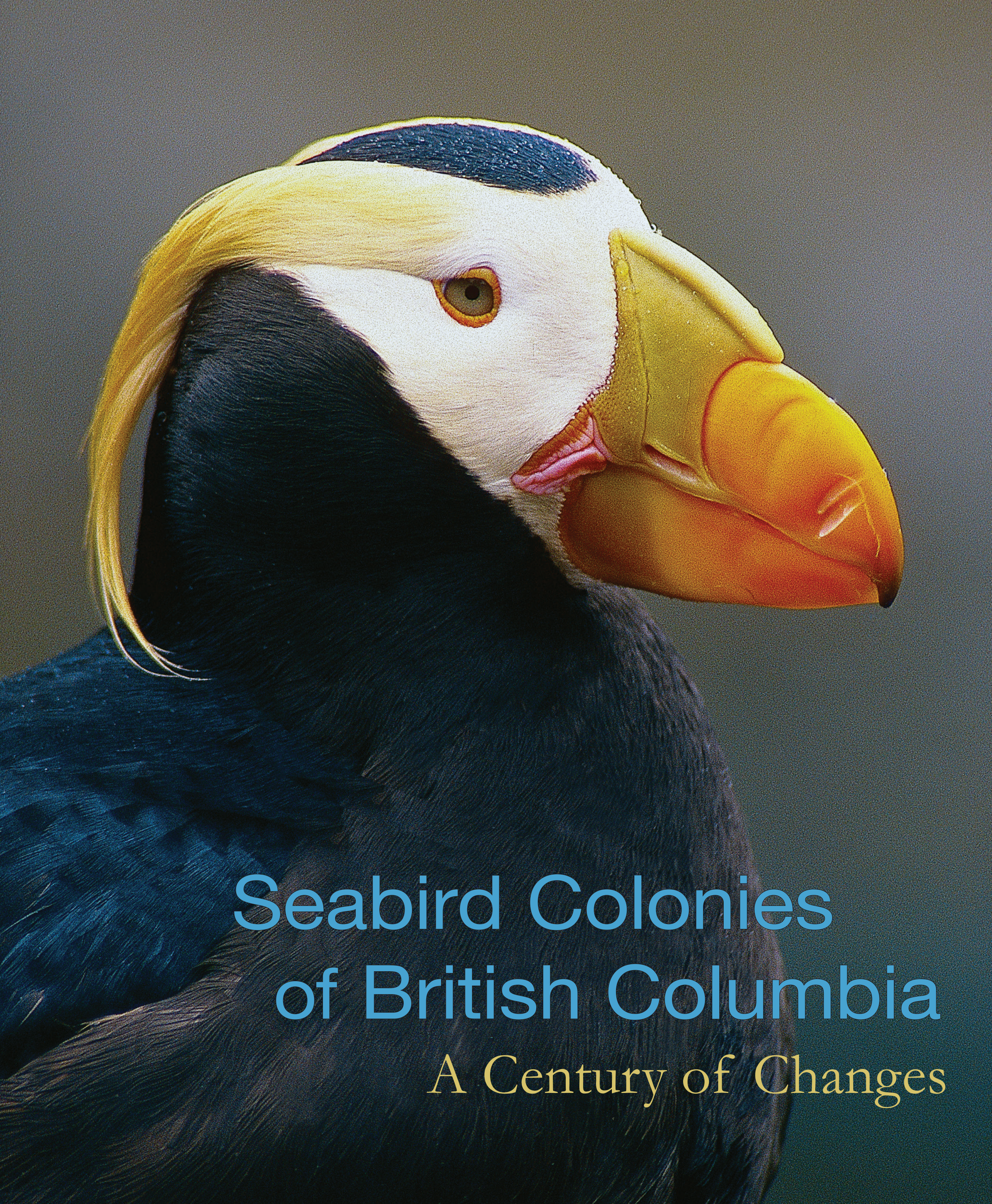
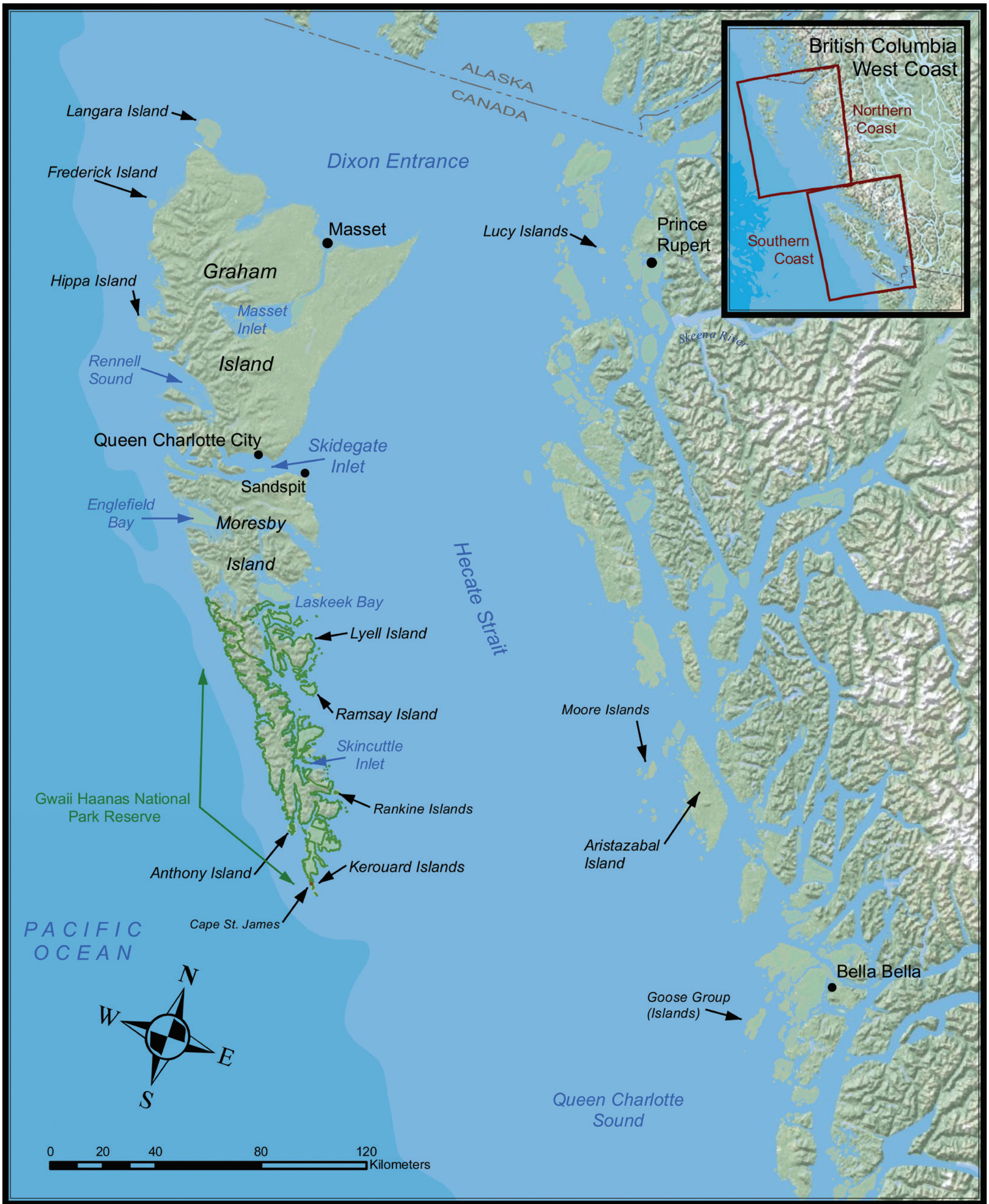


Seabird Colonies of British Columbia

A Century of Changes



Northern Coast, British Columbia

Seabird Colonies of British Columbia
A Century of Changes

Michael S. Rodway
R. Wayne Campbell
Moira J.F. Lemon

Triangle Island is the most important colony and home to 22% of the total seabird breeding population in British Columbia. *Photos of "Puffin Rock" area by Michael S. Rodway, July 2009.*

A TRIBUTE

Harry R. Carter – The Formative Years

Harry Carter often came to mind during the preparation of this updated seabird catalogue. Harry was a passionate seabird biologist and of all people would have most appreciated what we have tried to accomplish. He always asked Michael when the promised British Columbia (BC) seabird catalogue would be finished and persistently encouraged its completion. We always thought we would send the first copy to him. His recent death is still a shock and it saddens us that we never got to share this publication with him. Wayne and Michael are grateful to have shared some of Harry's formative years as a seabird biologist and we have many fond memories of surveying seabird colonies along the BC coast with him during his student years.

Harry's career as a prominent and respected seabird biologist was launched when he was an undergraduate in his first-year biology program at the University of Victoria. He was offered a summer job at the BC Provincial Museum preparing skeletons through a federal government-funded summer program. After several smelly weeks in the lab boiling and tediously plucking muscles from mammal skeletons, it became clear that Harry preferred to be working outdoors. At that time, Wayne was the assistant curator in the Birds and Mammal Division at the museum, and was coordinating the province's inaugural survey of seabird nesting colonies as part of his larger project on *The Birds of British Columbia* (1990-2001). After discussions with curator Charles Guiguet, who also had an interest in seabirds, having co-authored *A Catalogue of British Columbia Seabird Colonies* with Rudi Drent in 1961, Harry was included in a team to participate in the seabird colony surveys. In 1974, the first of four years at the museum, Harry eagerly helped count nesting seabirds on islands in Haro Strait and the southern Strait of Georgia as well as banding Glaucous-winged Gulls on larger islands. Five-day work weeks usually turned into full seven-day work weeks and soon the May to mid-July nesting season was over. Like a seasoned biologist, Harry spent the rest of the summer transferring field notes and photographs to individual colony files for permanent storage.

The four months of that first seabird season were euphoric for Harry, after which he was eager to return to university. Since there were no ornithologists on staff at the University of Victoria, Charles and Wayne encouraged him to transfer to the University of BC in Vancouver. There he could be introduced to Dr. Ian-McTaggart Cowan, Head of the Zoology Department, and staff ornithologist Jamie N.M. Smith. At the time seabird research was not being conducted at UBC but Cowan, who was now involved in the updated bird book for BC, gave Harry permission to compile some of the summer seabird data for a wildlife management course he was teaching. Later, some

Harry checking burrows on Byers Island off the central mainland coast during the inaugural seabird surveys conducted by the BC Provincial Museum in the 1970s. Harry was passionate about exploring and protecting the world's nesting seabirds right up to his death in 2017. *Photo by R. Wayne Campbell, 27 June 1976.*

of that information appeared in *The Birds of British Columbia* project (1980-2001).

At the same time, Wayne was continuing research on *A Bibliography of British Columbia Ornithology* (1978) that he had started in the mid-1960s to update the museum publication A *Review of the Bird Fauna of British Columbia* (1947). After Harry's commitment and genuine interest in the seabird surveys, Wayne invited Harry to participate in the project as an author. The task was tedious and demanding and lasted several years. It involved photo-copying articles, cross-referencing them by author and geographic location, and transferring relevant bird records to index cards in a separate master file for later reference. It was Harry's first glimpse into the early history of ornithology in BC. It seemed unusual that a teenager would become fascinated with such a topic, but his appetite for basic knowledge only grew over the years and led to a life-time interest in documenting the early history of ornithology in the province.

Harry was also an excellent multi-talented athlete, and in high school especially enjoyed rugby and soccer. During his first summer's work he and Wayne played in the government soccer league and following many games, after a trip to the pub, they returned to the museum to work on the ornithology bibliography.

In 1975, Harry's father, an orthopedic surgeon in Victoria, was delighted that his son had discovered a career path so early in his education. To support his new-found passion, Dr. Carter purchased a boat, the *Tedmac*, which was used in ensuing summers as a mother ship for seabird explorations further afield. Prior to the surveys, Dr. Carter had to take classes with the Victoria (Power) Squadron to become certified on seamanship, navigation, and other related subjects. Later, Harry Jr. also had to enroll in courses that taught basic knowledge necessary to operate boats safely and legally in the province. The provision of the *Tedmac* and the commitment and rapidly-gained skill of both father and son in skippering their boat through the remote waters of the entire BC coast were instrumental in the success of those early seabird surveys.

After completing his undergraduate degree at UBC, Harry began a M.Sc. at the University of Manitoba with Professor Spencer Sealy who became his primary seabird mentor and lifelong colleague. Harry had met Spencer when he took the seabird course at the Bamfield Marine Station in 1976, and discussions with Spencer during that course and during Spencer's sabbatical at the BC Provincial Museum in 1978-79 further fueled Harry's interests. Harry's thesis work on the at-sea biology of Marbled Murrelets focused his attention on seabird conservation issues. Upon graduation in 1985, his passion for seabirds remained high but there were few career opportunities at the time in BC. Harry headed for California where he had worked at Point Reyes Bird Observatory before graduating. His early years of experience surveying BC colonies were just the beginning and Harry went on to conduct surveys and lead conservation efforts for seabirds throughout the Pacific northwest and later in Japan in association with the U.S. Fish and Wildlife Service and Humboldt State University. After 20 years away, in 2003 Harry returned to his home town of Victoria where he continued his seabird work. A little more than a month before he died, Harry travelled to Japan to participate in the Japanese Murrelet Symposium and promote the study and conservation of seabirds there.

Harry was a prolific author. Besides his many reports as a wildlife consultant, his bibliography includes more than 100 titles, including several books and many peer-reviewed papers, some of which were published in *Wildlife Afield*. He recently received a *Lifetime Achievement Award* from the Pacific Seabird Group for his long-term contributions to seabird science, conservation, and education.

In April, 2017, Harry was diagnosed with stage 4 cancer and underwent gene therapy and radiation in an attempt to slow its progress. On April 30, 2017, he passed away in a hospice in Victoria, BC.

CONTENTS

FROM THE EDITORS

Nesting Seabirds in British Columbia – From Inventory to Conservation

Although seabirds account for less than 6% of the 316 species breeding in British Columbia (BC),[154] they are among the most vulnerable group of birds. Their colonial nesting habits on remote islands concentrate large proportions of their populations in small areas where they are at risk from local perturbations in the environment such as oil spills and introduced mammalian predators. The total number of these birds that nest in BC is estimated at 5.6 million. For some species, like Cassin's Auklet, Ancient Murrelet, and Rhinoceros Auklet, numbers are significant as they comprise most of the world's breeding populations.

Not everyone is passionate about seabirds, but over the past 125 years, a few observers have brought the 16 species that breed in BC to the forefront. The early interest started with collectors in the late 1800s[169] and by the early 1900s lighthouse keepers and naturalists were counting nests and banding young at select colonies. For decades the information remained scattered and anecdotal until UBC graduate student Rudolph H. Drent, with help from provincial museum curator Charles J. Guiguet, compiled and published the province's first seabird colony catalogue in 1961.[213] That treatise immediately stimulated interest from others and soon banding programs intensified, surveys of islands expanded, and species research was initiated. Eighteen years later the province's first coastal survey was completed by R. Wayne Campbell while employed at the British Columbia Provincial Museum (BCPM). During the 1980s, more comprehensive surveys were directed by Kees Vermeer and Gary W. Kaiser, Canadian Wildlife Service (CWS) biologists, and conducted by Michael S. Rodway, who also participated in the earlier BCPM surveys, and Moira J.F. Lemon, also a CWS employee. The results were published in *The Birds of British Columbia* [136, 137] and in the International Council for Bird Preservation publication *Status and Conservation of the World's Seabirds*.[473] Reliable baseline data were available following that decade of intensive survey efforts and most major seabird colonies in the province were protected by ecological reserves or other sanctuaries.

More recently, studies became more research-oriented, although regular monitoring of some important colonies is still necessary. Some challenging topics include determining the ecological requirements for highly specialized species; identifying major staging, feeding, and wintering sites where large numbers of marine birds aggregate and are vulnerable to oil spills and human disturbance; discouraging the human introduction of alien predators on nesting islands; and assessing the impacts of global warming and climate change on life history strategies of nesting seabirds. Many of these topics, which require long-term research, are currently being managed by CWS.

Knowledge, disseminated widely, is essential to the future welfare of nesting seabirds in BC. This special two-issue volume of *Wildlife Afield* is the first installment of an updated catalogue of BC seabird colonies. It presents an overview of BC's breeding seabird species, including summaries of provincial populations and nesting distributions, methods used to obtain estimates of numbers, and conservation issues that need to be addressed to ensure a future for this remarkable group of birds.

R. Wayne Campbell and Spencer G. Sealy

(Note: superscript numbers in the text refer to entries in the Literature Cited that begins on page 251)

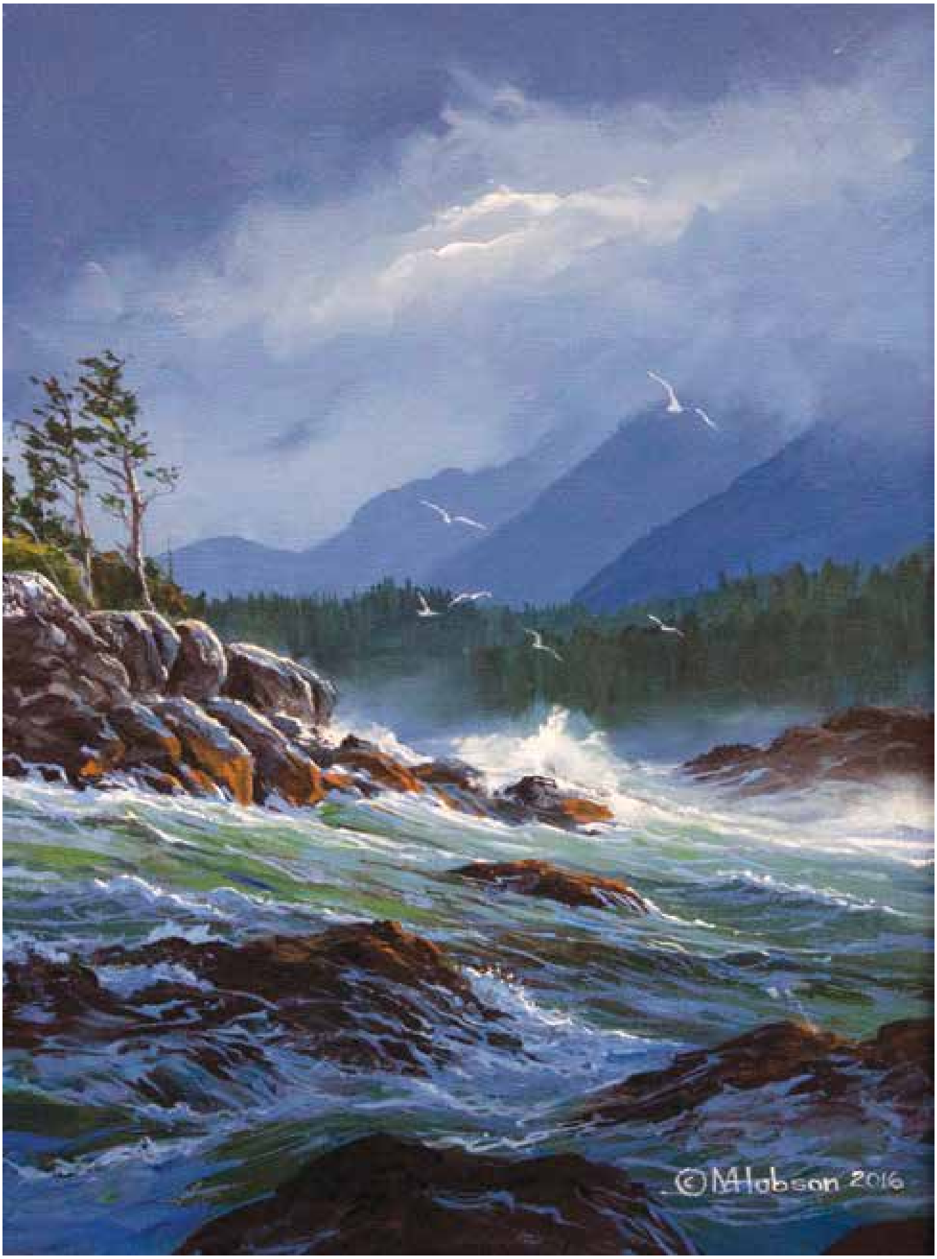
On The Covers

Front: Tufted Puffin. *Photo by Jared Hobbs.*
Back: Silhouetted Double-crested Cormorants. *Photo by R. Wayne Campbell.*
Inside covers: Maps prepared by HR GISolutions Inc., Victoria, B.C.

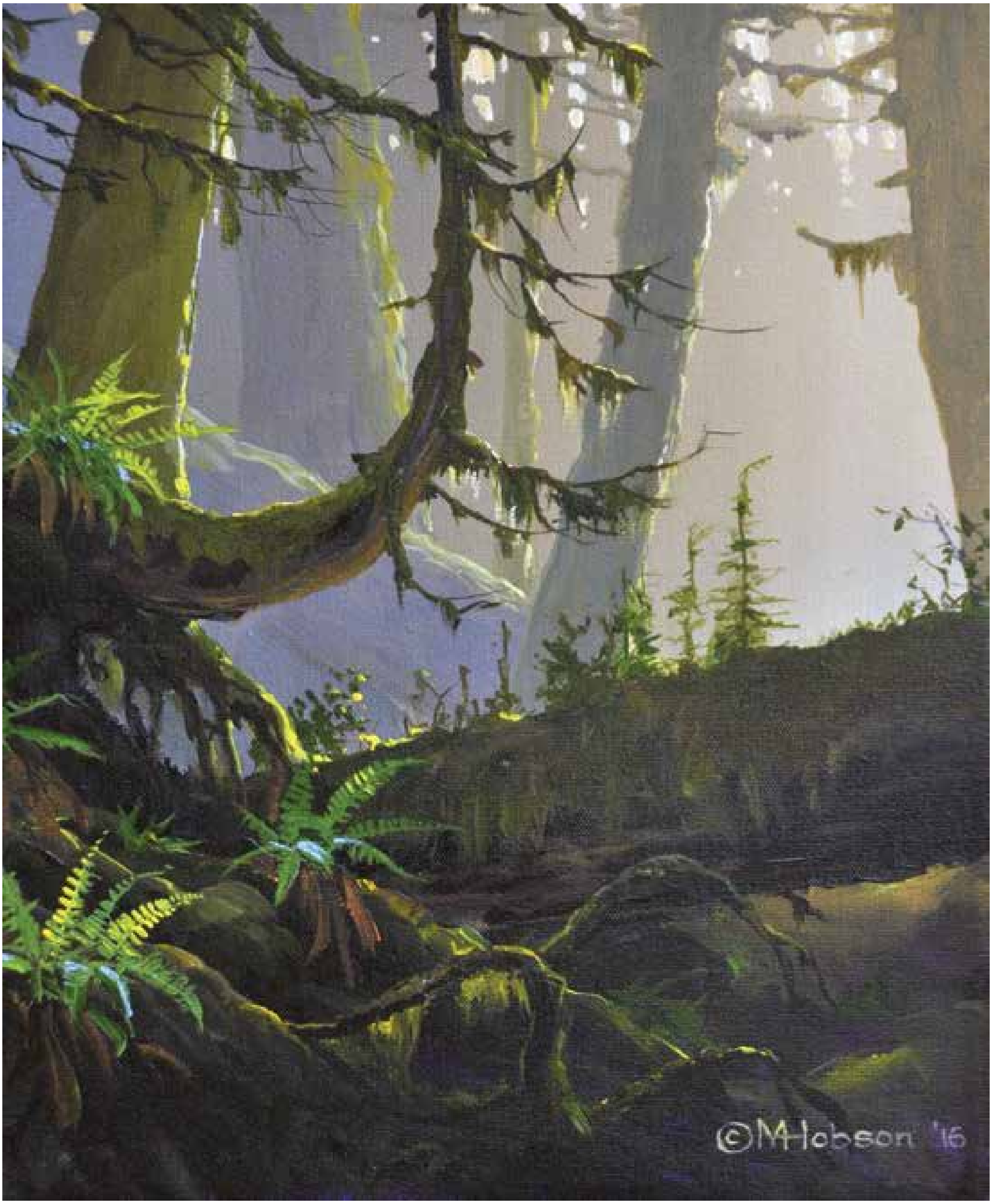
Inc.]

Most of the almost 80,000 Tufted Puffins breeding in British Columbia nest on four islands off the wild, west coast of Vancouver Island. In total, over 5.6 million seabirds nest at 542 colonies in the province. [Paintings "Tufted Puffins Riding Pacific Swells" (top) and "Amphitrite Light" *courtesy Mark Hobson, Coastline Art Inc.*]

In this catalogue, we are most concerned with 16 seabird species that depend on coastal islands in British Columbia for nesting, but 52 other marine-dependent bird species also spend at least part of their lives here. [Paintings “Short-tailed Albatross” (top) and "Spindrift & Rip Currents" *courtesy Mark Hobson, Coastline Art Inc*.]



Although seabirds in British Columbia nest in a wide variety of habitats, including downtown bridges and high-rise buildings in large coastal cities, most are concentrated on forested, grassy, and rocky islands off the outer coast. [Painting "Flores Island - Dagger Point" *courtesy Mark Hobson, Coastline Art Inc.*]



Six seabird species nest in old-growth forest in British Columbia, but the inland-nesting Marbled Murrelet is most threatened by the rapid loss of old-growth forest habitat due to logging along the entire eastern North Pacific coast. [Painting "Where Trees Grow Old" *courtesy Mark Hobson, Coastline Art Inc.*]

Wildlife Afield 13(1&2):1-298, 2016

SEABIRD COLONIES OF BRITISH COLUMBIA: A HISTORY TO 1990. Part 1: Introduction and Provincial Summary

Michael S. Rodway[1], *R. Wayne Campbell*[2], *and Moira J.F. Lemon*[3]

[1]*Wildwing Environmental Research, Box 47, Gold Bridge, British Columbia, Canada V0K 1P0, (msrodway@alumni.sfu.ca)*

[2]*2511 Kilgary Place, Victoria, British Columbia, Canada V8N 1J6*

[3]*4997 57th Street, Delta, British Columbia, Canada V4K 3E7*

PREFACE

Much of this updated history of seabird colonies in British Columbia (BC) was prepared during the late 1980s by Michael Rodway. Colony and species accounts were written using historical data compiled by Wayne Campbell in the late 1960s through the 1980s and more recent data gathered during the 1980s by the Canadian Wildlife Service (CWS) of Environment Canada (now Environment and Climate Change Canada). Seabird inventory files to compile and organize historical data on islands with and without nesting seabirds were developed by Wayne while he was a museum curator at the University of British Columbia (UBC) and then at the British Columbia Provincial Museum (BCPM; now the Royal British Columbia Museum). The inventory files were developed as an offshoot of the BC Nest Record Scheme (BCNRS) that was initiated in the Department of Zoology at UBC in 1955.[413] The BCNRS was initially on loan to the BCPM during the preparation of *The Birds of British Columbia*,[136,137,138] but since 1972 has been maintained by Wayne and Eileen Campbell, and now has over 800,000 breeding records for birds in the province.[116, 154, 412] Sources for the compilation of seabird records included: copies of field notes of early collectors, naturalists, and biologists; two ornithological bibliographies that collated published and unpublished literature;[135, 140] a photo-file of rare and unusual records of BC vertebrates initiated at UBC in 1970;[132] data from the province-wide survey of seabird colonies coordinated by Wayne, conducted by Wayne, Michael, and many others, and supported in part by the BCPM, the British Columbia Ecological Reserves Unit, and private donations during the 1970s; and other records contributed to the BCNRS. CWS data from the 1980s was gathered during a decade of rigorous surveys of colonial-nesting seabird populations, directed by Kees Vermeer and Gary Kaiser, and carried out by Michael, Moira Lemon, and colleagues.

A draft manuscript was largely completed by 1990. It formed the basis for a BC contribution in the publication on the status and conservation of the world's seabirds by the International Council for Bird Preservation (ICBP)[473] (Figure 1). The updated population estimates also contributed to the species accounts in *The Birds of British Columbia* [136, 137] (Figure 2). Although these publications are significant references for breeding seabirds in the province through 1990, they were not able to provide the space to discuss individual islands and species' biology in detail. Our intentions have always been to make this document more comprehensive and widely available and to update it with seabird data collected since 1990.

Figure 1. The ICBP publication *Status and Conservation of the World's Seabirds* allows countries and their administrative divisions to put in perspective the significance of nesting seabird populations under their jurisdiction. For example, an estimated 74% of the world's population of Ancient Murrelets breed in BC, essentially all on the Queen Charlotte Islands (Haida Gwaii). *Photo by Jared Hobbs.*

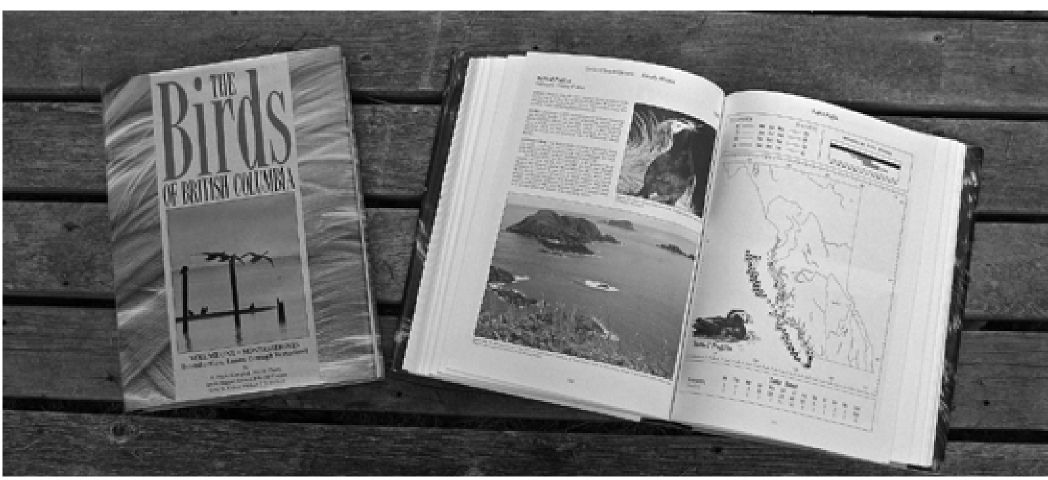


Figure 2. A major impetus for the provincial seabird colony inventories was to enhance species accounts for *The Birds of British Columbia* project that started in the 1960s in Greater Vancouver and was carried over to become a major work by the BCPM and CWS during the 1970s and 1980s. Initially, only two pages were allotted for each species (text and a map) but colony surveys provided information that allowed accounts to be expanded to at least six pages for most of the 16 breeding species. The species summaries, however, were still only a general overview of distribution and populations.

As they have a habit of doing, good intentions gave way to other commitments and years have passed. The task of updating the seabird colony histories has become more intimidating as the number of agencies, students, wildlife consultants, and private individuals conducting studies and collecting data on seabird colonies has increased. We have decided to make the histories to 1990 that we do have completed available to interested parties. Our hope still is to compile all post-1990 data to update the histories, but we accept that we are unlikely to accomplish this ongoing task without input and help from other involved individuals and agencies. We envision this as a next step and invite suggestions as to how it might occur. Ideally, we could create an accessible and dynamic online document that could be updated by participants with additional data – something along the lines of a Wikipedia article. For now, we have limited ourselves to completing the histories of seabird colonies to 1990.

We chose 1990 as our cut-off because we were already close to completing the accounts to that date, and because 1990 was the last year of the focused CWS surveys that provided population estimates for the entire province. We have added considerable new information from 1989 and 1990 surveys of cormorants, Black Oystercatcher (*Haematopus bachmani*; Figure 3), Glaucous-winged Gull (*Larus glaucescens*), and Pigeon Guillemot (*Cepphus columba*) that were not available when the original accounts were written. Some of the colony histories have also been revised with other data from 1990 and earlier that have come to light since this document was initially prepared. We have also corrected some entries where mistakes have been found. Where differences in specific data occur between this release and past publications, including CWS technical reports (Figure 4), the data here should be considered correct. Publications since 1990 pertaining to historical records plus online searches through the Ornithology Information System [428] and the ornithology archives at the Royal British Columbia Museum [490] were used to validate early egg-collection records as well as uncover nesting and specimen records that we were unaware of in 1990. Thus, although those who have seen the earlier summary publication [473] will find some familiar material, there are major differences between this article and the original document and summary publication.

Figure 3. Black Oystercatcher is included in this seabird catalogue because it is confined to a narrow band of rocky marine shores and is considered a keystone species that serves as an indicator of the overall health of the intertidal community.[544] *Photo by R. Wayne Campbell.*

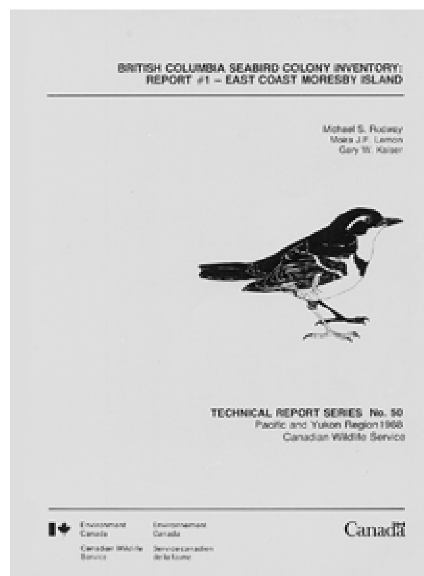


Figure 4. Nine detailed technical reports, compiled by Michael Rodway, Moira Lemon and others, summarize results of seabird colony surveys along the BC coast in the 1980s by CWS. These important documents were major references used in the present catalogue.

Survey data from 1990 and earlier are still the most current data available for most colonies of burrow-nesting species and for surface nesting species in a number of coastal regions. Surveys completed by CWS between 1980 and 1990 provide the only comprehensive estimate of provincial populations, although some colonies have not been revisited since the BCPM surveys of the 1970s. A few regional surveys conducted since 1990 provide updates and trends for surface nesting species in certain areas,[41, 171, 180] while others update specific colony estimates.[170, 298, 374, 463] In addition, the BCNRS has received results from annual surveys of select colonies in the Strait of Georgia and Juan de Fuca Strait, especially for Double-crested (*Phalacrocorax auritus*), Brandt's (*P. penicillatus*) and Pelagic (*P. pelagicus*) cormorant (Figure 5), Black Oystercatcher, and Glaucous-winged Gull.[146, 152, 153, 154, 155] We have not included data from those post-1990 surveys in our colony accounts and summary tables. We have, however, cited and discussed recent work for each species in the Species Accounts section. In this way we identify where our historical analyses are incomplete and provide direction to more recent data known to us.

Figure 5. The Pelagic Cormorant colony on Arbutus Island, northwest of Swartz Bay, BC, has been monitored, most recently by Wayne Campbell and Ron Jakimchuk, during the 1990s and early 2000s. *Photo by Ronald D. Jakimchuk, 31 May 2014.*

Reviving the draft document and preparing it for a more comprehensive publication proved to be a more onerous undertaking than we first anticipated. It is a prime demonstration of the challenges and pitfalls of digital storage. The document was written using word-processing and spreadsheet programs that are now outdated. Files were backed up on the then-current 5.25-inch floppy disks. Finding a drive to extract the files from the 5.25-inch floppies required some sleuthing, but the most difficult process was translating files created with old software into a format that could be read by "modern" programs. Using intermediary programs we managed to import files into a current Microsoft Word program, but most text arrived with corrupted characters that required tedious manual correction (Figure 6). We are thus making sections of the document available as they are revived and completed. This means that some minor discrepancies from the data presented here in the introductory chapter may develop as further chapters in the series are completed.

```
.pa
èINTRODUCTIONì


     Seabird¼ áarÕ áa¯ áintegraý elemen¶
i¯ thÕ marinÕ áecosysteÝ áoµ ácoastaý i
i
Britisþ Columbia«  The¨ arÕ als´ inspirinþ
companion¼ t´ thosÕ wh´ traveý áit¼ i
i
waters« áá The¨ áádepenõ áo¯ áselec¶
áhabita¶ áfo_ ábreeding¼ ááanõ ááspecifiÕ
i
i
oceanographiÕ ácondition¼ áfo_ foraging«
Incidentaý event¼ i¯ thÕ ácoursÕ áoµ i
i
huma¯ áaffair¼ áca¯ perturÕ thosÕ
environment¼ anõ áthreate¯ áthei_
ásurvival«  i
i
Informeõ managemen¶ i¼ requireõ t´ redeeÝ
alread¨ impacteõ area¼ anõ t´ áavoiõ i
i
futurÕ ádisturbance«
```

Figure 6. Rapidly changing electronic technology created a major problem in retrieving seabird colony data for this catalogue that was originally stored on 5.25-inch floppy discs in the 1980s. The time lag and incompatibility of new word-processing software encrypted data so each word had to be deciphered and retyped.

The designation and sequence of bird species and their common and scientific names follow the American Ornithologists' Union *Check-list of North American Birds* [10] and latest checklist of BC birds,[144] although recent research by taxonomists has recommended changes in species order.[182] Four-letter species codes are from Campbell et al.[144] Mammal names are from Hatler et al.[316] and Nagorsen.[414] Geographical names used here are those that were in common use in 1990 and found on all the maps, tables and text prepared at that time. Many places in the Queen Charlotte Islands (Haida Gwaii) are now known by their Haida names and we have tried to acknowledge both names where places are first mentioned.

SUMMARY

Drent and Guiguet published the first catalogue of BC seabird colonies in 1961, summarizing data available at that time. The present updated catalogue describes every documented seabird colony in the province and presents all known historical data on nesting seabird populations at those colonies up to 1990. Colony accounts have been organized geographically and will be presented in forthcoming regional chapters to be published in *Wildlife Afield* by the Biodiversity Centre for Wildlife Studies. In this introductory chapter, we: review the major programs that have been undertaken to improve our knowledge of breeding seabird populations in the years 1961-1990; detail the methods that have been used to survey nesting populations; summarize total provincial populations and trends as well as the distribution and abundance of each species as of 1990; and discuss conservation issues currently facing breeding seabirds in BC. In each species account we also discuss survey work conducted since 1990 to identify where our historical analyses are incomplete and provide direction to more recent data.

Since 1961, major efforts to inventory seabird nesting populations have been undertaken by: the Department of Zoology at UBC and BC Parks Branch staff stationed at Miracle Beach and Mitlenatch Island Nature Park (1962-1972); Wickaninnish Provincial Park/Pacific Rim National Park (1965-1975); independent contractor Ken Summers on the east coast of Moresby Island (1971); the BCPM (1973-1977); and CWS (1975-1990). Surveys completed by CWS between 1980 and 1990 provide the only comprehensive estimate of provincial populations, although some colonies have not been revisited since the BCPM surveys of the 1970s. We have estimates based on replicable line transect techniques for most colonies of burrow nesting species and total nest counts for most colonies of surface-nesting species. Survey data collected up to 1990 are still the most current data available for most colonies of burrow-nesting species and for surface nesting species in several coastal regions.

As of 1990, 16 species of seabirds are known to breed on the coast of BC, including two storm-petrels, three cormorants, one gull, nine alcids, and one shorebird, Black Oystercatcher, that is also considered a "seabird" here because it feeds and breeds only in the nearshore coastal environment. Distribution and breeding populations are well known for colonial species, but information is speculative, incomplete, or lacking in some coastal areas for the non-colonial nesting Marbled Murrelet (*Brachyramphus marmoratus*). Although Black-legged Kittiwake (*Rissa tridactyla*) was suspected of breeding near Prince Rupert in the late 1970s and throughout the 1980s, it was first confirmed breeding in June 1997 on Holland Rock. Therefore it is not included in this summary (Figure 7).

Figure 7. Although suspected of breeding west of Prince Rupert in the late 1970s, Black-legged Kittiwake was not added to the official list of birds breeding in BC until 1997.[319] The species is not included in the current catalogue that covers the period from the late 1800s to 1990. *Photo by R. Wayne Campbell.*

Data gathered up to 1990 indicate that over 5.6 million colonial seabirds nest at 542 sites in the province. Five species comprise the vast majority of that population: 48% Cassin's Auklets (*Ptychoramphus aleuticus*), 27% Fork-tailed (*Oceanodroma furcata*) and Leach's (*O. leucorhoa*) storm-petrels, 13% Rhinoceros Auklets (*Cerorhinca monocerata*) and 10% Ancient Murrelets (*Synthliboramphus antiquus*). Using data available in 1990 from other areas, we calculated that BC supports major portions of estimated world breeding populations of Cassin's Auklets (80%), Ancient Murrelets (74%) and Rhinoceros Auklets (56%). Populations in BC are concentrated in small clusters of colonies, making large segments of the international population vulnerable to local environmental perturbations. Although seabirds account for less than 6 percent of the 316 species breeding in BC, they are part of our avifauna that is especially vulnerable and threatened.

Important threats to seabirds in BC recognized in 1990 include introduced native and non-native mammalian predators, loss of old-growth forest habitat, human disturbance, oil and chemical spills, gill-net drowning, and outdoor recreational activities. Eradication of introduced Black and Norway rats (*Rattus rattus* and *R. norvegicus*) on several impacted seabird colonies since 1990 has removed some of the concern about mammalian predators, but Northern Raccoons (*Procyon lotor*; Figure 8) continue to be an imminent threat to breeding seabirds in the Queen Charlotte Islands (Haida Gwaii). This threat is particularly serious for Ancient Murrelets that occur only in the Queen Charlotte Islands and are designated as a species of special concern by the Committee on Status of Endangered Wildlife in Canada (COSEWIC). Loss of old-growth forest habitat and contamination of the marine environment continue to be major concerns for Marbled Murrelets, although much work has been

Figure 8. Northern Raccoon was introduced on east-central Queen Charlotte Islands in the early 1940s and has spread throughout the islands. Hartman and Easton [306] estimate that 80% of burrow-nesting species, including storm-petrels and alcids, are potentially at risk of predation. *Photo by Alan D. Wilson*.

Remembering Anne Vallée

We want to pay tribute in this work to Anne Vallée (Figure 9) *who fell to her death off the steep slopes of Triangle Island on 31 July 1982 while taking time out of her own studies to assist us with our surveys of Tufted Puffins* (Fratercula cirrhata). *Anne was studying Tufted Puffins as part of her graduate program at UBC and had spent two previous field seasons on the island. The working title of her thesis was "*The Relationship between Nesting Density and Productivity in the Tufted Puffin (*Lunda cirrhata*)." *Starting out as a M.Sc. candidate, her status was elevated to Ph.D. candidate after her 1980 field work. Reasons given for upgrading her status were "the quality of the student", and "the viability and interest of the study". Her dedication and passion for the birds and the science would have undoubtedly led her to a remarkable career in wildlife biology. In 1983, the ecological reserve at Triangle Island was renamed the Anne Vallée Ecological Reserve in her honour, and her parents established the Anne Vallée Ecological Fund that awards scholarships each year to students addressing problems of animal ecology in relation to human settlements and activities such as agriculture, forestry, fishing, and tourism. Though she did not get to finish her work, some of her results contributed to the long-term investigation on the relationship between Tufted Puffin reproductive performance and climate change.*[277] *As an aside to her main work, she was the first to discover Thick-billed Murres* (Uria lomvia) *nesting in BC.*[555] *Alison Watt has given us an intimate portrait of Anne in her wonderful book, "*The Last Island*"*[614] *that portrays Alison's time as Anne's research assistant on Triangle Island in 1980. Two of us (Michael and Moira) treasure the time we spent with Anne on the island in 1982. Anne's spirit resides there still and, as Alison said, her tragic loss is still difficult to believe.*

Figure 9. The biffy with the best view! Moira Lemon, Michael Rodway and Anne Vallée (left to right) proudly posing at their newly constructed outhouse on Triangle Island, 1982. *Photo by Moira J.F. Lemon.*

done and more nesting habitat has been protected since they were designated a threatened species by COSEWIC in 1990. Disturbance from increasing numbers of recreational boaters and ecotourism, a threat to seabird colonies that Drent and Guiguet issued a plea for protection from in 1961, is still a concern, especially for conspicuous cormorant and puffin colonies and for fragile storm-petrel, Ancient Murrelet and Cassin's Auklet colonies in some areas. Concern about fuel spills from tankers and other boats plying the coast and from proposed oil exploration in Hecate Strait was heightened by the spill from the *Nestucca* barge in Washington that spread oil the entire length of Vancouver Island in December 1988. Today, the moratorium on oil tanker traffic for BC's north coast implemented by the federal government will help reduce risks to seabird populations on the outer coast. However, approval of the Kinder Morgan pipeline will increase tanker traffic and risks to nesting and wintering birds in the Strait of Georgia and Juan de Fuca Strait. Seabird mortality due to gill-net fisheries in BC was first quantified by Carter and Sealy in Barkley Sound in 1979 and 1980 and is still a concern. Studies since 1990 have provided better documentation of fisheries-related mortality, although data are still considered preliminary. Climate change was not a recognized threat to breeding seabird populations in 1990, although anomalous weather patterns were known to be associated with seabird reproductive failures. Today, it is apparent that climate change can disrupt or modify oceanographic productivity and compromise seabird survival and reproductive success. The apparent loss in BC of more than 20% of the world's population of Cassin's Auklets between 1989 and 2009 is likely related to climate change.

Long-term monitoring of breeding populations and productivity is an important follow-up to completed baseline population inventories. Further studies are required on ways to control Northern Raccoons to protect seabird colonies in the Queen Charlotte Islands, the nesting and at-sea distribution of Marbled Murrelets and its relationship to remaining old-growth forest throughout the coast, the levels and effects of human disturbance that can be tolerated on seabird colonies, and the potential impacts of climate change on nesting seabird populations.

INTRODUCTION

Seabirds are a fascinating group of well-adapted animals and an integral element in the marine ecosystem of coastal BC. They are also inspiring companions to those who travel its waters. Many seabird species range widely and spend most of their life on the open ocean, coming to land only for a brief period to breed. These birds fly, feed, and rest in a vast, hostile environment that has no shelter and is characterized by strong winds, high waves, and patchily-distributed food. Most people are familiar with "seagulls" from encounters at parks and beaches or while travelling on ferries, and may have seen the colourful and bizarre-looking puffins from pictures in magazines. But few are aware that 68 marine-dependent species occur regularly along the coast of BC (Table 1, page 22). Some of those species, for example Brant (*Branta bernicla*), Yellow-billed Loon (*Gavia adamsii*), Black Turnstone (*Arenaria melanocephala*), and Heermann's Gull (*Larus heermanni*), have close contact to the sea for much of their life but do not breed in the province (Figure 10). A few others like Wandering Tattler (*Tringa incana*) and Red-necked Phalarope (*Phalaropus lobatus*) nest as solitary pairs inland in BC but spend the greater part of their life on rocky coasts or at sea.

This catalogue of seabird colonies considers those marine-dependent species that rely on maritime forested and rocky island habitats for breeding in BC (Table 1, page 22). This criterion would include Black-legged Kittiwake but that species is not considered in detail because it was first confirmed breeding in BC in June 1997, seven years after the cut-off year for this updated catalogue. Marbled Murrelet is an anomalous member of the auk family that, although it inhabits marine waters throughout the year and feeds there while breeding, it does not nest colonially on maritime islands like all other auks in BC. Instead, it places its nest predominantly on the mossy limbs of old-growth trees as far as 101 km, though generally less than 50 km from the ocean shore.[186, 472] Because Marbled Murrelets are a seabird species, and because they are vulnerable to many of the same threats as other, colonial-nesting auks, we include a species account for them in this catalogue. However, they are not considered in colony accounts unless there is specific evidence of nesting on colony islands. Thus, of the 68 marine-dependent species in BC, 16 are considered in this catalogue, including two storm-petrels, three cormorants, one shorebird, one gull, and nine auks.

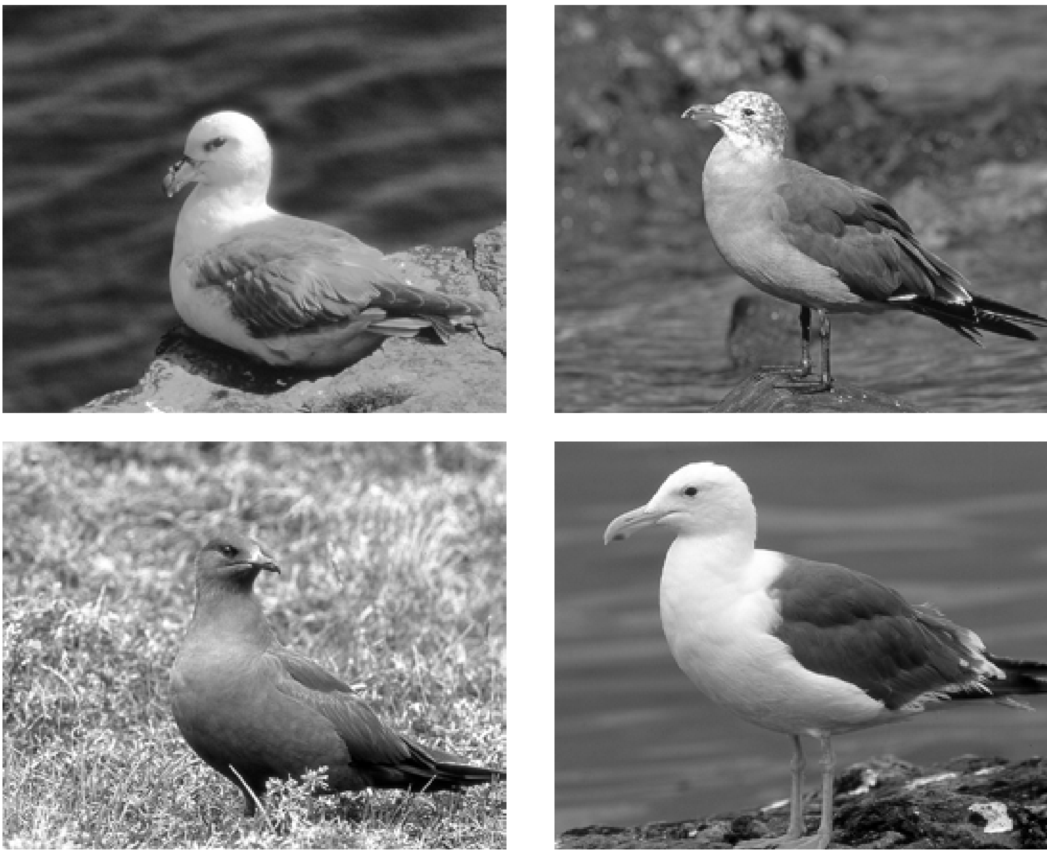


Figure 10. The 16 species of seabirds breeding in BC considered in this catalogue constitute a minority of the marine-dependent birds that regularly inhabit our coastal and offshore waters. Northern Fulmar (*Fulmaris glacialis*), Heermann's Gull, Western Gull (*Larus occidentalis*), and Parasitic Jaeger (*Stercorarius parasiticus*), pictured clockwise from the top left, are some of the additional species of seabirds, comprising millions of birds, which, though not breeding here, also depend on the ocean waters of BC for a significant part of their annual cycle. *Photos by R. Wayne Campbell.*

Table 1. Total number of marine-dependent species in common taxonomic groups occurring annually in British Columbia (BC) through 2015, with numbers of species in each group that breed almost exclusively on islands along the BC coast. Marine-dependent species include those that spend most of their year in the marine environment and breed along or near the coast. Exceptions are Double-crested Cormorant, that also breeds further inland in BC, and Marbled Murrelet, that is not predominantly an island-nesting species.

Taxonomic Group[a]	Total Number of Species	Island-breeding Species in BC
Loons	1	0
Albatrosses	2	0
Fulmars, Petrels and Shearwaters	7	0[b]
Storm-Petrels	2	2
Pelicans	1	0
Cormorants	3	3[c]
Swans, Geese and Ducks	5	0
Plovers	2	0
Oystercatchers[d]	1	1
Sandpipers and Phalaropes	14	0
Jaegers and Skuas[e]	4	0
Gulls and Terns[f]	17	2[f]
Murres, Auks and Puffins	9	9
Total	68	17

[a]Taxonomic order follows Campbell et al.[136,137]
[b]Northern Fulmar has exhibited breeding behaviour on Triangle Island but nesting is unconfirmed.
[c]Two active Double-crested Cormorant colonies occur in the interior, one at Creston and the other at Stum Lake,[558, 650] but the species is generally considered a seabird in BC.
[d]Generally not considered a true seabird family but included here because Black Oystercatcher has been considered a "seabird" by our criteria.
[e]Parasitic Jaeger is purported nesting in northwestern BC but records lack supporting details.[246]
[f]Includes Black-legged Kittiwake that was confirmed nesting in 1997.[319]

Seabirds depend on suitable habitat for breeding and specific oceanographic conditions for foraging (Figure 11). Human activities can perturb those environments and threaten seabird survival. Informed management is required to redeem already impacted areas and to avoid future disturbance. Seabirds nesting in maritime habitats comprise less than 6% of the 316 species of birds breeding in BC [154] but like elsewhere in the world they are among the most vulnerable and threatened species because of their colonial nesting behaviour. Single events, both natural and human, can seriously impact concentrated populations at colonies. Natural threats such as extreme weather and availability of food may affect foraging and survival, but it is human perturbations that are of most concern. Some of these include oil spills, by-catch of gill-net and other fisheries, various chemical contaminants in the ocean, human litter, including plastics and fishing gear, introductions of predators such as Norway Rats [352] and Northern Raccoons,[307] habitat destruction, human disturbance (Figure 12), urbanization, tourism, and climate change.

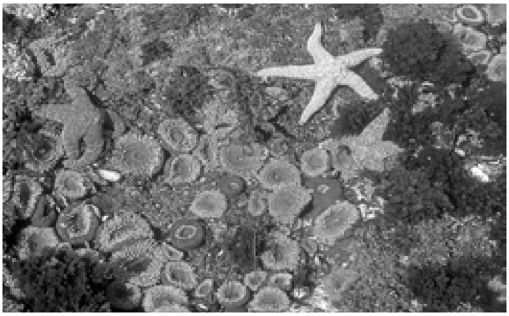


Figure 11. Monitoring coastal intertidal communities provides a strong indicator of the state of health of our oceans. *Photo by R. Wayne Campbell.*

Figure 12. Among the many natural and human disturbances to nesting seabirds is the landing of helicopters near cliff-nesting species like cormorants and murres. Fortunately, this occurs infrequently today as federal regulations make it an offence to disturb and harass migratory birds, especially during the breeding season. *Photo by R. Wayne Campbell, Mitlenatch Island, BC, mid-1960s.*

British Columbia Coastal Environment

The geological history of the coast has shaped nesting habitat for seabirds in BC. Our coastline is highly irregular, with deeply cut fiords and hundreds of islands forming almost 27,300 km of shoreline [549] (Figure 13). Its present shape is a product of an ongoing history of tectonic uplift and subsidence, sedimentation at varying ocean levels, volcanic intrusions, erosion, and intense scouring and gouging by a series of massive glaciers, the last of which retreated from the coast starting about 13,000 years until about 10,000 years ago.[337, 496, 549]

Figure 13. Hundreds of islands, large and small, forested and rocky, dot the BC coast. Over 500 of these support nesting seabirds. *Photo by R. Wayne Campbell, off Acous Peninsula, BC, 24 June 1975.*

Coastal areas developed forest ecosystems, broadly divisible into two biogeoclimatic zones: the Coastal Douglas-fir Zone, confined to the Strait of Georgia, with warm, dry summers and mild, wet winters, and characteristic stands of Douglas-fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), arbutus (*Arbutus menziesii*) and Garry oak (*Quercus garryana*); and the Coastal Western Hemlock Zone over the remainder of the coast, with cool, cloudy summers, mild, high-rainfall winters, and frequent fog and drizzle throughout the year, and with a predominance of western hemlock (*Tsuga heterophylla*), western redcedar and Sitka spruce (*Picea sitchensis*).[22, 285, 357, 422, 455] Exposed islands off the northwest tip of Vancouver Island and the south tip of the Queen Charlotte Islands developed treeless, wind-pruned mantles of grasses, ferns, and shrubs.[158]

Habitat influences the distribution of nesting seabird species in BC. Ideal burrowing habitat occurs under old-growth forests and in the lush grassy, herbaceous, or shrubby vegetation on exposed and smaller islands. Burrow-nesting species are absent from the north and east coasts of Graham Island and on the southern west coast of Vancouver Island due to the lack of suitable island habitat. Many low, rocky or grassy islands along the coast provide suitable habitat for surface-nesting species, but the dearth of cliff-nesting habitat may limit breeding populations of murres.[381]

The distribution of small native and non-native mammalian predators restricts the use of island habitats by nesting seabirds. American Mink (*Neovison vison*) occur on nearshore islands along the entire mainland coast, including the Gulf Islands and Vancouver Island.[316] It is absent from the Queen Charlotte Islands and outer islands along the mainland coast that support large populations of burrow-nesting seabirds (Figure 14). American Marten (*Martes americana nesophila*) is indigenous to larger islands in the Queen Charlotte Islands. Smaller, offshore islands remained historically free of mammalian predators.[192, 245] Introductions of mammalian predators to some of those islands resulted in the decline or elimination of seabirds nesting there. The spread of introduced predators is the most immediate threat to nesting seabird populations in the Queen Charlotte Islands.

Figure 14. The absence of American Mink and other mammalian predators is one reason why isolated islands support large populations of nesting seabirds. *Photo by R. Wayne Campbell.*

Winds, ocean currents, and coastal bathymetry influence foraging habitat for seabirds. The continental shelf off BC extends from 20 km to 80 km off the coast of Vancouver Island, and becomes very narrow along the west coast of the Queen Charlotte Islands. Prominent seamounts, such as the Bowie Seamount west of the Queen Charlotte Islands, rise from offshore depths of over 3,000 m to within 37 m of the surface. Learmonth Bank at the entrance to Dixon Entrance rises to within 35 m of the surface. Currents over the continental shelf are driven primarily by prevailing winds, which are controlled by the locations and intensities of the Aleutian Low and the North Pacific High pressure systems. Winds are primarily from the southeast and southwest during winter, shifting to northwest during summer as the high pressure system builds. Northwest winds create weak regions of upwelling along the west coast, becoming most developed along Vancouver Island in such areas as the entrance to Barkley Sound. Localized upwelling occurs where ocean currents are deflected around seamounts and underwater ridges and in inshore waters where strong tidal streams move through constricted passages such as Active Pass in the Strait of Georgia. Those upwelling areas are important feeding grounds for seabirds.[218, 591, 604] Shifts from prevailing northwest winds to southerly winds during summer halt wind-driven upwelling, reducing phytoplankton productivity and causing fish species feeding in the area to disperse.[549] The decrease in available prey, combined with excessive rainfall and rough sea conditions that often accompany those weather changes may contribute to seabird reproductive failures and die-offs [484, 566, 568] (Figure 15).

Figure 15. This dead Cassin's Auklet, extracted from a burrow and held by Charlotte Whitney, may have died from starvation. *Photo by R. Wayne Campbell, Frederick Island, BC, June 1988.*

Objectives and Organization

This document provides information on the distribution and historical changes of seabird breeding populations in the province, and the factors that may have affected those populations. It is intended as an aid to resource managers and as a reference document for those involved in seabird research, but it should also appeal to anyone interested in the natural history of the coast. Our purpose is to present details about how surveys were conducted and what was observed during historical visits to each colony. We give estimates of the abundance and distribution of nesting populations recorded during each visit and evaluate whether differences in those estimates indicate real changes or not. We also provide anecdotal information about our experiences conducting seabird surveys and about the natural history and conservation of nesting species. Anecdotes are inserted into relevant sections of the main text and are distinguished from the main text by using a shaded background and a different font. These anecdotes along with numerous photographs are included to give a fuller appreciation of the breeding seabirds, their nesting habits and habitats, and the dedicated people who have been privileged to investigate and share part of their lives.

Drent and Guiguet published the first catalogue of BC seabird colonies in 1961,[213] summarizing data available at that time. The present updated catalogue describes every documented seabird colony in the province and presents all known historical data on nesting seabird populations at those colonies up to 1990. Colony accounts have been organized geographically and will be presented in forthcoming regional chapters to be published in *Wildlife Afield* by the Biodiversity Centre for Wildlife Studies. In this introductory chapter, we: review the major programs that have been undertaken to improve our knowledge of breeding seabird populations in the years 1961-1990; describe the methods that have been used to survey seabird colonies and estimate nesting populations; present a synopsis of the general breeding biology of each nesting species; summarize total provincial populations and trends as well as the distribution and abundance of each species as of 1990; and discuss conservation issues currently facing breeding seabirds in BC. In each species account we also discuss survey work conducted since 1990 to identify where our historical analyses are incomplete and provide direction to more recent data known to us.

A Life Lesson to Remember

People on the coast take care of each other. This is particularly true of lighthouse keepers that we have known and that have been welcomingly helpful and hospitable during all our years of seabird work. Lighthouse keepers are often our only encounter with other humans while surveying seabird colonies on the remote outer coast. And they take safety seriously. Worried lighthouse keepers taught me (Michael) a life lesson early in my seabird career, at a time before cell or satellite phones were invented.

During a delightful visit at the lighthouse on Pine Island, off northern Vancouver Island, I casually mentioned that my co-worker and I planned to next survey Egg Island, which also has a manned lighthouse. This required crossing a 32-kilometre expanse of open water in Queen Charlotte Sound whose rough waters turn back many boats much larger than our 12-foot rubber Zodiac. The weather was not cooperative and after battling rough seas for a couple of hours we decided to take refuge in the nearby and aptly named Storm Islands.

The weather did not improve in the next day or two and so we abandoned our plan to visit Egg Island and carried on to survey the rest of the colonies in the somewhat more sheltered waters of Queen Charlotte Strait. After a couple more weeks of blithely working our way from island to island we motored into a local town to gas up and get supplies. Much to our surprise, as soon as we hit the dock, we were surrounded by coast guard and police. It turns out we had been reported as missing persons by the light keepers on Pine Island who had radioed ahead to Egg Island to tell them to expect us. When we did not show up they alerted the coast guard who had been on the lookout for us ever since. The lesson – make sure you are going to do what you say you will, or else set up a clear contingency plan so that caring people know whether to worry about you or not.

EARLY KNOWLEDGE OF SEABIRDS BREEDING IN BRITISH COLUMBIA

Archibald Menzies' note of the "shag" colony at Deep Sea Bluffs, east of Broughton Island in Tribune Channel, in 1792, during his voyage with Captain Vancouver aboard the *MV Discovery* (page 92 of his journal),[421] is the first recorded visit to a seabird colony in BC. Menzies, a medical doctor and naturalist, made extensive botanical collections and kept some notes regarding fur-bearing mammals, but other than the shags (cormorants) nesting on Deep Sea Bluffs that they harvested for food, Menzies made little mention of seabirds in his journal, even though the expedition passed many of the main breeding areas for seabirds around Vancouver Island, including the Scott Islands. For most of a century after that, nesting seabirds were neglected or overlooked by early explorers, naturalists, and collectors in BC.

