHSP. Both islands are part of the U.S. Fish and Wildlife Service Oregon Islands National Wildlife Refuge.

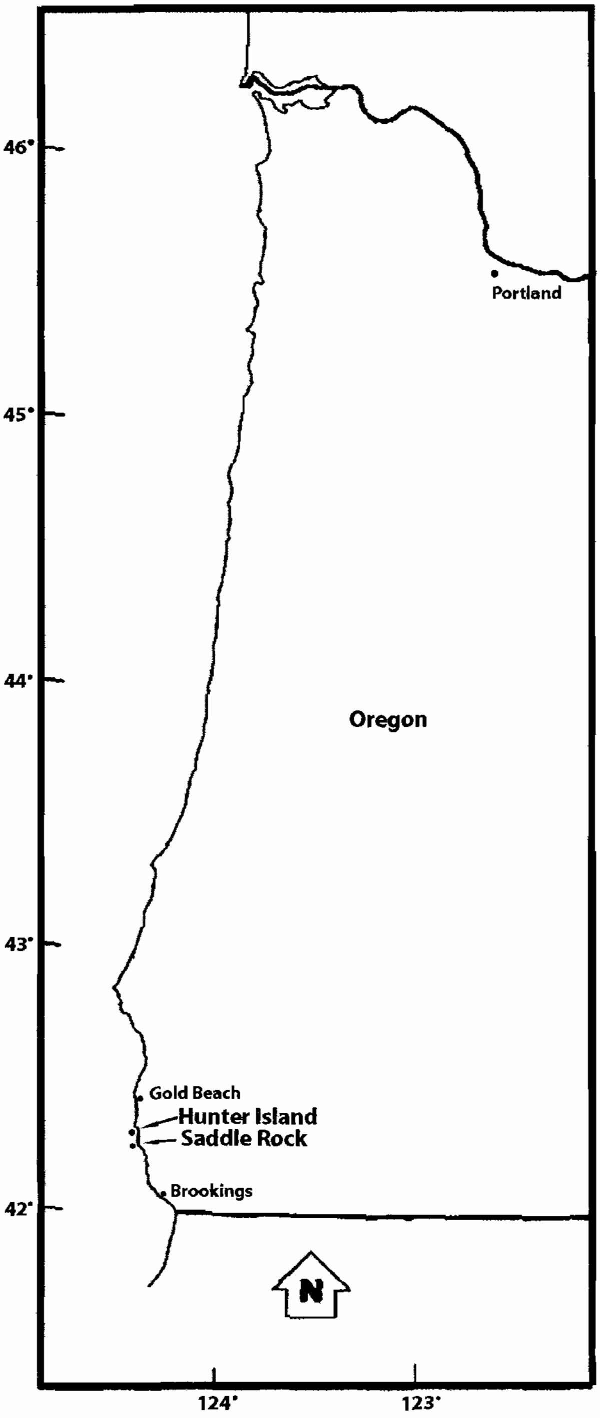

Figure 1: Locations of Saddle Rock and Hunters Island on the Oregon coast.

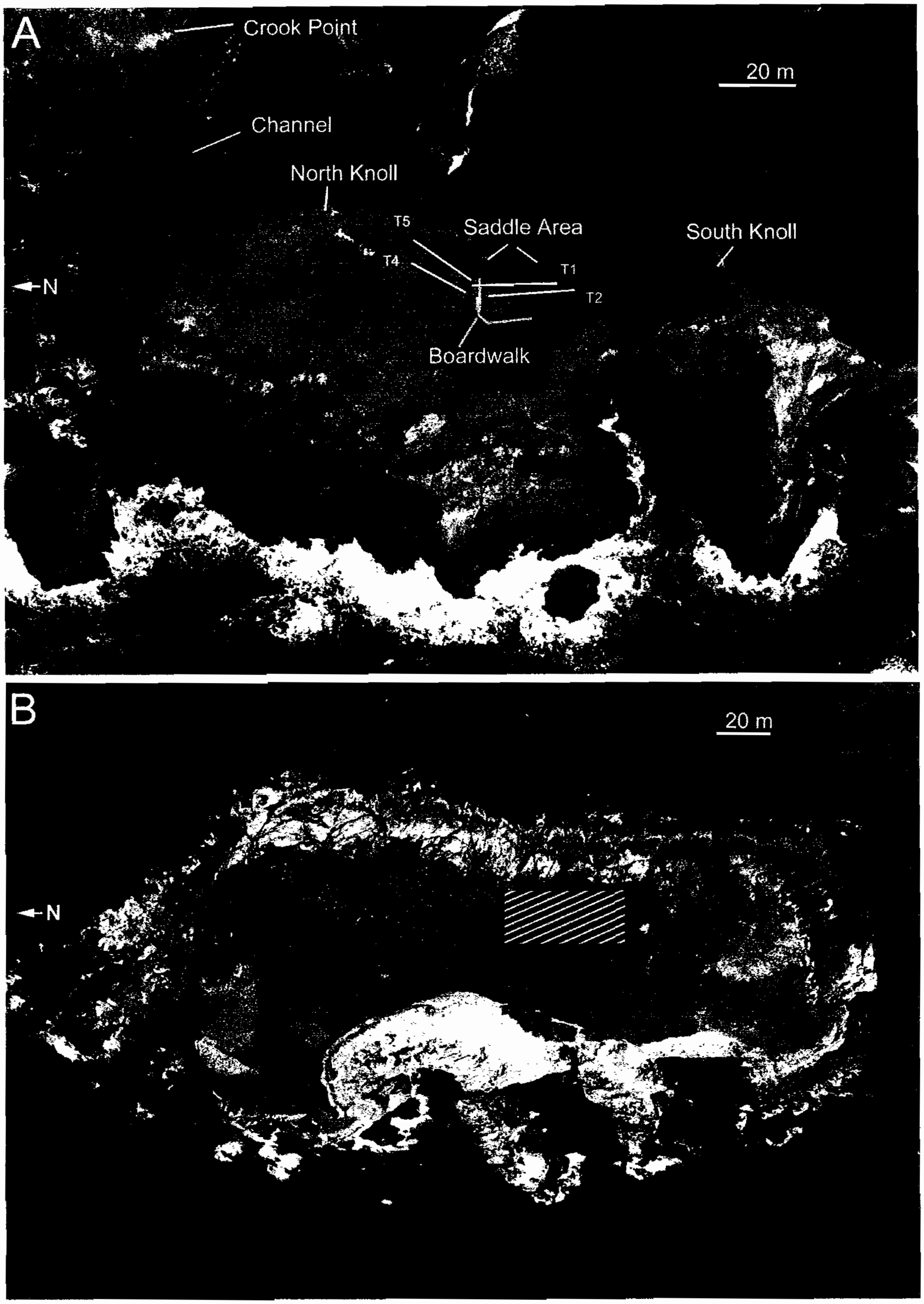

Figure 2: Aerial photographs of Saddle Rock and Hunters Islands; A) Saddle Rock; B) Hunters Island, the grid represents the approximate area sampled for occupancy in 2007.

Population Trends

To determine the status of the Saddle Rock LHSP colony relative to previous years I determined burrow occupancy rates and active burrow densities in 2007 and 2008, and compared these results with data collected by the USFWS from years prior to the onset of mammal predation on the island. I used the same sampling protocols used from by USFWS for occupancy rates. I determined active burrow densities for Saddle Rock and Hunter Island using the USFWS protocols with a slight deviation on Saddle Rock in 2008: plots sizes were increased to detect lower nesting densities. Sampling for both islands occurred between 28 July and 1 August with the exception of the 2008 trip to Hunter Island, which occurred on 2 July. Late July gives the most accurate reading for the season's breeding activity because most birds will have medium-sized chicks at this time. Early breeders are still likely to have chicks not yet fledged, and late breeders will at least be incubating. Researchers wore snowshoes at all times to minimize damage to burrows and vegetation.

Occupancy Rates

The occupancy rate at both sites was defined as the percentage of burrows that contained an adult, a chick, or an egg. For Saddle Rock, I inspected or "grubbed" 114 burrows in 2007 and 100 in 2008 from two locations on the colony. These locations were on a roughly 40-degree slope, and were covered in native vegetation. On the north and south knolls, the slopes faced south and north, respectively. These areas were also used in past occupancy counts. Grubbing was performed wearing latex gloves, a long sleeved shirt, and duct tape wrapped around the cuff. The researcher would sift through the vegetation to find a burrow entrance and reach an arm into it to determine if the nest chamber was empty or occupied. Burrows too long or curved to feel the nest chamber and burrows shorter than 8 inches were considered unfinished and were not used. To minimize disturbance, we retreated as soon as we felt a bird or an egg. Chicks were recorded as “large” if they were nearly adult sized and had emerged primaries. Medium sized chicks were fully pin-feathered and had sheathed primaries. Small chicks had only down feathers and no primary growth. Depth of all burrows was recorded, measuring from the entrance to the center of the nest chamber.

On Hunters Island I grubbed 123 burrows in 2007 and 100 in 2008. Due to a larger number of ground nesting birds on Hunters Island, I only used burrows from one location to minimize cormorant and gull disturbance in 2007. I used the grass-covered westward facing slope (also approximately 40 degrees inclination; Figure 2). In 2008 burrows were grubbed from multiple locations on the colony for a more random sample and sampling was performed at night on two evenings to minimize ground nesting bird disturbance.

Active Burrow Density

In 2007, active burrow density on Saddle Rock was determined using eight 1 m^2 square quadrats from two sections of the island: the north knoll and the south knoll (Figure 2). Five quadrats were on the northwest slope of the south knoll and three were on the southwest slope of the north knoll. Quadrats were selected by blindly tossing a marker, which delineated the upper left corner of the quadrat. All burrows were grubbed using the same technique as the occupancy counts. These burrows were also used for the occupancy assessment.

In 2008, on Saddle Rock, a 2 m^2 quadrat size was chosen because almost all values using 1 m^2 quadrats were zeros. In addition to sampling on the north and south knolls, I counted three quadrats from the saddle area for a better comparison with the 1979 and 1988 data. This area was not sampled in 2007 because a one-meter quadrat could not accurately sample the low nest densities in this area.

On Hunters Island in 2007, six 1 m^2 square plots were used. All plots were located on the westward facing slope of the island. Plots were not evenly distributed over the colony to minimize disturbance to ground-nesting seabirds located on other portions of the colony. In 2008, nine 1 m^2 plots were used. Two plots each were randomly chosen from the north end, the middle of the top, the middle of the west side, and the middle of the east side of the colony, with one additional plot located on the south end of the colony.

Population estimates for Saddle Rock were calculated by multiplying the area of three sections of the colony by the average density for that section. I estimated the area of the south knoll to be 2226 m^2, the saddle area to be 1659 m^2, and the north knoll to be 5261 m^2. These estimates were made by taking the USFWS area estimate for the whole (8860 m^2) and applying it to a had made three-dimensional model. The current USFWS area is considerably smaller than that used in 1979 and 1988, due to their course estimation methods. I, therefore, recalculated earlier nesting densities based on the new area calculations. In 2007, the saddle area was not sampled and the density was estimated by multiplying the ratio of the 1988 saddle area to the north knoll average densities by the

2007 north knoll average density. I justified this because, historically, the saddle area densities were much lower than north knoll densities, presumably due to differences in slope. As slope has remained constant, I assumed that the density ratio would remain constant as well. In 2008, the saddle area was sampled in the same manner as in 1979 and 1988. Population values for each section were added together to get the overall Saddle Rock population estimate.

The 2007 population estimate for Hunters Island was calculated by multiplying the average active burrow density by 11 323 m^2, the most recent USFWS area estimate of Hunters Island. All past population estimates have been recalculated using this area.

Predator Identification

The species of mammalian predators was determined using a combination of motion sensing cameras and scat analysis. From March through October 2007, mammalian scat was collected at Saddle Rock. From June through August 2007 mammalian scat was also collected from the Crook Point area adjacent to the colony. All scat samples were identified as river otter or raccoon scat, or placed into the unknown mammal category. In the lab, percent LHSP by volume was determined visually. The number of LHSP per scat was determined by reconstructing skeletons found in the scat. Duplicates of a single bone, the skull for example, would indicate two separate petrel predation events.

Beginning in May 2007, a Cuddeback digital infrared camera trap was set up on the Saddle Rock boardwalk and recorded motion triggered still images during night and day. In June 2007 this was replaced by three Bushnell digital infrared cameras which recorded 15-second video clips. In 2008, a Bushnell and a Cuddeback remained on the colony from April to September. These were positioned at various locations on the colony where sampling indicated predation events were common. Data were retrieved from the cameras and batteries were replaced every two weeks. Digital photos were reviewed in the lab for mammal presence.

Predation Pressure

Predation pressure in 2007 was assessed using three approaches: 1. relative predation rates throughout the breeding season were determined by collecting petrel remains from four permanent transects every two weeks from 3 March to 8 October; 2. the proportion of burrows whose inhabitants were preyed upon throughout the season was determined by following the fate of 65 burrows in four locations on the colony; 3. colony-wide nightly predation was determined by collecting all petrel remains across all accessible portions of the colony on four days during the breeding season.

Four transects were chosen in areas that were accessible and seemed to be representative of Saddle Rock storm-petrel breeding habitat. All were covered by soil and vegetation common over most of the colony. Two transects ran across the saddle area with an incline of roughly 15 degrees and two ran up the south side of the north knoll with an incline of roughly 35 degrees. All transects were 30m long by 2 m wide (Figure 2). Beginning in April, 2007, transects were walked every two weeks. All petrel remains on the transects were collected. Piles of remains that consisted of at least five feathers were considered "predation events". Collections of fewer than five feathers were conservatively assumed to be incidental feather loss by live birds. Single wings without feathers or other body parts near them were considered to be blown in from another area of the colony, and were not considered a predation event belonging to the transect. Piles of feathers were assumed to be the result of mammal-caused predation events because gulls regularly swallowed petrels whole and raptors used specific locations on the colony to de-feather and consume petrels (pers. obs.). If remains were associated with a burrow that appeared to have been dug out by a mammal, this was recorded.

Four areas were selected for the burrow fate study. All four were in areas with a fairly steep slope because burrow density is highest in steeper areas. Two plots were selected in areas where the vegetation was primarily native. One native vegetation plot (N1) was on the north slope of the south knoll. We followed the fate of 23 burrows in this plot. The other (N2) was on the southwest slope of the north knoll, where we followed ten burrows. The other two plots were chosen in patches of non-native, *Carpobrotus edulis,* monoculture. The plot on the east side of the south knoll (I1) contained 22 marked burrows. The plot on the southeast slope of the north knoll (I2) contained ten marked burrows. Burrows within plots were marked if we were sure there was evidence of storm-petrel occupation. A burrow was grubbed if there were obvious signs of bird excavation, but was only marked if it was long enough to be considered a complete burrow. Burrows shorter than eight inches without an obvious nest chamber were considered incomplete and were not used. Feathers and bird droppings at the entrance were also used as an indicator of petrel habitation. Burrows with bird remains in front of them were rejected. A total of 65 active burrows were marked. Every two weeks from 19 May through 11 September 2007, marked burrows were assessed for signs of mammal disturbance or predation.

Whole-colony searches for predation events were performed on four days in 2007, June-August. Each search consisted of two days of collection. Nightly predation rates were estimated by removing all remains on day one, then enumerating remains the following day. To facilitate the search, Saddle Rock was divided into three sections, the south knoll and saddle area, the west side of the north knoll, and most of the east side of the north knoll for these surveys. To ensure consistent search effort, a person searched one of the three sections of the island for two hours. All remains were collected. All searches occurred just before daybreak when there was just enough light to access the colony, to minimize loss of remains due to gull scavenging. The search covered approximately 80% of the available breeding habitat on Saddle Rock. Predation values for the surveyed areas were extrapolated to estimate the whole-colony value.

Rodent Predation

Evidence of rodents was present on Saddle Rock. I observed rodents scurrying in the vegetation and under the boardwalk, and several references to "mice" were recorded in the field notes from 1979 to 1997. To determine the species present, live traps were deployed on two nights. On 8 June 2008, 15 live traps were baited with a mixture of peanut butter, oatmeal, and raisins, and placed under the boardwalk (Figure 2). Traps were spaced roughly ten meters apart and were placed in the evening and checked 12 hours later. On 17 June 2008, 42 traps were set in a similar manner, but were placed roughly three meters between each trap. Captured rodents were identified, photographed and released.

