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Historical Colony Status and Recent Extirpations of Burrow-nesting Seabirds at Seabird Rocks, British Columbia

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Abstract

At Seabird Rocks, British Columbia, Cassin's Auklet (*Ptycoramphus aleuticus*) and Rhinoceros Auklet (*Cerorhinca monocerata*) populations were extirpated and populations of Leach's Storm-Petrels (*Oceanodroma leucorhoa*) and Fork-tailed Storm-Petrels (*O. furcata*) were greatly reduced between 2002 and 2011, apparently due to predation by Northern River Otter (*Lontra canadensis*). Low seabird predation by otters was first noted in 1972 and otters likely accessed the island regularly before 2003, although not every year. High seabird predation by otters from at least 2005 to 2011 reflected extended presence of at least one family group of otters. Tufted Puffins (*Fratercula cirrhata*) declined after 1970 and did not breed there after 1998. Extirpation of breeding puffins apparently was related to human disturbance, and possibly to oil spill mortality, prey changes, and eagle predation. Seabird Rocks is the only breeding location for these five burrow-nesting seabirds in Pacific Rim National Park Reserve and in the Barkley Sound area on southwest Vancouver Island. To better understand the degree of loss and all factors affecting burrow-nesting seabirds at Seabird Rocks, we compiled and re-examined historical information on occurrence, population size, and conservation issues for all six species of burrow-

Figure 1. Seabird Rocks, British Columbia, has an area of 0.3 ha and reaches an elevation of 15 m. About 0.1 ha of the islet is vegetated with grasses and forbs (mostly *Elymus* spp. and *Heracleum* spp.) surrounding a central band of salmonberry (*Rubus spectabilis*). There is a navigation light atop the highest knoll, June 2010. *Photo by Peter V. Clarkson.*

nesting seabirds at this colony. Pigeon Guillemot (*Cepphus columba*) was first documented breeding in 1894 and 1896 and Leach's Storm-Petrel and Tufted Puffin in 1943. Surveys in 1970 and 1972 recorded all six burrow-nesting species. After re-assessing the most recent and only comprehensive survey in 1988, population estimates were revised: Leach's Storm-Petrel – 715 pairs; Fork-tailed Storm-Petrel – 318 pairs; Pigeon Guillemot – 50 to 70 pairs; Cassin's Auklet – 269 pairs; Rhinoceros Auklet – 140 pairs; and Tufted Puffin – four pairs. No major changes in population sizes for storm-petrels, guillemots, and auklets were evident from 1970 to 2002 and major impacts from gill-net fishing, oil pollution, predation, or human disturbance were not observed for these species during this period, although Cassin's and Rhinoceros auklet population sizes may have been reduced by gill-netting and oil spills.

Introduction

Seabird Rocks (48.75º N; 125.15º W; Figures 1, 2, and 3) support the only breeding populations of two storm-petrel species, two auklet species, and one puffin species in the vicinity of Barkley Sound and adjacent areas on the southwest coast of Vancouver Island, British Columbia, comprising the majority of breeding seabirds in Pacific Rim National Park Reserve (PRNPR) (Guiguet 1971, Hatler et al. 1978; Rodway 1991; Figure 4). Eight species of seabirds have been documented breeding there: Fork-tailed Storm-Petrel (*Oceanodroma furcata*); Leach's Storm-Petrel (*O. leucorhoa*); Pelagic Cormorant (*Phalacrocorax pelagicus*); Glaucous-winged Gull (*Larus glaucescens*); Pigeon Guillemot (*Cepphus columba*); Cassin's Auklet (*Ptychoramphus aleuticus*); Rhinoceros Auklet (*Cerorhinca monocerata*); and Tufted Puffin (*Fratercula cirrhata*). Breeding and occurrence of seabirds were first documented between 1894 and 1945 by early naturalists. Population surveys were conducted between 1970 and 1982 by the British Columbia Provincial Museum (BCPM; currently known as the Royal British Columbia Museum [RBCM]), PRNPR, Bamfield Marine Sciences Centre (BMSC), and the Canadian Wildlife Service (CWS). Much information from work between 1894 and 1982 at Seabird Rocks has not been previously published or widely available. Between 1986 and 2002, several detailed studies by the University of Victoria (UVIC), BMSC, Simon Fraser University (SFU), and CWS were conducted at Seabird Rocks (Burger et al. 1993; Davoren and Burger 1999; Davoren 2000; Bertram et al. 2002, unpubl. data). The only extensive surveys of burrow-nesting species were conducted in 1988 (Burger 1988); these estimates were included in seabird population summaries for the west coast of Vancouver Island (Rodway and Lemon 1990) and British Columbia overall (Rodway 1991).

Figure 2. Densely vegetated, burrow-nesting habitat on the sides of knolls on Seabird Rocks, June 2010. *Photo by Peter V. Clarkson.*

Figure 3. About two-thirds of Seabird Rocks consist of rocky and beach habitats, 27 May 2011. *Photo by Percy N. Hébert.*

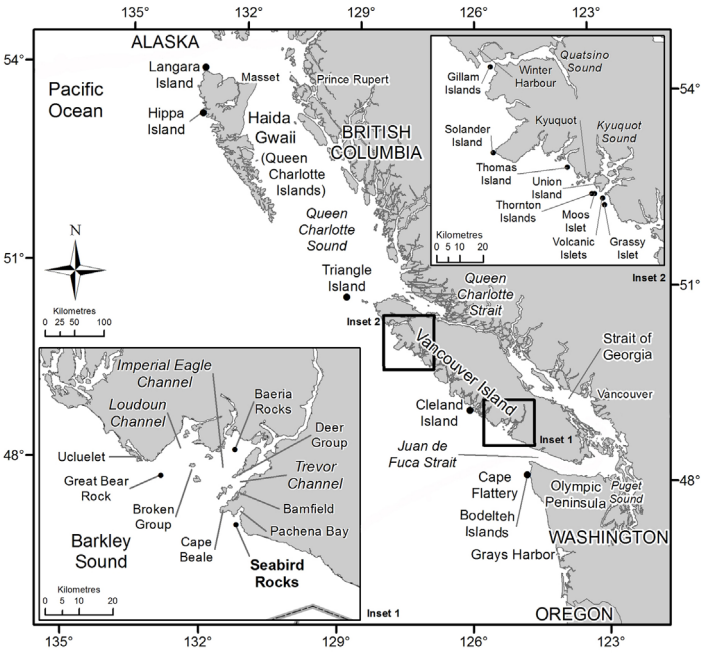

Figure 4. Location of Seabird Rocks (inset 1) in relation to other seabird colonies (black dots) in the vicinity of Barkley Sound, colonies at northwest Vancouver Island (inset 2), and other locations along the British Columbia coast mentioned in the text. *Map prepared by CloverPoint Cartographics Ltd., Victoria, British Columbia*.

Figure 5. Usually the first species to be noticed when landing on small islands to check for nesting seabirds are Glaucous-winged Gulls, either flying noisily over the colony or standing on territories. *Photo by R. Wayne Campbell.*

From 2005 to 2011, PRNPR and others visited Seabird Rocks annually to survey Glaucous-winged Gulls (Figure 5), Black Oystercatchers (*Haematopus bachmani*), and Pelagic Cormorants (White et al. 2006, Carter et al. 2007; Crawford and Irvine 2010; PVC and YZ, unpubl. data). However, burrow-nesting species had not been surveyed since 1988 or studied since 2002. Between 2005 and 2010, many unoccupied burrows, relatively large numbers of seabird carcasses, and the absence of Tufted Puffins were noted. In 2011, PRNPR and Carter Biological Consulting (CBC) conducted more extensive surveys at Seabird Rocks and suspected that five of six burrow-nesting species (all except Pigeon Guillemot) had been extirpated or nearly extirpated, apparently due mainly to extensive predation by at least one family group of Northern River Otters (*Lontra canadensis*) (Clarkson et al. 2011a, b). In 2012, additional PRNPR surveys (YZ and PVC, unpubl. data) confirmed apparent extirpations of Cassin's Auklets, Rhinoceros Auklets, and Tufted Puffins, recorded greatly reduced numbers of Leach's and Fork-tailed storm-petrels still attending the colony, and confirmed the presence of one to two family groups of otters at the island. Extirpation of breeding auklets and puffins and the potential future extirpation of breeding storm-petrels at the Seabird Rocks colony is a major concern.

For this paper, we collated published and unpublished information on the known history of occurrence, breeding population size, predation, and other conservation issues for all six species of burrow-nesting seabirds at Seabird Rocks from 1894 through 2011. We also revised 1988 breeding population estimates after discovering errors in the original calculations. This information will assist PRNPR with assessing the degree of loss of seabird populations from otter predation and future goals for restoration and monitoring of this important seabird colony. We also include several unpublished historical records of surface-nesting seabirds and Black Oystercatchers that indicate predation impacts on both surface-nesting and burrow-nesting species for future work that examines trends in surface-nesting species. However, we did not compile all information on surface-nesting species or fully assess changes in their populations.

Methods

Historical breeding records and information on burrow-nesting seabirds at Seabird Rocks were obtained from: (1) the literature, including unpublished sources; (2) British Columbia Nest Record Scheme (BCNRS; Myres et al. 1957; Campbell et al. 2011); (3) unpublished data of the authors; (4) unpublished data from researchers between 1995 and 2002, especially D. Bertram and G. Davoren; (5) and specimen records in museum collections.

Specimen records were obtained through the Ornithology Information System [ORNIS], online museum databases, or in-person visits by HRC for the following museums: Canadian Museum of Nature (CMNAV; Gatineau, Quebec), with assistance from M. Gosselin; Museum of Comparative Zoology (MCZ; Cambridge, Massachusetts), with assistance from J. Trimble; Royal British Columbia Museum (RBCM; Victoria, British Columbia; Figure 6), with assistance from G. Hanke, M. McNall, L. Kennes, and K. Sendall; University of British Columbia (UBC; Beaty Biodiversity Museum, Cowan Tetrapod Collection, Vancouver), with assistance from R. Kenner; and University of Nebraska State Museum (UNSM; Lincoln, Nebraska), with assistance from T. Labedz.

Distances of islands from the adjacent mainland were estimated using Google maps distance calculator.

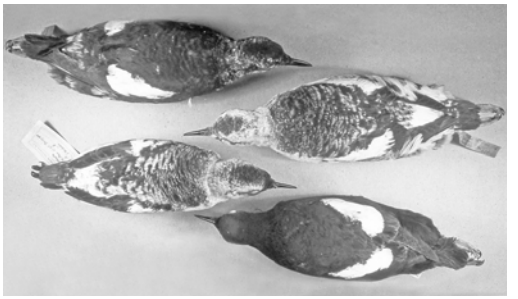

Figure 6. Ornithology collections in North American museums are important sources of historical information on seabirds, such as these Pigeon Guillemot specimens housed in the Royal British Columbia Museum in Victoria. *Photo by R. Wayne Campbell.*

Results

Records of Breeding and Occurrence (1894 to 1912)

Drent and Guiguet (1961) did not list any breeding records of seabirds at Seabird Rocks prior to 1943. We uncovered the following records in the Seabird Rocks area in 1894 to 1912. Macoun (1900) reported two Pigeon Guillemot eggs (CMNAV #E411) and two Black Oystercatcher eggs (CMNAV #E410) collected at "Sea Bird Island, Barclay [sic] Sound, west coast of Vancouver Island, June 1st 1896 by Dr. C. F. Newcombe." However, Macoun and Macoun (1909) did not mention these specimens. The original labels read Bird I., Barclay Sd., B.C. C.F.N. *1.6.96* (M. Gosselin pers. comm.). We could not confirm whether these specimens were actually from Seabird Rocks or from other more accessible rocks or islands where these species also breed in Barkley Sound (e.g., Baeria Rocks, Great Bear Rock; see Figure 4) (Drent and Guiguet 1961, Guiguet 1971). However, we also found an earlier Pigeon Guillemot egg (RBCM #E1667) (Figure 7) collected by Newcombe on 14 June 1894 with "Pachena Bay" and the date written on the egg. The only island with breeding seabirds in or near Pachena Bay is Seabird Rocks (Guiguet 1971; Campbell 1976). One Glaucous-winged Gull egg (RBCM #E211) also was collected by Newcombe on 14 June 1894 on the west coast of Vancouver Island, apparently at Seabird Rocks, based on the collection date matching RBCM #E1667 and no other gull colonies nearby. We believe that the 1894 and 1896 egg specimens were obtained by Newcombe at Seabird Rocks. We also found six specimens of Leach's Storm-Petrel (MCZ #251099, #251100, #251101, #251102, #251103; UNSM #9315) that had been reported as collected by C. Ackerman at Cape Beale, near Seabird Rocks, on 27 April 1912, which are the first occurrence records for Leach's Storm-Petrel in the Seabird Rocks area.