The early written record was poor and rarely referred to seabirds.[377] The first provincial checklists [238, 239] were mainly "presence/absence" based on information from "word of mouth" and conjecture without specific details (Figure 16). In the 1890s, breeding was reported for four seabirds species and Black Oystercatcher (Table 2, page 27), but all lacked supporting information even though recent archival research has uncovered substantiating evidence of breeding at that time for some species.[167, 169]

Figure 16. Although not included in Fannin's checklist of BC birds in 1891, an estimated 56% of the world's nesting population of Rhinoceros Auklets is now known to nest in the province. *Photo by R. Wayne Campbell, Cleland Island, BC, July 1967.*

Twenty-seven years later, Brooks and Swarth [58] had little more to work with for their account of BC birds. Most bird collectors in the early 1900s did not publish results of their excursions, and those that did [429] were not specific. The number of confirmed nesting species more than doubled, however, mainly due to Brooks' collecting trips along the coast and his intimate knowledge of the activities of fellow collectors.[168]

A second provincial bird book [407] was published 22 years later and a new breeding species, Double-crested Cormorant (Figure 17)[405] was added, increasing the provincial list to 13 species (Table 2, page 27). For the first time specific details, including location and breeding evidence, were published, derived mostly from museum and private collections. Marbled Murrelet remained as a breeding species despite the lack of confirmation of an actual nest with eggs or nestlings.

Figure 17. In summer 1927, Walter Burton found Double-crested Cormorant nesting on Mandarte Island, in Haro Strait east of Sidney, the first record for BC. James A. Munro confirmed a nest with eggs and two additional empty nests on 19 July 1927.[405] *Photo by R. Wayne Campbell, 25 June 1974.*

After WW II ended Charles Guiguet returned from service and obtained a Bachelor degree at UBC. He accompanied Dr. Ian McTaggart-Cowan on a collecting trip to the Queen Charlotte Islands in 1946. During that trip and a subsequent visit the next summer, Charles gathered records of nesting seabirds at many colonies on the west coast of Graham Island

Table 2. Change in species diversity for seabirds suspected and confirmed breeding in British Columbia, 1891 through 2015. Species are designated: not listed in a publication (NL); listed as occurring but not nesting (L); suspected breeding but not confirmed (S); and confirmed breeding (X).

	Year						
Species	1891[a]	1898[b]	1925[c]	1947[d]	1961[e]	1990[f,g,h]	2015
Northern Fulmar	L	L	L	L	L	S[i]	S[i]
Fork-tailed Storm-Petrel	L	L	X	X	X	X	X
Leach's Storm-Petrel	L	L	X	X	X	X	X
Brandt's Cormorant	NL	NL	S[j]	L	L	X	X
Double-crested Cormorant	L	L	L	X	X	X	X
Pelagic Cormorant	X	X	X	X	X	X	X
Black Oystercatcher	X	X	X	X	X	X	X
Western Gull	S[k]	S[k]	L	L	L	L	L
Glaucous-winged Gull	X	X	X	X	X	X	X
Black-legged Kittiwake	L	L	L	L	L	L	X
Common Murre	S[l]	S[l]	X	X	X	X	X
Thick-billed Murre	NL	NL	L	L	L	X	X
Pigeon Guillemot	X	X	X	X	X	X	X
Marbled Murrelet	S[m]	S[m]	X[m]	X[m]	X	X	X
Ancient Murrelet	L	L	X	X	X	X	X
Cassin's Auklet	L	L	X	X	X	X	X
Rhinoceros Auklet	NL	NL	X	X	X	X	X
Horned Puffin	NL	NL	L	L	L	X	X
Tufted Puffin	X	X	X	X	X	X	X
Total	**5**	**5**	**12**	**13**	**13[n]**	**16**	**17**

[a]Fannin.[238]
[b]Fannin.[239]
[c]Brooks and Swarth.[58]
[d]Munro and Cowan.[407]
[e]Drent and Guiguet.[213]
[f,g,h]Campbell et al.[136, 137] and Rodway.[473]
[i]Breeding remains unconfirmed (e.g., eggs and/or nestlings recorded) despite observations of courtship and adults on nests since 1974 on Triangle Island.[484, 603]
[j]Breeding not confirmed; based on presence of roosting birds in summer.
[k]Incorrectly listed as breeding in the Similkameen Valley (southern Okanagan region) and suspected but not confirmed breeding on the coast. Pearse[439] reported one or two pairs breeding on Seabird Rocks (off Barkley Sound), as well as a mixed Western/Glaucous-winged Gull pair. Due to extensive hybridization in southern BC, Western Gull was removed as a breeding species in the province in subsequent publications.[170]
[l]Although considered "an abundant resident", specific breeding information is lacking.
[m]The first accepted and confirmed breeding record (e.g., dead adult and eggshell fragments in felled old-growth western redcedar) of Marbled Murrelet in the province was found near Masset (Queen Charlotte Islands) in 1953.[292] Two years later an incubating adult was found in a bigleaf maple (*Acer macrophyllum)* tree at Elk Creek about 12 km southeast of Chilliwack.[495]
[n]Drent and Guiguet[213] did not include Black Oystercatcher in their catalogue.

and in Skidegate Inlet. In 1948, Ian recommended Charles for the position of curator of the Birds and Mammal Division at the BCPM, a position he held until he retired in 1980.[219, 345] However, an advanced degree was required for that position and so Charles started a Master's thesis on the ecology of the Goose Islands under Ian's supervision. Charles completed that thesis in 1950.[291] During his 33 years as a civil servant, Charles documented seabirds nesting on the Goose Islands, Scott Islands, Solander Island, Bunsby Islands, and numerous sites in Barkley Sound. He also participated in the BCPM coastal seabird survey in the 1970s.

Guiguet's early interest in seabirds and his extensive knowledge of seabird colonies motivated Drent to compile and publish the province's first catalogue of seabird colonies.[213] They did not include Black Oystercatcher and so considered only 12 species (Table 2, page 27). Nesting by Marbled Murrelet had finally been confirmed. That publication stimulated future seabird work and led to the first provincial survey completed in conjunction with *The Birds of British Columbia* project.

Three additional species, Brandt's Cormorant, Thick-billed Murre, and Horned Puffin (*Fratercula corniculata*; Figure 18), were confirmed nesting in the province over the next two decades,[134, 532,555] bringing the provincial list to 16 species by the early 1980s. No new species were reported during the comprehensive surveys of seabird colonies conducted by CWS during the 1980s, leaving the provincial total at 16 species as of 1990. The confirmation of breeding by Black-legged Kittiwake in 1997,[319] after the 1990 cut-off year for this updated catalogue, brought the present provincial total to 17 species (Table 2, page 27).

Figure 18. Since the late 1940s, sightings of Horned Puffins along the coast became more frequent and nesting was suspected.[515] Breeding was confirmed in 1977 when a single egg was located in a rock crevice on Anthony Island (SGang Gwaay).[134] *Photo by Alan D. Wilson*.

HISTORY OF MAJOR SURVEY EFFORTS, 1961-1990

Historical information prior to 1961 was summarized by Drent and Guiguet.[213] At that time, the distribution of most seabird species breeding in BC was known only in broad outline, and colony data were sporadic and many areas were unexplored. Estimates of population size were anecdotal, except for a few major cormorant and gull colonies, for which numerical estimates were available. Between then and 1990, various survey efforts helped assess nesting seabird distribution and abundance in the province, and a number of updates to the known status of seabird populations were published, including Manuwal and Campbell,[381] Vermeer and Sealy,[585] Campbell et al.,[136, 137] and Rodway.[473] The following presents a brief history of the major inventory programs of breeding seabird populations in BC in the years 1961-1990. Outside of those major survey programs, published data [101, 102, 106, 134, 156, 172, 244, 293, 295, 296, 338, 555] and unpublished records contributed by many observers to the BCNRS have also added to our knowledge.

University of British Columbia (Department of Zoology) and British Columbia Parks Branch (Mitlenatch Island Nature Park and Area), 1962-1972

In 1961, the same year that Rudi Drent and Charles Guiguet published *A Catalogue of British Columbia Sea-bird Colonies*,[213] Rudi, as a graduate student, began a provincial seabird inventory and monitoring program with the Department of Zoology at UBC to update that catalogue. Although satisfied with the earlier effort, and grateful to the BCPM for publishing the compilation (Figure 19), Rudi was acutely aware that the protection and conservation of seabirds in the province required a more wide-ranging inventory of active colonies with supporting

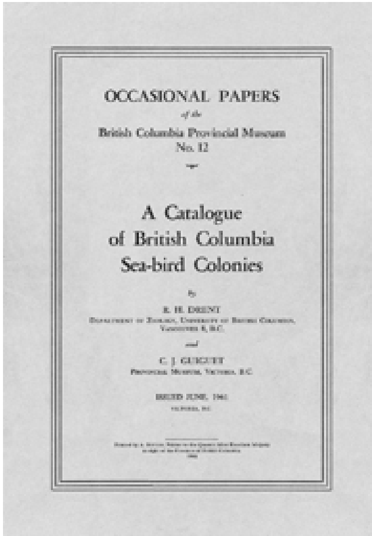


Figure 19. While completing his Master of Arts thesis on the breeding biology of Pigeon Guillemot at UBC in 1959 and 1960,[212] Rudi Drent pulled together historical information on BC seabird islands from the extensive records by his coauthor Charles Guiguet, other records from museum collections, field notes of collectors and amateur ornithologists, lighthouse keepers, naturalists, and files in the BCNRS for the 65-year period 1896 to 1960. The compilation was published in a 173-page book *A Catalogue of British Columbia Sea-bird Colonies.*

biological and natural history information for the 12 known breeding species. In spring 1961, he solicited the help of keen amateurs by contacting Wayne, who had a group of 20 or so volunteers dedicated to erecting and monitoring hundreds of Wood Duck nest boxes in the Lower Mainland. With the help of Professor Miklos D.F. Udvardy, they organized the province's first "Birders Nite" at UBC that was attended by 45 interested people. By summer 1961, seabird colonies within the Greater Vancouver area were being surveyed, including those at Siwash Rock, Passage Island, Christie Islet, and Pam Rocks. In addition, young Glaucous-winged Gulls were being banded at larger colonies. Rudi published some of the ornithological research on Mandarte Island [212, 214] and was instrumental in encouraging the BCPM to publish a monograph on Glaucous-winged Gulls.[565] Rudi returned to the Netherlands for his Ph.D. at the University of Groningen from 1962 to 1967. During that period Wayne frequently sent Rudi results of local surveys and noteworthy observations of seabirds, including notes from a trip to band Ancient Murrelets on Langara Island in the Queen Charlotte Islands from 28 April to 3 May 1966.[89, 90, 95] Rudi always replied with a lengthy letter of thanks.

Shortly after completing his Ph.D., Rudi returned to UBC and was offered a position as an assistant professor in the Department of Zoology. He immediately rekindled his interest in seabird ecology and accepted students for research on Double-crested and Pelagic cormorants,[466, 467] Pigeon Guillemot,[8] and Glaucous-winged Gull [610] (Figure 20). Local colonies were monitored (Figure 21), results were published in annual bird reports of the Vancouver Natural History Society,[97, 148, 149, 150] and nest cards were completed for the BCNRS.

Figure 20. John Ward, a Ph.D. student of Dr. Drent's, found that in supernormal broods of Glaucous-winged Gulls, chicks grew better on natural foods than a combination of natural and refuse foods. In this photo, a newly hatched Glaucous-winged Gull chick was added to a clutch of two eggs. *Photo by R. Wayne Campbell, 5 July 1974.*

While Rudi worked on his Ph.D. abroad, Wayne continued surveying colonies and banding young gulls in the Greater Vancouver area.[127] In 1963, Wayne applied for a summer naturalist position with BC Parks Branch and was offered a job in nature centres

Figure 21. On 31 May 1941, W.S. Maguire collected a set of five Double-crested Cormorant eggs on Christie Islet in Howe Sound, BC. The species was not recorded nesting again until Drent and Campbell found three pairs nesting on 18 July 1970. The discovery was published in Greater Vancouver's first annual bird report.[148] *Photo by R. Wayne Campbell.* BC Photo 4139.[132]

at Manning Park or Miracle Beach. He chose the latter because it was close to the ocean where he could explore seabird colonies at the northern end of the Strait of Georgia on days off. In the interim, there was growing concern among Parks Branch staff about increasing disturbance from recreational boaters to nesting seabirds on nearby Mitlenatch Island. The 155-ha island, established as a nature park in 1961, has the largest seabird colony in the northern Strait of Georgia. Two wardens were stationed on the island to protect the nesting seabirds, and in 1964 David Stirling hired Wayne, with a support letter from Rudi Drent, for the position. Wayne worked as a naturalist on Mitlenatch Island for three summers, leaving in 1967 for Wickanninsh Park. Breeding populations on the island were surveyed each year and thousands of young Glaucous-winged Gulls were banded.[118, 119, 120] In addition, larger seabird islands were surveyed from Powell River to Nanaimo including Vivian Island (Figure 22), Ballenas Islands, Snake Island, and Five Finger Island.

Figure 22. Occasionally visitors to Mitlenatch Island offered their larger boats to survey other seabird colonies nearby. Vivian Island, a 50 km round trip, had four species nesting, including a small population of Pelagic Cormorants, indicated by the "whitewash" in the photo. *Photo by R. Wayne Campbell, 13 June 1981.*

With research projects underway, Rudi had time to explore potential seabird colonies farther afield. He was fascinated with a group of islands off the central mainland coast in Hecate Strait to the west of Aristazabal Island, about 600 km north of Vancouver. The islands were isolated and free of small mammalian predators, ideal conditions for nesting seabirds. They included two groups: Moore, McKenney, and Whitmore islands; and Byers, Conroy, Harvey, and Sinnett islands. Collector Thomas T. McCabe had previously visited these islands on 2 and 6 June 1936 and found Glaucous-winged Gulls and Pigeon Guillemots nesting and collected four adult Tufted Puffins.

Rudi organized a trip, and in late May and early June 1970, Rudi and his wife Nel, Wilfred Schofield (a bryologist from UBC), and Wayne visited about 10 of these islands. Eggs and/or nestlings for seven of the 12 species of seabirds known to breed in the province were found (Figure 23). Other noteworthy ornithological information collected included sightings of unusually dark-plumaged Fox and Song sparrows, suggesting subspecies status, and observations of several pairs of Peregrine Falcons that were heard daily and seen frequently attacking passing Bald Eagles as if defending a nest site. This behaviour was baffling as there were no suitable nesting cliffs on any of the islands. Years later peregrines were discovered nesting in abandoned eagle nests on several of the islands (Figure 24).[142]

Figure 23. When safe anchorages were found for the mothership, Rudi Drent also participated in searching for nesting seabirds. Burrowing here he discovered an incubating Rhinoceros Auklet. *Photo by R. Wayne Campbell, Byers Islands, BC, 2 June 1970.*

Rain, a Log and a Long Night

Every seabird colony island in BC requires a different strategy for landing. Some, like Triangle Island and Solander Island, are more safely visited by helicopter. In many cases a mothership, from which a smaller boat can be launched, provides a safe haven to return to. But, once on the island, these lifelines may be temporarily lost. Even with a helicopter several days of bad weather may need to be endured before one can return.

In 1970, Rudi Drent decided to explore a group of islands off the central mainland coast and invited Wilf Schofield, a bryologist from UBC, and me (Wayne) to accompany him. Rudi had his father's boat shipped from Holland, and with a borrowed rubber dinghy from the Department of Zoology, we set off from Vancouver for the 600 km trip in late May. It seemed to take forever. We had to overnight in Campbell River so we could make it through the strong tidal currents in Seymour Narrows on slack tide. Another two days in Port Hardy were spent waiting for calm weather to make the passage across Queen Charlotte Sound. We finally arrived at Aristazabal Island, found a safe anchorage, and anxiously awaited the morning.

The strategy was to drop Wilf and me off at high tide, return in 10 or 12 hours, and pick us up on the incoming high tide. Once the dingy was secured, Wilf and I immediately went different directions to pursue our feather and moss interests, knowing that everything we saw and found was new information. Time passed quickly and neither of us pioneers noticed that the weather was changing. By late afternoon a storm front enveloped the islands and heavy rain and strong winds started. We scrambled to huddle under the rubber dingy but it was too small. I found a large moss-covered log that would become our haven for the night. With knees pinned to chest we sat motionless for 16 hours avoiding drops of water from the log. At one point Wilf mentioned, "It could be worse. If mosses didn't cover this log absorbing water we would be drenched by now." The experience seemed otherworldly, and only an occasional screaming Peregrine Falcon overhead and a chitting Pacific Wren, also seeking refuge under the same log, provided a reality check!

Fortunately the storm subsided overnight and at about 07:30 hr Rudi Drent and the mothership were *waiting offshore with hot oatmeal, crisp toast, and steeped tea.*

Figure 24. On Byers Island in 1970, it seemed odd that an adult Peregrine Falcon would be heard screaming, as if defending a territory, when there were no suitable nesting cliffs nearby. Six years later they were found nesting in abandoned Bald Eagle nests. *Photo by R. Wayne Campbell, Byers Islands, BC, 27 June 1978.*

After nearly four years at UBC, Rudi returned permanently to the University of Groningen in 1972 and concentrated his research on geese. Wayne was now fully preoccupied with *The Birds of British Columbia* project and plans for an updated seabird catalogue were now in limbo. Rudi's personal influence on students and colleagues during his tenure in BC was immense and our seabird work today carries on his legacy. He died on 9 September 2008.[551]

Wickaninnish Provincial Park/Pacific Rim National Park, 1965-1975

The province's first comprehensive regional survey of seabird colonies was carried out from 1965 to 1975 along an 83-km-stretch on the central west coast of Vancouver Island between Seabird Rocks, off Pachena Bay, and Cleland Island, 14 km west of Tofino. During the 11-year period, 27 nest sites of 11 species of seabirds were surveyed and monitored, and numerous nestling Brandt's Cormorants (Figure 25) and Glaucous-winged Gulls were banded. Much of the survey work was conducted by Wayne Campbell and David Hatler, in part supported by the BC Parks Branch, and later by Pacific Rim National Park and contracts from CWS. Additional research was conducted on Cleland Island by students from UBC, under the direction of Rudi Drent.

In 1965, BC Parks Branch initiated the summer naturalist interpretive program at Wickaninnish Provincial Park. The seasonal naturalist reports by Frank Buffam in 1965 and 1966 [64, 65] and Wayne from 1967 to 1969 [88, 93, 96] were the first continuous observations for the region. The initial reports dealt primarily with park statistics and suggestions for future nature interpretive programs but also included seabird data. Canada's first nesting colony of Brandt's Cormorant was discovered in the park in 1965 [532] and checked again in 1967.[131] During Wayne's time at the park, he took every opportunity, on days off and on work days between morning nature walks and evening talks, to explore and survey local seabird colonies. The interpretive program continued each summer until 1969 when negotiations were started to establish the region as a national park. In 1970 the region was designated as a national park reserve, the first such designation in BC. It is yet to obtain its promised status as a national park.

Figure 25. A provincial Glaucous-winged Gull banding project, initiated in the early-1960s by Wayne, was expanded later in the decade to include cormorants and colonies on the west coast of Vancouver Island. In this photo, Michael G. Shepard is banding nestling Brandt's Cormorants on Sea Lion Rocks, BC. *Photo by R. Wayne Campbell, August, 1970.*

Lost in a Fog Bank

During a morning in late July 1969, while Bill Verbruggue and I (Wayne) were concentrating on surveying seabirds nesting on Great Bear Rocks in Barkley Sound, a fog bank slowly enveloped the island. At first it was thin and cool but soon the adjacent shoreline was quickly disappearing. We decided to terminate the survey and head back to safety. The bank now had the consistency of pea soup and without a compass we headed for shore. About 30 minutes later, expecting to see shore at any moment, we noticed small numbers of Sooty Shearwaters (Ardenna grisea) *flying by and a few were grounded by the dense fog and were swimming within a few metres of our boat. We then realized that we had travelled at least 2-3 km offshore and that the next stop might be Japan! We cut the motor and drifted on the calm surface for 10-15 minutes and noticed that there was a movement of Glaucous-winged Gulls passing by regularly, some with empty crops and others with throats filled with food. The latter were obviously returning from feeding at sea with food for their young. We quickly surmised that by following the food-laden gulls we would eventually end up at a colony. About 45 minutes later we were back at Great Bear Rocks within 50 m of where we had departed earlier! We anchored in a kelp bed and within an hour or so the fog had dissipated. We finished the survey and returned to Ucluelet where we purchased a compass.*

Although not part of Pacific Rim National Park Reserve, nearby Cleland Island became a focal point for seabird studies because of the diversity of species and numbers of birds nesting.[130] The significance of the island for breeding seabirds was noted early on by G. Clifford Carl, Director of the BCPM. With his encouragement, in 1969 Rudi Drent and his students from UBC assembled an 8 x 8-foot prefabricated, wooden research cabin on the island (Figure 26) and began seabird research.[537] Interest in the large numbers of Black Oystercatchers nesting on the island resulted in two Ph.D. dissertations.[288, 308] With supporting new research, the 7.7-ha island was officially designated BC's first ecological reserve on 4 May 1971.

Figure 26. As part of his research on the biology and ecology of seabirds in the province, Rudi Drent built a prefabricated cabin at UBC and transported it to Cleland Island to serve as a work station for students. *Photo by R. Wayne Campbell, 8 May 1970.*

In 1968, David Hatler began an ecological study of coastal American Mink for his Ph.D.[312] He was subsequently contracted by CWS to inventory mammals [311] and birds [314] in Pacific Rim National Park. During that period, David (Figure 27) and Wayne visited and surveyed most of the seabird colonies in the area at least once, the results of which were included in a book published by the BCPM.[315] Wayne returned infrequently to band birds and survey colonies through 1975.

Figure 27. The first comprehensive regional survey of seabird colonies in BC was carried out on the central west coast of Vancouver Island in the late 1960s and early 1970s by Wayne Campbell and David Hatler. In this photo, Dave is photographing nesting Brandt's Cormorants on Sea Lion Rocks off Long Beach. *Photo by R. Wayne Campbell, 27 July 1969.*

East Coast Moresby Island (Cumshewa Head to Skincuttle Inlet), 1971

Occasionally, hopeful biologists are fortunate to find a topic early in their education that fulfills their passion and need for adventure and leads to a career that contributes to knowledge and conservation of wildlife. The evolution of Ken Summers's career began as an undergraduate at UBC in 1968 when M.Sc. student, Dave Mossop, hired him for the summer to help with his Blue (Sooty) Grouse (*Dendragapus fuliginosus*) work. During the following term, between classes and on weekends, Ken volunteered at the Vertebrate Museum in the Department of Zoology, where Wayne was curator. He helped to reorganize the bird and mammal collections and to de-flesh a beaked whale (*Mesoplodon* sp.) to preserve its skeleton, despite the smell that few would be willing to tolerate (Figure 28).

Figure 28. Ken Summers (left) was one of five volunteers to help flense a beaked whale, the bones of which were added to the collections in the Vertebrate Museum at UBC. *Photo by R. Wayne Campbell, Vancouver, BC, circa 1969.*

Ken's passion for seabirds was kindled when he was hired by Rudi Drent to conduct research on Cleland Island. When Rudi was beginning a research program there in 1969, Wayne, and Dave Mossop recommended Ken as a capable and enthusiastic assistant. Ken spent the summer studying Rhinoceros Auklets.[537] At the end of the summer, Rudi gave Ken his last printed copy of his 1961 seabird catalogue. Ken poured over this during the winter and noticed that there was virtually nothing known on nesting seabirds for the east coast of Moresby Island.

The next year, Wayne recommended that Jim Bendell, a professor of zoology at UBC, hire Ken as a field assistant for a contract to do an environmental assessment for the Skagit Valley. Ken worked with David King and Al Grass, but by spring the lure of discovering new seabird colonies dominated Ken's thoughts. Inspired by the support, enthusiasm, and pioneering work of early researchers, especially Wayne and Rudi, he never looked back. He purchased a used 12' 8" Canova inflatable boat and a used 9.8 horsepower Mercury motor and got ready for the experience of a lifetime.

Wayne introduced Ken to David Ellis who also had wanted to explore the Queen Charlotte Islands, especially to search for remnants of Dawson Caribou that he surmised may still exist in remote bogs of Graham Island. David volunteered to help Ken, and the pair spent 62 days exploring and surveying islands for nesting seabirds along a 90-kilometre stretch of coastline off eastern Moresby Island between Cumshewa Head and Skincuttle Inlet. They also visited a few islands further south while spending two days on board the Federal Department of Fisheries vessel *Arrow Post*. They never got to search for Dawson Caribou.

No Groceries, No Problem

From mid-May to mid-July, 1971, Ken Summers and friend David Ellis surveyed the rugged east coast of Moresby Island in the Queen Charlotte Islands for nesting seabirds. Ken used his own funds to finance the adventurous trip, spending most of them on purchasing a boat, motor, and other field gear, and on air transport costs to and from the Queen Charlotte Islands. Paying additional air freight for two month's supply of food was out of the question.

The food budget for the trip was $50, which was spent on staples such as oatmeal, rice, flour, sugar, butter, and salt (for bannock) purchased in Sandspit. They also purchased one large tin of canned meat (as emergency rations) and a few fresh oranges. For 60 days the fellows basically lived off the land. For protein they ate two deer, a sea urchin, a dozen gull eggs, numerous abalones, lots of fish and clams, some shrimp, and an octopus. After eating the latter their *jaws were so sore from chewing "rubber" they didn't bother to catch any more. Drinking water was available in coastal streams. Food expenses for the two-month trip were about 40 cents a day per person!*

Occasionally they found old cabins to spend the night but mainly camped. At one site, the ground was too wet to pitch a tent so they set it up inside a dilapidated building (Figure 29).

Obtaining fuel for their outboard motor proved more problematic. Once, they were stranded in Hutton Inlet for 10 days waiting for supplies and survived on porridge, rice, gull eggs, fish, miner's lettuce, and plantain (the emergency ration of meat survived). When expected supplies still had not arrived they had just enough fuel to get to Hotspring Island, where they went hoping to find help. Luckily they obtained some fuel and were able to carry on. The logging camp at Thurston Harbour proved a helpful source for precious fuel that allowed them to complete their surveys.

Figure 29. Rain is a constant in the Queen Charlotte Islands and setting up a tent in the forest every night can be discouraging. On one occasion, when there was nothing but soggy ground, Ken Summers and David Ellis found a dry base to pitch their tent inside a dilapidated cabin. *Photo by Ken R. Summers, Section Cove, Burnaby Island, BC, June 1971.*

The personally-funded survey was a significant contribution in identifying new locations of seabird colonies and species diversity in the province. In total, 45 colony sites were visited that included 70 species' nesting locations that were unknown to Drent and Guiguet.[213] Population estimates for species were listed for each island (Figure 30). They estimated a total breeding population of over 76,000 pairs for 10 species, but cautioned that their estimates were probably too low. The published results [535] contributed greatly to major summary publications in the years following.[136, 137, 536]

Figure 30. Between 17 May and 17 July, 1971, Ken Summers, with help from Dave Ellis, surveyed 45 seabird colony locations along the east coast of Moresby Island, Queen Charlotte Islands, BC. Tufted Puffin was one of the nesting species they were searching for along the 90-kilometre coastline. *Photo by Alan D. Wilson.*

British Columbia Provincial Museum, 1973-1978

The first survey of the entire coastline was completed between 1974 and 1978 as part of *The Birds of British Columbia* project (see Figure 2). Most colony sites were identified, and total nest counts were made for surface-nesting species, which included three species of cormorants, Black Oystercatcher, and Glaucous-winged Gull. Population estimates for burrow-nesting species were based on varying degrees of exploration, supplemented with partial counts of burrows, unsystematically placed transects and sample quadrats, mapping and measurement of colony areas on marine charts and air photos, and estimates of burrow occupancy rates derived from excavated burrows or by monitoring knock-down rates of small sticks placed in burrow entrances.[104, 105, 115, 474, 536]

The history of that first provincial survey of seabird colonies by the BCPM began over a decade earlier in Vancouver. With Rudi Drent's permanent departure to the Netherlands in 1972, the updated seabird catalogue project, already a decade in the making, was now in limbo. During the same period, Wayne had started compiling records to update Munro and Cowan's 1947 book *A Review of the Bird Fauna of British Columbia*.[407] By 1972 he had amassed nearly 300,000 bird records from across the province. The intent now was to incorporate the new seabird catalogue information into an updated provincial bird book, to be called *The Birds of British Columbia*.

In November 1972, Ian McTaggart-Cowan, now Dean of Graduate Studies at UBC, invited Wayne, who was then Curator of the Vertebrate Museum at UBC, for dinner. Ian knew that Wayne already had a substantial database to update Munro and Cowan's earlier bird book, and that Wayne would be moving to the BCPM early in the New Year. Ian suggested it would be a good opportunity to work together on an update and that he could get support from the BCPM to publish it. It helped, of course, that the Director of the BCPM, Bristol Foster (Figure 31), and the curator of the Bird and Mammal Division, Charles Guiguet, were both his former students! Ian asked Wayne to prepare an outline for the project.

Figure 31. Dr. J. Bristol Foster, Director of the BCPM from 1968 to 1974, was a fervent supporter of the *The Birds of British Columbia* project and participated in the museum seabird surveys. In this photo, he is searching for abalones on an ebbing tide. *Photo by R. Wayne Campbell, Barkley Sound, BC, early 1970s.*

Wayne prepared a detailed outline for the book in December 1972 and discussed it with Ian at UBC. Wayne emphasized the need to associate birds and their seasonal habitats, to incorporate data from specimen records housed in North American museums and records from published and unpublished (gray) literature, and to improve the knowledge of nesting seabirds by completing a survey of potential nesting sites along the entire BC coast. Ian was hesitant about tackling a seabird survey at that scale, but he was supportive, anticipating financial support that might come with Wayne's appointment at the BCPM.

Unfortunately, the Bird and Mammal Division budget at the BCPM was insufficient to support new initiatives, although Wayne was able to conduct some seabird surveys during his first summer at the BCPM in 1973. However, a government-sponsored summer student program in the early 1970s allowed some projects to begin and heralded the possibility of a provincial seabird inventory. Summer student Harry Carter, later a prominent seabird biologist (Figure 32), became enthralled with marine birds and convinced his father, Harold "Doc" Carter, an orthopedic surgeon, to buy a boat that could serve as a mothership for coastal explorations (Figure 33). Bristol Foster helped with some external funding and individual contributions allowed the surveys to become a reality in 1974 (Figure 34). The primary purpose of the provincial survey was to identify all nesting colonies, count all nests of surface-nesting species like cormorants, Black Oystercatcher, and Glaucous-winged Gull, and obtain approximate estimates of burrow-nesting populations [105, 115] for *The Birds of British Columbia* project (Figures 35 and 36).

Figure 32. In the early 1970s, while an undergraduate student at the University of Victoria, Harry Carter participated in the inaugural coastal seabird surveys sponsored in part by the BCPM. He became a well-known seabird biologist working in BC, United States, and abroad. In this photo, Harry (bending) and Michael Rodway are examining a nest on Munsie Rocks, south of Kyuquot, BC. *Photo by R. Wayne Campbell, 24 June 1975.*

Figure 33. The late Harold "Doc" Carter, an orthopedic surgeon in Victoria, BC, aboard the *Tedmac* he purchased to serve as the mothership for the first provincial survey of seabird colonies from 1974 to 1977. *Photo by R. Wayne Campbell, near Conroy Island, BC, 27 June 1976.*

Figure 34. In 1974, Bristol Foster left the BCPM to direct the Ecological Reserves Unit of the provincial government. He was able to acquire some funding to post signs on established protected islands during the seabird surveys. In this photo, "Doc" Carter (bottom) and Marilyn Paul are erecting a sign on Whitmore Islands, BC. *Photo by R. Wayne Campbell, 26 June 1976.*

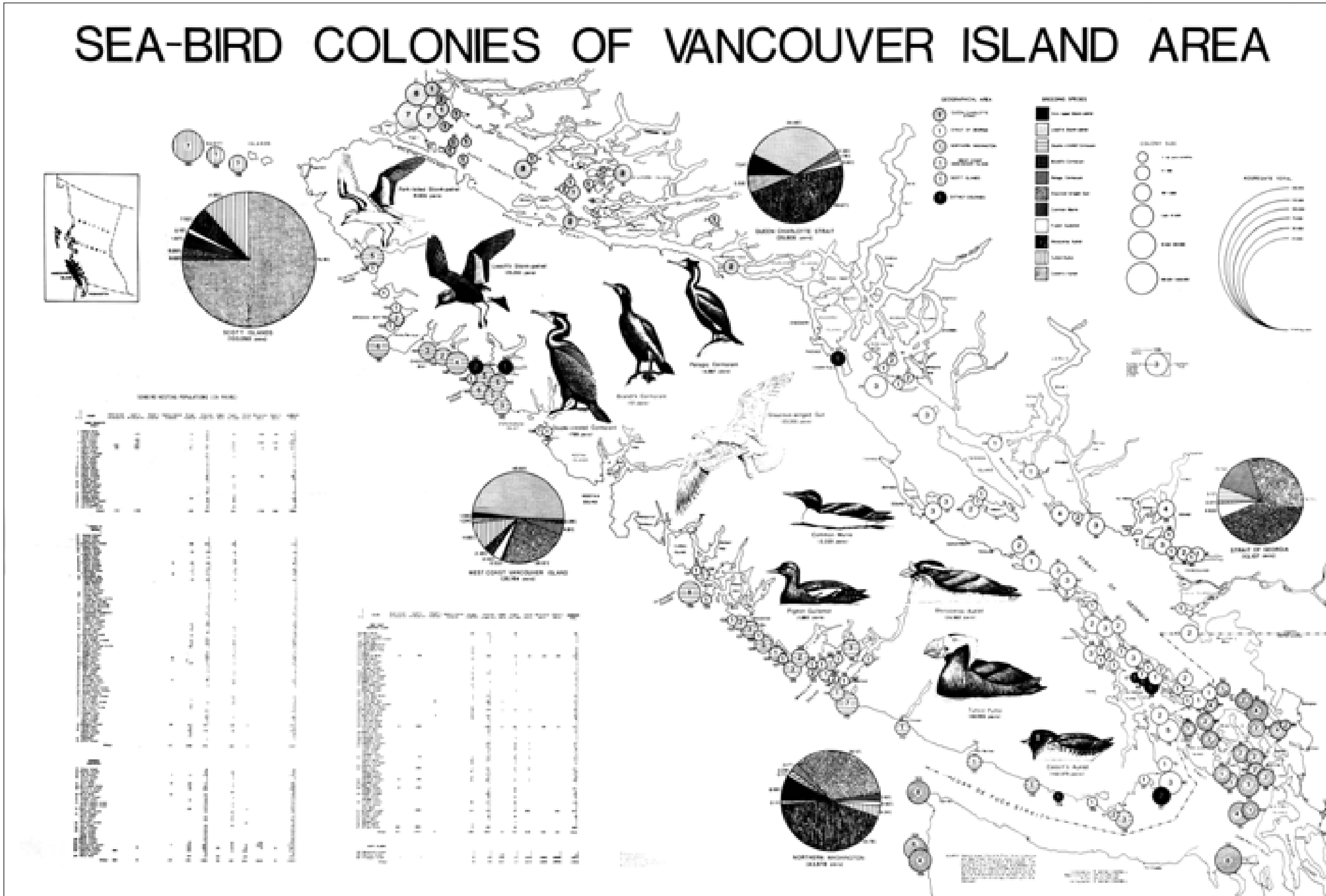


Figure 35. This wall map [105] was compiled and drafted as part of an undergraduate course in cartography in the Geography Department at the University of Victoria. The summary put colonies in perspective for Vancouver Island and led to the protection of significant sites by provincial and federal governments.

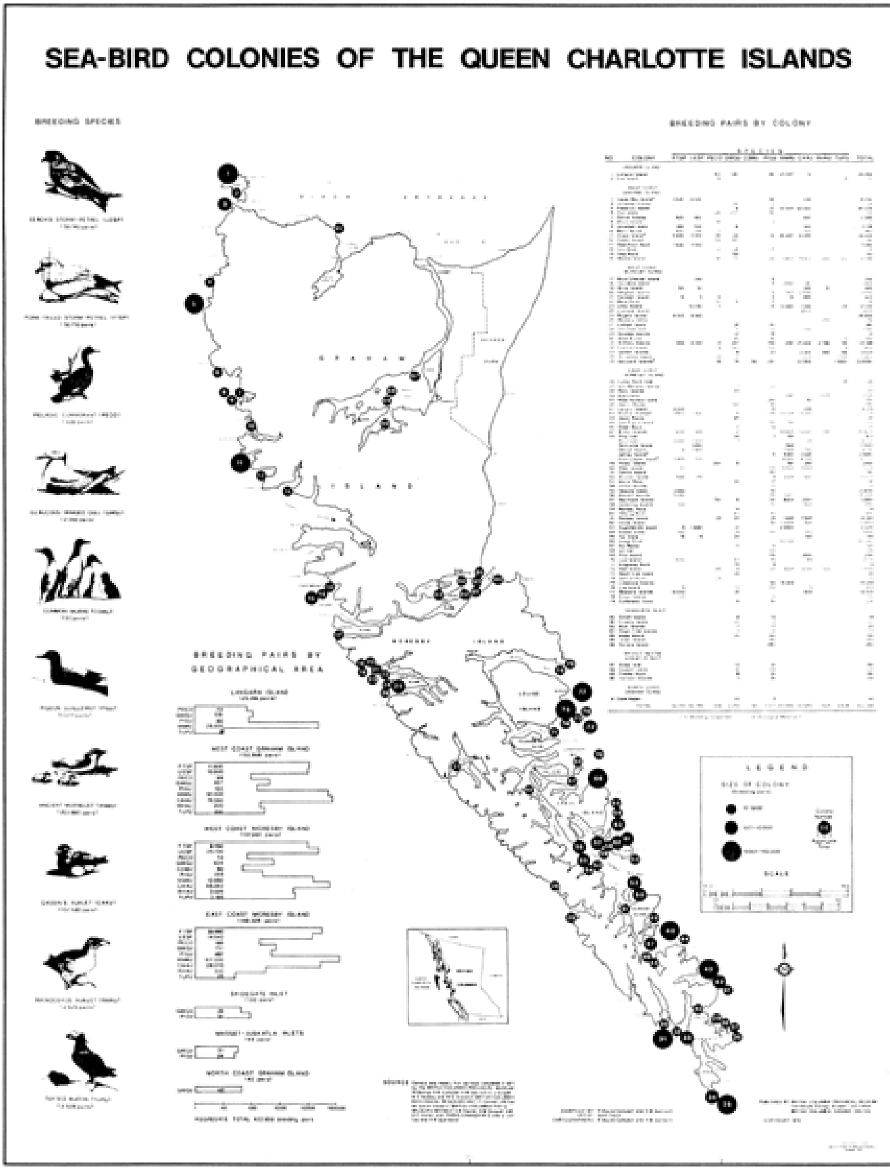


Figure 36. In the early 1970s, unsustainable logging plans on southern Moresby Island in the Queen Charlotte Islands led to a proposal to protect the area. Logging continued in the face of public controversy and protest from the Haida Nation until 1987. The following year the *South Moresby Agreement* was signed, paving the way to designate the area as the South Moresby National Park Reserve (now the Gwaii Haanas National Park Reserve). This map [115] highlighted the early significance of the area for nesting seabirds in the Queen Charlotte Islands. The Islands Protection Society's well-timed book *Islands at the Edge: Preserving the Queen Charlotte Islands Wilderness* [344] helped with the final decision to protect the archipelago.[107]

Canadian Wildlife Service, 1974-1990

The Canadian Wildlife Service was first established as a small federal agency in 1947, with its mandate defined under the Migratory Birds Convention Act of 1917. In the early years, with few staff, it focused largely on the management of waterfowl, with its presence felt mainly in the prairies and eastern part of the country. Early seabird surveys were conducted in the Gulf of St. Lawrence in 1925. By the 1950s, intensive seabird colony inventories and research began in the Maritimes and the Arctic where harvesting of seabirds and contaminants were a concern. It was not until CWS had grown to a sufficient size, and the management structure divided into five regions, that the Pacific and Yukon region came into being. A BC office was established in 1972, first at UBC in Vancouver and then more permanently on the Alaksen National Wildlife Area in Delta.

A CWS seabird program began in BC in 1974. Kees Vermeer (Figure 37) had conducted his graduate studies on Glaucous-winged Gulls in BC (Figure 38)[565] and in 1974 was with the Prairie region of CWS. With a CWS presence now on the Pacific coast, Kees saw an opportunity to expand beyond his interest in contaminants in fish-eating birds to include Pacific seabirds and pelagic ecology. He moved to the Pacific and Yukon office and immediately initiated studies on the largest and most remote seabird colony in the province, Triangle Island. With solid background data on the island from Carl et al.,[158] Kees moved a prefabricated trailer from the summit of the island down to the shore of the south bay to serve as a base camp for his studies. Ken Summers and Daniel Bingham were hired as assistants and conducted much of the field work for the next few seasons. Kees studied food provisioning and reproductive performance of Cassin's Auklets, Rhinoceros Auklets and Tufted Puffins breeding on the island,[566, 567, 568, 569, 576, 577, 578, 588] and estimated seabird nesting populations on Triangle and the adjacent Sartine Island.[593, 603, 605]

Figure 37. Kees Vermeer (front right), with archaeology students at Port au Choix, NL, had a passion for marine birds and directed research for the Canadian Wildlife Service, Pacific and Yukon Region, from 1974 until he retired in 1994. He was a prodigious author. *Photo by Rebecca Vermeer, July 2008.*

Figure 38. The graduate research on Glaucous-winged Gull carried out on Mandarte Island, BC, by Kees Vermeer, was first proposed and encouraged by Rudi Drent. The work was the first on the breeding biology and ecology for this common species. *Photo by R. Wayne Campbell, 5 August 1995.*

In 1980, Kees extended his studies to Ancient Murrelets and Cassin's Auklets nesting farther north in the Queen Charlotte Islands. He sent Moira Lemon and Trudy Carson (now Trudy Chatwin) to conduct fieldwork on Frederick Island off the outer west coast of Graham Island.[572, 573, 582, 591] Kees also conducted studies on the nesting biology of storm-petrels in the Queen Charlotte Islands [580, 589] and coordinated many population studies of cormorants, Black Oystercatchers, Glaucous-winged Gulls, and Pigeon Guillemots in various regions of the coast throughout the 1980s.[236, 571, 575, 581, 584, 590, 594, 595, 596, 597, 598, 599, 600, 601] The many publications that he and his co-workers produced over the years provided the foundation for more elaborate ecological work in later years.[76]

Seabird nesting populations on Frederick Island were completely surveyed in 1980. That survey represented the beginning of CWS's comprehensive inventory program of colonial-nesting seabird populations in BC (Figure 39). The next season, Kees invited Michael, who had previously conducted surveys of the area during the BCPM surveys, to conduct a survey of Langara Island, located north of Frederick Island at the northwest tip of the Queen Charlotte Islands. Moira was again conducting studies on Frederick Island that year and first met Michael when he boated down by zodiac from Langara Island. It was not until 1982, when Kees sent them to survey Lyell Island, on the east coast of Moresby Island, and then Triangle Island, that Moira and Michael first worked together. Their productive partnership continued throughout the rest of the CWS seabird colony inventory program.

After 1982, the inventory program expanded under the supervision of Gary Kaiser (Figure 40) to include colonies along the entire coast. From 1983 to 1990, Gary innovatively secured funding through numerous programs to keep the surveys going. Field work was carried out by Moira, in her position as a CWS Wildlife technician, and Michael, as an independent contractor, with field crews of enthusiastic students hired through available government student programs. Doug Bertram, one of those energetic students, went on to earn graduate degrees. His M.Sc. thesis investigated comparative growth rates of Rhinoceros Auklet chicks in different coastal regions.[34] He went on to lead the CWS/Simon Fraser University Triangle Island Research Program and later as a CWS employee, continued seabird research and was for a time head of the Marbled Murrelet Recovery Team.

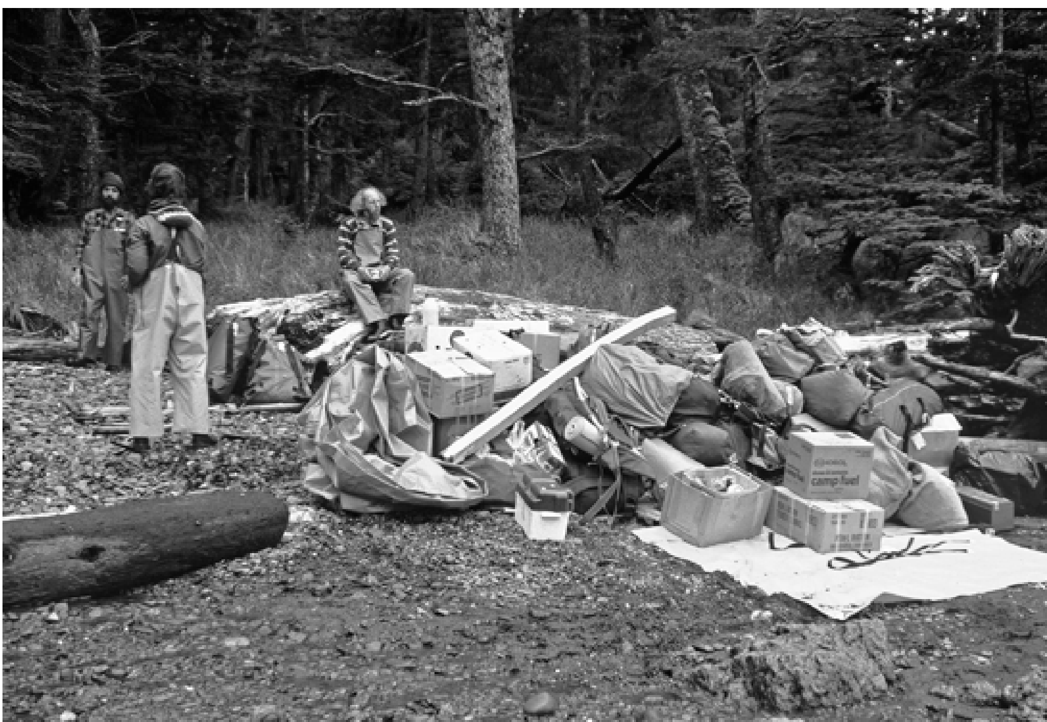


Figure 39. Setting up and dismantling camps on larger islands, like Hippa Island, for lengthy seabird colony surveys was a major effort. Surveyors, from left to right, are Michael Rodway, Yves Turcotte, and Tony Gaston. *Photo by Moira J.F. Lemon, 27 May 1983.*

Figure 40. Gary Kaiser administered the CWS seabird surveys from 1983 to 1990. Shown here with other authors of the first two volumes of *The Birds of British Columbia*, from left to right: Neil Dawe, Gary Kaiser, and John Cooper (standing) and Wayne Campbell, Ian McTaggart-Cowan and Michael McNall (sitting). *Photo in Victoria, BC, 27 October 1986.*

During the mid-1980s, CWS research scientist Tony Gaston, who studied murres at colonies in the eastern Arctic, became interested in west coast seabirds. He began in-depth studies of Ancient Murrelets from a camp on Reef Island, a steep and rugged island located off the north-east coast of Moresby Island in the Queen Charlotte Islands.[256] As chair of the CWS national seabird committee, he supported and encouraged the continued research, inventory and monitoring of BC's seabird colonies. The inventory program also benefited from the advice of CWS statistician G.E. John Smith as well as biologist Jean-Pierre L. Savard, who together conducted research on the most effective methods for obtaining statistically robust estimates of breeding populations.[499]

Except for a few small colonies on the west coast of the Queen Charlotte Islands, all colonies of burrow-nesting species were surveyed with standardized, replicable sampling techniques,[480, 499] which provided baseline population data for most of the coast.[475, 476, 477, 480, 481, 482, 484, 485, 582] Total counts comparable to those made in the 1970s were repeated for cormorants, Black Oystercatchers, and Glaucous-winged Gulls.[470, 581, 590, 594, 595, 596, 597, 600] Numbers of Pigeon Guillemots,[225, 236, 598, 599] and Common (*Uria aalge*) and Thick-billed murres in attendance at colonies were counted, but no standardized methods were used to estimate breeding populations, except for Common Murres on Triangle Island.[471] The most thorough, regional count of Pigeon Guillemots attending colonies was conducted in Skidegate Inlet in the Queen Charlotte Islands in 1990 [599] (Figure 41). That study resulted in a more accurate estimate of total numbers associated with that region, but a disproportionate estimate of the relative importance of that area to provincial populations because less dedicated surveys have likely underestimated Pigeon Guillemot numbers in other areas.

Figure 41. The thorough survey of Pigeon Guillemots in Skidegate Inlet in the Queen Charlotte Islands in 1990 included counting birds on the water as well as birds hauled out on intertidal rocks at colony islands. *Photo by R. Wayne Campbell, Cleland Island, BC, 15 May 1965.*

OVERVIEW OF SURVEY METHODS

Census methods used by surveyors on the BC coast have evolved from specimen collections and anecdotal accounts to total counts and systematic sampling schemes. Total counts are readily performed at most colonies of surface nesting species in the province, and we have at least two, and often more, comparable counts for those species at most sites. Colonies of burrow nesting species are more difficult and time consuming to census and most large colonies have only been surveyed once with replicable quadrat sampling techniques. Population estimates for larger colonies of burrow-nesting species from earlier surveys are not comparable to those derived from the systematic sampling schemes used during the later CWS surveys. However, information on the presence or absence of nesting species and colony areas described and mapped during different surveys is comparable and provides important trend data.

During intensive seabird population surveys by the BCPM and CWS, complementary data were recorded about: seabird nesting habitats, staging areas, and behaviour; evidence of predation on nesting seabirds; the presence of other bird and mammal species, especially predators; signs of human disturbance; and other information on survey conditions, colony islands, and nesting species that might help interpret survey results and historical changes (Figure 42).

Figure 42. During surveys to estimate species breeding populations, incidental observations and findings were recorded. In this photo, a depredated Ancient Murrelet egg was pulled from a burrow and placed at the entrance. *Photo by Michael S. Rodway, McPherson Point on Langara Island, BC, 16 May 1977.*

Hidden Surprise

Half of the seabird species breeding in BC, including the storm-petrels and most auks, nest in underground holes. This helps them avoid bad weather and predators and provides a relatively constant microclimate where they can raise their chicks. But this behavior can have consequences for surveyors. I (Wayne) vividly recall one painful and messy experience.

In spring 1966, I was lured to the Queen Charlotte Islands to find my first Ancient Murrelet nest. I ended up on Langara Island at the First Nations village of Dadens. After a short search I found scattered burrows on a grassy hillside under a spruce forest. I rolled up my sleeves and began searching. The first three burrows were empty and I became a bit discouraged. In the fourth, however, I felt some gooey stuff at the end then suddenly "ouch", something struck my hand. I assumed it must be an incubating murrelet that had pecked me. Startled, I quickly removed my arm from the burrow to find a wriggling mouse hanging on my index finger with its incisors firmly planted on the tip. It was then the finger started hurting! The mouse scampered away leaving me with a bleeding and pulsating fingertip.

Later, the gooey stuff was determined to be a broken murrelet egg (see Figure 42)*, probably preyed upon by a Black Rat. The mouse may have been feeding on the albumen and yolk. I was thankful the culprit that bit me wasn't a rat! For over two weeks after the trip I was still typing with seven fingers!*

The biggest surprise of this experience was when I found out that the mouse, Keen's Mouse (Peromyscus keeni)*, was previously unrecorded for Langara Island, even though earlier biologists had made concerted efforts to trap it by. Despite my greater success, I didn't volunteer any more of my fingers for the advancement of science.*

Most current estimates of breeding populations are from surveys conducted by CWS between 1980 and 1990.[225, 236, 470, 471, 475, 476, 477, 480, 481, 482, 484, 485, 581, 590, 594, 595, 596, 597, 599, 600] Methods used to survey nesting seabirds are described in detail in those regional reports. We present a less detailed summary of those methods here.

Island Exploration

Extensive explorations of potential breeding sites were conducted by the BCPM between 1974 and 1977.[104, 115] Virtually all islands surrounding Graham and Moresby islands in the Queen Charlotte Islands, and all islands in Queen Charlotte and Johnstone Straits, along the west coast of Vancouver Island, and in the Strait of Georgia were visited. Along the northern mainland coast, all outer, western islands were explored, but we did not thoroughly explore the many large, inner islands that occur in that area. Islands closer to the mainland shore that we did explore were found to harbour small mammalian predators and be consistently devoid of ground-nesting seabirds. We thus explored all areas that we considered potential seabird nesting sites. The many islands explored during those and other surveys that did not support nesting seabirds are listed in Appendices in forthcoming regional chapters that will be published in *Wildlife Afield*.

The extent of exploration undertaken during the BCPM surveys depended on habitat, colony type, and available time. All treeless islands and perimeter areas of forested islands where seabirds were sighted were explored completely on foot unless landing was prohibited by stormy weather. Most forested islands were partially explored on foot, especially in areas that appeared suitable for burrowing, and their entire perimeters were examined from the water. Most currently known colonies were identified during the BCPM surveys.

Data on the distribution and abundance of nesting seabirds gathered during the BCPM surveys were used as the baseline for planning CWS surveys. All islands where nesting had been reported or suspected on previous surveys were first explored to determine whether current nesting occurred (Figure 43). Other islands in the same vicinity as known colony islands were also visited. Small islands were completely examined. On large islands the entire perimeter was explored to a distance of 50 m from shore, as well as frequent sections of the interior up to 200 m from shore. If no nesting seabirds were found no further searching was undertaken. If nesting was encountered, exploration was continued to determine colony boundaries and the appropriate census techniques. Survey methods were selected according to the area, habitat, and species of birds nesting on an island.[420]

Figure 43. Many of the larger islands, such as Reef Island, a significant Ancient Murrelet colony, were initially circumnavigated by inflatable boat to determine potential sites for breeding seabirds and suitable places to land. *Photo by R. Wayne Campbell, 29 May 1996.*

A Dedication to the Inflatable Boat

Over the years, inflatable Zodiacs, Achilles, and a Canova have been our faithful fleet. Seemingly fragile, supported only by air, rubber and glue, these small, inflatable boats are surprisingly tough and stable and were indispensable to our work on the seabird colonies. Inflatable pontoons around the outside create an extremely seaworthy and maneuverable craft that is very difficult to tip over. Their inflatable keel allows them to flex just a little so they ride down the trough and up to the crest of a wave without taking on water, something a solid keel would not always do. You may get splashed by some wind-driven waves, but if things get a little rough, retreating to the bottom of the boat allows the pontoons to ride higher. Our favorite by far was the Canova – a 16 footer which rumor had it was built in the 1940s and that we unearthed and resurrected from a locker at the back of the CWS storage barn. The shape of its bow parted the waves in a way no others would, and it rose up to plane with seemingly little effort. With a 15 or 25 hp outboard motor, the boats were light enough that a crew of four could carry them up the beach, or with wheels attached to the transom, roll them up over rocks and logs to a safe spot above the high tide where they could be secured with a line to a tree.

Out on the water, boat and driver would find the pathways through the waves, looking for the route that provides the smoothest ride, sometimes staying on top of the crests as the waves roll beneath the boat. Out in the open Pacific swells, the boat ahead would alternately appear and disappear, or all you might see would be three little heads on the surface of the waves, dwarfed by the immensity of the sea. To get onto small islets and rocks, with waves sometimes 20 feet high swelling up the rocky shores, we would have to be dropped off from the boat. Crouched on the bow with feet on the pontoons, perched on this stable platform, you leapt off just as the nose of the boat and crest of the wave converged and barely touched the rock. One exact moment of perfect timing, perfect communication and perfect landing – the leaper to the rock runs up farther, out of the range of the waves, the driver and boat reverse out on the back of the surge to a safe distance to await the next drop-off (Figure 44). *When moving day came, packed up full with just enough room for your feet, we would head out, a small flotilla on the wide open sea, bound for our next campsite. They took us to places of immense beauty, through seas both tranquil and tempestuous. They were our lifeline. At the end they carried us home.*

Figure 44. Timing was critical for being dropped off on islands for surveys. Here Marilyn Paul navigates a Zodiac between surges and swells to get Michael Rodway onto a rocky island. *Photo by R. Wayne Campbell, False Egg Island, BC, 18 June 1976.*

Total Counts

Total nest counts were made for three species of cormorants, Black Oystercatcher, and Glaucous-winged Gull, unless nests were inaccessible and could not be seen. Estimates of numbers of breeding pairs equaled the number of nests counted plus, if necessary, an estimate of nesting pairs in areas that were inaccessible. Exceptions to this protocol were used by Vermeer et al.[594] They surveyed many very small colonies from the water and estimated numbers of nests from the number of territorial pairs counted.

Empty nests were included in counts, except remnants of obvious old, unattended nests from previous seasons and nests that were very close together, likely the result of one pair building multiple nests within their territory. This latter exception applied mainly to Black Oystercatcher. Empty nests can result from females not having laid yet, eggs being taken by predators, precocial chicks hidden away from the nest, or chicks that have already fledged. It is standard practice to include them in counts.[36, 420, 465] For Glaucous-winged Gull, we followed Nettleship's [420] protocol and included partially constructed nests ("a nest is considered to be any structure more elaborate than a simple scrape – it must have some built-up edge to qualify"; p. 15). Counting empty nests introduces possible bias if some pairs build more than one nest.[424] We accepted this potential bias because: the frequency of this behaviour could not be determined during our regular surveys, which did not include replicate surveys in a single nesting season; the potential bias was likely less than if empty nests were excluded, especially considering that some nests may have been missed; [23] and it was important to maintain consistency so that counts could be compared. The potential bias was likely low for Glaucous-winged Gull because pairs only complete one nest, although others may be started.[563] Such nest starts would have been counted if they were partially built-up and not located right next to a completed nest. Potential bias may be higher for Black Oystercatcher, as they sometimes build multiple nests within a single territory,[12, 318] but we attempted to minimize this bias by excluding multiple empty nests that were too close together to have been built by different nesting pairs (Figure 45).

Figure 45. For surface-nesting seabirds, empty nests were included in survey totals as they are usually built annually. This empty Black Oystercatcher scrape of barnacle and snail shells was included in survey results. Agitated adults suggested that chicks were nearby. *Photo by R. Wayne Campbell, July 1978.*

For burrowing species, total counts were made when all burrows were accessible and easily tallied during the exploration of the island. This method was appropriate on small islands with few burrows or on larger islands with scattered burrows around perimeter areas. Estimates of numbers of breeding pairs equaled the number of burrows counted multiplied by a median occupancy rate for the species in question (see below). Nesting populations were estimated differently for surface and burrow nesting species because, by-and-large, surface nests are constructed each year and represent a current reproductive effort, whereas burrows can persist for a number of years even when not being used. Some oystercatcher scrapes, and elaborate stick nests of Double-crested Cormorants can persist across seasons but those generally bear some evidence of recent refurbishing if they are being reused. Also, surface-nesting birds attending nests are visible on the colony when surveys are conducted whereas burrow-nesting birds, especially those that are nocturnal on their nesting grounds, cannot be seen.

Numbers of Pigeon Guillemots attending colonies fluctuates dramatically and no attempt was made to estimate actual nesting populations during surveys. Total numbers of Pigeon Guillemots seen around colonies were counted, but on most surveys no standardized observation techniques were employed.[225, 420] An exception was the comprehensive study and repeated surveys at times of maximum attendance conducted in Skidegate Inlet by Vermeer et al. in 1990. [598, 599] Those surveys yielded much higher numbers of birds around colonies than previous counts,[102, 470] although actual breeding populations were still unknown.

Photographic Counts

At Common and Thick-billed murre colonies (Figure 46), total numbers of murres present were counted or estimated but no attempt was made to determine actual nesting populations, except in 1989 on Triangle Island when Common Murres were censused using the methodology outlined in Birkhead and Nettleship.[39] During that survey, total population was estimated using counts from photographs, adjusted by a ratio of direct counts to counts from photographs determined at a study plot. The proportion of breeding sites to total birds present on the study plot was used to estimate breeding population. Detailed methodology is presented in Rodway.[471]

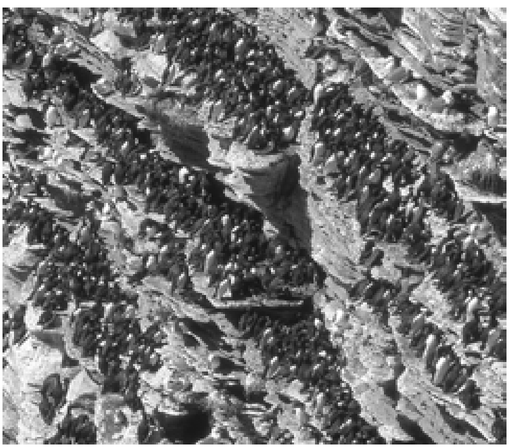


Figure 46. Visual estimates of the number of murres (called guillemots in Scotland) at this colony at Noup Head on the Isle of Westray in Scotland would likely be misleading. A more accurate total can be made by projecting the image on a screen and counting the birds. *Photo by R. Wayne Campbell, 21 June 1995.*

Partial Counts

On small islands where a total count of burrow-nesting species was not feasible or practical, but the colony area or population was too small to warrant sampling by transects, burrows in representative portions of the island were counted and figures were extrapolated to the rest of the area (Figure 47). Population estimates equal the number of burrows estimated multiplied by the median occupancy rate (see below).

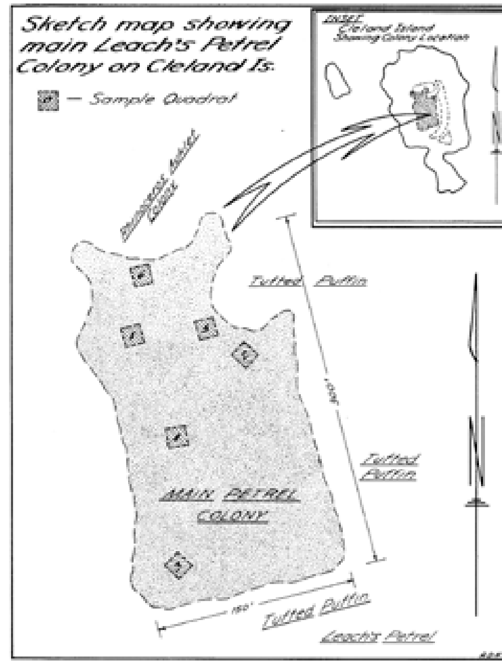


Figure 47. On Cleland Island, a small fragile seabird colony west of Tofino, Leach's Storm-Petrels nest primarily in a patch of cow parsnip (*Heracleum maximum*) and American dunegrass (*Leymus mollis*), an area of about 92 m x 46 m. The soft soil precluded a total survey, therefore six quadrats were sampled that could be reached by walking safely on scattered driftwood. The extrapolated nesting population of Leach's Storm-Petrels in that area in 1967 was 4,635 pairs and the total for the island was estimated at 5,000 pairs. *Reproduced from Campbell and Stirling.*[130]

Strip Transects

These were used primarily on storm-petrel colonies that were too small to sample effectively with line transects and quadrats. Measured strips of uniform width were run at systematic intervals across the colony area, and all burrows were counted within them to give an estimate of the overall density of burrows. Occupancy rate, colony area, and total population were calculated as described below under line transects.

