Monitoring and Control of Raccoons on Seabird Colonies in Haida Gwaii (Queen Charlotte Islands)

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ABSTRACT

More than 1.5 million seabirds breed in Haida Gwaii, B.C. Most are burrow-nesters concentrated at 64 colony sites. These globally significant seabird colonies have been put at risk due to the introduction of raccoons (*Procyon lotor*) to enhance the local fur trade in the 1940s. Evidence collected in the early 1990s indicated that raccoons pose a serious threat to approximately one-half of the burrow-nesting seabirds that breed in Haida Gwaii. Significant proportions of the world population of ancient murrelets (*Synthliboramphus antiquus*) are at risk. In response to this threat Parks Canada, Environment Canada's Canadian Wildlife Service, the Laskeek Bay Conservation Society, and the British Columbia Ministry of Environment, Lands and Parks (B.C. Environment, Wildlife Branch, and B.C. Parks) formed an interagency working group to develop a monitoring and control program. Three factors influenced the selection of seabird colony islands for annual monitoring: the number and species of seabirds present; island accessibility to raccoons; and the presence of other introduced predators. The islands chosen support approximately 90% of all ancient murrelets, rhinoceros auklets (*Cerorhinca monocerata*), and storm petrels (*Oceanodroma* spp.), and about 70% of Cassin's auklets (*Ptychoramphus aleuticus*) breeding in Haida Gwaii. All raccoons observed on seabird colony islands during the annual surveys were killed. In addition, raccoons have been killed at 1 off-colony site that had consistently served as a source area. 1998 was the first year in which no raccoons were found on any of the monitored seabird islands. Analysis of the results from the first 5 years of monitoring and control has allowed the working group to modify the program. The revised program will be less costly and labour-intensive, while still providing protection for the nesting seabirds.

Key words: ancient murrelet, auklet, *Cerorhinca monocerata*, Haida Gwaii, introduced species, predation, *Procyon lotor*, *Ptychoramphus aleuticus*, Queen Charlotte Islands, raccoon, seabird, *Synthliboramphus antiquus*.

Introduced predators are considered to be among the greatest threats to seabird conservation worldwide (e.g., Johnson and Stattersfield 1990). Widespread declines and extirpations in seabird populations within the past century have been attributed to predation by nonnative mammals (Moors and Atkinson 1984). Raccoons (*Procyon lotor*) were deliberately introduced to Graham Island in Haida Gwaii (Queen Charlotte Islands; Fig. 1) by the Provincial Game Commission to enhance the local fur trade in the early 1940s (Carl and Guiget 1972). By 1992, raccoons had spread through the archipelago and had reached some of the smaller islands that support breeding colonies of seabirds. Seabirds possess few morphological or behavioural defenses against mammalian predators. Furthermore, their habit of nesting in colonies during well-defined breeding seasons leave the birds concentrated in time and space. Those habits increase the probability that a terrestrial predator that reaches a colony island will have an impact on a significant portion of the birds' populations.

By the late 1980s, biologists had collected circumstantial evidence that raccoons were negatively affecting some seabird colonies in Haida Gwaii (e.g., Rodway 1991). Those observations prompted the formation of the Working Group on Raccoon-Seabird Interactions (referred to as "the Working Group" for the purposes of this paper), made up of representatives of the British Columbia Ministry of Environment, Lands and Parks (B.C. Parks and B.C. Environment),

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Environment Canada (Canadian Wildlife Service), the Laskeek Bay Conservation Society, and Parks Canada. The Working Group assessed the evidence for raccoon impacts on seabirds and developed a management plan.

This paper summarizes the management plan and presents results from the first 4 years of implementation. Also discussed are proposed modifications to the management plan that will result in a less costly and labour-intensive program, and yet still provide protection for the nesting seabirds of Haida Gwaii.