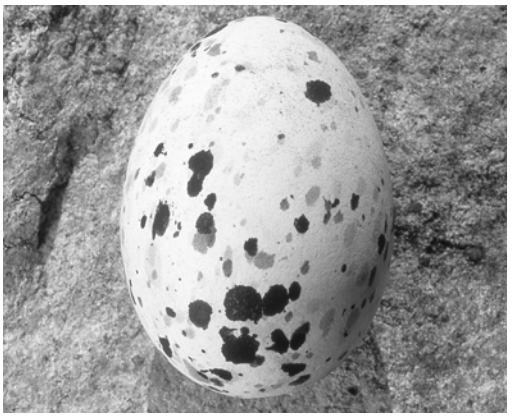

Figure 7. The earliest evidence of seabirds breeding on Seabird Rocks, was a Pigeon Guillemot egg collected in 1894 (an example is shown here). *Photo by R. Wayne Campbell.*

Theed Pearse's Observations (1943 and 1945)

Naturalist Theed Pearse visited Seabird Rocks on 19 August 1943 and 11 August 1945, and first documented most species of burrow-nesting and surface-nesting seabirds (Pearse 1946a, unpubl. field notes retrieved by RWC for the BCNRS). Drent and Guiguet (1961) mistakenly noted the 1943 visit as 1944. On 19 August 1943, Pearse reported many observations in his unpublished field notes:

Figure 8. While banding young Glaucous-winged Gulls on Seabird Rocks, in the mid-1940s, Theed Pearse kept notes of all birds seen. *Photo by R. Wayne Campbell.*

Leach's Storm-Petrel – "in the guano dirt between rocks were numerous burrows of Beale's Petrel; there must be a considerable number as in a very short time I found three holes with a youngster … walking over some of these peaty-like places it seemed to sink and one feared to cover in some burrows."

Pelagic Cormorant – one recorded but not nesting.

Black Oystercatcher – "there were some oystercatchers, perhaps 20, and a pair were [sic] very fussy near the landing and I found a nest, collection of bits of clam shells and a rotten egg. Possibly there were young birds around."

Glaucous-winged Gull – about 400 adults and a number of young recorded, 37 banded (Figure 8).

Western Gull (*Larus occidentalis*) – One to two pairs plus a mixed Western/Glaucous-winged pair; breeding not confirmed, but one pair stayed together in same place.

Pigeon Guillemot – "probably completed nesting; a few in water offshore; none flying around rocks."

Rhinoceros Auklet – One recorded on the water.

Tufted Puffin – "that puffins nest and probably on the central mound was evidenced by one or two birds flying in with fish and there were half a dozen in the water offshore with Pigeon Guillemots."

Pearse (1946a) thought his observations of breeding Leach's Storm-Petrels at Seabird Rocks were the first evidence of breeding by this species on Vancouver Island but this was not the case. Although not widely known in the 1940s, Leach's and Fork-tailed storm-petrels had been found breeding at several locations around northern and western Vancouver Island between 1909 and 1929, including Cleland Island in nearby Clayoquot Sound in 1925 (Drent and Guiguet 1961, Carter 2004, Carter and Sealy 2011). Pearse (1946b) reported breeding by Western Gulls, but Drent and Guiguet (1961) later indicated extensive hybridization between Glaucous-winged Gulls and Western Gulls in southern British Columbia and removed Western Gull as a breeding species in the province. Pearse was the first to document breeding Tufted Puffins at Seabird Rocks, in 1943 (see unpublished field notes above), but he did not publish this finding.

Pearse (1946a: 133) also published a good description of Leach's Storm-Petrel breeding habitats and predation at Seabird Rocks, as follows:

"The Rock, more of an exposed reef, has an area of some two acres [about 0.8 ha, an overestimate] above high tide, is of an uneven surface cut up by small gullies and a hillock rises on the south side some fifty feet [about 15 m] above the general level. On sides of this hillock and in the gullies there is a considerable growth of vegetation, a rush-like grass predominating [see Figure 2]. The result of the yearly dying down of this vegetation plus guano has formed peat-like areas and it is in these the petrels have their nests. Without attempting any count it was evident there was a considerable number of nests scattered through these peaty areas, particularly as many burrows would not have been visible owing to the vegetation ... In one burrow, opened up [on 11 August 1945], there was a bird and an egg but the condition of the latter, congealed yolk, made it doubtful if it was even this year's laying (this egg is now in the collection of Mr. Walter Maguire, New Westminster, B.C. [Note: egg not found at UBC or RBCM], other burrows did not produce any birds but, as [Leach's Storm-Petrel] banding was off, I did not attempt much in this way … I picked up a dead [Leach's] petrel and saw the remains of others, also where three glaucous-winged gulls had been plucked so it looked as though some predator, possibly a [Great] horned owl (*Bubo virginianus*) [Figure 9] was working the rock, which is only about four miles [4.6 km, apparently measured to the Cape Beale area, not the nearest point] from Vancouver Island."

Figure 9. Theed Pearse suspected that a Great Horned Owl may have been responsible for dead, plucked Glaucous-winged Gulls found on Seabird Rocks in 1945. *Photo by R. Wayne Campbell.*

British Columbia Provincial Museum Survey (1970)

BCPM (Charles J. Guiguet and J. Bristol Foster) spent one day on Seabird Rocks on 12 June and provided the first detailed description of burrow-nesting and surface-nesting seabird populations (Guiguet 1971). Excerpts of observations for burrow-nesting species included:

Storm-Petrels – "Island honeycombed with burrows of [Leach's and Fork-tailed storm-petrels], both uncovered from shallow burrows in a very few seconds after landing, indicating dense population. Fragile nature of this small rookery precluded extensive digging." Specimens of an adult and downy young Fork-tailed Storm-Petrel were collected (RBCM #11665, #11666), as well as a brooding adult and fresh Leach's Storm-Petrel egg (RBCM #11667; egg uncatalogued).

Pigeon Guillemot – "Between 70 and 80 guillemots perched on this island. Adults on nests and eggs in heavy beach debris located upon landing [Figure 10], did not search further. Breeding population of 70 pairs indicated."

Figure 10. Pigeon Guillemots perched in small groups on low rocky outcrops usually indicates nesting in nearby crevices or cavities. *Photo by R. Wayne Campbell.*

Cassin's Auklet – "Although concrete evidence of this species nesting on the Seabird Rocks was not found, it almost certainly does so. The species is seen in small numbers annually during the summer in Barkley Sound. Digging of burrows on this fragile rookery was discontinued due to the obvious damage being done."

Rhinoceros Auklet – "Two incubating adults were uncovered in very short order, and it was obvious from burrows that an appreciable nesting population utilizes the island. More than 40 adults in breeding plumage were observed nearby. Two fully incubated eggs were collected [Note: eggs not found at UBC or RBCM]."

Tufted Puffin – "A burrow, excavated, contained an incubating adult and one egg. The egg was collected. [Note: egg not found at UBC or RBCM.] A small nesting population is indicated, some 24 individuals were circling and on the sea in the vicinity of the island."

Pacific Rim National Park Reserve Survey (1972)

PRNPR (DFH) conducted a trip to Seabird Rocks on 24-25 July and provided a careful description of burrow-nesting and surface-nesting seabirds (Hatler et al. 1973, 1978). Excerpts of observations for burrow-nesting species included:

Storm-Petrels – "two [of 12 burrows examined] contained an adult [Leach's Storm-Petrel; Figure 11] on a single egg … Nine burrows contained adults [Leach's], probably on eggs, and the remaining burrow contained a cold egg." DFH also found a "nearly-fledged nestling" Fork-tailed Storm-Petrel. More than 500 pairs of Leach's Storm-Petrel were estimated; no estimate was made for Fork-tailed Storm-Petrels.

Figure 11. Adult Leach's Storm-Petrel extracted from its dirt burrow. *Photo by R. Wayne Campbell.*

Pigeon Guillemot – "a nest with a single egg [was found] under a drift stump on the east side of the island ... a maximum of 84 Pigeon Guillemots was seen [during counts from the peak of the island]. This agrees with Guiguet's count and indicates that a realistic estimate of a breeding population for the island would be 50 pairs or more."

Cassin's Auklet – "several burrows of Cassin's Auklets were found in a patch of wild rye (*Elymus* sp.) on the southwest end of the vegetated area on Seabird Rocks [Of 17 examined] 13 burrows were empty, three burrows had nearly fledged chicks, and 1 burrow had a small, dead chick. A few burrows of the Rhinoceros Auklet, and many of Leach's Storm-Petrel, were among the Cassin's Auklet "colony," making an estimate of its size difficult. The *Elymus* patch, a rough ellipse about 15 m by 50 m, could accommodate up to 700 pairs at a density of one burrow per square metre. There appeared to be holes in at least this density, but many belonged to other species, especially storm-petrels and, as the data given above indicate, two thirds of the Cassin's burrows proved to be empty. There are probably fewer than 100 pairs of Cassin's Auklets nesting on Seabird Rocks."

Rhinoceros Auklet – "two [of 10 burrows examined] contained single, half-grown young, one an unattended egg, and seven were empty. On the evening of July 24, Rhinoceros Auklets were landing over much of the island and were seen walking among the piles of drift logs, on areas of bare rock, and throughout the vegetated area. Most of the burrows of Rhinoceros Auklets were found under *Elymus* and *Heracleum* [Cow Parsnip] although some occurred at the edges of, but not far inside, the central patch of *Rubus spectabilis* [Salmonberry]. The number of nesting pairs is difficult to assess because of the number of empty burrows encountered ... Judging from the number of birds which arrived on the island on the night of July 24, 1972, an estimate of 150 pairs would not be out of line. There may well be more."

Tufted Puffin – "There is a small colony of Tufted Puffins on Seabird Rocks which nests mostly among *Elymus* on the knoll supporting the D.O.T. [Department of Transport] light. The east side of this knoll has been compacted and caved in, apparently by D.O.T. personnel who service the light, and it supports few active burrows. One dead egg was found near the mouth of a burrow at the edge of the path through this area on July 24, 1972 ... On July 24, 1972, adults carrying fish were seen to land in the colony, but the maximum number seen around Seabird Rocks at one time on that and the following day was 13. There may be as few as 20 pairs in the main colony, but this probably could be increased, perhaps doubled, if disturbance around the light was reduced. There are also a few puffins nesting among the drift logs on the lower parts of the island. One downy young was found there on the visit on July 24."

On the July 1972 visit, Hatler et al. (2008) found the remains of several Leach's Storm-Petrels and five Rhinoceros Auklets that had only partially been eaten and that DFH suspected had been preyed upon by otters (Figure 12).

Figure 12. Rhinoceros Auklet remains (shown here) and Leach's Storm Petrel remains (see Figure 27) found by David Hatler in 1972 provided the first evidence of Northern River Otter predation on nesting seabirds on Seabird Rocks. *Photo by R. Wayne Campbell.*

British Columbia Provincial Museum Survey (1975)

BCPM (Michael G. Shepard, Marilyn A. Paul and Betty L. Peers) surveyed nesting seabirds at Seabird Rocks on 16 July, as part of the first complete survey of seabird colonies on the west coast of Vancouver Island, under the direction of RWC and C.J. Guiguet (Campbell 1976, unpubl. data). Observations compiled in the BCNRS were as follows:

Leach's Storm-Petrel – 50-100 pairs estimated (three eggs found).

Brandt's Cormorant (*P. penicillatus*) – Four recorded around island (not breeding).

Pelagic Cormorant – 23 nests counted (most with eggs).

Black Oystercatcher – Seven nests counted (eggs or chicks in four nests) (Figure 13).

Figure 13. Soon after hatching, Black Oystercatcher chicks (top centre) leave their nest scrape to hide in adjacent habitats to avoid predators. *Photo by R. Wayne Campbell.*

Glaucous-winged Gull – 279 nests counted (most with eggs or young).