Line Transects With Quadrats

Line transects were used on all large colonies (>1,000 pairs) of burrow-nesting species. Transect bearings were generally perpendicular to the shoreline and transects were run from the shore to past the farthest distance that burrows extended inland. Sample quadrats were systematically distributed at standard intervals along transects (Figures 48 and 49). Burrows were counted within quadrats to obtain unbiased estimates of burrow density.[380, 499]

Transect location. After the colony was mapped during exploration, equally spaced transects were run throughout colony areas. Transect spacing ranged from 50 m to 200 m apart, depending on colony and quadrat sizes (see below). We attempted to sample 1% of the area of a colony. Transects were spaced and start points located by measuring perpendicular to the transect bearings (along the shore if this was feasible), or by locating reference points plotted on air photos (for areas where the topography was extremely dissected or impassable).

Quadrats. Quadrats were set at predetermined intervals along transect lines, with the first quadrat at the shore edge of the vegetation, unless that was inaccessible, and the last placed beyond the interior extent of the colony. Quadrats ranged in size from 1m x 1m to 7m x 7m, depending on the density of burrowing. The size was selected so that an average of at least one burrow occurred in each quadrat. Low density colonies of Ancient Murrelets often required large quadrats to obtain burrows within them, while dense colonies of storm-petrels or Cassin's Auklets could be better sampled with smaller, more frequent quadrats.[499] Quadrat spacing varied from 5m for 1m x 1m plots, to 40m for 7m x 7m plots. All burrows were counted within each quadrat.

"Regen" Bashing – or How to Walk a Straight Line

Numbers of burrows in a colony need to be estimated when it is not feasible to tally all of them. Counting burrows in a number of small plots or quadrats gives an estimate of the density of burrows in different areas. But it is important that there are no biases in where those plots are placed in order to provide an accurate estimate of burrow density over the whole colony. Running transects through the colony at predetermined intervals and counting burrows in quadrats spaced at predetermined intervals along those transects accomplishes this and avoids the temptation to say, "that looks like a nice spot, lets count burrows over there".

With such transects, you have to go where the line takes you regardless (except for safety concerns) of what you have to go through. In coastal forests where species like Ancient Murrelets nest, it is common to run into patches of regenerating saplings or "regen", which can be incredibly dense. On the Queen Charlotte Islands, those patches are often regenerating Sitka spruce, which have sharp, prickly needles. We use 50 m chains or tapes to lay out the transects, and if you are the unfortunate new recruit whose task it is to haul that chain, then the worst thing is to run smack into a thick patch of spruce "regen." Unless it is a very small patch that you can throw the chain over, you must simply put your head down and struggle on through. The person marking the end of the chain must guide you so that you approximate the best straight line possible and so keep the distribution of the quadrats unbiased. Thus, if you are a little Ancient Murrelet hidden in your burrow you will hear a constant, "a little to the left; more to the right" emanating from above. Things can get worse of course. In a coastal rainforest, the bush is often dripping wet – "regen" bashing just got even more torturous. And the very epitome of the experience is when your chain gets tangled in the thick "regen" and you have to turn around and go back in to release it! All in a day's work for a seabird surveyor.

Figure 48. Line transects were used to estimate breeding populations for burrow-nesting birds, such as Rhinoceros Auklet. On transects set up perpendicular to the shore, surveyors often had to "bash" through a band of impenetrable shore vegetation. *Photo by R. Wayne Campbell, Pine Island, BC, 16 June 1976.*

Figure 49. A sample quadrat along a transect line is being set up, from left to right, Teresa Shepard, Keith Taylor, Michael Rodway, and Marilyn Paul. *Photo by R. Wayne Campbell, Pine Island, BC, 16 June 1976.*

<u>Colony area</u>**.** Colony area was defined to include all portions of an island where burrows with recent signs of activity (droppings, feathers, regurgitated food, fragments of eggshell or egg membrane, worn entrances or tunnels, excavation, or fresh nesting material) were located. Colony areas were considered abandoned if burrows were located but no signs of recent activity were observed.

Determining colony boundaries and whether a sample quadrat fell within the colony often required careful exploration. If active-looking burrows were found in a quadrat then it was clear that that quadrat was within the colony. It was less clear whether a quadrat was within the colony when there were no burrows in the quadrat. In that case, the surrounding area was searched for colony evidence. If no burrows were found within a distance halfway to adjacent quadrats along the transect, nor within a lateral radius half the distance to adjacent transects, then that area was not considered colony and the quadrat data was not used in density calculations. If burrows and signs of activity did occur within this range, then the area was considered part of the colony and the quadrat data was used as part of the burrow density sample. If active looking burrows were observed in the vicinity of one quadrat, but were absent from the area surrounding an adjacent quadrat, the colony boundary was delimitated halfway between the two quadrats, unless an obvious border was encountered. The same criteria were applied between transects. This degree of resolution of colony boundaries was as accurate as time and equipment allowed for extensive Ancient Murrelet colonies where burrows were often scattered at low densities. For storm-petrels, Cassin's and Rhinoceros auklets, and Tufted Puffins, whose colony boundaries were usually less extensive and more discrete because burrows occur more frequently, a finer resolution could be obtained, and precise measurements were often possible.

Distance, elevation, and slope measurements were taken along transects as well as during the exploration. This information was used to draw colony areas on detailed topographic maps or air photos. The horizontal surface area of the colony was measured on that map with a compensating polar planimeter, and this value was then adjusted for slope to determine the colony area (GIS technology became available after 1990 and is now used to determine colony areas).

Burrow density. Counts from all plots within the colony area were used to calculate an average burrow density for the entire colony. This average density was used for population calculations. If consistent differences in densities were encountered in different parts of a colony, those areas were separately mapped and individual density rates were calculated. Assigned density classes were unique to a particular colony and could not be equated to those designated for other colonies. Their purpose was to demarcate areas of nesting concentration within a colony.

Burrow occupancy**.** The percentage of burrows that actually contained nesting birds was determined by complete examination of a sample of burrows (Figure 50). If an adult, egg, chick, or freshly hatched egg membrane was found, the burrow was considered occupied. Burrows were considered empty in the current nesting season if all tunnel branches were explored and none of the above was found. Signs such as a well-worn entrance or droppings did not reliably indicate occupancy and were not used to distinguish between occupied and empty burrows. Exploring burrows longer than an arm's reach required digging one or more access holes until the end was reached. Excavated holes were immediately patched with sticks or cedar shakes and soil. The contents of many burrows were impossible to determine because they extended under roots or fallen trees or into cavities within tree bases. To minimize disturbance, adults were not pulled from burrows unless we needed to confirm species identity.

To obtain a representative sample of the entire colony, we attempted to determine the occupancy of each burrow located within surveyed quadrats. Due to time constraints we were often unable to accomplish this. In those cases we selected quadrats from different areas of the colony and explored every burrow in each quadrat selected. On some colonies, transects were run early in the nesting season before all birds were nesting, and occupancy was determined later in one or two areas. Such areas were chosen where burrows were frequent and a sample could be obtained within one day by all workers present. To minimize the bias of selecting likely or easy looking burrows within those areas, we started from a central point and explored every burrow encountered within an expanding radius until we had samples of 20 to 40 burrows with known contents. This sample size provided a reasonably accurate estimate of occupancy rate in a manageable amount of time. The size of those areas was not measured.

Figure 50. Sample quadrats along line transects were examined for contents. In this photo, Harry Carter is holding a Cassin's Auklet and egg just extracted from a burrow on Byers Island off the central mainland coast of BC. *Photo by R. Wayne Campbell, 27 June 1976.*

On small colonies that were not transected, and on transected colonies where an occupancy rate was not determined, either due to lack of time or because our survey occurred too early or too late in the breeding season, we estimated nesting populations using a median occupancy rate based on data from all other colonies of that species surveyed in BC. We used a median rather than an average rate because occupancy data have been collected from various regions of the coast during different years, and without further studies on temporal and regional variations and the factors that influence them, we considered the median to best represent the occupancy rate likely to be encountered on any island. To calculate a median rate for storm-petrels we only used occupancy rates determined when both species were nesting (end of June to beginning of August [589]), unless there was only one species present. On some colonies we were too early to determine an occupancy rate for Leach's Storm-Petrels, but were able to obtain a rate for Fork-tailed Storm-Petrels. In those cases we calculated population estimates for both species by using the median storm-petrel occupancy rate, deriving the number of Leach's Storm-Petrels by subtracting the number of Fork-tailed Storm-Petrels from the total.

Total burrows and current nesting estimates**.** The total number of burrows was the product of the overall average density of burrows as determined in the quadrats and the total area of the colony. Total burrows multiplied by the occupancy rate gave an estimate of nesting pairs. Standard errors for burrow density and occupancy rate were combined to give a standard error for the population estimate. Estimates of occupancy rate determined from a single plot and median occupancy rates do not have a standard error. In those cases, the standard error for the population estimate was derived solely from the standard error for burrow density, resulting in a lower standard error than would be the case if burrow occupancy had been determined.

Identifying a Seabird Without the Bird

In the bird-watching world, plumage patterns and/or song are used to identify a species. Even nocturnal birds like owls can be surveyed using call detections. However, eight of the 15 colonial-breeding seabirds in BC nest at least some of the time in burrows or crevices where they cannot be seen or heard. Diurnal species like Tufted and Horned puffins and Pigeon Guillemots are often visible outside their nests, but the five other, nocturnal species are a challenge to detect, especially when burrows of different species are mixed.

The most reliable method to identify the species is to extract an adult from its burrow. This can be time-consuming, and invasive. For example, one record-long Rhinoceros Auklet burrow had six meters of tunnel that required well over an hour to explore and then repair, and caused unwanted disturbance to the nesting birds. Alternatively, we developed a set of criteria for distinguishing burrows of storm-petrels, Ancient Murrelets, Cassin's Auklets, and Rhinoceros Auklets. These included size of entrance, wear at the entrance, droppings in and around the burrow entrance, regurgitated food (for Cassin's Auklet), feathers found in the burrow, eggshell fragments found in the burrow, and odour. Storm-petrels often nest in conjunction with Cassin's Auklets and less often with Ancient Murrelets. Storm-petrel burrows are 5-7cm wide and their musty odour is distinctive. However, we have found storm-petrels nesting in old Cassin's Auklet burrows, and they will sometimes dig their smaller tunnel off the ends of larger burrows of Tufted Puffins. Feathers left in the burrow can sometimes separate Fork-tailed from Leach's storm-petrels, but most times the burrows of these congeneric species are indistinguishable.

Ancient Murrelets, Cassin's Auklets, and Rhinoceros Auklets are often found nesting in the same areas, though the most frequent associations are Ancient Murrelets and Cassin's Auklets, or Cassin's Auklets and Rhinoceros Auklets. The burrows of Ancient Murrelets and Cassin's Auklets range between 10 and 12 cm in width; Rhinoceros Auklet burrows are between 12 and 15 cm wide (see Fischer and Griffin [241] for additional comments on using nest dimension to identify burrow-nesting seabirds). The burrow entrances of Ancient Murrelets and Rhinoceros Auklets are relatively clean and those of the former species are less worn. The droppings of Ancient Murrelet are yellowish-white and placed away from the entrance. Rhinoceros Auklet droppings are larger, generally globular, pale yellow with black, viscous blobs, and are often deposited to one side of the burrow entrance. Cassin's Auklets leave white fecal streaking along the approach and into the entrances of their burrows. Cassin's Auklet droppings also have a more arresting odour, as does their regurgitated food, some of which they invariably lose at the entrance to their burrows when delivering it. Abdominal feathers (which are often lost in the burrows) of each species cannot be distinguished by size. However, the colour pattern of their afterfeather (or aftershaft) that grows off the base of the main feather is distinctive: Ancient Murrelet afterfeathers are half dark and half *white; Cassin's Auklet afterfeathers are mostly dark with a tip of white; and the colour of the Rhinoceros Auklet afterfeather is uniform greyish white and is similar to that of the base of the main feather. Eggshell fragments of Cassin's Auklets and Rhinoceros Auklets are both white and are indistinguishable unless a major portion of the shell is present and can be identified by size. Fragments of Ancient Murrelet eggshell are easily identified by their colour – pale olive background with dark speckling throughout* (Figure 51).

Figure 51. Combinations of the size of a burrow, droppings, regurgitated food, shed feathers, and eggshell fragments can be used to determine a species that otherwise cannot be identified. The burrow (top) of Ancient Murrelet is small, between 10-12 cm wide, and its eggs (bottom), unlike the pure white eggs of other nocturnal burrow-nesting species, are patterned. *Photos by R. Wayne Campbell, Limestone Islands, BC, June 1995.*

Predation and Mortality

Sightings or other evidence of predators present on colonies were recorded. During exploration and along transects, signs of predation encountered on the ground and in burrows were tallied to indicate prey species and intensity of predation. Areas around Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), Common Raven (*Corvus corax*), and Northwestern Crow (*Corvus caurinus*) nests, and around Northern River Otter (*Lontra canadensis*) runs and dens and American Mink food caches, were examined in detail. Pellets and scats were inspected (Figure 52). Digging around burrows was noted. Density of prey remains recorded in survey quadrats was used to estimate the amount of predation on a colony and provided coarse comparisons in predation levels among colonies. Evidence of intraspecific predation by Glaucous-winged Gulls was recorded and often photographed.

Mortality caused by other factors, such as exposure to severe weather, entanglement, collisions with trees, logs, and human structures, feather impairment from slug slime, disturbance from aircraft, illegal shooting, cactus ensnarement, and oiling were also noted.

Figure 52. Pellets ejected by a nesting Bald Eagle contained remains of three Leach's Storm-Petrels. *Photo by R. Wayne Campbell, Gillam Islands, BC, 28 June 1975.*

Staging

Common and Thick-billed murres, Pigeon Guillemots, Ancient Murrelets, Rhinoceros Auklets, and Tufted Puffins typically aggregate on the water adjacent to their colony. For the nocturnal Ancient Murrelets and Rhinoceros Auklets, birds gather on staging areas before dusk, prior to flying into their nesting slopes, Methods used to locate these staging areas included: scans by binoculars and telescope from shore; and water transects run in inflatable boats when the weather was calm. If, during water transects, birds were not encountered, the boat was often stopped so that birds might be heard calling from the water. This was only useful for Ancient Murrelets, as we have never heard Rhinoceros Auklets calling on their staging areas.

DATA PRESENTATION AND ORGANIZATION

Key to Summary Tables

There is a wide variety in the kind and quality of data that have been collected by the numerous observers who have contributed to our historical knowledge of breeding seabirds in BC. Many of the early records are specimens that confirm nesting but give no information on population sizes (Figure 53). On colony summary tables we cite original publications of those records or we reference museum specimen numbers for collected eggs that confirm breeding. More recent surveys give population estimates, but they are derived by various methods and amount of effort, and are often not comparable. In compressing this diversity of data into tabular form, we have tried to define the quality of the data presented by using the following codes. Only total counts and estimates derived from systematic sampling of quadrats along transect are considered comparable among observers and visits. Derived estimates from transects were given ±1 standard error in CWS technical reports and the ICBP summary publication [473] and are presented that way here on species summary tables. We rounded off those estimates and present them without standard errors to simplify tabulation on colony, regional and provincial tables that summarize historical records for all nesting species.

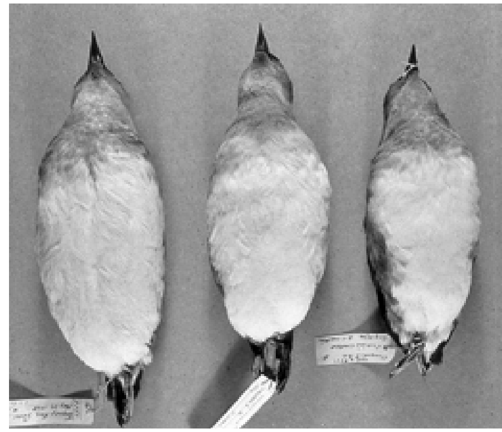


Figure 53. Many of the early bird collectors focused on obtaining specimens, such as these Cassin's Auklets, and rarely took the time to estimate breeding populations or record other aspects of seabird natural history. *Photo by R. Wayne Campbell, BC Provincial Museum, Victoria, BC, August 1979.*

<u>Data Codes Used On Summary Tables</u>

x: Breeding confirmed in at least one nest but no population estimated. When followed by a number (e.g., **x**3) it indicates the number of nests where breeding was confirmed and does not indicate a population estimate. We define confirmation by these criteria:

1. For all species, breeding is confirmed by the presence of eggs in a burrow, nest or on a nesting ledge, or unfledged young in or near a nest, including recently hatched or broken eggshells or dead young. These are the only criteria accepted for all surface-nesting species except Pelagic Cormorant, and for Horned Puffin. Stricter criteria are used for Horned Puffins than other burrow- or crevice-nesting species because of their rare breeding status. Whole or depredated eggs found away from a nest site are not considered confirmation as these can result from predation on females carrying eggs.

2. For all burrow- or crevice-nesting species except Horned Puffin, adults in burrows, including adults flying in or out of a burrow or crevice and prey remains of adults that have been dug out of burrows by a mammalian predator, is also considered confirmation. Subadults or nonbreeding birds visiting burrows may create a bias in the criteria but we consider breeding likely to occur on a colony that is being visited.

3. For Pelagic Cormorants, we extend our definition to include adults sitting in nests or standing on the edge of nests (Figure 54). We have used extended criteria for them because there are many places where Pelagic Cormorants nest in inaccessible sites where it is impossible to obtain more definite evidence without compromising the reproductive efforts of the birds, and/or the safety of survey crews.

S: Breeding suspected. Used when no confirmation of breeding has been obtained, but because of other evidence observed, breeding is suspected. Evidence includes adults on territories and adults flying or sitting in the vicinity of likely nesting sites (cormorants, Black Oystercatcher, Glaucous-winged Gull, murres, Pigeon Guillemot, and puffins; Figure 55), partially constructed or empty nests (all surface-nesting species), and burrows with signs of activity in or around them such as worn entrances, droppings, feathers and eggshell fragments (all burrow-nesting species).

e: Estimated population. Indicates a total population estimate, but, because methods used to obtain estimates varied and were not replicable, is not comparable to other estimates. If no confirmation has been obtained, an "**S**" accompanies it. When used alone following a number, it means that breeding

Figure 54. When nest contents could not be determined for Pelagic Cormorants, it was assumed that birds were breeding when they were in the nest in incubating/brooding position or standing on the side of a nest. *Photo by R. Wayne Campbell, Passage Island, BC, 7 June 1981.*

Figure 55. Tufted Puffins were suspected of breeding when adults were observed standing near suitable nesting habitat. *Photo by R. Wayne Campbell, Solander Island, BC, 14 August 1981.*

of at least one pair was confirmed (see "**x**" above). We have included partial counts under this category because it is often difficult to determine what portion of a colony was counted, making precise replication impossible.

t: Calculated population. Equals the number of occupied burrows calculated from standardized transect and occupancy sampling techniques, and measured colony areas. Methods are replicable and population estimates derived by these methods are comparable.

Number with no code or followed by a code, e.g., 213 or 200eS: Population estimates. Numbers presented without a letter code (e.g., **213**) indicate that a total count of all nests or burrows was conducted and breeding was confirmed. One or more letter codes (**e**, **S**, or **t**) following a number qualify the population estimate as indicated above. Surveyors counting gull and cormorant nests usually included all nests observed, whether empty or with eggs or young. For oystercatchers there has been a tendency for some observers to report only those nests with eggs or young. We have attempted to remedy this by examining original notes to extract total nests counted. In some cases this over-estimates actual nesting pairs, but often more accurately represents the total when young are hidden and only empty scrapes are found. When a total count is presented for burrow-nesting species, it represents an estimate of total nesting pairs derived by multiplying the total count of burrows by a median burrow occupancy rate.

Number in square brackets, e.g., [12]: Number of nests that contained eggs or young. Used only for surface-nesting species and when the contents of all nests have been determined (Figure 56). If a number in square brackets is presented, it will always follow a total count population estimate (i.e., a number with no code). The two together thus give the total number of nests and the number of nests that contained eggs or young. For example, **427[401]**, indicates that a total of 427 nests were counted, 401 of which contained eggs or young, and thus 26 were empty. Presenting these data addresses the problem discussed above in regards to the counting of empty nests and provides additional information to help interpret differences among counts.

Figure 56. On most Glaucous-winged Gull colonies it is possible to obtain a complete count of all nests and contents. *Photo by R. Wayne Campbell, Chain Islets, BC, 23 July 1973.*

Number in round parentheses, e.g., (12): Number of birds in breeding plumage on or near the colony. Used only for Pigeon Guillemot, Common Murre, and Tufted and Horned puffins. As the nests of these species are often difficult to find or are inaccessible, these numbers often give a better indication of the size of the population at a particular site than the numbers of nests found. However, the numbers of these birds in attendance at a colony fluctuates through the day and through the season, and may include a subadult population, meaning that counts cannot be compared between visits. Extended, standardized observations are required to make counts comparable.[212, 225, 420] When just a number in brackets is presented without any other qualifying codes (e.g., "**S**" for breeding suspected), it indicates that observers just recorded birds sighted and either provided no other information or stated that there was no evidence of nesting. Although these kinds of records on their own were not considered sufficient to designate a site a breeding colony (in which case they are listed in appendices of islands surveyed with no history of nesting), we include them in historical tables for established colonies to provide a complete summary of where birds have occurred.

E: Extirpated. Used only for burrowing species for which previous nesting at a site had been confirmed, and a thorough search has revealed no current activity. **Zero** is used for abandoned sites of surface nesting species like cormorants which are known to use nest sites intermittently,[172] and for previously suspected, but unconfirmed colonies of burrow nesting species.

What Comes After – the Other Side of Seabird Surveys

After the field work is finished and crews are safely back home and equipment is cleaned up and stored, the real work begins. Months are spent transforming pages and pages of transect survey data, maps, measurements of colony areas, and copious field notes from many observers, into a useable form for estimating populations and writing reports. This task lasts over the winter and lacks the excitement and adventure of exploring seabird colonies. In the current electronic age, it is hard to remember, even for us geezers who were working long hours before home computers became available, what it was like compiling data and writing reports by hand. It seems like a science fiction story set in an alternate universe. Field notes from BCPM surveys were laboriously compiled onto paper Seabird Inventory forms that became part of a satellite collection to the BCNRS. Earliest CWS inventory reports were painfully compiled by hand and only through the diligent fingers of CWS office assistants like Susan Garnham, were transformed into typed documents that could be published. Revisions were nightmares because, for anything major, the entire text had to be retyped. Susan never complained! Colony maps were drawn by hand and "Letraset" was cut and pasted to delineate different nesting areas and other features (Figure 57).

Our first introduction to computerized work was when CWS biologist Gary Kaiser, who was supervising the inventory program, bought a small machine that had the stunning capability to store an entire page of typed text on a single microcassette! Needless to say, it took a pile of cassettes to save an entire report, but now text revisions could be accomplished without having to retype the entire document. Later, Michael scraped together his savings and bought an early Zenith laptop with a fold-down, liquid crystal display for over $4,000. It had no internal memory but had two, 5¼" floppy drives. A program disc was inserted into one drive and a separate disc to store the data was inserted into the other drive. Those floppy discs initially had a phenomenal storage capacity of 360 kilobytes that by the late 1980s had progressed to a whopping 1.2 megabytes on a double-sided, high-density disc. Report writing had entered the modern age! The rest, as they say, is history.

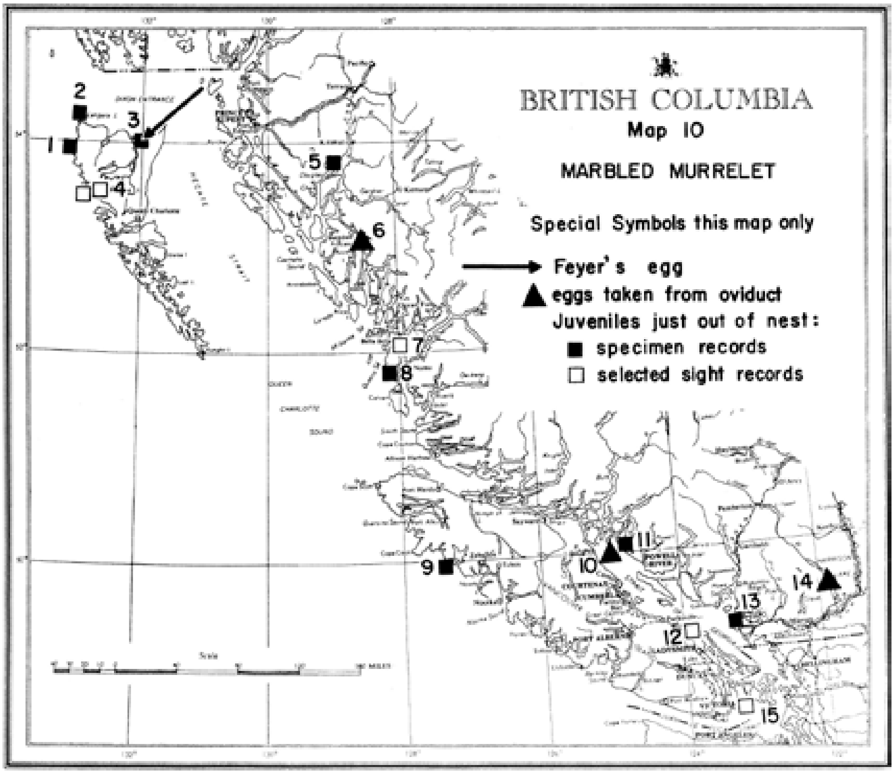


Figure 57. The maps of species nesting sites for the first seabird catalogue [213] were prepared by Rudi Drent using manufactured sheets of typefaces for numbers and letters, and other artwork ("Letraset"), that had to be transferred to a pre-printed government base maps. The 15 maps took him many days to prepare!

Coastal Regions and Colony Names

We have divided the BC coast into 12 geographic regions (Figure 58). Forthcoming chapters of this catalogue will present detailed summaries of historical seabird breeding records for each colony, a summary of population estimates for all colonies in each region, and a more in-depth discussion of regional trends and threats. Here, we summarize populations for each species, provincial populations by region, and present an overview of trends, threats, and management considerations. Location names are from the Gazeteer of Canada: British Columbia,[275] except for names in quotations, which have been assigned by the authors to avoid confusing lists of unnamed sites. Geographic regions and colony identity numbers correspond to those used in CWS Technical Reports [470, 475, 476, 477, 480, 481, 482, 484] and in the ICBP summary paper.[473] Geographically-ordered colony identity numbers were assigned at intervals of 10 to allow future insertion of newly discovered colonies in geographic sequence. A few new identity numbers have been inserted where historical data have been found or reinterpreted after reports were published.

Deciding whether to include a site as a colony was straightforward in most cases. However, there were a variety of situations where nesting was not confirmed but was suspected (see Key to Summary Tables above for the criteria we used to define confirmed and suspected breeding) and it was less clear whether the location should be called a breeding colony. In cases of suspected breeding, we defined a site as a colony if, based on available evidence, observers seemed

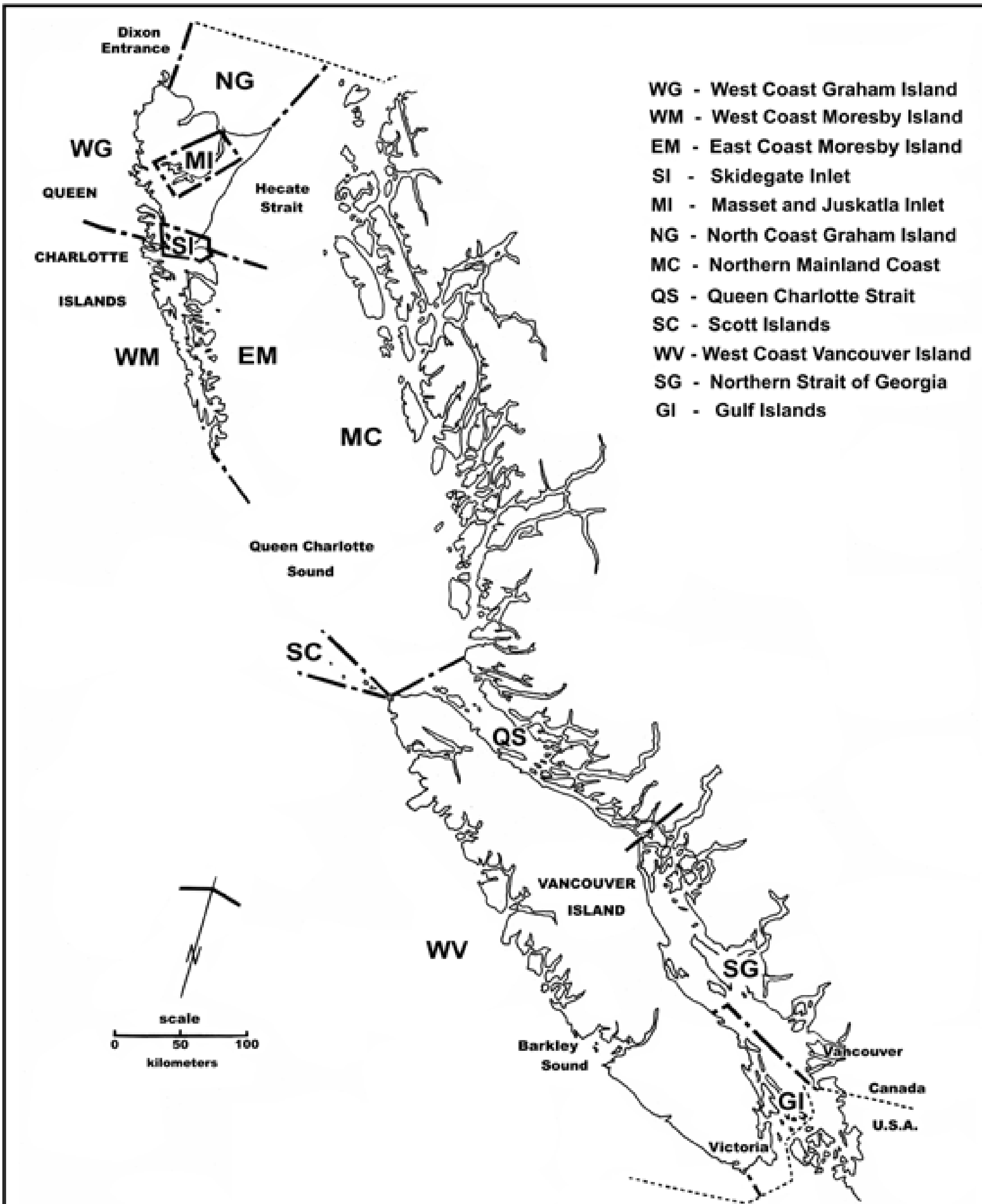


Figure 58. Twelve geographic regions used to summarize seabird breeding populations in coastal British Columbia.

confident that at least some birds were breeding. We did not give colony status to numerous sites where birds were present that may have been nesting (e.g., a pair of Black Oystercatchers) but no evidence of nesting was found and observers were unsure if birds were breeding. Such sites are listed in appendices along with all other sites surveyed with no record of breeding by seabirds in forthcoming chapters of this catalogue. Future surveys will undoubtedly confirm breeding at some of those sites and they can then be given colony status and inserted into our numbering scheme.

Population Estimates as of 1990

Population estimates are considered representative of actual breeding populations on the BC coast as of 1990, except for Pigeon Guillemots. There are obvious sources of error, but overall numbers are probably indicative of real nesting populations for all other species. No attempt has been made to estimate nonbreeding populations and total numbers of birds using the BC coast are larger than the breeding estimates presented here (Figure 59).

Almost all sources give population estimates for specific colonies in numbers of nests or breeding pairs, and on species tables we list individual records as given in original documents. For transected colonies of burrow-nesting species we include colony area, burrow density, and burrow occupancy estimates, and sampling effort and standard errors for those estimates. On some storm-petrel colonies that were surveyed before Leach's Storm-Petrels were nesting, it was possible to determine the proportion of burrows occupied by Fork-tailed Storm-Petrels, but not the overall occupancy rate for both species.[480] Where population estimates were based on partial or total counts of burrows, we give the percentage of burrows counted relative to total numbers estimated. This is listed under "area sampled" as it by-and-large represents the proportion of the colony area where burrows were counted.

On regional and provincial summary tables (Tables 3 and 4, pages 63-64), breeding population estimates are given in total birds rather than total pairs to include numbers of murres, Pigeon Guillemots and puffins sighted around colonies when no estimates

Figure 59. Aggregations of non-breeding birds, mainly cormorants, Black Oystercatchers (shown), and Glaucous-winged Gulls, were frequently recorded during surveys, but have not been included in population estimates. *Photo by R. Wayne Campbell, near Thurston Harbour, Queen Charlotte Islands, BC, 11 July 1977.*

of breeding pairs have been obtained. Estimates of breeding pairs for other species are multiplied by two to obtain the number of total birds. Where we have an estimate of total breeding pairs of Tufted Puffins derived from transect sampling techniques or total counts, the number of breeding birds also equals twice that estimate. The total number of Pigeon Guillemots equals the number of birds sighted around a colony, or twice the number of confirmed nests found, whichever is greater.

Current breeding population estimates listed for a particular colony are generally from the most recent survey as of 1990 unless that survey was incomplete and a better estimate for the entire colony was available from a previous survey. We sometimes used different criteria to derive current estimates for Pigeon Guillemots because their numbers fluctuate dramatically throughout the day and seasonally and repeat counts are required to obtain reliable estimates of total birds associated with a colony. When CWS surveys on a particular colony were conducted over more than one year, we considered the maximum count for Pigeon Guillemots from those years to be the best and current estimate, unless there was a better, more recent survey. This applied only to a few colonies on the east coast of Moresby Island in the Queen Charlotte Islands that were surveyed over two and rarely three years,[480] and to colonies on the northern west coast of Vancouver Island that were surveyed in 1988 [475] and 1989.[236]

We considered whether using maximum counts from two years of survey data would bias overall estimates or mask potential year-to-year changes and decided that using maximum counts from sequential years of survey data likely increased the accuracy of current population estimates for Pigeon Guillemots and did not introduce any unwanted biases into those estimates. At 29 colonies surveyed in both 1988 and 1989 on the west coast of Vancouver Island, 13 colonies had higher counts in 1988 and 9 had higher counts in 1989, indicating no real trend and suggesting that counts were more affected by variability in attendance and survey effort and timing than annual changes in populations. For example, on Gillam Islands, we surveyed for two days and counted a maximum of 45 birds in 1988, whereas only one Pigeon Guillemot was recorded when surveyors just boated around the island in 1989. Total numbers of Pigeon Guillemots counted at the 29 colonies surveyed in both 1988 and 1989 were 563 in 1988, 655 in 1989, and 823 if maximum counts from the two years were used.

For Black Oystercatchers, we considered surveys from land superior to those conducted from the water because nesting birds are not always obvious from the water. They often "hunker down" when disturbed (Figure 60). If birds were not detected on surveys from the water but had been found nesting on previous land surveys, we considered counts from the land survey to be the better and current estimate. This applied to a few colonies surveyed only from the water on the west coast of Vancouver Island [475, 590] and in the Strait of Georgia [595] where oystercatchers were not detected but had previously been confirmed nesting. Further justification for this protocol was provided by the work of Stephanie Hazlitt, [318] who showed that almost a third of nest sites are missed on a single survey from the water, and that birds tend to nest in the same site from year to year.

Tables 5 and 6 (pages 65-67) list numbers of confirmed and unconfirmed breeding sites for each species and for the total birds at a colony. For total birds, a colony is considered a confirmed breeding site if confirmation of breeding by at least one species has been obtained.

Figure 60. When disturbed or threatened, adult Black Oystercatchers often crouch down as if on a nest, making detection from the water problematic. *Photo by R. Wayne Campbell, Ramsay Island, BC. 6 June 2000.*

To arrive at total population estimates, data from various years have been combined. For species like cormorants that shift sites from year to year, more reliable estimates would be obtained if all sites were surveyed during a single season. Year-to-year variations in breeding effort in relation to environmental conditions affects population estimates made in different years. How these variations have affected overall population estimates is unknown. If survey methods are sensitive enough to detect differences, estimates would be highest in years of maximum breeding effort. Research is required on how to distinguish seasonal changes in breeding effort from actual population changes.

We have reliable total population estimates for storm-petrels, but the proportion of the two species is unknown at several major colonies. CWS surveys in the Queen Charlotte Islands and on the northern mainland coast were timed to coincide with the nesting periods of Ancient Murrelets and Cassin's Auklets (April to June). Many islands were thus surveyed before the majority of Leach's Storm-Petrels were incubating, though burrows were prepared and courting adults were present. Further surveys at the appropriate time (July) are required to reliably determine proportions of the two species at some colonies in those areas.

We have estimates based on replicable line transect techniques for most colonies of burrow-nesting species. On the west coast of Graham Island, the three major colonies have been surveyed with replicable methods, but we have only rough estimates from the 1977 BCPM survey for smaller colonies of burrow-nesting species. The Ancient Murrelet colony on Kunghit Island, at the south end of Moresby Island, was not transected during the 1980's CWS surveys, but was surveyed with transects in 1993.[298]

PROVINCIAL POPULATIONS

As of 1990, 16 seabird species, including one shorebird that we consider a "seabird", are known to breed on the many islands along the BC coast: Fork-tailed Storm-Petrel, Leach's Storm-Petrel, Double-crested Cormorant, Brandt's Cormorant, Pelagic Cormorant, Black Oystercatcher, Glaucous-winged Gull, Common Murre, Thick-billed Murre (Figure 61), Pigeon Guillemot, Marbled Murrelet, Ancient Murrelet, Cassin's Auklet, Rhinoceros Auklet, Tufted Puffin, and Horned Puffin. Black Oystercatcher has been included because this species feeds and breeds only in the coastal environment and nests on most of the same islands as the other seabirds.

Figure 61. Occasionally, Thick-billed Murres visit BC waters from their subarctic and arctic breeding grounds. The species was first reported in the province near Langara Island on 28 June 1970 [137, 511] and from 1981 to at least 1989 small numbers nested on Triangle Island. The white bill stripe is the main field mark used during surveys to separate it from Common Murre. *Photo by Alan D. Wilson.*

Breeding distribution is known, and we have reliable population estimates for all species except Marbled Murrelets. Marbled Murrelets are non-colonial, inland breeders and are not considered in our population estimates. Data gathered up to 1990 indicate that over 5.6 million birds of the other 15 species are estimated to breed at 542 sites (Tables 3 and 5, pages 63 and 65). Cassin's Auklet populations account for almost half (48%) of that total. The next most abundant species are storm-petrels (27%), Rhinoceros Auklets (13%), and Ancient Murrelets (10%). Black Oystercatchers, Glaucous-winged Gulls and Pigeon Guillemots nest at the most sites. Using 1990 estimates from other areas reveals that BC supports major portions of the known world populations of Cassin's Auklets (80%), Ancient Murrelets (74%) and Rhinoceros Auklets (56%).

Breeding populations are concentrated in small clusters of colonies, making large numbers of birds vulnerable to local perturbations of the marine environment. Fifty-six percent of the total breeding population is concentrated in two areas less than 100 km apart: the outer three islands of the Scott Islands, and five islands at the mouth of Queen Charlotte Strait (Table 4, page 64). A major oil spill in this area could be devastating to many of these bird populations. The Queen Charlotte Islands support another 27% of the total, concentrated in five clusters of colonies on the west coast of Graham Island and east and west coasts of Moresby Island. Available data are inadequate to determine province-wide population trends in most cases, but numerous, previously documented colonies have been abandoned, indicating at least local impacts and population declines for most species (Table 6, pages 66-67).

Black-legged Kittiwake had not been recorded as a breeding species in BC in 1990 and is not included in this catalogue. Abundant along the outer BC coast in summer,[503] they have been extending their breeding range southward in southeast Alaska.[529, 554] This species was confirmed breeding in BC on 23 June 1997, when three nests were found on Holland Rock in Chatham Sound off the northern mainland coast.[138, 319]

Five other seabird species, Northern Fulmar, Western Gull, Herring Gull (*L. argentatus*), Mew Gull (*L. canus*), and Caspian Tern (*Hydroprogne caspia*), are potential breeders on maritime islands in BC. Northern Fulmars are present on the outer coast all year,[385, 136] and small numbers (<10) have been observed prospecting cliffs and usurping Pelagic Cormorant nests on Triangle Island.[484, 603] A pair of Western Gulls was suspected breeding on Seabird Rocks on the west coast of Vancouver Island in 1943,[439] but details of this record have not been considered sufficient to give the species breeding status in the province.[137, 213] On Cleland Island, Campbell and Stirling [130] observed one bird on territory with a Glaucous-winged Gull in 1967, and Dave Mark [642] reported one Western Gull sharing incubation duties with a Glaucous-winged Gull in 1978. A pair of hybrids was observed defending a nest with young on Triangle Island in 1989.[484] Hybridization between these two species is well documented in Washington and Oregon.[336]

Herring Gull has a circumboreal breeding range and in western North America nests primarily on inland lakes and rivers.[449] Its breeding range here extends south to Bridge Lake and Okanagan Lake in south-central BC [92, 152] (Figure 62), although there is an unsubstantiated record from 1927 of a small colony in Masset Inlet in the Queen Charlotte Islands.[201] Elsewhere, the species also nests on maritime islands; large colonies occur on the Atlantic coast of Canada and in Alaska. Currently, the closest maritime breeding colony is in Adams Inlet, southeast Alaska, about 568 km northwest of the BC/Alaska border.[208] Herring Gull hybridizes with Glaucous-winged Gull in southern Alaska.[336]

Of the six species of inland-nesting gulls in BC, only Mew Gull breeds near the coast, nesting at lakes on Vancouver Island, along the mainland coast, and on the Queen Charlotte Islands.[98, 137, 477, 486, 579] Nesting sites on the Brooks Peninsula on Vancouver Island were only 2.5 km from the ocean,[133] and some nests found on the Queen Charlotte Islands were less than four km from marine shores.[486] Adults nesting near the coast forage in protected waters on mud flats and inlets during the breeding season.[210] At more inland sites, such as Cowichan Lake on Vancouver Island and Harrison Lake in the Lower Mainland, adults forage on nesting lakes and depend less on the marine environment. Mew Gull do nest in marine habitats in other areas, including coastal cliffs and islands

Table 3. Summary of seabird breeding populations in British Columbia as of 1990.[a] Estimates are of total breeding birds.

REGION	FTSP and/or LSPE[b]	FTSP[c]	LSPE[d]	Total Storm-Petrels	DCCO[e]	BRCO[f]	PECO[g]	BLOY[h]	GWGU[i]	COMU[j]	TBMU[k]	PIGU[l]	ANMU[m]	CAAU[n]	RHAU[o]	TUPU[p]	HOPU[q]	All Species
Queen Charlotte Islands																		
West Coast Graham Island		35,200	40,600	75,800			232	188	1,234			861	266,000	218,300	400	663	5	563,683
West Coast Moresby Island	99,940	4,564	17,700	122,204			36	84	1,664	158		800	39,260	238,740	69,000	1,593	26	473,565
East Coast Moresby Island	49,540	15,420	49,840	114,800			82	290	1,648			2,339	235,052	143,660	5,364	323	3	503,561
Skidegate Inlet								106	364			2,975						3,445
Masset and Juskatla Inlet								74	162			272						508
North Coast Graham Island								34	226			175						435
Total Queen Charlotte Islands	***149,480***	***55,184***	***108,140***	***312,804***			***350***	***776***	***5,298***	***158***		***7,422***	***540,312***	***600,700***	***74,764***	***2,579***	***34***	***1,545,197***
Northern Mainland Coast		60,180	41,110	101,290			126	322	6,654			1,421	0	45,010	234,560	30	3	389,416
Queen Charlotte Strait		120,000	553,200	673,200			72	104	1,688			433		13,420	324,300			1,013,217
Scott Islands		6,000	25,400	31,400		78	1,482	58	2,154	8,200	14	802		1,980,000	83,400	69,800	17	2,177,405
West Coast Vancouver Island		86,040	312,940	398,980		112	842	682	11,948	2		1,119		70,140	2,280	6,237	6	492,348
Strait of Georgia																		
Northern Strait of Georgia					444		1,670	58	11,416			536						14,124
Gulf Islands					3,014		2,278	140	16,310			673			12	2		22,429
Total Strait of Georgia					***3,458***		***3,948***	***198***	***27,726***			***1,209***			***12***	***2***		***36,553***
BRITISH COLUMBIA TOTAL	**149,480**	**327,404**	**1,040,790**	**1,517,674**	**3,458**	**190**	**6,820**	**2,140**	**55,468**	**8,360**	**14**	**12,406**	**540,312**	**2,709,270**	**719,316**	**78,648**	**60**	**5,654,136**
Percent of all species	3	6	18	27	0	0	0	0	1	0	0	0	10	48	13	1	0	100

[a] Excluding Marbled Murrelet (see text).
[b] Total number of storm-petrel burrows was known but the proportion of burrows occupied by each of the two storm-petrel species was not determined.
[c-q] Species acronyms as follows: [c]FTSP–Fork-tailed Storm-Petrel, [d]LSPE– Leach's Storm-Petrel, [e]DCCO–Double-crested Cormorant, [f]BRCO–Brandt's Cormorant, [g]PECO–Pelagic Cormorant, [h]BLOY–Black Oystercatcher, [i]GWGU–Glaucous-winged Gull, [j]COMU–Common Murre, [k]TBMU–Thick-billed Murre, [l]PIGU–Pigeon Guillemot, [m]ANMU–Ancient Murrelet, [n]CAAU–Cassin's Auklet, [o]RHAU–Rhinoceros Auklet, [p]TUPU–Tufted Puffin, and [q]HOPU–Horned Puffin.

Table 4. Percentage of species populations breeding in each geographic region in British Columbia as of 1990.

REGION	FTSP and/or LSPE	FTSP	LSPE	Total Storm-Petrels	DCCO	BRCO	PECO	BLOY	GWGU	COMU	TBMU	PIGU	ANMU	CAAU	RHAU	TUPU	HOPU	All Species
Queen Charlotte Islands																		
West Coast Graham Island		11	4	5			3	9	2			7	49	8	0	1	8	10
West Coast Moresby Island	67	1	2	8			1	4	3	2		6	7	9	10	2	43	8
East Coast Moresby Island	33	5	5	8			1	14	3			19	44	5	1	0	5	9
Skidegate Inlet								5	1			24						0
Masset and Juskatla Inlet								3	0			2						0
North Coast Graham Island								2	0			1						0
Total Queen Charlotte Islands	***100***	***17***	***10***	***21***			***5***	***36***	***10***	***2***		***60***	***100***	***22***	***10***	***3***	***57***	***27***
Northern Mainland Coast		18	4	7			2	15	12			11	0	2	33	0	5	7
Queen Charlotte Strait		37	53	44			1	5	3			3		0	45			18
Scott Islands		2	2	2		41	22	3	4	98	100	6		73	12	89	28	39
West Coast Vancouver Island		26	30	26		59	12	32	22	0		9		3	0	8	10	9
Strait of Georgia																		
Northern Strait of Georgia					13		24	3	21			4						0
Gulf Islands					87		33	7	29			5			0	0		0
Total Strait of Georgia					***100***		***58***	***9***	***50***			***10***			***0***	***0***		***1***

Table 5. Number of current seabird breeding sites in British Columbia as of 1990.

REGION	FTSP and/or LSPE	FTSP	LSPE	Total Storm-Petrels	DCCO	BRCO	PECO	BLOY	GWGU	COMU	TBMU	PIGU	ANMU	CAAU	RHAU	TUPU	HOPU	All Species
Queen Charlotte Islands																		
West Coast Graham Island		7	6	7			7	26	19			25	4	8	1	3	1	34
West Coast Moresby Island	5	8	5	9			4	18	19	2		23	10	12	11	11	4	33
East Coast Moresby Island	12	17	9	19			4	61	34			68	17	23	6	1	1	78
Skidegate Inlet								22	16			26						34
Masset and Juskatla Inlet								15	11			15						16
North Coast Graham Island								2	2			2						2
Total Queen Charlotte Islands	***17***	***32***	***20***	***35***			***15***	***144***	***101***	***2***		***159***	***31***	***43***	***18***	***15***	***6***	***197***
Northern Mainland Coast		6	7	7			4	43	49			45		7	9	4	2	59
Queen Charlotte Strait		3	5	5			3	23	22			18		4	4	0		30
Scott Islands		2	2	2		1	5	3	3	1	1	4		3	1	3	3	5
West Coast Vancouver Island		4	7	7		2	13	78	40	1		46		3	2	8	1	91
Strait of Georgia																		
Northern Strait of Georgia					5		15	25	56			25						70
Gulf Islands					9		18	48	62			47			1	1		90
Total Strait of Georgia					***14***		***33***	***73***	***118***			***72***			***1***	***1***		***160***
BRITISH COLUMBIA TOTAL	**17**	**47**	**41**	**56**	**14**	**3**	**73**	**364**	**333**	**4**	**1**	**344**	**31**	**60**	**35**	**31**	**12**	**542**
Confirmed on any survey [a]	14	41	38	50	14	3	72	316	314	3	1	258	26	52	19	22	1	522
Unconfirmed [a]	3	6	3	6	0	0	1	48	19	1	0	86	5	8	16	9	11	20

[a] See Key to Summary Tables on pages 53-56 for definitions of confirmed and unconfirmed breeding sites.

Table 6. Total number of historically used seabird breeding sites in British Columbia, and numbers of those historical sites that were abandoned as of 1990.

REGION	FTSP	LSPE	Total Storm-Petrels	DCCO	BRCO	PECO	BLOY	GWGU	COMU	TBMU	PIGU	ANMU	CAAU	RHAU	TUPU	HOPU	All Species
TOTAL HISTORICALLY USED BREEDING SITES																	
Queen Charlotte Islands																	
West Coast Graham Island	12	11	13			13	26	20			27	6	10	3	5	1	35
West Coast Moresby Island	9	6	10			8	21	19	2		25	10	13	12	12	4	33
East Coast Moresby Island	24	11	24			11	66	39			74	25	28	7	2	1	79
Skidegate Inlet							24	20			28						36
Masset and Juskatla Inlet							16	14			17						17
North Coast Graham Island							4	2			2						4
Total Queen Charlotte Islands	***45***	***28***	***47***			***32***	***157***	***114***	***2***		***173***	***41***	***51***	***22***	***19***	***6***	***204***
Northern Mainland Coast	9	8	10			7	50	53			49	1	7	12	5	2	61
Queen Charlotte Strait	3	5	5			8	25	29			20		5	4	2		35
Scott Islands	2	2	2		1	5	3	3	2	1	4		5	2	3	3	5
West Coast Vancouver Island	6	9	9		5	46	81	63	3		57		3	2	10	1	113
Strait of Georgia																	
Northern Strait of Georgia				6		19	27	59			32						74
Gulf Islands				13		31	50	68			51			1	1		96
Total Strait of Georgia				***19***		***50***	***77***	***127***			***83***			***1***	***1***		***170***
BRITISH COLUMBIA TOTAL	**65**	**52**	**73**	**19**	**6**	**148**	**393**	**389**	**7**	**1**	**386**	**42**	**71**	**43**	**40**	**12**	**588**
Confirmed on any survey	52	48	62	19	6	144	342	360	6	1	282	34	57	23	28	1	567
Unconfirmed	13	4	11	0	0	4	51	29	1	0	104	8	14	20	12	11	21

Table 6. (cont'd)

REGION	FTSP	LSPE	Total Storm-Petrels	DCCO	BRCO	PECO	BLOY	GWGU	COMU	TBMU	PIGU	ANMU	CAAU	RHAU	TUPU	HOPU	All Species
	NUMBER OF HISTORICAL BREEDING SITES THAT WERE ABANDONED AS OF 1990 [a]																
Queen Charlotte Islands																	
West Coast Graham Island	5	5	6			6	0	1			2	2	2	2	2	0	1
West Coast Moresby Island	1	1	1			4	3	0	0		2	0	1	1	1	0	0
East Coast Moresby Island	5	2	5			7	5	5			6	8	5	1	1	0	1
Skidegate Inlet							2	4			2						2
Masset and Juskatla Inlet							1	3			2						1
North Coast Graham Island							2	0			0						2
Total Queen Charlotte Islands	***11***	***8***	***12***			***17***	***13***	***13***	***0***		***14***	***10***	***8***	***4***	***4***	***0***	***7***
Northern Mainland Coast	3	1	3			3	7	4			4		0	3	1	0	2
Queen Charlotte Strait	0	0	0			5	2	7			2		1	0	2		5
Scott Islands	0	0	0		0	0[b]	0	0	1	0	0		2	1	0	0	0[b]
West Coast Vancouver Island	2	2	2		3	33	3	23	2		11		0	0	2	0	22
Strait of Georgia																	
Northern Strait of Georgia				1		4	2	3			7						4
Gulf Islands				4		13	2	7			7			0	0		6
Total Strait of Georgia				***5***		***17***	***4***	***10***			***14***			***0***	***0***		***10***
BRITISH COLUMBIA TOTAL	**16**	**11**	**17**	**5**	**3**	**75**	**29**	**57**	**3**	**0**	**45**	**10**	**11**	**8**	**9**	**0**	**46**
Confirmed on any survey	10	10	13	5	3	72	23	46	3		24	7	5	4	8		45
Unconfirmed	6	1	4	0	0	3	6	11	0		21	3	6	4	1		1
TOTAL SITES ABANDONED (%)	25	21	23	26	50	51	7	15	43	0	12	24	15	19	23	0	8
CONFIRMED SITES ABANDONDED (%)	19	21	21	26	50	50	7	13	50		9	21	9	17	29		8

[a] Numbers of abandoned sites do not always equal the differences between total historical sites and total current sites (Table 5) because observations or records were inadequate to define the current status of some colonies. Note that changes in site use do not necessarily represent changes in overall breeding populations.
[b] Nests were freshly built and breeding was confirmed during the most recent survey (1987) on Lanz and Cox islands in the Scott Islands but all nests were abandoned later that season at those two colonies.

in Alaska and rocky islets, sea stacks, sand dunes, and foreshore areas in the western Palearctic,[74, 398] making it a potential candidate to colonize marine islands in BC.

Caspian Tern is primarily an inland breeder in North America and is not considered in this catalogue, although there is one coastal breeding record in BC prior to 1990. An adult with flightless young was sighted on a sandy beach at Roberts Bank at the mouth of the Fraser River in 1984.[137, 199] Sightings of Caspian Terns have been increasing in the province, particularly in the Fraser River delta and south-central interior. Recently, a colony has become established on buildings in Richmond in the Fraser River delta.[51, 442] The only earlier colony in the interior was discovered in 1998 west of Prince George.[139]

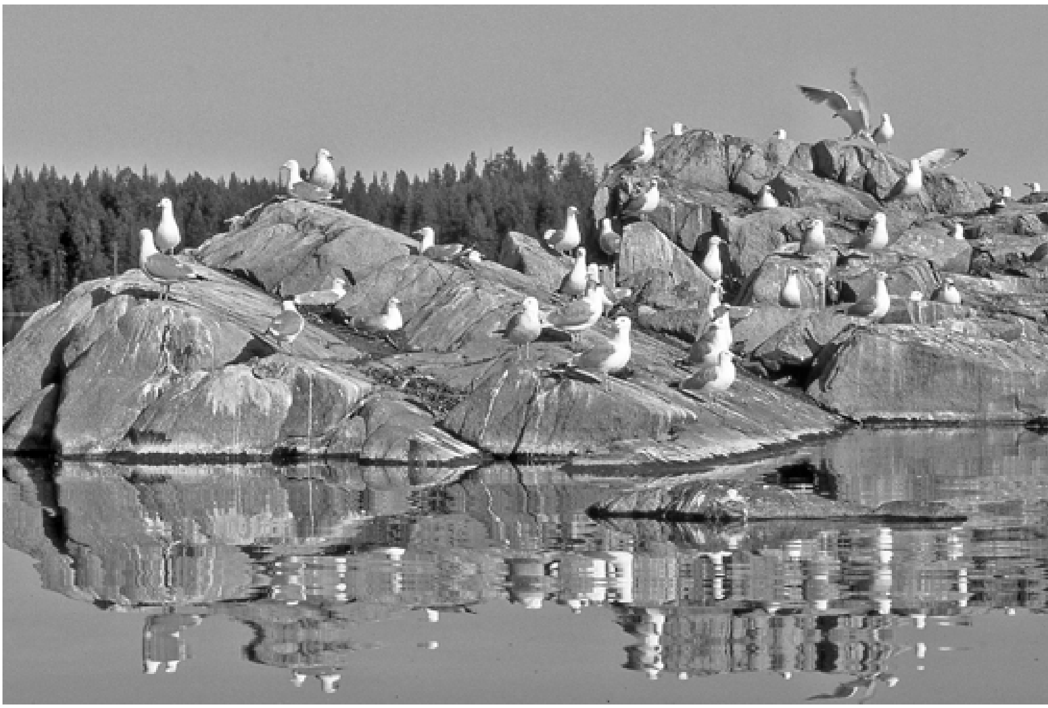


Figure 62. All Herring Gull colonies in BC are currently on islands in freshwater lakes, but this large, aggressive, and adaptable species has potential to expand its maritime breeding range into the province from colonies established in coastal southeast Alaska. *Photo by R. Wayne Campbell, Bridge Lake, BC, 2 June 1994.*

SPECIES ACCOUNTS

Fork-tailed Storm-Petrel

Oceanodroma furcata **FTSP**

(*Fork-tailed Petrel*, *Grey Storm-Petrel*, *Grey Sea Swallow*)

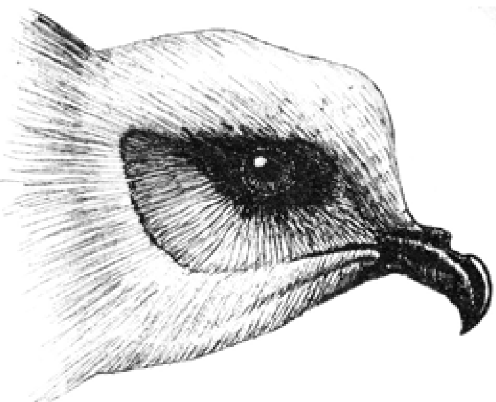


Figure 63. An estimated 380,000 Fork-tailed Storm-Petrels are known to breed at a minimum of 47 sites in British Columbia, accounting for 4-8% of the estimated world population. *Drawing by Keith Taylor.*

Part of the tube-nosed family Hydrobatidae, Fork-tailed Storm-Petrel is the only grey storm-petrel in the North Pacific. At a distance, in bright sun, its blue-grey plumage can look whitish. Like a diminutive shearwater, it contours through the waves close to the water surface with shallow wing flaps and stiff glides. It is generally seen singly or in small flocks, but larger aggregations occur, especially in foggy weather or over prey concentrations in offshore waters. For example, Paul Lehman [639] estimated a feeding flock of 10,000 Fork-tailed Storm-Petrels (and an equal number of Leach's Storm-Petrels) about 110 km northwest of Triangle Island on 5 August 2013. The species wanders widely in search of food and may be seen near shore and in bays and inlets along the outer coast of BC from March to August. In late summer, there is a small southward movement in the northern Strait of Georgia. It has also been found feeding on fish oil and scraps under artificial lights of fish-processing plants in Tofino in summer.

Tough enough to withstand the furies of the open ocean, yet on land it seems a fragile creature, fluttering like moths through the vegetation to find its burrow. Fork-tailed Storm-Petrel is disoriented by bright lights at night and will fly into ships' rigging or straight into a fire like moths into a flame.

APPEARANCE

Similar species: Leach's Storm-Petrel; possible confusion with non-breeding Phalarope spp.

Size: Smaller than an American Robin (*Turdus migratorius*); **Length:** 20-23 cm (8-9 in); **Wingspan:** 46 cm (18 in); **Mass:** 56 g (2.0 oz).

Adult
- smoky blue-grey, lighter underneath
- darker forehead
- black patch through eye
- short, black, tubenose bill

Seen in flight
- blue-grey plumage
- dark flight feathers and wing linings
- longish, forked tail
- black bill, legs, and feet

Flight
- frequently settles on water
- follows ships
- stiffer, less erratic flight than Leach's Storm-Petrel
- sometimes makes shallow dives

BREEDING

In BC, Fork-tailed Storm-Petrel (Figure 64) nests on small, forested or grassy islands usually intermixed with and outnumbered by Leach's Storm-Petrels. Though the species will nest in association with auklets or Tufted Puffin, and may even dig its tunnel off the ends of larger alcid burrows, storm-petrels tend to nest on smaller islands than burrowing alcids, often occupying outer islets, while alcids occupy larger, central islands of an island chain. Fork-tailed Storm-Petrel gives a raspy call as it is flying

Figure 64. Fork-tailed Storm-Petrel is found only in the North Pacific Ocean, from the Kurile Islands in Japan/ Russia to northern California. The incubation period is prolonged and may reach 68 days depending on food resources. *Photo by R. Wayne Campbell, Cleland Island, BC, 18 May 1970.*

over its colony at night. Calls from burrows will be answered by mates circling overhead, suggesting that calls serve in pair-bonding and perhaps to help locate nest sites. Newly mated pairs call together and preen each other in the burrow.

Seasonal and diurnal attendance at colony: Attends colony under cover of darkness and rarely seen near colonies during the day. Does not gather on the water around colonies. Along with the congeneric Leach's and Ashy (*O. homochroa*) storm-petrels, duration of nesting season is the longest of any northeastern Pacific seabird, lasting over six months from the first arrival of birds at the colony, likely in March in BC, to the departure of the last fledged chick in September.[589] In BC, first eggs are laid at the beginning of April.[136] Because the nesting season of Leach's Storm-Petrel, that typically nest on the same colonies, is delayed 53-60 days compared to Fork-tailed Storm-Petrel, the overall breeding season for storm-petrels at colonies in BC generally lasts about eight months, from March to November.[589]

Nest: The 50-150 cm-long burrow, dug in the open or in the forest under grasses, forbs, shrubs, tree roots, and fallen logs, ends in a nest chamber, sometimes lined with scattered stems of dry grass.

Eggs: Elliptical to subelliptical. Smooth, white, non-glossy; often tiny reddish specks around larger end. **Size:** 33 mm (1.3 in) x 25 mm (1.0 in). **Average clutch size (maximum clutch size):** 1(1). **Incubation period:** 37-68 days.[47] Partners alternate shifts of 1-5 days. Incubation period often prolonged by egg neglect. Egg neglect of a few days during incubation is common among species that feed far from their nests. Fork-tailed Storm-Petrels neglect their eggs for 11 days on average and up to 7 days at a time, more than in any other species studied. Embryos are able to withstand extensive periods of chilling, an advantage when parents have difficulty finding food or are delayed by storms at sea.

Young: Hatched with down feathers, eyes closed. First down blackish-brown above, grey below, with bare chin and lower face. Second down thicker and all grey, lighter on underparts (Figure 65). Brooded for 1-8 days. **Average number (maximum):** 1(1). **Fledging period:** 50-68 days. Both parents feed chicks, but weight gain can be erratic, with chicks often losing weight during storms. Chicks are heavier than parents when they fledge. Like most other tubenoses, storm-petrels concentrate an energy-rich oil from their prey that they regurgitate to feed their chicks. The caloric value of this oil may be as much 35 times higher than that of the prey, and its production may be essential to allow adults to carry sufficient energy back to their chicks from distant foraging grounds. Single food loads of fishes, crustaceans, and oil brought to chicks may weigh as much 30% of the adult weight.