BACKGROUND

More than 1.5 million seabirds breed at 180 sites in Haida Gwaii (Rodway 1991). Nine of the 12 seabird species that breed on the archipelago are burrow- or ground-nesters and, thus, vulnerable to mammalian predators. The burrow-nesting species represent approximately 99% of the total regional population of seabirds and are concentrated in colonies at 65 sites. Those sites support an estimated 50, 16, and 2% of the world's populations of ancient murrelets (*Synthliboramphus antiquus*), Cassin's auklets (*Ptychoramphus aleuticus*), and rhinoceros auklets (*Cerorhinca monocerata*), respectively (Gaston and Masselink 1997). The latter 2 species are provincially Blue-listed, and the ancient murrelet has been designated as Vulnerable by COSEWIC, due to the threat posed by introduced predators (Gaston 1994). Tufted puffins (*Lunda cirrhata*) are also Blue-listed.

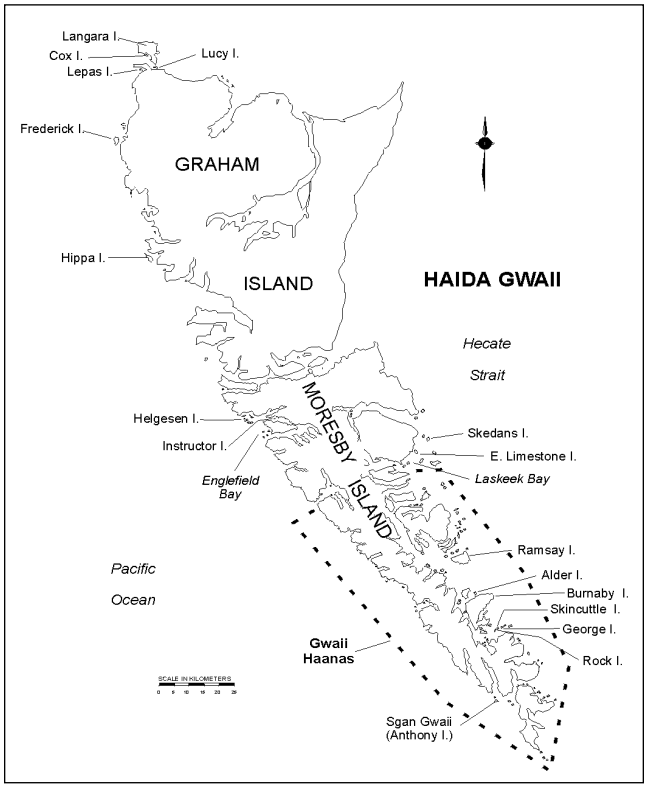

Figure 1. Haida Gwaii, showing the place names used in the text.

Another species of special concern is Peale's peregrine falcon (*Falco peregrinus pealei*). Approximately two-thirds of the British Columbia population of Peale's peregrine falcons, Blue-listed and designated as Rare by COSEWIC, nest in Haida Gwaii (Campbell et al. 1990, Edie 1995). These raptors depend heavily on ancient murrelets as a food source (Nelson 1977) and have declined on at least 1 site where introduced predators eliminated a large proportion of the seabirds (Gaston 1994).

In addition to being an integral component of the Haida Gwaii ecosystem, seabirds of this region represent an important part of the cultural background of the Haida. They are also valued by tourists and, thus, are of economic benefit to the people of Haida Gwaii.

Circumstantial evidence of seabird colony destruction by raccoons in Haida Gwaii has been noted over many years: of 7 known cases of colony abandonment by breeding seabirds, 5 occurred on islands where raccoons have been documented (e.g., Rodway et al. 1988, Gaston 1994). In the early 1990s, 2 studies provided direct evidence of the tremendous destructive potential of raccoons to breeding seabirds (Gaston and Masselink 1997, Hartman et al. 1997).

In 1991, 3 raccoons on East Limestone Island killed an estimated 6% of the approximately 1,200 pairs of breeding ancient murrelets and caused reproductive failure in approximately 10% of the pairs (Gaston and Lawrence 1993, Hartman et al. 1997). Raccoons excavated burrows and ate eggs, chicks, and adults. They also exhibited surplus killing tendencies. The mammals were eradicated prior to the 1992 breeding season. In 1992, predation rates decreased by about 80% from the levels recorded in 1990 (n = 82) and 1991 (n = 106), and no burrow excavations, broken eggs, dead chicks, or headless carcasses were observed (Gaston and Lawrence 1993, Hartman et al. 1997).