To determine whether rodents were responsible for egg depredation, Japanese quail (*Coturnix coturnix)* eggs were placed in abandoned petrel burrows and monitored for signs of disturbance. The use of quail eggs to test predation rates has been used for various tree nesting species (Haskell 1995; Roper 1992), and the mean quail egg length falls within the 95% confidence interval of LHSP egg sizes. By grubbing burrows in areas covered by native vegetation, 100 abandoned and completely empty burrows were selected and marked with a landscaper flag. On 1 July 2008, quail eggs were placed in the nest chambers of these burrows, along with the primary and secondary feathers of one wing of a LHSP in an attempt to mimic the scent trail of an active burrow. Burrows were checked at 24 hrs, 48 hrs, two weeks and four weeks for signs of disturbance. Depredated eggs were photographed and any disturbance to the burrow entrances was recorded. Damaged or depredated eggs were replaced whenever found. Two motion-sensing cameras were trained on eight of the burrows for the last two-week period of the experiment.

RESULTS

Population Trends: Occupancy Rates

The Saddle Rock burrow occupancies were lower in 2007 and 2008, compared to previous years (Figure 3). The occupancy rates at Hunters Island in 2007 and 2008 were higher than those of Saddle Rock. No historical data exists on Hunters Island occupancy rates, but the 2007 value is outside the Saddle Rock 95% confidence interval between the years of 1979 and 1995, and the 2008 value is within this interval.

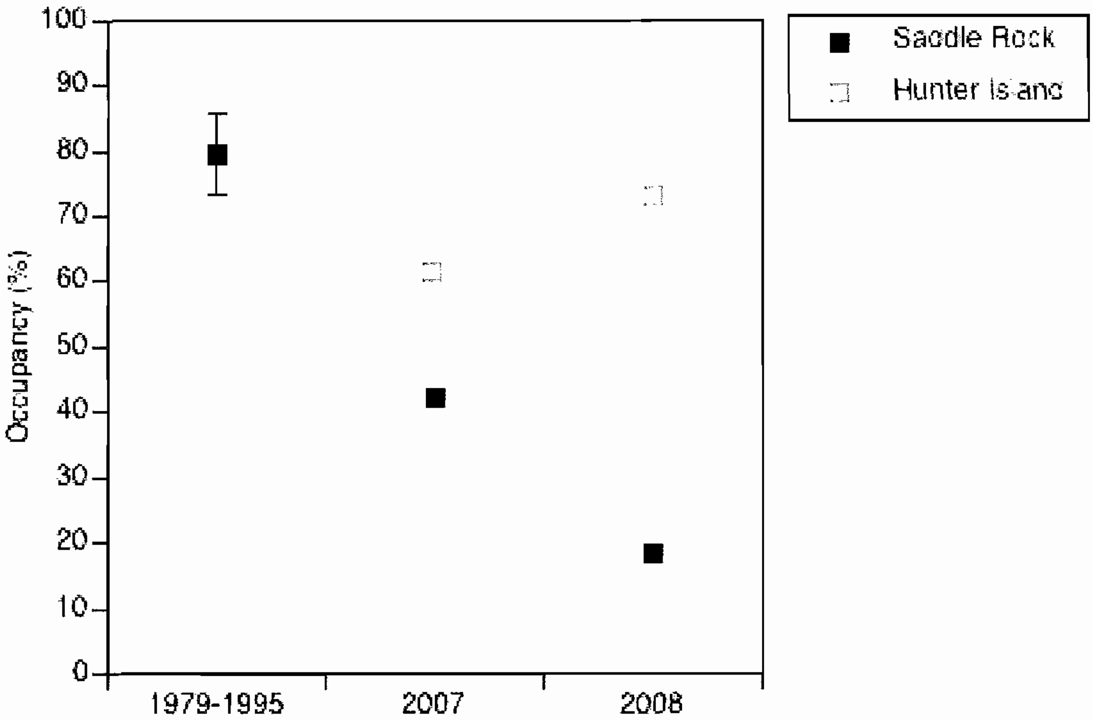

Figure 3: Occupancy data for Saddle Rock. The 1979-1996 series indicates the mean ratio of occupied burrows to empty burrows in occupancy surveys performed between those years (N=14). Error bars indicate the 95% confidence interval. The individual 2007 and 2008 occupancy rates are given for Saddle Rock and Hunters Island.

Occupancy surveys also revealed differences in burrow contents on Hunters Island and Saddle Rock (Table 1). In both years Saddle Rock had a higher rate of cold eggs and dead chicks than Hunters Island. There was also a difference in the timing of events in the colonies. The percent of large chicks, as indicated by a relative visual method, was higher on Hunters Island in 2007, indicating that the colony phenology may have been different in this year (Table 2).

Table 1: Burrow contents by percent from 2007 and 2008 occupancy surveys. Burrows were categorized as being empty, containing one or more adults and no eggs or chicks, a warm or incubated egg or chick with or without an adult, a cold egg, or a dead chick.

Saddle Rock	**Empty**	**Adult(s)**	**Egg**	**Chick**	**Dead Egg**	**Dead Chick**
Jul-07 (n=114)	57.9	7.9	0.9	32.5	4.4	0.9
Jul-08 (n=100)	81.5	0.0	0.0	9.8	5.0	1.6
Hunters Island						
Jul-07 (n=123)	37.4	4.1	13.0	48.8	1.6	0.0
Jun-08 (n=100)	27.0	64.0	25.0	23.0	1.0	0.0

Table 2: Chick sizes by percent from 2007 and 2008 occupancy surveys. These are the relative sizes of chicks found in burrows during the occupancy surveys in 2007 for Saddle Rock and Hunters Island.

Saddle Rock	**Small**	**Medium**	**Large**
Jul-07 (n=37)	48.6	43.2	8.1
Hunters Island			
Jul-07 (n=60)	10.0	43.3	46.7

Population Trends: Active Burrow Density

The average active burrow density for 1979 did not differ significantly between Saddle Rock and Hunters Island (Figure 4). In 1988, the active burrow density was higher on Saddle Rock than Hunters Island, but not significantly. The 2007 and 2008 densities were lower on Saddle Rock than on Hunters Island in both years. A pair-wise contrast with a Bonferroni correction using density values from the two knolls on Saddle Rock places 1979 and 1988, and 2007 and 2008 into two statistically different groups ($P<0.05$), with the 2007 and 2008 group being less dense than the earlier years. Hunters Island densities are significantly different between 2007 and the earlier years, but there is no difference between 2008 and 1979 or 1988 (Bonferroni, $P<0.05$). I suspect my value for 2007 is unreasonably high due to my sampling design for that year. Regardless, the density on Hunters Island did not show the dramatic decline of that on Saddle Rock in 2007.

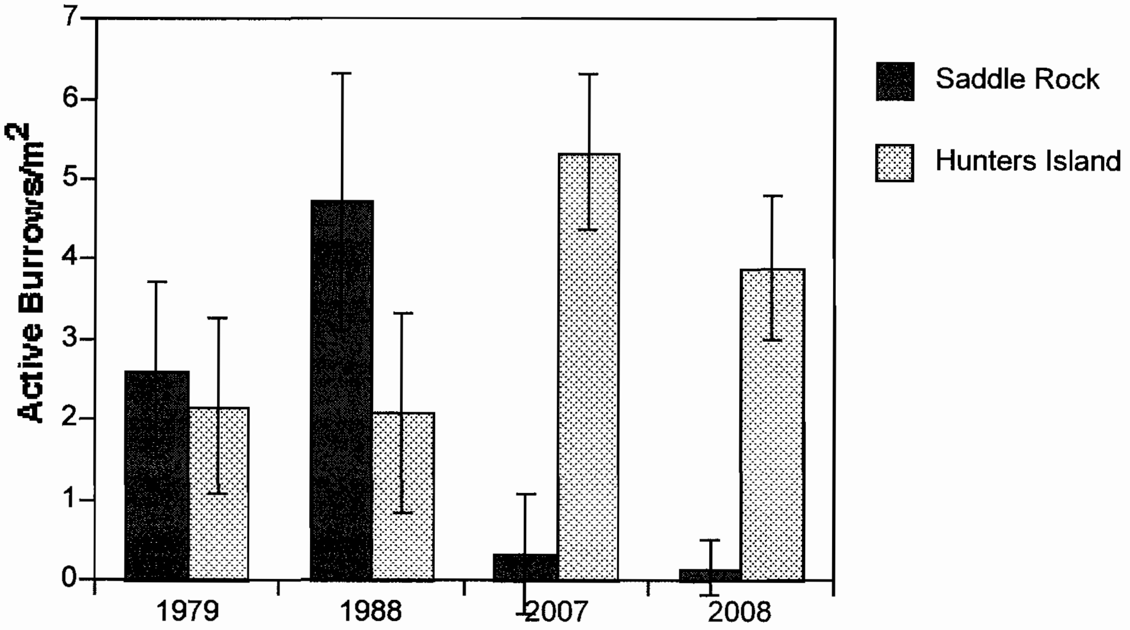

Figure 4: Mean active burrow densities. Bars indicate the mean active burrow density in sloped habitat for each island in 1979, 1988, 2007, and 2008. Light bars represent Saddle Rock data and dark bars represent Hunters Island data. Error bars represent the 95% confidence interval.

The population estimates from 1979 and 1988 are not different between Saddle Rock and Hunters Island in either year (Figure 5). Populations did not change between 1979 and 1988 on either island. Saddle Rock showed a sharp decrease between 1988 and 2007, while the Hunters Island population increased. Population sizes did not change between 2007 and 2008 for either island. The 2008 population estimate for Saddle Rock was 3000 breeding birds (95% confidence interval +/- 5400).

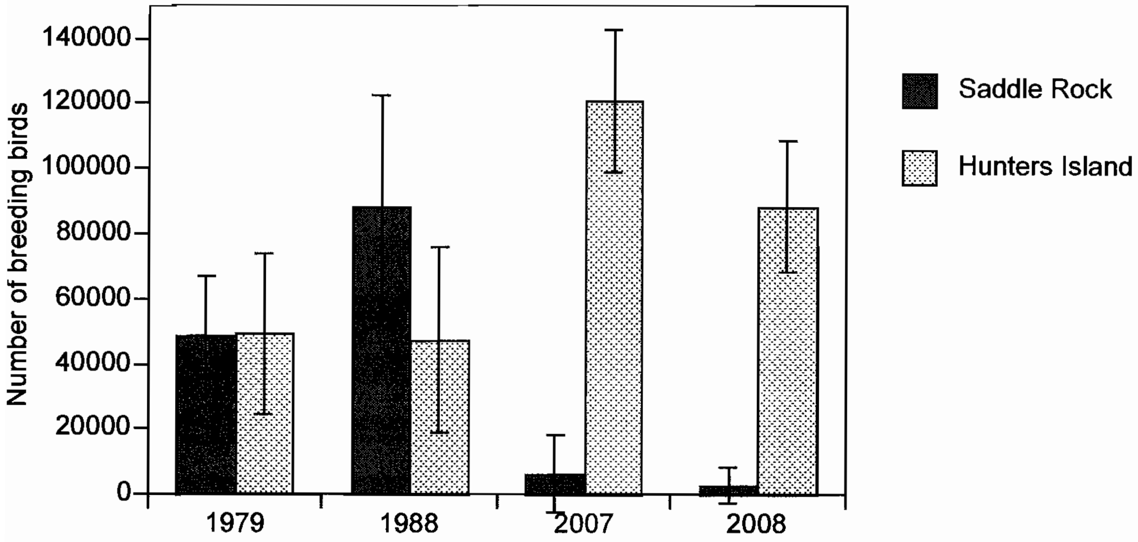

Figure 5: Breeding population estimates for the Saddle Rock and Hunters Island colonies. Error bars indicate 95% confidence interval.

Predator Identification: Scat Analysis

Of 170 scats collected, 102 were from otter, 30 from raccoon and 38 remained unknown. Of all scats collected, 25% contained petrel. Storm-petrel comprised 17% of otter, 37% of raccoon, and 39% of unknown scat samples. Scats generally contained one diet item with traces of or no other items. On average, 17% of otter diet and 26% of raccoon diet was composed of storm-petrel, and 33% of the combined, unknown mammal samples was composed of storm-petrel (Figure 6). River otter diet contained 51% fish, while raccoons ate no fish. River otter diet contained 21% crustacean and raccoon diet contained 44% crustacean. Most of the crustaceans consumed by both raccoon and river otter were mole crabs (*Emerita analoga*) with smaller amounts of *Pachygrapsus* and *Hemigrapsus* shore crabs, which are distributed in the intertidal. Birds other than LHSP contributed 10% to otter diet and 14% to raccoon diet, and were characterized by large white body feathers. These most likely belonged to Western Gulls. Vegetation, mainly in the form of blackberry seeds, contributed to 16% of raccoon diet and <1% of river otter diet. Other prey items were scarce. Two otter scat samples contained solitary sea squirts, indicating sub-tidal foraging. Unidentifiable mammal scats were comprised almost entirely of crustacean or storm-petrel.

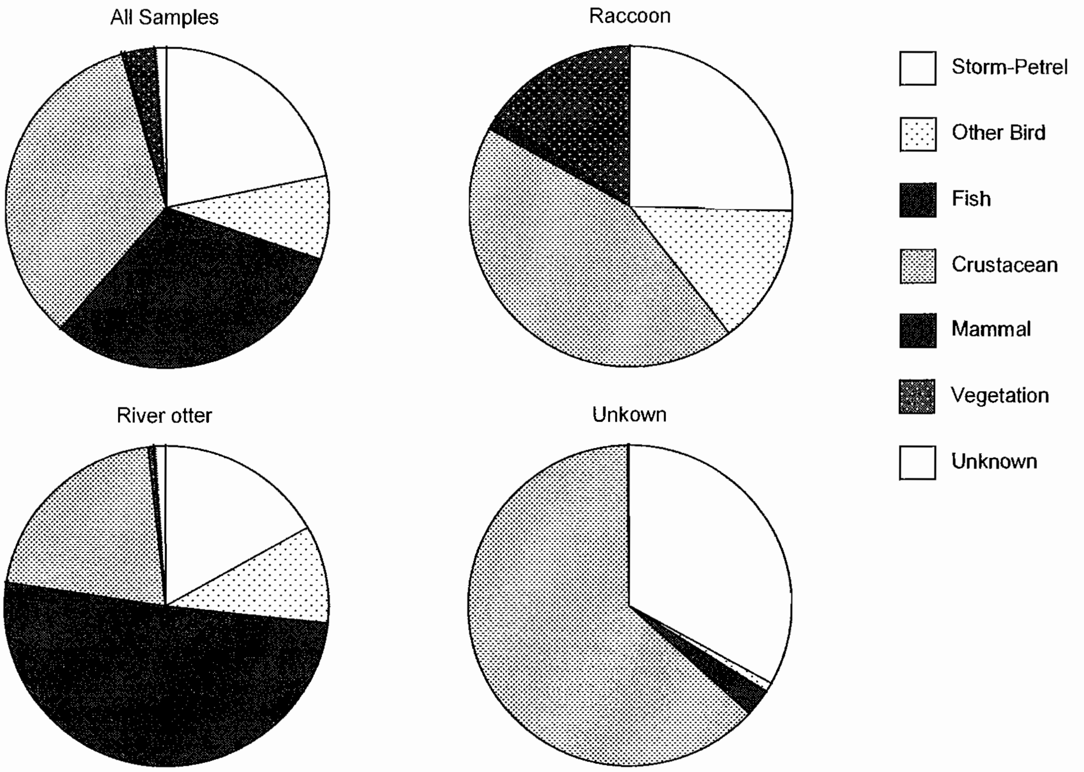

Figure 6: Mammal diet pie charts, indicating percentages of each item in diets of each group based on scat collected from Crook Point and Saddle Rock between the 7 March and 15 August. All samples, N = 170; river otter, N = 102, raccoon, N = 30; unknown, N = 38.

Within the scats containing storm-petrel, feathers, ribs and vertebrae were always present. The proximal ends of both the humerus and femur were generally present. On occasion, entire legs were found including the skin of the feet. Wing bones extending beyond the humerus were never present. Usually one or more skulls or keels could be found in each sample. Of 170 samples, 43 contained storm-petrel but only six contained more than one skull in a single scat. In a sample collected in 2005 for a different study, one scat contained nine storm-petrel beaks. Often, there were components of multiple birds, but there were no skulls or only one skull, indicating that mammals do not always eat heads.