Figure 65. Fledging times for Fork-tailed Storm-Petrel chicks vary with colony location, year, and a "gorge-and-fast" feeding regime that may last up to 68 days.[45] The entire breeding cycle for one pair may last an amazing 4½ months! *Photo by R. Wayne Campbell, Hippa Island, BC, 21 June 1977.*

Lifespan: Poorly known; maximum 25 years.[378]

CONSERVATION

Breeding populations in BC comprise 4-8% of the estimated world population of 5-10 million birds, centred in the Aleutian Islands, Alaska.[46] Aggregations at colonies are vulnerable to introduced predators and human disturbance. Introduced racoons and rats are the most serious threat to nesting populations in the Queen Charlotte Islands. Removal of rats from the abandoned colony on Langara Island will hopefully lead to recolonization. Like other Procellariforms, storm-petrels are prone to ingest plastic particles while foraging [40] and may regurgitate them to their chicks.[45] Although not the most frequent species caught, substantial numbers of Fork-tailed Storm-Petrels were drowned in Japanese drift nets that killed in the order of half a million seabirds a year prior to a United Nations moratorium issued in 1992.[205, 207]

Population trends to 1990 (for both storm-petrel species)

Fork-tailed Storm-Petrels breed earlier than Leach's Storm-Petrels in BC.[136, 589] On the most recent surveys, a number of colonies in the Queen Charlotte Islands were only surveyed early in the season before Leach's Storm-Petrels may have been present. Thus, the ratio of Fork-tailed to Leach's storm-petrels was not determined at those sites, which included 17 colonies on the west and east coasts of Moresby Island. To derive a total provincial population estimate for the two species, we estimated the proportions of each species at those 17 colonies, based on the ratio of the two species determined at all other colonies in the Queen Charlotte Islands that were surveyed at appropriate times to detect both species (Tables 3 and 7, pages 63 and 72). At a few small colonies, no birds were identified in burrows and which storm-petrel species were breeding was unknown (Table 7).

Table 7. Estimates of breeding populations (pairs) of Fork-tailed and Leach's storm-petrels at colonies in British Columbia as of 1990. See Key to Summary Tables on pages 53-56 for an explanation of the letter codes used to qualify population estimates.

Location	Colony Area (ha)	Burrow Density: Burrows/ha ± SE	Burrow Density: No. of Sample Plots	Burrow Density: Area Sampled (%)	Burrow Occupancy: Percent Occupancy ± SE[a]	Burrow Occupancy: Sampling Effort (%)	Total Storm-Petrels (pairs ± SE)	FTSP (pairs ± SE)	LSPE (pairs ± SE)	Survey Year	Source[b]
West Coast Graham Island											
WG-010 Langara Island								E		1981	482
WG-020 Cox Island								E	E	1981	482
WG-050 "Lepas" Islet							8,000e	3,500e	4,500e	1977	115
WG-090 "Wooded" Islet							100e	100e		1980	482
WG-120 Tian Islets								E	E	1986	470
WG-130 Solide Islands							1,600e	800e	800e	1977	115
WG-140 Queen Island								E	E	1977	650
WG-160 Ogilvie Island								E	E	1977	650
WG-170 McKenzie Island									E	1977	650
WG-190 "Kiokathli" Islets							800e	300e	500e	1977	115
WG-210 Barry Islet							700e	500e	200e	1977	115
WG-230 Hippa Island	3.8	7,521 ± 912	57	0.9	82 ± 4	0.32	23,682 ± 3,085	10,894 ± 1,419	12,788 ± 1,666	1983	482
WG-250 "Seal Point" Islet							3,000e	1,500e	1,500e	1977	115
West Coast Moresby Island											
WM-010 "Buck Channel" I.							250e	S	250e	1977	115, 650
WM-030 Helgesen Island	0.7	310 ± 200	7	1.0	M		184 ± 119	184 ± 119		1986	481
WM-040 Willie Island								E	E	1986	481
WM-050 Carswell Island	0.7				M		270eS			1986	481
WM-070 Instructor Island	2.3	770 ± 350	23	0.9	M		1,603 ± 728	x		1986	481
WM-080 Lihou Island	16.0	938 ± 183	42	0.9	M		13,660 ± 2,666	x	x	1986	481
WM-100 Luxmoore Island	3.7	1,708 ± 519	24	0.6	M		5,683 ± 1,727	x	x	1986	481
WM-110 Rogers Island	6.6	4,804 ± 834	25	0.3	M		28,743 ± 4,990	S	x	1986	481
WM-210 "East Nangwai" Grp.							2	2		1977	650
WM-280 Anthony Island	6.2	1,894 ± 245	33	0.5	M		10,683 ± 1,385	2,096 ± 272	8,587 ± 1,113	1985	481
East Coast Moresby Island											
EM-040 Rainy Islands							100eS	S		1986	480
EM-070 Charles Island				80			100e	100e		1986	480
EM-100 Langtry Island	1.3	10,413 ± 3,464	8	0.6	M		12,319 ± 4,098	x	x	1985	480
EM-120 Rankine Is. - West	3.9	666 ± 200	9	0.6	M		2,363 ± 710	332 ± 100	2,031 ± 610	1984	480
- East	2.3	5,730 ± 1,380	12	0.5	M	0.19	11,993 ± 2,888	1,687 ± 406	10,306 ± 2,482	1985	480
EM-220 Bolkus Islands				40	M		230eS	S		1985	480
EM-260 Rock Islet - Main[c]	1.5	5,386 ± 1,273	7	0.4	M	0.16	7,414 ± 1,753	1,922 ± 454	5,492 ± 1,299	1985	480
- Others[c]	1.3	8,096[c]	6	3.0	M		9,585	2,485	7,100	1985	480
EM-270 Skincuttle Island	4.8	975 ± 429	9	0.9	M	0.19	4,259 ± 1,874	x	x	1985	480
EM-280 George Island							E	0	E	1985	480
EM-300 East Copper Island				10			40eS	20eS	20eS	1985	480
EM-310 Howay Island				40			10eS	10eS		1985	480
EM-360 Sels Islet								0		1986	480
EM-400 Alder Island	0.4	140	3	31	M		60S			1985	480
EM-420 Arichika Island								0	0	1985	480
EM-450 Hoskins Islets								E		1986	480
EM-490 Bischof Islands				4			50eS			1985	480
EM-500 Hotspring Island							900e	x	S	1986	480
EM-540 Agglomerate Island	9.5	640 ± 140	20	0.5	M	0.03	5,533 ± 1,210	x	S	1985	480
EM-550 Kawas Islands				20	M		700e	x		1985	480

Table 7. cont'd

			Burrow Density			Burrow Occupancy						
	Location	Colony Area (ha)	Burrows/ha ± SE	No. of Sample Plots	Area Sampled (%)	Percent Occupancy ± SE[a]	Sampling Effort (%)	Total Storm-Petrels (pairs ± SE)	FTSP (pairs ± SE)	LSPE (pairs ± SE)	Survey Year	Source[b]
EM-560	Tar Islands				26	M		330e	x	x	1985	480
EM-650	Lost Islands				100	M		80	80	x	1983	480
EM-690	Reef Island				27	M		140e	x		1983	480
EM-730	Low Island				100	M		160	x		1983	480
EM-740	Skedans Islands				45	95	1.71	1,100e	1,100e		1983	480
EM-780	Kingui Island								0		1977	650
Northern Mainland Coast												
MC-240	Dupont Island					24		100eS	50eS	50eS	1988	476
MC-270	Wells Rocks								0		1988	476
MC-290	Moore Islands	3.8	4,250 ± 1,018	30	0.3	M	0.17	14,813 ± 3,548	8,862 ± 2,123	5,951 ± 1,425	1988	476
MC-300	McKenney Islands	1.9	2,500 ± 490	13	0.3	M	0.25	4,442 ± 833	1,525 ± 286	2,917 ± 547	1988	476
MC-310	Whitmore Islands[d]	0.2				M		576 ± 139	342 ± 83	234 ± 56	1988	476
MC-340	Byers Islands								E	E	1988	476
MC-350	Sinnett Islets	2.5	13,571 ± 1,879	21	0.3	M	0.16	30,380 ± 4,206	19,158 ± 2,652	11,222 ± 1,554	1988	476
MC-360	Conroy Island							75e		75e	1988	476
MC-370	Harvey Islands				10			200eS	100eS	100eS	1988	476
MC-420	Fingal Island								E		1988	476
Queen Charlotte Strait												
QS-030	Storm Islands	10.3	26,000 ± 2,510	68	0.1	90 ± 3	0.02	242,070 ± 24,653	50,835 ± 5,177	191,235 ± 19,476	1987	477
QS-050	Reid Islets	0.3	38,600 ± 6,500	7	0.9	91	0.09	11,503 ± 1,937		11,503 ± 1,937	1987	477
QS-100	Tree Islets	2.5	24,600 ± 2,500	17	0.3	90 ± 5	0.06	55,319 ± 6,458	8,298 ± 969	47,021 ± 5,489	1986	477
QS-110	Pine Island				11			100eS		100eS	1985	477
QS-120	Buckle Grp. -Bright I.	0.8	19,900 ± 4,100	10	0.5	95 ± 6	0.12	15,691 ± 3,355	941 ± 201	14,750 ± 3,154	1987	477
	- Herbert I.	0.5	25,700 ± 4,200	7	0.5	92 ± 7	0.09	12,030 ± 2,188		12,030 ± 2,188	1987	477
Scott Islands												
SC-010	Triangle Island							300e	100e	200e	1989	484
SC-030	Beresford Island	1.7	11,000 ± 1,857	50	0.3	81 ± 7	0.11	15,478 ± 2,950	2,941 ± 560	12,537 ± 2,390	1987	484
West Coast Vancouver Island												
WV-010	Gillam Islands	2.9	40,476 ± 6,917	21	0.1	98 ± 2	0.04	114,778 ± 19,793	42,468 ± 7,323	72,310 ± 12,470	1988	475
WV-080	Solander Island	3.4	20,970 ± 1,718	67	0.8	97 ± 2	0.11	69,767 ± 5,858	0	69,767 ± 5,858	1989	475
WV-150	Thomas Island	0.8	10,833 ± 3,118	9	0.5	85 ± 3	0.30	7,269 ± 2,107	0	7,269 ± 2,107	1988	475
WV-210	Moos Islet									E	1988	475
WV-220	Thornton Islands	0.3	3,000 ± 1,800	5	0.8	M		712 ± 427	S	712 ± 427	1988	475
WV-270	Volcanic Islets				22			50e		50e	1988	475
WV-300	Grassy Island									0	1988	475
WV-410	Cleland Island	1.6	4,765 ± 2,338	17	0.9	83 ± 18	0.16	6,351 ± 3,326	699 ± 366	5,652 ± 2,960	1988	475
WV-850	Seabird Rocks				28	100	0.01	1,033e	318e	715e	1988	170

[a] M indicates that a median occupancy rate (91%) for BC colonies was used.[480]

[b] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.

[c] On Rock Islets, density on the main islet was sampled with quadrats but on the other islets, six strip transects were used and no standard error was calculated. Species totals have been recalculated from those given in Rodway et al.[480]

[d] The two small islets off Whitmore Islands where storm-petrels were nesting were included with the Moore Islands chain for sampling purposes.[476]

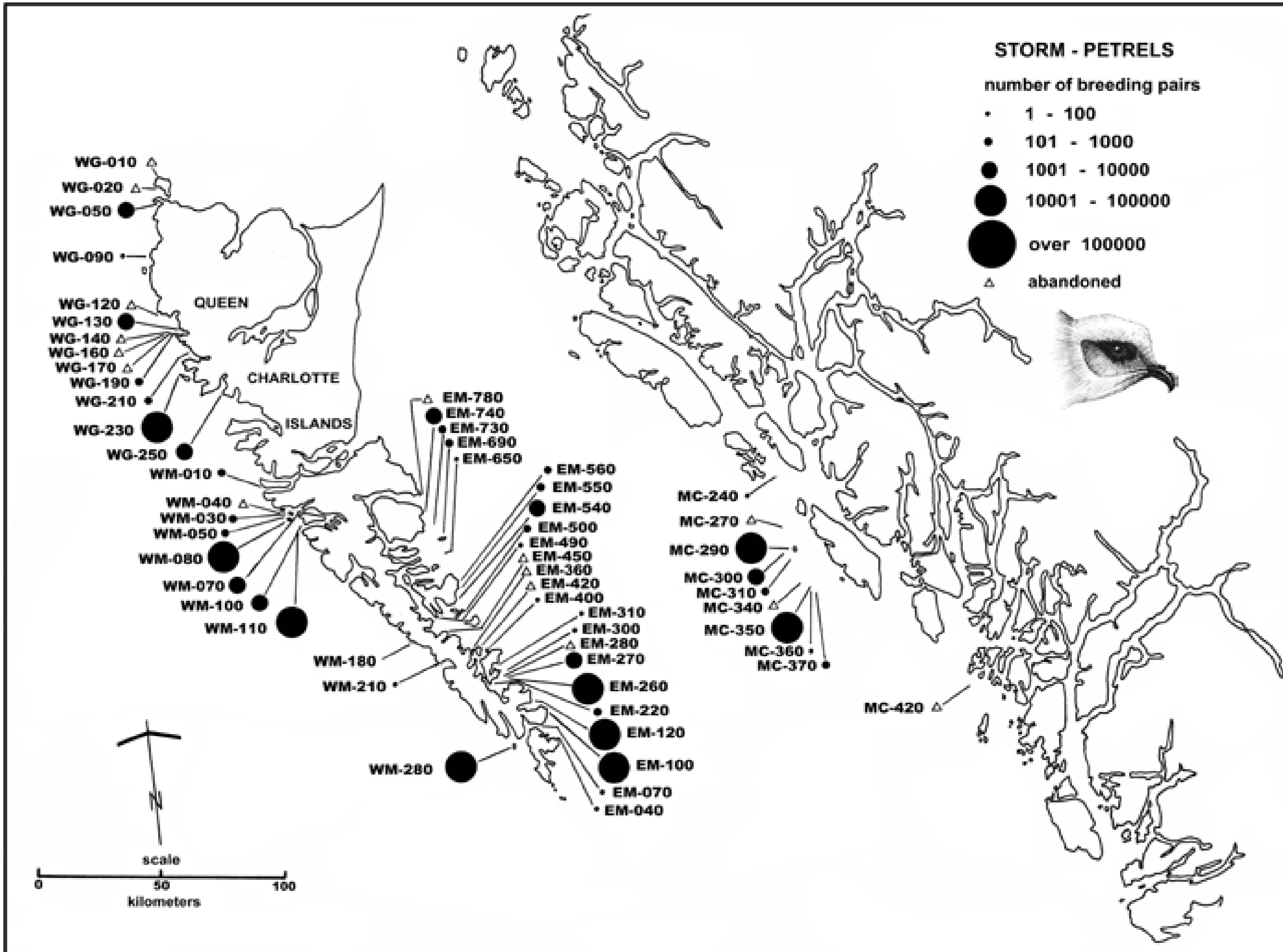


Figure 66. Combined Fork-tailed and Leach's storm-petrel colonies in northern British Columbia. Site codes refer to colonies listed on Table 7.

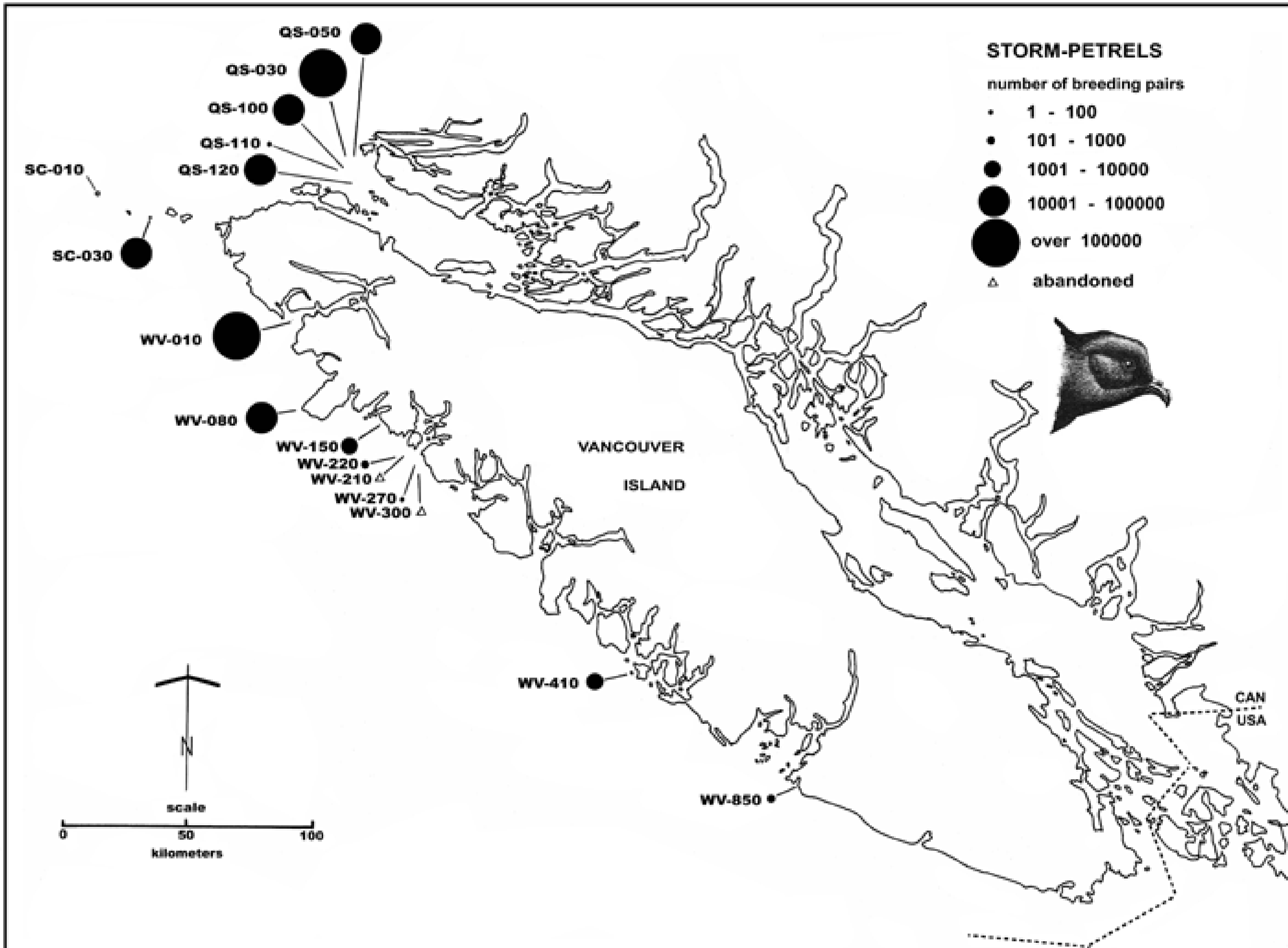


Figure 67. Combined Fork-tailed and Leach's storm-petrel colonies in southern British Columbia. Site codes refer to colonies listed on Table 7.

Estimates as of 1990 indicate that over 1.5 million storm-petrels breed at 56 sites in British Columbia (Figure 66 and 67; Tables 3 and 5, pages 63 and 65). Most colonies support both Fork-tailed and Leach's storm-petrels, though Leach's outnumber Fork-tailed at the majority of sites (Table 7, pages 72-73). An estimated 380,000 Fork-tailed and over 1.1 million Leach's storm-petrels are known to breed at a minimum of 47 and 41 sites, respectively. Populations are concentrated in a cluster of seven colonies around the north end of Vancouver Island, which accomodate 56% and 76% of the provincial total for Fork-tailed and Leach's storm-petrels, respectively (Figures 66 and 67; Table 7). Two of those colonies, the Storm Islands in Queen Charlotte Strait and Gillam Islands on the west coast of Vancouver Island, together support almost 50% of the total provincial population of both species. Skedans Islands, in the Queen Charlotte Islands, is one of the few colonies that we were quite sure supported only Fork-tailed Storm-Petrels. On the survey there in 1983, occupancy rate was 95% and only Fork-tailed Storm-Petrels were found in burrows. Conversely, colonies on Reid Islets in Queen Charlotte Strait and on Solander and Thomas islands on the west coast of Vancouver Island appeared to be exclusively occupied by Leach's Storm-Petrels.

Storm-Petrels have abandoned or been extirpated from 10 previously confirmed colonies in the province, seven of them in the Queen Charlotte Islands (Table 6, pages 66-67). Three colonies on the west coast of Graham Island were ravaged by American Black Bears (*Ursus americanus*) in 1947 and apparently never recovered.[213] Colonies on Langara Island and Cox Island disappeared by the early 1970s, likely because of introduced rats.[115, 511, 650] On the northern mainland coast, the small colony on Fingal Island disappeared since Guiguet [291] visited the area in 1948. Heavy use by Northern River Otters was noted there in 1988.[476] Intensive river otter predation may have contributed to the abandonment of the colony on Moos Islet on the west coast of Vancouver Island between 1982 and 1988.[475] The effect those abandonments have had on total breeding populations is unknown.

Populations since 1990

We know of few changes to population estimates for storm-petrels since 1990. In the Queen Charlotte Islands, Gaston and Masselink [266] resurveyed Lihou Island in Englefield Bay in 1993 and found similar numbers nesting as in 1986.[481] They also found that Fork-tailed Storm-Petrels were still nesting on Instructor Island in the face of invasive Northern Raccoons that had likely eliminated nesting populations of Ancient Murrelets and Rhinoceros Auklets. Harfenist [298] suspected a few storm-petrels were nesting on the north end of the Gordon Islands, which would be a new site for storm-petrels. She re-counted burrows on Charles Island in 1993, finding numbers similar to those estimated in 1986. Nesting was also reported on Frederick Island [299] where we had heard birds in 1977, 1980, and 1981 but never found burrows. Lemon [371] confirmed about 400 pairs of Leach's Storm-Petrels nesting again on George Island in 1996 that we thought were extirpated in 1985. As in 1977, small numbers of Fork-tailed Storm-Petrels were suspected nesting as well. Laskeek Bay Conservation Society documented Fork-tailed Storm-Petrels calling on East Limestone Island each year since 1990,[254] heard them calling from burrows in 1994,[268] and found one incubating in 1999 [283] and in 2004,[178] thus confirming a new nesting site for this species. Unfortunately, neither nest was successful. The small colony on Seabird Rocks on the west coast of Vancouver Island may have been nearly extirpated by river otters between 2002 and 2011.[170]

Leach's Storm-Petrel

Oceanodroma leucorhoa **LSPE**

(*Mother Carey's Chickens*, *Wave Runner*, *Beal's Petrel*)

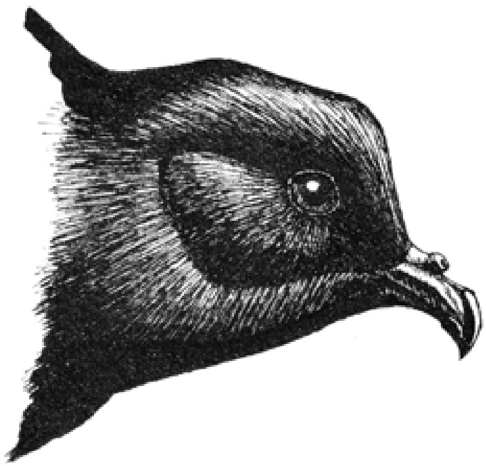


Figure 68. Leach's Storm-Petrel is a member of the four tube-nosed families that include albatrosses, petrels, shearwaters, and storm-petrels, and is the most widespread breeding species of that group in the North Pacific and North Atlantic Oceans. *Drawing by Keith Taylor.*

These birds fly so low over the water in a storm, sometimes pushing off a wave with their feet, that they seem to walk on the water, gaining them the name "storm-petrel" after Saint Peter who tried to walk upon the sea. Their agility in manoeuvring through waves likely also accounts for the common name "wave runner". "Mother Carey's Chickens" was derived from the incantation of "Mater Cara" or "Dear Mother" as a call by sailors for divine help during storms. It was bad luck to kill a storm-petrel.

Leach's Storm-Petrels forage in pelagic waters and travel to and from their breeding colonies under the cover of darkness. Foraging adults are dispersed at sea and may travel hundreds of kilometres from their nest site, feeding on the wing on plankton and nekton such as small myctophid fishes, amphipods, and euphausiids plucked from the water's surface.

Navigating Across the Open Ocean

A Leach's Storm-Petrel leaves its nesting burrow and flies hundreds of kilometres away searching the open ocean for food. How it navigates over long distances without mountains and coastlines to guide it on its return home has long been a mystery. In the 1930s, David Lack and Ronald Lockley [361, 376] *carried out some long-range homing experiments. They flew two Manx Shearwaters* (Puffinus puffinus) *by airplane from a nesting colony on Skokholm on the west coast of Wales and released them in Venice, Italy, in the Adriatic Sea. This species never visits the Mediterranean region and normally migrates over water. When released, the birds first headed south, but one then veered west in the direction of the Italian Alps, and one was back in its burrow in 341 hrs 10 minutes (14 days 40 minutes)! The island of Skokholm is at least 1,479 km (920 mi) northwest of Venice if the bird flew directly overland and over the mountains. If it went by sea, which seemed more likely, it would have travelled almost 6,000 km (3,700 miles). Another Manx Shearwater was released in Boston Harbour after a two-day trip from Skokholm. Twelve days, 12 hours, and 31 minutes later, the bird was back in its burrow having travelled traveled 5,149 km (3,200 mi) across the Atlantic Ocean averaging 402 km (250 mi) per day. In another study, breeding adult Leach's Storm-Petrels* (Figure 69) *experimentally displaced from their normal range found their way back to their burrows from as far away as 4,800 km, travelling up to 500 km per day.*[450] *These and subsequent studies implied that such birds must be able to determine their location, and the direction from that location back to their breeding colony. In other words, they must have a "map" and a "compass".*

Later, ornithologists studying migration found that birds use a "sun-compass" during the day and a "star compass" at night but that they can also navigate in complete darkness.[38, 402] *Initially proposed in the mid-1800s, the idea that birds might possess a magnetic sense was dismissed as unlikely until the middle of the 20th century when experiments showed that European Robins* (Erithacus rubecula) *will reverse their migration direction if the magnetic field is reversed. Since then, microscopic crystals of magnetite have been reported around the eye and* *inside nerve endings in the nasal cavity of the upper beak of pigeons. These crystals may allow the bird to sense the intensity and direction of the magnetic field and provide the map that helps them determine their location.*[626]

The discovery of a second, chemical mechanism that birds use to orient in a magnetic field was even more startling. It was known that pigeons home better when they can see out of their right eye than out of the left and it was suggested that perhaps they had a magnetic sense linked to the right eye. In the 1970s it was discovered that certain chemical reactions respond to magnetic fields in the presence of light. Further studies showed that birds use this mechanism but that it only operates in the right eye! The two mechanisms together help provide the map and compass needed to navigate long distances.

In addition, sense of smell has recently been shown to be more important than the magnetic senses for navigation by pigeons and petrel species.[456] *Evidence suggests that petrels can use scent trails detectable over great distances to find foraging areas and to locate their breeding colony, similar to the way salmon use chemical trails in the water to find their way back to their natal streams.*

Figure 69. Homing experiments with Leach's Storm-Petrels involved banded birds that could be identified individually. *Photo by R. Wayne Campbell, Cleland Island, BC, August 1988.*

APPEARANCE

Similar Species: In BC, only Fork-tailed Storm-Petrel.

Size: Smaller than an American Robin; **Length:** 19-22 cm (7.5-8.5 in); **Wingspan:** 45-48 cm (18-19 in); **Mass:** 38-54 g (1.3-1.9 oz).

Adult
- brownish-black; crown, flight feathers, and tail slightly darker
- white rump not visible when sitting
- short, slender, hooked, black bill

Seen in flight
- white rump, often with central dark line
- long, pointed wings with obvious angle at carpal and pale diagonal bands
- legs do not project beyond forked tail

Flight
- buoyant and graceful
- alternates deep, tern-like wing flaps with short glides on bowed wings
- abrupt changes in speed and direction

BREEDING

Leach's Storm-Petrel (Figure 70) nests on small, offshore forested or grassy islands in colonies ranging from <100 to 191,000 breeding pairs in BC, and to several million pairs elsewhere. Both sexes call when flying over the colony, especially on foggy, cloudy, or moonless nights, creating a riot of sound on larger colonies. Young birds engage in communal, aerial courtship at colonies when 3-4 years old, and first breed at 3-6 yrs. Partners reunite at the nest site, and court in the burrow or on the surface under vegetation. Purr calls are mostly used during courtship but can be heard throughout the nesting season. Paired birds breed together for 1-16 yrs.

Seasonal and diurnal attendance at colony: Leach's Storm-Petrel, like its congener, is strictly nocturnal when nesting to avoid avian predators and only rarely is seen in inshore waters during the day, then usually only when disoriented in heavy fog. Does not gather on the water around colonies. The species nests

Figure 70. Leach's Storm-Petrels may first breed as 3-year-olds but most commonly when 5-6 years-old. Immatures regularly visit the colony during the breeding season. *Photo by R. Wayne Campbell, Cleland Island, BC, August, 1971.*

later than Fork-tailed Storm-Petrel. Nesting season in BC lasts over six months from the first arrival of birds at the colony, likely in April or May, to the departure of the last fledged chick at the beginning of November.[136,589] The breeding cycle of one pair can last nearly four months. In BC, first eggs are laid in mid-May.

Purring Petrels

Walking under a Sitka spruce forest in the midnight darkness we were entranced by a melodic purring emanating from the ground under our feet – not one singer, but two – a duet, rising in pitch and punctuated with single, longer notes to begin the refrain again. Wood nymphs? A pair of enamoured felines? This was the love song of Leach's Storm-Petrels, mates nestled together in their burrow in the forest floor. Hearing it is one of the most magical experiences on a seabird colony in BC, and perhaps anywhere else.

Nest: Chamber is lined with a variety of twigs, cones, leaves, or short, dry grass stems at the end of a 30-115 cm burrow that is excavated mainly by the male and located under tree roots, logs, grass tussocks, and into open ground. Nests may be reused year-to year, especially if owners breed successfully.

Eggs: Subelliptical to oval. Smooth, white, non-glossy; sometimes with purplish stippling around larger end. **Size:** 33 mm (1.3 in) x 24 mm (0.9 in). **Average clutch size (maximum clutch size):** 1(1). **Incubation period:** 37-50 days. Sexes alternate 2-6 day shifts. Egg neglect for several days is common. Egg may be replaced if lost within a week after laying.

Young: Hatched with down feathers, eyes closed for 5-14 days. First down long, bluish-grey, replaced with blackish, second down. Bill grey; legs and feet grey to flesh-coloured. Brooded by one parent for 2-12 days. **Average number (maximum):** 1(1). **Fledging period:** 56-79 days. Chicks are fed 65% of nights by 1 or 2 parents, generally reaching a mass 50% larger than the parents. They lose most of this extra fat before fledging.

Lifespan: Poorly known, perhaps 15-20 years if surviving to breeding age; highest mortality just after fledging; maximum >36 years.[339]

CONSERVATION

About 6-7% of an estimated world population of 17 million breeding Leach's Storm-Petrels [339] nest in BC. Nesting concentrations are highly vulnerable to habitat degradation or introduced mammalian predators. Colonies reached by introduced rats and Northern Racoons in the Queen Charlotte Islands have been abandoned. Control of those predators is essential for the continued existence of nesting colonies in that area. Storm-petrel burrows are fragile and easily destroyed by people or other large mammals walking over nesting habitat. Investigator disturbance is also a concern. Eggs were abandoned in half the burrows investigated by Wilbur.[622] Dispersed, offshore foraging habits make storm-petrels less vulnerable to contamination from oil spills than other seabird species that dive or concentrate on the water around their colonies. Leach's Storm-Petrels also ingest plastic particles and have been found in other areas with large volumes of plastic in their gizzards.[248]

Population trends: See Fork-tailed Storm-Petrel above. Colony locations are shown in Figures 66 and 67 (pages 74 and 75) and nesting populations in Table 7 (pages 72-73).

Finding Your Way Home in the Dark

Birds generally have good vision and, relative to their body size, their eyes on average are almost twice as large as those of most mammals.[38] Their eyes look small because except for the pupil they are covered with skin and feathers. Most birds probably have better colour vision than we do. Many and perhaps most species can detect UV light in addition to the red, green and blue light that we can detect. With their UV sensitivity, birds pick up clues in their environment that are invisible to us. Thus seabirds like cormorants, gulls, and Pigeon Guillemots that are navigating during daylight and that stay within sight of land likely can use vision to find their nests. But how does a storm-petrel or an Ancient Murrelet find its particular burrow at night among hundreds, or thousands, of other similar-looking burrows - especially when that burrow is located in a dark forest that sometimes even owls with their night-adapted vision would have trouble seeing in?

We readily detect the pleasant, musty odor of storm-petrels when we are close to their nest sites and recent research has convincingly demonstrated that Blue Petrels (Halobaena caerulea), *a subantarctic nesting species, use odour clues to find their particular burrow at night.[48] Petrels approach islands from downwind, using their keen sense of smell to locate their burrow. Hearing also may be important for some species. Seabirds can recognize their mates or their parents or offspring by their calls and can distinguish their unique voices from a cacophony of other calls around the colony. Storm-petrels calling from their burrows may help the partner return to the burrow after a long-distance foraging trip. Ancient Murrelets, Cassin's Auklets, and Rhinoceros Auklets call during the night, but their collective choruses often develop after many birds have returned and it is not clear whether they could be using vocal cues to find their burrows. Also, it is not known whether these species use their sense of smell to find their way home.*

Most likely birds use and integrate information from all their senses, with different senses being more important at different times. Multiple senses also allow individuals to compensate if one sense is compromised. Thus, when in sight of land, petrels can find their nests sites using visual cues if olfactory senses are blocked. Though much has been learned, many mysteries remain and more amazing details of how seabirds find their way across ocean expanses and back to their nest sites are yet to be discovered.

Double-crested Cormorant

Phalacrocorax auritus **DCCO**

(*White-crested Cormorant*, *Cormorant*, *Crow Duck*, Hypoleucos auritus)

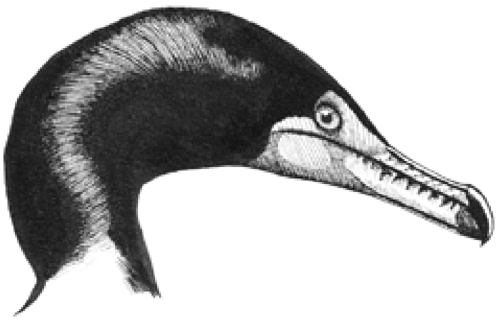


Figure 71. In BC, Double-crested Cormorant breeds on the inner south coast and inland at Creston in the West Kootenay and Stum Lake in the Chilcotin. *Drawing by Keith Taylor.*

Our cormorants are poorly named. Pelagic Cormorants do not go far to sea, but they do have "double crests". Double-crested Cormorants have no "crests" but rather "tufts" like a Tufted Puffin, and should be called "Tufted" Cormorants. Or perhaps because Double-crested is our only cormorant that breeds on inland waters, they should be called "Freshwater" Cormorants. Double-crested Cormorant is the only cormorant species in BC that flies over land, and can be seen overhead flying in V formation like geese. Superb fishers in both marine and freshwater, in the Strait of Georgia they dive for mostly non-commercial species like gunnels (Pholidae), perch (Embiotocidae), prickleback (Stichaeidae), Pacific Sand Lance (*Ammodytes hexapterus*), and sculpins (Cottidae). Birds sometimes form large co-ordinated lines to herd schooling prey into confined bays. They are conspicuous when perched on a piling or breakwater with their wings stretched out to dry (Figure 72). They often roost with Brandt's and Pelagic cormorants that look similar from a distance. Fossil records indicate that Double-crested Cormorants have inhabited the Strait of Georgia for at least 5,000 years.[332]

Figure 72. The plumage of Double-crested Cormorant is not water-repellent and the species has less preen oil than most other birds; hence, it must spread its wings to dry after wetting. *Photo by Alan D. Wilson.*

APPEARANCE

Similar species: Brandt's Cormorant and Pelagic cormorant, especially immatures.

Size: Goose-sized; **Length:** 74-91 cm (29-36 in); **Wingspan:** 122-137 cm (48-54 in); **Mass:** 1.8-3.0 kg (4.0-6.6 lbs).

Adult breeding
- black body, glossy head
- bronze-black scales on back
- orange throat pouch
- whitish tufts rarely visible

Immature
- dark brown above
- whitish neck and breast
- orange throat pouch
- long, yellowish, hooked bill

In flight
- thick, crooked neck
- head level above body
- large head and bill
- long tail

BREEDING

On the coast, nests on the ground on small islets with little or no vegetation, in trees on small rocky islets (Figure 73) or larger forested islands, and on offshore pilings, towers, or beacons. Colony size has ranged from 1 to almost 1,500 pairs in BC, and, historically, to perhaps 350,000 pairs in Baja California.[175] Double-crested and Pelagic Cormorants frequently nest together, with pelagics on steeper, peripheral areas and double-crested on more level and gently-sloping bluffs or central sites. Males return first to the colony, claim a nest site, and then advertise for a female. Pair bonds are evident only at the nest, and mates are apparently monogamous within a nesting season.

Seasonal and diurnal attendance at colony: Active at colony during the day; inactive at night.[310] Birds are often on the water around colonies but not highly aggregated except if birds are flushed from nests or roosts by natural or human disturbance. In BC, birds return to colonies in March or April to claim nest sites and build or refurbish nests, and are present through September. Eggs have been recorded from 20 April to 2 September, although late-hatched chicks may not survive.[136]

Nest: Constructed of sticks and seaweeds lined with grasses, rootlets, feathers, parts of dead birds, and a variety of marine debris. Ground nests that persist from year to year can become large, guano-covered stick pillars over a metre high.

Eggs: Long subelliptical. Pale blue, unmarked, uneven outer chalky layer; becoming stained in nest. Laid 1-2 days apart. **Size:** 61 (2.4 in) x 39 mm (1.5 in). **Average clutch size (maximum clutch size):** 2-4(11). **Incubation period:** 27-28 days, by both sexes; 1-3-hour shifts, female more during first half of period.

Figure 73. This tree-nesting colony of Double-crested Cormorants on the coast was abandoned when people took attractive pieces of stunted junipers as house ornaments. *Photo by R. Wayne Campbell, Ballingal Islets, BC, 8 June 1976.*

Distinguishing features of the heads of cormorant species breeding in British Columbia.
From top to bottom: Brandt’s, Pelagic, and Double-crested cormorant. *Painting by Keith Taylor.*

Pelagic Cormorants are not pelagic and instead depend on healthy nearshore waters for feeding. Propelled by big, webbed feet and using wings for steering, they dive among kelp beds to catch small fishes. [Painting "Pelagic Cormorants - Diving for Gobies" *courtesy Mark Hobson, Coastline Art Inc.*]

Young: Hatched naked, feeble, eyes closed for 3-4 days. Skin brownish turning blackish purple, covered with black, woolly down by 14 days (Figure 74). Brooded for 14-15 days. Both parents feed chicks, 4-10 feeds per day, and bring water on hot days. **Average number (maximum):** 2-3(8). **Fledging period:** 35-42 days. At 3-4 weeks, young from ground nests form creches and move freely around the colony. By 7 weeks they accompany parents on feeding trips, and become independent at 10 weeks.

Figure 74. Double-crested Cormorant nestlings are covered with black, woolly down when about two weeks old. *Photo by R. Wayne Campbell, Christie Islet, BC, 2 August 1973.*

Lifespan: About 50% of fledglings survive their first year. Average life expectancy for adults is 6.1 years; maximum 22 years 6 months.[310, 378]

CONSERVATION

Numbers of Double-crested Cormorants in North America have fluctuated dramatically over the last century in response to changes in persecution, pesticide use, and prey availability. BC colonies presently support less than 1% of the estimated North American population of over 360,000 breeding pairs, although culling operations in response to perceived or real conflicts with humans may be reducing populations in some areas.[310] Otherwise, oil spills, fishing gear, and pollutants are main threats to adults and immatures. Disturbance is the most serious threat to nesting cormorants in BC. In the Strait of Georgia, disturbance from increasing human and Bald Eagle activity flushes adults and leaves eggs and young vulnerable to predation and hyperthermia. Small chicks may die in less than 10 minutes if left exposed to the sun (Figure 75).

Figure 75. After being flushed from its perch by humans, an adult Bald Eagle created havoc for nesting Double-crested Cormorants at Rose Islets, BC. The inflated neck on this nestling resulted from short exposure to the sun after the brooding adult was flushed off. *Photo by R. Wayne Campbell, 13 July 1974.* BC Photo 4140.[132]

The Double-crested Cormorant was considered "Threatened" and placed on the BC Conservation Data Centre's Red List in 2001.[401] Last reviewed in 2013, that status has been revised to Blue or "Species of Special Concern".[55]

Olfactory Shock – Gasp!

Though BC has no immense concentrations of surface-nesting seabirds to rival the guano birds of South America, the olfactory experience of approaching downwind of a Double-crested Cormorant colony is still a shock. Nests built on the ground or in trees become so covered with feces that trees often die, entombed in a bone-white coat of guano. Add the odour of rotting fish dropped by parents that have been harassed by gulls and crows while trying to feed young, an impenetrable swarm of buzzing black flies, and fresh gooey guano that seems to be everywhere you try to step - you get an idea of what you are *missing if you have never had the privilege of visiting a Double-crested Cormorant colony, especially near the end of the nesting season. It is a gagging experience!* (Figure 76)

Figure 76. All cormorant colonies, including this small Pelagic Cormorant site on Lewis Reef in Oak Bay, BC, reek of guano and dead fishes. Sean Campbell (left) and his sister Tessa, had to hold their noses during the survey. *Photo by R. Wayne Campbell, 12 July 1981.*

Population trends to 1990

Nesting by Double-crested Cormorants in BC is confined to the sheltered waters of the Strait of Georgia, Haro Strait, and Strait of Juan de Fuca. Populations dramatically increased since they began breeding, likely around 1920 on Ballingal Islets.[175, 213, 406] They were first confirmed nesting in the province in 1927 on Mandarte Island.[405] Darcus [201] reported one pair of Double-crested Cormorants nesting amongst a large colony of at least 500 pairs of Pelagic Cormorants on Langara Island at the northwest tip of the Queen Charlotte Islands in 1927, but the record was not confirmed and was not accepted by Drent and Guiguet.[213]

Colonization of the Strait of Georgia was likely part of a general expansion into inner waters from colonies on Washington's outer coast.[213] Populations responded to the gradual cessation of "egging", which reached such alarming proportions at the beginning of the 19th century that wardens were posted to protect major colonies. Climate amelioration and associated changes in food supply were also considered factors that may have contributed to population increases.[213, 584] Five colonies had been established by 1960, although the Christie Islet site with one confirmed nest in 1941 was no longer active in the late 1950s.[213] A single nest was found on that colony again in 1963, but it was not until the 1970s that greater numbers began to nest there. Six established colonies were abandoned by the late 1970s and have not been used since (Table 8, page 88), whereas five new colonies were founded during the 1980s.[175, 596] Such changes in colony use over short periods of time emphasize the need for complete surveys of all known nesting locations as well as exploration of other areas for potential new colonies to obtain accurate estimates of total breeding populations.

Numbers may have peaked around 1987/88 when a total of 2,032 pairs were nesting at 15 sites.[473, 596] Although 6 of 8 colonies surveyed in 1989 [533] and 1990 [54] increased since 1987, declines at the largest colony on Mandarte Island as well as at Sand Heads resulted in a lower total population estimate of 1,729 pairs nesting at 14 sites as of 1990 (Figure 77, Tables 3, 5, and 8, pages 63, 65, and 88). The colony on Mandarte Island reached a maximum of 1,463 nests in 1981.[650] Disturbance from log-booming activities may have contributed to the decline of the Bare Point colony from 198 nests in 1983 [584] to 25 nests in 1988 [632] and 18 nests in 1990.[54] Disturbance from pleasure boaters, which Drent and Guiguet issued an urgent plea against in 1961, was considered the cause of the decline in the Rose Islets colony from 111 pairs in 1977 to two pairs in 1987.[474, 584, 596]

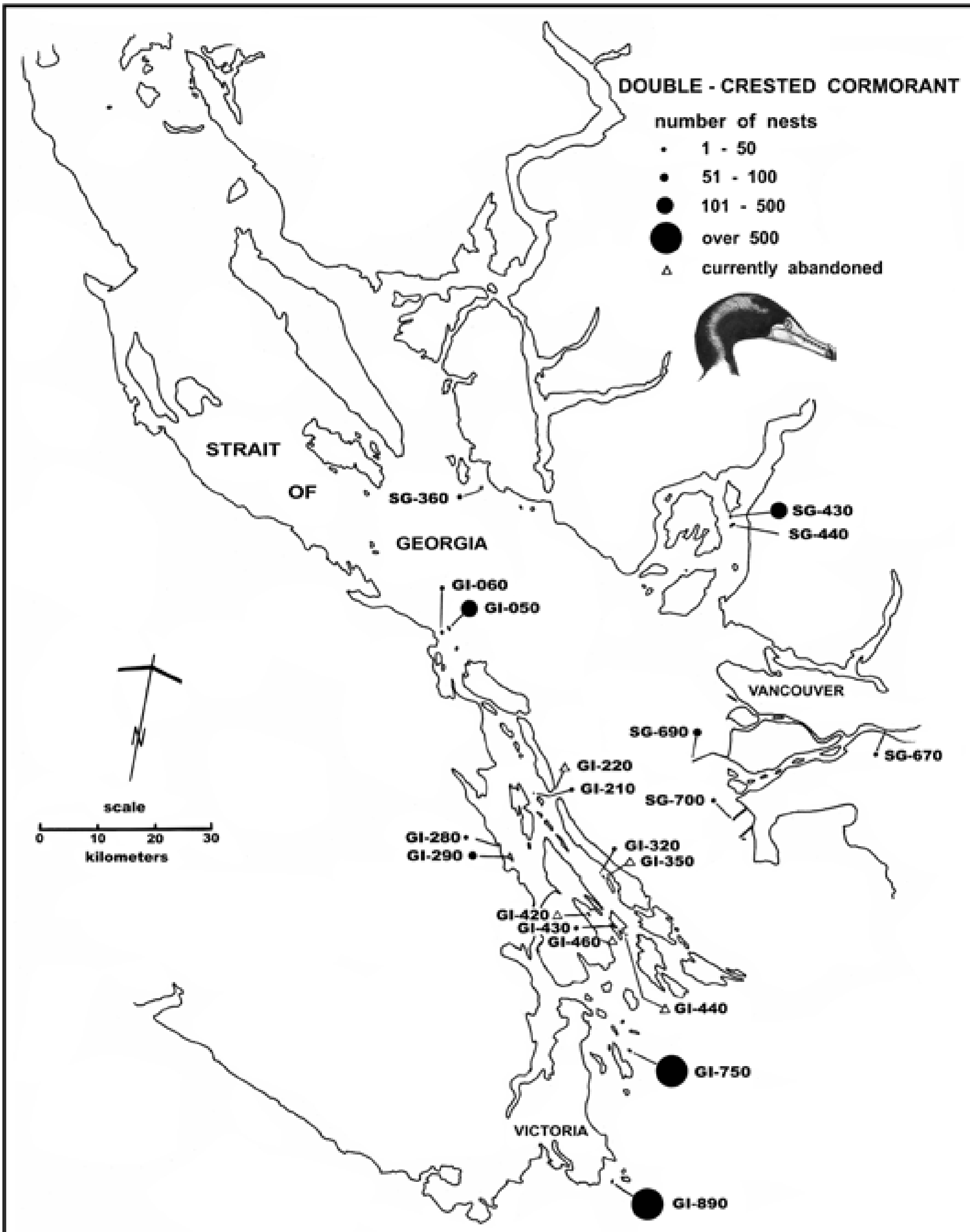


Figure 77. Double-crested Cormorant colonies in British Columbia. Site codes refer to colonies listed on Table 8.

Table 8. Estimates of breeding populations (numbers of nests counted) of Double-crested Cormorants at colonies in British Columbia as of 1990.

Location		Nests	Survey Year	Source [a]
Northern Strait of Georgia				
SG-360	Franklin Island	5	1987	596
SG-430	Christie Islet	145	1989	533
SG-440	Pam Rock	0	1989	648
SG-670	Queen's Reach	1	1983	650
SG-690	Sand Heads	29	1989	533
SG-700	Westshore Terminal	42	1987	596
Gulf Islands				
GI-050	Five Finger Island	180	1989	533
GI-060	Hudson Rocks	26	1989	533
GI-210	Rose Islets	2	1987	596
GI-220	Canoe Islet	0	1987	596
GI-280	Bare Point	18	1990	54
GI-290	Shoal Islands	72	1989	533
GI-320	Ballingal Islets	25	1987	596
GI-350	Charles Island	0	1977	175
GI-420	Chain Islands	0	1987	596
GI-430	Annette Inlet	25e [b]	1988	175
GI-440	Red Islets	0	1978	650
GI-460	Channel Islands	0	1987	596
GI-750	Mandarte Island	473	1990	54
GI-890	Chain Islets	686	1990	54

[a] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.
[b] Number of nests was estimated (see key to letter codes on pages 53-56).

Populations since 1990

We know of several partial surveys of Double-crested Cormorants since 1990.[180, 401] The most recent and complete survey in 2000 documented a total of 602 nests at 11 sites, revealing a continued decline since 1987/88.[180] Authors suggested that the causes of decline were related to a combination of Bald Eagle disturbance, change in prey availability, and human disturbance. New colonies were discovered on Mitlenatch Island in 1993 [401] and on Galiano Cliffs (14 nests) and McCrae Islets (1 nest) in 2000.[180] The colony on Mitlenatch Island had increased to 70 nests by 2000. To the best of our knowledge, colonies at Queen's Reach in the Fraser River, Chain Islands (Second Sister Island) in Ganges Harbour, and Annette Inlet on the west side of Prevost Island have not been revisited since the 1980s. Note that Queen's Reach was not surveyed by Vermeer and Rankin [584] in 1983 or by Vermeer et al. [596] in 1987 as was suggested by Table 2 in Moul and Gebauer.[401] The single nest there was reported by Ron Pilkey [650] in 1983 and as far as we know the site has not been revisited.

Since 1990, Double-crested Cormorants have extended their breeding range into the interior of British Columbia at two locations. Four nests were discovered on an island in Stum Lake, in the Chilcotin, in 1993.[401, 647] That colony increased to at least 25 nests by 2008.[78, 647] In the Creston valley, breeding was first recorded at Leach Lake in 2003, when 3 pairs were found nesting, increasing to at least 160 pairs by 2016.[195, 557, 558]

Brandt's Cormorant

Phalacrocorax penicillatus **BRCO**

(*Brandt Cormorant*, *Sea Crow*, Compsohalieus penicillatus)

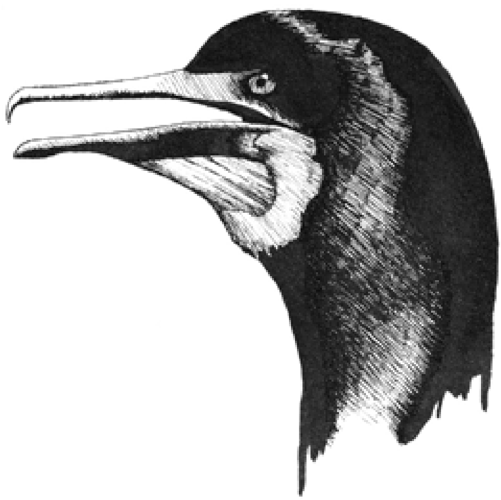


Figure 78. Brandt's Cormorant, endemic to North America, is an enigma in British Columbia. It may nest for several years in succession and suddenly disappear as a breeding species for decades. *Drawing by Keith Taylor.*

Large groups of tall, black birds standing sentinel-like in close ranks on shoreline rocks, or swimming in close formation with only their heads and long necks exposed, are likely Brandt's Cormorants. They also fly in large groups in line or V formation close above the water when travelling between roosting and feeding locations where they dive for Pacific Herring (*Clupea pallasii*), Surfperch, and other fishes. Several thousand have been seen feeding during the winter in the turbulent waters of Active Pass on the BC Ferries route between Vancouver and Victoria. Thousands also gather where Pacific Herring are spawning in the Strait of Georgia in March. They are known to feed on 93 different fish species and several invertebrates. [608]

Brandt's Cormorant occurs only in the marine environment along the west coast of North America. Unlike many breeding species in British Columbia, it has a reverse migration. Post-breeding birds from colonies in Washington, Oregon, and California arrive on the west coast of Vancouver Island in early to mid-August, increasing in numbers through September. In April and May, Brandt's Cormorants return to their southern breeding grounds.

Like many seabirds, Brandt's Cormorant is affected by unpredictable changes in El Niño-Southern Oscillation, a situation in the tropical Pacific Ocean when warm water prevails and food supplies decline. This periodic event usually impacts breeding effort and reproductive success [7] and may partially explain the irregular pattern of nesting by Brandt's Cormorants in the province.

Beautiful in Black

At first glance, Brandt's Cormorant is a nondescript, black bird - you wouldn't compare it to a striking-looking puffin or peacock, would you? Take a closer look. In breeding plumage, the vivid blue throat pouch colour, edged with buff, rivals the colours sported by any species in the bird world. Combine that with deep blue eyes, purple-green iridescence on head and neck, and delicate white filoplumes on the neck and back, and you have one of the most arresting birds on our coast (see coloured insert, page 83).

APPEARANCE

Similar Species: In BC, Double-crested and Pelagic cormorant, especially immatures.

Size: Goose-sized; **Length:** 81-89 cm (32-35 in), **Wingspan:** 112-124 cm (44-49 in), **Mass:** 1.4-2.7 kg (3.1-6.0 lbs).

Adult breeding
- black with purple-green gloss
- bright blue throat pouch
- buffy band below throat
- white plumes on neck and back (Figure 79)

Immature
- dark brown above
- slightly paler below
- pale V across breast
- buffy band below throat

In flight

- head and neck straight
- tail shorter than DCCO
- head rounded above
- only over marine waters

Figure 79. The buffy throat band is the best feature to quickly identify an adult Brandt's Cormorant as the blue throat patch only shows when expanded and the white plumes are present only for a short period. *Photo by Alan D. Wilson.*

BREEDING

Colonies are usually on the windward side of small rocky islands, with maximum colony size of 110 pairs in BC, and over 8,000 pairs in California. Males defend a small territory, and attract females by throwing back their heads to display their blue throat patches, ruffing out their white neck plumes, and waving their wings. Nests are located on gentle shoulders and tops of rocky slopes or on broad cliff ledges, and are spaced about 1 m (3 ft) apart on average. Mates copulate at the nest site. Though highly gregarious, they are intolerant of intruders into their small territories. Fights can be intense, grappling rivals thrashing wildly about and tumbling over the rocks, and may continue intermittently for days. Most pair bonds last one breeding season, a few pairs breed together for 2 years. Females start breeding (at 2-7 years) slightly earlier than males (at 2-9 years).

Seasonal and diurnal attendance at colony: Active at colonies during the day. Individuals are frequently present on the water around colonies. Birds flushed for extended periods from nesting or roosting areas by natural or human disturbance may aggregate on the water. Brandt's Cormorant is the latest of the cormorants breeding in BC, with eggs recorded from 20 June to 9 September.[136] Last young likely fledge in early October.

Nest: A substantial circular bowl, 40-80 cm wide built of Scouler's surfgrass (*Phyllospadix scouleri*), common eelgrass (*Zostera marina*), seaweeds, and feathers (Figure 80). Males gather most material, often diving for seaweed, or stealing from a neighbour, but both sexes arrange the nest. Many pairs build nests but do not lay eggs. Nest-building may take 10 days.

Eggs: Long subelliptical. Pale blue with uneven outer chalky layer, unmarked; becoming stained in nest (see Figure 80). **Size:** 62 (2.4 in) x 38 mm (1.5 in). **Average clutch size (maximum clutch size):** 2-3(6). **Incubation period:** 28-32 d. Sexes alternate incubation duties every 5 hours on average, longer when food is scarce.

Young: Hatched naked. Skin looks greasy-black, covered with dense greyish down by 10 days, except head, which stays naked until near fledging. Brooded by both parents for 5-10 days, then shaded when it is hot. Fed 3-9 times per day. **Average number (maximum):** 2-3(6). **Fledging period:** 40-42 days. Chicks begin to form creches after adults stop continuous attendance at nest.[162] At first, creches are formed mainly at dawn and dusk when 2-14, relatively immobile, small chicks from adjacent nests huddle together. These creches tend to break up during mid-day when parents return with food. As chicks get older, creches get larger, up to 78 chicks, and their location moves towards the ocean. Near fledging, chicks attend creches through the day, and then throughout the night as well. Parents will feed chicks at the creche past the time when chicks can fly.

Lifespan: 17% of chicks return as adults ≥ 2 years old; maximum 18 years.[608]

Figure 80. Many Brandt's Cormorant nests in British Columbia are composed of circular piles of Scouler's surfgrass, a green slender flowering marine plant with flat blades that dry quickly in sun and wind. The stained eggs in the nest suggest that incubation is advanced. *Photo by R. Wayne Campbell, "White" Island near Portland Point, BC, 4 August 1969.*

CONSERVATION

Surveys up to 1990 found that breeding numbers in BC fluctuated between 60-150 pairs, a small proportion of the present world population of about 75,000 pairs centred in California.[608] Disturbance may be the most important immediate threat to nesting birds and can cause colony abandonment. Eggs and chicks are preyed upon by Glaucous-winged Gulls, Northwestern Crows, and Common Ravens when adults are flushed off nests by approaching humans, boats, kayaks, low-flying aircraft, or Bald Eagles. Birds are concentrated when nesting and feeding, making them highly vulnerable to oil spills year-round. Entrapment in fishing nests and accumulation of pesticides and other pollutants are also concerns. Sustainable management of Pacific Herring stocks is important for wintering and breeding birds. Brandt's Cormorant was placed on the BC Conservation Data Centre's Red List in 2005.[55]

Population trends to 1990

Brooks and Swarth [58] reported that Brandt's Cormorants were "nesting in numbers" on Solander Island off the west coast of Vancouver Island on 22 July 1904, and Taverner [541] incorporated Brooks' observation into his description of their breeding range in BC. However, this record was apparently based only on Brooks' observations of birds present in summer and was not accepted as a breeding record by Drent and Guiguet.[213] Drent and Guiguet thus did not include Brandt's Cormorants as a breeding species in BC. Observations of large numbers of birds on Mandarte Island led Drent and Guiguet in 1961 to predict colonization of the Gulf Islands in the near future. That had not occurred as of 1990 (see below).

Brandt's Cormorant was first confirmed nesting in 1965 on Sea Lion Rocks off Long Beach on the mid-west coast of Vancouver Island.[532] Since then,

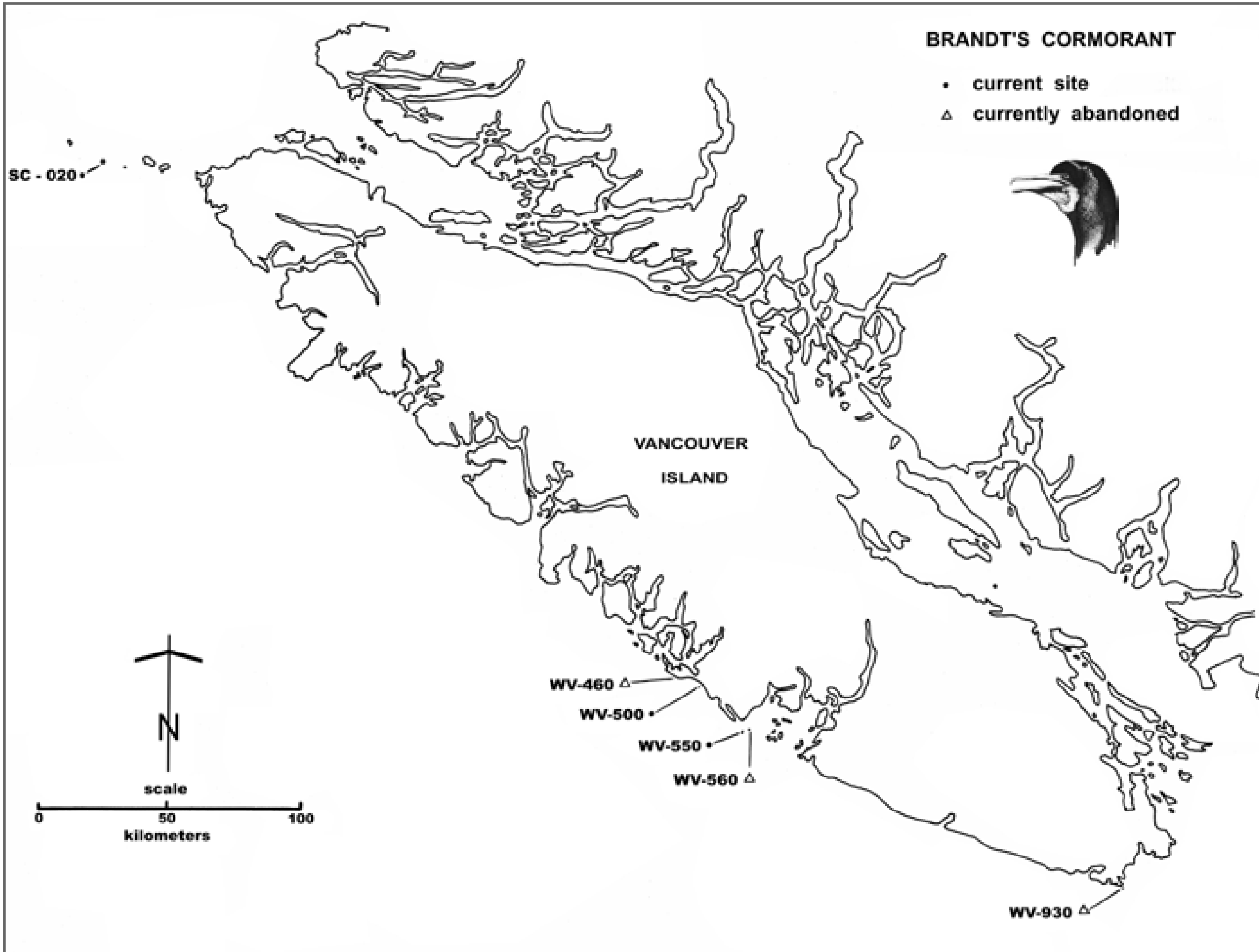


Figure 81. Brandt's Cormorant colonies in British Columbia. Site codes refer to colonies listed on Table 9.

Table 9. Estimates of breeding populations (numbers of nests counted) of Brandt's Cormorants at colonies in British Columbia as of 1990.

Location		Nests	Survey Year	Source [a]
Scott Islands				
SC-020	Sartine Island	39	1989	484
West Coast Vancouver Island				
WV-460	"White" Island	0	1989	643
WV-500	Sea Lion Rocks	5	1989	643
WV-550	Starlight Reef	51	1989	643
WV-560	Great Bear Rock	0	1989	643
WV-930	Race Rocks	0	1989	643

[a] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.