Pigeon Guillemot – 50 birds recorded around island (several carrying fish) and one nest with one egg under driftwood.

Rhinoceros Auklet – 100 pairs estimated (18 adults seen around island; 10 dead birds found – "probably killed by American Mink (*Neovison vison*)."

Tufted Puffin – Burrows near peak of island (10 adults recorded around island).

Bald Eagle (*Haliaeetus leucocephalus*) – One adult recorded.

Campbell (1976) reported breeding estimates for burrow-nesting seabird species at Seabird Rocks derived mainly from unpublished July 1972 data (Hatler et al 1973; Table 1). Twenty-three Pelagic Cormorant nests were observed by the BCPM field crew in 1975 (also see Carter et al. 2007), whereas none were reported breeding in 1972 by Hatler et al. (1973, 1978).

Ten dead Rhinoceros Auklets found by the BCPM field crew in July 1975 were originally suspected of being killed by American Mink. Although minks occur widely on the Deer Group and Broken Group islands in Barkley Sound (DFH, unpubl. data), we are not aware of any confirmed records for Seabird Rocks. The diagnosis of probable mink predation was based on decapitation of several of the carcasses (M.G. Shepard, pers. comm.) but decapitations also are a feature of predation by a number of other carnivores, including river otters (DFH, unpubl. data).

Bamfield Marine Sciences Centre Burrow Survey (1979)

BMSC (Rudolf H. Drent, RWC, HRC, and many students) conducted a day trip to Seabird Rocks on 17 July, during a field trip for the Marine Birds course. Results from this trip were presented in a student's unpublished class report (Ferguson 1979), available in the library at the BMSC and at the RBCM (Vertebrate Zoology Division). Storm-petrels and Cassin's Auklets (Figure 14) were found nesting on a knoll in a gully. Using measurements made with a surveyor's tape (HRC assisted with most of these measurements), the areas of the knoll (34 m x 33 m = 1,122 m^2, rounded to 1,000 m^2) and gully (16 m x 19 m = 304 m^2, rounded to 250 m^2) were estimated.

Table 1. Estimates of numbers of breeding pairs of burrow-nesting seabirds at Seabird Rocks, in 1970-1975 and 1988.

Species	1970-1975[1]	1988 Original[2]	1988 Revised[3]
Fork-tailed Storm-Petrel	10	194	318
Leach's Storm-Petrel	500	432	715
Pigeon Guillemot	50	ND	(50-70)[4]
Cassin's Auklet	100	164	269
Rhinoceros Auklet	150	133	140
Tufted Puffin	20	8	4

[1] Sources: Campbell (1976), Hatler et al. (1978).

[2] Source: Rodway and Lemon (1990).

[3] Source: This study.

[4] Source: Estimate from 1970-1975 data, including 70 pairs estimated in 1970 (Guiguet 1971).

Figure 14. Harry Carter with an adult Cassin's Auklet and egg extracted from a dirt burrow amid grasses on Byers Island, British Columbia, 27 June 1976. *Photo by R. Wayne Campbell.*

Ten Leach's Storm-Petrel burrows and eight "unknown" burrows were counted within a 3-m x 3-m plot; for storm-petrel nests, recorded nest contents were: (1) adult and young (n = 4); (2) adult and egg (n = 1); and (3) empty (n = 5). A total of 2,500 burrows of storm-petrels and auklets, apparently mostly Cassin's Auklets, were estimated based on 18 burrows/9 m^2 over a total area of about 1,250 m^2. For later comparison between the 1979 and 1988 surveys (see Discussion), we derived 1979 estimates of: (1) 1,388 storm-petrel burrows by multiplying the density of storm-petrel burrows in the single plot (1.11/m^2) by the estimated colony area (1,250 m^2); (2) 50% occupancy of the 10 storm-petrel burrows in the single plot; and (3) 1,113 auklet burrows by multiplying the density of "other" burrows in the single plot (0.89/m^2) by the estimated colony area (1,250 m^2). Other observations included:

Fork-tailed Storm-Petrel – One burrow on the knoll (with adult and chick).

Double-crested Cormorant (*P. auritus*) – One recorded (not nesting).

Brandt's Cormorant – 21 recorded (not nesting).

Pelagic Cormorant – 56 recorded (not nesting).

Glaucous-winged Gull: 191 nests: empty (*n* = 79), one egg (*n* = 29), two eggs (*n* = 44), three eggs (*n* = 27), four eggs (*n* = 1), one chick (*n* = 3), three chicks (*n* = 1), "scrambled" (presumably broken but not depredated) eggs (*n* = 7) (Figure 15).

Figure 15. Some Glaucous-winged Gull nests on rocky islands off the west coast of Vancouver Island are composed entirely of seaweeds, as grasses, the typical material elsewhere, are scarce. *Photo by R. Wayne Campbell.*

Black Oystercatcher –Seven recorded but no nests reported.

Pigeon Guillemot – One egg in "rubble" (likely referring to driftwood piles).

Rhinoceros Auklet – One chick.

Tufted Puffins – 12 recorded.

Bald Eagle – Four recorded.

Canadian Wildlife Service Survey (1982)

CWS (Gary W. Kaiser and J. Reeve) conducted a brief seabird survey at Seabird Rocks on 12 June and noted (G.W. Kaiser, unpublished field notes in BCNRS):

Pelagic Cormorant – 47 recorded (not nesting).

Black Oystercatcher – Three nests counted (two eggs each; Figure 16) and at least five nests estimated.

Figure 16. On Seabird Rocks, small numbers of Black Oystercatchers nest on the upper beaches among driftwood or at the edge of vegetation. *Photo by R. Wayne Campbell.*

Glaucous-winged Gull – 195 nests counted (most with eggs).

Common Murre (*Uria aalge*) – Four recorded (probably on the water; not nesting).

Pigeon Guillemot – 33 recorded.

Tufted Puffin – Eight recorded.

Bald Eagle – Four subadults recorded.

University of Victoria Research (1986-1997)

Many seabird studies were conducted by UVIC (AEB and others) between 1986 and 1997 (e.g., Burger et al. 1993). Below, we: (1) present details for 1986 observations; (2) reassess the important 1988 burrow survey and population estimates; (3) present observations of predators in 1986-1993; and (4) provide general notes for research in 1995-1997.

Observations (1986)

AEB and others conducted various overnight and day visits to Seabird Rocks on: (1) 5 June (AEB, R. Wilson); (2) 6-9 and 13-14 June (R. Wilson); (3) several other times in June and July (D. Duncan); and (4) 20-21 August (AEB). On the 5 June visit, AEB noted:

Fork-tailed Storm-Petrel – Grubbed a few storm-petrel burrows and found one adult Fork-tailed Storm-Petrel with a brood patch.

Double-crested Cormorant – Several observed (not nesting).

Brandt's Cormorant – Several observed (not nesting).

Pelagic Cormorant – Two roosting adults observed; nesting not noted but little attention was paid to cormorants overall.

Black Oystercatcher – 15 pairs estimated (three nests with eggs found).

G*laucous-winged Gull* – 300-400 gulls present, including 100 immatures; many nests were being built but no eggs were seen, and estimated 600-700 of all ages roosting on 20-21 August.

Pigeon Guillemot – 121 recorded (and suspected more) around the island (no nests found, but little time spent looking).

Cassin's Auklet – Grubbed a few burrows and found three adults incubating eggs and one cold egg.

Rhinoceros Auklet – Many occupied burrows.

Tufted Puffin – Nine observed (more suspected); one pair with a warm egg found in a burrow on the east side high on the hill with the navigation light.

Bald Eagle – Four flying over the island; later, two immatures sitting on the island (Figure 17).

On the 20-21 August visit, AEB noted Glaucous-winged Gulls (only one pair had a chick; 600-700 of all ages roosting), Leach's Storm-Petrels, Cassin's Auklet, Rhinoceros Auklet (Figure 18), and Tufted Puffin still feeding young, and observed several fledged Pigeon Guillemots near the island. Twelve Leach's Storm-Petrels, five Fork-tailed Storm-Petrels, one Cassin's Auklet, and three Rhinoceros Auklets were mist-netted at night. Breeding failure was evident for most Glaucous-winged Gulls, and AEB also noted breeding failure on Baeria Rocks in 1986. Duncan reported many depredated gull eggs scattered about, possibly the result of Northwestern Crow (*Corvus caurinus*) predation (two pairs of crows bred on the island).

Figure 17. Small numbers of Bald Eagles, adult and immatures, roost on Seabird Rocks, especially during periods when marine and bird prey are easily available nearby. *Photo by R. Wayne Campbell.*

Figure 18. By the third week of August, Rhinoceros Auklet young on Seabird Rocks are large and often just show traces of downy plumage. *Photo by R. Wayne Campbell.*

Burrow Survey (1988)

On 30 July 1988, AEB and D. Garnier conducted the only detailed survey of burrows of storm-petrels and alcids at Seabird Rocks (Burger 1988). Population estimates from this survey were used in the regional report by Rodway and Lemon (1990) and in the provincial summary by Rodway (1991). By comparing the summary provided in Rodway and Lemon (1990) with Burger (1988) and AEB's field notes, we (1) more exactly articulated how storm-petrel and alcid breeding estimates were made; (2) detected errors in determining burrow totals for certain sections and habitats; and (3) detected estimation errors in determining the number of breeding pairs for certain species.

Seabird Rocks was delineated into seven habitat sections (Figure 19; Table 2) in which populations of burrow-nesting seabirds were estimated in 1988. We reassessed the estimates of each species for each of the habitat sections and revised them where necessary:

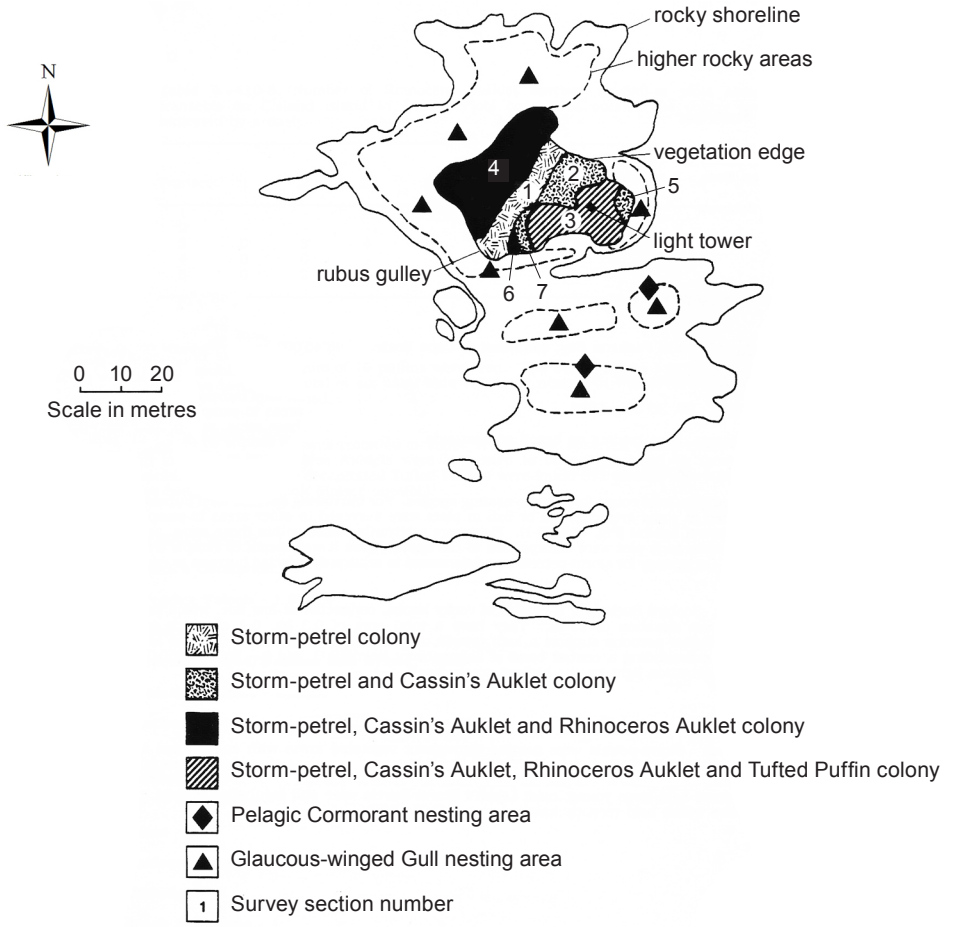

Figure 19. Sections of Seabird Rocks, used by burrow-nesting seabirds in 1988 (from Rodway and Lemon [1990] as modified from Hatler et al. [1973]; note that section #4 was not labeled originally but is given here).