Predator Identification: Camera Traps

Only the Cuddeback camera repeatedly captured photos of predators in 2007. The three Bushnell cameras only captured one image of a river otter throughout the season and no raccoons. The Cuddeback was only functional during late May, September, and early October. During these time periods, 22 images of raccoons were captured on 14 nights (Table 3). No river otter images were captured with the Cuddeback at any time. Four images contained two raccoons. Raccoons were captured only at night between 21:44 and 06:14 hours. On nights where the camera took multiple images, the longest interval between the first capture and the last capture was 5 hr 47 min. Tidal heights corresponding to the first capture of each night ranged from -0.06 m to 1.65 m.

Table 3: 2007 Raccoon still images recorded by the Cuddeback camera trap. Date, time, number of raccoons in each photo, and tidal height corresponding to each time are indicated. Asterisks specify the first appearance of raccoons during each evening.

Date	Time	# Raccoons	Tidal height (m)
25-May*	02:12	1	0.59
26-May*	01:36	1	0.6
26-May	01:37	1	0.6
29-May*	03:16	1	0.34
12-Sep*	03:03	1	1.34
12-Sep*	23:40	1	1.54
13-Sep	02:27	1	1.68
14-Sep*	01:10	1	1.65
16-Sep*	23:47	2	0.48
17-Sep	05:21	1	1.34
19-Sep*	00:07	1	0.31
19-Sep	00:59	1	0.37
19-Sep	04:11	1	0.99
19-Sep	04:17	1	1
19-Sep	05:17	2	1.16
20-Sep*	02:08	1	0.34
20-Sep*	22:26	2	0.98
24-Sep*	06:14	1	0.23
1-Oct*	21:44	2	-0.06
7-Oct*	02:06	1	0.45
8-Oct*	00:46	1	1.27
8-Oct	00:56	1	1.2

In 2008, the Cuddeback and Bushnell cameras only returned mammal images when trained on flagged burrows containing quail eggs for the egg predation experiment. All images contained one raccoon, present at night. Images correspond with depredated quail eggs in the marked burrows.

Predation Pressure: Transects

Of the "predation events" found on the transects, 32% of them were associated with a burrow that appeared dug out. The contents of a pile of remains left by a predation events ranged from a few feathers to a pair of wings, two legs, a head, and a uropygial gland (Figure 7). Most of this variation can be explained by the freshness of the carcass. Wind speeds frequently reaching 45 knots on the colony readily swept wings and feathers away. Gulls, ravens, and turkey vultures frequent the colony, and both gulls and ravens could be counted on to be circling the colony, scavenging the remains each morning after mammalian predators had been present. Occasionally, carcasses would be found "inside-out". These consisted of the inside out skin of the body of the bird with one or both wings and one or both legs still attached by the skin, tucked up inside the skin. These remains were still considered to be mammalian caused due to all femura and humeri being bitten in half, similarly to the other carcasses. It was impossible to tell whether the remains were the result of a river otter or a raccoon-caused mortality. Eighteen predation events included a severed, banded leg (Table 4). These banded birds had a mean minimum age of 5.2 yrs (SE +/- 0.7yrs) and the oldest bird found was 15 or more years old (USFWS banding data). Very rarely a wing would be found disarticulated at the shoulder joint. This is characteristic of avian predation on birds (D. Ledig, USFWS, pers. comm.) and was not included.

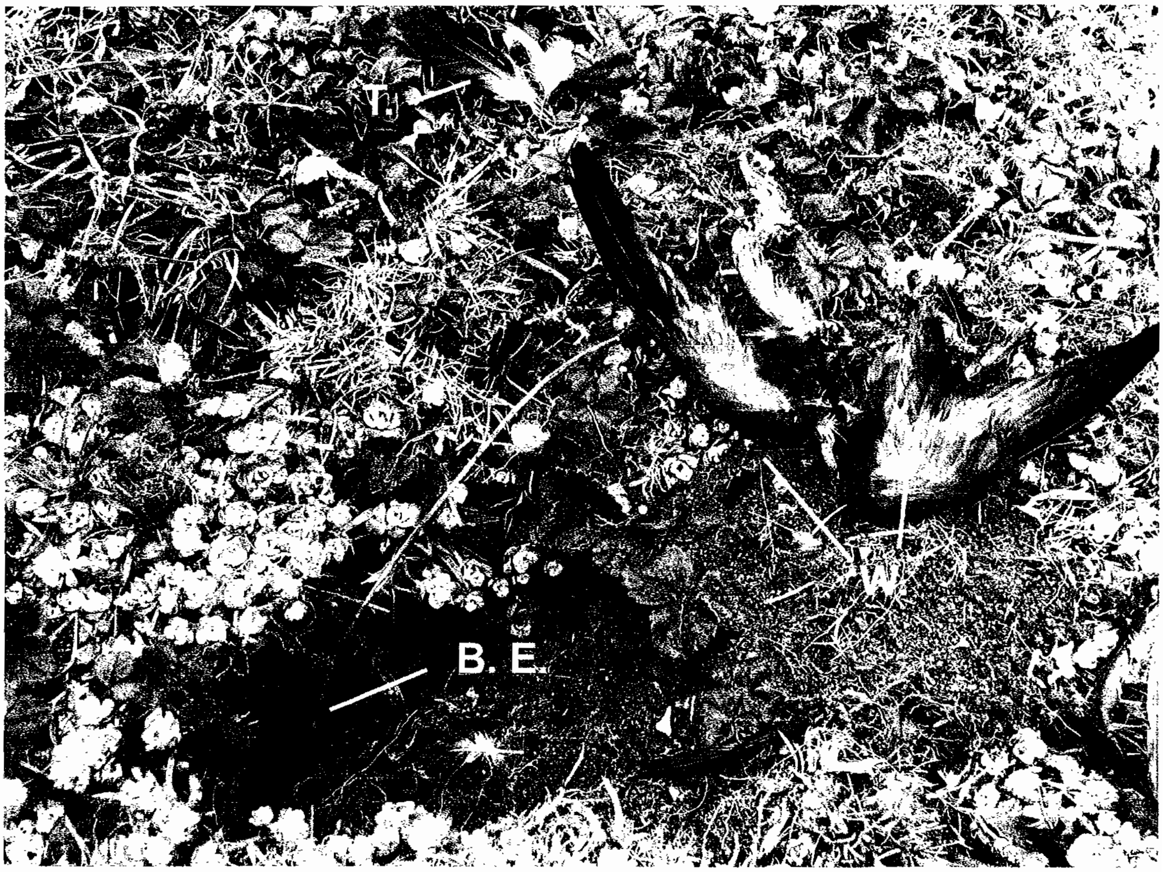

Figure 7: LHSP remains from mammalian depredation; (B. E.) burrow entrance; (W.) wings; (T.) tail feathers (Photo by A. Pollard).

Table 4: Band numbers from depredated LHSP found on the transects. Band numbers, date at banding, age (adult or chick) at banding, date of collection of carcass, and minimum age is included. Birds banded as chicks are aged precisely.

Band #	**Band Date**	**Adult/Chick**	**Date Collected**	**Age**
1371 02241	Aug-93	A	Aug-07	15+
7901 05759	Aug-97	C	Aug-07	10
7901 05898	Aug-97	C	Aug-07	10
7901 06628	May-04	A	Jun-07	4+
7901 06683	Jun-04	A	Aug-07	4+
7901 06685	Jun-04	A	Sep-07	4+
7901 07141	Jun-04	A	Aug-07	4+
7901 07252	Jun-04	A	Jun-07	4+
7901 07406	Jun-04	A	Aug-07	4+
7901 07408	Jun-04	A	Aug-07	4+
7901 07413	Jun-04	A	Aug-07	4+
7901 07569	Jun-04	A	Aug-07	4+
7901 15683	Jul-04	A	May-07	4+
7901 15733	Jul-04	A	Aug-07	4+
7901 15835	Jul-04	A	Aug-07	4+
7901 16707	Aug-05	A	Aug-07	3+
7901 16771	Aug-05	A	Jun-07	3+
7901 06649	Jun-04	A	Apr-08	5+

Predation events were found on at least three transects on every sampling day. Predation rates on the colony varied widely between transects and between sampling days (Figure 8). Average predation events/m^2 between all transects ranged from 0.012 to 0.083, with predation significantly higher on sampling days on or right after a new moon (ANOVA with log transform, $P = 0.05$, $F = 8.24$; Figure 9). Predation rates from the transects within the saddle were significantly lower than rates from the transects on the south slope of the north knoll (ANOVA with log transform, $P<0.001$, $F= 16.78$), which reflects LHSP nest densities. Stepwise multiple regression (Table 5) testing transect slope, moon phase, and date as predictive variables revealed the model to be significant ($P < 0.0001$), with slope and moon phase contributing significantly ($P = 0.0002$ and $P = 0.0040$, respectively). The total number of predation events collected from the transects between 17 March and 8 October 2007 was 163.

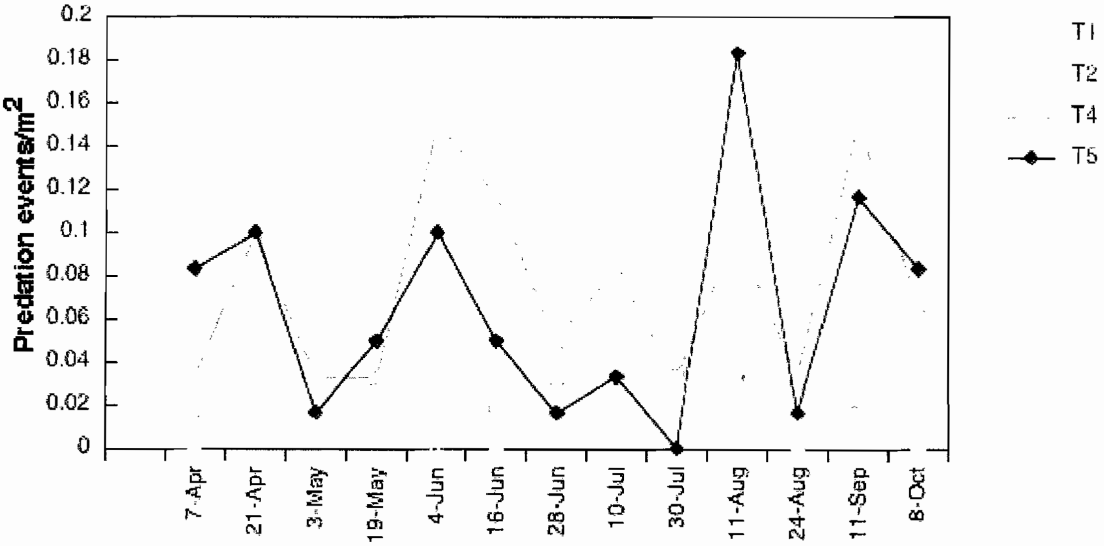

Figure 8: Predation on individual transects. Data points indicate the mean predation events/m^2 for each transect individually for each sampling day.

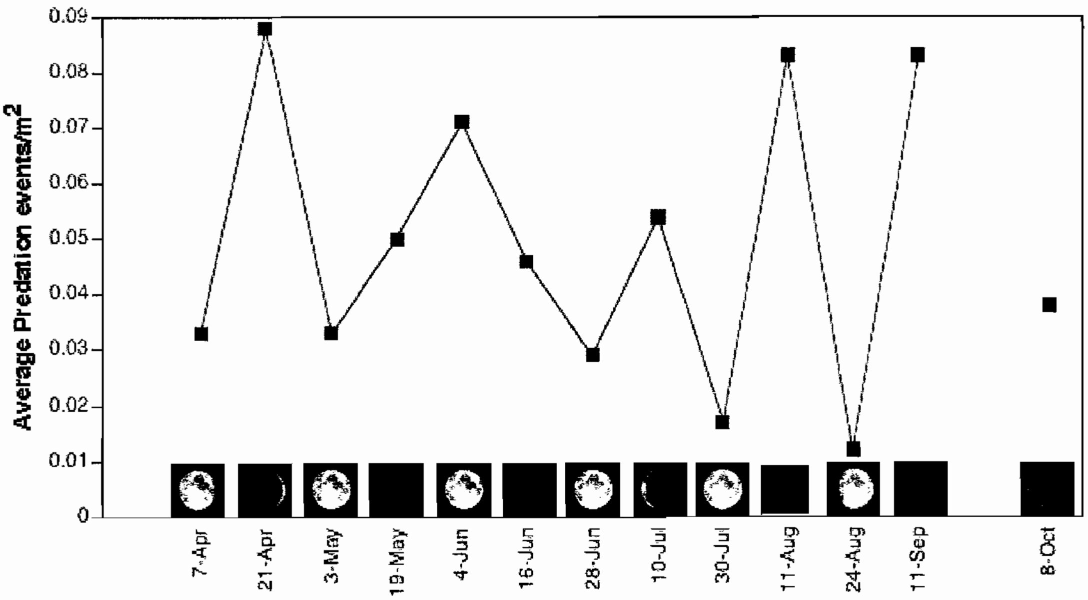

Figure 9: Averaged predation events between transects. Data points represent the mean predations events/m^2 on the transects between 7 April and 8 October 2007. Moon phase is indicated for each date.

Table 5: Stepwise multiple regression of the slope and moon phase as predictors for predation rates. The adjusted R^2 is listed for the model, and the partial R^2 is listed for slope and moon phase.

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**P Value**	**R^2**
Model	2	129.5	64.7	13.7	<0.0001	0.333
Slope	1			15.7	0.0002	0.239
Phase	1			9.1	0.004	0.359
Error	49	231.3	4.7			

Predation Pressure: Burrow Fate

Depredated LHSP were found from burrows in all sampling plots throughout the sampling period. There was no significant difference between the cumulative predation rates in iceplant and native vegetation plots (ANOVA, arcsine transform, $P = 0.19$, $F = 3.94$), but there significantly more mammalian disturbance (bird remains and/or visible signs of mammalian digging) in iceplant plots than in native plots (ANOVA, arcsine transform, $P = 0.01$, $F = 81.49$). Several burrows in each plot were considered to be mammal disturbed but not depredated because they had been dug out but there were no remains found in front of them (Figure 10). Table 6 shows cumulative depredation and disturbance in each plot. By the end of the sampling period 48% of all burrows had petrel remains in front of them during the season, and 78% had petrel remains or had been visibly disturbed by a mammal (note: sample sizes were different for each plot). One burrow was found with remains in front of it on 10 July, and again on 11 September, and another burrow was found with remains in front of it on 29 June, and was found to have a small chick in it on 12 August.

Figure 10: LHSP burrows in iceplant vegetation; A) Intact burrow; B) Dug out burrow.

Table 6: Cumulative percent of burrows depredated or disturbed by mammals in each vegetation plot. Depredated burrows are burrows that were found with LHSP remains outside of them during the sampling period. Disturbed and/or depredated burrows are burrows that were found with LHSP remains outside them and/or looked disturbed by a mammal at some point during the sampling period.

	% Depredated burrows	**% Disturbed and/or depredated burrows**
Iceplant 1 (N=22)	64	91
Iceplant 2 (N=10)	60	90
Native 1 (N=22)	27	64
Native 2 (N=10)	50	70
Combined plots (N=64)	48	78

The active burrow density survey results from July 2007 were used to estimate a population of 6200 breeding birds or 3100 active burrows. On this date 36% of my marked burrows had been preyed upon, with an additional 12% being preyed upon by the end of the sampling period on 11 September. I have assumed homogenous predation rates over the entire colony and used these percentages to extrapolate a colony-wide predation estimate. I estimate that on 5 May, 4600 burrows were occupied, but 2300 were depredated by 11 September, leaving only 2200 burrows untouched.

Predation Pressure: Whole Colony Searches

There was considerable mammalian predation on two of the four whole-colony search nights in 2007 with 47 and 26 predation events. Both of these nights were within two days of the new moon. We only surveyed roughly 80% of the available nesting habitat on the island, so I estimate the actual predation for these nights to be 59 and 33 predation events per night. On the other two surveys we found one and zero predation events. The average nightly predation, after compensating for 20% of the colony not being surveyed, is 23 (SE +/- 14) birds. The average nightly predation on the two nights the predators were present is 46 (SE +/- 13) birds. The transect monitoring showed predation happening at some level during every two week period between 11 March and 8 October, encompassing 211 days. By multiplying the average nightly predation (23 birds, SE +/- 14) by 211 days, 4900 (SE +/- 1900) birds are estimated to have been depredated by mammals in 2007.