Figure 82. Of the 150 pairs of Brandt's Cormorants nesting in BC in 1970, 107 nests were on Great Bear Rocks. *Photo by R. Wayne Campbell, Great Bear Rocks, BC, 24 July 1970.*

they have nested intermittently at four sites in the same area, using at most only two sites at one time (Figure 81). Maximum numbers were recorded in 1970 when 150 pairs nested at Sea Lion Rocks and Great Bear Rocks (Figure 82), but numbers have declined since. Those colonies may have suffered from disturbance.[315] Ken Morgan [643] reported five pairs nesting on Sea Lion Rocks and 51 pairs nesting on Starlight Reef in 1989.[475] "White" Island, near Portland Point, and Great Bear Rocks, in Barkley Sound, were unused on recent visits. In 1987, three pairs colonized Race Rocks off Victoria,[121] but Ken Morgan saw none there in 1989 (Table 9, page 93).

Vermeer et al.[593] reported adults attending nests on Sartine Island off the northwest tip of Vancouver Island in 1975, but breeding was not confirmed. No birds were present in 1987, but nesting was confirmed in 1989, when 39 nests with large young were recorded [484] (Table 9). The total provincial breeding population at the three sites occupied in 1989 was 95 pairs (Table 3, page 63).

There is an unconfirmed nest record on the northern mainland coast. On 27 June 1976, one cormorant nest on Steele Rock contained a large egg that observers, Harry Carter and Keith Taylor suspected belonged to a Brant's Cormorant. Eight Brant's Cormorants in breeding plumage were present.[650] In 1988, there were 116 immature Brant's Cormorant roosting but neither Brandt's or Pelagic cormorants were nesting.[476]

Records of intermittent breeding along the west coast of Vancouver Island, as well as in southeast Alaska [528, 608] make it seem more likely that the observations made by Brooks on Solander Island in 1904 may have indicated breeding at that time, although we know of no other records of Brandt's Cormorants on that colony.

Ringing for Information

Before the advent of micro satellite transmitters that now can be attached to birds, the only way to determine the movements and survival of individual birds was to band them, or, as our British colleagues say, ring them. Banding programs in North America are jointly administered by the United States Geological Survey and the Canadian Wildlife Service, and banding records are reported to and compiled by the Bird Banding Laboratory located at the Patuxent Wildlife Research Centre in Maryland. An early seabird banding program in BC carried out by Wayne and friends in the 1960s and 1970s provided valuable information about the movements of Brandt's Cormorants. Leg bands were put on 169 nestlings at colonies on the central west coast of Vancouver Island (Figure 83; also see Figure 25). *Five young were later found dead on southern beaches (3%), all within eight months of banding. One was from nearby Long Beach (1 km distant), three from Washington (280-308 km distant) and one from California. The latter location was from Lake Earl, the largest lagoon in the state, about 800 km from where the nestling was banded seven months earlier. This revealed southward post-fledging movements of young from BC colonies. Banding also revealed northward dispersal in this species. A colour-banded adult Brandt's Cormorant was seen on Starlight Reef, Barkley Sound, BC, on August 4, 1974 that had been banded on the Farallon Islands, CA, in 1971, about 1,252 km (778 mi.) to the south.*[315]

Figure 83. Desmond Belton participated in banding nestling Brandt's Cormorants in the early 1970s. *Photo by R. Wayne Campbell, Great Bear Rocks, BC, 25 August 1970.*

Populations since 1990

Since 1990, Drent and Guiguet's prediction of colonization of the Gulf islands came true in 2013 when three completed nests were found on Mandarte Island, two of which fledged chicks.[173] Another nest was half built with an attendant adult.[634] Carter et al.[173] stated that Mandarte Island was the only active colony in British Columbia at that time.

Pelagic Cormorant

Phalacrocorax pelagicus **PECO**

(*Violet-green Cormorant*, *Baird's Cormorant*, *Shag*, Stictocarbo pelagicus)

Figure 84. Pelagic Cormorant breeds from the Kurile Islands in east-central Asia, east across the North Pacific Ocean to the Aleutian Islands and along the entire Pacific coast of North America, south to northern Baja California. In BC, it is the most widespread and numerous cormorant species. *Drawing by Keith Taylor.*

The Pelagic Cormorant is found only in marine waters in BC, but contrary to its name, rarely strays farther than a few kilometres from land. It is our smallest and least gregarious cormorant, often feeding, flying, and roosting singly or in small groups (Figure 85). Querulous growls, groans, and hisses heard at colonies and communal roosts reinforce one's impression of an antisocial nature. Birds are inshore foragers over rocky reefs and sand or mud flats in waters up to 100 m deep, where they dive to depths of up to 36 m for gunnels, sand lance, sculpin, and shrimp.[331] They join multispecies foraging flocks when prey is abundant, tending to dive at the centre of the flock. As the northern subspecies is called, they are truly "resplendent" when the sun catches the violet-green iridescence of their fresh nuptial plumage.

Figure 85. Pelagic Cormorant is the smallest of the three cormorant species breeding in BC and can easily be identified from a distance by its long black body, thin neck, and slender bill. Up close, in the breeding season, adults have a red face patch (see coloured insert, page 83). *Photo by R. Wayne Campbell, Sidney, BC, 27 July 2010.*

Built for Diving

Cormorants are specialized for diving. Modified barbs on wing feathers that allow water to penetrate reduce buoyancy. Though making diving easier, this wettable plumage limits the duration of diving bouts and restricts birds to coastal areas close to shoreline roost sites where they can dry their wings. Body feathers are waterproof and keep most of the bird warm and dry when diving in cold, coastal waters. Like other diving birds, they have a large blood volume and an enhanced oxygen-storage capacity in blood and muscle. They have webs between all four toes and huge thigh and hip muscles for paddling. They stroke their feet simultaneously to propel themselves through the water while holding their wings tight to their sides or slightly extended for steering. This sleek profile and powerful propulsion enables them to catch even the fastest fish.

APPEARANCE

Similar Species: In BC, Brandt's Cormorant and Double-crested Cormorant.

Size: Smaller than goose; **Length:** 63-73 cm (25-29 in), **Wingspan:** 91-102 cm (36-40 in), **Mass** 1.4-2.1 kg (3.2-4.6 lbs).

Adult breeding
- glossy greenish-black body
- white patches on flanks
- head double-crested, red face
- white plumes on neck

Immature
- dark brown, slightly paler below but without contrast
- slender dark bill
- fleshy-brown face

In flight
- small and slender
- straight profile head-to-tail
- pencil-shaped neck and head
- white flanks when breeding

BREEDING

Solitary to colonial nester on offshore islands, headlands, and man-made structures along the inner and outer coast. Most colonies have < 50 nests; the largest recorded colony in BC was 603 nests on Mandarte Island in 1981 (Figure 86). Nests are built on narrow ledges on seaward- or landward-facing cliffs or in sea caves and less commonly on beams and ledges of beacons, bridges, and abandoned ships. Nest sites are often reused from year to year, but birds frequently shift nest-site and colony locations between and within years. Male chooses nest site and advertises for female by wing-waving to expose white

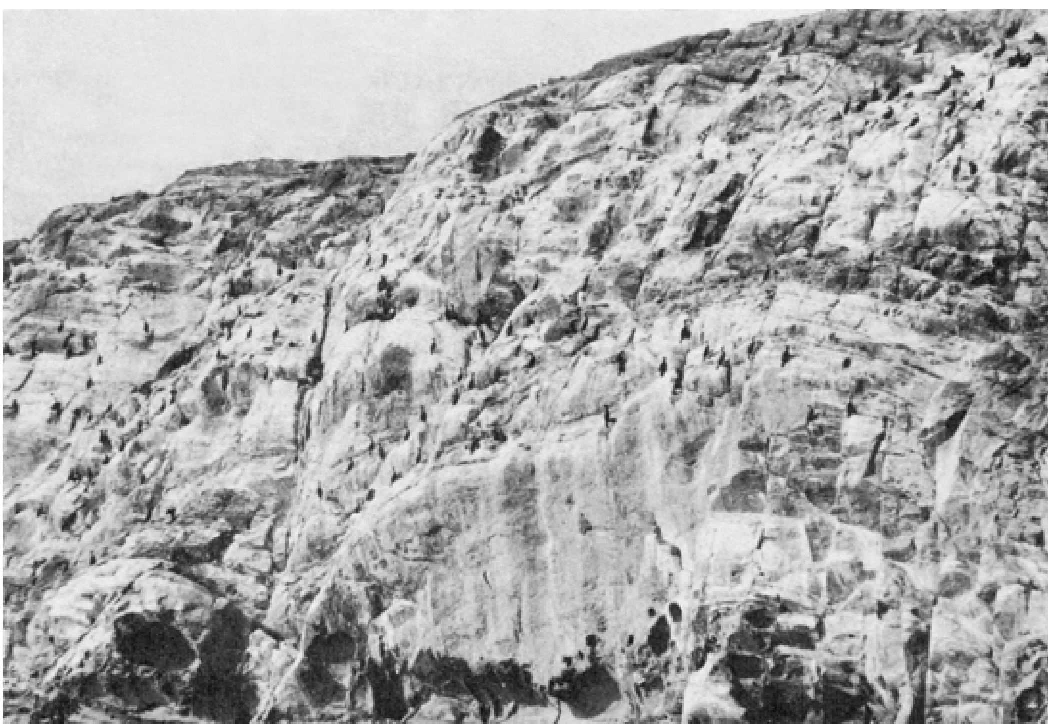


Figure 86. The largest Pelagic Cormorant colony reported in British Columbia was 603 nests in 1981 on Mandarte Island in Haro Strait. *Photo by Rudolf H. Drent, 22 August 1960.*

rump patches. Female selects male and is accepted or rejected by him. Copulation occurs on the nest site. First breeds at 3 years.

Seasonal and diurnal attendance at colony: Like other cormorants in BC, active at colonies only during the day. Flocks seldom loaf at sea,[333] but individuals frequently occur on the water around colonies where they may bath after incubation shifts.[331] Birds may aggregate on the water around colonies if disturbed for extensive periods or if breeding is unsuccessful. Nesting season in BC extends from March or April through October.[136] Earliest eggs were recorded on 23 April at a colony on the Second Narrows Bridge,[334] but egg-laying more typically begins in mid-May at BC colonies.[214]

Nest: A compact bowl made of seaweeds, grasses, feathers, and marine debris such as rope and plastics, often cemented together with guano and lined with dry grasses (Figure 87). The male begins building and is assisted by female after pairing.

Figure 87. In the more protected waters of the Strait of Georgia and Haro Strait, the nests of Pelagic Cormorants often contain contour and wing feathers of Glaucous-winged Gulls and grasses. *Photo by R. Wayne Campbell, Christie Islet, BC, 8 June 1981.*

Eggs: Long subelliptical. Pale blue, unmarked, uneven outer chalky layer; becoming stained in nest (see Figure 87). Laid 2 days apart. **Size:** 59 (2.3 in) x 37 mm (1.5 in); **Average clutch size (maximum clutch size):** 3-4(8); **Incubation period:** 28-32 days. Mates change shifts 3-5 times during day, females incubate at night.

Young: Hatched naked, helpless (Figure 88). Grey skin later covered with dark grey down, paler on thighs. Brooded and fed by both parents, attended continuously for 14-48 days. Fed by regurgitation; chick inserts head into parent's mouth. **Average number (maximum):** 2-3(7). **Fledging period:** 28-59 days.

Figure 88. Shortly after hatching, naked nestling Pelagic Cormorants are vulnerable to avian predators and direct sunlight. *Photo by R. Wayne Campbell, Sea Lion Rocks, Long Beach, BC, 27 July 1969.*

Lifespan: Poorly known; maximum 17 years 10 months.[183]

CONSERVATION

Available estimates suggest that about 5% of the estimated North American population of 130,000 birds [331] breeds in BC. World population may be in the order of 400,000 birds. Variable and intermittent use of nesting sites makes it difficult to accurately determine breeding populations and monitor trends. Region-wide surveys are required to determine current population status. Human disturbance at nesting colonies can cause high mortality of eggs and chicks and needs to be controlled in areas of increasing recreational traffic. Oil spills, gill-net entanglement, and pollutants that affect prey populations are concerns. The northern subspecies *P. p. pelagicus* that nests in the northern half of the British Columbia coast was placed on the BC Conservation Data Centre's Red List in 2005.[55]

One Nest, Two Species

Some species like Brown-headed Cowbirds (Molothrus ater) *are obligate brood parasites and lay their eggs in other species nests, where they are incubated and chicks are raised by the parasitized host. In seabirds, egg dumping is a very rare event. In a massive 14-year study of 69,775 nests of "seabirds" along the west coast of Scotland from 1996 to 2009, only 123 nests (0.2%), for 19 different species, were found containing the eggs of two different species.[194] The samples for mixed clutches, however, included cormorants (2 species), gulls (6 species), terns (2 species), waterfowl (6 species) and waders (3 species), not all of which are true seabirds.*

In BC, the frequency of egg dumping by seabirds is also very low. Foreign eggs have been found in nests of Leach's Storm-Petrel, Double-crested Cormorant, Brandt's Cormorant, Pelagic Cormorant (Figure 89)*, Black Oystercatcher, Glaucous-winged Gull, Common Murre, and Cassin's Auklet. Sometimes egg dumping is mutual. For example, Leach's Storm-Petrel eggs have been found in Cassin's Auklet nests and vice versa. It is unknown whether this behaviour is ever adaptive; most evidence suggests it is not a successful strategy and may just be accidental in these species. Cassin's Auklets were found incubating abnormal clutches, one with two Cassin's Auklet eggs and two with Ancient Murrelet eggs and a Cassin's Auklet egg, in three nests on Frederick Island in 1980-1981. Those nests were later abandoned. On the Farallon Islands, Pigeon Guillemot females sometimes lay in the same nest but those 3-4 egg clutches are never successful.[2]*

For participants in the BC Nest Record Scheme, finding a dump nest is a bonus as one nest equates to two different species cards!

Population trends to 1990

Archibald Menzies recorded (page 92 of his journal) a colony of "shags" at Deep Sea Bluffs, located in Simoom Sound east of Queen Charlotte Strait, in 1792, during his voyage with Captain Vancouver aboard the *MV Discovery*.[421] The next record in British Columbia was in 1891 when Fannin [238] reported breeding on islands close to Sidney Island in the Strait of Georgia, which most likely referred to Mandarte (Bare) Island.[213] Pelagic Cormorants are now known to breed along the entire coastline (Figures 90 and 91), but all large colonies (Table 10, page 101) and the majority of the nesting population occurs in the south on the east and west sides of Vancouver Island. As of 1990, an estimated 3,410 pairs were breeding at 73 sites, with 58% of the population nesting in the Strait of Georgia, 22% in the Scott Islands and 12% on the west coast of Vancouver Island (Tables 3, 4 and 5, pages 63-65). Populations were increasing through most of the 20th century but have recently been declining in most coastal regions.

Figure 89. Occasionally nests involving two seabird species are found during surveys. In this photo, a Pelagic Cormorant laid an egg (bottom) in a Glaucous-winged Gull nest containing a full clutch of incubated eggs. *Photo by R. Wayne Campbell, Chain Islets, Oak Bay, BC, June 1973.*

Historical records are adequate to demonstrate tremendous population increases at major colonies in the Strait of Georgia during the first half of the 20th century.[213, 441] By 1960, more than 1,000 pairs were documented nesting at 35 sites in the province, including over 881 of those pairs at 15 sites in the Strait of Georgia (Figure 92). Even so, some colonies had been abandoned by then and problems with human disturbance were already apparent at several others.[213] Total populations in the Strait of Georgia continued to increase through 1974 [104] and may have reached a peak around 1983 at 2,305 pairs (excluding Race Rocks which we place in the West Coast Vancouver Island region).[584] Populations decreased to 2,236 pairs in 1987 [596] and to an estimated 1,974 pairs by 1990

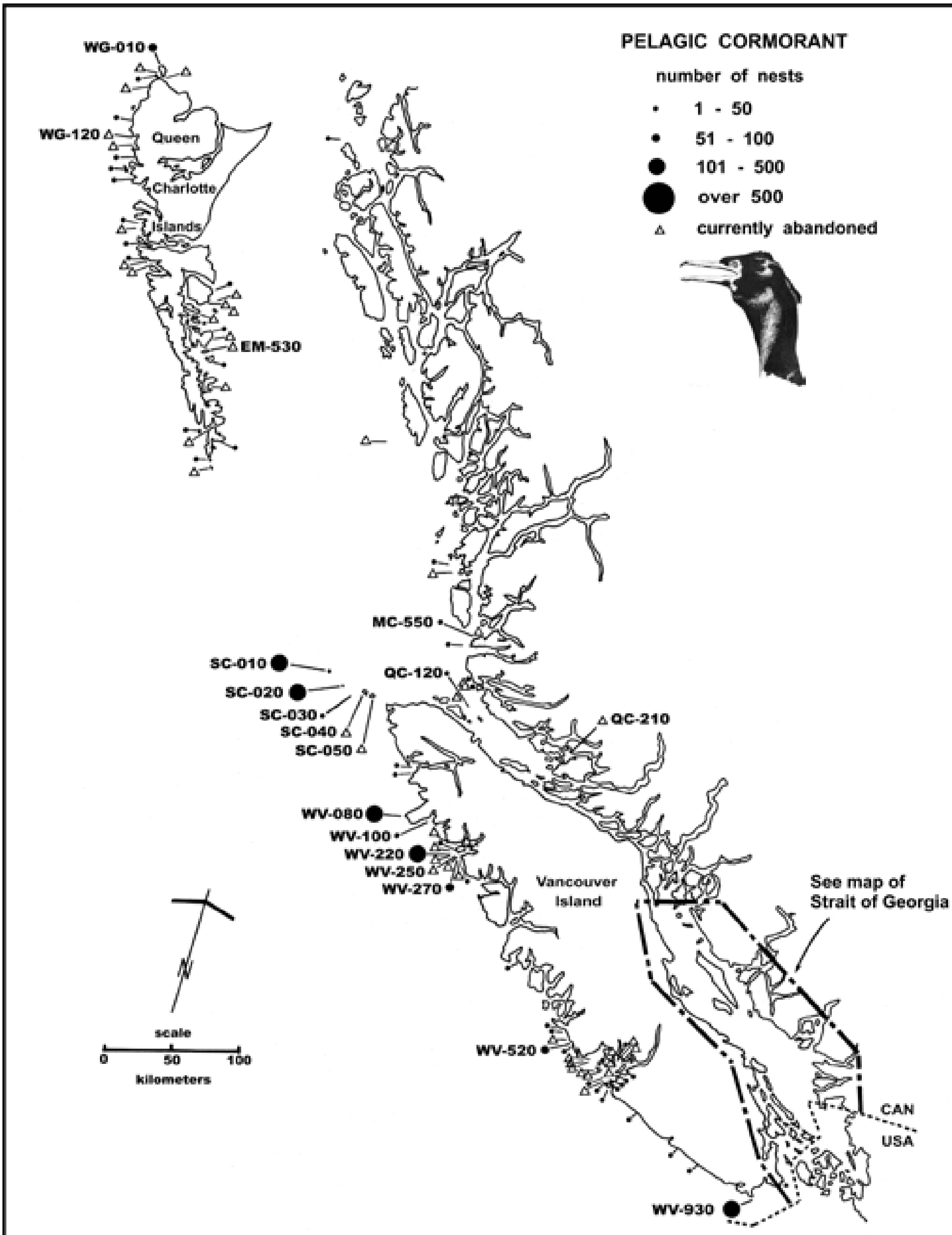


Figure 90. Pelagic Cormorant colonies in northern British Columbia and on the north and west coasts of Vancouver Island. Colonies with present or past populations greater than 50 pairs are identified with site codes and refer to colonies listed in Table 10.

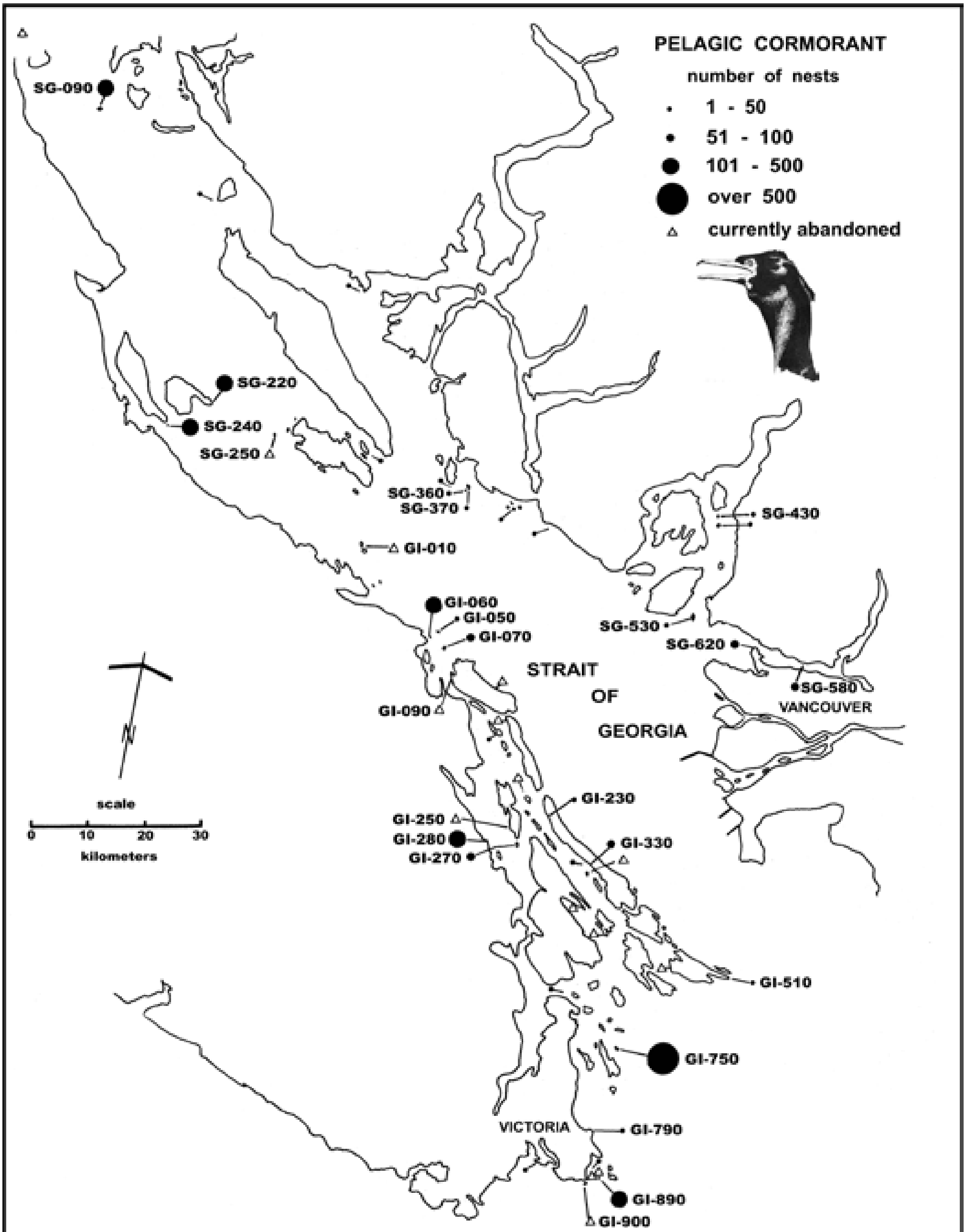


Figure 91. Pelagic Cormorant colonies in the Strait of Georgia, BC. Colonies with present or past populations greater than 50 pairs are identified with site codes and refer to colonies listed in Table 10.

Table 10. Estimates of breeding populations (numbers of nests counted) of Pelagic Cormorants at major colonies (>50 pairs) in British Columbia as of 1990. Colonies with historical populations greater than 50 pairs are also included (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC).

Location		Nests	Survey Year	Source [a]
West Coast Graham Island				
WG-010	Langara Island	52	1986	470
WG-120	Tian Islets	0	1988	634
East Coast Moresby Island				
EM-530	Murchison Island	0	1986	470
Northern Mainland Coast				
MC-550	Dugout Rocks	18	1988	476
Queen Charlotte Strait				
QC-120	Buckle Group	6	1987	477
QC-210	Deep Sea Bluff	0	1982	477
Scott Islands				
SC-010	Triangle Island	433	1989	484
SC-020	Sartine Island	168[b]	1989	484
SC-030	Beresford Island	6	1989	484
SC-040	Lanz Island	56[b]	1987	484
SC-050	Cox Island	78[b]	1987	484
West Coast Vancouver Island				
WV-080	Solander Island	67eS[c]	1989	594
WV-100	O'Leary Islets	10eS[c]	1989	594
WV-220	Thornton Island	39	1989	594
WV-250	Munsie Rocks	0	1989	594
WV-270	Volcanic Islets	72	1989	594
WV-520	Florencia Islet	0	1989	594
WV-930	Race Rocks	152	1989	594
Northern Strait of Georgia				
SG-090	Mitlenatch Island	334	1990	54
SG-220	St. John Point	124	1990	54
SG-240	Chrome Island	80	1990	54
SG-250	Sisters Islets	0	1987	596
SG-360	Franklin Island	22[d]	1987	596
SG-370	Merry Island	3	1989	533
SG-430	Christie Island	10	1989	533
SG-530	Passage Island	16	1987	596
SG-580	Second Narrows	90	1987	596
SG-620	Prospect Point	86[d]	1989	533
Gulf Islands				
GI-010	Ballenas Islands	0	1987	596
GI-050	Five Finger Island	52	1989	533
GI-060	Hudson Rocks	104	1989	533
GI-070	Snake Island	74	1987	596
GI-090	Gabriola Cliffs West	0	1987	596
GI-230	Galiano Cliffs North	24	1979	650
GI-250	Augustus Pt.	0	1981	650
GI-270	Tent Island	74	1987	596
GI-280	Bare Pt.	40	1990	54
GI-330	Galiano Cliffs Central	72	1987	596
GI-510	East Point	12	1987	596
GI-710	Little Group/Dock Island	71	1990	54
GI-750	Mandarte Island	311	1990	54
GI-790	Gordon Head	24	1987	596
GI-890	Chain Islets	204	1990	54
GI-900	Trial Islands	0	1987	596

[a] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.

[b] On Sartine Island, only 49 nests were active later in the season; on Lanz and Cox islands, all nests were abandoned later in the season.

[c] Numbers of nests were estimated from the number of adults standing at suspected nest sites (see key to letter codes on pages 53-56).

[d] Nest count for Franklin Island included Merry Island, and for Prospect Pt. included Siwash Rock.

(see Strait of Georgia chapter). Highest numbers were recorded at the largest colony on Mandarte Island in 1981. Although total numbers have not decreased dramatically since 1983, considerable variation has occurred at individual colonies and 17 historical sites in the Strait of Georgia were not used during the most recent surveys (Table 6, pages 66-67). Many of those changes in the Strait of Georgia and elsewhere likely reflect intermittent use of sites by small populations,[172] but major colonies on Gabriola Island (367 pairs in 1974)[104] and Trial Islands (107 pairs in 1960)[213] have been abandoned, and other colonies such as Bare Point have declined [54, 596] (see the Strait of Georgia chapter for further discussion, comparison and some correction of these estimates).

On the west coast of Vancouver Island, surveys in 1988 [475] showed little population change from 1975,[104] but surveys in 1989 showed dramatic decreases and evidence of breeding failure.[594] Changes in census technique may account for some of the differences. Many colonies were surveyed from the water in 1989, some of which have colony areas that are not visible from the water (e.g., 27% of the nests on Solander Island in 1988 were visible only from the top of the island). However, differences due to census methods would have accounted for only a small proportion of the overall decline from about 1,300 pairs in the 1970s to 382 nesting pairs in 1989. Thirty-three historical sites on the west coast of Vancouver Island were not used in 1989 (Table 6, pages 66-67), and others such as Volcanic Islets experienced obvious breeding failure. Except for one new colony of 12 pairs on Vancouver Island cliffs south of Pachena Bay, declines were evident at all colonies except Race Rocks at the southern end of Vancouver Island (note that Table 1 in Vermeer et al.[594] implies increases at a couple of colonies, but this is due to errors in the 1975 data presented; see West Coast Vancouver Island chapter for further discussion, comparison, and some corrections to those data).

Although disturbance is clearly a concern at many colonies,[172] we agree with Vermeer et al.[594] that human disturbance, Bald Eagle disturbance or predation, and mortality from the *Nestucca* oil spill [483] were unlikely to be responsible for the region-wide decline observed in 1989. Vermeer et al.[594]

Figure 92. The largest Pelagic Cormorant colony in the northern Strait of Georgia is located on the steep rocky cliffs along the south side Mitlenatch Island. Eighteen nests were found in 1949 and, although fluctuating annually, numbers increased to over 500 nests by the mid-1960s. In 1990 the population was 334 breeding pairs. *Photo by R. Wayne Campbell, August 1966.*

speculated that reduced nesting populations and breeding failures were indicative of food shortage. Contrary trends at Race Rocks and in the outer Scott Islands, where the highest historical nest count occurred in 1989,[484, 487] may have been related to more stable, productive waters in those areas. Additional surveys are required to determine if the reduced breeding population recorded in 1989 over most of the west coast Vancouver Island region reflects actual population decline or just poor breeding conditions that year.

Survey results from 1976-1977 and 1986-1988 also indicate population declines in the Queen Charlotte Islands, on the northern mainland coast, and in Queen Charlotte Strait from 661 pairs nesting at 34 sites to 274 pairs nesting at 22 sites.[470, 476, 477] Declines in the Queen Charlotte Islands during that period were only apparent on the west coast of Moresby Island. On the east coast of Moresby Island, numbers declined earlier from 181 pairs at 5 sites in 1971[535] to 48 pairs at three sites in 1977.[115, 650] Populations in the Queen Charlotte Islands may have been underestimated and the interpretation of historical trends confounded because there may have been some cave-nesting sites[635] that were not detected during the various surveys, especially along the west coast of Moresby Island.[303] However, decreases and abandonments at many known colonies, and the consistent pattern of decline in most regions of the BC coast, suggest that indicated trends are real.

Human disturbance (Figure 93) is a major concern in the popular recreational areas of south Moresby Island (Gwaii Haanas National Park Reserve) in the Queen Charlotte Islands, Checleset Bay and Barkley Sound on the west coast of Vancouver Island, and in the Strait of Georgia. Colonies established on the Second Narrows Bridge (also known as the Iron Worker's Memorial Bridge) and on Prospect Point in Vancouver, however, have demonstrated great tenacity in the face of disturbance.[334, 596]

Populations since 1990

Since 1990, partial surveys through the 1990s and a more complete survey in 2000 indicated continued declines to 1088 pairs at 19 nesting sites in the Strait of Georgia.[180] Eight colonies in the Strait of Georgia, plus Race Rocks on the west coast of Vancouver Island, that were active as of 1990, were abandoned in 2000. At the same time, new colonies were established in the Vancouver urban area on the Burrard Street (39 nests) and Granville Street (47 nests) bridges, and the colony on the Second Narrows Bridge increased substantially from 90 nests in 1987 to 201 nests in 2000. Several historical colonies were not surveyed in 2000, including the Dock Island colony in the Little Group near Sidney, which had 55 nests in 1989[533] and 71 nests in 1990.[54] Chatwin et al.[180] suspected that disturbance by humans and Bald Eagles and possible changes in prey availability were related to declines in cormorant numbers. Although human traffic is intense at urban bridges, perhaps these sites provide refuge from the kind of disturbance that cormorants consider a threat. Declines were also reported: on the west coast of Vancouver Island in Barkley Sound, based on surveys conducted in 2006 and 2007 by Carter et al.;[171] on Triangle Island, where Rodway et al.[487] found fewer nests in 2009 and 2010 than in 1989; and in western Queen Charlotte Strait where Carter and McClaren[163] found only one active colony (4 nests on Dugout Rocks) out of eight historical breeding sites surveyed in 2014. They also found one nest on Pine Island, which had not previously been confirmed as a nesting site, although Young[629] suspected breeding there in 1929.

Figure 93. Disturbance by well-meaning but uninformed tourists can impact nesting seabirds, especially surface nesters, along the British Columbia coast from May to August. *Photo by R. Wayne Campbell, Skedans Island, BC, 5 June 1990.*

Black Oystercatcher

Haematopus bachmani **BLOY**

(*American Black Oystercatcher*)

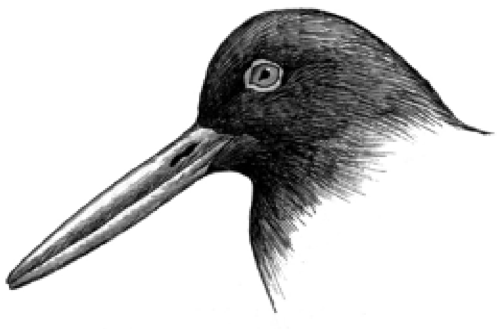


Figure 94. Black Oystercatcher cannot be confused with any other bird in British Columbia. *Drawing by Mark Nyhof.*

Black Oystercatchers inhabit rocky intertidal shores along the west coast of North America from Alaska to Baja California. Some birds in northern parts of the breeding range are migratory, whereas those to the south, including British Columbia, are present year-round, although there are local movements. Often announcing its presence with raucous calling that can be heard above the loudest surf, the bold Black Oystercatcher with its long, bright red bill and pink legs cannot easily be missed or mistaken for any other species (Figure 95). The appearance changes south of Oregon where birds have increasing amounts of white body feathers and browner abdomens. On the southern peninsula of Baja California its range overlaps slightly with the black-and-white American Oystercatcher (*H. palliatus*).

Inappropriately named, Black Oystercatchers rarely take oysters, and then only locally. The main foods are mussels, limpets, and chitons. The former are harvested with a quick jab of their bill into a gaping shell to sever the adductor muscle that closes the shell. Limpets and chitons are dislodged with a quick jab of the bill. Foraging oystercatchers often have to leap out of the path of incoming waves.

Sentinel of the Pacific Coast

Oystercatchers are vocal birds. Loud, sharp, contact calls can be heard throughout the year, serving to locate other birds, especially mates, to announce departure or arrival from roosts or territories, or as greetings when partners reunite. The more elaborate Piping Display, a series of sharp notes accompanied by bowing, rotating or running side by side, is given during territorial defence or between reuniting partners. They are also quick to sound the alarm whenever humans or other potential predators approach, alerting nesting partners and warning young to hide. Other birds nesting in the same areas benefit from their vigilance and their loud alarm calls. Young oystercatchers are noisy too. In summer, flocks of non-breeding birds rampage around outer islands like groups of rowdy teenagers on a Saturday night.

Feeding birds will chase gulls and other shorebirds feeding nearby, and will also use their long bill to poke small birds that wander into their territory. I (Michael) once saw an oystercatcher with a sense of humour approach a sleeping, female Harlequin Duck (Histrionicus histrionicus) *and jab her in the side with its bill. The startled duck leapt several feet into the air to the obvious amusement of the oystercatcher.*

APPEARANCE

Similar Species: None.

Size: Crow-sized; **Length:** 42-47 cm (16.5-18.5 in); **Wingspan:** 71-91 cm (28-36 in); **Mass:** 500-700 g (17.6-24.7 oz).

Adult

- all-dark body
- long, red-orange bill
- pale pink legs
- yellow iris with red eye ring

Juvenile

- tawny fringe on dark brownish feathers of back and undersides
- bill pale orange with dark tip
- brownish iris with orange eye ring

In flight

- all-dark body and wings

- long, straight, heavy bill
- flight strong and direct, though slow
- small, often noisy flocks

Figure 95. Black Oystercatcher behaves as a year-round sentinel in British Columbia, alerting other wildlife by its loud calls, *Photo by Alan D. Wilson.*

BREEDING

Solitary to loosely colonial nester on small rocky islands and along exposed shorelines of forested areas. Pairs establish a composite nesting and feeding territory that they defend during the breeding season and sometimes year-round. Birds are monogamous and pairs remain together for years, with a low rate of divorce. Courtship occurs on the territory. Nests are in the open, well camouflaged, and often partially obscured by vegetation, rocks, or driftwood. Multiple scrapes are often made, mainly by male, by pressing chest into finer substrates or less frequently by excavating sod with the feet. Female chooses which nest to lay in and often reuses the most elaborate. Chicks are brooded continuously for the first 1-2 days, and then intermittently for up to three weeks by both parents. Young accompany parents to feeding areas by seven days, begin feeding at 10 days , and at 50 days still obtain >50% of food from parents. Begin pairing at three years, and first breed at five years.

Seasonal and diurnal attendance at colony: Active diurnally on colonies. Never seen on water except for bathing in small pools. Breeding season in BC extends from early April, when nest sites are claimed, through the end of September when the latest chicks fledge.[460] Clutches occur from late April to mid-August.[137]

Nest: Usually within a few metres of high tide mark on bare rock or grassy patches on rocky outcrops, and on sand, pebble, or shell beaches; occasionally on man-made structures including rooftops. Nest is lined with bits of shell, pebbles, or wood chips (Figure 96). Occasionally some are constructed entirely of grasses (Figure 97).

Figure 96. Typical Black Oystercatcher nests have a substrate of barnacle shells (shown) or a variety of limpet and mussel shells. It is very unusual to find two nests abutting each other and clutches of four or more eggs. *Photo by R. Wayne Campbell, near Table Island, BC, 17 June 1978.*

Figure 97. Occasionally Black Oystercatcher nests in British Columbia are constructed entirely of grasses. *Photo by R. Wayne Campbell, Conroy Island, BC, 27 June 1978.*

Eggs: Oval to pyriform. Smooth, glossy, cream to olive buff, with dark splotching, especially at larger end (see Figures 96 and 97). Laid at 24-hour intervals. Never left unguarded. **Size:** 56 mm (2.2 in) x 39 mm (1.5 in); **Average clutch size (maximum clutch size):** 2-3(5) (see Figure 96); **Incubation period:** by both sexes 26-28 days.

Young: Hatched with down feathers. Upper parts sooty black with pale buffy tips, neck and breast grey; two, parallel, black stripes down the back; abdomen whitish; legs grey; bill dark with pinkish base. **Average number (maximum):** 1-2(4). **Fledging period:** First flight 38-40 days.

Lifespan: Annual survival after one year >90%; age 9-16 years; maximum 16 years.[12, 460]

CONSERVATION

Recent population estimates suggest that BC houses 10-20% of global populations.[545] As of 1990, 7% of historic nesting sites in BC were abandoned when last surveyed (Table 6, pages 66-67), but it is unknown whether this indicates loss or just intermittent use of some sites. At the same time, populations have expanded into inlets and sounds in the southern part of the province. For example, by the late 1960s, nesting Black Oystercatchers had moved into Howe Sound, at Christie Islet, in the Strait of Georgia.[91] Introduced predators and human disturbance have caused some abandonment. In Skidegate Inlet, most nest failures were due to predation by raccoons and tidal flooding.[597] Most pairs breed on sloping beaches or rocky areas not far above the high tide line and nests and eggs are susceptible to being swept away by storm surges or swells at high tide. Wakes from cruise ships, tankers, and ferries in inlets can damage or wash away nests in areas where large waves are unusual. An intensive study in Alaska, using infrared cameras at night, documented nocturnal nest predation by American Mink, American Marten, and Wolverine (*Gulo gulo*), and diurnal predation by Black Bear.[531]

Efforts are needed to protect water quality to maintain productive intertidal habitats required for foraging, and to limit human disturbance at main nesting and feeding sites. Recreationists (frequently sea kayakers) camping on beaches can disturb nesting birds and impact nesting success. The burgeoning aquaculture industry may impact oystercatchers through changes in local water quality, and through occupation of small islets and shoreline areas used for nesting. Oil spills along the coast are a major concern. Oil from the *Exxon Valdez* spill in Alaska killed 20% of the oystercatcher population, disrupted breeding activity, and reduced chick survival in the spill zone.[12] Global warming, which could impact sea levels and intertidal food supplies, is a growing concern.

An Oyster Banquet

Many writers, including us, have claimed that the name of the Black Oystercatcher is a misnomer. But for the birds living on Mitlenatch Island, in the northern Strait of Georgia, the name is apt. At this location, oystercatchers actually supplement their intertidal diet with oysters!

Pacific Oysters were introduced on Mitlenatch Island about 1958, but it wasn't until 1966 that park naturalists Wayne Campbell and Ken Kennedy first noticed oystercatchers feeding on oysters [86] (Figure 98). It thus apparently took about eight years for the nesting birds to learn to open oyster shells. Birds searched at the edges of ebbing and rising tides for oysters with their shells slightly agape. When they found one, they quickly inserted their chiseled bill into the opening. Usually a tussle ensued that could last for several minutes before the oyster shells were pried apart and the meat was eaten. On more than one occasion, we have seen oystercatchers get into trouble when the oyster clamped onto their bill, the tide began rising around them, and they were unable to free themselves.

By 1978, breeding oystercatchers on Mitlenatch had developed a more efficient technique for harvesting oysters. As Rob Butler and John Kirbyson [81] described, the birds simply chipped a hole through the valve, inserted the bill, and severed the adductor muscle that holds the shells together. Oysters had little defense against this technique.

There are at least 14 additional oyster farms on the inner and outer coast of southern British Columbia but only lease holders at Fanny Bay, on the east coast of Vancouver Island, have reported Black Oystercatchers feeding on their oysters.

Figure 98. Pacific Oysters (*Crassostrea gigas*) were introduced to Mitlenatch Island in the late 1950s and today cover an area of about 1,000 m^2 of a mud-gravel and sand-gravel substrate in a protected bay. *Photo by R. Wayne Campbell, Camp Bay, Mitlenatch Island, BC, June, 1965.*

Population trends to 1990

A total of 1,070 pairs of Black Oystercatcher are estimated to nest at 364 sites, as of 1990 (Tables 3 and 5, pages 63 and 65). Small numbers have been observed at many more sites that have not been designated colonies because evidence of breeding was lacking (see Appendices titled "Islands surveyed with no record of breeding by seabirds" in forthcoming regional chapters of this catalogue for lists of and numbers of birds sighted at such sites). Breeding likely occurs at some of those sites as well as other sites where birds have not been detected. Total breeding populations thus are probably somewhat larger than indicated.

Black Oystercatcher is a widespread breeder and nests at the majority of identified seabird colony sites along the British Columbia coast. It nests at similar numbers of sites as Glaucous-winged Gulls and Pigeon Guillemots (Table 5, page 65). Although it has been noted that Black Oystercatchers and Glaucous-winged Gulls often nest on the same island,[595, 597] the relative abundance of Black Oystercatchers in the various regions of the coast differs from that of Glaucous-winged Gulls. Half of the breeding population of Glaucous-winged Gulls occurs in the sheltered waters of the Strait of Georgia. For Black Oystercatchers, over 90% of the population breeds outside the Strait of Georgia, mostly in the Queen Charlotte Islands (36%) and on the west coast of Vancouver Island (32%; Table 4, page 64). Small numbers breed at most sites. Largest colonies occur on Cleland Island (44 pairs), McQuarrie Islets (37 pairs), Triangle Island (25 pairs) and Storm Islands (18 pairs) off the west side and north end of Vancouver Island; on the Moore Islands (21 pairs) off the central mainland coast; and on "Grassy" Islet (16 pairs) and "Naden" Rocks (15 pairs) off the west and north sides of Graham Island in the Queen Charlotte Islands. In total, twenty-one individual colonies support 10 or more nesting pairs. As of 1990, the largest colonies in the Strait of Georgia support 3-4 pairs, although as many as 6-8 pairs have been recorded in the past on Mitlenatch Island, Hudson Rocks, Mandarte Island, and Chain Islets.

Population trends are difficult to infer from available data because repeated and complete historical surveys using the same methods to locate nests are lacking [80, 595] (Figure 99). Counts in the Queen Charlotte Islands in 1977 and 1986 suggested an increase of over a third, but a greater proportion of empty nests were recorded in 1986 and confidence in the apparent trend was low.[470] The number of nesting pairs documented in the 1990 study in Skidegate Inlet by Vermeer et al.[597] was the same as the number of nests counted there in 1986.[470] However, 33 of the 54 nests tallied in 1986 were empty. The opposite pattern was apparent on the west coast of Vancouver Island. Counts there were higher in 1975 than 1988 at colonies surveyed in both years but more empty nests recorded in 1975 accounted for most of the difference.[475, 650] Numbers of pairs estimated nesting at colonies surveyed in 1989 on the west coast of Vancouver Island [590] were similar to those recorded in 1975,[475, 650] but many sites were surveyed only from the water in 1989. In Queen Charlotte Strait, oystercatchers were recorded nesting at more sites in 1982/1987 (20) than in 1975/1976 (14), but total numbers were similar and suggested little population change.[477, 650] The most complete counts in the Strait of Georgia were conducted in 1978 and 1987 when 78 and 67 nests were counted at 44 and 43 colony sites, respectively, although a number of known nest sites were not surveyed each year.[595, 650] Similar numbers of nests at 28 colonies surveyed in both 1978 (51 nests) and 1987 (47 nests) again suggest little population change. Interpretation of trends would be assisted if future surveys use consistent methods, count nests from land, and if information on empty nests was consistently recorded, including whether those nests are likely associated with hidden young and whether multiple nests are close together and likely represent one nesting territory.

Figure 99. Inconsistencies in census methods make statements on population trends problematic. For example, estimated Black Oystercatcher breeding populations from counts of adults viewed from the sea cannot be reliably compared to nest counts from a complete search for nests and chicks on land. *Photo by R. Wayne Campbell, Mitlenatch Island, BC, July 1965.*

Populations since 1990

Extensive surveys for Black Oystercatchers have been conducted and many new nesting sites have been confirmed since 1990, especially on the east coast of Moresby Island and in the Strait of Georgia and Gulf Islands. Surveys since 1990 suggest that breeding populations have remained stable or perhaps increased. In the Queen Charlotte Islands, Laskeek Bay Conservation Society (LBCS) has been monitoring colonies in the Laskeek Bay area annually since 1992. They recorded 24 pairs and found 18 nests with eggs at six colonies (Lost, Reef, South Low, East Limestone, Low and Skedans islands) during the first year of surveys in 1992.[264] Fifteen pairs were estimated nesting at those colonies as of 1990. LBCS found more nests the following season at seven colonies (Kingsway Rock was added with one nest), totalling 28 nests with eggs or chicks.[260] With some fluctuations, numbers of nests on monitored colonies have remained similar since, e.g., 24 nests with eggs or chicks in 2013 [438] and 32 nests with eggs or chicks in 2014,[286] except there were only 10 nests with eggs or chicks in 2002.[523] Laskeek Bay was designated as an Important Bird Area in 1999 for its population of oystercatchers.[179]

Additional sites were surveyed to the south of Laskeek Bay in 1994,[268] and surveys were conducted as far south as Ramsay Island in 2004 [178] and 2006.[469] A more extensive survey from Laskeek Bay south to Woodruff Bay on Kunghit Island was conducted in 2005 in a co-ordinated effort by LBCS and CWS.[468, 640] LBCS has also been working in conjunction with Parks Canada and the Pacific Wildlife Foundation partnered with BC Parks to monitor populations in the coastal national parks. As part of that collaboration, LBCS conducted surveys over a larger area of Gwaii Haanas National Park Reserve in 2010, 2011, 2013, and 2014.[286, 437, 438]

On the extensive survey in 2005, CWS surveyed the area from Woodruff Bay on Kunghit Island north to De La Beche Inlet on the west side of Juan Perez Sound (encompassing designated colonies from the east side of Kunghit Island [EM-010] north to Hoskins Islets [EM-450]), while LBCS surveyed the Laskeek Bay colonies south to Ramsay Island (including designated colonies from Ramsay Island [EM-470] north to Skedans Islands [EM-740]). As far as we can tell, Tatsung Rock (EM-460), which had four pairs nesting in 1986, was not surveyed in 2005. On the CWS portion of the 2005 survey, 114 pairs of Black Oystercatchers were confirmed nesting at 51 sites, 93 pairs at 36 colonies where 84 pairs were estimated nesting as of 1990, and 21 pairs at fifteen new nesting sites.[640] New nesting sites included three successfully nesting pairs on tidally-connected rock outcrops on the mudflat at the head of Carpenter Bay, on the main shore of Moresby Island. Those and some other unusual nest sites indicated that Black Oystercatchers are more flexible in their choice of nesting habitat than has been previously assumed and that surveys should cover all shoreline areas. LBCS found 78 nests with eggs or chicks in the area they surveyed in 2005. The previous year, LCBS found 66 nests in the same area. As of 1990, 48 pairs were estimated in that area. In the combined area surveyed by CWS and LBCS, 192 nests with eggs or chicks were found in 2005 compared to 132 pairs estimated nesting (75 confirmed with eggs or chicks) as of 1990. Much of the difference may be due to more complete coverage of shoreline areas, timing of surveys, and the discovery of many new nesting sites in 2005.

Most sites where Black Oystercatchers were confirmed nesting during the LBCS and CWS surveys along the east coast of Moresby Island since 1990 were at previously identified seabird colonies. Breeding by Black Oystercatchers had been confirmed at most of those colonies, but at some colonies, breeding had been previously suspected but never confirmed as of 1990 (Garcin Rocks, Howay Island, Arichika Island, Alder Island, Ramsay Rocks, Topping Islands, Titul Island, South Low Island, and Low Island). At others, oystercatchers had been sighted but there had been no previous evidence of nesting (George Island and Jeffrey Island), or there were no previous records of oystercatchers on the island (the south islet off Hutton Point, which is included in the Hutton Island colony, and Dog Island). In addition, nesting was confirmed at sites that were not designated seabird colonies as of 1990. Oystercatchers had been recorded at some of those sites prior to 1990 (Kunga Island, Faraday Island, Stansung Island, Sivart Island, All Alone Stone, and Haswell Island) but not at others ("Otter" Islet [we are unsure of the location of this islet; see Gaston et al.[268]], Shuttle Islands, Lyell Point [western extremity of Lyell Island], Nelson Point and the point due west of Nelson Point on Louise Island, two rocky islets in Skaat Harbour, a rock off Section Island, an islet in Poole Inlet, a rock at the mouth of Collison Bay southwest of Nest Islets, five sites in Carpenter Bay [3 at the head, one in South Bay and one in Koya Bay], and the rocky point on the southwest side of Treat Bay). In total, 26 new nesting sites of Black Oystercatchers have been identified along the east coast of Moresby Island since 1990, bringing the total number of known, historical breeding sites for that region to 92 (see Table 6, page 66). In addition, Black Oystercatchers have been found breeding again at two sites where they were historically suspected nesting but were absent as of 1990 (Titul Island, EM-640 and Garcin Rocks, EM-090). As far as we can tell from available data, this brings the number of current breeding sites on the east coast of Moresby Island to 89 (see Table 5, page 65), 86 of which are now confirmed. Wanderer Island (EM-350), Park Island (EM-370), and Gil Islet (EM-600) remain historically suspected breeding sites, although no oystercatchers were found nesting at those sites on the surveys conducted since 1990.

On the north coast of Graham Island, new nesting locations have been reported on the sandy beach at Skonun Point [189] and on rocky areas in the McIntyre Beach and Rose Spit Important Bird Area.

Hipfner et al.[329] studied breeding biology and reproductive success on Triangle Island from 2003-2011. Numbers of nests with eggs found ranged from nine to 15 in the study area on the south and west sides of the island. We found 10 nests in that area in 1989.[484] Parks Canada [431] conducted some surveys in Pacific Rim National Park in the early 2000s that indicated an increasing population on Seabird Rocks and Florencia Island. Surveys in 2004 indicated stable populations since 1983 on Cleland Island and other colonies in Clayoquot and Barkley sounds.[184]

We know of two surveys in the Strait of Georgia since 1990. During her studies in 1996-1997, Hazlitt [318] found 34 breeding territories on 15 islands in the southern Gulf Islands where Vermeer et al.[595] had reported 16 nests in 1987. Three territories found on Sidney Spit represent a new breeding location for the species and a new seabird colony identified since 1990. A more comprehensive survey in 2005-2006 plus data from 1997-1999 resulted in an estimate of 92 pairs nesting in the Strait of Georgia,[80] more than the 64 pairs tallied by Vermeer et al.[595] in 1987, but similar to our estimate of 99 pairs nesting as of 1990 (Table 3, page 63). Twelve new breeding sites were found in the 2005-2006 study: Cortez Bay, Copeland Islands, Whitestone Islet, Paisley Island, and Hodgson Islands (rock) in the northern Strait of Georgia; and Brandon Islands (rocks), Wallace Island (rock), Turtle Rock, Unit Rocks, Harris Islet (we are unsure of the location of Harris Islet), Chatham Islands and Discovery Island in the Gulf Islands region.[80] An additional nesting site on the Tsawwassen Breakwater was also found since 1990.[634] Nesting on the Tsawwassen jetty had been confirmed earlier in 1989 (Figure 100). Of the new breeding sites found for Black Oystercatchers in the Strait of Georgia, only Hodgson Islands, the Tsawwassen Breakwater, Wallace Island, and Discovery Island were previously designated as seabird colonies as of 1990.

Figure 100. Black Oystercatcher has nested on the BC Ferries Tsawwassen jetty since at least 1989. Note nest in bottom centre of photo. *Photo by R. Wayne Campbell, Tsawwassen ferry jetty, Delta, BC, 9 June 2013.*

Glaucous-winged Gull

Larus glaucescens **GWGU**

(*Sea Gull*, *Garbage Hawk*, *Garbage Goose*)

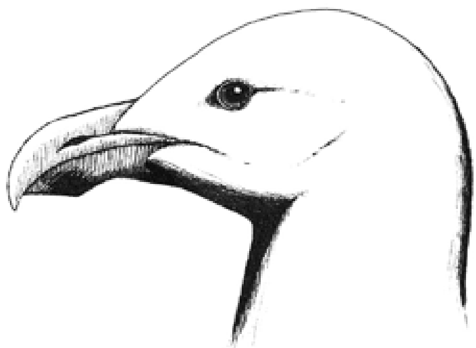


Figure 101. This Pacific Northwest gull is a familiar sight year-round from the Alaskan coast to northwestern Oregon. Occasionally a few wander into the southern interior of British Columbia. *Drawing by Keith Taylor.*

Though applied to many types of gulls, whether they are near the sea or not, in BC the appellation "sea gull" is rightly reserved for the Glaucous-winged Gull. It is resident and common along our coast and is the species often seen following ferries. Floating effortlessly and often pacing even the fastest boat with nary a wingbeat, they seem masters of the air, akin to the angels. But its raucous squabbling and screeching when mooching in city parks and scavenging on beaches, at the dump, or following a fish boat, betray a baser nature. Huge flocks of up to 20,000 aggregate where Pacific Herring, salmon, or Eulachon (*Thaleichthys pacificus*) are spawning. At night the gulls roost in large flocks on the water in sheltered bays, inlets, rivers, and lakes, or on small islands and log booms. Though common in coastal BC throughout the year, some birds from colonies in BC migrate up to 2,050 km southward after the breeding season.

Deadly Disease

Most seabird surveyors are unaware that a life-threatening disease can be transmitted by Glaucous-winged Gulls. The culprit is Aspergillus fumigatus, *a common air-borne mould (fungus). It is inhaled daily by most people but only affects those with weakened immune systems or lung diseases.*[365] *On seabird colonies, it is present in the soil and can be released into the air from drying gull droppings. James Kippen, lighthouse keeper on Merry Island off Sechelt from 1966 to 1978, collapsed while walking on a ramp to survey nesting gulls and cormorants on the island. Both he and his wife Ethel were regular participants in the BC Nest Record Scheme. James went undiagnosed for five years and received regular shots of cortisone, which, as an immunosuppressant, could only have exacerbated the problem, before it was suggested by another lightkeeper that his symptoms indicated a form of chronic pulmonary aspergillosis. While winter trips to Mexico helped alleviate breathing problems, James eventually succumbed to the disease.*

Though previously uncommon, concern about the disease has increased in recent years because the number of immunosuppressed patients, such as those with cancer, and immunosuppressive therapies used to treat autoimmune diseases such as rheumatoid arthritis have increased. Today, A. fumigatus *has become the most prevalent airborne fungal pathogen, causing severe and usually fatal invasive infections in many cancer patients.*[365] *Protective measures to avoid breathing these airborne pathogens should be taken by seabird surveyors, especially those with compromised immune systems.*

APPEARANCE

Similar Species: Other large gulls.

Size: Larger than a mallard; **Length:** 61-68 cm (24-27 in); **Wingspan:** 132-137 cm (52-54 in); **Mass:** 737-1403 g (1.6-3.1 lbs).

Adult breeding

- white with pale grey mantle
- wingtips grey with white spots
- yellow bill with red spot
- pink legs and feet

Adult winter

- same as breeding except head streaked with brown
- opportunistic scavenger, common in harbours and garbage dumps

Juvenile in flight

- mottled greyish-buff overall
- wing colour same as body
- black bill
- light barring on rump

BREEDING

Single to colonial nester on small offshore islets, headlands of larger islands, rooftops (Figure 102), jetties, bridges, and other man-made structures along the coast, and rarely further inland on lakes. Colony size is mostly less than 100 pairs; maximum size of 3,500 nests. Males establish nesting territory of 6-20 m^2, and fights between rivals can be fierce and sometimes bloody. Female solicits courtship feedings from mate by tossing her head upward and calling. Courtship feeding peaks just before egg-laying and stops when the clutch is complete. Chicks peck at their parents' bill to elicit feedings. A 1980 study of breeding birds [570] showed that refuse occurred in 69% of adult and 22% of chick feedings in the Strait of Georgia but was uncommon elsewhere. Lower frequencies of refuse in both adult (41%) and chick diets (4-16%) were found in the Strait of Georgia in a 2009-2010 study.[202] Young first breed at 4-7 years. Fidelity between mates is high and pair bonds are long-term.

Urban Nightmare

As Glaucous-winged Gull populations increased on the inner south coast in the 1960s, mainly attributed to an increase in available refuse, pairs starting exploiting human structures and habitats in cities for nesting. The first urban roof-nesting was reported in 1962 in Vancouver Harbour and slowly, over the following 13 years, numbers and sites increased and small populations became established. New habitats included jetties, bridge abutments, and abandoned scrap yards.[101, 426, 457, 498] Nesting gulls quickly became a nuisance, their droppings were fouling buildings and eroding gravel rooftops, people were being attacked, and part of the gulls' diet now included young Rock Pigeons that they eviscerated.[497] Office workers were aghast! Later, a similar situation developed in Victoria at the south end of Vancouver Island, with flat-and pitch-roofed urban houses used as new nest sites.

Since the early 1990s, two pairs of Glaucous-winged Gulls have been nesting on the roof of the Fish and Wildlife Branch office at 780 Blanshard Street in Victoria. In 1993, technician Andy Stewart and I (Wayne) decided to monitor the nests and band the young. Big mistake – the adults were able to identify us without needing to band us! The day after banding, one of the adults – "Larry", as we affectionately called him - flew from the roof ledge to the adjacent parking lot and dive-bombed one of us as we got out of the car. It was an embarrassing experience because the swoop was accompanied with loud noisy calls. "Larry" singled us out for the rest of the nesting period. The adults finally left the building with two young in August.

The following year "Larry" was back at it again even before nesting had begun. Attacks were less frequent but it was still humiliating to have to explain to others parking their cars why we were being targeted. At least we could also identify him!

Figure 102. Glaucous-winged Gull nest and eggs on roof of BC Fish and Wildlife Branch office at 780 Blanshard Street, Victoria, BC. The adult's vantage point to survey the area is well marked by white droppings. *Photo by R. Wayne Campbell, 29 June 1993.*

Seasonal and diurnal attendance at colony: Active at colonies during the day. Common singly or in small groups on the water around colonies, but generally roosts ashore. At Mandarte Island in southern BC, birds return to colonies from early February to late April.[565] First eggs are laid at the end of April, and clutches have been recorded as late as 20 August.[137] Late chicks are present through September.

Nest: Loose bowl of grasses, mosses, forbs, twigs, and debris usually built on the ground but also on human-made structures; rarely in trees. Most material gathered from territory, but seaweeds often used on bare, rocky areas (Figure 103). Nest sites are reused from year to year.

Figure 103. Frequently, Glaucous-winged Gull nests found on rocky headlands or islets along the west coast of Vancouver Island are constructed entirely of seaweeds, in this case bladderwrack (*Fucus gardneri*). *Photo by R. Wayne Campbell, McQuarrie Islets, BC, 23 June 1975.*

Eggs: Subelliptical. Smooth or slightly granular, non- to slightly glossy, pale olive to olive-green with pale grey or violet to dark olive-brown blotches and scrawls (see Figure 103). **Size:** 72 (2.8 in) x 50 mm (2.0 in), third egg smaller; **Average clutch size (maximum clutch size):** 3(5); **Incubation period:** 27 days, equally shared.

Young: Hatched with down feathers. Buffy with black spots, eyes open, bill and feet black; mobile, will run and hide after 2 days. Fed mostly regurgitated fish 5-10 times per day by both parents. **Average number (maximum):** 2-3(4). **Fledging period:** 37-53 days.

Lifespan: Only 6% of chicks survive to breeding age. For birds that live to 4 years, average lifespan is 9.5 years; maximum 37 years, 2 months, 11 days.[109]

CONSERVATION

About 15% of the estimated North American breeding population of 180-200,000 pairs [563] nest in BC. Reduction in human harvest of eggs and chicks, and increased availability of garbage and fisheries waste resulted in population expansion during the 1900s (Figure 104). Changes in garbage disposal methods and reduction in fishing activity could reverse this trend. Birds are vulnerable to oil and other contaminates in nearshore waters. Introduced mammalian predators can eliminate nesting colonies. Bald Eagles prey on larger young, immatures, and adults. Pursuit of adult or immature gulls can be prolonged and often becomes a battle of endurance with the intended victim trying, often successfully, to outmanoeuvre and soar above the attacking eagle. Human disturbance at colonies increases predation on eggs and chicks by conspecifics and corvids, but nesting birds show great tenacity in the face of disturbance, dive-bombing and defecating on intruders. Roosting birds are hazards at airports and feeding birds spread garbage at dumps.

Figure 104. Ed Sing (left) and Eileen Campbell reading and recording numbers on banded Glaucous-winged Gulls at the Vancouver Landfill in Delta, BC. By visiting the nearby colony on the Tsawwassen ferry breakwater, they determined that adults travelled 14 km, one way, several times a day with food from the dump to feed their young. *Photo by R. Wayne Campbell, Delta, BC, 15 November 1969.*

Experience Pays Off

Gull banders are among the most passionate and patient of volunteers. Their activities take place on remote, slippery, and stinky islands. Just getting to the islands depends on the vagaries of weather and sea conditions that would frustrate less dedicated individuals. Once on land, the constant screaming and attacking by territorial birds is intimidating. Gulls can be menacing and their attacks often result in bloody wounds.

In the 1960s, the Pacific International Chapter of the Western Bird-Banding Association was established to study the movements of Glaucous-winged Gulls in the Pacific Northwest.[127] *Banding was focused on colonies in the Strait of Georgia, Haro Strait, and the central west coast of Vancouver Island. Many volunteers that participated in the project had never visited a seabird colony or banded birds* (Figure 105). *The neophytes, however, learned quickly. On Christie Islet, in Howe Sound, Bill Hughes and Jack Sarles both encountered the wrath of gulls when disturbed. Both men, balding and without protective hats, were viciously struck on their heads by the bill and feet of diving gulls. A trickle of blood ran down Bill's head but Jack looked as if he had been in a major fight. Head wounds always look worse than they are but we decided to abandon the trip and get Jack to a hospital. Four stitches and a week later Wayne and Jack returned to the islet but this time Jack was wearing a hard hat!*

In the early 1970s, the banding program included colonies in the southern Strait of Georgia and Haro Strait, especially Greater Chain Island in Oak Bay off Victoria. This was a particularly nasty colony and volunteers required previous experience before banding. On every trip over a period of seven years, a pair of old gulls left their territory on top of the island and flew screaming at the banders approaching the island when they were still a couple hundred metres away. This behaviour was disconcerting to new banders. They were instructed to grab a short piece of driftwood and tuck it in their shirt behind their neck leaving about nine inches projecting above their head. The rationale was that attacking gulls would strike the tip of the stick leaving the bander both hands free to catch and hold the young birds for banding. It worked – there were no casualties!