Table 2. Number of burrows estimated for five species of seabirds within seven sections of Seabird Rocks (see Figure 18) in 1988, using original or revised estimates (see text).

Section	Area (m^2)	Storm-Petrel[1] (original)	Storm-Petrel[1] (revised)	Cassin's Auklet (original)	Cassin's Auklet (revised)	Rhinoceros Auklet (original)	Rhinoceros Auklet (revised)	Tufted Puffin (original)	Tufted Puffin (revised)
1	150	54	54	0	0	0	0	0	0
2	80/250[2]	151	472	44	139	0	0	0	0
3	Unk[3]	88	175	78	124	8	17	8	8
4	Unk	133	132	29	29	156	156	0	0
5	84.5	103	103	9	9	0	0	0	0
6	Unk	4	4	18	18	9	9	0	0
7	60	93	93	40	40	0	0	0	0
Total	Unk	626	1,033	218	359	173	182	8	8

[1] Includes Fork-tailed and Leach's storm-petrels.
[2] Original estimate, 80; revised estimate, 250.
[3] Unknown; direct count used.

Section #1 (*Rubus* thicket in NW gulley) – Original estimate: a 5 m x 30 m plot was searched and nine storm-petrel burrows were counted. Burrow densities were determined for storm-petrels ($0.36/m^2$) and Cassin's Auklet ($0.00/m^2$). Fifty-four storm-petrel burrows were extrapolated, using a roughly estimated area of 5 m x 30 m (150 m^2). Revised estimate: None required.

Section #2 (*Rubus* thicket on N slopes) – Original estimate: A 3-m x 3-m plot was searched and 17 storm-petrel burrows (one with a probable large Fork-tailed Storm-Petrel chick) and five Cassin's Auklet burrows were counted. Outside the plot, three Leach's burrows were found, two with eggs and one with an adult but the egg was either not present or not detected. Burrow densities were determined for storm-petrels ($1.89/m^2$) and Cassin's Auklet ($0.56/m^2$). Totals of 151 storm-petrel burrows and 44 Cassin's Auklet burrows were extrapolated, using a roughly estimated area of 8 m x 10 m (80 m^2). Revised estimate: AEB field notes stated a total area of about 250 m^2 and 364 storm-petrel burrows and 138 Cassin's Auklet burrows were extrapolated. AEB and Garnier rounded up to 400 storm-petrel burrows because 364 was thought to be "low" and rounded down to about 100 Cassin's Auklet burrows because 138 was thought to be "too high." However, the storm-petrel estimate may have seemed low due to an error in extrapolation. Based on our re-examination of these field notes, the extrapolated number of burrows should have been 472 and 139 for storm-petrels and Cassin's Auklets, respectively.

Section #3 (grasses on all sides of knoll) – Original estimate: Direct count of nests yielded 88 storm-petrel (one with Leach's Storm-Petrel chick and one with Fork-tailed Storm-Petrel chick), 78 Cassin's Auklet, eight Rhinoceros Auklet, and eight Tufted Puffin burrows. Revised estimate: AEB field notes stated a total of 175 storm-petrel burrows (including one Leach's Storm-Petrel nest and one Fork-tailed Storm-Petrel nest), 124 Cassin's Auklet, 17 Rhinoceros Auklet, and eight Tufted Puffin burrows for this area. The numbers reported by Rodway and Lemon (1990) reflected a partial count for this area by AEB and did not include burrows counted by Garnier. A revised estimate was not required for Tufted Puffin.

Section #4 (grassy tussock in NW lower area) – Original estimate: Direct count of 133 storm-petrel burrows (including four Leach's Storm-Petrel nests and one probable Fork-tailed Storm-Petrel nest), 29 Cassin's Auklet burrows, and 156 Rhinoceros Auklet burrows. Revised estimate: AEB field notes stated a total of 132 storm-petrel burrows, which we consider to be most accurate. Revised estimates were not

required for Cassin's and Rhinoceros auklets.

Section #5 (grassy tussock on level patch in SE area) – Original estimate: For this patch of grasses (13 m x 6.5 m), a 3-m x 3-m plot was searched and 11 storm-petrel burrows (one with a large chick, possibly a Fork-tailed Storm-Petrel) and one Cassin's Auklet burrow were counted. Burrow densities were determined for storm-petrels (1.22/m^2) and Cassin's Auklet (0.11/m^2). Totals of 103 storm-petrel burrows and nine Cassin's Auklet burrows were extrapolated. Revised estimate: None required.

Section #6 (more open grasses on W side of knoll) – Original estimate: Count of four storm-petrel burrows, 18 Cassin's Auklet burrows (two with chicks, others unknown), and nine Rhinoceros Auklet burrows. Revised estimate: None required

Section #7 (grasses on W side of knoll) – Original estimate: For this grassy area (12 m x 5 m), a 3-m x 3-m plot was searched and 14 storm-petrel burrows (one with a large unidentified chick; one with a Leach's adult and egg) and six Cassin's Auklet burrows were counted. Burrow densities were determined for storm-petrels (1.56/m^2) and Cassin's Auklet (0.66/m^2). Totals of 93 storm-petrel burrows and 40 Cassin's Auklet burrows were extrapolated. Revised estimate: None required.

Below, we provide details for original and revised estimates of breeding populations for six burrow-nesting species surveyed in 1988:

Fork-tailed Storm-Petrel – Rodway and Lemon (1990) estimated 194 breeding pairs from a total of 626 storm-petrel burrows, an occupancy rate of 100% (i.e., all storm-petrel burrows excavated contained adults, eggs, or chicks), and a ratio of four Fork-tailed Storm-Petrel nests: nine Leach's Storm-Petrel nests (i.e., 31% Fork-tailed Storm-Petrel). From data provided by AEB (unpubl. field notes), 14 grubbed storm-petrel burrows contained: four Fork-tailed Storm-Petrel chicks; eight Leach's Storm-Petrel adults with eggs; one Leach's Storm-Petrel with no egg; and one unidentified storm-petrel chick. For Fork-tailed Storm-Petrel chicks, two had been definitely identified as this species, and two were only suspected to be this species (i.e., one "probable" and one "possible"), based on size and assumed earlier breeding by Fork-tailed Storm-Petrels. Thus, actual evidence of storm-petrel eggs or chicks had been noted in only 13 of 14 burrows, although an egg may not have been detected in one burrow where only an adult Leach's Storm-Petrel was detected. All 14 burrows were treated as occupied (i.e., 100% occupancy). With exclusion of the unidentified chick and inclusion of a Leach's Storm-Petrel adult without an egg, the species ratio of four Fork-tailed Storm-Petrel nests (31%): nine Leach's Storm-Petrel nests (69%) was calculated. Our confidence in the accuracy of this ratio is low because it was based on a small sample of burrows with some irregularities. However, birds captured at Seabird Rocks in mist nets in 1986-1987 had similar proportions (Table 3). Using the revised total of 1,033 storm-petrel burrows, we revised the 1988 estimate to 318 pairs, 1.6 times the original estimate (Rodway and Lemon 1990).

Leach's Storm-Petrel – Using a total of 626 burrows, an occupancy rate of 100%, and 69% Leach's Storm-Petrels, Rodway and Lemon (1990) estimated 432 breeding pairs. Using the revised total of 1,033 burrows, we revised the 1988 estimate to 715 pairs, 1.7 times greater than the original estimate (Rodway and Lemon 1990).

Pigeon Guillemot – Rodway and Lemon (1990) noted that 65 birds had been reported around the island on 30 July but nesting was not confirmed (Figure 20). No population estimate was given but numbers counted were similar to those in 1970 and 1972, when 50-70 pairs were estimated (Guiguet 1971, Hatler et al. 1978). We suggest using 50-70 pairs for the 1988 estimate, because we did not find any evidence to suggest that the estimate of 50 pairs in 1972 was more accurate than the estimate of 70 pairs in 1970. Counts in 1970, 1972 and 1988 were not peak counts and may under-represent total numbers. On 5 June 1986, the greatest recorded count of 121+ Pigeon Guillemots was obtained in the morning.

Cassin's Auklet – Using a total of 218 burrows and a median British Columbia occupancy rate of 75%, Rodway and Lemon (1990) estimated 164 breeding pairs. We derived a revised 1988 estimate of 269 breeding pairs, using the revised total of 359 burrows (Table 2) and the same occupancy rate.

Table 3. Relative proportions of Fork-tailed and Leach's storm-petrels recorded on Seabird Rocks, in 1986-1993 (A.E. Burger, unpubl. data). These observations were made incidentally during research focused on Rhinoceros Auklets, except for data acquired on 30 July 1988.

Year	Dates	Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Method
1986	13-21 August	5 (29%)	12 (71%)	Mist-net captures from sunset to approximately 01:00 h [PDT] (see text). Many Fork-tailed probably fledged by these dates
1987	22 July – 18 August	63 (38%)	104 (62%)	Mist-net captures on 10 nights from sunset to approximately 01:00 h. Some Fork-tailed may have fledged by these dates
1988	30 July	4 (31%)	9 (69%)	Burrow inspection: not a systematic search. Excluded one unidentified chick and included one Leach's adult in a burrow without an egg
1992	19-21 June	~20 (100%)	0 (0%)	Mist-net captures from sunset to approximately 01:00 h. AEB commented on the apparent increase in Fork-tailed compared to 1986-1988
1992	19-21 June	~90%	~10%	Estimated proportion of vocalizations during mist-net operations, sunset to 01:00 h
1993	14 August	1 (17%)	5 (83%)	Burrow inspection: not a systematic search. Many Fork-tailed probably fledged by this date

Figure 20. Driftwood habitat used by Pigeon Guillemots for nesting on Seabird Rocks, 27 May 2011. *Photo by Percy N. Hébert.*

Rhinoceros Auklet – Using a total of 173 burrows and a median British Columbia occupancy rate of 77%, Rodway and Lemon (1990) estimated 133 breeding pairs. Our revised 1988 estimate is 140 breeding pairs, using the revised total of 182 burrows (Table 2) and the same occupancy rate.

Tufted Puffin – Rodway and Lemon (1990) noted that eight burrows had been counted but no estimate of breeding birds was determined. However, a maximum of four puffins was noted flying around the island on 26 June 1988 (AEB, unpubl. data). Rodway (1991) estimated eight breeding pairs, based on the burrow count. However, during all the visits to Seabird Rocks from 1986 to 1993, AEB located only one or two occupied burrows. We propose that a more reliable estimate for 1988 is four pairs, based on the number of puffins recorded. Higher numbers of puffins also were counted in other years, suggesting that eight pairs or more may have bred in some years. On 5 June 1986, nine puffins were observed at one time and more may have been present (AEB, unpubl. field notes). On 28 July 1987, 19 puffins were observed between the western point of Pachena Bay and Seabird Rocks between 20:50 and 21:40 h (AEB, unpubl. field notes). Burger (1987) reported a maximum of eight puffins seen at one time at the rocks between 22 July and 18 August 1987.

Avian Predators (1986-1993) – During many overnight visits, AEB (unpubl. data) and others made extensive observations of potential avian predators. Usually, no Bald Eagles were observed but at times one to four eagles were noted. Several gull carcasses found near the light beacon on 14 August 1993 were attributed to eagle kills. Up to three adult Northwestern Crows were seen regularly in 1986-1993. Breeding by crows was confirmed in 1986 (two nests, each with one week-old chicks on 5 June) and 1989 (flightless chick 2/3-grown on 24-25 June), and was likely in 1993 (empty nest with crow feces, indicating likely occupancy, found on 14 August). Almost complete breeding failure of the Glaucous-winged Gulls in 1986 and again in 1987 was attributed to egg predation (i.e., large numbers of avian depredated eggs were found [Figure 21], possibly eaten by crows, but the identity of the egg predator was not confirmed). A Peregrine Falcon (*Falco peregrinus*) made several passes over the island on 21 August 1986 but none were reported on other visits between 1986 and 1993.