Rodent Predation

On 9 June 2008, 15 live traps yielded five Oregon voles, *Mictorus oregoni*. On 19 June, 42 traps yielded six Oregon voles. No other species were found in the traps.

The first two days of the quail egg experiment yielded two damaged but not depredated eggs. At two weeks and four weeks there were many depredated and missing eggs (Table 7) as well as signs of digging in multiple burrows. The magnitude of digging suggested an animal larger than a rodent was responsible. All of the depredated eggs found were located outside of the burrow, usually within 0.5 m of the burrow entrance. Bite patterns on the eggs shells were not consistent with rodent predation on eggs, which is usually characterized by a strip of gnawed egg along the long axis of the egg (Blight *et al.* 1999). Camera data showed a raccoon in the vicinity of the marked burrows during the period when they were depredated.

Table 7: Percents of quail eggs depredated from LHSP burrows. Eggs were considered depredated if they were broken open and empty. Impact broken eggs were eggs that had a slight dent in them but were not broken open and were considered to be the result of researcher handling.

	2-Jun	3-Jun	18-Jul	1-Aug
Intact	98	100	52	41
Depredated	0	0	29	45
Missing	0	0	19	14
Impact broken	2	0	0	0

DISCUSSION

Population Trends: Occupancy Rates

Occupancy rates reveal reproductive success in recent years, as LHSP burrows on Saddle Rock do not appear to stay intact for very many years without birds occupying them. If abandoned burrows stayed intact, Saddle Rock would have had much higher densities of unoccupied burrows. Birds must re-excavate their burrows yearly due to natural erosion. The method of only selecting burrows for the occupancy survey that have reachable nest chambers probably limits the study to burrows that have been occupied recently. A low occupancy rate in a given year suggests a high degree of abandonment during that year, or perhaps the previous year. The 2007 and 2008 burrow occupancy rates on Saddle Rock were 42.1% and 18.5%, respectively, which is well below any rate taken between 1979 and 1997. These low occupancy rates likely indicate high levels of mortality among individuals who returned to the colony during these years to re-excavate their burrows. Low occupancy rates can be the result of poor ocean conditions causing low food availability, however, the Hunters Island occupancy rates being much higher in 2007 and 2008 than those of Saddle Rock suggest a unique pressure at Saddle Rock. This is further supported by the burrow fate study, which showed high levels of predation in marked burrows throughout the season on Saddle Rock.

Chicks found on Saddle Rock were smaller than those found on Hunters Island during the same time period, suggesting a difference in parental input or behavior between the breeding adults on the two islands. Despite the proximity, these two islands may be home to separate populations of LHSP displaying differences in reproductive timing, with Hunters Island birds breeding earlier. Observations from the 2008 USFWS seabird survey suggest Hunters Island may be reproductive earlier than several islands on the Oregon coast (A. Kocourek, pers. comm.). Alternatively, the smaller average chick size on Saddle Rock could be partially related to mammalian predation on Saddle Rock. Heavy predation on Saddle Rock may lower the average age of breeders. The abundance of vacated burrows provides nest space for birds that have yet to breed due to nest habitat limitation. If predation pressure is strong enough, an abnormally high percentage of parents could be first time breeders. Young LHSP parents have been shown to have lower probability of raising a chick to fledging (Mauck *et al.* 2004). Chicks of young birds are likely to be smaller at a given age than those of older parents. Alternatively, smaller chicks on Saddle Rock may be the result of a higher percentage of single parent nests, due to high mortality rates. Single parent Leach's storm-petrel chicks have been shown to have 50% slower growth rates compared to two-parent chicks of similar age, with most chicks failing to fledge (Takahashi *et al.* 1999). A combination of younger average parent age and an abundance of single-parent nests may explain the smaller average size of chicks on Saddle Rock than on Hunters Island.

Population Trends: Active Burrow Density

The lower active nest densities on Saddle Rock in 2007 and 2008 are due to multiple years of poor reproductive success on Saddle Rock. This drop in density was not seen in the Hunters Island survey results. Veit *et al.* (1996) demonstrated an increase in at sea densities of LHSP in the California current system between 1987 and 1994, and Yen *et al.* (2005) showed an increase in at sea abundance in the Gulf of Alaska between 1996 and 2003, indicating an overall increase in LHSP in the Eastern Pacific population. Whatever is influencing the breeding success on Saddle Rock appears to be unique to Saddle Rock, rather than being the result of a widespread population decline.

One interesting result was the apparent density increase found on Hunters Island in 2007 and 2008. It is possible that Saddle Rock birds reestablished themselves on Hunters Island. The Hunters population showed a population increase from 1988 in 2007 and 2008, with a significant increase in 2007. Although the significant increase in 2007 may be partially the result of very localized sampling, it is possible that there was a genuine increase on this island. Black-legged Kittiwakes, after a reproductive failure, have been shown to move to colonies where conspecifics had high reproductive success *(Danchin et al.* 1998). Leach's Storm-petrels are known to scout for nest sites and colonize islands other than their natal colony (Podolsky and Kress 1989), and have been shown to move to different burrows on the same colony after investigator disturbance (Blackmer *et al.* 2004). The increase in burrow density on Hunters Island may be the result of Saddle Rock birds moving after a reproductive failure. This could be tested by mist netting on Hunters Island to look for birds banded on Saddle Rock in previous years.

Predator Identification: Scat Analysis

LHSP remains composed 17% of otter scat and 26% of raccoon scat, suggesting that both mammals depend to some extent on LHSP for their diet. However, with only 30 raccoon scats sampled, it is difficult to determine from scat samples whether or not they utilize the storm-petrel colony more than river otters. A high proportion of river otter samples contained fish remains. Most of the unknown scat samples did not contain fish, suggesting that they were from raccoons. Since 33% of unknown scat was composed of LHSP, this would suggest that raccoons rely more heavily on LHSP than river otters. This is supported by the data from the camera traps. During the entire sampling period, only one otter image was recorded while 22 raccoon images were recorded. Unfortunately, without knowing the relative numbers of each, it is not possible to determine which species has the larger impact on LHSP mortality.

A high proportion on non-LHSP feathers were found in the scat of both raccoon and river otter. Almost all of these were white feathers and likely belonged to Western Gulls, who commonly roost on Saddle Rock. Between 1979 and 1997 there was a large Western Gull colony (approx. 100 pairs) on Saddle Rock but was observed to be absent by 2004. River Otters have been shown to prey on gulls (Robertson *et al.* 2001) and it is likely that the recent addition of mammalian presence on Saddle Rock contributed to the extirpation of the gull colony.

Predator Identification: Camera Traps

The disparity between the number of raccoon images verses the number of river otter images captured may suggest raccoons utilize the colony more than river otters. However, uneven sampling combined with possible territoriality between the two species confounds conclusive determination.

Interestingly, raccoons were recorded on the colony during tidal heights ranging from -0.06 m to 1.65 m. Saddle Rock is only accessible to the mainland without swimming during minus tides. One night-vision observation made in 2008 by D. Ledig of a raccoon swimming across the channel at high tide suggests a permanent inhabitance on the mainland with foraging visits to Saddle Rock at night, regardless of tide level.

Predation Pressure: Transects

I expected to find predation rates following a bell shaped curve with less occurring in early March and October when petrels numbers are low at the beginning and end of the breeding season, and a peak in early summer when both breeding adults and non-breeding sub-adults are present at the colony. This was not the case. The predation correlated more strongly with moon phase, with highest predation rates recorded when the sampling day was within two days of the new moon and lowest rates occurring when the sampling day was within two days of the full moon. I expect only sampling earlier than 3 March and later than 8 October would reveal the beginning and end of the predation pattern. This suggests that river otters and raccoons rely on LHSP as prey items for at least seven months of the year.

Since we sampled approximately every two weeks, I expected that the remains we found would be a record of all the predation that occurred during each two-week period. However, if this was the case, the intervals between sampling days would encompass nights with a variety of moon phases and a moon phase signal would not be identifiable. As there was a clear correlation with moon phase, it is evident that sampling sessions only revealed predation rates within the last few nights, not the last 14 nights. This is not surprising as gulls regularly visit the colony early in the morning to scavenge the remains left by mammalian predators. Gull pellets were found regularly on the colony composed mostly of petrel wings that were originally severed by a mammal. Also, high wind speeds at Saddle Rock are likely to blow away much of the petrel remains left on the colony by mammals.

This correlation between moon phase and predation rates is due to lower availability and higher difficulty in catching petrels on bright nights. Fewer LSHP are caught in mist nests and fewer vocalizations are heard on moonlit nights than on new moons or cloudy nights (Mougeot and Bretagnolle 2000). This is partially because birds are more likely to avoid the net when there is more light, and partially because fewer petrels are in the air on bright evenings, presumably to avoid avian predators. The birds that come to the colony start arriving at the nets later in the night and stop hitting the nets earlier on bright nights (pers. obs.). This "selfish herd" behavior decreases an individual bird's likelihood of being depredated by a gull or owl (Hamilton 1971). Mammals appeared to prefer capturing birds as they were entering or exiting their burrows, rather than expending the energy to dig them out of the nest chambers. There is a large disparity between the number of bird remains we found and the number of burrows that had been visibly disturbed. Often bird carcasses were found outside of a completely intact burrow. Thus, birds condensing their nest exchanges into a shorter period of time would decrease the percentage of birds the mammals could consume each night. In addition, birds may have had more success at avoiding predators on bright evenings. It is likely the predators responded to this and were more likely to make foraging trips to the island on dark evenings.

Predation Pressure: Burrow Fate

Predation rates were higher in iceplant areas than in native vegetation areas, though this difference was not significant. There was, however, a significant difference in overall mammalian disturbance between the two vegetation types. My sample size was very small (N=4), and predation rates may have been significantly higher in iceplant areas if I had been able to find more iceplant plots. There may be some interaction between vegetation type and predation rates. I observed that petrel burrows were more visible in areas dominated by low-lying, dense iceplant vegetation. Although most predation events recorded on the colony were not associated with a dug out burrow, mammals sometimes chose to dig up burrows to retrieve the bird inside. The higher occurrence of dug out and depredated birds in iceplant areas may indicate that mammals have an easier time finding burrows in these areas. However, any effect that the iceplant invasion may have on storm-petrel survival is small in comparison to the overall impact of mammalian predation. Predation rates are extremely high all over the colony.

Two burrows were recolonized after a predation event. The claim by Ainley and Spears (2007) that half the Leach's Storm-petrels in the East Pacific population are non breeders suggests that there are large numbers of birds that are scouting for nest sites. LHSP are known to utilize vacant burrows instead of digging a new one (Podolsky and Kress 1989). Recolonization of vacated burrows on Saddle Rock is probably common. Also, some of the remains found in front of marked burrows may belong to scouting birds, and not the actual residents of the burrows. The 48% of marked burrows that were found with a depredated bird outside may be higher than the actual proportion of burrows on the colony whose occupants were depredated.

Predation Pressure: Whole Colony Searches

The whole colony searched revealed an estimated 4900 (SE +/- 1900) birds depredated colony wide during the sample season. This study did not incorporate the very beginning or very end of the breeding season, so this is likely an underestimate of the actual 2007 predation. Also, many of the remains left by mammalian predators were scavenged by gulls before we could count them. The marked burrow study estimated that at least one parent from each of 2300 burrows was depredated colony wide during its 129-day study period. Again, this estimate would be much higher if it included more of the breeding season (roughly 250 days). As the overall depredation estimates were fairly close to each other, it is likely that colony-wide predation by mammals in 2007 was in the mid to low thousands. As the population estimate is also in the mid to low thousands, this is a very high predation rate.

These data suggest that the Leach's Storm-Petrel colony on Saddle Rock is severely at risk of extinction. The remaining birds on Saddle Rock are either remnants of the much larger breeding population of past years, or new breeders. The occurrence of severed, banded petrel legs (Table 4) occurring on the colony indicates that at least some of the birds were long-term residents of Saddle Rock. However, if fewer than 4000 birds are still breeding on the colony and thousands are being eaten each year, it will not take long for the colony to be extirpated. The time interval to extirpation, if mammalian depredation continues will depend partially on the abundance of Saddle Rock sub-adults looking for nest habitat and the propensity of LHSP to immigrate to colonies besides their natal ones.

Most work on seabird colony extirpation has been done on colonies suffering introduced predators. Both raccoons and river otters are native to the Oregon coast. This begs the question 'why now?' I've developed several rather un-testable hypotheses regarding this. One is that the raccoons and river otters, both highly social animals, have simply learned of a new feeding opportunity. If these particular animals are removed, this "cultural advancement" will die out with them, and the storm-petrel colony will rebound.

Anthropogenic effects are difficult to qualify, but they cannot be ruled out as a possible factor for the recent onset of raccoon and river otter predation on LHSP on Saddle Rock. There is speculation that the removal of sea otters opens habitat for river otters, although I have found no documented evidence of territoriality between the two species. Sea otters were extirpated from Oregon in the early 1900's. If these two species do compete for habitat, acquisition of the Crook Point area by river otters should have happened decades ago. However, extensive river otter trapping efforts throughout the 1900's may have delayed this transition. River otter trapping has decreased in Oregon in the last two decades (Mike Roberts, pers. comm.), which may have resulted in an increase of river otter populations, thereby increasing their need to expand into different foraging niches. The ever-present decline in fish stocks in rivers and streams may also be forcing river otters into new foraging patterns (Dave Ledig, pers. comm.).

Another anthropogenic influence may be that of the Saddle Rock researchers. Yearly visits to the colony between the years of 1979 and 1997, following by intense seasonal sampling in 2004 and 2005 would have left scent trails. Whelan *et al.* (1994) found that raccoons use human olfactory cues to locate artificial nests. I have observed that coastal raccoons and river otters often utilize similar diet items, and I hypothesize that once one predator found this new food source, the other quickly followed.

The current trend may be part of a natural pattern. Optimal foraging strategy predicts that eventually the density of prey items will be low enough that it will no longer be profitable for the mammals to forage on the colony (MacArthur and Pianka 1966). This "cultural advancement" may become lost after a generation of raccoons and river otters. At this point, the remaining petrels may cue other birds to nest on the colony, thereby inducing a population increase (Grubb 1973; Podolsky and Kress 1989). The proximity of Saddle Rock to the mainland allows the possibility of periodic, near extirpation and subsequent re-colonization. Our data revealing Saddle Rock as a large breeding colony only extends back a few decades, hiding any oscillations occurring at intervals longer than 30 years. This question could be answered by continuing past efforts to survey the Saddle Rock colony with a sustainable, long-term monitoring protocol.

Another possibility for the recent occurrence of mammalian predation is that this is a permanent change for Saddle Rock due to natural, topographical changes that have occurred in the area, making this colony accessible for the first time to terrestrial predators. Continued predation may completely extirpate the colony indefinitely. Again, work on Saddle Rock only extends a handful of decades, and the topography of the channel separating the colony from Crook Point may not have been so shallow a century or two ago. A gradual topographical change making Saddle Rock more accessible to predators may just now have noticeable effects. Heavy predation may occur as long as there are birds attempting to nest on the colony.

Regardless of the cause of the decline, Saddle Rock is unlikely to ever be a stable, successful breeding colony without significant trapping efforts. If we deem it our responsibility to be the stewards of this colony, the best-case scenario is that removing particular mammals will result in the elimination of predation. Alternatively, mammalian depredation on LHSP may continue to be a problem as long as there are raccoons and river otters in the area that will recruit to Crook Point. If this is the case, the decision will have to be made whether one colony of a relatively common seabird is worth the expense of yearly trapping efforts. If Saddle Rock is a discrete breeding population, its loss will have a minimal effect on the greater population. However, members of the large population of non-breeding LHSP may recruit to Saddle Rock because there is no competition for nest space, regardless of their natal colony, especially if there are remnants of the original Saddle Rock population around. Colonial seabirds demonstrating high philopatry have been shown to colonize colonies where there are vocal or visual indicators of conspecifics (Parker *et al.* 2007). If this is the case, continued predation on these birds will create a sink for the larger Oregon and California breeding population. This may warrant the cost of continued trapping, especially if there is some concern that our presence has caused the mammalian predation.