The decade or so of intense seabird banding yielded many published articles including new information on longevity, mortality, dispersal, and age at first breeding [83,100,109,315] (Figure 106).

Figure 105. The success of any injury-free banding expedition, in part, includes dressing for the occasion. In this photo, Bill Anderson (left) and two visitors to Wickaninnish Park, are well dressed and protected from faecal bombing and physical attacks by territorial Glaucous-winged Gulls. *Photo by R. Wayne Campbell, Sea Lion Rocks, BC, July 1967.*

Population trends to 1990

The distribution of Glaucous-winged Gulls in British Columbia (Figures 107, 108, and 109) is similar to that of Pelagic Cormorants. Of 27,734 pairs estimated to breed in the province as of 1990, 50% nest in the Strait of Georgia and 26% nest on the west coast of Vancouver Island, including the Scott Islands (Tables 3 and 4, pages 63-64). The largest colonies occur on Mitlenatch Island, Mandarte Island and Chain Islets in the Strait of Georgia, and on Cleland Island on the west coast of Vancouver Island (Table 11, pages 119-120). Most of the 333 nesting sites (Table 5, page 65) are located on maritime islands, but a burgeoning population has colonized urban sites in Victoria (110 pairs in 1986 [338]) and Vancouver (about 500 pairs in 1986 [601]), and one to two pairs nest on Fulmore Lake, 3.5 km from the nearest salt water at the head of Port Neville in the Johnstone Strait area.[477] In 1972, Merilees [390] observed a single Glaucous-winged Gull nesting with a Herring Gull on Okanagan Lake, over 300 km inland from Vancouver.

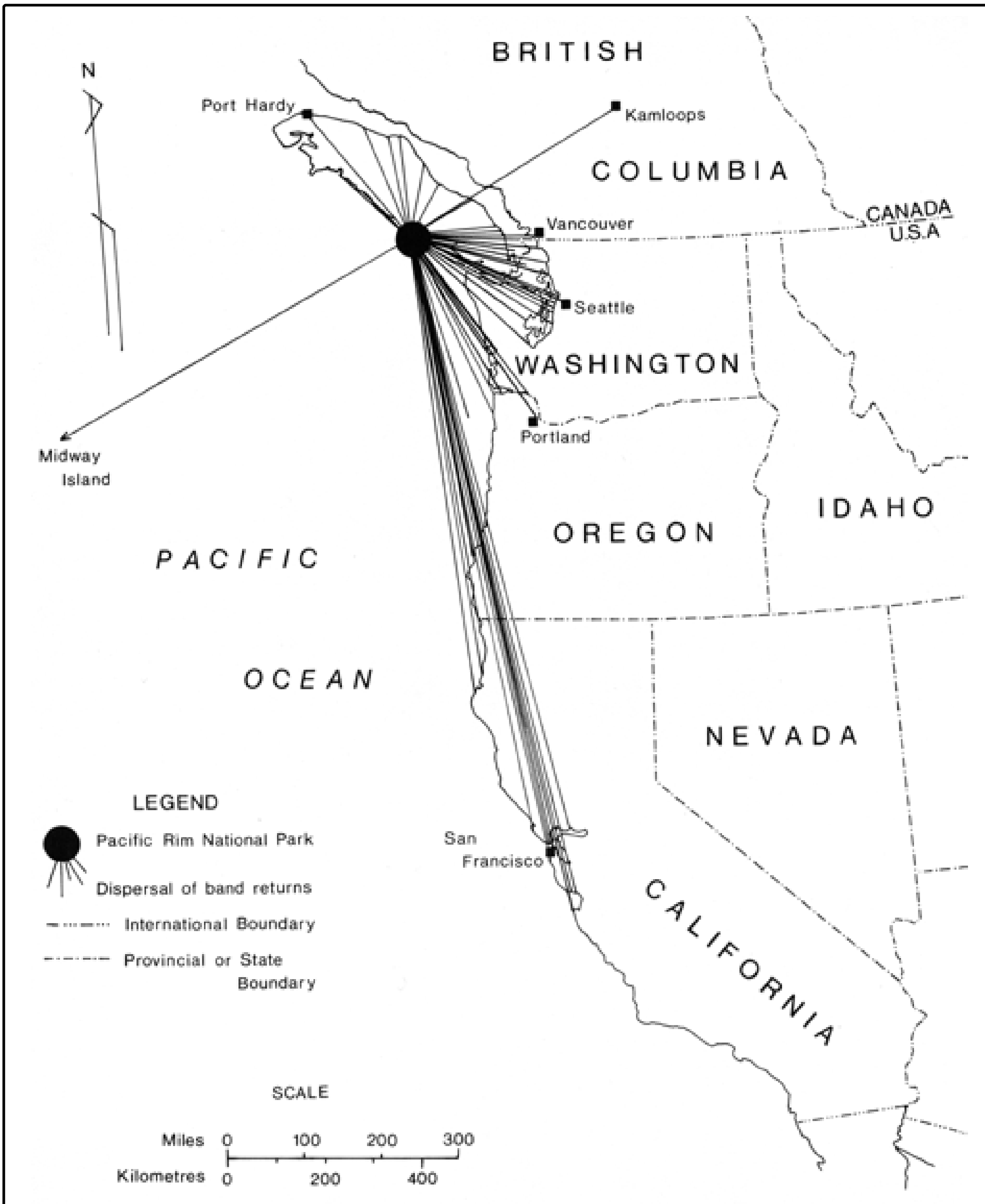


Figure 106. At least 6,552 young gulls were banded on six colonies on the central west coast of Vancouver Island between 1967 and 1972 resulting in 297 (4.5%) recoveries. As might be expected, most band returns were from coastal areas, some as far south as Carmel in California (1,430 km). Two noteworthy returns were from Kamloops, 425 km inland in BC, and Midway Island, in the North Pacific Ocean, nearly 5,000 km southwest of Vancouver Island (from Hatler et al.[315]).

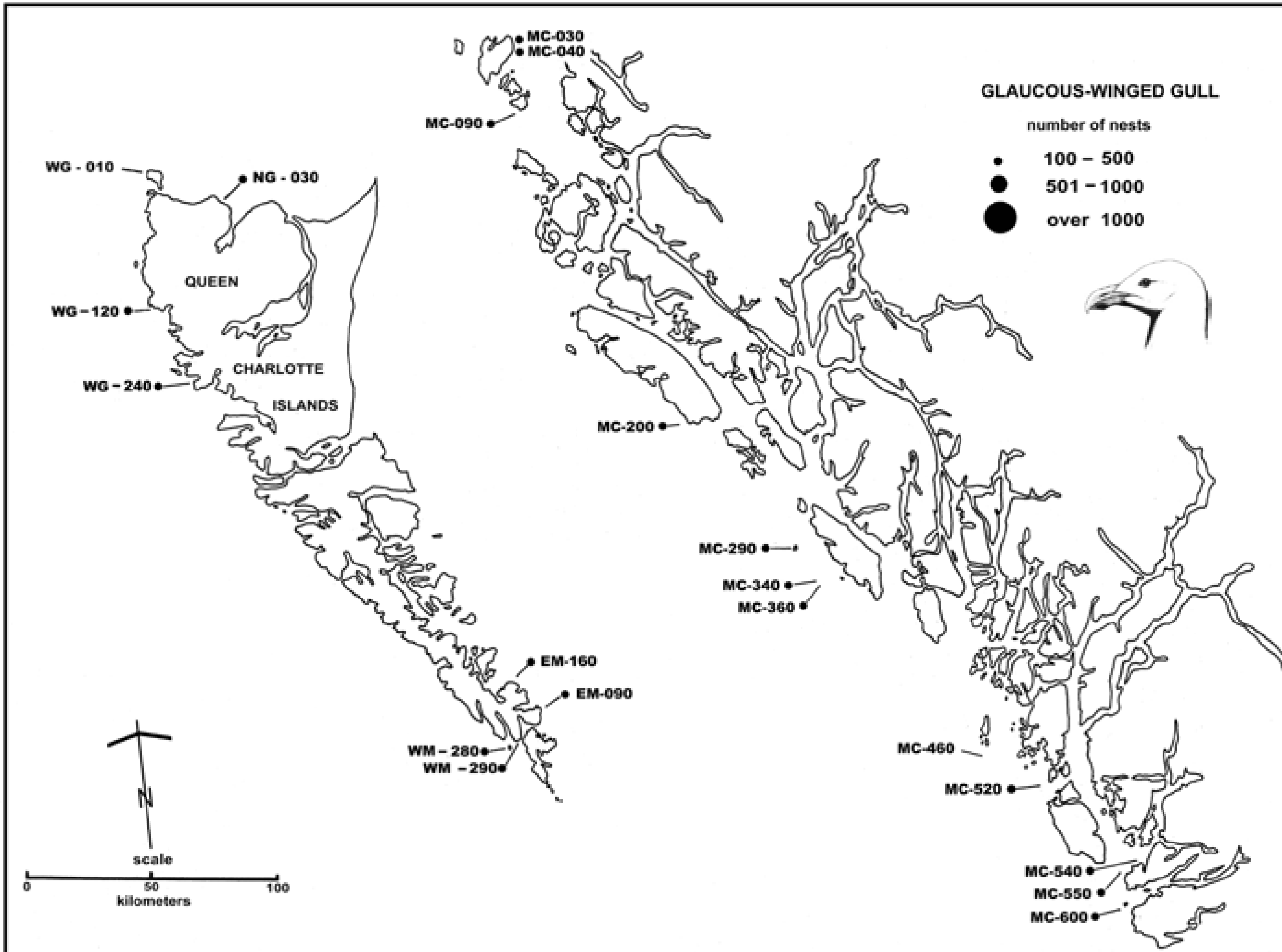


Figure 107. Major Glaucous-winged Gull colonies (>100 pairs) in northern British Columbia. Smaller colonies have not been mapped (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC). Site codes refer to colonies listed on Table 11.

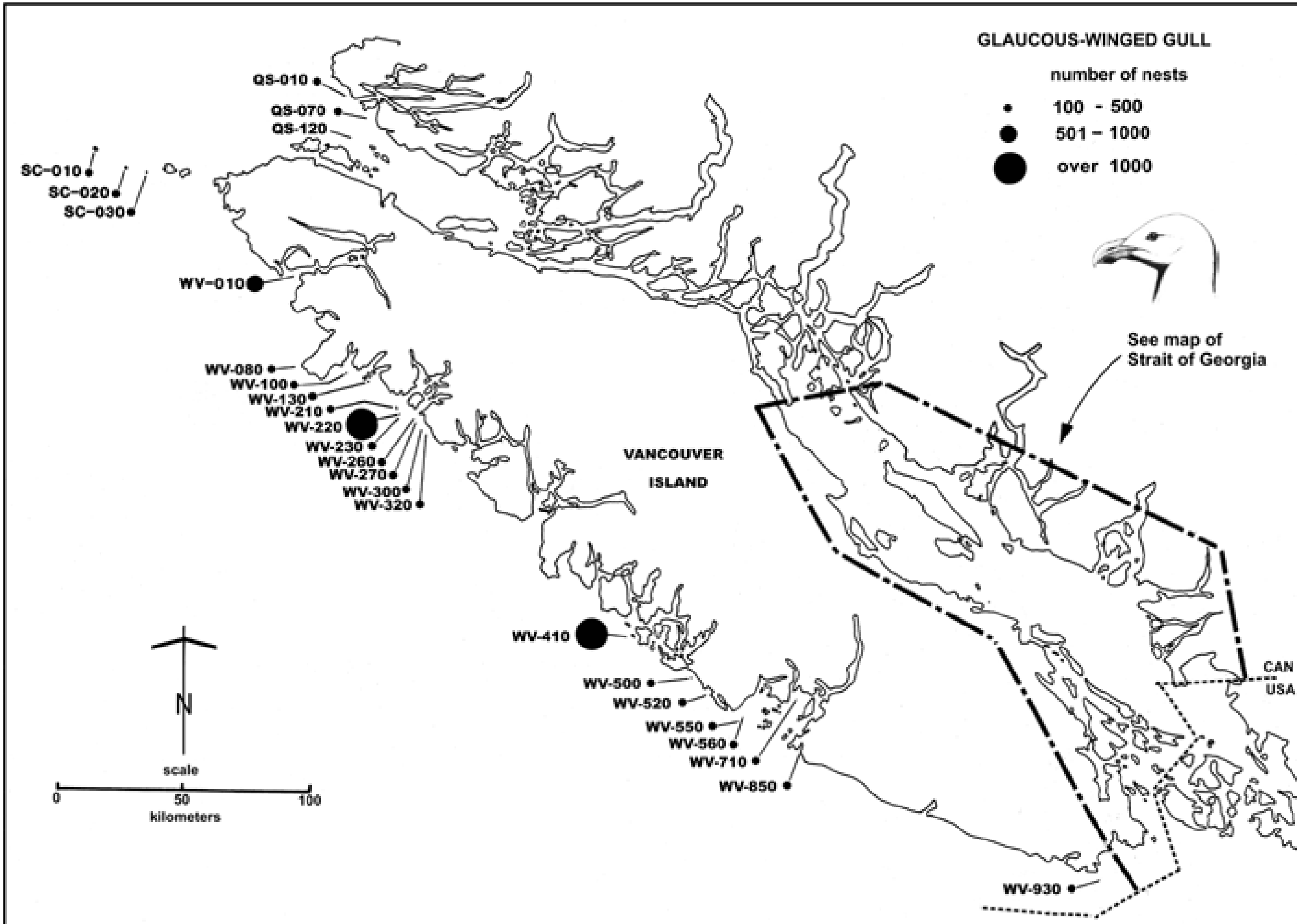


Figure 108. Major Glaucous-winged Gull colonies (>100 pairs) on the north and west coasts of Vancouver Island. Smaller colonies have not been mapped (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC). Site codes refer to colonies listed on Table 11.

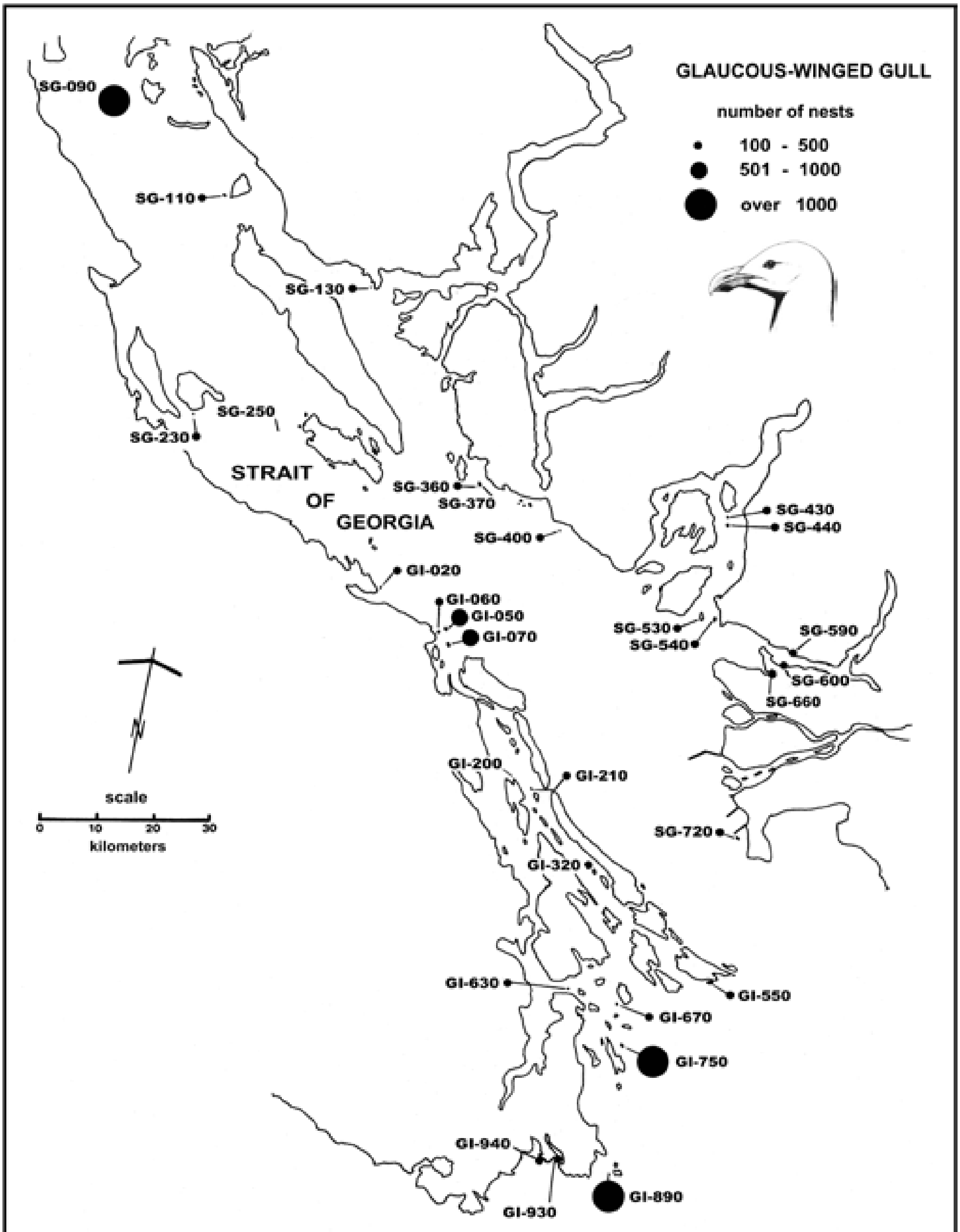


Figure 109. Major Glaucous-winged Gull colonies (>100 pairs) in the Strait of Georgia. Smaller colonies have not been mapped (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC). Site codes refer to colonies listed on Table 11.

Table 11. Estimates of breeding populations (numbers of nests counted) of Glaucous-winged Gulls at major colonies (>100 pairs) in British Columbia as of 1990. Colonies with historical populations greater than 100 pairs are also included (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC). See Key to Summary Tables on pages 53-56 for an explanation of the letter codes used to qualify population estimates.

Location		Nests	Survey Year	Source[a]
West Coast Graham Island				
WG-010	Langara Island	73	1986	470
WG-120	Tian Islets	212	1988	634
WG-240	Sadler Island	114	1986	470
West Coast Moresby Island				
WM-280	Anthony Island	352	1986	470
WM-290	Flatrock Island	145	1986	470
East Coast Moresby Island				
EM-090	Garcin Rocks	102	1986	470
EM-160	Joyce Rocks	197	1986	470
North Coast Graham Island				
NG-030	“Naden” Rocks	110	1986	470
Northern Mainland Coast				
MC-030	Grey Island	108	1988	476
MC-040	Green Island	248	1988	476
MC-090	“Simpson” Rocks	178	1988	476
MC-200	Joseph Island	245	1988	476
MC-270	Wells Rocks	83	1988	476
MC-290	Moore Islands	150	1988	476
MC-340	Byers Islands	112	1988	476
MC-360	Conroy Island	208	1988	476
MC-460	Gosling Rocks	83	1988	476
MC-520	North Pointers	119	1988	476
MC-540	Major Brown Rock	319	1988	476
MC-550	Dugout Rocks	141	1988	476
MC-600	Egg Rocks	140	1988	476
Queen Charlotte Strait				
QS-010	Bremner Islet	144	1982	477
QS-070	Rogers Islands	138	1982	477
QS-120	Buckle Group	65	1987	477
Scott Islands				
SC-010	Triangle Island	577e	1989	484
SC-020	Sartine Island	390e	1989	484
SC-030	Beresford Island	110e	1989	484
West Coast Vancouver Island				
WV-010	Gillam Islands	477	1989	594
WV-080	Solander Island	530eS	1989	594
WV-100	O’Leary Islets	92eS	1989	594
WV-130	Bunsby Islands	105eS	1989	594
WV-210	Moos Islet	79[b]	1989	594
WV-220	Thornton Islands	523	1989	594
WV-230	“Mimulus” Islets	[b]	1989	594
WV-250	Munsie Rocks	119[b]	1989	594
WV-260	Nipple Rocks	72	1989	594
WV-270	Volcanic Islets	155	1989	594

Table 11 cont'd.

Location		Nests	Survey Year	Source[a]
WV-300	Grassy Island	73	1989	594
WV-320	McQuarrie Islets	62eS	1989	594
WV-410	Cleland Island	1,848	1989	594
WV-500	Sea Lion Rocks	120eS	1989	594
WV-520	Florencia Islet	186	1989	594
WV-550	Starlight Reef	320	1989	594
WV-560	Great Bear Rock	175	1989	594
WV-710	Baeria Rocks	130	1989	594
WV-850	Seabird Rocks	225	1989	594
WV-930	Race Rocks	424	1989	594
Northern Strait of Georgia				
SG-090	Mitlenatch Island	2,100	1986	581
SG-110	Vivian Island	208	1986	581
SG-130	McRae Islet	262	1986	581
SG-230	Norris Rocks	287	1986	581
SG-250	Sisters Islets	25	1986	581
SG-360	Franklin Island	216	1986	581
SG-370	Merry Island	6	1986	581
SG-400	White Islets	490	1986	581
SG-430	Christie Islet	454	1986	581
SG-440	Pam Rock	109	1986	581
SG-530	Passage Island	384	1986	581
SG-540	Grebe Islets	108	1986	581
SG-590	North Vancouver	158e	1986	601
SG-600	Vancouver Harbour	112e	1986	601
SG-660	False Creek	172e	1986	601
SG-720	Tsawwassen Breakwater	238	1986	581
Gulf Islands				
GI-020	Ada Islands	124	1986	581
GI-050	Five Finger Island	671	1986	581
GI-060	Hudson Rocks	247	1986	581
GI-070	Snake Island	673	1986	581
GI-200	Ragged Islets	69	1986	581
GI-210	Rose Islets	116	1986	581
GI-320	Ballingall Islets	145	1986	581
GI-550	Java Islets	298	1986	581
GI-630	Arbutus Island	150	1986	581
GI-670	Imrie Island	216	1986	581
GI-750	Mandarte Island	2,363	1986	581
GI-890	Chain Islets	2,432	1986	581
GI-930	Victoria	110	1986	338
GI-940	Brothers Islands	143	1981	650

[a] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.
[b] We suspect that the count listed for Moos Islet in Vermeer et al.[594] may include WV-230 "Mimulus" Islets, and the count listed for Munsie Rocks may include WV-240 "Crag" Rocks. Maximum count for Munsie Rocks prior to 1989 was 72 pairs in 1975 and this colony may have never had >100 pairs nesting.

Historical data available for the major colonies in the Strait of Georgia suggest that populations in that area tripled in the 60 years prior to 1990.[83, 101, 213, 581] Intensive egging in the early part of the century suppressed population levels.[213, 354, 355] The gradual decline of that practice, following protection of seabird colonies under the Migratory Birds Convention Act of 1916, combined with the increase in refuse as a food source are the main factors considered responsible for population growth,[79, 565, 570, 571] although the importance of refuse has been questioned.[464, 610] Repeat surveys of most colonies in 1974, 1978, 1981, and 1986 indicated continued population growth up to about 1978, after which numbers appeared to stabilize. Totals counted were 9,682 pairs at 50 sites in 1974, 13,028 pairs at 73 sites in 1978 (except Mandarte Island that was surveyed in 1977; see Strait of Georgia chapter), 11,924 pairs at 66 sites in 1981, and 13,863 pairs at 76 sites in 1986.[338, 581, 601] Trends have varied at different colonies. Numbers on Mitlenatch Island peaked at 2,558 pairs in 1978, whereas the highest counts on Mandarte Island (2,363 pairs) and Chain Islets (2,432 pairs) occurred in 1986. Highest counts also occurred in 1978 at eight other large colonies. Although numbers at island colonies may have stabilized, populations may still be increasing at urban sites. Vermeer [575] reported a 9% increase in the nesting population and in the number of sites used by rooftop-nesting gulls in a study area along False Creek in Vancouver between 1986 and 1989. That study area was considered representative of downtown Vancouver and recorded trends in the nesting population were probably indicative of urban populations generally.[575]

Figure 110. Populations of Glaucous-winged Gulls in BC vary over the years. Banders have a good sense of local trends from the number of young banded. *Photo by R. Wayne Campbell, Mitlenatch Island, BC, July 1965.*

Population counts from 1975-1977 and 1986-1988 indicated increases of 30% in the Queen Charlotte Islands [470] and 48% along the northern mainland coast over that period.[476] Overall estimates in Queen Charlotte Strait and on the west coast of Vancouver Island were similar in the 1970s and 1980s, but individual colonies showed contrasting trends, some increasing and some decreasing. However, survey data for those regions were collected over multiple years in both time periods making accurate comparisons problematic.[104, 475, 477, 650] We do have surveys of a large proportion of the colonies on the west coast of Vancouver Island repeated in 1975, 1988 and 1989. Those counts indicate a 9% increase from 1975 to 1988, followed by an 18% decline between 1988 and 1989 (see West Coast Vancouver Island chapter). The lower numbers nesting in 1989 than 1988 corresponds to a similar difference observed for Pelagic Cormorants in that area, and supports speculation that food shortage may have compromised seabird reproductive performance along the west coast of Vancouver Island in 1989.[594] Fledging success was also reduced at west coast Vancouver Island colonies studied in 1989 compared to colonies in the Strait of Georgia (Figure 110). As with Pelagic Cormorants, the decrease was not seen in the outer Scott Islands or at Race Rocks at the extreme northern and southern ends of the Vancouver Island west coast, again supporting the contention by Vermeer et al.[594] that different oceanographic conditions prevail in those areas compared to the rest of the Vancouver Island west coast.

Traditional egg harvesting still occurred in some areas through 1990. Vermeer et al.[600] documented egging at the four largest colonies in Skidegate Inlet, in the Queen Charlotte Islands, in 1990. Continued egging throughout the nesting season resulted in reproductive failure at one colony, but fledging success was similar in undisturbed and egged colonies if egging only occurred early in the season, although timing was delayed. Vermeer et al. [600] found 182 pairs nesting at 18 islands in 1990 compared to 51 nests at 11 sites in 1977 and 116 nests at 13 sites in 1986.[115, 470, 650] Many nests were empty in 1977 and 1986, which likely also indicated egging at that time. This suggested that gull populations were still increasing there, even with some degree of egging, although the more intensive study and repeated searches for nests in 1990 may have confounded the comparison with previous surveys.[600]

Populations since 1990

Since 1990, most studies indicate a reversal in population trends, except in the Queen Charlotte Islands. In the Strait of Georgia, Sullivan et al.[534] found a decrease of 31% in numbers nesting at 14 colonies between 1986 and 1997-1999, and Blight et al.[41] reported an ~50% decline from a high in the 1980s to 2009-2010. The latter study included about 60% of the known colony islands, containing about 96% of the nesting population recorded by Vermeer and Devito [581] in 1986. Neither study included urban nesting populations. Blight et al.[41] concluded that those omissions were unlikely to bias their results, although Vermeer [575] reported that urban populations were increasing rapidly after 1986, and we know that hundreds of pairs now nest on the tops of high-rise towers in downtown Vancouver [645] that were outside Vermeer's study area. We also have some concern about differences in survey methods used and thus in the interpretation of their results (see below). Increased disturbance and predation by Bald Eagles and changes in the availability of forage fish have been suggested as causes of the recent declines.[41, 534] A more recent survey of the colony on Mitlenatch Island tallied 1,313 nests with eggs (1,488 total nests) in 2015 compared to 1,152 nests with eggs counted in 2010.[646] Carter [161] surveyed some colonies north of Vancouver in 2014.

Differences in survey methods used by Blight et al.[41] in 2009-2010 compared to previous studies confound the interpretation of their results. Blight et al.[41] counted only active nests, which they defined as containing at least one egg or evidence of depredation, whereas previous studies generally counted all nests whether empty or containing eggs.[104, 474, 594] Perhaps there has been some confusion about the definition of "active" nests. Provincial protocols for counting gull nests [465] specify that active nests be counted and contents recorded, including empty nests. Excluding empty nests in 2009-2010 confounds comparisons because previous counts (used by Blight et al.[41] in their analyses) on similar dates at, for example, the largest colonies on Mitlenatch and Mandarte islands have included between 1% and 19% empty nests.[650] Larger proportions of empty nests may occur when reproductive conditions are poor and numbers of pairs nesting are low or when nesting is delayed. A count conducted before laying was completed in 1981 on Mitlenatch Island included 49% empty nests (1,922 total nests). Vermeer and Devito [581] did not specify whether they included empty nests in their 1986 Strait of Georgia counts, but we believe that methods were the same as those used on the west coast of Vancouver Island, where Vermeer et al.[594] specifically stated that empty nests were included, and elsewhere. [115, 470, 600] Vermeer and Devito [581] reported that some or all nests were empty on some colonies that were impacted by human or Bald Eagle disturbance, making it clear that empty nests were included in their estimates of nesting populations. As discussed above, empty nests recorded in Skidegate Inlet were likely a result of egging.[600] Excluding those nests from counts would have seriously underestimated nesting populations. Thus, there is some uncertainty about total nesting populations and the magnitude of the decline in the Strait of Georgia at the time of the study by Blight et al.[41] We recommend that all nests be counted and their contents reported in future studies (Figure 111).

Pacific Rim National Park Reserve personnel have conducted some recent surveys of colonies along the west coast of Vancouver Island. A survey of the largest west coast Vancouver Island colony on Cleland Island found 27% fewer nests in 2004 than in 1989,[184] and more recent surveys show some decline on Seabird Rocks but stable populations on Florencia Island since 1989.[431] Traditional egg harvesting apparently continues on Cleland Island, but its impact on nesting populations is unknown. White et al.[619] suspected that increasing Bald Eagle disturbance may have reduced reproductive success of gulls nesting on Seabird Rocks in that area.

In the Queen Charlotte Islands, Laskeek Bay Conservation Society has been monitoring colonies in the Laskeek Bay area on the east coast of Moresby Island since 1992. During the first years of surveys they found a slight increase in total numbers of nests at the five surveyed colonies (Lost Islands, Kingsway Rock, Reef Island, Low Island and Skedans Islands) since 1986 (from 213 in 1986 to 235 in 1992 and 244 in 1993), although contrary trends were seen at individual colonies.[260, 264] Gaston and Lawrence [264] reported large numbers of Bald Eagles roosting on Low and Skedans islands where numbers of nesting gulls were much reduced compared to those of 1986. A total of 360 nests were counted at six colonies surveyed in 1994 (Cumshewa Island was added),[268] a 44% increase from the 250 nests counted at those colonies in 1986. Increases were most pronounced on Lost Islands where numbers of nests almost tripled. Numbers have fluctuated: 280 nests with eggs were counted in 2014, and the long-term average number of nests with eggs counted on these colonies has been 259.[286] Thus, populations of Glaucous-winged Gulls nesting in Laskeek Bay have remained higher over the last couple of decades than in the 1980s, although comparisons are compromised because empty nests were included in counts conducted prior to 1990 and in the Laskeek Bay counts up to 1994 but not in the more recent counts when only nests with eggs have been reported.

Figure 111. Interest in nesting seabirds has increased dramatically since 1990. A diverse group of individuals and organizations now collect data on nesting seabirds, and many want to contribute their survey results for conservation efforts. Unfortunately, counts may not be helpful in assessing trends if consistent methodologies are not followed. When counting Glaucous-winged Gull nests, it is important to include empty nests, like this one near completion at the Vancouver Shipyards Company. *Photo by R. Wayne Campbell, Vancouver, BC, July 1978.*

Common Murre

Uria aalge **COMU**

(*Common Guillemot*, *California Murre*, *Thin-billed Murre*)

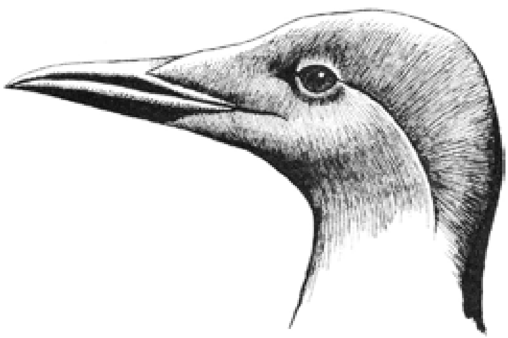


Figure 112. Common Murre has a circumpolar distribution in cooler waters in the North Atlantic and North Pacific oceans where it is one of the most numerous seabirds. *Drawing by Keith Taylor.*

Common Murre is one of the most abundant seabirds in northern oceans. At high latitudes, it is migratory and disperses from colonies in Alaska as far south as central California. Post-breeding males with their single young, mainly from colonies to the south, begin to appear in the Strait of Juan de Fuca and along the west coast of Vancouver Island in mid-July, but the main influx occurs in August when flocks of between 1,000 and 2,000 birds appear. A large flock of 2,200 birds was counted in the vicinity of Brooks Peninsula in 13 August 1981.[133] Murres disperse throughout inland waters and aggregate again in spring during the Pacific Herring spawn. Wintering birds leave BC again in early April. Two unusually large aggregations were observed off the central west coast of Vancouver Island in the 1970s: about 10,000 birds in Wickaninnish Bay on 25 July, 1972 and 9,000 birds in Barkley Sound on 19 August, 1977.[210, 315]

Like other alcids, Common Murre is an awkward walker, ballistic flyer, and elegant diver. Groups are most often seen passing by, flying bullet-like with rapid wing beats low over the water heading in line formation in search of feeding grounds. During the breeding season it may travel over 100 km from its colony to find food. Some observers will watch them swimming offshore, see them disappear when they dive, and, if lucky, be rewarded when they surface with a fish that they quickly dispatch by swallowing it head first. Few observers will witness their ungainly clamouring about their breeding colonies. Almost none will see them where they most excel – underwater. Able to dive to depths of 180 m [446] using their wings they can "fly" faster underwater than their fish prey can swim.

Camouflaged for Fishing

Why are some divers like murres black above and white below while others like cormorants are all black?

Colour differences may be related to how a bird approaches its prey underwater. Birds that come at their prey horizontally along the bottom are most camouflaged if they are all black, whereas birds that approach their prey from above are least visible if their undersides are white like the water surface. Why then are some birds like Pigeon Guillemots black in the summer but turn white in the winter? A good question.

APPEARANCE

Similar Species: In BC, Thick-billed Murre and Marbled Murrelet in winter.

Size: Crow-sized; **Length:** 40-43 cm (16-17 in); **Wingspan:** 71 cm (28 in); **Mass:** 830-1300 g (1.8-2.9 lbs).

Adult breeding
- brownish-black above, white below, boundary at neck rounded (Figure 113)
- sides streaked with brown
- long, slender, pointed bill

Winter on water
- white on underparts extends up throat, chin, and behind eye
- black line extends through white behind eye

Juvenile
- dark above, white below
- head dark to bill level

• white chin and throat
• shorter bill

Figure 113. Common Murre, the largest alcid in BC, has a black back and head, white underside, and long slender bill. Historically the species has been confirmed nesting at only six sites in the province. *Photo by R. Wayne Campbell, Cleland Island, BC, August 1969.*

BREEDING

Single to colonial nester on a few islands off the outer coast. Colonies in BC are small, ranging from one to 4,100 pairs, compared to colonies of hundreds of thousands elsewhere. Common Murre forms long-term pair bonds that are renewed each year at the colony. Though socially monogamous, males often try to force extra-pair copulations on females. Females seldom co-operate, but occasionally females initiate copulation. They have an elaborate greeting ceremony, clashing open bills together and calling loudly whenever a mate returns. Paired birds frequently preen each other. At departure, chicks leap off nesting cliffs at dusk and are led off by the male who tends them at sea until they are independent. Some birds breed at 3 years old, but most not until 5-7 years old.

Seasonal and diurnal attendance at colony: Birds are active on the colony during the day and may be present on the water around the colony throughout the day during the breeding season. At the main BC colony on Triangle Island, hundreds to thousands of murres are present on the water from late March through August.[327] Attendance on land peaks in the early morning and in the evening with maximum numbers recorded around 20:00 hr.[471] At these times there may be more birds on the water than on land. In 1982, when murres were successfully nesting, over 5,000 birds were regularly concentrated on the water to the west of Puffin Rock. About 12,000 birds were clustered on the water in several groups around the island at most times of the day during our visit in July 1984, when nesting was unsuccessful.[484] Murres departed the waters around Triangle Island for the evening, flying north in flocks of 5-150 birds between the hours of 21:30 and 22:30, and returned in the morning. Birds on the water were vocal throughout the day and large groups could still be heard calling from the water east of Puffin Rock at 22:15 hr on the evening of 15 July 1984.

In a study conducted on Triangle Island from 2002 to 2007, murres began attending nesting cliffs at the end of March or early April and laid eggs from mid-May to mid-July, with most eggs laid from end of May to mid-June.[327] This phenology was about a month earlier than that indicated by previous observations in 1949,[158] 1980-1981,[556] and 1989,[471] that found most eggs laid in the last week of June or early July, and most chick departures in September. However, in 1975, all adults and their chicks had left the colony by the end of August,[603] which suggests a chronology more similar to that found in 2002-2007. Timing of breeding on Triangle Island thus appears to vary from year to year, likely in response to oceanographic conditions. Even during the 2002-2007 study, phenology varied by about 25 days among years.[327] Overall, evidence suggests that timing has advanced in recent years, concordant with a general phenological advance at all trophic levels driven by changing oceanographic conditions.[379]

Behaviour of birds on the water around colonies has not been well studied. At Cape St. Mary's in Newfoundland, large concentrations of Common Murres first appear in the early spring about 6 or 7 km offshore. Within a few days they gradually move towards the colony until several thousand are present at the base of the cliffs. Birds on the water engage in frequent communal displays, which perhaps function in pair formation and to synchronize breeding.[552]

Nest: No nest is built (Figure 114). Eggs are laid on bare rock on cliff ledges, sloping rock faces, and tops of rocky islets, or on bare earth on grassy slopes. Adult rests the egg on webbed feet during incubation. Over 90% of pairs occupy the same nest site from year to year. Murres are one of the most densely-breeding seabirds; densities >20 pairs/m^2 are common and incubating birds are often touching their neighbours. Pairs defend their small nest site and in dense groups aggressive interactions among neighbours occur about every 20 min. Ritualized threat and appeasement signals keep most interactions from developing into fights.

Eggs: Pyriform. Finely granular, non-glossy, variable white through blue or green, unmarked or marked with brown or black blotches or scribbles. **Size:** 81 (3.2 in) x 50 mm (2.0 in); **Average clutch size (maximum clutch size):** 1(1); **Incubation period:** 28-35 days by both sexes in 12-24 hour shifts. The pyriform shape does not seem to be an adaptation to keep eggs from rolling off cliff ledges as previously thought. The rolling radius is wider than many nesting ledges and the shape confers little advantage in terms of loss. Parents carefully transfer the egg from foot to foot when they exchange incubation duties. Unique colour and markings allow parents to recognize their own eggs (Figure 114).

Young: Hatched with down feathers. Head black with white streaking, body sooty-brown above, whitish below. The chick is never left unattended. Fed fishes by both parents. **Average number (maximum):** 1(1). **Fledging period:** departs colony with parent male at 16-30 days, able to fly about 3 weeks later.

Lifespan: Annual adult survival is 87-95%; maximum 34 years 8 months.[4, 378]

CONSERVATION

Common Murre colonies in BC support a small fraction of the estimated global population of 13-21 million birds.[4] Murres are highly vulnerable to oiling mortality and hundreds of thousands have died in spills such as the *Exxon Valdez*, *Nestucca*, and *Apex Houston* along the Pacific coast (Figure 115). Most of BC's breeding population is concentrated at one colony off northwestern Vancouver Island and is at risk in the event of a local spill. Large numbers of wintering birds are also at risk; at least 30,000 died in Washington and BC from the *Nestucca* spill.[69] Many die from chronic low-volume spills caused by bilge pumping, leaking tanks, and offloading accidents. In addition, Common Murres are the species that suffer the highest mortality globally from entrapment in fishing gear. The amount of mortality in BC from this cause is unknown. Climate change and fisheries activities that affect prey availability, and disturbance at colonies are also concerns. Like other species, murres also suffer mortality from natural causes, including predation, parasite infection, starvation, intense storms, and death from falling off breeding cliffs. In BC, Common Murre is the most frequent species found on beached bird surveys [71] (Figure 116). It was placed on the BC Conservation Data Centre's Red List in 2015.[55]

Figure 114. Each Common Murre egg is unique and the location and size of the patterns and markings on the shell allow parents to recognize their own egg. The eggs in the photo are from different nests that were side-by-side. *Photo by R. Wayne Campbell, Royal BC Museum, Victoria, BC, July 1983.*

Figure 115. Oil spills can be disastrous for aggregations of Common Murres. *Photo by R. Wayne Campbell, Copinsay, Scotland, 18 June 1993.*

Population trends to 1990

Common Murres have been confirmed nesting on Triangle Island since 1900 [290] (Figure 117). This was the only breeding site in British Columbia accepted by Drent and Guiguet.[213] In addition to Triangle Island, Brooks and Swarth [58] noted small colonies on Solander Island and near Ucluelet on the west coast of Vancouver Island. They also mentioned a large breeding colony on the west coast of Graham Island in the Queen Charlotte Islands reported by the Haida of Masset. Based on Guiguet's thorough explorations in those areas in the 1940s and 1950s, and without any substantiating evidence, Drent and Guiguet [213] did not accept those breeding records, although they felt that the Ucluelet location remained an open question. A female with a fully formed egg collected at Langara Island by Cumming [198] also was not accepted as a breeding record for British Columbia. Drent and Guiguet [213] speculated that the bird had originated from the large colony north of Langara Island on Forrester Island in southeast Alaska.

Figure 116. The highest mortality rate for Common Murre occurs from July to September each year when young leave the colony, venture to sea, and become separated from their parents. In this photo Bill Anderson is photographing a juvenile Common Murre that washed ashore on Long Beach, BC. *Photo by R. Wayne Campbell, August 1968.*

Figure 117. All of the early nesting records for Common Murres on Triangle Island, BC were from private egg collectors and provincial museum collecting expeditions. In 1949, the breeding population was "conservatively estimated to number about 3,000 birds".[158] *Photo by G. Clifford Carl, Triangle Island, BC, 29 June 1949.*

Common Murres have never been confirmed nesting on Solander Island,[133] and the only confirmed breeding site for murres in the Queen Charlotte Islands is at the south end of the archipelago on the Kerouard Islands, where breeding was confirmed in 1977.[115] A few pairs have bred intermittently since 1969 on Cleland Island, Florencia Islet, and Starlight Reef off the central west coast of Vancouver Island, not far from Ucluelet.[104, 156, 315] This evidence thus supports the judgements made by Drent and Guiguet.[213] Small numbers of Common Murres have been seen attending potential nesting habitat on rocks off Anthony Island (SG̱ ang Gwaay), north of the Kerouard Islands, and at "White" Island, south of Cleland Island, but no evidence of eggs or young has ever been found at those sites.[176]

As of 1990, a total of 8,360 birds were estimated breeding at four of seven (six confirmed) historically-used sites (Figure 118; Tables 3, 5, 6, and 12, pages 63, 65, 66, and 130). Triangle Island supports 98% of the total population (Tables 4 and 12, pages 64 and 130). Most of the rest of the population nest on the Kerouard Islands. Forty birds were suspected nesting north of the Kerouard Islands on "Cone" Islet on the mid-west coast of Moresby Island in 1977. We have no recent records and breeding has never been confirmed for that site. The fourth active site is on Starlight Reef where one egg that was likely being incubated was found in 1989 after a hiatus in breeding since 1980.[174] Breeding was reported on Sartine Island in 1968 and 1975,[296, 593] but has not been recorded since, although 113 birds were present on the water during the survey in 1989.[484] Nesting has not been observed on Cleland Island since 1982 or on Florencia Islet since 1969.[160, 174]

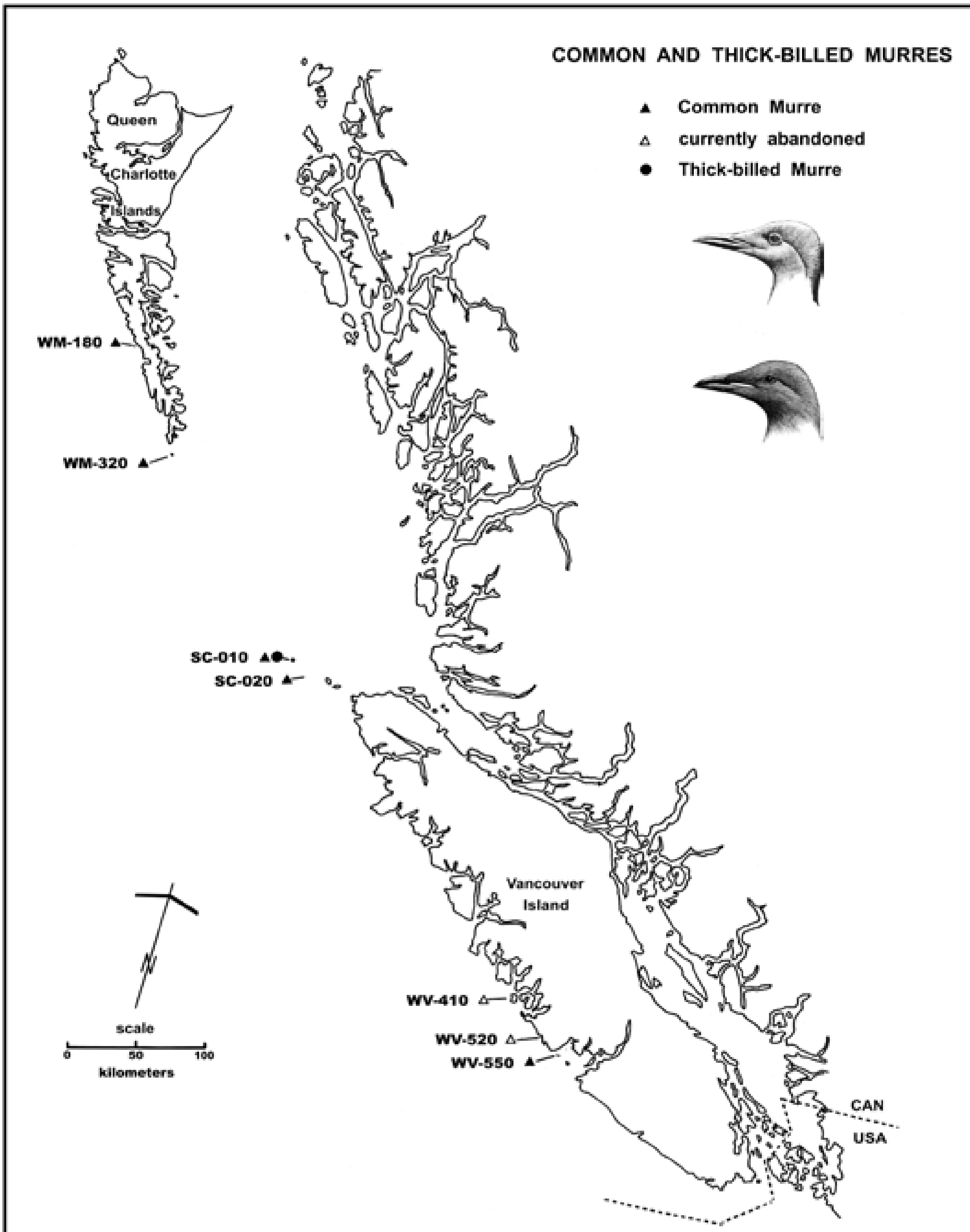


Figure 118. Common and Thick-billed murre colonies in British Columbia. Site codes refer to colonies listed on Table 12.

Table 12. Most recent counts of Common and Thick-billed murres at all colonies, and estimates of breeding populations on Triangle Island in British Columbia as of 1990.

Location		Common Murre Total Birds	Common Murre Population Estimate (pairs ± SE)	Thick-billed Murre Total Birds	Thick-billed Murre Population Estimate (pairs)	Survey Year	Source[a]
West Coast Moresby Island							
WM-180	"Cone" Islet	40	S			1977	650
WM-320	Kerouard Islands	118	x			1989	634
Scott Islands							
SC-010	Triangle Island	9,943 ± 202	4,077 ± 83	41	7e[b]	1989	484
SC-020	Sartine Island	113 on water	0			1989	484
West Coast Vancouver Island							
WV-410	Cleland Island	0	0			1988	475
WV-520	Florencia Island	0	0			1982	475
WV-550	Starlight Reef	1	1			1989	174

[a] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.
[b] Breeding population estimated from the number of birds present that appeared to be incubating (see key to letter codes on pages 53-56).

Populations since 1990

Since 1990, the status of Common Murre in British Columbia has been reviewed by Carter et al.[176] and Hipfner.[325] Hipfner reported about 27% fewer birds on Triangle Island in 2003-2004 than 1989. His 2003-2004 count of 377 birds on the Kerouard Islands was similar to the maximum recorded count of 400 birds by Wayne Campbell and Al Whitney in mid-June 1987.[108, 481] Other counts of 118 birds in 1989 (see West Coast Moresby Island region), 200 in 1995, and 0 in 1997 by Wayne [176] indicate that numbers fluctuate substantially. No birds were nesting at other historical sites in 2003-2004,[325] although "Cone" Islet still has not been revisited since 1977. Carter et al.[174] were confident that two pairs bred on Cleland Island in 2006. Thus, intermittent breeding by a few birds continues at colonies on the mid-west coast of Vancouver Island (Figure 119).

Figure 119. Up to eight pairs of Common Murres nested on Cleland Island, BC, in 1975.[156] Two pairs were probably breeding in 2002,[174] but none since. *Photo by R. Wayne Campbell, Cleland Island, BC, August 1969.*

Thick-billed Murre

Uria lomvia **TBMU**

(*Brünnich's Guillemot*, *Pallas Murre*, *Crowbill*)

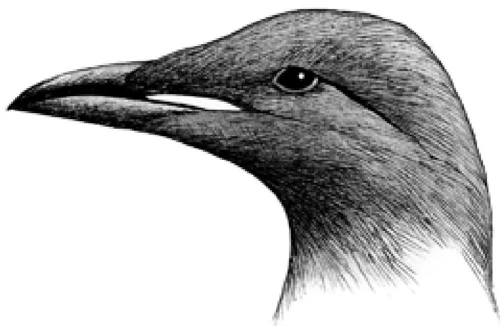


Figure 120. Although reported in the vicinity of Triangle Island in the 1970s, Thick-billed Murre was not confirmed breeding on the island until 1981.[555] *Drawing by Mark Nyhof.*

Thick-billed Murre (Figure 121) is a hardy, northern bird, and though millions live north of us in Alaska, few venture south into our waters, summer or winter. A few dozen decided they prefer the warmer climes of southern BC and have set up an anomalous breeding outpost off northwestern Vancouver Island, 800 km south of their main breeding range. Thus, careful scrutiny of murres in outer coastal waters may be rewarded – look for the heavier, shorter build compared to Common Murre. Thick-billed Murre is one of the deepest-diving birds, recorded to depths of 210 m, and can remain underwater for more than 3 minutes, pursuing fishes and crustaceans.[196] It may travel up to 170 km from breeding colonies, flying at speeds of 65-75 km/hour, to find food.

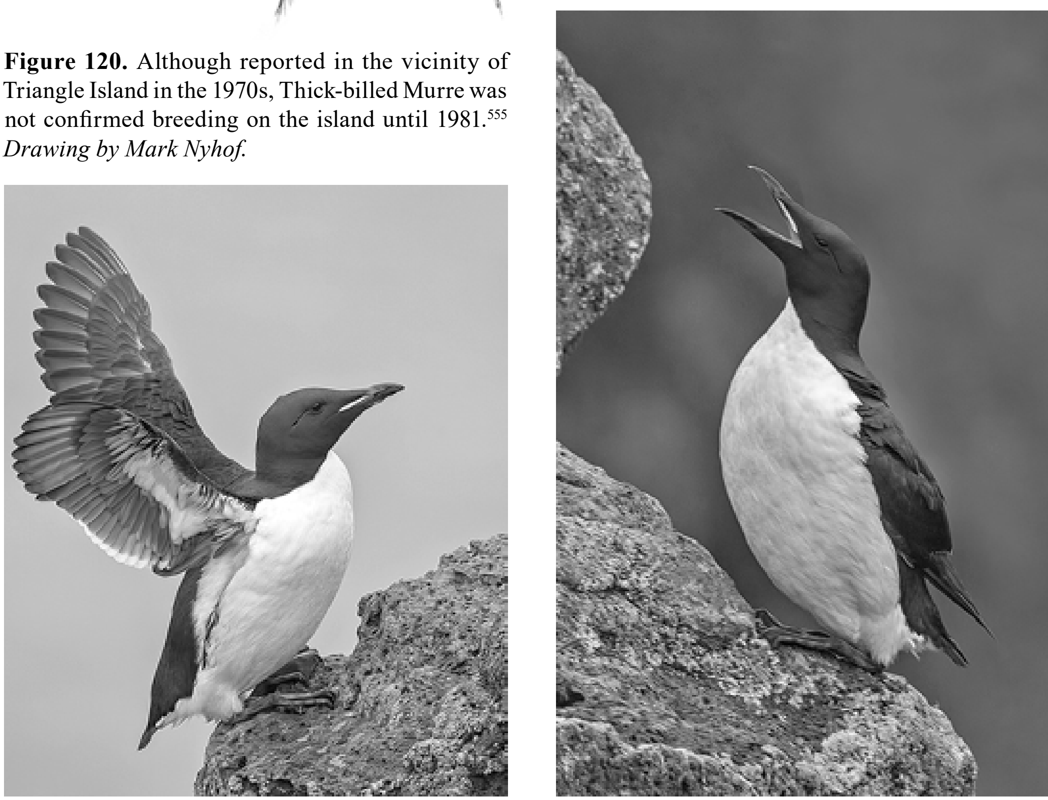


Figure 121. Besides the obvious light streak in the bill, an adult Thick-billed Murre can be differentiated from Common Murre by its stout, less slender bill, a sharp inverted "V" where the white on the breast meets the throat, and a browner back. Both species sit upright on their tarsi when perched and cling with sharp toe nails. *Photos by Alan D. Wilson.*

APPEARANCE

Similar Species: In BC, Common Murre and Marbled Murrelet in winter.

Size: Crow-sized; **Length:** 43-48 cm (17-19 in); **Wingspan:** 71-81 cm (28-32 in); **Mass:** 760-1200 g (1.7-2.6 lbs).

Adult breeding
- blackish above, white below, boundary at neck "V"
- relatively short, thick bill
- thin white stripe on bill

Adult standing
- chunkier than Common Murre
- top of bill evenly rounded
- pale streaks on flanks
- leans forward at an angle

In flight
- flight strong and direct
- short, fast-beating wings
- flies just above the water
- taxis when taking off

BREEDING

Nests in BC only on Triangle Island, mixed with Common Murres. Its breeding biology is similar to the Common Murre's (see above).

CONSERVATION

Thick-billed Murre is abundant throughout Arctic waters with an estimated world population of 15-20 million birds.[261] Oil pollution is likely the greatest threat to both murre species in BC. Maintaining a moratorium against oil exploration and tanker traffic off the BC coast is probably the most important action that can be taken to protect these species (Figure 122). High-seas drift nets used to kill millions of diving seabirds, including murres, and the global banning of driftnet fishing in 1992 was a positive step for the conservation of those species. Disturbance to breeding birds by tourists, researchers, fishing boats, and aircraft can reduce breeding success. Thick-billed Murre was placed on the BC Conservation Data Centre's Red List in 1996 because of its limited breeding distribution in British Columbia only on Triangle Island.[55]

Population trends to 1990

Thick-billed Murre only breeds on Triangle Island where they were first reported in 1981 [555] (Figure 118, page 129). Nineteen pairs were observed nesting in 1981, and 70 birds were counted on nesting ledges mixed with Common Murres in 1982. In 1989, a maximum of 41 birds was recorded, seven of which appeared to be incubating [484] (Table 12, page 130). This is the southern-most known breeding site in the eastern Pacific Ocean.

Populations since 1990

Although they have been present in other years, no birds were seen at their usual breeding sites during surveys of Common Murres on Triangle Island in 2003.[325]

Figure 122 . Pollution from accidental spills or discharges of waste products by cargo vessels and crude oil tankers pose threats to many seabird species, especially murres. *Photo by R. Wayne Campbell, Strait of Juan de Fuca, BC, 1 August 2003.*

Pigeon Guillemot

Cepphus columba **PIGU**

(*Sea pigeon*)

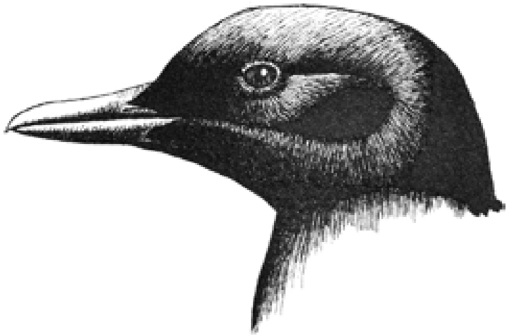


Figure 123. Pigeon Guillemot is widely distributed across the North Pacific Ocean from the Kuril Islands in Japan and Kamchatka Peninsula in Russia to the Aleutian Islands in Alaska and south to California. The largest colony is on the Farallon Islands in California but in North America the centre of abundance is in Alaska. *Drawing by Keith Taylor.*

On almost any spring and summer excursion along coastal waters, one or two or even a small group of smallish, black seabirds with conspicuous white wing patches can be spotted either diving in shallow waters or roosting on a rocky islet or bluff (Figure 124). If they are standing ashore, be ready for a shock – their flamboyant red legs are a startling surprise (Figure 125). Watch for them to gape at their neighbours – the inside of their mouth is a similar flaming red colour. Pigeon Guillemot is so widespread on suitable seabird nesting islands that one of the early marine bird surveyors, the late Charles Guiguet, used them as an indicator to locate possible colonies of less conspicuous species. It is a diurnal, nearshore feeder that eats a wide variety of small fishes and invertebrates, such as crabs and shrimp.

The species is mostly reported in BC from April through September, but they are also commonly seen when they have transformed to mostly white in winter. There is no evidence of a migratory movement by BC guillemots and it is often assumed that birds seen in winter are those that also breed nearby. However, each year the BC coast is inundated with guillemots from

Figure 124. Small flocks of adult and nonbreeding Pigeon Guillemots roosting on intertidal rocks is a common sight along the BC coast in summer. *Photo by R. Wayne Campbell, Cleland Island, BC, 17 May 1995.*

the south and north. Post-breeding birds leave colonies in California in August and migrate northward, some of which arrive in BC in mid-September. Those birds depart BC in March and April. Birds from Alaska colonies begin to arrive later, in early October and return to colonies in March.

Figure 125. In breeding plumage**,** the black body, white wing patches, and red feet of the Pigeon Guillemot are unmistakable. Sexes are alike. This species feeds closer to shore than other alcids in BC. *Photo by R. Wayne Campbell, Mitlenatch Island, BC, 4 June 1968.*

APPEARANCE

Similar Species: In BC, juvenile and winter-plumaged Marbled Murrelet and White-winged Scoter.

Size: Larger than American Robin; **Length:** 30-35 cm (12-14 in); **Wingspan:** 55-59 cm (21.7-23.2 in); **Mass:** 410-550 g (14.5-19.4 oz).

Adult breeding
- black body and bill
- white wing patch
- slender neck
- red legs and feet

Adult winter
- mostly white body
- upperparts mottled with black
- dark wings with white patch
- dark streak through eye

Juvenile
- like winter adult, darker above, more mottled on breast and sides
- less distinct white wing patch
- orange legs and feet

BREEDING

Solitary to colonial nester on small islands and around the perimeter of larger islands and headlands wherever suitable nest sites free of mammalian predators are found. Most colonies are <50 birds; largest in BC support a few hundred birds. First breeding at 3-5 years, they form long-term, monogamous pair bonds with few divorces. Pairs copulate on shore near the nest or roost site. Both paired and unpaired males frequently attempt forced copulations but are rarely successful. Pairs reuse the same nest site for years. Male returns first to claim and defend site, then both partners may spend over a month “cleaning house” and preparing a nest scrape. Eggs are laid at 3-day intervals, mostly in the morning.

No Passport Required

Identifying individually banded birds in research projects can provide useful information on breeding season time budgets and on the roles of the sexes in courtship, nest-building, incubation, and vigilance. Beyond the colony, the band may contribute additional information on a species’ activities and wanderings throughout its life. This might include determining age at first breeding, dispersal and migration movements, and longevity.

Repeat sightings of marked individuals revealed that: Pigeon Guillemot may first attempt to breed when three years old but most breed during the following two years; most guillemots remain within 30 km of their natal site; and nearly 90% of adults breed at the same nest in successive years.[417] *But there are always exceptions to the rule. So, it was a surprise when a chick, colour-banded on the Farallon Islands, 35 km offshore of San Francisco, California, showed up on Mandarte Island, 1,200 km north, in its third year, and nested!* [234]

Seasonal and diurnal attendance at colony: Active at the colony during the day and often aggregates on the water around the colony. Groups of a few birds to hundreds of birds may occur around BC colonies, depending on colony size. Variation in attendance at colonies is pronounced in relation to time of day, tidal cycle, and season.[598] Maximum numbers occur in the early morning, at high tide, and during the pre-breeding period. Birds engage in spectacular, zig-zag water chases and other displays on the water. Diurnal staging off the colony may function in courtship, pair formation, and as a prelude to copulation.[234] Often forages within sight of colonies; at most a few kilometres away. In the Queen Charlotte Islands, birds gather on the water off colonies beginning in early April, first coming ashore by mid-April.[599] Eggs have been recorded from 10 May to 17 August in BC, and unfledged young may be present until mid-September.[137]

Nest: Uses a wide range of concealed sites including: crevices and cavities in cliffs, boulder rubble, and caves; under driftwood; in burrows excavated at the edge of the vegetation; and under wharves (Figure 126), piers and ferry docks, and other human-made structures and discarded debris (Figure 127). Occasionally nests in the open in tall grasses, forbs, or sedges that obscure the nest. No nest is built, but loose material is cleared to make a depression.

Figure 126. The use of crossbeams under wharves as nesting sites for Pigeon Guillemots was first noticed in BC in the mid-1970s.[106] *Photo by R. Wayne Campbell, Queen Charlotte City, BC, 14 July 1977.*

Figure 127. Pigeon Guillemot, an adaptable breeding species, was found nesting among this pile of abandoned cable in Skidegate Inlet, BC. *Photo by R. Wayne Campbell, 18 June 1974.*

Eggs: Pointed ovate to elongate ovate. Smooth, non-glossy, pale cream with dark brown and grey blotches concentrated around blunt end (Figure 128). **Size:** 61 (2.4 in) x 41 mm (1.6 in); **Average clutch size (maximum clutch size):** 2(3); **Incubation period:** 28-32 days. Sexes alternate shifts lasting from 40 minutes to 17 hours.