Figure 21. Predation of Glaucous-winged Gull eggs by Northwestern Crows can have a major impact on breeding success. *Photo by R. Wayne Campbell.*

Northern River Otter (1986-1989) – AEB (unpubl. observations) and others confirmed the presence of at least one otter on Seabird Rocks, based on scats, a well-trampled runway (east side of the island), and a sighting of an otter (date not recorded). In 1987, a well-worn runway was found in the vegetation, littered with scats. Most contained fish bones, but a few had bird bones and feathers. Two feather piles of Rhinoceros Auklets were noted in "the tower area of bush." In 1991, two dead Pigeon Guillemots were found in or at the entrance to nest cavities, but the cause of death was not determined. On 24 June 1992, AEB reported to PRNPR that no sign of otters living on the island was evident. The otter run among the bushes on the east side, just north of the ladder, was overgrown, whereas in 1986-1988 this area was well-trampled and littered with otter scat. Similarly, AEB reported no sign of otter on 14 August 1993. It seems likely that one or more single otters were resident or visited the island between 1986 and 1991, with limited impacts to seabirds, but none were present in 1992 and 1993.

Davoren Research (1995-1997) – Gail K. Davoren (under AEB's supervision) conducted studies of Rhinoceros Auklets (Figure 22) at Seabird Rocks in 1995-1997 (Davoren 1997, 2000; Burger and Davoren 1999, Bertram et al. 2002), but gathered no information on population sizes. Davoren (*in litt.*, 21 December 2012) could not: "...recall seeing any otters on the island or any predation events. Most of the chicks in my burrows made it to the end."

Figure 22. Nestling growth and diet of Rhinoceros Auklets were studied on Seabird Rocks between 1995 and 2002. *Photo by R. Wayne Campbell.*

Simon Fraser University and Canadian Wildlife Service Research (1998-2002)

Rhinoceros Auklets were studied by Douglas F. Bertram (SFU and CWS) in 1998-2002, assisted by Moira J.F. Lemon (CWS) in 1998-1999, PVC (PRNPR) in 2000-2002, and J.F. Savard (son of J-.P. Savard, CWS) in 2000 (Bertram et al. 2002). Each year, single nights were spent on Seabird Rocks between 19 and 24 July. Brief day trips also were made on 7 August 1998 and 8 August 2001. Researchers inspected burrows during the day and collected prey loads from adult Rhinoceros Auklets arriving after dark. A sample of 15-17 chicks was removed from marked burrows, then weighed and measured during each July visit. Bertram (unpubl. data) kept notes on various other nesting species and a summary for each species is provided below:

Fork-tailed Storm-Petrel – 1998: grubbed one burrow with chick and heard vocalizing at night on 21 July. *1999, 2001, 2002*: heard vocalizing at night.

Leach's Storm-Petrel – 1998: grubbed burrows with adult and egg (*n* = 4), found one dead unidentified storm-petrel at the mouth of a burrow (possibly killed by a Rhinoceros Auklet), and heard vocalizing at night on 21 July; grubbed one bird on 7 August. *2000*: grubbed burrows with chicks (*n* = 2) (Figure 23) and one incubating adult on 20 July. *2001*: heard vocalizing at night. *2002*: grubbed burrows with cold eggs (*n* = 2) and one rotten egg – also heard vocalizing at night on 23 July.

Figure 23. In June, when most Leach's Storm-Petrel eggs hatch, the fluffy down of new nestlings is a soft bluish-gray. *Photo by R, Wayne Campbell.*

Pelagic Cormorant – 1998: many roosting but did not check for nesting on 21 July. *2001*: no nests but 50 adults noted on 19 July. *2002*: no nests but 110 adults noted on 23 July.

Black Oystercatcher – 1998: nests with eggs (*n* = 4) found on 21 July.

Glaucous-winged Gull – 1998: most nests hatched or empty, but a few had eggs (*n* = 2) or two dead chicks (*n* = 1); three downy chicks in a rock crevice, one wandering chick, and several large young on 21 July. *1999*: no chicks present, some empty nests, and only one nest with abandoned eggs on 19 July.

Pigeon Guillemot – 1998: many present but no total count, with some holding fish on 21 July.

Cassin's Auklet – 1998: one chick found in a burrow on 19 July.

Rhinoceros Auklet – 1998: in addition to chicks removed from marked burrows (*n* = 16), other grubbed burrows on 21 July contained broken eggs or eggshells (*n* = 4), one neglected or abandoned egg (*n* = 1), or were empty (*n* = 4) or unknown (*n* = 6); on 7 August, chicks removed from marked burrows (*n* = 3) and empty burrows (*n* = 14). *1999*: chicks removed from marked burrows (*n* = 17), neglected or abandoned egg (*n* = 1), empty (*n* = 3), and unknown (*n* = 1). *2000*: chicks removed from marked burrows (*n* = 16), empty (*n* = 6) and eggshells only (*n* = 1). *2001*: chicks removed from marked burrows (*n* = 17), adult incubating egg (*n* = 3), one egg (probably abandoned) (*n* = 1), and empty (*n* = 3, one probably fledged) – also heard vocalizing at night and thought to be less numerous in 2001 than in 2000; on 8 August, chicks removed from marked burrows (*n* = 3). *2002*: chicks removed from marked burrows (*n* = 15), empty (*n* = 12), rotten egg (*n* = 2), cold egg (*n* = 1), flattened egg (*n* = 1), and adult with chick (*n* = 1) – also heard vocalizing at night.

Tufted Puffin – 1998: a "couple" were seen flying around the cone of the island on 21 July.

Pacific Rim National Park Reserve Surveys (2005-2010)

Brief PRNPR surveys were conducted on 6 July 2005 (PVC assisted by Katie M. O'Reilly [BMSC]), 19 July 2006 (PVC assisted by J. Mark Hipfner and B. Addison [CWS]), 5 July 2007 (PVC assisted by Joanna L. Smith [BMSC]), 28 May and 2 July 2008 (YZ and PVC), 1 June and in July (day not recorded) 2009 (YZ and PVC), and 27 May and 29 June 2010 (YZ and PVC). A summary of information for each species is provided below:

Fork-tailed Storm-Petrel – 2006: One carcass.

Leach's Storm-Petrel – 2005: dead adults (n = 3) near burrows. *2006*: over 25 carcasses around burrow entrances near the base of the navigation light, most with head and breast tissue removed. In grubbed burrows, an adult (n = 1) and a chick (n = 1), the latter near the ladders. *2007*: marked burrows unoccupied with entrances and runways overgrown. Some active burrows near base of light but not grubbed. *2008*: on 28 May, a carcass (wings only) beside a Rhinoceros Auklet burrow entrance, and two carcasses near the base of light and base of the ladder.

Unidentified Storm-Petrel – 2009: on 1 June, storm-petrel wing found. *2010*: on 29 June, a few freshly used storm-petrel burrows (with minimal use) near base of light.

Pelagic Cormorant – 2005: no nests. *2006*: no nests and about 25 Pelagic and Brandt's Cormorants on the far reef. *2007*: 16 counted. *2009*: on 1 June, no nests and 74 counted.

Black Oystercatcher – 2006: five separate chicks observed. *2008*: on 28 May, 12 nests (11 with eggs, one empty); on 2 July, two pairs re-nested deep inside narrow rock clefts which was unusual, suggesting defense from predators. *2009*: on 1 June, 13 nests with eggs and one nest without eggs. *2010*: on 27 May, nine active nests; on 29 June, three pairs re-nested 0.9-1.2 m inside narrow rock clefts, possibly to avoid predation.

Glaucous-winged Gull – 2005: 126 nests (106 empty and eggs depredated [White et al. 2006]; Figure 24). *2006*: 140 nests. *2007*: 120 nests (29 empty) one carcass (apparently eagle predation). 2008: on 2 July, 131 nests (49 empty). *2009*: survey conducted (results not available). *2010*: on 29 June, much gull egg depredation (avian predators suspected).

Figure 24. Unseasonable weather, storms, predation, and human disturbance can delay breeding by Glaucous-winged Gulls. *Photo by R. Wayne Campbell.*

Rhinoceros Auklet – 2005: one cold egg and six marked burrows empty. *2006*: marked burrows unoccupied; auklet runways and entrances appeared overgrown. Approximately 10 adult carcasses scattered near the base of light, with head and breast tissue removed (two carcasses were very fresh). About 100 birds on the water around island. *2007*: marked burrows unoccupied; entrances and runways overgrown. Some active burrows near base of light but not grubbed. *2008*: on 28 May, 25 on the water near the island. *2009*: most burrows overgrown.

Bald Eagle – 2005: eight (five adults). *2007*: three juveniles. 2008: on 28 May, two; on 2 July, three.

Owls – 2008: A large 2" x 5" (5-cm x 13-cm) pellet containing bones and feathers at base of light (possibly owl or gull).

Northern River Otter – 2006: fresh otter scat (contents not noted) and a runway through a Rhinoceros Auklet burrow site. *2008*: on 28 May and 2 July, lots of fresh otter scat (contents not noted) and runways throughout

the burrow area and interior of island. *2009*: on 1 June, lots of otter sign. *2010*: on 27 May, lots of otter sign and recent otter activity.

Pacific Rim National Park Reserve and Carter Biological Consulting Surveys (2011)

PRNPR and CBC conducted three brief day visits to Seabird Rocks on 27 May, 5 July and 25 July to gather more information on continuing seabird predation, determine whether certain species of seabirds are still attending the colony, investigate the cause of predation, and develop potential restoration concepts (Clarkson et al. 2011a, b). Two acoustic recording devices (Songmeter; Concord, Massachusetts) and complete carcass searches (with all fresh carcasses removed) were used to obtain information on predation and occurrence of different nocturnal seabirds between 27 May and 25 July. Data have been only briefly scanned so far by Luke R. Halpin (unpubl. data) for species occurrence. Two motion-activated infrared cameras (Reconyx; Holmen, Wisconsin) were used to record images for identifying predators during day and night but only one camera in driftwood habitats functioned properly from 27 May to 10 June. Nest surveys for Black Oystercatchers and Glaucous-winged Gulls were conducted but results are not reported here. Seabird and predator observations included:

Fork-tailed Storm-Petrel – Detected vocalizing with Songmeter.

Leach's Storm-Petrel – Detected vocalizing with Songmeter and single birds visible in infrared camera images. Partial carcasses found on 27 May (n = 2, wings and rumps) and 5 July (n = 3, wings and rumps).

Unidentified Storm-Petrel – Partial carcasses found on 27 May (n = 6, wings only), 5 July (n = 2), and 25 July (n = 9, wings only).

Pelagic Cormorant – None nesting on 27 May or 25 July; small numbers roosting.

Black Oystercatcher – On 27 May, one fresh feather pile (primaries and breast feathers).

Glaucous-winged Gull – Partial carcasses found on 27 May (one fresh feather pile and one chick wing from 2010) and 25 July (one adult partly eaten). On 27 May, few gull nests were evident. On 5 July, all gull nests were empty and some broken (depredated or scavenged) eggshells were noted. On 25 July, most nests seen were empty but a few nests in outer rocky areas had eggs (one, two or three eggs; one egg in a two-egg nest was pipping) and one chick (one to two weeks old) was seen hiding in the grass. Nests with eggs in July likely were mainly relaying attempts after otter predation (see below) but some may have been missed by otters, especially in outer rocky habitats.

Cassin's Auklet – No carcasses found and not detected with Songmeter or camera. On 27 May, one feather pile of a possible Cassin's Auklet found (most of carcass missing and auklet species could not be confirmed).

Rhinoceros Auklet – On 25 July, three partial carcasses (wings only) found, two on the soil-covered ledge at the base of the rocky hill (near the base of the metal ramp to the light at the entrances to deep rock crevices which lead into the hillside) and one higher up (beside the metal ramp and not near potential nest sites). Not detected with Songmeter or camera.

Tufted Puffin – On 25 July, a single adult Tufted Puffin (Figure 25) circled above the island upon our arrival. As the boat departed, one adult puffin also was seen on the water about 200 m off the northwest side. This was the first observation of Tufted Puffins attending the island area since 1998 (PVC and YZ, unpubl. data).

Figure 25. After not being reported for 13 years, an adult Tufted Puffin was observed flying over Seabird Rocks in 2011. *Photo by R. Wayne Campbell.*

Bald Eagle – On 25 July, one immature eagle was observed. The remains of diving duck and several eagle feathers were found. Most eagles perch on the light structure; up to eight were noted in 2011 (PVC and YZ, pers. obs.).