On Helgesen Island, where 9–12 raccoons were sighted in 1993, approximately 30,000 burrow-nesting seabirds were eliminated between 1986 and 1993 (Gaston and Masselink 1997). Numbers of rhinoceros auklets, ancient murrelets, and Cassin's auklets on the island declined by approximately 79, 83, and 95%, respectively. The 10,000 pairs of rhinoceros auklets that were lost represented about 30% of the Haida Gwaii breeding population. Evidence that raccoons were responsible for the declines included a large number of burrows that had been excavated by the mammals. In addition, all fresh raccoon scats found on active colony areas contained seabird feathers. Over the same 7-year period, seabird populations on nearby raccoon-free islands increased or were stable (Gaston and Masselink 1997).

By 1992, raccoons had spread to 86% of all islands surveyed in the archipelago that were within 400 m of a

Table 1. Approximate percentage of Haida Gwaii breeding populations of burrow-nesting seabirds covered by 1995 and 1999 management plans. Calculations do not include islands with introduced rats.

Year of plan	Percentage of population covered by plan				
	ANMU[a]	CAAU	RHAU	TUPU	Petrel spp.
1995	87	71	89	5	91
1999	82	89	89	82	85

[a] ANMU = ancient murrelet; CAAU = Cassin's auklet; RHAU = rhinoceros auklet; TUPU = tufted puffin; petrel spp. = *Oceanodroma* spp.

potential source site for dispersing raccoons, and to 1 island approximately 1,000 m from a potential source area (Hartman 1993). Over half of the burrow-nesting seabirds in Haida Gwaii breed on islands within 1,000 m of a potential source area. Although the accessibility of an island to raccoons is influenced by factors other than over-water crossing distance, such as exposure and water currents, the figures above strongly suggest that a large proportion of the archipelago's seabirds are potentially at risk. To date, raccoons have reached at least 7 and possibly 11 islands that support extant seabird colonies (Harfenist and Kaiser 1997).

1995 MANAGEMENT PLAN

In response to the threat posed by raccoons to seabird populations on Haida Gwaii, the Working Group developed a management plan (Working Group 1995*a*). The plan consists of 4 main components: monitoring, control, research, and communication. Several agencies are involved in the issue of raccoon-seabird interactions: the Archipelago Management Board (Council of Haida Nations and Parks Canada); British Columbia Ministry of Environment, Lands and Parks (B.C. Environment, Wildlife Branch, and B.C. Parks), and Environment Canada (Canadian Wildlife Service). Each of the organizations supports the concept of control of introduced species as a means of protecting native species, therefore mandates are consistent with regard to this type of resource management issue.

Monitoring

Our current understanding of raccoon distribution is based primarily on observations of the animals and/or their scats from the last 15 years (e.g., Rodway et al. 1988, van den Brink 1992) and the results of the first 5 years of a raccoon monitoring program (Working Group unpubl. data), and provides limited insight into the raccoon's long-term patterns of range expansion. In the absence of the ability to predict dispersal patterns and probabilities, the Working Group endorsed a large-scale, ongoing, annual monitoring program.

The management plan lists islands that should be checked annually for the presence of raccoons and denotes which government agency is responsible for each island. The responsibility for annual monitoring lies with Parks Canada within Gwaii Haanas, with B.C. Parks within ecological reserves, and with the Canadian Wildlife Service in all other areas. The plan refers to a supplementary monitoring plan (Working Group 1995*b*) that presents the rationale for including or excluding islands. The islands were chosen on the basis of 3 main criteria: probability of access by raccoons (based on over-water crossing distance, exposure, and water currents); size and composition of the seabird population; and status of the island with regard to rats, another introduced predator. In general, large nearshore colonies are of higher priority than are smaller, more offshore ones. Colonies with rats are not included in the annual monitoring list. The selected islands support approximately 90% of all ancient murrelets, rhinoceros auklets, and storm petrels (*Oceanodroma* spp.), and 70% of all Cassin's auklets breeding in the archipelago (Table 1).