The high degree of philopatry in Leach's Storm-petrels (Huntington *et al.* 1996) likely only exists in favorable conditions. A bird of breeding age who cannot find room for a burrow on it's natal colony may seek out space on another colony rather than continue being non-reproductive. Thus, Saddle Rock may be recruiting storm-petrels originating from a pool of non-breeding adults fledged from many colonies. If this is the case, Saddle Rock LHSP will have higher genetic diversity and less synchronous breeding than the surrounding colonies. My own evidence, as well as evidence from USFWS, suggests that within storm-petrel colonies on the southern Oregon coast there exists distinct differences in timing of reproduction. For example, the Hunters Island LHSP bred earlier than those of several of the nearby colonies in 2008. This may be indicative of closer genetic relatedness among individuals within a colony compared to those from other colonies. An analysis of genetic variance and phenology would help inform management decisions for the Saddle Rock colony.

BRIDGE II

Chapter II demonstrates the importance of burrow monitoring for detecting impacts of predation. The steep population decline on Saddle Rock could not have been seen without determining the content of an adequate sample size of burrows. Chapter III investigates the time efficiency and accuracy of three different techniques for determining the contents of LHSP burrows.

CHAPTER III

THE APPLICABILITY OF CALL PLAYBACK AS A MONITORING TECHNIQUE FOR DENSELY POPULATED COLONIES OF LEACH'S STORM-PETRELS (*OCEANODROMA LEUCORHOA*)

Leach's Storm-petrels (*Oceanodrom leucorhoa*, LHSP) are small, burrow nesting seabirds found breeding on islands throughout the northern hemisphere. They are one of the most common and widespread seabirds with an estimated eight million breeding pairs worldwide (Huntington *et al.* 1996). They are far-ranging, planktotrophic birds that forage in pelagic habitats ranging from the equatorial Pacific and Atlantic, to the north Atlantic and the Aleutian Islands (Huntington *et al.* 1996; Spear and Ainley 2007). Their dependency on pelagic ocean productivity and their relative abundance make LHSP ideal indicators of global ocean conditions. Consistent, long-term monitoring projects shed light on trends in LHSP breeding success and it may be possible to link LHSP success with trends in ocean conditions within the foraging range of breeding populations of these birds.

Long-term monitoring projects for LHSP breeding colonies include those of the Alaska Maritime National Wildlife Refuge, encompassing the Aleutian and the Priblof Islands (Byrd and Dragoo 1997) and Kent Island in New Brunswick (Huntington *et al.* 1996). The nocturnal, burrow nesting habits of this species make monitoring difficult. Most monitoring projects of reproductive success use a technique called "grubbing" to monitor the contents of nest burrows. Grubbing involves a researcher reaching through the nest entrance back to the nest chamber during breeding season and recording the contents. Often the adult or chick is removed from the burrow and banded. LHSP are long lived birds and usually nest in the same burrow from year to year (Huntington *et al.* 1996). Researchers who monitor the same burrows annually using the grubbing technique may decrease breeding success. On Kent Island, New Brunswick, 50% of storm-petrels deserted their eggs if disturbed once a week during incubation. Birds only disturbed once were much less likely to abandon. Of the birds that abandoned, 71% did not return to that burrow the following year, indicating disturbance can have long term effects on breeding success (Blackmer *et al.* 2004). These findings encourage the development of less invasive monitoring methodology.

On Great Duck Island, Maine, Ambagis 2004 compared the use of call playbacks and video cameras to traditional grubbing as LHSP censusing techniques. The call playbacks consisted of playing the calls of conspecifics into the entrance of a burrow to elicit a response from the incubating adults. She also used a camera on the end of a flexible cable to visualize nest contents. Although neither the playbacks or the camera detected all occupied burrows, both proved to be more successful than grubbing, which had a very poor success rate in determining occupancy (Ambagis 2004).

Great Duck Island is a relatively sparsely populated colony. This study attempts to test the viability of call playback as a monitoring technique in densely populated colonies. In addition, I tested whether the response rate is dependant on time of night or colony density.

Saddle Rock (N 42.250 W -124.414) and the nearby Hunters Island (N 42.324 W -124.425) are two significant Leach's Storm-petrel colonies located on the southern

Oregon coast. Both are part of the Oregon Islands National Wildlife Refuge, and are under the care of the U. S. Fish and Wildlife Service. Saddle Rock storm-petrel nesting habitat consists of an area of approximately 9100 m^2 of vegetation covered soil encompassing two steep hills with a relatively flat area between them. It is separated from the mainland by a 65 m-wide channel during high tide. Hunters Island is comparable in size to Saddle Rock, with 13 800 m^2 of vegetation-covered soil. LHSP nesting habitat is arranged along a flat-topped ridge with steep sides. It is separated from the mainland by 600 m of water during high tide. The density of active nests in 2007 was 0.5 active burrows/m^2 (95% confidence interval -0.2 to 1.2) on Saddle Rock and 5.3 active burrows/m^2 (95% confidence interval 4.4 to 6.3) on Hunters Island.

On 29 June 2007, I used call playbacks, video sensing, and grubbing to assess the contents of 35 burrows as a pilot study. These burrows were randomly selected and marked on Saddle Rock. Late June was chosen because this is during peak hatching for Saddle Rock and most adults would still be incubating or brooding (U. S. Fish and Wildlife, unpublished data).

Between 20:00 and 21:00 hrs, all burrows were grubbed. If a bird was present, the researcher would quickly remove their arm to diminish disturbance. If there was nothing in the burrow and it was clear there were no side-passages within the burrow, the nest was considered empty. If the nest chamber could not be reached, or it was empty but the ends of any side passages could not be reached, the nest contents were considered unknown. No excavation was performed to enhance the researcher's ability to reach the nest chamber.

A Peeper Video Probe System with a Peep-A-Roo 2.5 cm probe, by Sand Piper Industries was used to visually inspect burrow contents. The camera consisted of a battery pack, a head mounted monitor, and a probe with IR bulbs on a four m gooseneck cable. Immediately after each burrow was grubbed, a second researcher would video the burrow. This researcher was not informed of the results of the grubbing. The probe was placed inside the mouth of the burrow and maneuvered to the nest chamber of the burrow. Often, the researcher had to place an arm inside the burrow to steer the camera probe. The entire volume of the burrow was explored and the contents were recorded. If the nest chamber could not be reached, or it could be reached but was empty and the ends of side passages could not be reached, the nest contents were considered unknown. Eighteen burrows were inspected before 21:00 hrs, and the remaining 17 burrows were tested between 05:30 and 07:00 hrs on 30 June.

Beginning at 00:00 hrs on 30 June, recorded calls were played into the openings of the marked burrows using Sony hand-held tape players. Calls were recorded from the Cornell Birds of North America library. To avoid bias, researchers were not aware of the results of the grubbing or video visualization performed earlier. A recording of two chatter calls separated by a churr call were played into the mouth of the burrow three times. Each time, the researcher would listen for five seconds for a response from a bird inside the burrow. The researcher would place his ear right at the entrance of the burrow to differentiate between responses from the target burrow and neighboring burrows. Testing of all burrows was completed by 01:30 hrs.

The average density of burrow entrances on Saddle Rock was determined by counting entrances in five one-m^2 plots on 29 July in the vicinity of the pilot study. A one-m^2 quadrat was tossed randomly, and all burrow entrances were counted within the plot. These values were averaged for the overall density on this area of the colony.

In 2008, I tested the call playback method with the grubbing method on Saddle Rock and Hunters Island on two nights each. The video method was rejected due to inefficiency. I suspected grubbing burrows hours before the call playbacks in 2007 may have caused birds to leave the burrow, compromising the call playback results. In 2008, call playbacks were used first and grubbing occurred immediately after. On 31 May and 18 June 90 and 67 burrows were censused on Saddle Rock, respectively. On 21 June and 2 July, 60 and 48 burrows were censused on Hunters Island, respectively. All burrows (N = 265) were randomly chosen in daylight in several areas of each colony and marked. After 23:00 hrs, when petrels began arriving at the colony, and ending before 04:30 hrs, when petrels ceased calling, recorded calls were played into each burrow. Immediately after the call playback was used, another researcher would grub each burrow. In an attempt to minimize the percent of 'unknown' burrows, researchers would slightly excavate some burrows to gain access to the nest chambers. Dirt was pulled from the floor of the burrow, effectively widening it. Once the nest contents were determined, the dirt was replaced and patted down. Burrow contents and time of night were recorded for each burrow.

Burrow entrance density for each colony was estimated by averaging burrow entrances in 15 one m^2 plots on Saddle Rock on 1 July and nine one m^2 plots on Hunters Island on 2 July. The densities of burrows occupied by at least one adult for each sampling night were calculated by multiplying the average burrow entrance density by the proportion of adult occupied burrows for each night.

In the pilot study each technique placed a large number of burrows in the 'unknown occupancy' category (Table 1). The low success rate of grubbing is attributed to a high percentage of burrows whose nest chambers could not be reached, due to narrow burrow entrances or burrows being longer than an arm's length. The camera technique had a similar problem with burrows being too curved to navigate the camera probe through. Call playbacks only detect active burrows and cannot distinguish between empty burrows and burrows in which birds are present but do not respond, thus the 65.7% of burrows that failed to give a response to the call playbacks were deemed 'unknown'. Call playbacks failed to detect 43% of burrows known to be inhabited from the grub and/or camera techniques. All three techniques revealed birds that neither of the other two detected. Time investments differed with each technique, with playbacks taking an average of 1.7 min./burrow, grubbing taking 2.6 min./burrow, and camera investigation taking 5.4 min./burrow (Table 1).

Table 1: Results of the 2007 pilot study at Saddle Rock (N=35). These percentages reflect the outcome of each monitoring technique. The combined value represents the total percentage of burrows determined to be occupied by any of the techniques. Asterisk indicates that the grub time alone includes the amount of time it took to find each burrow entrance.

Monitoring technique	**% Active burrows**	**% Empty burrows**	**% Unknown**	**Time investment for 35 burrows (min)**
Playback	34.3	0.0	65.7	60
Camera	34.3	14.3	51.4	190
Grub	20.0	8.6	71.4	90 *
Combined	51.4			

The 2008 grubbing technique, which included partial excavation of burrows, greatly reduced the number of burrows whose nest contents could not be determined from the 2007 pilot study technique. The total percentage of 'unknown' grubbed burrows was 26.0% and the total percentage of 'unknown' burrows investigated by call playback was 68.7%. Grubbing revealed an occupancy rate of 47.7% within the determinable burrows, including nests with adults, eggs, and/or chicks, for a total of 103 occupied burrows. Call playbacks elicited a response from 48 of these burrows, for a 46.6% response rate. This low response rate is partially due to the fact that unattended chicks and eggs do not respond. The response rate from burrows that were known to have an adult in them was 52.4%. There was also a high percentage (16%, 18 of 112 burrows) of 'false positives', or burrows from which a response was detected, but grubbing proved the burrow was without an adult. Table 2 shows the breakdown of burrow contents revealed using the grubbing technique and the call playback response rates.

Table 2: The contents of 265 burrows (investigated by grubbing) are given with the number and percent of these that gave responses to the call playback technique. Burrows in the 'Adult' category had at least one adult in them and may have also had an egg, a chick, or another adult.

Burrow Contents	**# Burrows**	**Playback Responses**	**% Response**
Empty	94	14	14.9
Egg only	7	1	14.3
Chick only	11	3	27.3
Adult	84	44	52.4
Unknown	69	21	30.4
Total	**265**	**83**	**31.3**

The rate of false positives differed between nights and between colonies. The Saddle Rock false positive rates were 11 and 7% on 31 May and 18 June, respectively. The Hunters Island false positive rates were 40 and 17%, on 21 June and 2 July, respectively. When added to the 2007 pilot study results, false positive rates were significantly, positively correlated with the density of burrows containing at least one adult ($R = 0.87$, $N = 5$, P = 0.02, Figure 1). False response rate for the pilot study in 2007 was 17%.

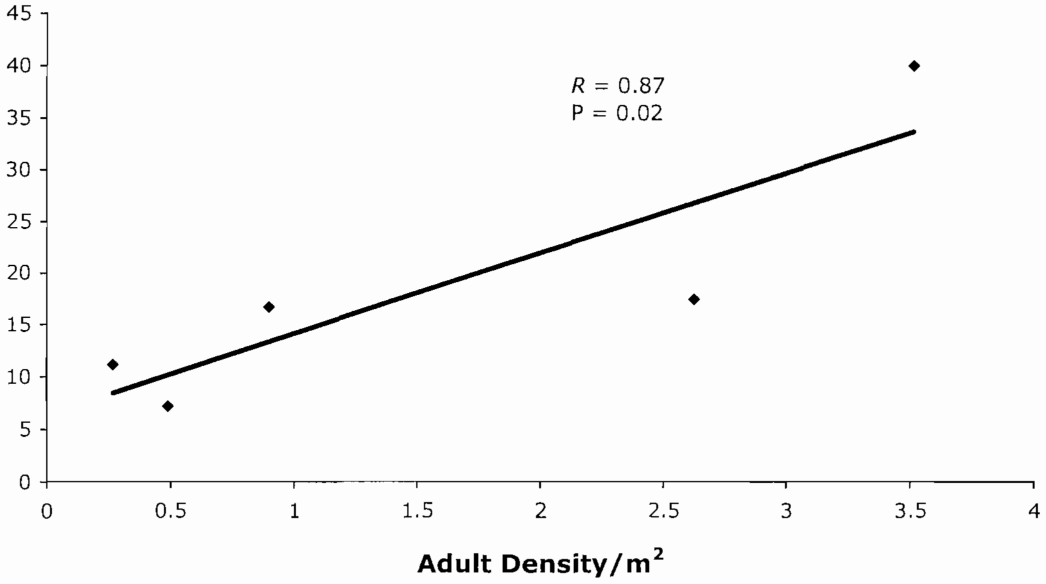

Figure 1: Response rates versus adult density; the percentage of empty burrows from which a response was detected, plotted against the density of burrows containing at least one adult.

Response rates ranged from 63% between the hours of 0:00 and 0:59 to 17% between the hours of 4:00 and 4:59. The rate of responses from burrows known to be occupied varied with the time of night and were significantly, negatively correlated with one-hour time bins ($R = 0.87$, $N = 6$, $P = 0.02$, Figure 2).

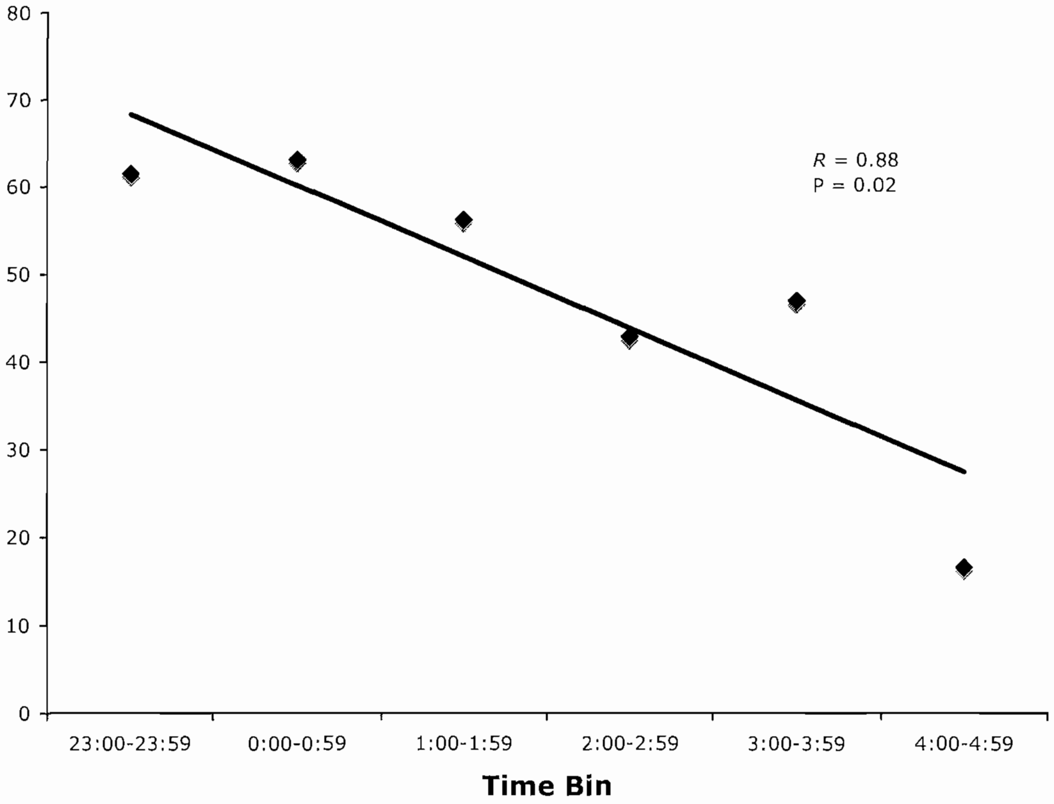

Figure 2: Response rate versus time of night; the response rate of adult LHSP to call playbacks is plotted against the time bin in which the playback was performed, including all 2008 sampling nights.