Figure 128. Of the nine species of alcids breeding in BC, only Pigeon Guillemot (shown) and Ancient Murrelet lay more than one egg. *Photo by R. Wayne Campbell , Royal BC Museum, Victoria, BC, July 1983.*

Young: Hatched with thick blackish-brown down feathers, eyes open. Brooded by both parents until 5-7 days old. Fed equally by both parents about 1-2 fish per hour. **Average number (maximum):** 1(2). **Fledging period:** 29-39 days. Leaves nest independent of parents usually at night or in late evening.

Lifespan: Only 26% live >2 years. Annual survival of breeders is 76-89%; maximum >17 years.[235, 378]

Specialist or Generalist?

The age-old dilemma – is it better to be a specialist (e.g., limited diet) or a generalist (e.g., varied diet)? Apparently, if you are a Pigeon Guillemot, it is better to be a specialist. Parents that specialized on specific prey types delivered larger prey items to their chicks and tended to fledge more chicks than generalist parents. Also, parents that delivered higher-caloric, schooling fishes like Pacific Sand Lance and Pacific Herring had higher reproductive success than those that fed their chicks low-lipid, demersal fishes like sculpins and blennies.[278]

CONSERVATION

The location of Pigeon Guillemot nests in often-inaccessible crevices makes it difficult to census breeding populations and monitor population trends. Of the approximately 87,000 birds that have been counted in the vicinity of colonies worldwide,[235] about 14% have been counted in BC. However, the estimated world population is in the order of 235,000 birds.[234] They are highly vulnerable to oil pollution, gill nets, and introduced mammalian predators, although their widespread distribution decreases risks to the overall population from local impacts. Impacts of the *Exxon Valdez* spill in Alaska were most pronounced for Pigeon Guillemots.[410] Populations in the spill area declined by over 50% and had not recovered almost a decade later.[343] Aquaculture development may displace birds from nearshore feeding habitat.

No One Knows

How many Pigeon Guillemots breed in British Columbia? Of the 16 species of seabirds now breeding in BC, estimated population size is the most uncertain for Pigeon Guillemots. Typical survey methodologies are ineffective as the species nests singly (Figure 129) *or in small clusters in a wide variety of habitats, from rocky islets and cliffs to wharves and human debris, and nest types, including under boulders and other natural or artificial substrates, in rock crevices, and in burrows. Nests are often difficult to locate and population estimates are derived from counts of total birds in the vicinity of potential colonies. Unfortunately, this approach has serious drawbacks. The number of birds in attendance around a colony depends on the time of day (best in morning), height of tide (best at maximum high), time in breeding season (pre-breeding best), and weather (less windy best), and is affected by changing food supplies, variability in annual reproductive success, and human disturbance (high at some colonies). Most surveys are one-time counts and do not consider most of these parameters. Thus, the size of the breeding population of Pigeon Guillemot in BC remains a guesstimate. Current counts probably under-estimate actual population size.*

Pigeon Guillemots are the most frequently encountered breeding alcid in the province, nesting at an estimated 344 sites (Table 5, page 65). Major concentrations are identified on Figures 130 and 131 and Table 13. Actual breeding populations have not been determined. A total of 12,406 birds was counted around colonies (Table 3, page 63), but this probably underestimates the total nesting population. Sixty percent of those birds were sighted in the Queen Charlotte Islands, most abundantly in Skidegate Inlet and on the east coast of Moresby Island (Table 4, page 64). Large numbers in Skidegate Inlet were recorded during repeated, dedicated surveys for this species conducted in 1990.[599] Those surveys likely provided a more accurate estimate of populations using that area, but a biased estimate of the relative importance of the area to provincial totals because less dedicated surveys likely underestimated populations in other regions. Number of birds tallied in Skidegate Inlet in 1990 was more than double the previous largest count in 1977 and four times the number counted during the previous survey in 1986. Dedicated surveys in other regions would likely increase estimated total provincial populations by similar amounts.

Figure 129. Nesting habits and attendance patterns of Pigeon Guillemots make it difficult to accurately estimate breeding populations. *Photo by R. Wayne Campbell, Chain Islets, BC, 19 June 1973.*

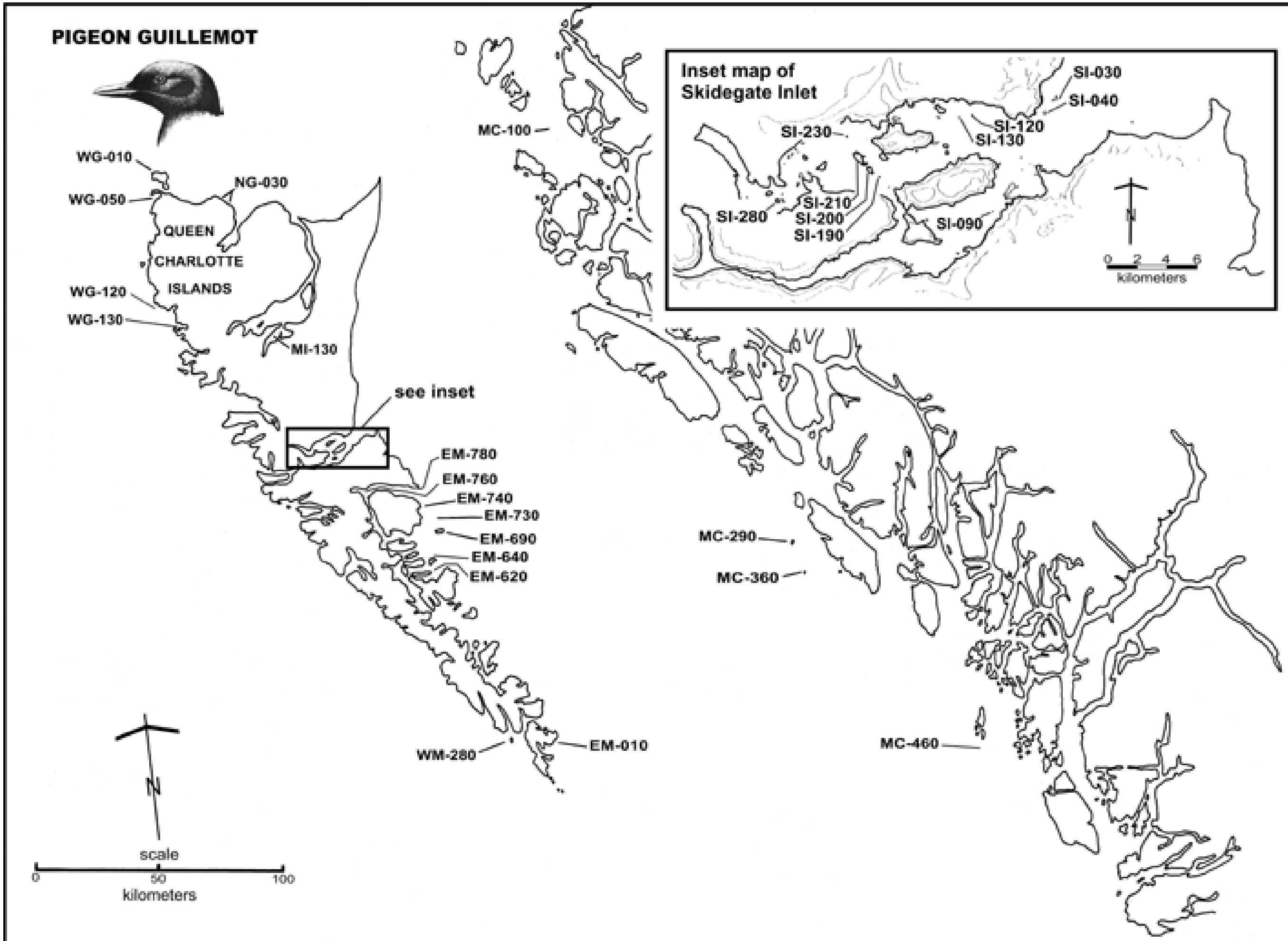


Figure 130. Major concentrations of Pigeon Guillemots (>100 birds) at colonies in northern British Columbia. Smaller colonies have not been mapped (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC). Site codes refer to colonies listed on Table 13.

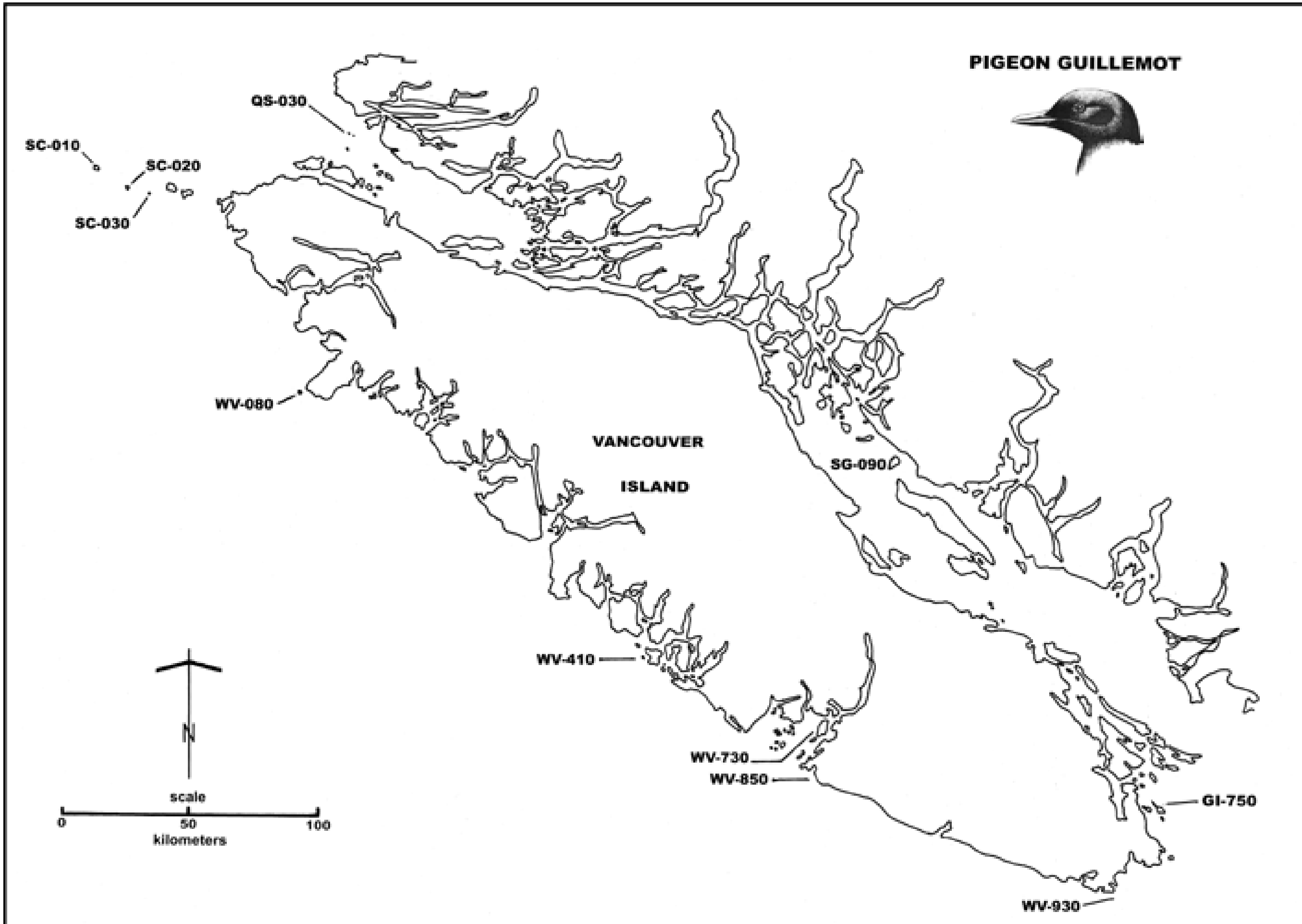


Figure 131. Major concentrations of Pigeon Guillemots (>100 birds) at colonies in southern British Columbia. Smaller colonies have not been mapped (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC). Site codes refer to colonies listed on Table 13.

Table 13. Most recent counts of Pigeon Guillemots at major colonies (>100 birds) in British Columbia as of 1990. Colonies with historical records of greater than 100 birds are also included (see Tables 3-6 on pages 63-67 for a summary of all known colonies in BC).

Location		Birds	Survey year	Source[a]
West Coast Graham Island				
WG-010	Langara Island	187	1988	650
WG-050	"Lepas" Islet	173	1986	470
WG-120	Tian Islets	27	1988	634
WG-130	Solide Islands	110	1977	650
West Coast Moresby Island				
WM-280	Anthony Island	395	1985	481
East Coast Moresby Island				
EM-010	Kunghit Island	155	1986	480
EM-620	Kul Rocks	1	1986	480
EM-640	Titul Island	114	1983	480
EM-690	Reef Island	338	1985	267
EM-730	Low Island	115	1983	480
EM-740	Skedans Islands	136	1983	480
EM-760	Nedden Island	174	1977	650
EM-780	Kingui Island	4	1977	650
Skidegate Inlet				
SI-030	Torrens Island	516	1990	599
SI-040	Jewell Island	311	1990	599
SI-090	Lillihorn Island	590	1990	599
SI-120	Maple Island	151	1990	599
SI-130	Gooden Island	169	1990	599
SI-190	Angle Island	191	1990	599
SI-200	Claudet Island	160	1990	599
SI-210	Burnt Island	264	1990	599
SI-230	Meyer Island	50	1990	599
SI-280	Sandstone Islands	110	1990	599
Masset Inlet				
MI-130	Steilta Islets	131	1986	470
North Coast Graham Island				
NG-030	"Naden" Rocks	142	1986	470
Northern Mainland Coast				
MC-100	Lucy Islands	197	1983	476
MC-290	Moore Islands	187	1988	476
MC-360	Conroy Island	148	1988	476
MC-460	Gosling Rocks	31	1988	476
Queen Charlotte Strait				
QS-030	Storm Islands	111	1987	477
Scott Islands				
SC-010	Triangle Island	331	1989	484
SC-020	Sartine Island	176	1987	484
SC-030	Beresford Island	267	1987	484
West coast Vancouver Island				
WV-080	Solander Island	107	1989	236
WV-410	Cleland Island	352	1989	236
WV-730	Swiss Boy Island	2	1989	236
WV-850	Seabird Rocks	90	1989	236
WV-930	Race Rocks	160	1989	236
Northern Strait of Georgia				
SG-090	Mitlenatch Island	134	1987	225
Gulf Islands				
GI-750	Mandarte Island	241	1987	225

[a] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.

On the most recent surveys in the period leading up to 1990, birds were absent from 9% of the sites where nesting had previously been confirmed (Table 6, pages 66-67). However, not seeing birds at a site more likely reflects problems with survey methodology and timing than actual colony abandonment. Birds have been recorded at many sites where no evidence of breeding has been obtained. For example, at Faraday Island located off the east coast of Moresby Island, Ken Summers and David Ellis recorded 50 Pigeon Guillemots east of the island in 1971,[650] BCPM crews noted 23 present in 1977,[650] and 40 were counted around the island by CWS surveyors in 1984,[480] but no evidence of nesting was obtained on any of those surveys. Thus, Faraday Island and other such sites have not been given colony status in our current summary. Future surveys dedicated to Pigeon Guillemots would undoubtedly discover nesting at many of those sites as well as other sites where birds have not yet been recorded. Records of birds counted at such sites are presented in Appendices titled "Islands surveyed with no record of breeding by seabirds" in forthcoming regional chapters of this catalogue.

Predation by introduced Northern Raccoons reduced reproductive success of Pigeon Guillemots in Skidegate Inlet [599] and is a concern for nesting populations within reach of raccoons throughout the Queen Charlotte Islands archipelago. The most obvious source of mortality during provincial surveys was predation on eggs, mostly by Northwestern Crows but also by Common Ravens (Figure 132). This was particularly evident on Mitlenatch Island where there is a substantial nesting population of crows who learn the location of hidden eggs by watching adult guillemots entering nest sites. Disturbance from recreationists, who search for nests among the driftlogs and flush guillemots from their nests, increases the risks of crow predation.

Figure 132. During seabird surveys and research on seabirds in British Columbia since the 1960s, there were at least 143 instances recorded of predation on Pigeon Guillemot eggs by corvids. *Photo by R. Wayne Campbell, Dawson Island, BC, 13 July 1974.*

Populations since 1990

We know of no recent surveys of Pigeon Guillemot colonies. Laskeek Bay Conservation Society has been monitoring reproductive performance on East Limestone Island. They have been experimenting with artificial nest boxes and put out 10 wooden nest boxes in 2001.[523] On 6 July 2002, one of the boxes contained three eggs laid by two different females.[523] Two boxes were used in 2003,[179] four in 2004,[178] and eight held chicks in 2005.[468] Most nest boxes have been used each year since.[286] Researchers have recently equipped some boxes with video cameras which provide a non-intrusive means of studying attendance patterns and feeding rates.[520] The program has thus been a success.

An unusual nest site was discovered on 21 July 2007 aboard the small ferry, the *M.V. Kwuna* that travels back and forth all day between Graham and Moresby islands in the Queen Charlotte Islands.[204] One pair was successfully raising two chicks inside one of the metal pillars that house the hydraulics for the landing ramp; delivering food to the chicks while the ferry was moving.

Marbled Murrelet

Brachyramphus marmoratus **MAMU**

(*Fogbird* and *Fog Lark used by loggers; Kiss-Me-Arse and Australian Bumble Bee used by fishermen*)

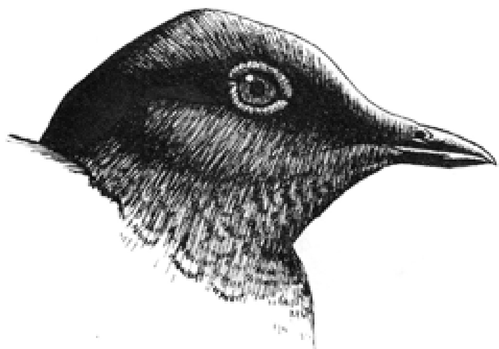


Figure 133. Long called "Enigma of the Pacific", Marbled Murrelet only began to give up its life secrets in the last few decades. For more than a century, ornithologists searched in vain to find a nest. Rewards were offered. A nest was finally discovered in North America in 1955, although it was not until 1974 that the first one was definitively reported. *Drawing by Keith Taylor.*

It took 185 years between the time North American ornithologists first described Marbled Murrelet in 1789 and when they finally published a nest record in 1974 (although an unpublished nest record from 1955 has recently been uncovered – see below)! Today, due to its high conservation concern and intense searching, nearly 200 nests are known. In BC, the species was suspected of breeding in the province in 1919 but an actual nest had not been discovered.[57] Clues included brood patches or a developing egg in the oviduct of an adult female collected, flightless young found in the forest away from the marine environment, and young at sea showing an egg tooth. Nest-fugitive young, however, provided the most convincing evidence (Figure 134). Through 1989, there were 11 inland records of young Marbled Murrelets, of which six could be traced to specific locations and were considered reliable breeding records.[137]

Figure 134. This flightless Marbled Murrelet was picked up in downtown Chilliwack, BC, about 63 km from the ocean, and driven 86 km to Vancouver where it was released at sea off Stanley Park. Although the precise nesting location could not be pinpointed, the record remains noteworthy for knowledge about the species' life history. *Photo by Ivan Polivka, 7 July 1987.* BC Photo 1242.[132]

Tree-nesting was strongly suspected in BC on two occasions. In 1947, after loggers felled a tall tree near Masset in the Queen Charlotte Islands, an adult and broken egg shells were found on the ground.[292] Two decades later, two flightless young, likely from two separate nests,[504] fell out of another tree cut down near Holberg, a tiny village at the north end of Holberg Inlet on northern Vancouver Island. Unfortunately, one died. The nestlings were well grown, but still had a prominent egg tooth and the primary feathers were still sheathed.[305] The first actual nest record for the province, recently discovered in the field notes of the late Glenn Ryder, was in 1955 in the Elk Creek area about 12 km southeast of Chilliwack in the central Fraser River valley [495] (Figure 135).

Figure 135. An adult Marbled Murrelet on its nest on a mossy branch of a bigleaf maple located near Elk Creek, southeast of Chilliwack, BC, on 12 June 1955. This discovery predates by 19 years the famous tree nest discovered in California in 1974.[37] The Elk Creek nest is one of only two nests found in a deciduous tree;[53] most tree nests are in conifers. *Drawing by Glenn R. Ryder.* BC Photo 3780.[132]

"Keer Keer" and a Whirr of Wings

Walking deep into an intact old-growth forest in BC is like a journey into antiquity – to a time before Columbus sailed and when the world was still considered flat. Then, watersheds in BC were unlogged and the mild, wet, coastal climate sustained giant spruce, Douglas-fir, hemlock, and cedar that were festooned with lush growths of mosses and lichens. Overnighting in this ancient realm is a magical experience. Waking early, when the faint, first light of day is barely penetrating the swirling morning mist, one might hear a high "keer keer" call followed by a whirr of wings as a small football shape whizzes by overhead just above the tree tops. Unbelievably, this was a Marbled Murrelet, a seabird akin to the murres and puffins, on its way to its nest. What is a web-footed bird doing in an old-growth forest? It took a long time to learn that this little brown alcid actually lays its egg and raises its young on a large branch of an old tree in these ancient forests!

Marbled Murrelet feeds day or night, mostly singly or in twos, in nearshore marine waters and rarely in freshwater lakes up to 75 km inland. The at-sea diet is mostly small, schooling fishes, like Pacific Sand Lance and Pacific Herring, as well as euphausiids. On interior lakes these birds dive for young Sockeye Salmon or Kokanee (*Oncorhynchus nerka*).

APPEARANCE

Similar Species: In BC, Pigeon Guillemot in winter and Ancient Murrelet in winter (Figure 136).

Size: American Robin-sized; **Length:** 24-25 cm (9.5-10 in); **Wingspan:** 41 cm (16 in); **Mass:** 188-269 g (6.6-9.5 oz).

Adult breeding

- dark brown above
- heavily mottled buffy below
- rusty barring on back
- chunky body, slender bill

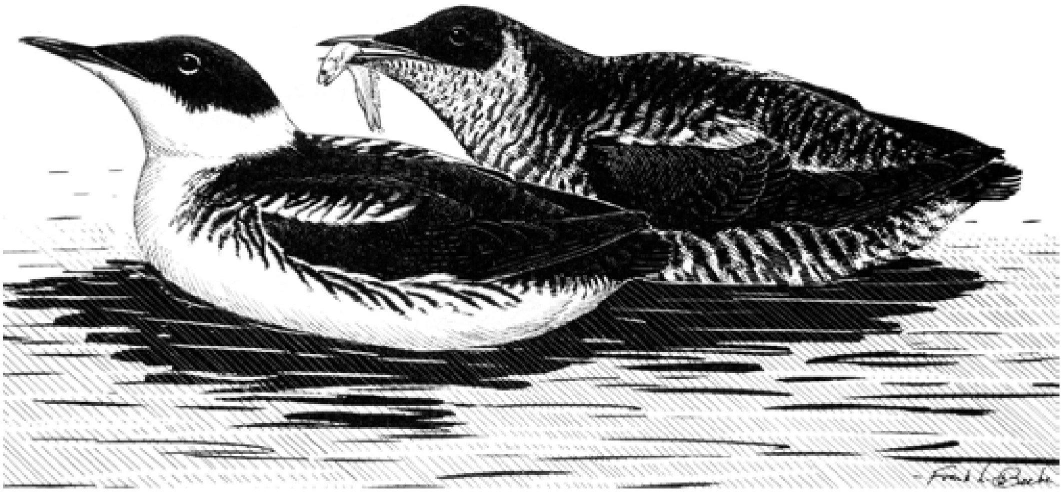


Figure 136. The summer and winter plumages of Marbled Murrelet are quite different. In summer the body is mottled brown and in winter the black-and-white body with a stripe above the wing and white throat separate it from similar alcids. It dives with a quick flick of its wings, hence the term "kiss-me-arse." *Drawing by Frank L. Beebe.*

Adult winter

- blackish-brown above
- white below
- white line at base of wing
- partial white collar

Juvenile

- like winter adult but dusky-mottled below, and white collar and wing line less distinct
- same as adult winter by 2 months

BREEDING

Solitary and occasionally a loose colonial nester in coastal old-growth coniferous and mature forests up to 1,260 m elevation and as far as 101 km, but mostly less than 30 km, inland.[186, 479] Scant data suggest that average nesting density is probably one or fewer breeding pairs per 10 ha of forest, although clustered nests have been found as close as 38 m apart. Pairs may have multiple nest sites that they defend, using different sites from year to year. Courtship begins in early spring at sea when some birds are still in winter plumage and continues through the summer. Courtship display at sea and social activity over inland forest peak in July, probably involving nonbreeders and subadults prospecting for mates and nest sites. Birds are highly vocal at sea and when flying inland, but are generally silent close to their nests. Copulation occurs in trees and at sea.

Seasonal and diurnal attendance at colony: Not colonial. Breeding season in BC extends from April through September, and eggs likely occur from 22 April to 31 July.[165, 504, 505]

Nest: Merely a depression in the moss or duff on large limbs of old-growth conifers such as Douglas-fir, yellow cedar (*Xanthocyparis nootkatensis*), Sitka spruce, and western hemlock; rarely, on the ground on interior cliff ledges or in deciduous trees [53] (see Figure 135). Few nest sites and nest trees are reused inter-annually.

Eggs: Subelliptical. Smooth, non-glossy, pale olive green to greenish yellow with brown, black and purple spots more prevalent at blunt end. **Size:** 60 (2.4 in) x 38 mm (1.5 in); **Average clutch size (maximum clutch size):** 1(1); **Incubation period:** 28-30 days. Sexes alternate every 24 hours at dawn.

Young: Hatched with thick down feathers. Back and head yellowish, underparts buffish-grey, mottled on back with irregular brown and black spots, distinct black spots on head and neck. Brooded for 1-2 days. Fed usually single fish 1-8 times per day by both parents. **Average number (maximum):** 1(1). **Fledging period:** 27-40 days. Chicks remain motionless or sleep most of the time until near fledging. On the two evenings before departure they become very active, flapping their wings, pacing around and peering over the edge of the nest platform, and preening off their down to reveal the black-and-white juvenal plumage underneath (see Figure 134). They fly alone to sea after sunset.

Lifespan: First year survival is about 70%; adult survival 83-93%; maximum >10 years.[186, 378]

CONSERVATION

Population size is poorly known. Breeding population in BC was estimated to be about 45,000-50,000 birds in 1990.[479] Since then, better survey techniques have doubled that estimate and the most recent compilation suggest that about 26% of the global population of 360,000-420,000 birds reside in BC.[186] Population trends in the province are difficult to assess although some coastal residents have noticed a decline in summer daytime numbers off sites where old-growth forests have been logged. As early as 1944, Pearse [440] noted a decline in Marbled Murrelets in the Comox area of the Strait of Georgia that he associated with logging of coniferous forests. Two sets of surveys in Clayquot Sound, near Tofino, 10 years apart (1982 and 1992) showed a 40% decline in detections.[353] Other boat surveys have documented declines in other areas on the west coast of Vancouver Island, in the Queen Charlotte Islands, and in the Strait of Georgia.[186] In general, populations appear to be declining throughout their range in North America as much as 4-7% per year.[26]

Removal and fragmentation of old-growth forest nesting habitat is the greatest threat to populations [513] (Figure 137). Fragmentation is a concern because nesting failure is higher near forest edges, possibly as a result of increased numbers of nest predators such as Steller's Jay (*Cyanocitta stelleri*) and Common Raven. Fragmentation also changes the microclimate of trees near exposed edges and may make perimeter areas less suitable for nesting. At sea, Marbled Murrelet is highly vulnerable to oil pollution and gill nets. About 1% of the population occurring off Vancouver Island may have been lost in the *Nestucca* oil spill.[70] Aquaculture operations may trap some birds and affect nearshore prey. Marbled Murrelets were given "Threatened" status by the Committee on the Status of Wildlife in Canada in 1990 [472] and have been maintained at that status since.[72, 186] They were previously red-listed in BC but were assigned Blue (Species of Special Concern) status in 2010.[55]

Most of the population of Marbled Murrelets in BC nest on the mainland, on Vancouver Island, and on Graham and Moresby islands in the Queen Charlotte Islands.[186, 472] Small numbers likely nest in the interior of some large islands where colonies of other seabird species occur, especially in the Queen Charlotte Islands, but there are no data on breeding distribution or abundance of Marbled Murrelets on those islands. Thus they are not dealt with further in this catalogue, except we mention historical records of notable concentrations of birds and behaviours that suggest breeding on specific colony islands.

Figure 137. Over the past 50 years the numbers of Marbled Murrelets on the water in Skidegate Inlet during the breeding season decreased as logging increased. *Photo by R. Wayne Campbell, west of Sandspit, BC, 17 June 1974.*

Ancient Murrelet

Synthliboramphus antiquus **ANMU**

(*Sea Sparrow*, *Night Pigeon*, *Old Man*)

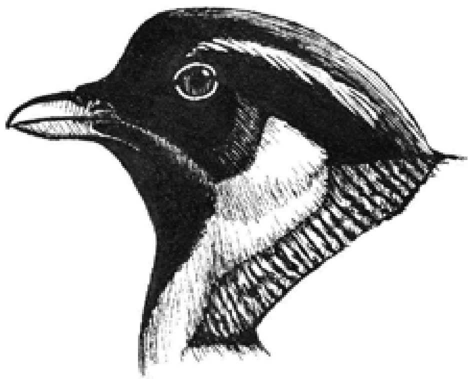


Figure 138. Ancient Murrelet is among the most fascinating of seabirds and is unique in that it is the only species in BC that rears its young at sea.[502] It is also the only seabird in the province to have its own book![256] *Drawing by Keith Taylor.*

This "old man" of the sea, though "greying" on the head and back, shows none of the decrepitude associated with old age. It is a sprightly diver – gone with a quick flit of its wings – and is more manoeuvrable in flight and on the ground than most auks. The Ancient, along with its congeners the Craveri's (*Synthliboramphus craveri)*, Guadeloupe (*S. hypoleucus*), Scripp's (*S.scrippsi*), and Japanese murrelets (*S. wumizusume*), are the only seabirds to raise their young entirely at sea. The synchronous departure from colonies of 100s or 1,000s of chicks during peak nights is a spectacle to behold. Ancient Murrelets dive in small groups, feeding primarily on euphausiids, plus juvenile Pacific Sand Lance, Pacific Herring, and other small fishes.

Two Different Worlds

The islands that support colonies of burrow-nesting seabirds have two faces. During the day, the forest is a calm place – a few songbirds sing and the peace is only occasionally broken when larger birds like eagles engage in noisy territorial disputes. At night all is different. To witness the transformation of the forest at night on these colonies is an almost mystical experience (Figure 139).

Just before dusk we settled ourselves down against some comfortable mossy log to wait. As the last evening song of the Swainson's Thrush faded and the sky dimmed to darkness, a hush fell over the forest, with only the muted sound of the surf along the shore in the distance. But we were not alone – eagles, perched low on some tree branch, and the tiny Saw-whet Owl – also waited expectantly. Surrounded by darkness with only a glimmer of light between the trees from the open shore, we waited quietly. Then we heard it – the blurring sound of fast beating wings, a thump, a pause, and then the soft scuffling of feet. In the dimness, a flash of white – the underbelly of an Ancient Murrelet. More would follow, sometimes crashing into branches, then falling like stones to the forest floor. We became aware of a chorus from the shoreline area – Cassin's Auklets had arrived and started singing their distinctive "let me in, let me in" call. Storm-petrels joined in, singing a joyful trill on their aerial dance through the forest. And all around us the Ancient Murrelets began their melodious songs. Soon the forest was alive with these songs. But the night of pandemonium lasted only a few hours. Amidst the chorusing, we again heard the flurry of wing-beats as birds began to leave. As the sky began to lighten, the singing stopped, and only the whirring sound of the last set of wings heading out to sea broke the stillness. Silence in the forest, the dawn slowly forming. Then the spell was broken, as the first crow with its rowdy voice announced the beginning of the day.

Figure 139. Tourist Ken Spicer waiting for the spectacle of the evening flight of seabirds on East Limestone Island, along the east coast of Moresby Island, BC, during an interpretive tour. *Photo by R. Wayne Campbell, 6 June 2000.*

APPEARANCE

Similar Species: In BC, Marbled Murrelet in winter.

Size: American Robin-sized; **Length:** 24-27 cm (9.5-10.5 in); **Wingspan:** 43 cm (17 in); **Mass:** 153-249 g (5.4-8.8 oz).

Adult breeding (Figure 140)
- blue-grey back, white below
- black crown, nape, and throat
- white plumes ring crown
- short, yellowish bill

Adult winter
- black cap, grey back
- white throat
- partial white collar
- lacks white plumes

In flight
- head held high
- dark stripe between white wing linings and white belly
- short pointed wings

Figure 140. Ancient Murrelet is the only alcid with a small yellow bill in breeding plumage. The white head streaks suggest an elderly or "ancient" look. *Photo by Jared Hobbs.*

BREEDING

Colonial nester on forested islands under old-growth Sitka spruce, western hemlock, and western redcedar (Figure 141); occasionally under younger, regenerating stands. Nests as far as 500 m inland and up to 280 m elevation. Colony size ranges from six to almost 70,000 pairs; most colonies are >1,000 pairs. Birds first breed at 2-4 years, but may choose long-term mates during the season prior to breeding, pairing either on the colony or on staging areas. Newly paired birds sometimes excavate burrows late in the breeding season, though they will not breed until the next year. Birds defend a small area around their burrow and keep the entrance area clean. Ancient Murrelet has an elaborate vocal repertoire with at least nine different calls that it uses on the ocean and on the colony.[349] Males sing from elevated perches, often in trees or on stumps, and from the ground or burrow, probably to attract females and perhaps as territorial signals.

Seasonal and diurnal attendance at colony: Activity on the colony is strictly nocturnal, but birds gather in large rafts during the hours before sunset and until after sunrise at predictable staging areas [508] (also called "gathering grounds" [256]), 1-3 km offshore, from which they may visit the colony after dark. Groups begin to gather on staging areas in mid- to late afternoon (16:00 to 18:00 hr) so that many individuals spend at least five hours of a day in

Figure 141. The nesting population of Ancient Murrelets on Reef Island, along the east coast of Moresby Island, BC, was estimated at 4,942 pairs in 1985. The island, dominated by Sitka spruce, has an area of about 249 ha. *Photo by R. Wayne Campbell, Reef Island, BC, 29 May 1996.*

these areas.[256, 510] Birds do not feed on staging areas,[507] but engage in much social display and vocalization throughout the season.[256] Most individuals gathering early in the season are breeding birds; non-breeding birds become abundant on the staging grounds and on the colony after chicks begin to hatch at the middle to the end of May.[256, 511] Staging areas may thus function in the re-uniting of pairs and strengthening of pair bonds early in the season, and in courtship and pair formation later in the season when non-breeding birds are present. However, the purpose of these gatherings remains speculative; no studies to determine their function have been conducted. At Langara and Frederick islands, individuals first began to attend staging areas at the end of March, maximum numbers occurred during the last weeks of May through the first half of June, and aggregations still formed through mid-July.[508, 511, 591]

Breeding phenology differs at colonies on the east and west coasts of the Queen Charlotte Islands, and is about 5-10 days earlier on the east coast.[256] Birds first arrived on the nesting slopes on 5 April at Langara Island on the west coast [508] and in mid-March at Reef Island and nearby colonies on the east coast.[256] Egg-laying extended from mid-April to late May on Langara Island and from the last few days of March through 21 May on Reef Island. Departure of family groups at Langara Island started on 26-27 May and was last recorded during the first week of July. Median departure date was 5 June (calculated from the median hatch date given of 3 June) on Frederick Island, also on the west coast.[591] At Reef Island, the exodus of chicks and parents extended from the second week of May until the middle of June, with median departure dates of 23-27 May over four years of studies. Non-breeding birds continue to gather on staging areas and visit colonies after most breeders have left. Activity at the colony peters out after the end of June on the east coast but carries on through early July at Langara Island.[256, 508]

Nest: Small cup lined with grasses, leaves, twigs, and cones at the end of a 30-200 cm burrow excavated by both sexes under tree roots, stumps, fallen logs, and less commonly under grass tussocks, in open ground, or under rocks. Burrows are reused in consecutive years. Most burrows are curved so that birds are not visible from the entrance. Adults will gather sticks and vegetation to obscure the entrance of short burrows.

Eggs: Long elliptical or subelliptical. Smooth, semi-glossy, pale buff to olive brown, with brown speckles evenly distributed or sometimes concentrated at blunt end (Figure 142). Laid 7-8 days apart. **Size:** 59 (2.3 in) x 38 mm (1.5 in); **Average clutch size (maximum clutch size):** 2(2); **Incubation period:** 29-47 days. Parents alternate 1-6 day shifts.

Figure 142. The shell of most Ancient Murrelet eggs has small brown speckles distributed evenly over the entire egg. *Photo by R. Wayne Campbell, Limestone Islands, BC, June 1995.*

Young: Hatched with down feathers. Greyish to black above, slightly mottled with grey, whitish to yellowish below, black on head, chin, cheeks, and nape, white around eye and behind ear. **Average number (maximum):** 2(2). **Fledging period:** Not fed on colony and departs at 2 (1-4) days with parents for open sea.

Lifespan: Annual survival of breeders is 77%;[256] maximum unknown.

A Short Stay in the Nest

Early in April, the winter quiet of the forests on nesting islands transforms as Ancient Murrelets return from the ocean and begin their short annual link with the land. Deep beneath the trunks of spruce and hemlock, and under moss-covered logs, the birds dig twisting tunnels which, entwined by roots, provide a quiet and protected place to lay eggs. A slight rise at the end leads to a twig encircled nest cup, where, over the course of a week, two large eggs (each about 22% of female body mass[506]*) are laid* (see Figure 142). *Each adult takes turn keeping the eggs warm, arriving in the forest for their shift under cover of darkness.*

Their tenure beneath the ground is short lived, just long enough for both eggs to hatch. The chicks, with a thick coat of down, and a body burning with energy, remain tucked under the wings of the attending adult in this dark warm burrow for two days, awaiting the return of the other parent[348] (Figure 143). *Darkness falls, and the whirr of wings through the forest increases. Down through the tunnel comes the singing signal – it is time to leave the nest. With an explosion of urgency, the chicks race along the tunnel towards the song. Encouraged from behind by one parent and led by the parent freshly returned from the sea, they make their way down through the forest. On legs and feet nearly the size of their parents, the chicks - like cotton balls on springs - run, bounce, and tumble their way over any obstacle in their path. The song of the adult, the downward path, the slight dim glow through the trees, all lead them on towards the shore. And all around them are other family groups, all following the same ancient calling. During the peak of hatching the forest floor is alive with a symphony of peeping chicks and chorusing adults, as a flurry of chicks make their journey through the short dark night. Close to the forest edge, the adults take wing and settle just offshore, calling insistently to the chicks. A multitude of their brethren has gathered in the surrounding waters, family groups and non-breeding juveniles alike to welcome the new generation.*

Onwards now by themselves, the chicks make their way through the hazards of bluffs, downed trees and across the cobbles and rocks at the shore, to the

Figure 143. Two days after hatching, Ancient Murrelet chicks are called from the protection of their burrow by their parents and guided across the forested slopes of their nesting colony to the ocean where they are reared. *Photo by R. Wayne Campbell, Bolkus Islands, BC, 27 May 1977.*

ocean. Capable swimmers and divers, they navigate through lapping waves or crashing surf. In the melee of sound, the chicks and parents recognize each other's call, and now, reunited, they quickly paddle away from shore. Darkness retreats, the horizon grows lighter. Dawn. The families are now far from shore, and their world is now one of water and air.

CONSERVATION

Data available as of 1990 indicate that British Columbia supports 74% of the estimated world breeding population,[247, 279, 309, 389, 522, 554, 607, 613, 630] although available estimates of breeding populations at Alaskan colonies may underestimate total birds breeding there.[258] Introduced rats and Northern Racoons threaten British Columbia populations and are undoubtedly responsible for population declines at impacted colonies. Concentrations of birds in staging areas around colonies are highly vulnerable to oil spills. Aggregations of many thousands of birds around major colonies – a maximum of 53,000 birds were estimated attending the staging area off Hippa Island in 1983 – puts a large proportion of the Ancient Murrelet population in BC at risk on any one day during the breeding season. Incubating birds frequently abandon eggs if disturbed by researchers early in incubation. Large numbers of birds on the colony are taken by Bald Eagles, who pounce from low perches onto birds scuttling across the forest floor in the dark, and by Peregrine Falcons at sea (Figure 144). At some colonies, Northern Saw-whet Owls have learned to hunt chicks as they travel towards the sea to join their parents. Ancient Murrelet was listed as a species of Special Concern by COSEWIC in 1993 [257] and was blue-listed in BC in 2000.[55] The status was re-examined and maintained at Special Concern in 2004.[185] A management plan for the species has been developed.[229]

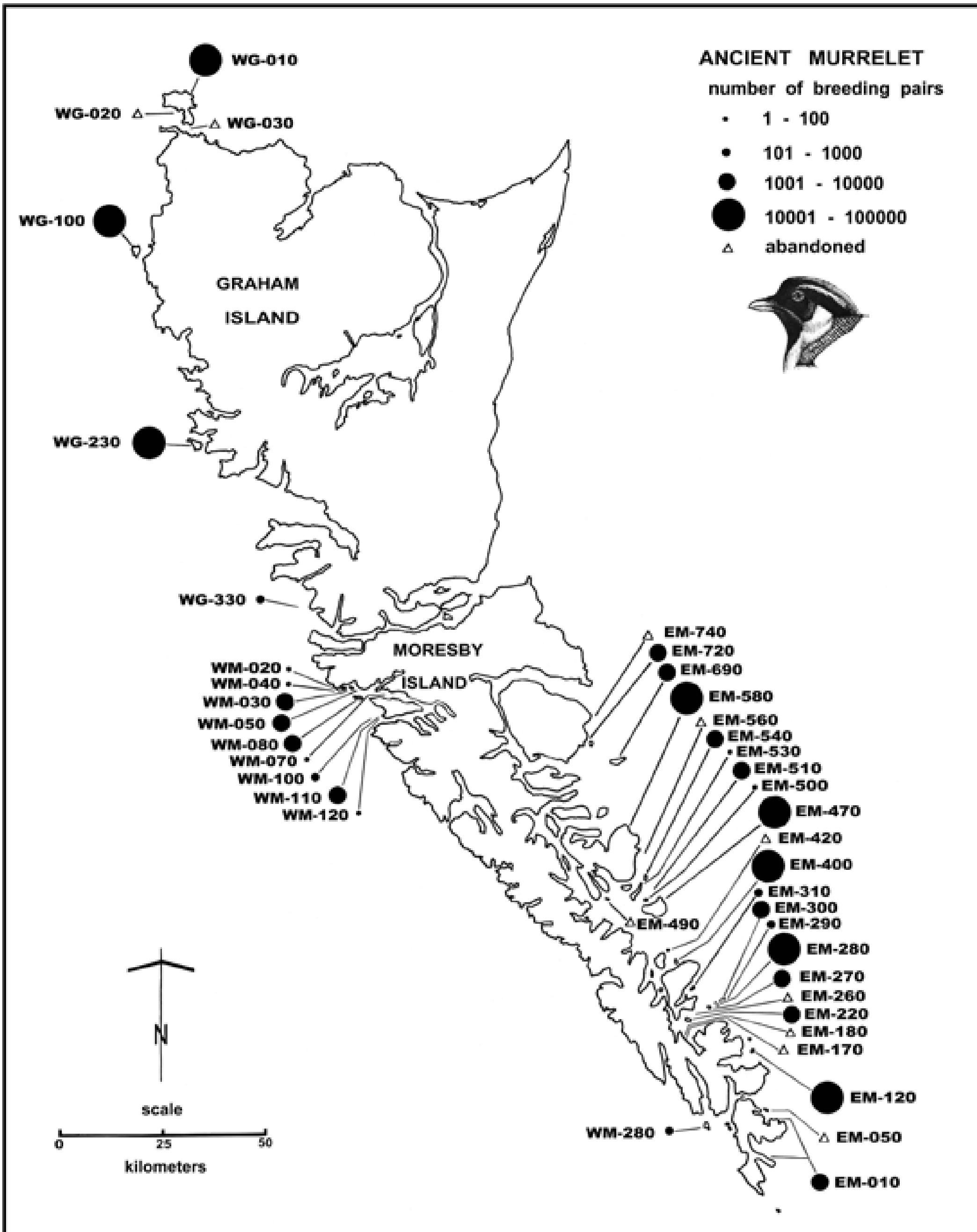


Figure 145. Ancient Murrelet colonies in British Columbia. Site codes refer to colonies listed on Table 14.

Table 14. Estimates of breeding populations (pairs) of Ancient Murrelets at colonies in British Columbia as of 1990. See Key to Summary Tables on pages 53-56 for an explanation of the letter codes used to qualify population estimates.

			Burrow Density			Burrow Occupancy				
	Location	Colony Area (ha)	Burrows/ha ± SE	No. of Sample Plots	Area Sampled (%)	Percent Occupancy ± SE[a]	Sampling Effort (%)	Population Estimate (pairs ± SE)	Survey Year	Source[b]
West Coast Graham Island										
WG-010	Langara Island	45.6	1,358 ± 225	31	0.2	38 ± 8	0.04	24,059 ± 6,149	1988	482
WG-020	Cox Island							E	1981	482
WG-030	Lucy Island							E	1981	482
WG-100	Frederick Island	109.4	1,154 ± 89	128	0.3	54 ± 5	0.06	68,407 ± 8,114	1980	482
WG-230	Hippa Island	98.3	520 ± 66	188	0.5	78 ± 4	0.23	40,094 ± 5,455	1983	482
WG-330	Marble Island							1,000e	1977	115
West Coast Moresby Island										
WM-020	Saunders Island							50e	1986	481
WM-030	Helgesen I. - Main	15.4	700 ± 140	31	0.5	63 ± 8[c]	0.22	6,795 ± 1,597	1986	481
	- Little	1.6	860 ± 330	14	0.8	63 ± 8[c]	0.22	862 ± 346	1986	481
WM-040	Willie Island							10eS	1986	481
WM-050	Carswell Island	6.8			7.7	M		1,700eS	1986	481
WM-070	Instructor Island	2.3	530 ± 150	23	0.9	M		764 ± 216S	1986	481
WM-080	Lihou Island	30.3	338 ± 45	68	0.8	M		6,452 ± 868	1986	481
WM-100	Luxmoore Island	3.1	518 ± 137	17	0.5	M		1,012 ± 268S	1986	481
WM-110	Rogers Island	5.2	521 ± 197	19	0.3	M		1,692 ± 634S	1986	481
WM-120	Cape Kuper				100	M		10	1986	481
WM-280	Anthony Island							200e	1985	481
East Coast Moresby Island										
EM-010	Kunghit Island	44.2						8,800e	1986	480
EM-050	High Island							0	1985	480
EM-120	Rankine Is. - West	38.3	1,042 ± 105	89	0.6	66 ± 8	0.16	26,180 ± 4,041	1984	480
EM-170	Sea Pigeon Island							E	1985	480
EM-180	Boulder Island							E	1985	480

Table 14. cont'd

			Burrow Density			Burrow Occupancy				
	Location	Colony Area (ha)	Burrows/ha ± SE	No. of Sample Plots	Area Sampled (%)	Percent Occupancy ± SE[a]	Sampling Effort (%)	Population Estimate (pairs ± SE)	Survey Year	Source[b]
EM-220	Bolkus Is - Main	16.5	636 ± 88	33	1.0	83 ± 9	0.17	8,727 ± 1,554	1985	
	- Others	12.3			15.3	[d]		1,170e	1985	480
EM-260	Rock Islet							0	1985	480
EM-270	Skincuttle Island	6.1	627 ± 174	14	1.1	57 ± 21	0.37	2,182 ± 982	1985	480
EM-280	George Island	27.1	558 ± 74	57	1.0	77 ± 6	0.37	11,614 ± 1,751	1985	480
EM-290	Jeffrey Island	4.0	408 ± 204	7	0.9	M	0.18	1,028 ± 514	1985	480
EM-300	East Copper Island	17.8	388 ± 83	31	0.9	63 ± 11	0.28	4,365 ± 1,170	1985	480
EM-310	Howay Island							300e	1985	480
EM-400	Alder Island	47.4	467 ± 48	83	0.9	65	0.10	14,388 ± 1,479	1985	480
EM-420	Arichika Island							E	1985	480
EM-470	Ramsay Island	138.7	203 ± 21	229	0.8	65 ± 7	0.11	18,161 ± 2,783	1984	480
EM-490	Bischof Islands							E	1985	480
EM-500	Hotspring Island							6e	1984	480
EM-510	House Island	20.0	294 ± 44	36	0.9	45	0.53	2,646 ± 396	1984	480
EM-530	Murchison Island							20e	1984	480
EM-540	Agglomerate Island	9.5	360 ± 76	20	0.5	M		2,155 ± 455	1985	480
EM-560	Tar Islands							0	1985	480
EM-580	Lyell Island	125.8	163 ± 28	221	0.4	52 ± 3	0.37	10,663 ± 1,930	1982	480
EM-690	Reef Island	47.3	120 ± 17	125	2.6	63[e]	0.75	3,576 ± 507[f]	1989	256, 272
EM-720	Limestone Is. - East	14.9	160 ± 30	98	1.7	61 ± 6	3.37	1,449 ± 305	1983	480
	- West	4.4	120 ± 30	42	4.7	20 ± 8	7.55	106 ± 50	1983	480
EM-740	Skedans Islands							E	1983	480

[a] M indicates that a median occupancy rate (63%) for BC colonies was used.[480]
[b] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.
[c] Occupancy was determined from burrows sampled on both the "Main" and the "Little" Helgesen island combined.
[d] Occupancy rate was determined on the main Bolkus island.
[e] Occupancy rate on Reef Island was determined in 1985; same as BC median rate.
[f] Total burrows and number of breeding pairs on Reef Island were recalculated from area and density estimates given in Gaston et al.[272].

Figure 144. Decapitated Ancient Murrelet in Peregrine Falcon aerie at Explorer Bay on Langara Island, BC. *Photo by Michael S. Rodway, 17 May 1977.*

Population trends to 1990

Except for a single burrow containing an incubating adult found on the northern mainland coast in 1970,[137] and three eggs that may have been collected on Triangle Island off the northwest tip of Vancouver Island in 1949,[166] Ancient Murrelets in British Columbia are restricted to the Queen Charlotte Islands where, as of 1990, an estimated 540,000 birds nest at 31 sites (Figure 145, Tables 3, 5, and 14, pages 63, 65, and 152). Populations were undoubtedly larger in the past. Ancient Murrelets have disappeared from seven sites and are known to have declined at six others. Introduced rats, raccoon or marten are present on at least seven of the affected colonies and the further spread of raccoons is of imminent concern for the future wellbeing of Ancient Murrelet populations.

Declines are best documented on Langara Island and Limestone Islands.[29, 30, 265, 418, 480, 482, 637] As recently as the 1950s, the nesting population on Langara Island likely rivalled the entire current nesting population in British Columbia [256, 418] (see Langara Island account). Though less clearly documented, population declines may have been substantial on other colonies impacted by introduced predators. Big islands like Kunghit and Lyell islands may have supported much larger populations prior to the invasion of rats to those islands. Colony area has declined at Dodge Point on Lyell Island since the 1970s and Haida people remember Ancient Murrelets nesting in other areas of Lyell Island that are now abandoned. Abandonment or declines of colonies on smaller islands, including Cox and Lucy islands adjacent to Langara Island, Saunders and Instructor islands in Engelfield Bay on the west coast of Moresby Island, and Sea Pigeon, Boulder, Arichika, Bischof and Murchison islands on the east coast of Moresby Island, likely involved thousands of breeding pairs. Estimated provincial populations as of 1990 are thus probably less than half of those of 40 years prior. Declines are globally significant.

Populations since 1990

There has been considerable work on Ancient Murrelets since 1990, although only a few colonies have been resurveyed. Permanent plots established on Rankine, George and Ramsay islands in the 1980s to monitor Ancient Murrelet populations have been resurveyed at 5-year intervals since.[216, 324, 368, 370, 371, 372, 373] Trends in numbers of burrows counted in permanent plots indicated stable or increasing populations at monitored colonies.[216, 375, 478] Resurveys of George (in 1996) and Rankine (in 2000) islands with transects showed similar trends as those from permanent plots.[478] Population estimates from those surveys showed an increase from 11,600 pairs in 1985 to 17,000 pairs in 1996 on George Island [371] and stable populations on Rankine Islands with 26,000 pairs estimated nesting in the 1980s and in 2000.[640] East Copper Island was resurveyed in 2003 and also showed an increase from 4,400 to 6,100 pairs between 1985 and 2003.[372] Repeat surveys on Reef Island indicated an increase of over 30% in burrow numbers between 1985 and 1995.[265]

Colonies monitored with permanent plots and East Copper and Reef islands have been free of introduced predators and the stable or increasing trends detected at these colonies do not reflect overall population trends in BC. The Ancient Murrelet colony on Lyell Island was resurveyed in 1992.[369] The colony area had further contracted and the estimated nesting population declined to 8,300 pairs from the 10,700 pairs estimated in 1982.[480] Impacts of introduced rats were obvious in 1992; half the occupied burrows inspected contained adults or eggs that had been killed by rats. Ancient Murrelet bones were also found in a number of unoccupied burrows. Harfenist [298] found a parallel situation on rat-infested Kunghit Island, where the colony area had contracted and estimated populations at two surveyed locations declined from 8,800 to 3,500 pairs between 1986 and 1993. The changes in estimated populations, however, are not as convincing because the main colony area on Kunghit Island was not surveyed with line transects in 1986.[480]

Ancient Murrelets also continued to decline on Langara Island to less than 20,000 pairs in 1993.[298] Rats were successfully eradicated from Langara, Cox, and Lucy islands in 1995-96 [352, 543] and although estimated Ancient Murrelet populations continued to decline through 1999,[215] signs of recovery on Langara Island were apparent by 2004.[463] The establishment of a commercial fishing lodge on part of the former colony has usurped nesting habitat, compromising potential population recovery. It also increases the risk of rat reintroductions.

Further impacts from Northern Raccoons have been found in Engelfield Bay on the west coast of Moresby Island. In 1993, signs of raccoons were found on Saunders, Helgesen and Instructor islands.[266] No sign of the remnant Ancient Murrelet populations present on Saunders and Instructor islands in 1986 [481] were found, and nesting populations on Helgesen Island had declined dramatically, especially on the north end of the island. Colonies surveyed by Gaston and Masselink [266] with no evidence of raccoons had similar or larger estimated populations than in 1986 (Lihou Island: 12,000 pairs in 1993 compared to 6,500 pairs in 1986).

Through the initiative of Tony Gaston of CWS and local residents of the Queen Charlotte Islands, the Laskeek Bay Conservation Society was formed in 1990 and established a camp on East Limestone Island where they have continued scientific and educational programs ever since. Their primary focus has been Ancient Murrelets but they have undertaken a broad range of activities (annual reports of their accomplishments are available online [364]). Further impacts of raccoons on the Ancient Murrelet colony have been investigated as part of their programs. In 1991, two raccoons that had taken up residence on East Limestone Island killed at least 11% of the Ancient Murrelet breeding population and reduced chick production by 36% [274] (Figure 146). Mortality of adults declined dramatically and chick productivity returned to normal in 1992 following the removal of those raccoons,[264] but invading raccoons were again present and predation rates increased in subsequent seasons.[260, 268] Predation rates were high in all seasons that raccoons have been present.[59] Nesting populations declined on East Limestone Island from an estimated 1600 pairs in 1989 to 1300 pairs in 1995 and 500 pairs in 2006.[374] Explorations of West Limestone Island showed that the small colony documented there in 1983 [480] was still extant but reduced in area in 1992.[264]

Figure 146. The introduced Northern Raccoon has expanded its range throughout the Queen Charlotte Islands, swimming between islands to reach seabird colonies. Two invading raccoons killed at least 11% of the breeding population of Ancient Murrelets and reduced chick production by 36% on East Limestone Island in 1991.[274] *Photo by R. Wayne Campbell.*

Travels of Ancient Murrelets

Long-term research is critical if you are responsible for managing over half of the world's population of Ancient Murrelets. For much of his career, ornithologist Tony Gaston has been unraveling the enigmatic life of this forest-nesting alcid. The results of his latest project are both astounding and significant![270, 271]

Tony and his colleague Laurie Wilson put geolocators, lightweight electronic archival tracking devices, on adults breeding at colonies on the west and east coasts of the Queen Charlotte Islands (QCI). These geolocators had to be recovered from birds when they returned to breed the following year. Stored data revealed that after adults departed the colonies with their chicks, those from the east coast moved into in Hecate Strait and southward into Queen Charlotte Sound, as previously thought,[516] *but families from west coast colonies moved steadily north and west towards Alaska. For the first few weeks, movement patterns on the west coast corresponded to the direction of surface currents; parents with their flightless young were likely drifting north with the Alaska Current. On the east coast, where there is little directional current, birds apparently paddled away from their colonies and then remained in the same general area after the first week.*

Most surprisingly, after 3-6 weeks, when their young could fly, all adults from both east and west coast colonies rapidly migrated north to western Alaska and the Bering Sea, where they likely moulted. Afterwards, some of the birds moved back south to spend the winter off North America as far south as California; the rest moved further west to spend the winter near Japan and China, having travelled about 8,000 km (5,000 mi) away from their colonies, a record migration distance for alcid species. It is unknown whether fledged young accompany the adults on the northward migration, but frequent sightings of independent young in July off BC[512, 517] *suggest that some and perhaps most remain in local waters throughout their first year. Birds wintering in Asia began moving rapidly east in February, arriving back near QCI in March. Interestingly, there was no relationship between where birds wintered and which colonies they came from.*

We already knew that Ancient Murrelets were highly vulnerable to oil spills when they gather on the water around their colonies during the breeding season, but part of the motivation for this study was to determine where and when birds breeding in BC are vulnerable to oil spills after they leave the colonies. Cargo ship traffic is more concentrated, and thus the probability of an oil spill is higher, in Queen Charlotte Sound and Hecate Strait than off the west coast of QCI. Thus, birds breeding on the east coast of QCI, which is about half of the BC population, are particularly vulnerable during the period that adults are escorting flightless young. Birds that move back to winter off North America, comprising about a third of the population, are vulnerable to spills in our waters from November on. Young birds that may not migrate northward are vulnerable throughout the post-breeding and wintering period.

Cassin's Auklet

Ptychoramphus aleuticus **CAAU**

(*Cassin Auklet*, *Little Diver*)

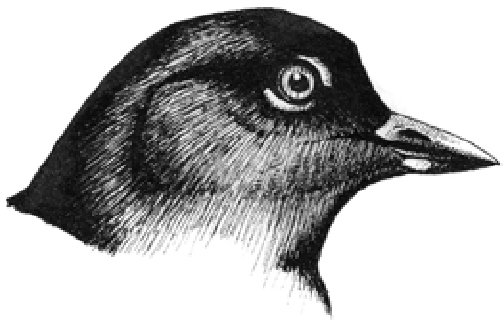


Figure 147. Due to its pelagic feeding habits and night-time breeding behaviour, Cassin's Auklet is always a challenge to observe. It breeds on islands along the west coast of North America from the Aleutian Islands in Alaska to Baja California. About 80% of the world's population breeds in British Columbia. *Drawing by Keith Taylor.*

A dumpy, dusky little diver, Cassin's Auklets are generally seen in small to large flocks far offshore where they feed day and night on oil-rich crustaceans such as copepods and euphausiids. Adults commonly travel 50-80 km from their nest sites looking for areas of upwelling with abundant zooplankton.[52] It is a pursuit diver, like all alcids, and uses its wings like flippers to pursue prey at depths up to 40 m or more.[73] They can take off easily, rising quickly from the water, skipping across the waves, and then flying low and direct.

During the breeding season, Cassin's Auklet are highly aggregated with over half the world population concentrated on three adjacent islands. These colonies are underground "cities" and true to their "urban" nature come alive only at night. Living in such concentration, these birds have an impact on their environment, depositing large quantities of waste, eroding the ground, and changing the vegetation. Abandoned at the end of the breeding season, the land has some chance to recover before the next year's influx.

APPEARANCE

Similar Species: In BC, Marbled Murrelet and Rhinoceros Auklet.

Size: Smaller than an American Robin; **Length:** 20-23 cm (8-9 in); **Wingspan:** 38 cm (15 in); **Mass:** 150-200 g (5.3-7.1 oz).

Adult (Figure 148)
- dark grey above, fading to paler grey on sides, white on belly
- white crescents around eye
- pale spot on black bill

Immature
- dark-brown iris gradually changing to white by 3 years
- wings and tail brownish
- whiter throat

In flight
- small, plump, dusky looking
- short, rounded wings
- rapid wing-beats
- rises swiftly from water

Figure 148. Unlike other auks, Cassin's Auklet lacks a distinct breeding plumage and is a dull grey-brown above and pale below year-round. Up close, distinguishing features include a pale spot on the bill and a small white spot above the eye. *Photo by R. Wayne Campbell, Solander Island, BC, 5 May 1976.*

BREEDING

Colonial nester on treeless and forested islands off the outer coast. Colonies range from <100 to over half a million pairs. Largest colonies are on treeless islands such as Triangle Island. Most birds start breeding at three years, forming monogamous, long-term pair bonds in the spring. If a mate is lost, the remaining partner may re-pair at any time. Birds are active on the colony only at night, when they socialize on the surface and defend a small area around their burrow. Their calls have variously been described as, "the agonized cry of a child", "the squealing of pigs", and "the harsh rasping of a saw". Periodically during the night the calling crescendos to a colony-wide chorus likened to "a frog pond in full cry" or "asylum inmates wailing at the moon". Like all true auklets, Cassin's regurgitate crustacean prey for their chicks from a specialized neck pouch. Chicks nibble at the pale spot on the lower mandible of a parent's bill to elicit feeding. Adults need to eat 67% of body weight per day to balance their energy requirements when feeding chicks.

Cassin's and Rhinoceros auklets, Ancient Murrelets, Tufted Puffins, and storm-petrels often nest in mixed colonies; distinguishing their burrows can be difficult. Helpful indicators include burrow size, smell, and cleanliness and shed belly feathers with distinctive colour patterns. On mixed colonies, Cassin's and Rhinoceros auklets occupy perimeter areas generally within 100 m of the shore, while Ancient Murrelets nest farther inland.

Messy birds

The adage "Don't foul your own nest" seems like good advice for a bird that secrets its nest away in a long burrow and travels to and from its nest under cover of darkness, presumably to keep itself and its nest inconspicuous and so reduce risks of predation. Cassin's Auklets, however, have clearly never heard that advice. Although they do keep the nest chamber clean, Cassin's Auklets have no qualms about fouling their burrow entrance. Unlike Ancient Murrelet burrows that are kept so meticulously clean it is sometimes difficult for a seabird surveyor to be sure the burrow is a nest site and not just a hole in the ground, active Cassin's Auklet burrows cannot be missed. Parent birds defecate at the burrow entrance leaving long streaks of white faecal matter that come to look like airport landing strips on the burrow approach. When they are feeding young, adults bring a pink mush of small crustacean prey stored in their throat pouch that they regurgitate to the chick. Inevitably some of this "gurge" gets spilled at the burrow entrance when parents return. By the end of the nestling period the entrance to a Cassin's Auklets burrow is often slimy with accumulated faeces and pink "gurge" from the adults. Meanwhile, the chick has been tidily using a small side chamber, often located near the entrance, for its latrine. Of course after a month, even a single chick makes a substantial pile of faeces! It's a delightful place to stick your arm, which of course you cannot do without getting your face close to the ground and breathing in the aroma. Talk about "in your face"! And when you reach in to explore the burrow, inevitably your hand finds the little side chamber where the chick has dutifully been busy. Maybe you'd like to check the next burrow?