Non-colony islands that may be important as stepping stones for raccoons between source areas and colony islands have also been identified (Working Group 1995*b*). The decision about the frequency at which such islands should be monitored was left up to the responsible agency.

Two main methods are outlined for detecting raccoons: scat searches, and spotlight surveys. The former method involves intensive searches for raccoon scats and latrines along a standardized shoreline transect. The transects are approximately 10 m wide and extend from the vegetation edge into the forest. Spotlight surveys involve skirting part or all of an island perimeter by boat at night, while scanning the shoreline and intertidal area with a 750,000+ candlepower spotlight. Raccoons can be detected by the reflection from their eyes. Details of the above methods are given in the monitoring plan (Working Group 1995*b*). Searching for evidence of predation has only limited usefulness as a detection method, because most carcasses are consumed or converted to feather piles within 24 hours (Hartman et al. 1997). The reliability of the monitoring methods is unknown.

Control

The management plan recommends that a control program be carried out on all colonies reached by raccoons. Given the high level of destruction that a small number of raccoons is capable of, the goal of control must be the complete eradication of the mammals from seabird colonies and should be

carried out in the same year as the raccoons are detected. The responsibility for carrying out control of raccoons on seabird colonies in Haida Gwaii rests with Parks Canada within Gwaii Haanas, with B.C. Parks within ecological reserves, and with the Wildlife Branch in all other areas.

The principle method used to control raccoons is hunting at night from a small boat. A spotlight is used to spot the raccoon; the animals are killed using a shotgun (see Working Group 1999 for details). Only skilled and trained staff are permitted to participate in the control, in order to minimize the probability that animals are wounded rather than killed humanely. Hunting with dogs and trapping have been used to control raccoons elsewhere in North America, but an attempt to use dogs on Limestone Island in 1992 failed because the dogs were unable to follow the raccoons over the steep and rocky terrain (Hartman 1994); thus, the method was not recommended for use on most seabird islands.

Removal of raccoons from shorelines adjacent to colony islands in order to reduce the probability of migration is considered in the management plan. However, the Working Group recommended that such a strategy should not be implemented unless a research project is conducted that demonstrates the effectiveness of the technique.

Research

Early research conducted on the interactions between raccoons and seabirds significantly increased our knowledge of the raccoon's current and potential impact on breeding seabirds of Haida Gwaii and formed the basis of the present management plan (Gaston and Masselink 1997, Hartman et al. 1997). However, because raccoons can cause severe damage within a single seabird breeding season, methods of detection and removal must be effective in the early stages of colonization, when raccoon densities may be low. Thus, the research priority is to evaluate the effectiveness of different monitoring and control methods under the environmental conditions found in Haida Gwaii. This includes an evaluation of preventative raccoon control from possible source areas to reduce the rate or probability of dispersal.

Communication

The management of raccoon-seabird interactions crosses the jurisdictional boundaries of several government agencies and is also of concern to non-government organizations and individuals. Annual meetings of the Working Group facilitate information exchange. As part of the plan, Parks Canada developed a central database for the results of all monitoring and control efforts, which ensures that information is not lost with changing personnel. In acknowledgment of increasing public involvement in conservation issues and the sensitivity of control programs, the plan encourages members of the Working Group to ensure that the public is kept informed about the issue and surrounding activities.

RESULTS

Monitoring

In the 4 years since the implementation of the management plan, the 31 seabird colony islands identified as important and vulnerable have been intensively monitored for the presence of raccoons. The results of these surveys indicated that raccoons are no longer on several of the islands from which they had previously been reported: no new signs of raccoons have been noted on Instructor, Rock, Skincuttle, George, Ramsay, or Skedans islands (Working Group unpubl. data). In some cases, the original reports may have been incorrect; for example, raven castings may have been misidentified as raccoon scats (Working Group 1995*b*). For the other islands, the results suggest that either the raccoon(s) left the island or that the individual(s) died before establishing a persistent population. Evidence of new populations of raccoons have been found 3 times during the annual surveys: on Alder and Helgesen islands, and the Limestone Islands (Gaston and Heise 1994, Working Group unpubl. data). In the case of Alder Island, a raccoon latrine was found, but the lack of evidence of raccoons during subsequent spotlight surveys and searches for signs of predation on the colony suggests that the raccoon either returned to nearby Burnaby Island or died.