The pilot study revealed a high level of uncertainty with all three techniques. Both grubbing and the camera technique failed to identify the contents of a high percentage of burrows, due to being too narrow or curved for access. However, both methods revealed empty *and* occupied burrows. The call playback method identified a higher proportion of occupied burrows than the other two techniques, but failed to categorize all of the burrows that did not elicit a response as occupied or empty. Thus, by using the camera or grubbing techniques, one can infer an occupancy rate based on the portion of occupied burrows to empty burrows within the burrows that could be determined, while the call playback technique only revealed a minimum occupancy rate. The limited information gained using the call playback technique may be worth the time efficiency of call playbacks and the minimal disturbance to the birds.

In 2008, grubbing included partial excavation to widen burrows that were too narrow to reach into. This reduced the proportion of burrows whose contents could not be determined to 26%, which surpasses the efficiency of the camera and call playback methods. The average call playback response rate (31.3%) was lower than in the pilot study, due to a higher percentage of burrows with unaccompanied chicks or eggs in the 2008 field data, as well as sampling that occurred across the entire night. Call response rates decreased later in the night, and the pilot study was performed between the hours of 00:00 and 01:00 hrs, while the 2008 data was collected throughout the night. The 2 July sampling session on Hunters Island was late in the breeding season and several burrows contained unbrooded chicks, which do not respond to call playbacks.

The correlation between adult occupied burrow density and the false positive response rate (Figure 2) reveals the problems associated with sampling extremely dense colonies. The soil was riddled with burrows on both colonies. Often I observed burrows only separated from one another by a thin layer of earth, which was likely penetrable to sound. In such instances, a researcher listening at the mouth of a burrow would have difficulty differentiating between a call emanating from the nest chamber of the target burrow, or on emanating from within a closely neighboring burrow. Ambagis (2004) used the call playback technique on a colony with a very low burrow density compared to

Saddle Rock and Hunters Island (the average nest density on Great Duck Island is roughly 0.006 burrows/m^2), where responses from closely neighboring burrows are less likely to confound results. No false positives were described.

Call playback monitoring LHSP may work well in colonies with adult densities lower than 0.3/m^2. Also, directional listening devices could greatly decrease the rate of false positives. For optimal censusing accuracy, I recommend the use of call playbacks in burrows first, followed by grubbing burrows that did not respond to the playback. This will decrease the amount of disturbance, and increase the time efficiency of the census. Alternatively, using call playback on multiple nights has been shown to increase response rates (Ambagis 2004), but will decrease time efficiency considerably. A higher percentage of burrows will elicit a response if sampling occurs in the peak incubation period. Also, a higher percentage of burrows will elicit a response in the early hours of petrel activity (23:00 to 01:00 hrs). Grubbing is more successful if the burrow is widened slightly to allow for a longer reach into the burrow. The effects of disturbance to the burrow have not been studied but abandonment rates are likely to be lower if birds are not removed from the burrows when grubbing occurs.

CHAPTER IV

GENERAL CONCLUSION

Chapter I stresses the importance of Saddle Rock as a colony for multiple seabird species, and as a valuable site for seabird research. It describes the current status of the island as having declining seabird biomass and species diversity due to raccoon and river otter depredation. In Chapter II, I present my research on the depredation of Leach's Storm-petrels on the island and the resulting population decline. Chapter III contains an account of my research into less disruptive ways to monitor Leach's Storm-petrels. I performed my research with conservation as the driving force. I hope this document will encourage the preservation of the Saddle Rock colony, with the eventual goal of continued seabird research at this site.

APPENDIX A

BAND NUMBERS USED ON SADDLE ROCK

Table 1: A summary of bands used on Saddle Rock between 1979 and 2005 with date, band range, age of bird (A= adult, C= chick), and the number of bands used.

Year	Date	Band Numbers	Chick/ Adult	# Bands Issued	# Bands to date	Researcher
1979	29-Jun	103 189901-103 189949	A	49	49	R. Pitman, USFWS
1979	12-Jul	103 189950-103 190000	A			R. Pitman, USFWS
1979	12-Jul	69 146503-69 146504	C	53	102	R. Pitman, USFWS
1979	23-Jul	69 146505-69 146517	C			R. Pitman, USFWS
1979	23-Jul	69 146518	A			R. Pitman, USFWS
1979	23-Jul	69 146519-69 146537	C			R. Pitman, USFWS
1979	23-Jul	69 146538	A			R. Pitman, USFWS
1979	23-Jul	69 146539-69 146554	C			R. Pitman, USFWS
1979	23-Jul	69 146555	A			R. Pitman, USFWS
1979	23-Jul	69 146556-69 146566	C			R. Pitman, USFWS
1979	23-Jul	69 146567	A			R. Pitman, USFWS
1979	23-Jul	69 146568-69 146577	C			R. Pitman, USFWS
1979	23-Jul	69 146579-69 146579	A			R. Pitman, USFWS
1979	23-Jul	69 146580	C			R. Pitman, USFWS
1979	23-Jul	69 146581	A			R. Pitman, USFWS
1979	23-Jul	69 146582	C			R. Pitman, USFWS
1979	23-Jul	69 146583	A			R. Pitman, USFWS
1979	23-Jul	69 146584-69 146587	C			R. Pitman, USFWS
1979	23-Jul	69 146588	A			R. Pitman, USFWS

1979	23-Jul	69 146589-69 146599	C			R. Pitman, USFWS
1979	23-Jul	69 146600	A	96	198	R. Pitman, USFWS
1980	4-Jun	1151 30601-1151 30700	A	100	298	R. Pitman, USFWS
1980	18-Jul	1151 30701	A			R. Pitman, USFWS
1980	18-Jul	1151 30702	C			R. Pitman, USFWS
1980	18-Jul	1151 30703	A			R. Pitman, USFWS
1980	18-Jul	1151 30704	C			R. Pitman, USFWS
1980	18-Jul	1151 30705	A			R. Pitman, USFWS
1980	18-Jul	1151 30706	C			R. Pitman, USFWS
1980	18-Jul	1151 30707	A			R. Pitman, USFWS
1980	18-Jul	1151 30708-1151 30714	C			R. Pitman, USFWS
1980	18-Jul	1151 30715	A			R. Pitman, USFWS
1980	18-Jul	1151 30716-1151 30717	C			R. Pitman, USFWS
1980	18-Jul	1151 30718-1151 30719	A			R. Pitman, USFWS
1980	18-Jul	1151 30720-1151 30721	C			R. Pitman, USFWS
1980	18-Jul	1151 30722	A			R. Pitman, USFWS
1980	18-Jul	1151 30723-1151 30724	C			R. Pitman, USFWS
1980	18-Jul	1151 30725-1151 30726	A			R. Pitman, USFWS
1980	18-Jul	1151 30727-1151 30730	C			R. Pitman, USFWS
1980	18-Jul	1151 30731-1151 30732	A			R. Pitman, USFWS
1980	18-Jul	1151 30733	C			R. Pitman, USFWS
1980	18-Jul	1151 30734	A			R. Pitman, USFWS
1980	18-Jul	1151 30735-1151 30737	C			R. Pitman, USFWS
1980	18-Jul	1151 30738	A			R. Pitman, USFWS
1980	18-Jul	1151 30739-1151 30744	C			R. Pitman, USFWS
1980	18-Jul	1151 30745	A			R. Pitman, USFWS

1980	18-Jul	1151 30746- 1151 30747	C			R. Pitman, USFWS
1980	18-Jul	1151 30748	A			R. Pitman, USFWS
1980	18-Jul	1151 30749- 1151 30752	C			R. Pitman, USFWS
1980	18-Jul	1151 30753	A			R. Pitman, USFWS
1980	18-Jul	1151 30754- 1151 30757	C			R. Pitman, USFWS
1980	18-Jul	1151 30758	A			R. Pitman, USFWS
1980	18-Jul	1151 30759- 1151 30760	C			R. Pitman, USFWS
1980	18-Jul	1151 30761	A			R. Pitman, USFWS
1980	18-Jul	1151 30762- 1151 30763	C			R. Pitman, USFWS
1980	18-Jul	1151 30764	A	64	362	R. Pitman, USFWS
1980	13-Aug	1151 30765- 1151 30767	C			R. Pitman, USFWS
1980	13-Aug	1151 30768	A			R. Pitman, USFWS
1980	13-Aug	1151 30769	C			R. Pitman, USFWS
1980	13-Aug	1151 30770	A			R. Pitman, USFWS
1980	13-Aug	1151 30771- 1151 30775	C			R. Pitman, USFWS
1980	13-Aug	1151 30776	LOST			R. Pitman, USFWS
1980	13-Aug	1151 30777- 1151 30780	C			R. Pitman, USFWS
1980	13-Aug	1151 30781	A			R. Pitman, USFWS
1980	13-Aug	1151 30782- 1151 30815	C			R. Pitman, USFWS
1980	13-Aug	1151 30816	A			R. Pitman, USFWS
1980	13-Aug	1151 30817- 1151 30821	C			R. Pitman, USFWS
1980	13-Aug	1151 30822	A			R. Pitman, USFWS
1980	13-Aug	1151 30823- 1151 30832	C			R. Pitman, USFWS
1980	13-Aug	1151 30833	A			R. Pitman, USFWS
1980	13-Aug	1151 30834- 1151 30855	C	90	452	R. Pitman, USFWS

1981	5-May	1151 30856- 1151 30910	A	55	507	R. Pitman, USFWS
1981	6-May	1151 30911- 1151 31000	A	125	631	R. Pitman, USFWS
1981	6-May	1151 30937	LOST			R. Pitman, USFWS
1981	6-May	1151 40801- 1151 40835	A			R. Pitman, USFWS
1981	31-Jul	1151 40836- 1151 40841	C			R. Pitman, USFWS
1981	31-Jul	1151 40842- 1151 40843	A			R. Pitman, USFWS
1981	31-Jul	1151 40844- 1151 40857	C			R. Pitman, USFWS
1981	31-Jul	1151 40858	A			R. Pitman, USFWS
1981	31-Jul	1151 40859- 1151 40905	C			R. Pitman, USFWS
1981	31-Jul	1151 40906	A			R. Pitman, USFWS
1981	31-Jul	1151 40907- 1151 40927	C			R. Pitman, USFWS
1981	31-Jul	1151 40928	A			R. Pitman, USFWS
1981	31-Jul	1151 40929- 1151 40931	C			R. Pitman, USFWS
1981	31-Jul	1151 40932	A			R. Pitman, USFWS
1981	31-Jul	1151 40934- 1151 40965	C			R. Pitman, USFWS
1981	31-Jul	1151 40966- 1151 41000	A	165	796	R. Pitman, USFWS
1981	31-Jul	1151 45201- 45232	A	31	827	R. Pitman, USFWS
1981	1-Aug	1151 45233- 45256	A			R. Pitman, USFWS
1981	1-Aug	1151 45257- 45280	C			R. Pitman, USFWS
1981	1-Aug	1151 45281	A			R. Pitman, USFWS
1981	1-Aug	1151 45282- 45313	C			R. Pitman, USFWS
1981	1-Aug	1151 45314	A			R. Pitman, USFWS
1981	1-Aug	1151 45315- 45319	C			R. Pitman, USFWS
1981	1-Aug	1151 45320	A			R. Pitman, USFWS
1981	1-Aug	1151 45321- 45346	C			R. Pitman, USFWS

1981	1-Aug	1151 45347-45400	A	169	994	R. Pitman, USFWS
1982	7-May	1151-45401-1151 45516	A			R. Pitman, USFWS
1982	7-May	1151-45443	LOST			R. Pitman, USFWS
1982	7-May	1151-45496	LOST			R. Pitman, USFWS
1982	17-Jun	1151 45517-1151 45600	A	200	1192	R. Pitman, USFWS
1983	9-Aug	1151 48501-1151 48512	C	12		R. Pitman, USFWS
1983	9-Aug	1151 45601-45673	C			R. Pitman, USFWS
1983	9-Aug	1151 45674	LOST			R. Pitman, USFWS
1983	9-Aug	1151 45675-45700	C			R. Pitman, USFWS
1983	9-Aug	1151 48001-1151 48009	C			R. Pitman, USFWS
1983	9-Aug	1151 48010-1151 48011	LOST			R. Pitman, USFWS
1983	9-Aug	1151 48012-1151 48028	C			R. Pitman, USFWS
1983	9-Aug	1151 48029	LOST			R. Pitman, USFWS
1983	9-Aug	1151 48030-1151 48055	C			R. Pitman, USFWS
1983	9-Aug	1151 48056	A			R. Pitman, USFWS
1983	9-Aug	1151 48057-1151 48076	C			R. Pitman, USFWS
1983	9-Aug	1151 48077	A			R. Pitman, USFWS
1983	9-Aug	1151 48078-1151 48084	C			R. Pitman, USFWS
1983	9-Aug	1151 48085	LOST			R. Pitman, USFWS
1983	9-Aug	1151 48086-1151 48150	C	258	1450	R. Pitman, USFWS
1984	2-Aug	1151 48514-1151 48526	A			R. Pitman, USFWS
1984	2-Aug	1151 48527-1151 48533	C	20	1470	R. Pitman, USFWS
1984	5-Sep	1151 48151-1151 48188	C			R. Pitman, USFWS
1984	5-Sep	1151 48189	LOST			R. Pitman, USFWS
1984	5-Sep	1151 48190-48266	C			R. Pitman, USFWS

1984	5-Sep	1151 48267- 1151 48274	A			R. Pitman, USFWS
1984	5-Sep	1151 48275	C- FTSP!			R. Pitman, USFWS
1984	5-Sep	1151 48276- 1151 48286	A	134	1603	R. Pitman, USFWS
1985	7-Apr	1151 48287- 1151 48494	A	208	1811	R. Pitman, USFWS
1985	15-Aug	1151 48495- 1151 48500	C			R. Pitman, USFWS
1985	15-Aug	1151 48534- 1151 48560	C			R. Pitman, USFWS
1985	15-Aug	1151 48561	LOST			R. Pitman, USFWS
1985	15-Aug	1151 48562- 1151 48692	C			R. Pitman, USFWS
1985	15-Aug	1151 48693	A			R. Pitman, USFWS
1985	15-Aug	1151 48694- 1151 48785	C			R. Pitman, USFWS
1985	15-Aug	1151 48786	A			R. Pitman, USFWS
1985	15-Aug	1151 48787- 1151 48800	C			R. Pitman, USFWS
1985	15-Aug	111 133702- 111 133715	C			R. Pitman, USFWS
1985	15-Aug	111 133716	LOST			R. Pitman, USFWS
1985	15-Aug	111 133717- 111 133732	C			R. Pitman, USFWS
1985	15-Aug	111 133733- 111 133743	A			R. Pitman, USFWS
1985	15-Aug	111 133744	LOST			R. Pitman, USFWS
1985	15-Aug	111 133745- 111 133801	A			R. Pitman, USFWS
1985	16-Aug	111 133802	C			R. Pitman, USFWS
1985	16-Aug	111 133803- 111 133855	A	424	2235	R. Pitman, USFWS
1986	17-Jul	111 133856- 111 133864	C			R. Pitman, USFWS
1986	17-Jul	111 133865	LOST			R. Pitman, USFWS
1986	17-Jul	111 133866- 111 133871	C			R. Pitman, USFWS
1986	17-Jul	111 133872	A			R. Pitman, USFWS