Raptors – On 25 July, two raptor pellets (based on small size and shape; smaller than typical gull pellets) were found at the light but were highly digested and prey could not be identified.

Northern River Otter – On 27 May, extensive fresh otter scat was found in the deep hollow area and on otter trails. In the deep hollow, a latrine and at least three dry bedding sites under rock cliffs and ferns were found. Otter trails were found throughout the burrow-nesting habitats, especially the lower areas. No otters were seen during the day. The latrine and extensive trails suggested that one or more otters had spent considerable periods of time on the island. Most scat contained fish vertebrae and at least three had bird feathers, with one that smelled characteristically like storm-petrel. On 25 July, extensive fresh otter scat was again found in the deep hollow area, on otter trails, within burrow-nesting habitats, and widely on the rocky areas around the vegetation. Otter trails seemed well maintained and recently used. No otters were seen during the day but the very large amount of scat suggested that a group of otters lived continuously on the island but were hidden during our visits. While bird prey appeared to be important (based on carcasses and some scat with feathers), otters also ate other marine prey. Some scat in the vegetated area had easily identified fish bones and one large crab.

Nocturnal images of up to 4 otters (Figure 26) were obtained with the camera. DFH considered the group of 4 otters to represent a family group because the centre individual had fairly "thin" features, especially the neck, and appeared to be a juvenile. A female with young also would be far more likely to stay on the island for a long period than would a wandering male, jibing with apparent continuous presence of otters on the island in 2011.

Otters were detected on 6 of 14 nights between 27 May and 10 June, indicating their continuous presence on the rocks during this period, likely breeding, and apparent presence of a family group.

Figure 26. Northern River Otters among driftwood at Seabird Rocks. The image was captured with a motion-activated Reconyx camera at 05:36 h on 2 June 2011. *Reproduced from Clarkson et al. 2011b*

Discussion

Colony Status (1894-1945)

Pigeon Guillemots, Black Oystercatchers and Glaucous-winged Gulls were recorded breeding at Seabird Rocks in 1894 and 1896 by Newcombe, but it was not clear if other seabird species also bred there in the late 19th century. At this time, Newcombe did not yet have experience with nocturnal burrow-nesting seabirds and likely did not consider inspecting burrows at Seabird Rocks for auklets or storm-petrels. He likely observed Pigeon Guillemots entering nest sites under driftwood and dug under or removed driftwood to obtain Pigeon Guillemot eggs. Prior to 1900, a relatively large population of Huu-ay-aht First Nation (HFN) peoples also had a main village at Anacla in Pachena Bay and harvested marine foods and gull eggs at Seabird Rocks (T. Happynook, HFN hereditary chief; pers. comm. to YZ). By the late 19th century, the HFN people had become greatly reduced by disease, some left this area, and harvesting of many wild foods stopped. The existence of a relatively large storm-petrel colony at Seabird Rocks in 1943-1945 suggests that all burrow-nesting species likely were present at this time and that at least for many decades before 1943, otters did not prey heavily on breeding seabirds there. Pearse (1946a, unpubl. field notes) did not mention breeding Cassin's or Rhinoceros auklets in 1943 and 1945, but he did not spend much time assessing burrow-nesting habitats and did not stay overnight when detection would have been easier.

Population Sizes (1970-2002)

Data on abundance of all six burrow-nesting seabirds at Seabird Rocks were not available until BCPM and PRNPR surveys in 1970 and 1972. Between 1970 and 2002, no evidence of changes in abundance for five of six species of burrow-nesting seabirds (i.e., except Tufted Puffin) was obtained. Most censuses, however, were incomplete (except for 1988), observations were not standardized to more easily detect possible trends, and no surveys were conducted after 1988. Our revised population estimates for 1988 (Table 1) best indicate the approximate size of auklet and storm-petrel populations at Seabird Rocks during this period. Differences between available sources for breeding population estimates of burrow-nesting seabirds at Seabird Rocks in 1970-1988 are summarized in Table 1. Survey techniques used in 1988 were the most repeatable and considered most accurate for auklets and storm-petrels. Higher burrow estimates in 1979 appeared to be related to rough estimates of colony area and the use of only one plot. In 1988, careful searches of all habitat sections were conducted, and direct counts were made in certain sections to avoid difficulties with determining areas of those parts of the colony. Burrow densities in plots in 1988 also varied extensively (i.e., range 0.36-1.89/m^2 for storm-petrels and 0.00-0.66/m^2 for Cassin's Auklets [n = 4) versus single values of 1.11/m^2 for storm-petrels and 0.89/m^2 for Cassin's Auklets for the single plot examined in 1979. Overall colony area was not estimated in 1988, making it impossible to assess whether the amount of habitat had been overestimated in 1979 or had changed between 1979 and 1988.

For Pigeon Guillemots, it has been difficult to estimate numbers of breeding pairs based on counts of birds observed at the colony during the day. In 1970-1972, estimates of 50-70 pairs were rough but have not been improved. Between 1970 and 1988, numbers of birds reported during the day at the island were variable (range = 33-84 guillemots) but did not appear to indicate any major changes over time. Only one 1986 count was conducted in the early morning (when highest counts usually are obtained), which resulted in the highest total count of 121 guillemots. No counts of adults were recorded from 1989 to 2002.

For Tufted Puffins, the number of adults observed at the colony during the day declined gradually from a high of 24 in 1970, to between eight and 13 in 1972-1988, to only two in 1998. None were recorded in 1999-2002.

Population Changes (2003-2011)

Between 2003 and 2011, both auklet populations were lost as breeding species and both storm-petrel populations were significantly reduced at Seabird Rocks. In addition, heavy predation on gull eggs (or high gull nest abandonment before or shortly after laying) was noted in 2005 and 2011, and unusual renesting of Black Oystercatchers in narrow rock clefts (apparently to avoid predation) was noted in 2008 and 2010. No efforts were made to measure population sizes of burrow-nesting species during

this period. After two years without on-island visits in 2003-2004, problems were first clearly evident in 2005 when carcasses of storm-petrels (Figure 27), empty Rhinoceros Auklet burrows, failure of most gull nests (with evidence of predation), lack of breeding Pelagic Cormorants, and many eagles were noted. However, evidence of predation by otters was not recorded in 2005. In 2006, greater evidence of predation of storm-petrels and Rhinoceros Auklets and unoccupied burrows was noted, along with otter sign. In 2007-2011, several pieces of evidence were gathered that indicated or suggested major predation impacts: 1) lack of island use by breeding auklets; 2) continued predation on and greatly reduced numbers of storm-petrels (i.e., few burrows); 3) continued predation on small numbers of Rhinoceros Auklets in 2011; 4) predation on gull and oystercatcher nests; 5) no breeding by Pelagic Cormorants; and 6) otter sign in most years. The most likely reason for loss of breeding auklets and great reduction of breeding storm-petrels in 2003-2011 was impacts from otters (discussed further below).

Figure 27. Scattered fresh carcasses of seabirds, including Leach's Storm-Petrels, indicate impacts by avian or mammalian predators. *Photo by R. Wayne Campbell.*

Factors Affecting Populations

Human Disturbance

Some habitat loss due to human activities occurred before burrows were surveyed in 1988, which may have reduced numbers of some burrow-nesting species. The fragility of this habitat has been reported by all workers at Seabird Rocks. Hatler et al. (1978) reported some loss of habitat for Tufted Puffins due to human destruction during visits to maintain the navigational light prior to 1972. Metal walkways and ladders were constructed over these pathways in the 1990s, which may have reduced impacts. In general, biologists have been careful to avoid fragile soil habitats, but all surveys and studies in burrow-nesting habitats had small impacts on the soils, despite efforts to reduce or minimize them. All overnight camping occurred on rocky shorelines and the beach. During the 1988 burrow survey, people crawled on their hands and feet to distribute their body weight more widely and mist-net captures in 1986-1992 were conducted on rocky habitats. Early observations and surveys in 1943, 1945, 1970 and 1972 also had low impacts, as biologists usually avoided these habitats except for small numbers of excavated burrows. However, the survey in 1979 was conducted less carefully (e.g., upright walking and making paths through dense vegetation). Some damage to soil habitats and some crushed burrows occurred during tape measurements, although the single plot was checked by people crawling on their hands and feet (HRC, pers. obs.). Given the small area of burrow-nesting habitat and various surveys and studies over time, a small but unquantified area of these habitats may have been trampled by researchers.

Few if any impacts from excavating burrows, handling birds and eggs in nests, or capturing birds for prey samples were noted by researchers during their research. In general, the various research projects were designed for one to three brief visits per year, usually day trips or single overnight trips, with personnel commuting by boat from Bamfield, Ucluelet, or Pachena Bay. However, when such research activities are conducted annually over many years, some impacts likely occur.

Few impacts from occasional flushing of Pelagic Cormorants, Glaucous-winged Gulls, Black Oystercatchers, Pigeon Guillemots, and Tufted Puffins likely occurred from sporadic non-overnight visits by biologists in 1894-1979 and from Canadian Coast Guard personnel servicing the light when the island was visited briefly during the breeding season. However, puffins visit nest sites during the day, flush easily due to human presence, nest sites were located on the main

knoll where the light structure is located (see Figure 2), and puffins declined between 1970 and 1998 before being lost as a breeding species. At this time, we do not have information on the timing and nature of light maintenance activities to best assess how all impacts may have occurred, but we do know that in 1972 some burrows had been damaged on the main hillock through light maintenance activities (Hatler et al. 1978). Earlier construction of the most recent light structure probably was more damaging, likely causing substantial soil loss on the main hillock and adjacent areas; later placement of metal walkways and ladders on the light hill also may have further affected these habitats, even though once in place fewer burrows may have been crushed on each maintenance visit. When such work is conducted in the breeding season, adults, chicks or eggs may have been killed in burrows or adults may abandon nests, possibly leading to complete colony breeding failure in a certain year and reduced breeding in subsequent years. More work is needed to obtain information on Coast Guard activities and potential impacts at Seabird Rocks. Recreational boaters and local residents also approached and in some cases visited the islands occasionally throughout the latter half of the 20th century, but the difficulties in landing on the rocky shoreline (i.e., beaches cannot be landed upon directly) and often rough seas around the island rendered these visits infrequent.

Major Oil Spills

Three major oil spills occurred near Barkley Sound in 1972, 1988, and 1991 but major impacts to the Seabird Rocks colony were not reported. However, depending on the size, location, wind, currents, timing and nature of mortality from an oil spill, it can be difficult to: (1) estimate the numbers of seabirds killed for all species from carcasses recovered and surveys conducted; and (2) detect and measure less than catastrophic impacts to nesting populations on a specific colony, especially without long-term monitoring data (Ford et al. 1987; Page et al. 1990; Burger 1993a,b; Figure 28).

Figure 28. Although major oil spills may be detected more quickly, and be of greater impact, minor spills such as leakage from wrecks and discharge at sea, can locally impact roosting and foraging species. *Photo by R. Wayne Campbell.*

Seabirds at Seabird Rocks may have been affected when the Japanese freighter *Vanlene* wrecked on the outer Broken Group Islands, Barkley Sound, in March 1972, but seabird mortality was not assessed (Herlinveaux 1972). Oil has continued to leak periodically from the sunken vessel. Small numbers of oiled seabirds found in eastern Barkley Sound in 1979-1980 may have represented lingering impacts of *Vanlene* oil on seabirds (HRC and SGS, unpubl. data).

The 1988 *Nestucca* spill may have had the greatest impact on burrow-nesting seabirds at Seabird Rocks. From December 1988 to February 1989, many oiled seabirds were recovered on the west coast of Vancouver Island (mainly Barkley Sound and Clayoquot Sound) after the American tug *Ocean Service* collided with the fuel barge *Nestucca* off Grays Harbor, Washington. Oiled seabirds recovered on Vancouver Island included: 274 Cassin's Auklets, five Pigeon Guillemots, one Rhinoceros Auklet, and three Tufted Puffins (Rodway et al. 1989). Much oil also was found on and removed from Seabird Rocks. The number of dead seabirds recovered on shorelines was undoubtedly a small fraction of each species killed (Burger 1993a,b). Some of the birds killed may have come from the Seabird Rocks colony (Burger 1992, unpubl. data). Boat and aerial surveys conducted in nearshore waters in the Barkley Sound area in March-April 1989 frequently detected Rhinoceros Auklets off Cape Beale and five Cassin's Auklets were observed in Pachena Bay on 22 March (Rodway 1989).