The low between-island dispersal rate of raccoons indicated by the above results has given the Working Group the confidence to remove 8 of the 31 islands from the list of sites to be checked on an annual basis (Table 2; Working Group 1999). The majority of the islands removed from the list are >1,000 m from a potential source area for raccoons. This reduced effort will allow agencies to focus more on some of the small and easily monitored non-colony islands that are potential stepping stones to important colonies. For example, Lucy Island has been added to the list in light of the successful eradication of rats from the Langara group of islands (Kaiser et al. 1997). Although Lucy Island no longer supports breeding seabirds, it is a stepping stone to Langara and Cox islands, which still support significant populations of ancient murrelets, tufted puffins, and peregrine falcons.

By collaborating, the responsible agencies have been able to decrease individual efforts in terms of human and fiscal resources, yet maintain an effective management program. For example, a Canadian Wildlife Service research crew conducted the monitoring on Frederick Island for B.C. Parks from 1996 to 1998. B.C. Parks also established a partnership with the Haida Fisheries Program, which now monitors Lepas Islet. Cost savings are estimated to have been $3–5,000/year for each agency.

Control

By 1998, the Wildlife Branch had eradicated raccoons at 2 sites: Limestone Islands (Schultze 1994), and Helgesen Island (Gaston and Masselink 1997, Harfenist unpubl. data).

Table 2. Islands selected for annual monitoring for raccoons (Working Group 1995*a*). The 8 islands listed in bold have been dropped from the revised monitoring scheme; the 6 islands in italics have been added (Working Group 1999).

Island	Population of breeding burrow-nesting seabirds[a] (no. of pairs)					Distance to source (m)	Comments
	ANMU	CAAU	RHAU	TUPU	Petrel spp.		
Cape Kuper	10	100	10			<50	
Rogers	1,700	40	20		28,700	100–200	
Lepas		200			8,000	"	
Instructor[b]					1,600	"	
Helgesen[b]	1,100	200	3,300		200	200–300	
Willie	10	200	80			"	
Alder[b]	14,000	3,200			60	"	
Rainy					100	"	
Limestones[b]	1,500	40				300–400	
Luxmoore	1,000	400	300		5,700	"	
Carswell	1,700	200	20		300	400–500	
Shuttle						"	stepping stone
Bischof					50	500–600	stepping stone
Skung Gwaii	200	24,700	13,600	16	10,700	"	
Charles			100		100	600–700	
Annette			20			"	stepping stone
Hippa	40,100	12,500		20	23,700	"	
Rock[b]		5,100			17,000	"	
Skincuttle[b]	2,200	1,000			4,300	"	
George[b]	11,600	5,900				"	
Jeffrey	1,000	2,700				"	
East Copper	4,400	10,900			40	"	
Frederick	68,400	89,900			100	700–800	
Faraday						"	stepping stone
Lyell Bay						"	stepping stone
Bolkus	9,900	1,000	20		200	800–900	
Gordon		600	100			"	
Langtry					12,300	"	
Ellen						900–1,000	stepping stone
Hotspring	6	10			900	>1,000	
Lihou	12,100	13,100	2,800	13	13,500	"	
Rankine	26,000	26,000			14,300	"	
Lucy						"	stepping stone
Howay	300	300			10	"	
Skedans[b]		100			1,100	"	
Ramsay[b]	18,200	12,900				"	
House	2,600	40				"	

[a] Population estimates from Rodway (1991), Gaston and Masselink (1997), and Harfenist (1994); estimates >100 have been rounded to nearest 100. ANMU = ancient murrelet; CAAU = Cassin's auklet; RHAU = rhinoceros auklet; TUPU = tufted puffin; petrel spp. = *Oceanodroma* spp.