1986	17-Jul	111 133872- 111 133900	C			R. Pitman, USFWS
1986	17-Jul	111 130901- 111 130916	C			R. Pitman, USFWS
1986	17-Jul	111 130917	LOST			R. Pitman, USFWS
1986	17-Jul	111 130918- 111 130931	C			R. Pitman, USFWS
1986	17-Jul	111 130932- 111 130933	A			R. Pitman, USFWS
1986	17-Jul	111 130934- 111 130945	C			R. Pitman, USFWS
1986	17-Jul	111 130946	A			R. Pitman, USFWS
1986	17-Jul	111 130947- 111 130959	C			R. Pitman, USFWS
1986	17-Jul	111 130960	A			R. Pitman, USFWS
1986	17-Jul	111 130961- 111 130963	C			R. Pitman, USFWS
1986	17-Jul	111 130964	A			R. Pitman, USFWS
1986	17-Jul	111 130965- 111 130981	C			R. Pitman, USFWS
1986	17-Jul	111 130982	A			R. Pitman, USFWS
1986	17-Jul	111 130983- 111 130984	C			R. Pitman, USFWS
1986	17-Jul	111 130985	A			R. Pitman, USFWS
1986	17-Jul	111 130986- 111 130997	C			R. Pitman, USFWS
1986	17-Jul	111 130998	A			R. Pitman, USFWS
1986	17-Jul	111 130999- 131000	C			R. Pitman, USFWS
1986	17-Jul	111 133901- 111 133903	C			R. Pitman, USFWS
1986	17-Jul	111 133904	A			R. Pitman, (USFWS)
1986	17-Jul	111 133905- 111 133900	C			R. Pitman, (USFWS)
1986	17-Jul	111 133910	LOST			R. Pitman, (USFWS)
1986	17-Jul	111 133911- 111 133929	C			R. Pitman, (USFWS)

1986	17-Jul	111 133930	A			R. Pitman, (USFWS)
1986	17-Jul	111 133931-111 133965	C			R. Pitman, (USFWS)
1986	17-Jul	111 133966	A			R. Pitman, (USFWS)
1986	17-Jul	111 133967-111 133975	C			R. Pitman, (USFWS)
1986	17-Jul	111 133976	A			R. Pitman, (USFWS)
1986	17-Jul	111 133977-111 133978	C			R. Pitman, (USFWS)
1986	17-Jul	111 133979	A			R. Pitman, (USFWS)
1986	17-Jul	111 133980-111 134000	C			R. Pitman, (USFWS)
1986	17-Jul	1401 37001-1401 37035	C			R. Pitman, (USFWS)
1986	18-Jul	1401 37036-1401 37100	A			R. Pitman, (USFWS)
1986	18-Jul	1401 37301-1401 37400	A			R. Pitman, (USFWS)
1986	18-Jul	1401 37201-1401 37237	C			R. Pitman, (USFWS)
1986	18-Jul	1401 37238-1401 37253	A			R. Pitman, (USFWS)
1986	18-Jul	1401 37254	LOST			R. Pitman, (USFWS)
1986	18-Jul	1401 37255-1401 37260	A			R. Pitman, (USFWS)
1986	18-Jul	1401 37261	LOST			R. Pitman, (USFWS)
1986	18-Jul	1401 37262-1401 37300	A			R. Pitman, (USFWS)
1986	19-Jul	1401 37401-1401 37404	A	541	2778	R. Pitman, (USFWS)
1987	11-Jun	1401 39001-1401 39300	A			R. LOWE (USFWS)
1987	11-Jun	3 LOST BANDS				R. LOWE (USFWS)
1987	11-Jun	1001 09601-1001 09622	A	319	3097	R. LOWE (USFWS)
1987	25-Jul	1401 37101-1401 37103	C			R. Pitman, USFWS
1987	25-Jul	1401 37104	A			R. Pitman, USFWS
1987	25-Jul	1401 37105-1401 37124	C			R. Pitman, USFWS

1987	25-Jul	1401 37125	A			R. Pitman, USFWS
1987	25-Jul	1401 37126-1401 37144	C			R. Pitman, USFWS
1987	25-Jul	1401 37145	A			R. Pitman, USFWS
1987	25-Jul	1401 37146-1401 37147	C			R. Pitman, USFWS
1987	25-Jul	1401 37148	A			R. Pitman, USFWS
1987	25-Jul	1401 37149-1401 37150	C			R. Pitman, USFWS
1987	25-Jul	1401 37151	A			R. Pitman, USFWS
1987	25-Jul	1401 37152-1401 37169	C			R. Pitman, USFWS
1987	25-Jul	1401 37170	LOST			R. Pitman, USFWS
1987	25-Jul	1401 37171-1401 37178	C			R. Pitman, USFWS
1987	25-Jul	1401 37179	A			R. Pitman, USFWS
1987	25-Jul	1401 37180-1401 37185	C			R. Pitman, USFWS
1987	25-Jul	1401 37186	A			R. Pitman, USFWS
1987	25-Jul	1401 37187-1401 37194	C			R. Pitman, USFWS
1987	25-Jul	1401 37195	LOST			R. Pitman, USFWS
1987	25-Jul	1401 37196-1401 37200	C			R. Pitman, USFWS
1987	25-Jul	1401 37601-1401 37617	C			R. Pitman, USFWS
1987	25-Jul	1401 37618	A			R. Pitman, USFWS
1987	25-Jul	1401 37619-1401 37625	C			R. Pitman, USFWS
1987	25-Jul	1401 37626-1401 37644	A			R. Pitman, USFWS
1987	25-Jul	1401 37645	A			R. Pitman, USFWS
1987	25-Jul	1401 37646-1401 37700	A			R. Pitman, USFWS
1987	25-Jul	1401 37405-1401 37406	A			R. Pitman, USFWS
1987	25-Jul	1401 37407-1401 37436	C			R. Pitman, USFWS
1987	25-Jul	1401 37437	A			R. Pitman, USFWS

1987	25-Jul	1401 37438-1401 37440	C			R. Pitman, USFWS
1987	25-Jul	1401 37441-1401 37442	A			R. Pitman, USFWS
1987	25-Jul	1401 37443-1401 37460	C			R. Pitman, USFWS
1987	25-Jul	1401 37461	A			R. Pitman, USFWS
1987	25-Jul	1401 37462-1401 37482	C			R. Pitman, USFWS
1987	25-Jul	1401 37483	A			R. Pitman, USFWS
1987	25-Jul	1401 37484-1401 37485	C			R. Pitman, USFWS
1987	25-Jul	1401 37486	A			R. Pitman, USFWS
1987	25-Jul	1401 37487-1401 37491	C			R. Pitman, USFWS
1987	25-Jul	1401 37492	A			R. Pitman, USFWS
1987	25-Jul	1401 37493-1401 37506	C			R. Pitman, USFWS
1987	25-Jul	1401 37507	A			R. Pitman, USFWS
1987	25-Jul	1401 37508-1401 37512	C			R. Pitman, USFWS
1987	25-Jul	1401 37513	A			R. Pitman, USFWS
1987	25-Jul	1401 37514-1401 37522	C			R. Pitman, USFWS
1987	25-Jul	1401 37523	A			R. Pitman, USFWS
1987	25-Jul	1401 37524-1401 37525	C			R. Pitman, USFWS
1987	25-Jul	1401 37526	A			R. Pitman, USFWS
1987	25-Jul	1401 37527-1401 37529	C			R. Pitman, USFWS
1987	25-Jul	1401 37530	A			R. Pitman, USFWS
1987	25-Jul	1401 37531-1401 37538	C			R. Pitman, USFWS
1987	25-Jul	1401 37539-1401 37540	A			R. Pitman, USFWS
1987	25-Jul	1401 37541	C			R. Pitman, USFWS
1987	25-Jul	1401 37542-1401 37543	A			R. Pitman, USFWS
1987	25-Jul	1401 37544-1401 37547	C			R. Pitman, USFWS

1987	25-Jul	1401 37548	A			R. Pitman, USFWS
1987	25-Jul	1401 37549- 1401 37560	C			R. Pitman, USFWS
1987	25-Jul	1401 37561- 1401 37600	A			R. Pitman, USFWS
1987	25-Jul	1401 39301- 1401 39330	A	423	3520	R. Pitman, USFWS
1987	20-Aug	1001 09623- 1001 09624	C			USFWS
1987	20-Aug	1001 09625- 1001 10000	A			USFWS
1987	20-Aug	1001 09634	LOST			USFWS
1987	20-Aug	1001 09930	LOST	375	3895	USFWS
1988	1-Aug	1371 03001- 1371 03007	C			USFWS
1988	1-Aug	1371 03008	A			USFWS
1988	1-Aug	1371 03009- 1371 03094	C			USFWS
1988	1-Aug	1371 03095	A			USFWS
1988	1-Aug	1371 03096- 1371 03109	C			USFWS
1988	1-Aug	1371 03110- 1371 03199	A			USFWS
1988	1-Aug	1371 03200	C			USFWS
1988	1-Aug	1371 03201- 1371 03243	A	243	4138	USFWS
1989	15-Jul	1401 38501- 1401 38504	C			USFWS
1989	15-Jul	1401 38505	A			USFWS
1989	15-Jul	1401 38506- 1401 38568	C			USFWS
1989	15-Jul	1401 38569	A			USFWS
1989	15-Jul	1401 38570- 1401 38675				USFWS
1989	15-Jul	1401 38608	LOST			USFWS
1989	15-Jul	1401 38640	LOST			USFWS
1989	15-Jul	1401 38676	A			USFWS
1989	15-Jul	1401 38677- 1401 38750	C			USFWS
1989	15-Jul	1401 38751- 1401 38824	A			USFWS
1989	15-Jul	1401 39331	A			USFWS
1989	15-Jul	1401 39332- 1401 39355	C			USFWS
1989	15-Jul	1401 39333	LOST			USFWS
1989	15-Jul	1401 39356	A			USFWS

1989	15-Jul	1401 39357-1401 39361	C			USFWS
1989	15-Jul	1401 39362	A			USFWS
1989	15-Jul	1401 39363-1401 39382	C			USFWS
1989	15-Jul	1401 39383	A			USFWS
1989	15-Jul	1401 39384-1401 39400	C			USFWS
1989	15-Jul	1401 39390	LOST			USFWS
1989	16-Jul	1401 38825-1401 38917	A	481	4619	USFWS
1990	23-Jun	1401 8003-1401 38004	C			USFWS
1990	23-Jun	1401 38930	C			USFWS
1990	23-Jun	1401 38931-1401 38932	A			USFWS
1990	23-Jun	1401 38933-1401 38935	C			USFWS
1990	23-Jun	1401 38936-1401 39000	A			USFWS
1990	23-Jun	1401 39401-1401 39415	A			USFWS
1990	23-Jun	1401 38005-1401 38200				USFWS
1990	23-Jun	1401 38191	LOST			USFWS
1990	23-Jun	1401 38401	A			USFWS
1990	23-Jun	1401 38402	LOST			USFWS
1990	23-Jun	1401 38403-1401 38417	A			USFWS
1990	23-Jun	1401 39416	A			USFWS
1990	23-Jun	1401 39417	LOST			USFWS
1990	23-Jun	1401 39418-1401 39500	A			USFWS
1990	23-Jun	1401 39435	LOST			USFWS
1990	23-Jun	1401 39453	LOST			USFWS
1990	23-Jun	1401 39472	LOST			USFWS
1990	23-Jun	1401 39473	LOST			USFWS
1990	23-Jun	1401 39476	LOST	378	4997	USFWS
1990	22-Jul	1371 03289-1371 03294	C			USFWS
1990	22-Jul	1371 03295	A			USFWS
1990	22-Jul	1371 03296-1371 03298	C			USFWS
1990	22-Jul	1371 03299	A			USFWS
1990	22-Jul	1371 03300	C			USFWS
1990	22-Jul	1371 03301	A			USFWS

1990	22-Jul	1371 03302- 1371 03322	C			USFWS
1990	22-Jul	1371 03323	A			USFWS
1990	22-Jul	1371 03324- 1371 03450	C			USFWS
1990	22-Jul	1371 03451	A			USFWS
1990	22-Jul	1371 03452- 1371 03458	C			USFWS
1990	22-Jul	1371 03459	A			USFWS
1990	22-Jul	1371 03460- 1371 03461	C			USFWS
1990	22-Jul	1371 03462	A			USFWS
1990	22-Jul	1371 03463- 1371 03466	C			USFWS
1990	22-Jul	1371 03467	A			USFWS
1990	22-Jul	1371 03468- 1371 03469	C			USFWS
1990	22-Jul	1371 03470	A			USFWS
1990	22-Jul	1371 03471- 1371 03473	C			USFWS
1990	22-Jul	1371 03474	A			USFWS
1990	22-Jul	1371 03475- 1371 03482	C			USFWS
1990	22-Jul	1371 03483	A			USFWS
1990	22-Jul	1371 03484	C			USFWS
1990	22-Jul	1371 03485	A			USFWS
1990	22-Jul	1371 03486- 1371 03514	C			USFWS
1990	22-Jul	1371 03515	A			USFWS
1990	22-Jul	1371 03516- 1371 03531	C			USFWS
1990	22-Jul	1371 03532	A			USFWS
1990	22-Jul	1371 03533- 1371 03571	C			USFWS
1990	22-Jul	1371 0359	LOST			USFWS
1990	22-Jul	1371 03572	A			USFWS
1990	22-Jul	1371 03573- 1371 03600	C			USFWS
1990	23-Jul	1371 03601- 1371 03858	A			USFWS
1990	23-Jul	1371 03604	LOST	568	5565	USFWS
1991	13-Jul	1401 38201- 1401 38218	C			USFWS
1991	13-Jul	1401 38418- 1401 38420	C			USFWS
1991	13-Jul	1401 38421	A			USFWS

1991	13-Jul	1401 38422-1401 38500	C			USFWS
1991	24-Aug	1371 02401-1371 02410	C			USFWS
1991	24-Aug	1371 02411	A			USFWS
1991	24-Aug	1371 02412-1371 02494	C			USFWS
1991	24-Aug	1401 38219-1401 38249	C			USFWS
1991	24-Aug	1401 38250	A			USFWS
1991	24-Aug	1401 38251-1401 38331	C			USFWS
1991	24-Aug	1401 38332	A			USFWS
1991	24-Aug	1401 38333-1401 38400	C	377	5942	USFWS
1992	14-Aug	1371 03859-1371 04019	C			USFWS
1992	14-Aug	1371 04020	A			USFWS
1992	14-Aug	1371 04021-1371 04163	C			USFWS
1992	14-Aug	1371 04164-1371 04388	A	530	6472	USFWS
1993	18-Aug	1371 02201-1371 02300	A			USFWS
1993	18-Aug	1371 02495-1371 02500	A			USFWS
1993	18-Aug	1371 04390-1371 04415	C			USFWS
1993	18-Aug	1371 04416	A			USFWS
1993	18-Aug	1371 04417	C			USFWS
1993	18-Aug	1371 04418	A			USFWS
1993	18-Aug	1371 04419-1371 04430	C			USFWS
1993	18-Aug	1371 04425	LOST			USFWS
1993	18-Aug	1371 04431	A			USFWS
1993	18-Aug	1371 04432-1371 04442	C			USFWS
1993	18-Aug	1371 04443	A			USFWS
1993	18-Aug	1371 04444-1371 04475	C			USFWS
1993	18-Aug	1371 04476-1371 04500	A			USFWS
1993	19-Aug	1371 02221-1371 02300	A	216	6688	USFWS
1994	9-Aug	1371 08001-1371 08081	C			USFWS
1994	9-Aug	1371 08082	A			USFWS

1994	9-Aug	1371 08083- 1371 08092	C			USFWS
1994	9-Aug	1371 08093	A			USFWS
1994	9-Aug	1371 08094- 1371 08167	C			USFWS
1994	9-Aug	1371 08168	A			USFWS
1994	9-Aug	1371 08169- 1371 08227	C			USFWS
1994	9-Aug	1371 08228	A			USFWS
1994	9-Aug	1371 08229- 1371 08233	C			USFWS
1994	9-Aug	1371 08234	A			USFWS
1994	9-Aug	1371 08235- 1371 08255	C			USFWS
1994	9-Aug	1371 08256- 1371 08534				USFWS
1994	9-Aug	1371 08265	LOST			USFWS
1994	9-Aug	1371 08535	C			USFWS
1994	9-Aug	1371 08536- 1371 08658	A			USFWS
1994	9-Aug	1371 08555	LOST	656	7344	USFWS
1995	14-Aug	1371 08659- 1371 08690	C			USFWS
1995	14-Aug	1371 08691	A			USFWS
1995	14-Aug	1371 08692- 1371 08741	C			USFWS
1995	14-Aug	1371 08742	A			USFWS
1995	14-Aug	1371 08743- 1371 08808	C			USFWS
1995	14-Aug	1371 08809	A			USFWS
1995	14-Aug	1371 08809- 1371 08980	C			USFWS
1995	14-Aug	1371 08981- 1371 08992	A			USFWS
1995	14-Aug	1371 8993- 1371 09000	C			USFWS
1995	14-Aug	1371 09001- 1371 09009	A			USFWS
1995	14-Aug	1371 09010	C			USFWS
1995	14-Aug	1371 09011- 1371 09050	A			USFWS
1995	14-Aug	1371 09051- 1371 09080	C			USFWS
1995	14-Aug	1371 09081- 1371 09092	A			USFWS
1995	14-Aug	1371 09093- 1371 09099	C			USFWS