The 1991 *Tenyo Maru* oil spill off Barkley Sound and the entrance to Juan de Fuca Strait also was a significant spill that affected many seabirds. It occurred in July 1991 when the Japanese fishing vessel *Tenyo Maru* collided with a Chinese freighter *Tuo Hai*, about 32 km northwest of Cape Flattery, in Canadian waters (Tenyo Maru Oil Spill Natural Resource Trustees 2000). Due to prevailing northwest winds and currents, oiled seabirds were recovered along the coasts of western Washington and Oregon, including: one Fork-tailed Storm-Petrel; one Leach's Storm-Petrel; 116 Cassin's Auklets; 281 Rhinoceros Auklets; and 127 Tufted Puffins (Tenyo Maru Oil Spill Natural Resource Trustees 2000). Numbers recovered on shorelines again were small fractions of those estimated killed (Figure 29). Some of these birds may have come from the Seabird Rocks colony, although the Seabird Rocks colonies appeared to be relatively intact one year after the *Tenyo Maru* spill, in 1993, and did not suffer immediate obvious impacts (AEB, unpubl. data).

Figure 29. A small patch of oil on the plumage of a seabird, such as the breast of this Common Murre, is often enough to kill it. *Photo by R. Wayne Campbell.*

Gill-net Mortality

Carter and Sealy (1984) documented mortality of 28 Marbled Murrelets (*Brachyramphus marmoratus*), 10 Common Murres, and one Rhinoceros Auklet (1 July 1980) in the Trevor Channel gill-net fishery in eastern Barkley Sound in 1980. In the late 1980s, HRC and SGS rediscovered three other frozen Rhinoceros Auklets (one with and two without incubation patches) that had been salvaged on 14 July 1979 off Cape Beale and kept in a freezer at the University of Manitoba (HRC and SGS, unpubl. data). These individuals were not included in our original assessment because, prior to freezing, we had not closely examined them to detect the tell-tale gill-net marks on their necks. While hundreds of murrelets were killed annually in this gill-net fishery in 1979-1980 (Carter and Sealy 1984), we suspect that the four Rhinoceros Auklet mortalities observed in 1979-1980 may have translated into an annual mortality of between five and 25 birds, because only small numbers of Rhinoceros Auklets occurred regularly in Trevor Channel and near Cape Beale during the fishing season in June and July 1979-1980 (Carter and Sealy 1984, unpubl. data). Gill-net

mortality in Barkley Sound may have had significant effects on the small colony of Rhinoceros Auklets breeding at Seabird Rocks during 1975 to 1995 when fishing effort was relatively high, and this possibly depressed the size of the 1988 breeding population (Carter and Sealy 1984, Smith and Morgan 2005). During the breeding season, most adults observed or netted in Barkley Sound likely were from the Seabird Rocks colony because this is the only breeding colony within typical foraging distance of eastern Barkley Sound (Guiguet 1971, Rodway 1991). Additional mortality of Rhinoceros Auklets in gill nets also occurred in waters southeast of Barkley Sound within Fishing Area 21 where eight Rhinoceros Auklet carcasses were recovered in the test fishery of 1995-2001, with a maximum of four in 1998 (Smith and Morgan 2005). However, most gill-net mortality in Area 21 likely occurred farther from Seabird Rocks or Cleland Island and may have mostly involved birds from Washington colonies.

Avian Predation

Potential avian predators of burrow-nesting seabirds that occur regularly at Seabird Rocks include Glaucous-winged Gull, Bald Eagle, and Northwestern Crow (Figure 30). About 200 pairs of Glaucous-winged Gulls nest at Seabird Rocks, yet gull predation of other seabirds was not noted, whereas several instances of avian predation on gulls was recorded. The earliest evidence of avian predation were dead Leach's Storm-Petrels and Glaucous-winged Gulls recorded in 1943 and 1945, possibly killed by a Great Horned Owl (Pearse 1946a,b). However, Bald Eagles may have been responsible for 1940s mortalities because they commonly prey on gulls at Seabird Rocks. In 1988, remains of Glaucous-winged Gulls beneath Bald Eagle nests in Barkley Sound revealed that this seabird species was frequently killed by eagles (Vermeer and Morgan 1989). In 1999-2004, numbers of eagles at Seabird Rocks peaked in late June when gulls were incubating or feeding small chicks (White et al. 2006). Bald Eagles have been increasing in recent decades in southern British Columbia (Piatt et al. 2007) and around Seabird Rocks (AEB, unpubl. observations). No observations of eagle predation on burrow-nesting seabirds have been noted but eagle harassment or kills may be partly responsible for the lack of breeding by Tufted Puffins since 1998, as well as the lack of breeding of Pelagic Cormorants since 2003 (Carter et al. 2007). In the Pacific Northwest, Bald Eagle predation and disturbance have led to declines in surface-nesting seabirds (Parrish 1995, Carter et al. 2001, 2007, White et al. 2006, Hipfner et al. 2012) but we have no evidence of significant eagle predation on burrow-nesting seabirds on Seabird Rocks. Northwestern Crows sometimes breed on the island and were suspected of preying on eggs and small chicks, possibly after eagles had flushed gulls, in 1986 and 1987. Gulls also eat the eggs and chicks of other gulls during colony flushing events.

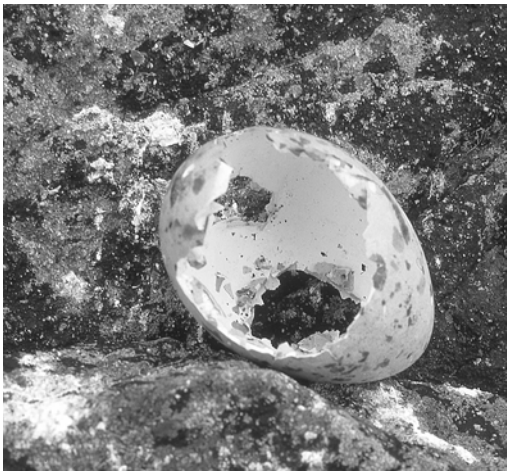

Figure 30. Northwestern Crows, which breed on Seabird Rocks, often prey on seabird eggs, including Pigeon Guillemot. *Photo by R. Wayne Campbell.*

American Mink predation

A well-established American Mink population generally precludes breeding by most seabirds on nearshore islands in Barkley Sound (Guiguet 1971). Guiguet did not report mink or their feces on Seabird Rocks in 1970, and neither did DFH in 1972 (Hatler 1976, Hatler et al. 1978), whose work was heavily focused on mink. In 1975-2011, there have been numerous opportunities for incidental sightings of mink or their feces but there have been no confirmed sightings, although many observers might not have looked for or recognized mink feces (Figure 31). It appears that Seabird Rocks (about 1.5 km from the

mainland) is rarely, if ever, visited by mink. However, at Cleland Island (about 2.0 km off Blunden Island) in nearby Clayoquot Sound, a mink was sighted in 1982 and at least 12 Rhinoceros Auklets were thought killed by it (Rodway and Lemon 1990). In 1985, four dead Tufted Puffins found in burrows at Cleland Island were also suspected to have been killed by mink (Rodway and Lemon 1990) but otters also were noted there. Mink remain a potential threat to breeding seabirds at Seabird Rocks but do not appear to have occurred there to any great extent from 1970 to 2011 and did not appear to contribute to reductions or loss of breeding seabirds.

Figure 31. While most coastal American Mink feed in the intertidal zone, some venture to seabird islands and opportunistically kill and often cache prey species. Piles of feces are usually present. *Photo by R. Wayne Campbell.*

Northern River Otter Predation

First noted by DFH in 1972, the presence of otters (Figure 32) or apparent predation by otters at Seabird Rocks was documented during seabird surveys in 1972 and 1986-1991. Evidence of residence of at least one or a succession of otters in 1986-1989 was significant because it apparently indicated greater time spent at the island. Otters were not reported in 1992-1993 and 1995-2002. Otters are also known to periodically impact certain Glaucous-winged Gull breeding colonies in the Strait of Georgia and the San Juan Islands/Sidney area (Hayward et al. 1975, Footitt and Butler 1977, Verbeek and Morgan 1978, Vermeer and Devito 1989).

Otters are common and widely distributed in Barkley Sound and Clayoquot Sound and they regularly access Seabird Rocks and many other seabird breeding islands (Hatler et al. 2008). Otters appear to more frequently travel greater distances from shore than mink, facilitating greater access to islands farther from the mainland or other island groups (DFH, unpubl. data). Hatler et al. (2008) noted that otters are primarily piscivorous but do prey on birds, especially in summer. Otters commonly co-occur with burrow-nesting seabirds in British Columbia, usually being considered to have only minor impacts on breeding populations (Rodway and Lemon 1990; Rodway et al. 1988, 1990, 1994). From 1970 to 2002, burrow-nesting seabirds at Seabird Rocks did not experience major otter predation impacts.

Between 2002 and 2005, otters reoccupied Seabird Rocks and likely began spending long periods at the island during this period. Rhinoceros and Cassin's auklets seemed to have been rapidly extirpated within a few years, possibly by a family group of otters. After this initial impact, predation on storm-petrels continued. Large numbers of storm-petrel carcasses and the only auklet carcasses were reported in 2006 and 2011, but carcass searches were not extensive in most years prior to 2011. Carter et al. (2007) also noted that the cessation of breeding of Pelagic Cormorants after 2003 occurred at the same time as otter impacts to burrow-nesting seabirds, although other factors also may have been involved. In 2011, at least four otters occupied the island for most of the year. At Seabird Rocks, seabird predation by otters appears to be the main reason for the loss of breeding Rhinoceros and Cassin's auklets and the great reduction of Fork-tailed and Leach's storm-petrels between 2002 and 2011.

Otters also have been reported killing large numbers of storm-petrels at: (1) Petrel Island, Haida Gwaii (see Figure 4 for location) in 1977 (HRC, pers. obs.) and 1983 (Rodway et al. 1994); and (2) Thornton Islands, Thomas Island, and the Gillam Islands, Vancouver Island, in 1988 (Rodway and Lemon 1990). At Moos Islet, Vancouver Island, loss of breeding Leach's Storm-Petrels occurred between 1982 and 1988, apparently due to otter predation (Rodway and Lemon 1990, Rodway 1991). At the Bodelteh Islands, Washington, heavy otter predation

Figure 32. Predation by Northern River Otters on Seabird Rocks is presumed to be the major cause of extirpations and decline of seabird populations. *Photo by R. Wayne Campbell.*

of Fork-tailed Storm-Petrels also was noted in 1979 and 1982, and possibly 1959 (Richardson 1960, Speich and Pitman 1984). At Prisoner Rock, California, heavy otter and mink predation was noted on Leach's Storm-Petrels in 1969-1972, 1979, and 1989 (Osborne 1972, Sowls et al. 1980, Carter et al. 1992). By 2012, this island was no longer used for breeding (H.R. Carter, unpubl. data).

For almost all breeding islands in British Columbia, we have not adequately monitored seabirds to assess the degree of otter impacts to colonies over time and cannot determine if impacts are periodic or continuous and whether they frequently lead to extirpation. Cases of apparent extirpation due to otter predation at Moos Islet and Prisoner Rock are known but long-term predation also apparently occurs at many locations. For example, Harfenist (2006) briefly visited Thomas Island in July 2006 and found a much reduced storm-petrel colony compared with 1988 (Rodway and Lemon 1990) as well as evidence of potential otter predation (i.e., dug out storm-petrel burrows, wings and feather piles, and scat), suggesting continued otter impacts since 1988. Halpin et al. (2012) briefly visited the Gillam Islands in May and July 2012 and noted heavy predation on storm-petrels, as noted in 1988. In these cases, river otter predation may reduce seabird populations without causing extirpation but more work is needed to study population trends at these colonies.