[b] These islands have been reached by raccoons (Hartman 1993); evidence for George, Rock, and Instructor is questionable.

Three raccoons were removed from East Limestone Island prior to the 1992 seabird breeding season. The control of raccoons at that site reduced the predation rate in the seabird colony by 80% (Hartman et al. 1997). On Helgesen Island, 3 years of control were required to remove all the raccoons: a total of 7 raccoons were killed (Gaston 1993, Harfenist unpubl. data). A single raccoon, presumed to be a new immigrant, was sighted on the island in 1997 and was eliminated (Harfenist unpubl. data). The control efforts on Helgesen have been successful: ancient murrelets, Cassin's auklets, and rhinoceros auklets have begun to recolonize areas from which they had been almost completely eliminated (Harfenist unpubl. data); 1998 was the first raccoon-free year on Helgesen Island in at least 6 years.

The success of the control efforts at both Limestone and Helgesen islands was strongly influenced by season, local

topography, and weather. The experience gained during nights of hunting raccoons have allowed the Working Group to modify the control protocols to increase the chances of success (Working Group 1999). For example, control efforts on seabird colonies are most effective if conducted outside the seabirds' breeding season, when raccoons are highly visible as they forage down in the intertidal zone. Predators are difficult to see and shoot when they are feeding in the uneven and elevated terrain of the seabird nesting habitat.

Control actions have only been initiated when raccoons have been identified on a seabird colony island. Though some control has been done on adjacent shorelines at the same time, a systematic control program on adjacent shorelines has not been adopted. Although it is likely that removal of raccoons would reduce the probability of raccoons migrating across to colony islands, there is still uncertainty as to the potential effects that removal will have on dispersal behaviour. Crews from the Laskeek Bay Conservation Society and the Wildlife Branch have periodically shot raccoons along the shoreline from which the mammals migrate over to the Limestone Islands. Thirty raccoons have been removed since 1991 (G. Schultze unpubl. data). No new raccoon colonizations have occurred on the Limestones since the 1994 seabird nesting season. Those limited results suggest that further investigation of this technique should be carried out.

Research

Research has been aimed at improving monitoring and control techniques. The Habitat Conservation Fund provided support to the University of Northern British Columbia to investigate the relative effectiveness of various methods. The research program investigated the efficacy of using infrared imaging from the air as a tool for detecting raccoons (Gilbert 1996). The conclusion was that the infrared system is effective at detecting raccoons foraging during low tide when ambient conditions are cool. However, tests were only conducted in areas of high raccoon density and lacked controls. The research also tested hunting raccoons with trained dogs and trapping as control methods. The former method has been successful only in situations where the terrain is flat and free of obstacles (e.g., on sandy beaches or in large estuaries), while on many islands in the archipelago raccoons can traverse topography where dogs and/or humans cannot safely follow. Trapping is labour-intensive and time-consuming. The easy availability of alternative high-quality food sources makes baiting and attracting the animals difficult.

Communication

Communication between the organizations involved in the management of raccoon-seabird issues has been critical to the development and updating of standardized methodologies. A formal annual meeting has now been scaled back to periodic conference calls. Members of the Working Group have participated in numerous public information sessions including talks, radio and newspaper interviews, and displays. The Laskeek Bay Conservation Society and Gwaii Haanas have featured introduced species in their newsletters, which are distributed to a wide audience.

CONCLUSIONS

After 4 years of implementation, the Working Group is confident that its activities are having a significant positive effect on the conservation of seabirds and their habitats at both local and regional scales. Continued monitoring is required to ensure that extant seabirds are not put further at risk from raccoons. However, analysis of the results to date suggests that a revised program that is less costly and less labour-intensive can still provide protection for the nesting seabirds.

The management plan described here was developed to limit the effects of raccoons on breeding seabirds. However, other parts of the intertidal, shoreline, and forest communities are also at risk from raccoons. These concerns remain to be addressed.

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