1995	14-Aug	1371 09101-1371 09109	A			USFWS
1995	15-Aug	1371 02501-1371 02663	A			USFWS
1995	15-Aug	1371 09110-1371 09150	A			USFWS
1995	15-Aug	1371 09151-1371 09180	C			USFWS
1995	15-Aug	1371 09181-1371 09192	A			USFWS
1995	15-Aug	1371 09193-1371 09200	C	704	8048	USFWS
1996	1-Aug	7901 05001-7901 05008	C			USFWS
1996	1-Aug	7901 05009	A			USFWS
1996	1-Aug	7901 05010-7901 05011	C			USFWS
1996	1-Aug	7901 05012-7901 05014	A			USFWS
1996	1-Aug	7901 05015	C			USFWS
1996	1-Aug	7901 05016	A			USFWS
1996	1-Aug	7901 05017-7901 05025	C			USFWS
1996	1-Aug	7901 05026	A			USFWS
1996	1-Aug	7901 05027-7901 05035	C			USFWS
1996	1-Aug	7901 05036	A			USFWS
1996	1-Aug	7901 05037-7901 05059	C			USFWS
1996	1-Aug	7901 05060	A			USFWS
1996	1-Aug	7901 05061-7901 05062	C			USFWS
1996	1-Aug	7901 05063	A			USFWS
1996	1-Aug	7901 05064-7901 05079	C			USFWS
1996	1-Aug	7901 05080	A			USFWS
1996	1-Aug	7901 05081-7901 05086	C			USFWS
1996	1-Aug	7901 05087	A			USFWS
1996	1-Aug	7901 05088-7901 05090	C			USFWS
1996	1-Aug	7901 05091	A			USFWS
1996	1-Aug	7901 05092	C			USFWS
1996	1-Aug	7901 05093	A			USFWS
1996	1-Aug	7901 05094	C			USFWS
1996	1-Aug	7901 05095	A			USFWS

1996	1-Aug	7901 05096-7901 05119	C			USFWS
1996	1-Aug	7901 05120	A			USFWS
1996	1-Aug	7901 05121-7901 05133	C			USFWS
1996	1-Aug	7901 05134-7901 05136	A			USFWS
1996	1-Aug	7901 05137-7901 05163	C			USFWS
1996	1-Aug	7901 05164	A			USFWS
1996	1-Aug	7901 05165	C			USFWS
1996	1-Aug	7901 05166	A			USFWS
1996	1-Aug	7901 05167	C			USFWS
1996	1-Aug	7901 05168	A			USFWS
1996	1-Aug	7901 05169-7901 05171	C			USFWS
1996	1-Aug	7901 05172-7901 05173	A			USFWS
1996	1-Aug	7901 05174-7901 05182	C			USFWS
1996	1-Aug	7901 05183	A			USFWS
1996	1-Aug	7901 05184-7901 05203	C			USFWS
1996	1-Aug	7901 05204-7901 05719	A	719	8767	USFWS
1997	19-Aug	7901 05720-7901 06023	C			USFWS
1997	19-Aug	7901 06024-7901 06242	A	523	9290	USFWS
2004		Contact PRBO				PRBO, Schuiteman, USFWS
2005	9-Jun	7901 16602-7901 16605	A			Schuiteman, USFWS
2005	10-Jun	7901 16606-7901 16613	A			Schuiteman, USFWS
2005	20-Jun	7901 16614-7901 16621	A			Schuiteman, USFWS
2005	21-Jun	7901 16622-7901 16646	A			Schuiteman, USFWS
2005	5-Jul	7901 16647-7901 16649	A			Schuiteman, USFWS
2005	7-Jul	7901-16650-790116666	A			Schuiteman, USFWS
2005	8-Jul	7901 16665-7901 16697	A			Schuiteman, USFWS
2005	1-Aug	7901 16702-7901 16704	A			Schuiteman, USFWS

2005	4-Aug	7901 16705-7901 16709	A			Schuiteman, USFWS
2005	5-Aug	7901 16710-7901 16747	A			Schuiteman, USFWS
2005	18-Aug	7901 16748-7901 16753	A			Schuiteman, USFWS
2005	19-Aug	7901 16754-7901 16757	A			Schuiteman, USFWS
2005	21-Aug	7901 16758-7901 16773	A			Schuiteman, USFWS
2005	22-Aug	7901 16774-7901 16788	A	185	9475	Schuiteman, USFWS

APPENDIX B

RAW DATA FROM 1979, 1988, 2007, AND 2008 NESTING DENSITY

Table 1: Raw data from the 1979, 1988, 2007, and 2008 active burrow density counts. These data were used to estimate the colony breeding population. Active burrows were those that contained an adult, an egg, or a chick.

28-Jul-79	N. knoll	Saddle	S. Knoll
	3	0	1
	5.5	0	0
	4	0	2
	4	1	
	4	0	
	6		
	1		
	5		
Mean	4.1	0.2	1.0
SD	1.6	0.4	1.0
SE	0.6	0.2	0.6
95% CI	1.1	0.4	1.1

Note: 2 additional plots were used in the original study from the top of the north knoll, but were eliminated from the comparisons made in this thesis for consistency with the 1988 survey; both plots had 8 active nests.

1-Aug-88	N. knoll	Saddle	S. Knoll
	5.5	1	2
	9	0	4
	6	0	
Mean	6.8	0.3	3.0
SD	1.9	0.6	1.4
SE	1.1	0.3	1.0
95% CI	2.1	0.7	2.0

29-Jul-07	N. knoll	Saddle	S. Knoll
	0	0.014	0
	1		0
	0		2
			0
			1
Mean	0.33	0.01	0.60
SD	0.58	0.00	0.89
SE	0.33	0.00	0.52
95% CI	0.65	0.00	1.01

Note: the saddle area value was estimated using the ratio of the north knoll to the saddle area from the 1988 survey.

1-Aug-08	N. knoll	Saddle	S. Knoll
	0.5	0	0.125
	0	0	0
	0	0.25	0.5
Mean	0.17	0.08	0.21
SD	0.29	0.14	0.26
SE	0.17	0.08	0.15
95% CI	0.33	0.16	0.29

Note: these are 2 x 2 m plots

APPENDIX C

BURROW CONTENTS FROM 1979-2008 OCCUPANCY SURVEYS

Table 1: Detailed burrow contents from occupancy surveys performed from 1979 to 2008.

Year	Date	# Burrows	Empty	Adult(s)	Dead Adult	Adult +Egg	Egg Only	Dead Egg	Adult+ Chick	Chick Only	Dead Chick	Multiple Chicks/eggs	% Occupancy	Researcher
1979	23-Jul	163	55	2	0	5	2	0	2	97	0	0	66.3	R. Pitman
1979	28-Jul	53	7	0	0	2	0	2	0	39	1	2	86.8	R. Pitman
1980	18-Jul	95	31	4	0	14	2	0	1	43	0	0	67.4	R. Pitman
1980	13-Aug	168	68	5	0	2	1	0	0	90	2	0	59.5	R. Pitman
1981	5-May	23	20	2	0	1	0	0	0	0	0	0	13.0	R. Pitman
1981	31-Jul	263	28	2	1	9	2	0	2	218	1	0	89.4	R. Pitman
1982	28-Apr	35	34	1	0	0	0	0	0	0	0	0	2.9	R. Pitman
1983	9-Aug	105	4	0	0	2	0	0	0	98	1	0	96.2	R. Pitman
1984	5-Sep	319	225	0	0	0	0	3	0	90	1	0	29.5	R. Pitman
1985	7-Apr	20	7	13	0	0	0	0	0	0	0	0	65.0	R. Pitman
1985	15-Aug	74	6	0	0	0	0	1	0	67	0	0	91.9	R. Pitman
1986	17-Jul	144	19	5	0	12	1	2	4	101	0	0	86.8	USFWS
1987	11-Jun	39	4	0	0	35	0	0	0	0	0	0	89.7	USFWS
1987	25-Jul	277	102	5	0	5	1	2	4	148	10	0	63.2	R. Pitman
1988	1-Aug	100	17										83.0	USWS
1989	15-Jul	134	20	11	0	4	5	0	6	88	0	0	85.1	R. Pitman
1990	23-Jun	100	9	40	0	18	0	4	9	20	0	0	91.0	R. Pitman
1990	31-Jul	103	16	1	0	3	0	0	3	80	0	0	84.5	USWS
1992	14-Aug	100	31	0	0	0	0	9	0	60	0	0	69.0	USWS
1993	6-Jul	100	31	8	0	24	19	0	1	15	2	0	69.0	R. Pitman
1993	18-Aug	100	43	3		0	0	2	1	51	0		57.0	USFWS
1994	9-Aug	100	18	0	0	0	0	6	0	75	1	0	82.0	USFWS
1995	14-Aug	100	14	0	0	0	0	2	1	83	0	0	86.0	USFWS
1997	19-Aug	100	30	0	0	0	0	2	0	68	0	0	70.0	USFWS
2007	29-Jul	114	66	4	0	1	5	0	4	33	1	0	42.1	USFWS, A. Pollard
2008	1-Jul	25	23	0	0	1	0	0	0	1	0	0	8.0	USFWS, A. Pollard
2008	1-Aug	100	81	0	0	0	5	0	0	12	2	0	19.0	USFWS, A. Pollard

APPENDIX D

SUMMARY OF FIELD NOTES FROM 1979-1997

Table 1: Summarized field notes regarding the breeding seabirds on Saddle Rock from Robert Pitman and Roy Lowe (USFWS) between the years 1979 and 1997.

Year	Date	Researcher	Species	Notes
1979		R. Pitman + D. Varoujean (USFWS)	DCCO	not present
			LHSP	53,000
			PECO	11 nests
			PIGU	12 nests
			TUPU	5 nests (N. Slope)
			WEGU	65 nests
1980		R. Pitman, USFWS	DCCO	not present
1981	5-May	R. Pitman, USFWS	BLOY	Saw up to 4 on rocks adjacent to island.
			FTSP	Heard 2-3 each night during banding, probably a few nests present.
			LHSP	Lots of fresh digging around island and petrel smell. Saw remains of several depredated petrels- lots of feathers with nothing else left.
			PECO	At least two nests present on the E side of the island, didn't check the S end.
			PIGU	1 pair seen scouting for crevices or nesting on the W side.
			TUPU	Saw several fly by, but none on island. No burrows seen (checked N slope).
			WEGU	Several hundred present, of 100 nests checked, 5 had single eggs, 3 had two eggs. The large aggregation was located on the rocks on the northwest side of the island, 12 nests were present on the top of the S. knoll, and 1-2 nests were present on the ledge on the NE side of the island.
1982	28-Apr	R. Pitman, USFWS	WEGU	Present, no nests, one copulation seen.
			TUPU	At least two were seen flying in the area, the burrows are still intact.
1983	9-Aug	R. Pitman, USFWS	BLOY	4-5 around island.

			LHSP	Chicks are almost all large and mostly downy, possibly a week from fledging.
			PIGU	1 roosting just down from gull colony and several audible throughout trip.
			TUPU	2 active burrows on N side of N knoll and 1 roosting adult in area.
			WEGU	~40 chicks present on colony, close to fledgling. 25 dead chicks found, most ~ 1 wk old, some as old as 4 wks. Large number of gooseneck barnacle regurge, suspected gulls had to switch to intertidal food sources due to lack of other food, which resulted in chick die off. 200-250 adults associated with the colony. 2 mouse depredated eggs shells found on E slope near bottom of N knoll. No successful nesting on top of N knoll.
1984	5-Sep	R. Pitman, USFWS	BLOY	4-5 around island, 1 juvenile.
			FTSP	1 caught in mist net.
			LHSP	Many chicks are still on colony, near fledging age, most nests were empty, indicating most birds were fledged.
			WEGU	All but one fledged. ~44 dead chicks found of varying ages. Many fish bones in gull colony, relatively few gooseneck scutes.
			Other	Strong odor of skunk, probably emanating from island.
1985	7-Apr	R. Pitman, USFWS	FTSP	Heard ~6 calling at night.
			LHSP	Strong petrel odor and fresh excavation. Saw 12 dead petrels, completely consumed except for wings and pectoral girdle, appeared mouse scavenged. Many call heard from burrows.
			WEGU	200-300 associated with W side of island, many staking out territory. A few nest scrapes were evident. Copulating and territorial displays seen. Regurge was composed of gooseneck scutes.
1986	17-Jul	R. Lowe (USFWS), R. Pitman	DCCO	Not present
			LHSP	Mostly downy chicks present.
			PECO	Min. 5 pairs on E. and S side, med. Sized chicks present.
			TUPU	One seen flying around the island with a fish in its beak at dusk.
			WEGU	250-300 adults on main colony. There were ~100 chicks. Only 4 dead chicks found. Lots of fish remains in colony. 6 regurgitated LHSP found
1987	25-Jul	R. Pitman, USFWS	DCCO	A small colony started up again this year, 3 pairs all with eggs, one just hatched chick present.

			LHSP	More dead chicks and empty nests than usual.
			PECO	Min. 10 nests on island, all on eggs.
			WEGU	250 chicks produced. They appear to be eating surf smelt and sand lance. Most chicks are near fledging; found 7 dead chicks. The colony extended into the dense grassy area near the W rocks. 12 chicks seen on the S side of the S knoll, and 2 pairs nesting on the NE ledge.
1988	1-Aug	R. Lowe (USFWS)	LHSP	An estimated 87,520 birds estimated.
			WEGU	No count made, reference made to earlier count in the season (field notes missing) of ~100 nests.
1989	15-Jul	R. Pitman, USFWS	DCCO	Min. 4 nests present, 1 with 2 eggs, 1 with 1 egg noted.
			WEGU	No count made but productivity looked low. Chicks were near fledging.
1990	23-Jun	R. Pitman, USFWS	DCCO	13 birds and 6 nests on top of S knoll, 1 with 1 egg, 1 with 2 eggs, 4 were empty.
			LHSP	Many chicks too small to band. No irrupted flight feathers yet. S knoll is covered in burrows when previously there were few. Colony size appears to be increasing.
			TUPU	Three seen flying around the n knoll. Likely 2 pairs breeding.
			WEGU	A relatively bad year: 60-70 chicks present. There were a lot of dead eggs and 15-20 dead chicks. Evidence of second clutches: several nests with eggs, some piping. Relatively little regurge, composed of smelts and barnacles. Several LHSP found in regurges of one adult.
			Other	Egg found that looks like it could be a Cassins auklet or a Rhino auklet. Iceplant seen taking over S. knoll, possibly due to DCCO nesting. Annual with magenta flower (?) encroaching on rest of island.
1993	18-Aug	R. Lowe (USFWS)	LHSP	Chicks near banding size
			WEGU	Gulls appear to have a higher than normal mortality of large chicks. Only two chicks were not flight capable yet.
1994	9-Aug	R. Lowe (USFWS)	LHSP	Some fledging size, one piping egg found, two adults with small chicks.
1996	14-Aug	R. Lowe (USFWS)	LHSP	Some have already fledged.
1997	19-Aug	R. Lowe (USFWS)	WEGU	Still present, no notes.

			Other	River Otter or raccoon present. Scat found on the E bench below the saddle, contained LHSP and gooseneck scutes. 150 pairs of LHSP wings found near gull colony.
2008	1-Aug	A. Pollard, USFWS	BLOY	Present in the area, but not on Saddle
			DCCO	Not Present
			FTSP	Not Present
			LHSP	Roughly 1500 active nests
			TUPU	Not present
			WEGU	2 nests

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