Final Thoughts

Prior to 2005, evidence of population changes was not found for storm-petrels, Pigeon Guillemots, and auklets at Seabird Rocks. Adequate prey resources, relatively low human disturbance and minor impacts to breeding habitats, relatively low avian and mammalian predation, and relatively low at-sea impacts apparently occurred for these burrow-nesting species at this colony during this period. However, Tufted Puffins declined gradually from 1970 to 1998 and no longer bred after 1998, partly due to human disturbance and impacts to breeding habitats, and possibly mortality from 1988 or 1991 oil spills. With a lack of standardized monitoring and no direct studies of Tufted Puffins, it is difficult to ascertain all of the causes for loss of breeding Tufted Puffins at Seabird Rocks, which also may include prey changes and eagle impacts. Several other small colonies in British Columbia also disappeared

between the 1970s and 1980s (Rodway 1991; Figure 33). Since the early 2000s, Tufted Puffins also no longer occur at Cleland Island (PVC and YZ, unpubl. data). More work is needed to examine all possible contributing causes. Since 2002-2005, two species of auklet have no longer bred and populations of two storm-petrels have been greatly reduced at Seabird Rocks, apparently mainly because at least one family group of otters has been spending much time at the island although reproduction appears to occur on the mainland (YZ, unpubl. data). Our revised population estimates for 1988 best indicate the magnitude of this regional loss of breeding auklets (Figure 34) but more work is needed to determine the magnitude of reduction in storm-petrel populations at Seabird Rocks, although we have no doubt that these populations are much lower than in 1988.

Figure 33. Rudi Drent inspects Tufted Puffin burrows at Wells Rocks, British Columbia, on 1 June 1970. This small colony was no longer active in 1988. *Photo by R. Wayne Campbell.*

Due to the importance of this breeding colony, and especially in light of recent otter impacts, PRNPR has been considering several restoration actions, including: 1) lethal or non-lethal removal of family groups of otters from Seabird Rocks; 2) blocking bedding sites to discourage long-term visits to Seabird Rocks; 3) social attraction at Seabird Rocks using broadcast vocalizations and decoys to encourage re-establishment and growth of auklet and puffin colonies and re-growth of reduced storm-petrel

Figure 34. The future of nesting seabird populations on Seabird Rocks, especially burrow-nesting species like Cassin's Auklet, will depend on whether restoration actions are successful. *Photo by R. Wayne Campbell.*

colonies; 4) removal or reduction of the light structure on Seabird Rocks which currently serves as an avian predator perch, especially for Bald Eagles (note: PRNPR has joint management authority with the Canadian Coast Guard for this structure); 5) installing predator-proof artificial nest sites at Seabird Rocks to help protect small numbers of breeding birds by reducing predation until colonies reach larger sizes; and 6) minimizing erosion and conducting plant restoration at Seabird Rocks to stabilize soils and restore burrowing habitats damaged by otter trails and burrow digging. Along with restoration actions, a long-term monitoring program would be advisable to measure changes in breeding seabird population size, reproductive success, banded individuals, diet, and predation at Seabird Rocks over time. Standardized identification, monitoring, and recording of otter or mink sign are also needed. With a reasonable monitoring program in the absence of heavy predation, the current status of prey availability for the resident seabirds also can be assessed. The Rhinoceros Auklet is the only species that has detailed prey data here (Burger et al. 1993, Davoren 1997, Davoren and Burger 1999, Bertram et al. 2002) but populations will first have to become firmly re-established before comparisons with past data will be possible. Effects from various forms of die-offs also could be explored. For example, a relatively large die-off of Cassin's and

Rhinoceros auklets occurred in winter 2005-2006, which also may have affected the Seabird Rocks colony at roughly the same time as major otter impacts (*Vancouver Sun* 2006). To avoid impacts to marine wildlife (i.e., seabirds, Black Oystercatchers, and marine mammals), monitoring visits should be brief and carefully conducted to protect the fragile soil and driftwood habitats used for breeding by several species of seabirds. More work also is needed to describe and monitor burrow-nesting habitats and vegetation. Marking and measuring the amount of habitat on different parts of the rocks would facilitate future comparisons.

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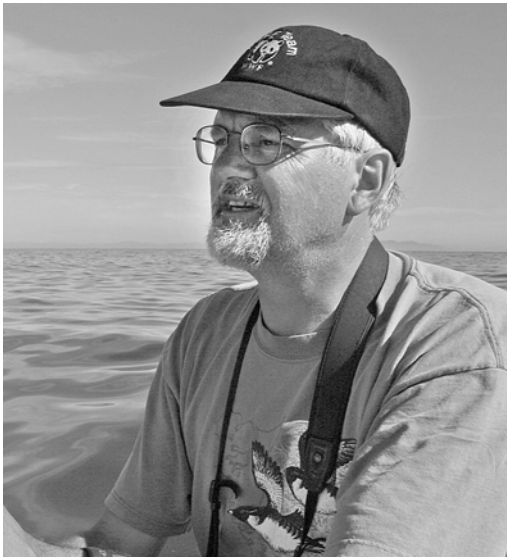
About the Authors

Harry is a private consultant specializing in seabird research, monitoring, surveys, restoration, and conservation. He began surveying seabirds in British Columbia in 1974 under the direction of Wayne Campbell and Charlie Guiguet (British Columbia Provincial Museum; now Royal British Columbia Museum) and participated in the first province-wide seabird colony survey between 1975 and 1977, along with Michael Rodway and several other team members. In 1979-1982, he conducted his M.Sc. studies on Marbled Murrelets and Common Murres in Barkley Sound under Spencer Sealy at the University of Manitoba. In 1983-2003, he worked mainly on seabirds and conservation issues in California through the Point Reyes Bird Observatory and Humboldt State University. After returning to live in British Columbia in 2003, Harry now commutes to California, Alaska, Mexico, and Japan for work on several projects. Since 2003, he resumed seabird surveys and historical seabird summaries in British Columbia, including work at Seabird Rocks in 2011 with Peter Clarkson and Yuri Zharikov.

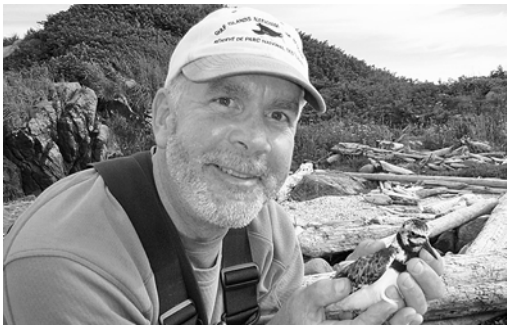
Harry Carter, Victoria, BC, June 2011. *Photo by Miriam Hughes.*

Alan is a biological consultant and an adjunct associate professor in the Department of Biology at the University of Victoria. He has undertaken research on seabirds for 35 years focusing on breeding biology, diving ecology and at-sea distribution. In the past 20 years has focused on studying Marbled Murrelets at sea and in their forest nesting habitat in British Columbia. From 1986 to 1997, he conducted various seabird studies at Seabird Rocks, along with his students and other researchers.



Alan Burger undertaking seabird surveys off the West Coast Trail near Seabird Rocks, June 2006.

Peter is a resource management officer for Pacific Rim National Park Reserve, responsible for seabird protection and restoration in the Park. Since 2000, he has conducted surveys of seabirds and Black Oystercatchers at Seabird Rocks, Barkley Sound, Clayoquot Sound, and along the West Coast Trail.

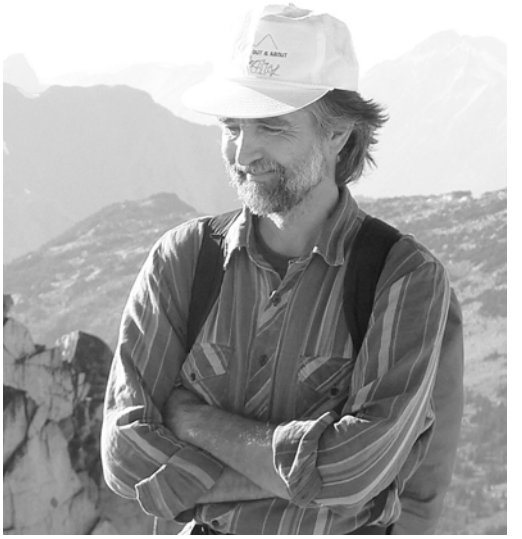


Peter Clarkson with Ruddy Turnstone (*Arenaria interpres*) at Seabird Rocks, 19 July 2012. *Photo by Yuri Zharikov.*

Yuri is a monitoring ecologist for Pacific Rim National Park Reserve, responsible for seabird research, monitoring, and restoration in the park. In 2002 and 2003, he conducted postdoctoral studies on Marbled Murrelets in Desolation and Clayoquot sounds, British Columbia, through Simon Fraser University with David Lank. Since 2008, he has surveyed of seabirds and Black Oystercatchers at Seabird Rocks, Barkley Sound, Clayoquot Sound, and along the West Coast Trail.

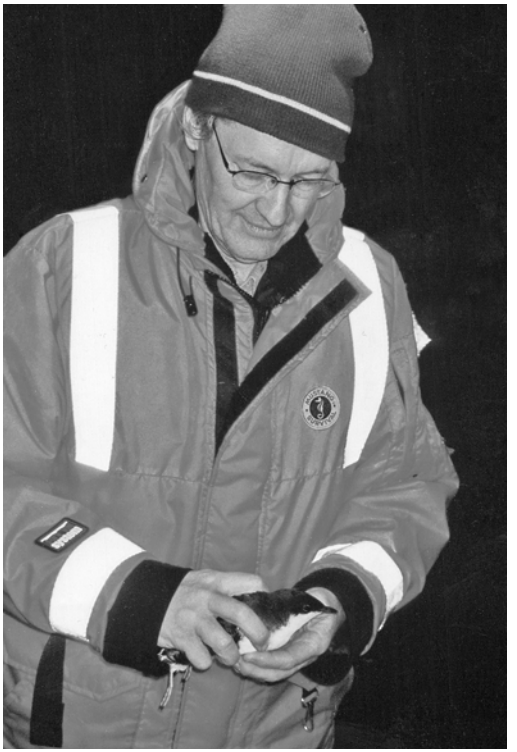
Yuri Zharikov, 2011.

Michael is a private wildlife consultant who started surveying seabirds in British Columbia between 1975 and 1977 when he also participated in the first province-wide seabird colony survey under Wayne Campbell. In the 1980s and early 1990s, he worked for the Canadian Wildlife Service, often partnered with Moira Lemon, and conducted detailed surveys of burrow-nesting and surface-nesting seabird populations throughout British Columbia, under Kees Vermeer and Gary Kaiser. He has published the most comprehensive summary of population sizes of all seabirds in British Columbia.



Michael Rodway, Hope, BC, summer 2006. *Photo by Heidi M. Regehr.*

Spencer is professor emeritus of Biological Sciences at the University of Manitoba in Winnipeg. His research has focused on the breeding biology and feeding ecology of seabirds in British Columbia and the northern Bering Sea region, social behaviour of foraging in tropical birds, and the behavioural and evolutionary interactions between avian brood parasites and their hosts. He is past editor of *The Auk* and recently assumed the editorship of *Wildlife Afield*. From 1979 to 1984, he conducted seabird research in Barkley Sound, near Seabird Rocks, along with graduate students, including Harry Carter.



Spencer Sealy, with Scripps's Murrelet (*Synthliboramphus scrippsi*) at Anacapa Island, California, May 2002. *Photo by Darrell L. Whitworth.*

Wayne is a retired biologist but started surveying seabirds in British Columbia between 1967 and 1969 in Clayoquot and Barkley sounds, while employed as a provincial park naturalist at Wickaninnish Park (now part of Pacific Rim National Park Reserve). In 1973, he moved to the British Columbia Provincial Museum and led the first survey of seabird colonies along the entire British Columbia coast between 1975 and 1977. He was lead author of the monumental four-volume *The Birds of British Columbia* (1990-2001). He is co-founder of the non-profit Biodiversity Centre for Wildlife Studies and has been associate editor of its bi-annual journal *Wildlife Afield* since its inception in 2004. Wayne's current research interests include assessing breeding populations of colonial-nesting fresh-water birds in British Columbia.

Wayne Campbell resting after searching a wetland for nesting birds near Tunkwa Lake, BC, June 2011. *Photo by Eileen C. Campbell.*

David is a private wildlife consultant but previously worked at Pacific Rim National Park Reserve in the early 1970s where he authored the *Birds of Pacific Rim National Park*, along with Wayne Campbell and Adrian Dorst. He conducted the second major seabird colony survey at Seabird Rocks in 1972 and made many observations of Northern River Otters while studying American Mink for his Ph.D. work at the University of British Columbia under Ian McTaggart-Cowan. He also is lead author of the Royal British Columbia Museum Handbook *Carnivores of British Columbia*.

David Hatler, June 2012. *Photo by Alison M. Beal.*