Messy Cassin's Auklet burrows had a positive spinoff - they stimulated one of the major innovations in our seabird studies, the development of the "sleeve". We used to designate an old shirt that we would put on, or just roll up our shirt sleeves, before sticking our arm in a burrow. The old shirt would get pretty foul by the end of a survey trip. In the early 1980s, the light bulb lit up – why not make a washable "sleeve" that we could put on for burrow exploration. We designed a shoulder-length sleeve that had a loop to fasten around your thumb to keep the sleeve from riding up your arm as you pushed your arm into a burrow, and a stretchy cord linking the sleeves over your shoulder to keep them in place. Additional sleeves have been made since and are still standard issue for CWS survey crews.

Seasonal and diurnal attendance at colony: Activity at the colony is the most nocturnal of any alcid; birds arrive and depart colonies in almost complete darkness.[263] Does not gather on the water near the colony like other auklets and Ancient Murrelets, and is rarely seen near colonies during the day, except early and late in the breeding season: small groups of 3-20 birds were sighted around Triangle Island on 13 March 1976 during the pre-breeding period; [137] four birds were recorded between Triangle and Sartine islands on 2 August 1975;[593] and fledgling birds were seen frequently seen near shore at Frederick Island in the latter half of July 1981 near the end of the breeding season.[482] A concentration of 420 birds was observed 6-8 km east of the colony on East Copper Island off the east coast of Moresby Island at 19:00 to 20:40 hr on 15 May 1985.[480] This was the largest concentration of Cassin's Auklets observed near a breeding colony, but it was not known whether this was a staging aggregation actually associated with that colony. Egg-laying in BC begins in early April and the last young fledge by the end of July or beginning of August.[137, 158, 482] Timing of hatch for Cassin's Auklets was very similar to that of Ancient Murrelets on Frederick Island, with a median date of 3 June for both species.[591]

Nest: An unlined chamber in 30-210 cm long burrow excavated by both sexes under grass tussocks, shrubs, and ferns in treeless habitat, and under tree roots (Figure 149), stumps, logs, and rocks in forested areas; also into banks or open ground. Burrows are reused year after year. Adults sometimes dig a side chamber to defecate in. Otherwise, adults and chicks do their business near the entrance or at the end of the burrow past the nest. The fowl mix of faeces and regurgitated crustaceans that get spilled at the entrance make Cassin's the least pleasant of seabird burrows to inspect.

Figure 149. At some colonies on the Queen Charlotte Islands, most burrows of Cassin's Auklets are excavated under tree roots. It may take the pair 3-4 weeks to excavate a burrow before occupancy. *Photo by R. Wayne Campbell, Skedans Islands, BC, 24 May 1996.*

Figure 150. During the long incubation period, the creamy-white, unmarked egg of Cassin's Auklet becomes stained from sitting on bare soil. *Photo by R. Wayne Campbell, Moore Islands, BC, June 1970.*

Eggs: Elliptical ovate to ovate. Smooth, non-glossy, creamy white, unmarked; frequently becoming nest-stained (Figure 150). **Size:** 48 (1.9 in) x 34 mm (1.3 in); **Average clutch size (maximum clutch size):** 1(1); **Incubation period:** 37-42 days. Sexes alternate 24-hour shifts, beginning the day egg is laid. Though they only lay one egg, adults have two incubation patches.

Young: Hatched with down feathers. Black to dark grey on back, lighter grey below, naked around eye, pink legs and feet turning blackish by 10 days. Brooded continuously for 3-4 days. Fed by both parents at night (Figure 151). **Average number (maximum):** 1(1). **Fledging period:** 41-50 days. Departs alone at night. In California, two broods may be produced in a single breeding season.[383]

Lifespan: Annual adult survival at Triangle Island was 75% (male) to 84% (female), except 44% for females during years of anomalous ocean conditions.[397] Average survival rate higher in the Queen Charlotte Islands: 88% on Reef Island;[255] 80% on Frederick Island.[33] Maximum known life span: 16 years.[378]

Figure 151. During the one-and-a-half month fledging period, the nestling Cassin's Auklet changes from a greyish-black ball of fluff to the two-toned body of grey above and white below as the juvenile feathers grow in and the downy feathers wear away. *Photo by R. Wayne Campbell. Storm Islands, BC, 13 June 1976.*

CONSERVATION

British Columbia supports about 76-80% of the estimated world breeding population.[383, 452, 527, 530, 554] Estimates from 1990 indicate that over half of the world population of 3.6 million birds breed on a small cluster of islands off the north end of Vancouver Island. Changes in availability of crustacean prey due to ocean temperature fluctuations caused several years of breeding failure and may have lowered adult survival rates at southern colonies. Populations at the Farallon Islands in California declined by over 50% between 1971 and 1998.[5, 611] In the Scott Islands off northwestern Vancouver Island, populations may have declined by 40% between 1989 and 2009.[478] An oil spill in the area of these breeding-season concentrations could decimate populations. Although Cassin's Auklets do not gather on the water around their colonies as do Ancient Murrelets, Rhinoceros Auklets, and Tufted Puffins, most forage 40-75 km off the colony, well within the impact zone of a major oil spill. They are also at risk from oil pollution during the winter; 32% of birds killed in the *Nestucca* spill were Cassin's Auklets.[483] Introduced rats, Northern Raccoons, and American Mink have impacted several colonies in the Queen Charlotte and the Scott islands, and the further spread of raccoons is a major threat to extant colonies in the Queen Charlotte Islands. Birds are vulnerable to gill-nets and to disturbance at the colony, especially early in the egg-laying period. Collisions with lighthouses cause some mortality.[514] Cassin's Auklets were listed as a species of Special Concern by COSEWIC in 2014,[187] and were blue-listed in BC in 2015.[55]

Population trends to 1990

Cassin's Auklets are the most abundant breeding seabird species in British Columbia, comprising 48% of the total seabird breeding population estimated as of 1990 (Table 3, page 63). Over 2.7 million birds nest at 60 sites (Figures 152 and 153), with 73% of the population breeding at three sites in the Scott Islands (Figure 153; Tables 3, 4, 5 and 15, pages 63-65 and 163-165). Most (22%) of the remainder breed in the Queen Charlotte Islands (Figure 152; Table 4, page 64).

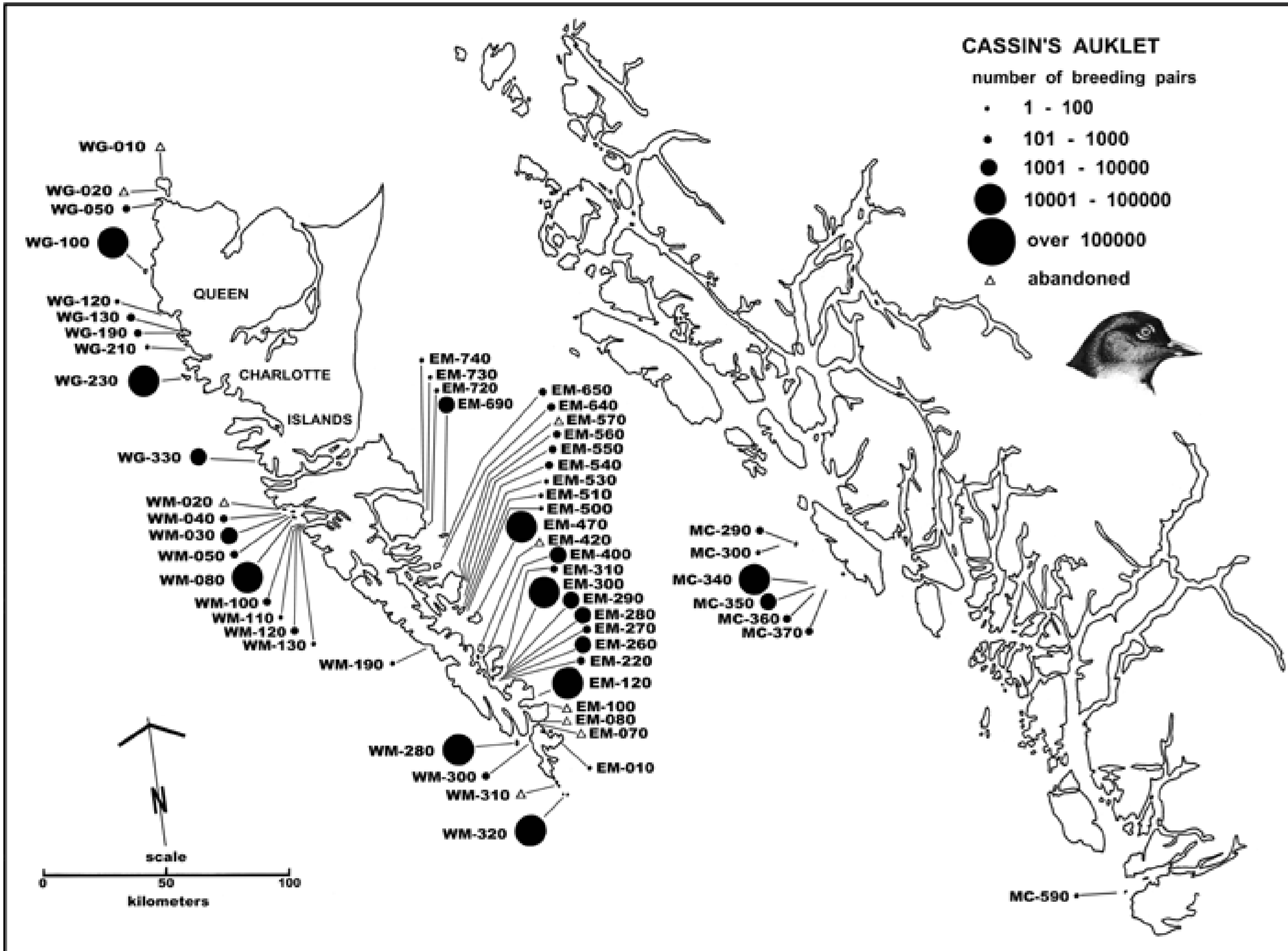


Figure 152. Cassin's Auklet colonies in northern British Columbia. Site codes refer to colonies listed on Table 15.

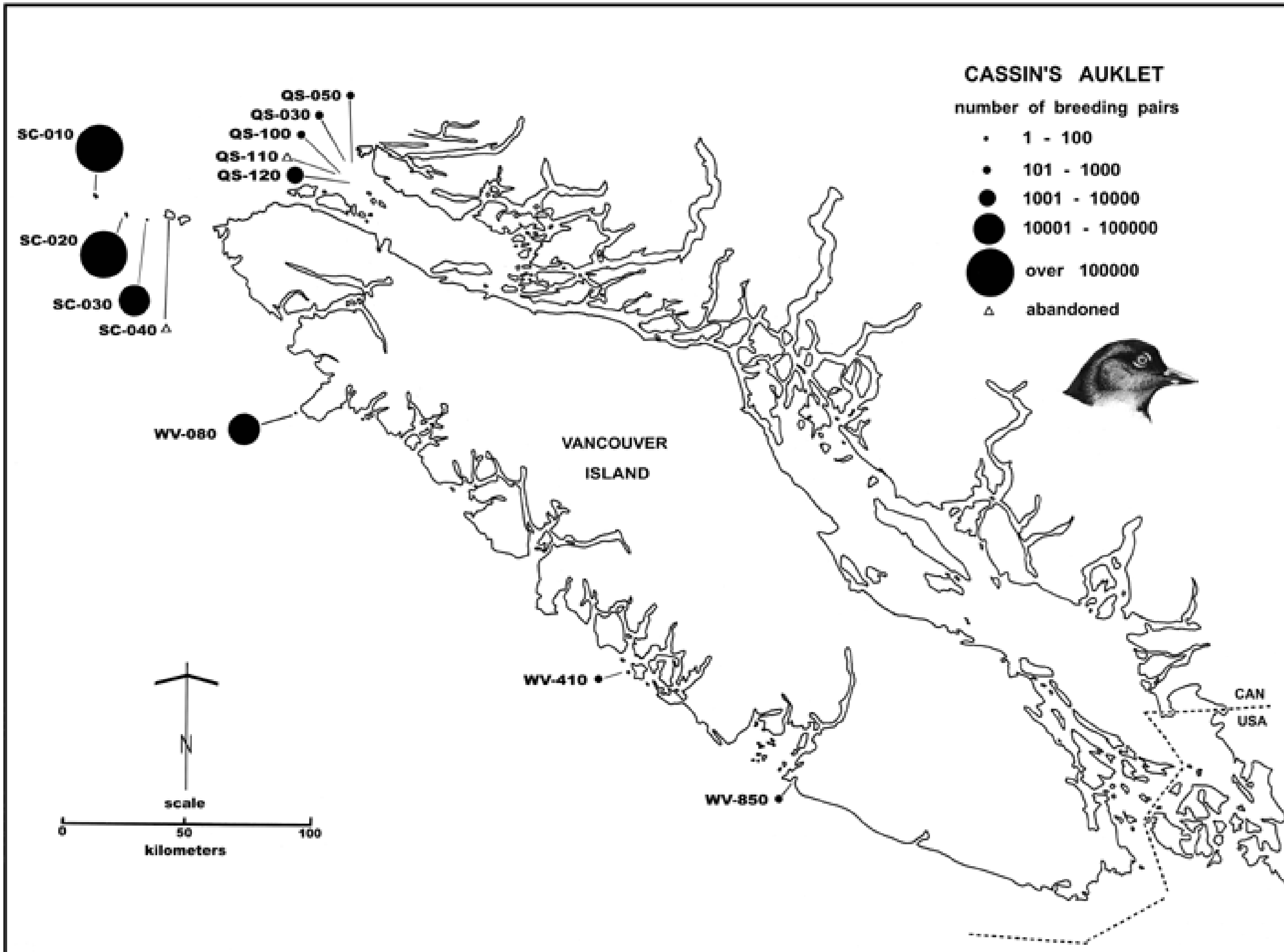


Figure 153. Cassin's Auklet colonies in southern British Columbia. Site codes refer to colonies listed on Table 15.

Table 15. Estimates of breeding populations (pairs) of Cassin's Auklets at colonies in British Columbia as of 1990. See Key to Summary Tables on pages 53-56 for an explanation of the letter codes used to qualify population estimates.

			Burrow Density			Burrow Occupancy				
	Location	Colony Area (ha)	Burrows/ha ± SE	No. of Sample Plots	Area Sampled (%)	Percent Occupancy ± SE[a]	Sampling Effort (%)	Population Estimate (pairs ± SE)	Survey Year	Source[b]
West Coast Graham Island										
WG-010	Langara Island							E	1981	482
WG-020	Cox Island							E	1981	482
WG-050	"Lepas" Islet							200e	1977	115
WG-100	Frederick Island	53.5	2,568 ± 305	76	0.4	65 ± 6	0.08	89,852 ± 13,169	1980	482
WG-120	Tian Islets							100e	1986	470
WG-130	Solide Islands							950e	1977	115
WG-190	"Kiokathli" Islets							300e	1977	115
WG-210	Barry Islet							100e	1977	115
WG-230	Hippa Island	27.4	550 ± 137	43	0.4	83 ± 3	0.40	12,540 ± 3,157	1983	482
WG-330	Marble Island							5,000e	1977	115
West Coast Moresby Island										
WM-020	Saunders Island	8.1	1,340 ± 360	34	0.4	0		E	1986	481
WM-030	Helgesen I. - south end	4.4	1,060 ± 430	22	0.5	M		3,529 ± 1,432	1986	481
	- rest of colony	5.9	47 ± 33	47	0.7	M		210 ± 147	1986	481
WM-040	Willie Island	0.1	1,600	1	5.0	M		170S	1986	481
WM-050	Carswell Island	0.6				M		180eS	1986	481
WM-080	Lihou Island	17.9	837 ± 186	34	0.6	M		11,240 ± 2,495	1986	481
WM-100	Luxmoore Island	1.3	400 ± 167	11	0.8	M		377 ± 158	1986	481
WM-110	Rogers Island							40eS	1986	481
WM-120	Cape Kuper				100	M		120	1986	481
WM-130	Moresby Islets				53	M		75e	1986	481
WM-190	"Between" Islet							100eS	1977	115
WM-280	Anthony Island	14.0	2,388 ± 295	111	0.7	74 ± 7	0.13	24,737 ± 3,840	1985	481
WM-300	Gordon Islands				70	M		700e	1985	481
WM-310	St. James Island							0	1986	481
WM-320	Kerouard Islands	4.6	22,600 ± 2,600	23	0.1	M		77,935 ± 8,966	1986	481
East Coast Moresby Island										
EM-010	Kunghit Island							50eS	1986	480
EM-070	Charles Island							0	1986	480
EM-080	Annette Island							0	1986	480
EM-100	Langtry Island							0	1985	480
EM-120	Rankine Islands - West	11.3	3,103 ± 493	33	0.7	62 ± 7	0.08	21,775 ± 4,306	1984	480
	- East	2.1	3,050 ± 1,340	12	0.5	[c]		3,978 ± 1,799	1985	480

Table 15. cont'd

	Location	Colony Area (ha)	Burrow Density: Burrows/ha ± SE	Burrow Density: No. of Sample Plots	Burrow Density: Area Sampled (%)	Burrow Occupancy: Percent Occupancy ± SE[a]	Burrow Occupancy: Sampling Effort (%)	Population Estimate (pairs ± SE)	Survey Year	Source[b]
EM-220	Bolkus Islands				53	M		960e	1985	480
EM-260	Rock Islet - Main[d]	1.2	2,880 ± 1,250	5	0.4	M		2,594 ± 1,127	1985	480
	- Others[d]	1.3	2,475[d]	7	3.1	M		2,500e	1985	480
EM-270	Skincuttle Island	2.0	653 ± 253	5	1.1	M		980 ± 380	1985	480
EM-280	George Island	7.0	1,130 ± 290	11	0.8	75 ± 7	0.10	5,933 ± 1,619	1985	480
EM-290	Jeffrey Island	2.5	1,497 ± 1,192	3	0.6	71 ± 8	0.19	2,673 ± 2,136	1985	480
EM-300	East Copper Island	9.3	1,404 ± 312	17	0.9	83 ± 7	0.23	10,876 ± 2,585	1985	480
EM-310	Howay Island							250eS	1985	480
EM-400	Alder Island	4.0	952 ± 290	12	1.5	80	0.38	3,174 ± 928	1985	480
EM-420	Arichika Island							E	1985	480
EM-470	Ramsay Island	22.7	880 ± 140	46	1.0	71 ± 11	0.12	12,887 ± 2,771	1984	480
EM-500	Hotspring Island							10eS	1986	480
EM-510	House Island							40eS	1984	480
EM-530	Murchison Island							50eS	1984	480
EM-540	Agglomerate Island				23	M		200eS	1985	480
EM-550	Kawas Islands				79	M		200e	1984, 85	480
EM-560	Tar Islands				80	M		120eS	1985	480
EM-570	Tuft Island							0	1982	480
EM-640	Titul Island				100	M		170	1983	480
EM-650	Lost Islands				100	M		210	1983	480
EM-690	Reef Island	6.2			78	M		1,700e	1983	480
EM-720	Limestone Is. - East				100	M		40	1983	480
EM-730	Low Island				100	M		30	1983	480
EM-740	Skedans Islands				100	M		100	1983	480
Northern Mainland Coast										
MC-290	Moore Islands							400eS	1988	476
MC-300	McKenney Islands							40eS	1988	476
MC-340	Byers Islands	11.8	1,875 ± 427	60	0.2	85	0.15	18,806 ± 4,283	1988	476
MC-350	Sinnett Islets	1.0	2,778 ± 1,584	9	0.4	M		2,126 ± 1,212	1988	476
MC-360	Conroy Island				25	M		450eS	1988	476
MC-370	Harvey Islands				50	M		710e[e]	1988	476
MC-590	Egg Island				100			5S	1988	476

Table 15. cont'd

	Location	Colony Area (ha)	Burrow Density: Burrows/ha ± SE	Burrow Density: No. of Sample Plots	Burrow Density: Area Sampled (%)	Burrow Occupancy: Percent Occupancy ± SE[a]	Burrow Occupancy: Sampling Effort (%)	Population Estimate (pairs ± SE)	Survey Year	Source[b]
Queen Charlotte Strait										
QS-030	Storm Islands							300eS	1987	477
QS-050	Reid Islets	0.3	1,071 ± 743	7	0.8	M		263 ± 182	1987	477
QS-100	Tree Islets							250e	1986	477
QS-110	Pine Island							0	1985	477
QS-120	Buckle Grp. - Bright I.	0.5	10,000 ± 2,990	7	0.6	M		3,699 ± 1,106	1987	477
	- Herbert I.	0.5	5,710 ± 2,230	7	0.5	M		2,179 ± 851	1987	477
Scott Islands										
SC-010	Triangle Island									
	- slopes & top ridges	65.3	10,518 ± 224	1870	1.1				1989	484
	- level interior	28.0	1,561 ± 198	248	0.4				1989	484
	- Total	93.3		2118	0.9	75 ± 3	0.03	547,637 ± 25,748	1989	484
SC-020	Sartine Island	14.9	27,816 ± 1,503	174	0.1	91 ± 4	0.01	375,902 ± 26,597	1987	484
SC-030	Beresford Island	5.5	13,400 ± 1,616	100	0.2	90 ± 10	0.01	66,067 ± 10,697	1987	484
SC-040	Lanz Island							0	1987	484
SC-050	Cox Island							0	1987	484
West Coast Vancouver Island										
WV-080	Solander Island	3.4	11,754 ± 1,198	67	0.8	84 ± 7		33,886 ± 4,321	1989	475
WV-410	Cleland Island	1.5	733 ± 277	15	0.8	M		805 ± 305	1988	475
WV-850	Seabird Rocks				38	M		269e	1988	170

[a] M indicates that a median occupancy rate (75%) for BC colonies was used.[480]

[b] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.

[c] Occupancy rate was determined on the west Rankine Island.

[d] On Rock Islets, density on the main islet was sampled with quadrats but on the other islets, six strip transects were used and no standard error was calculated. Totals have been recalculated from those given in Rodway et al.[480]

[e] Population estimate on Harvey Islands was recalculated from that given in Rodway and Lemon [476] using a median occupancy rate.

Four previously confirmed colonies in the Queen Charlotte Islands were abandoned by 1990, and suspected colonies on St. James Island in the Queen Charlotte Islands and on Cox and Lanz islands in the Scott Islands had disappeared (Table 15, pages 163-165). During this time, rats were present on Langara, St. James and probably Cox and Arichika islands in the Queen Charlotte Islands,[29, 481, 482] raccoons had invaded Saunders Island in the Queen Charlotte Islands, and mink were introduced to Lanz Island and raccoon were introduced to Cox Island in the Scott Islands.[158] Populations of Cassin's Auklets may have been substantial on some of those islands, judging from the large numbers currently breeding on adjacent, unperturbed islands.

Populations since 1990

Permanent monitoring plots for Cassin's Auklets established on select colonies have been resurveyed at 5-year intervals [216, 324, 368, 370, 372, 373] and have shown significant declines in burrow numbers on Rankine and Triangle islands.[478] A dramatic decline between 1989 and 2009 indicated by the permanent plots on Triangle Island was also evident on the other Scott Islands [328] and suggested that more than 20% of the world's breeding population may have been lost.[478] A declining trend since 1990 agrees with other indicators from productivity and survival studies and has likely been mediated by changing oceanographic conditions that have affected food supply [33, 35, 320] (Figure 154). A reversal of the declining trend on Triangle Island was seen between 2009 and 2014,[488] but a massive die-off the following winter [322] may have offset any potential population recovery. Numbers of burrows in permanent plots showed some decrease on East Copper Island between 1991 and 2003, whereas on Ramsay Island, numbers of burrows were stable or showed a slightly increasing trend.[216, 478]

Repeat transect surveys of East Copper Island in 2003 [372] and Rankine Island in 2000 [375] showed similar trends to those in permanent plots.[478] The population estimate on East Copper Island was 10,600 pairs in 2003.[372] A population estimate was not calculated for Rankine Island in 2000, but burrow density in sample quadrats showed the same decline as permanent plots.[478, 640] Cassin's Auklets were also resurveyed on George Island in 1996, giving an estimate of 4,300 pairs,[371] down from the 5,900 pairs estimated in 1985.[480] Surveys in Englefield Bay in 1993 revealed further declines on colonies impacted by raccoons; [266] only 200 pairs were estimated on Helgesen Island in 1993 compared to 3,700 pairs in 1986.[481] Over the same period, the estimated nesting population on raccoon-free Lihou Island increased from 11,200 to 13,100 pairs.[266] Several pockets of nesting Cassin's Auklets were found in 1993 on the north side of Carswell Island where they had not previously been reported. A few were still nesting on Kunghit Island in 1993.[298]

A small pocket of Cassin's Auklets was found nesting again on Langara Island in 2004 [463] following the successful eradication of introduced rats in 1995-96.[352] Removal of rats from the adjacent Cox Island as well as from St. James, Arichika, and Murchison islands along the coast of Moresby Island [434] hopefully will also result in recovery or re-establishment of nesting populations on those islands.

Figure 154. Changing oceanographic conditions may have affected the zooplankton food supply of this recently fledged Cassin's Auklet that washed ashore on Long Beach, BC. *Photo by R. Wayne Campbell, July 1967.*

Rhinoceros Auklet

Cerorhinca monocerata **RHAU**

(*Horned Puffin*, *Horn-billed Puffin, Unicorn Puffin*, *Rhinoceros Puffin*, *Rhino Auklet*)

Figure 155. Rhinoceros Auklet breeds in the North Pacific Ocean from Korea northeast to Alaska and south to California. The species comprises about 13% of the 5.6 million seabirds breeding in BC. BC populations account for an estimated 56% of the total world's population. *Drawing by Keith Taylor.*

The Rhinoceros Auklet is really a puffin. Like other puffins, it grows a prominent bill ornament in the early spring that it sheds after the breeding season, flies in large "wheels" around its nesting slopes, and feeds its young mainly fish carried in the bill, as it lacks the neck pouch of true auklets. Systematic grouping of Rhinoceros Auklets with the puffins has been confirmed using recent molecular techniques. Interestingly, this bird was named the "Horned Puffin" in the late 1800s, and it seems appropriate that they should reclaim this name from the presently misnamed Horned Puffin that has no horn at all.

Though often seen singly, especially in winter, they are common in flocks of 10s and sometimes 100s, frequently initiating or joining multi-species feeding flocks over schooling fish or swarming euphausiids. Nocturnal habits at colonies may be a response to diurnal predation and kleptoparasitism, especially by opportunistic Glaucous-winged Gulls, although other large auks that carry fish in their bill (Figure 156) are diurnal at the colony.

Figure 156. After all the effort of foraging widely and returning with fish to feed their young, seabird parents often lose their food loads, like this dropped bill-load of Pacific Sand Lance, to opportunistic gulls. If Rhinoceros Auklets return to feed their young during the day, they may be harassed by Glaucous-winged Gulls that steal the fish before nestlings can be fed. *Photo by R. Wayne Campbell, Cleland Island, BC, August 1968.*

From mid-to late August, after the breeding season, most birds start migrating towards California for the winter. Numbers in BC decrease through September and October. Chicks banded in BC in summer have been recovered in Oregon in August (2), southeast Alaska in September (1), and California in October (1) and December (1).[351]

Wheeling Rhinos

One of the highlights of the field season on Triangle Island is the nightly return of Rhinoceros Auklets to their nesting burrows on the steep grass and salmonberry covered slopes of South Bay. Sitting comfortably on a driftwood bench on the small cabin's front porch, looking out over the ocean as dusk settles in, we would listen to the distant growl of sea lions on Southeast Point and watch the silhouette of Puffin Rock fade into the night sky as we waited in anticipation. Out of the gathering mist the Rhinos start to appear, far out near the mouth of the bay at first, small groups of fifty or a hundred or so *flying by. Soon these small groups join up to become thousands strong, a huge continuous flock coming ever closer to shore, circling in a great wheel around the amphitheatre of the bay. Breaking out of this ever spinning mass, with wings beating furiously, they fly straight like arrows into the slope, landing in the grass tussocks near the entrance to their burrow. The cabin serves as a protective shield as the bombardment of birds pass close overhead, silvery fish clutched tightly in their bills, intent on feeding their hungry chicks. Night falls, still the birds come in, and from close by and all the way up the slope, we hear their groaning vocalizations as the nightly chorus begins. Departure from the colony is equally spectacular. Just before dawn, torrents of birds stream down the steeply contoured slopes of South Bay, the shrill whistling sound of thousands of wings streaking through the air and out over the ocean heralding the end of their short nightly visit. With the mass exodus complete for the night, we watch the last ghostly forms disappear in zigzagging flight out low across the water in the dim glow of morning.*

On Cleland Island, off Tofino, the nightly influx and exodus of Rhinoceros Auklets is a toned down event compared to that on Triangle Island, but is also a unique experience. Cleland is a low, flat island and wheeling birds fly right over the island, rocketing by just above the salmonberry that covers much of the area. They start mustering offshore about an hour before sunset and two hours later begin dropping from circling flocks into the salmonberry. The only safe vantage point is behind an old driftlog at the edge of the breeding area that provides some protection. Of many visitors taken to the island to witness the event, only one person, a medical doctor whose name will remain anonymous, did not heed the advice "Keep low and remove your glasses!" Inevitably, the doctor was struck in the forehead when he decided to stand up to take photos. The impact knocked him off the log, broke his glasses, and left a nasty-looking red welt between his eyes. Earlier advice should probably have included the comment, "take photos at your own risk"!

Figure 157. The vertical "horn" at the base of the orange bill and thin white plumes on the face characterize Rhinoceros Auklet in breeding plumage. *Photo by R. Wayne Campbell, Cleland Island, BC. August 1974.*

APPEARANCE

Similar Species: In BC, Cassin's Auklet, Tufted Puffin immature and winter.

Size: Smaller than crow; **Length:** 35-38 cm (14-15 in); **Wingspan:** 56 cm (22 in); **Mass:** 353-616 g (12.5-21.7 oz).

Adult breeding (Figure 157)
- blackish-brown above, fading to pale grey on sides, white belly
- yellow horn on orange bill
- white plumes on head

Adult winter
- heavyset with thick bill
- colour same as breeder
- bill paler without horn
- head plumes indistinct

In flight
- strong, direct flight
- taxis along water using wings to gain momentum for takeoff
- flies just above water

BREEDING

Colonial nester on treeless and forested islands free of mammalian predators in colonies of <100 to 90,000 pairs. Long-term pair bonds appear to be formed on land, possibly during the nestling period when large numbers of pre-breeders visit and vocalize on the colony. Birds defend the vicinity of the burrow entrance and perhaps a take-off, landing, and loafing area nearby using "Hunched Walk", "Gaped Bill", and "Upright Stance" postures accompanied by loud "huffs", "growling", and "barks". Grappling fights are common. "Mooing", a distinctive series of 7-12 mellow notes varying in pitch and speed, may be used for mate location and is given in flight when birds are leaving colony. Adults bring larger fish for chicks than they feed themselves.[203]

Rhinoceros Auklets have been known to usurp Cassin's Auklet nests, sometimes breaking eggs or killing chicks,[609] and expanding Rhinoceros Auklet populations likely have displaced Cassin's Auklets from some nesting areas. Being powerful but not very agile fliers, birds often collide with trees, logs, or other obstacles when arriving on colony. On Triangle Island, some kill themselves when accelerating down slope on departure by hitting drift logs at high speed. When working on colonies with those types of slopes, researchers are well advised to wear hard-hats. Collisions also sometimes occur between birds approaching the colony. Circling "wheels" of birds around the southern slopes of Triangle Island increase in size after dusk until perhaps 2,000 birds are circling together, rotating clockwise around the bay with an average rotational period of about one minute. The odd maverick bird will occasionally fly counter to the main wheel, sometimes causing head-on collisions from which birds fall stunned to the beach or water. In other areas on Triangle Island with fewer numbers, small flocks of 10-20 birds may circle in both directions without mishap.

Seasonal and diurnal attendance at colony: Activity on land is primarily nocturnal at colonies in BC, but occasionally birds begin to come ashore just prior to sunset and leave well after daylight, especially on overcast or foggy nights.[484, 537] Throughout the period that birds are present around colonies, from March through August,[259] birds gather at offshore staging areas each day beginning up to 3-4 hours before sunset until they move ashore after dusk. Birds are uncommon on the water around nesting colonies during the rest of the day. On Cleland Island, birds start to gather 1 h before sunset.[537] In the south bay of Triangle Island, arrival times at offshore staging areas varied under different weather conditions, earlier on dark, cloudy, or foggy nights, but in July birds generally gathered on the water between 20:00 and 22:00 hr.[484] Small circling flocks frequently moved in and out of staging groups during this same time period. Maximum count of birds on the staging area was 5,400 at 21:50 hr, just after sunset at 21:40 hr on 14 July 1985. Birds were never heard calling in flight or on the water and it is unknown what social activity occurs on staging areas or whether they may function mainly as mustering locations from which birds begin to circle and then land on nesting slopes. On Triangle Island, staging and circling flocks increase in size during the incubation period and large flocks first occur around the time chicks begin to hatch. Many of the birds joining these flocks at that time were suspected to be non-breeders because most birds delivering fish to their young appeared to fly directly to nesting slopes without joining circling flocks.[484] Thus, staging areas and circling behaviour may function in courtship and pair formation or in the education of naïve, young birds in regards to visiting the colony.

Staging areas are generally close to colonies, 300 to 500 m offshore at Teuri Island, Japan [612] and within 1 km of nesting slopes on Triangle Island. At Anthony Island in 1985 and 1986, we observed as many as 2,900 birds gathered 1-4 km off the colony at various times of the day,[451] although this may have been more of a feeding and loafing concentration than an actual staging area for the colony. Large numbers of birds were seen staging around Pine Island in 1975. No concentrations have been detected around the nearby colony on Storm Islands,[477] although thorough surveys at appropriate times have not been conducted.

In BC, birds first visit nesting slopes in March and begin laying eggs in the last week of April.[137, 259] Last chicks fledge in late August or early September.[137, 537]

Nest: Chamber lined with grasses, leaves, and seaweeds at end of 1-6 m long burrow under grass tussocks, shrubs, logs, tree roots, and stumps, and into open ground. Burrow excavated by both sexes at a rate up to 18 cm per night. Pairs often reuse the same burrow in subsequent years.

Eggs: Elliptical to subelliptical. Smooth, non-glossy, off-white with faint purplish blotches, becoming nest-stained. **Size:** 70 (2.8 in) x 47 mm (1.9 in); **Average clutch size (maximum clutch size):** 1(1); **Incubation period:** 39-52 days. Sexes alternate usually every 24 hours, occasionally up to 4 days.

Young: Hatched with down feathers. Dark greyish-brown above, paler below, mobile. Brooded for about 4 days. Fed 1-2 bill-loads of 1-19 fish per night. Equal effort by both parents. **Average number (maximum):** 1(1). **Fledging period:** 38-58 days (Figure 158). Older chicks exercise wings outside burrow at night.

Lifespan: Annual adult survival determined at Triangle Island was 86%; [397] maximum 31 years 1 month.[378]

Figure 158. On average, young Rhinoceros Auklets leave their burrows at night when 50 days old and become quite active in the colony, climbing through vegetation and over driftwood. *Photo by R. Wayne Campbell, Cleland Island, BC, August 1974.*

CONSERVATION

Data as of 1990 indicate that 56% of the estimated world population breeds in British Columbia.[247, 279, 309, 389, 452, 522, 527, 530, 554, 607, 613, 624, 641] Other compilations suggest that British Columbia populations comprise somewhere between 48% and 72% of the total world breeding population.[84, 259] As with Cassin's Auklets, major portions of the world's population are concentrated on only a few clustered colonies in British Columbia. Because they stage on the water around their colonies, Rhinoceros Auklets are highly vulnerable to oil pollution. Along with Common Murres, they are the most frequent species caught in coastal gill nets. Nesting populations in the Queen Charlotte Islands are at risk from introduced raccoons. Rats are a problem on at least one extant colony on Kunghit Island. Human disturbance at colonies is a concern, especially in the increasingly visited Gwaii Haanas National Park Reserve area. People walking over nesting habitat can collapse burrows. Keen's Mouse has been found to eat neglected eggs, and can be a major cause of egg loss.[42] Bald Eagles and Peregrine Falcons (Figure 159) prey on adults, and chicks grow faster in areas without eagles, presumably because adults are more willing to deliver food.[301] Risk of predation and kleptoparasitism may be the reason birds are nocturnal on the colony (see Figure 156).

Figure 159. Rhinoceros Auklet carcasses found in a colony can easily be identified as Peregrine Falcon kills by the cleanly picked sternum. *Photo by R. Wayne Campbell, Whitmore Island, BC, 26 June 1976.*

Population trends to 1990

As of 1990, almost 720,000 Rhinoceros Auklets were estimated breeding at 35 sites (Tables 3 and 5, pages 63 and 65). Two colonies in Queen Charlotte Strait, four colonies on the northern Mainland coast, and one colony in the Scott Islands supported 89% of that population (Figures 160 and 161, Table 16, pages 174-175).

Breeding populations of Rhinoceros Auklet have generally increased since the 1960s along the west coast of North America,[6] although four colonies invaded by rats (Langara, Cox, and the Moore Head area on Kunghit Island) or raccoons (Saunders Island) in the Queen Charlotte Islands and one suspected colony where mink were introduced (Lanz Island) in the Scott Islands have been abandoned. In the southern parts of its range, in California, numbers doubled annually from 1973 to 1977. New colonies also appeared. On Cleland Island the breeding populations rose from an estimated 25 pairs in 1967 [130] to 1,000 pairs in 1988.[475] Populations have increased on Triangle Island (estimated populations increased 66% from 25,100 pairs to 41,700 pairs between 1984 and 1989) but historical data are somewhat ambiguous and some of the increase may have been due to better exploration for burrows in 1989.[158, 295, 484, 567] Rhinoceros Auklets have also colonized more protected sites in the Gulf Islands, where 6 pairs were estimated nesting on Mandarte Island in 1986.[574] Historical estimates from other areas are inadequate to define trends.

Populations since 1990

Surveys of permanent plots established in the 1980s to monitor Rhinoceros Auklet populations have shown increases in numbers of burrows on all monitored colonies except Pine Island, which showed a decrease between 1984 and 2001.[478] Gaston and Masselink [266] resurveyed a number of colonies in Englefield Bay in 1993. Major declines were detected at colonies impacted by Northern Raccoons; populations on Helgesen Island decreased almost 80% between 1986 and 1993 and the remnant colony on Instructor Island was abandoned. The nesting population on raccoon-free Lihou Island remained stable over the same time period.[266] Estimated populations remained the same between 1986 and

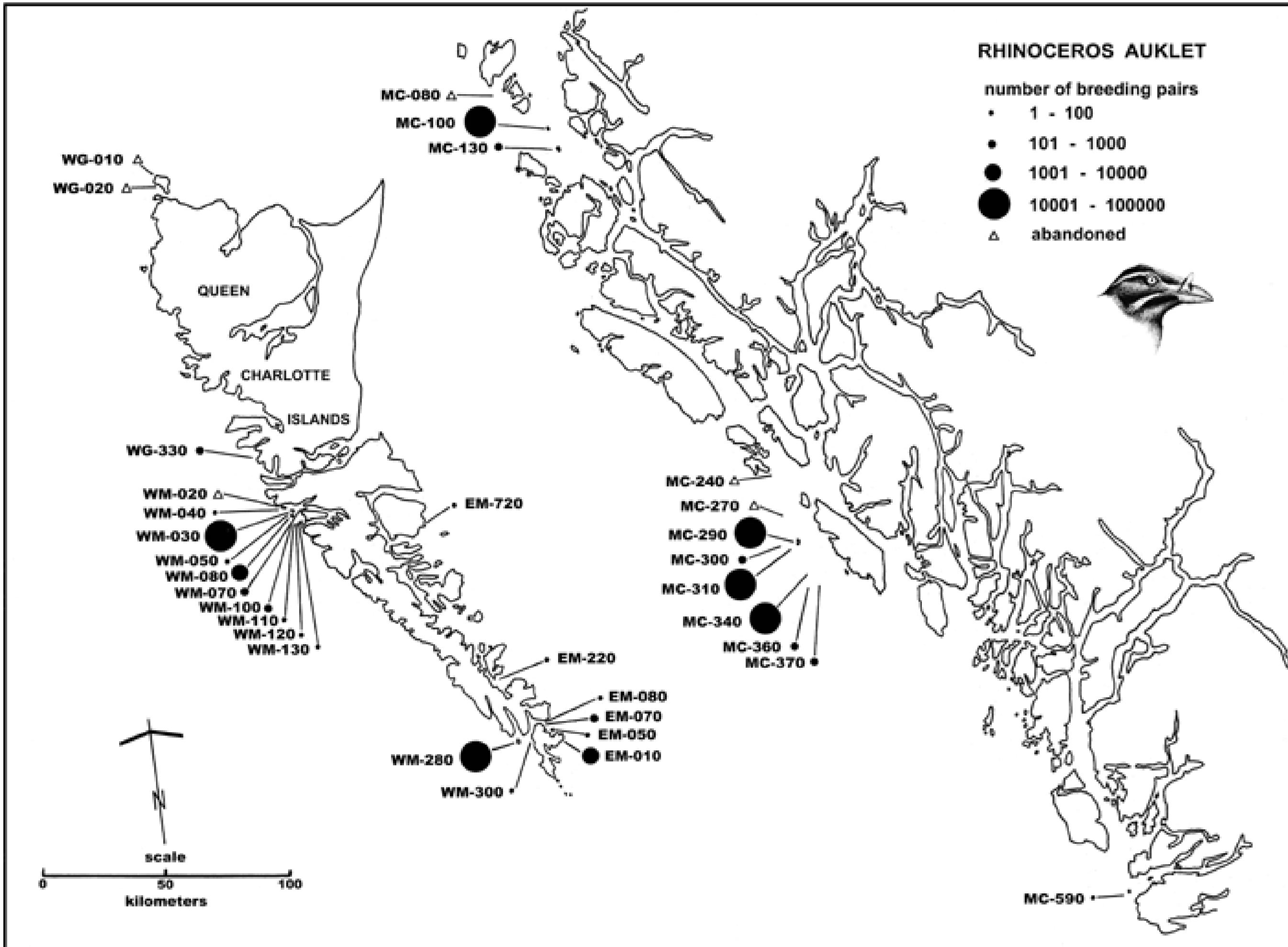


Figure 160. Rhinoceros Auklet colonies in northern British Columbia. Site codes refer to colonies listed on Table 16.

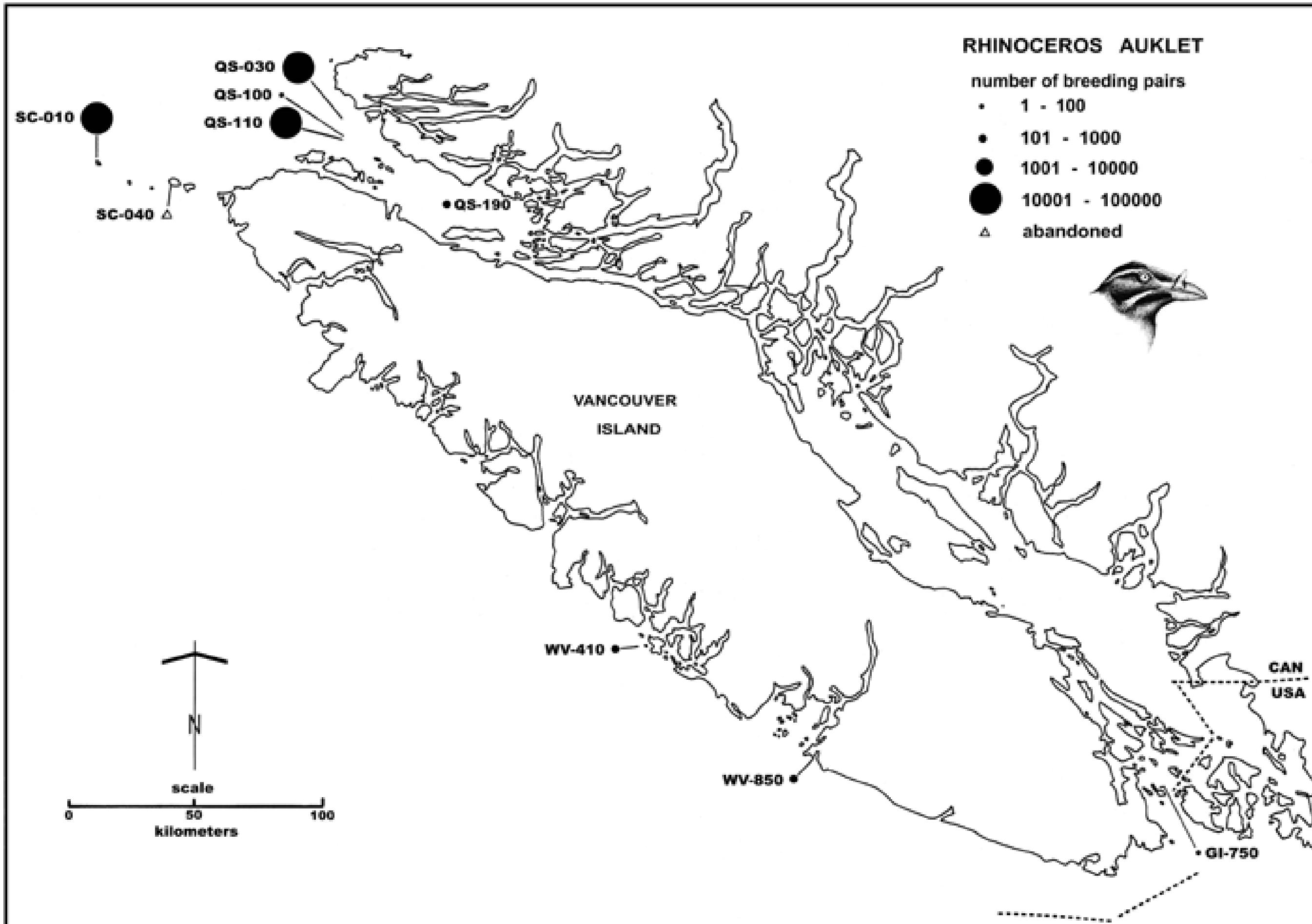


Figure 161. Rhinoceros Auklet colonies in southern British Columbia. Site codes refer to colonies listed on Table 16.

Table 16. Estimates of breeding populations (pairs) of Rhinoceros Auklets at colonies in British Columbia as of 1990. See Key to Summary Tables on pages 53-56 for an explanation of the letter codes used to qualify population estimates.

			Burrow Density			Burrow Occupancy				
	Location	Colony Area (ha)	Burrows/ha ± SE	No. of Sample Plots	Area Sampled (%)	Percent Occupancy ± SE[a]	Sampling Effort (%)	Population Estimate (pairs ± SE)	Survey Year	Source[b]
West Coast Graham Island										
WG-010	Langara Island							E	1981	482
WG-020	Cox Island							E	1981	482
WG-330	Marble Island							200e	1977	115
West Coast Moresby Island										
WM-020	Saunders Island	8.1	1,111 ± 345	34	0.4	0		E	1986	481
WM-030	Helgesen I. - Main	10.2	2,000 ± 330	65	0.6	M		15,636 ± 2,580	1986	481
	- Little	0.7	1,890 ± 570	7	1.0	M		953 ± 287	1986	481
WM-040	Willie Island	0.1	700	1	5.0	M		80tS	1986	481
WM-050	Carswell Island							20eS	1986	481
WM-070	Instructor Island	1.6	690 ± 240	16	0.9	M		848 ± 295S	1986	481
WM-080	Lihou Island	7.1	505 ± 170	19	0.7	M		2,745 ± 924	1986	481
WM-100	Luxmoore Island	0.6	629 ± 471	7	1.0	M		301 ± 226S	1986	481
WM-110	Rogers Island							20eS	1986	481
WM-120	Cape Kuper							10S	1986	481
WM-130	Moresby Islets				48			40eS	1986	481
WM-280	Anthony Island	11.9	1,808 ± 220	103	0.8	64 ± 7	0.08	13,771 ± 2,244	1985	481
WM-300	Gordon Islands				67			80eS	1985	481
East Coast Moresby Island										
EM-010	Kunghit Island							2,500e	1986	480
EM-050	High Island							10eS	1985	480
EM-070	Charles Island							130S	1986	480
EM-080	Annette Island							20S	1986	480
EM-220	Bolkus Islands				59			20eS	1985	480
EM-690	Reef Island							E	1986	637
EM-720	Limestone Is. - East							2S	1983	480

Table 16. cont'd

	Location	Colony Area (ha)	Burrow Density: Burrows/ha ± SE	No. of Sample Plots	Area Sampled (%)	Burrow Occupancy: Percent Occupancy ± SE[a]	Sampling Effort (%)	Population Estimate (pairs ± SE)	Survey Year	Source[b]
Northern Mainland Coast										
MC-080	Connel Islands							0	1987	476
MC-100	Lucy Islands	9.5	3,459 ± 183	206	1.1	M		25,299 ± 1,337	1983	476
MC-130	Rachael Islands				100			300S	1987	476
MC-240	Dupont Island							0	1988	476
MC-270	Wells Rocks							0	1988	476
MC-290	Moore Is. - Main	29.3	1,757 ± 126	113	1.0	77	0.06	39,663 ± 4,388	1988	476
	- Islets	0.8	1,429 ± 743	7	0.4	[c]		869 ± 452	1988	476
MC-300	McKenney Islands							130eS	1988	476
MC-310	Whitmore Islands	8.3	1,931 ± 266	25	1.0	77	0.16	12,382 ± 2,595	1988	476
MC-340	Byers Islands	9.5	4,268 ± 655	41	0.2	94 ± 3	0.08	37,911 ± 5,980	1988	476
MC-360	Conroy Island				13	M		500eS	1988	476
MC-370	Harvey Islands				69	M		160eS[d]	1988	476
MC-590	Egg Island				100	M		90	1988	476
Queen Charlotte Strait										
QS-030	Storm Islands	24.0	3,900 ± 330	147	0.6	77	0.03	72,138 ± 6,104	1987	477
QS-100	Tree Islets							100e	1986	477
QS-110	Pine Island	22.7	4,624 ± 360	82	0.9	85 ± 3	0.06	89,535 ± 7,819	1985	477
QS-190	Numas Islands				100	M		550	1982	477
Scott Islands										
SC-010	Triangle Island	11.2	5,494 ± 245	379	1.4	68 ± 6	0.08	41,682 ± 4,216	1989	484
SC-040	Lanz Island							0	1987	484
West Coast Vancouver Island										
WV-410	Cleland Island	1.5	880 ± 370	15	0.9	M		992 ± 417	1988	475
WV-850	Seabird Rocks				95	M		140e	1988	170
Gulf Islands										
GI-750	Mandarte Island							6e	1986	574

[a] M indicates that a median occupancy rate (77%) for BC colonies was used.[480]
[b] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.
[c] On the Moore Islands, occupancy rate was determined on the main island.
[d] Population estimate on Harvey Islands was recalculated from that given in Rodway and Lemon [476] using a median occupancy rate.

1993 on rat-infested Kunghit Island, although one area where a few burrows were found in 1986 appeared abandoned in 1993 and the area where the largest numbers of burrows were counted in 1986 was not fully explored in 1993.[298]

Further expansion into the sheltered waters of the Strait of Georgia has likely occurred; 2-3 pairs were suspected nesting on Mitlenatch Island in 1991 and subsequent years.[634]

Flying the Labyrinth

Most colonies of burrow-nesting alcids along the BC coast are on densely forested islands that present a variety of dangers and challenges to incoming and outgoing nocturnal birds. Alcid wings are short, ideal for "flying" underwater in pursuit of prey. However, in the air, their stubby wings require rapid flapping to remain aloft and maneuver. Rhinoceros Auklets are medium-sized birds and yet, despite their limited maneuverability, fly at great speed into the forest, dodging trees and other objects with amazing last-second adjustments. They are not always successful, and will, with alarming regularity, hit trees with a resounding crash. Some succumb to injuries but most often they recover, and finding themselves on the forest floor, scuttle off in hunched-over postures to find their burrows.

On treeless Triangle Island, birds arriving from the sea are not faced with the challenge of navigating a forest maze, but there are still obstacles with which they must contend. The chaotic jumble of drift-logs piled high above the tide line is an unnatural obstacle, and it is not unusual to find a bird that has died from a collision during its high-speed arrival or departure from the colony. The thickets of salmonberry that carpet much of Triangle Island have their own unique challenges (Figure 162). Although a dense, tall, and seemingly impenetrable thorny shrub, Rhinoceros Auklets (and Cassin's Auklets) nest beneath it. The labyrinth of intertwined branches occasionally entangles auklets, and unable to extricate themselves, they hang there and die. Fortunately, most are able to negotiate these mazes, although how they do so is bewildering to us. Even more remarkable is how their chicks fledge from these locations and find their way to the shore or to an opening where they can take their inaugural flight. I (Moira) once witnessed a solution by a bird departing just at dawn. I heard a rustling in the shoulder high salmonberry beside me. Branches swayed and bent, and suddenly out popped the head of a Rhinoceros Auklet, who deftly clambered up through the final top branches. Balancing on the uppermost leaves and spindly twigs, wings now extended and beating, the bird began running along this flexible canopy as if it was the ground surface, until it finally became airborne and continued on its journey to the open sea.

Figure 162. Cassin's and Rhinoceros auklets sometimes nest in burrows under impenetrable hillsides of two-metre high salmonberry. Getting into and out of the thicket poses issues for adults and fledglings. Surveyors Brian Carter (left), Ken Summers, and Dick Grinnell are laying out a line transect to sample the colony. *Photo by Michael S. Rodway, Triangle Island, BC, summer 1989.*

Tufted Puffin
Fratercula cirrhata **TUPU**
(*Sea Parrot*, *Crested Puffin*)

Figure 163. Tufted Puffin is restricted to the North Pacific Ocean where it breeds from northwestern Japan through the Bering Sea, Aleutian Islands, Gulf of Alaska, British Columbia, and south to northern California. The centre of the breeding population is in Alaska. *Drawing by Keith Taylor.*

A Tufted Puffin in its nuptial dress is the dandy of all seabirds. The bill is beyond good taste, and the head plumes are positively ostentatious! Imagine thousands of them, strutting about, pompously puffing themselves up, each challenging the rest, declaring themselves the most superb of all dandies. If you're going to get dressed up, why settle for subtlety, why not go all out, hang the neighbours. There is more to life than moderation, and puffins are the proof. If you are fortunate enough to see thousands of them standing on a colony undisturbed, their antics will captivate you until darkness takes them away. Everywhere you look, something will be going on – dirt flying out of a burrow from one housecleaning, a pair "billing" in a bonding ritual, two rivals tumbling down the slope locked in combat, a dreamer carrying a feather that caught its fancy into its burrow – a puffin pandemonium.

Tufted Puffin spends more time far at sea than other species of alcid. On the open ocean away from the colonies, the diet of adults and subadults is composed mostly of invertebrates (50-70%). During the breeding season adults rely heavily on schooling fishes that they also feed their young.[615] It is during this 3-4 month period that humans have become smitten with their antics and behaviour.

A Bill Bursting with Fish

Editors of nature magazines are keen to publish photos of puffins with bills overloaded with fish. The response from readers is immediate and is often followed with questions from curious naturalists, "How can a puffin catch and keep more fish after the first one is caught?" And, "how many fish can a puffin hold in its bill?"

In British Columbia, Tufted Puffins forage at the continental shelf slope during the day, which may be as far as 30-95 km offshore. It is not energy efficient to travel those distances to and from a colony with a single fish for a nestling. Puffins have two specialized structures in their mouths that allow them to catch and hold many slippery fish for long periods. The upper palate of the beak (roof of the mouth) has many tiny spines that hold fish already caught. The tip of the tongue is rough and coarse, useful in capturing a slippery fish. Once caught the fish is pushed to the above spines allowing the puffin to open its beak to catch more fish.

Photographers and researchers have answered the other query. On average, about 10 fish are carried at one time but in Britain an incredible 62 were counted in an Atlantic Puffin's (Fratercula arctica) *bill! In Alaska, 29 larval fish was the maximum bill load.*[616] *In British Columbia we have seen 22 larval Pacific Sand Lance carried crosswise in the bill at one time.*[634]

The ages of Tufted Puffins can be determined by examining the upper bill. Adults in breeding plumage have up to four vertical grooves near the end of the upper bill ornament. Younger birds have fewer grooves; second-year birds generally have two.

APPEARANCE

Similar Species: In BC, Horned Puffin; Rhinoceros Auklet in winter; non-breeding and immatures resemble same-aged Rhinoceros Auklets in summer.

Size: Smaller than crow; **Length:** 36-41 cm (14-16 in); **Wingspan:** 64 cm (25 in); **Mass:** 678-913 g (1.5-2.0 lb).

Adult breeding
- all dark body
- white face
- huge, red and yellow bill
- pale-yellow tufts on head

Juvenile
- blackish-brown above
- grey-brown throat and breast
- white or grey belly
- smaller brown bill

In flight (Figure 164)
- heavy, direct flight
- short, rounded wings
- red-orange feet (paler in immature)
- distinct head-bill profile

Figure 164. In breeding plumage, the all brown-black body, white face, blonde tufts above the ear, and orange feet and bill of Tufted Puffin are distinctive. Its short stubby wings are used to pursue prey underwater at speeds of 1-2 metres per second. *Photo by Alan D. Wilson, St. Paul Island, Alaska.*

BREEDING

Colonial nester on outer, treeless islands (Figure 165) and on headlands of larger, forested islands in colonies up to 26,000 pairs in BC and 163,000 pairs in Alaska. Also single to a few pairs nesting on some islands. At colonies during the pre-breeding period, puffins aggregate offshore where they engage in courtship and copulation. Courtship continues on land where pairs claim their burrows and defend them with lowered threat postures and bill gapes. Serious disputes break into wrestling matches with locked bills and kicking feet. Main call is a low grumbling. Pair bonds are long term and birds will reuse the same burrow from year to year. Chicks fledge at night without their parents, and are then independent at sea.

Seasonal and diurnal attendance at colony: Tufted Puffins are active during the day on their colonies, and during the breeding season may gather in large aggregations on the surrounding waters within a few hundred metres of the shore. On Triangle Island, especially later in the season, it is common to see 5-10 thousand puffins aggregated on the water in two or three clusters off the main nesting slopes on different sides of the island. Intensive courtship and copulation occurs in the large aggregations that gather on the water during the pre-laying period.[263]

Early in the season, diurnal attendance cycles from high numbers standing out on the colony and staging on the water to virtual absence over a period of a few days.[445] Peaks in attendance often occur in the morning and evening. Greater attendance occurs throughout the day later in the season, with highest numbers in the evening. Few birds stand around on the colony or attend gatherings on the water when feeding conditions at sea are poor. When attendance at the colony is high, birds circle around nesting slopes in large "wheels", especially later in the season when many nonbreeders are present. Parents bringing in fish will join the wheel briefly and then drop out as they come abreast of their burrow. This may give them some camouflage from kleptoparasitic Glaucous-winged Gulls that try to rob them of their bill-loads of fish (Figure 165).

In spring, the first returning puffins may be spotted in late April; the earliest date near a colony is 20 April. Most, however, return in early May when they are beginning to attend nesting sites *en masse*. Eggs have been recorded from 20 May to 31 July.[137] In late August, puffins begin to leave the colony for the open ocean. Most are gone by mid-September; the latest date is 28 September near Triangle Island.

Figure 165. Even when large numbers of adults are attending nesting slopes, a Tufted Puffin chick generally remains safely concealed in its burrow. However, older nestlings sometimes come to the burrow entrance to exercise their wings or perhaps when they anticipate food from a parent. At such times, both chicks and adults carrying food are threatened by marauding Glaucous-winged Gulls. *Photo by R. Wayne Campbell, Triangle Island, BC, July, 1974.*

Nest: Grass-lined bowl, generally in burrow, averaging 0.8 m and up to 3.0 m long, dug with bill and feet where there is sufficient soil on seaward-facing, 10-59° grassy slopes. Some burrows under shrubs and tree roots, a few nests in rock crevices and cliffs.

Eggs: Subelliptical to oval. Smooth, non-glossy, off-white, unmarked or with faint pale brown to purplish spots and scrawls, becoming nest-stained. **Size:** 71 (2.8 in) x 49 mm (1.9 in); **Average clutch size (maximum clutch size):** 1(1); **Incubation period:** 41-54 d. By both sexes.

Young: Hatched with down feathers. Brownish-black above, sooty-grey below, bill and feet brownish-black. Fed about 4 times per day, mostly in morning, by both sexes. **Average number (maximum):** 1(1). **Fledging period:** 40-59 days (Figure 166).

Figure 166. This young Tufted Puffin, about 50 days old, is near fledging and will soon leave its burrow at dusk and spend the next 4-5 years in pelagic waters before returning to breed. *Photo by R. Wayne Campbell, Solander Island, BC, 14 August 1981.*

Lifespan: Annual adult survival determined at Triangle Island was 96% for females and 91% for males; [397] maximum lifespan unknown.

CONSERVATION

BC supports 2-3% of the estimated world breeding population of 3.0-3.5 million birds.[84, 445] Concentrations of birds around colonies are vulnerable to oil spills. Tufted Puffins are also at risk from gill nets, introduced mammalian predators, human disturbance at the colony (Figure 167), and reductions in prey availability caused by changes in ocean conditions, and they frequently ingest plastics. Nesting birds suffered total reproductive failures during several recent years of warmer spring ocean temperatures. Rats were likely responsible for the abandonment of one and the decline of another small colony. Seven other small, historical colonies have been abandoned for reasons that are unknown, but possibly associated with increasing human disturbance. Close approaching boats will flush birds off nesting areas, and investigators disturbing incubating birds can cause abandonment. Research on reproductive success on Triangle Island suggests that climate change and warming ocean temperatures pose serious risks for puffins breeding in BC.[277] Tufted Puffin was placed on the BC Conservation Data Centre's Blue List in 2015.[55]

Population trends to 1990

Almost 90% of the 78,600 Tufted Puffins breeding in British Columbia nest in the Scott Islands (Tables 3 and 4, pages 63-64). Solander Island on the west coast of Vancouver Island supports another 8% of the population. Small numbers breed in most other regions of the coast at a total of 31 sites (Figure 168; Tables 5 and 17, pages 65 and 182-183).

Though overall populations appear unaffected, eight sites that had small historic populations have been abandoned. Except on Langara Island where rats may have been responsible, the causes for those abandonments are unknown. American Mink may threaten the extant population on Cleland Island,[475] rats are suspected to have restricted the population on St. James Island,[481] and human disturbance is a concern for conspicuous colonies in the South Moresby (Gwaii Haanas) area.[480]

Populations since 1990

Permanent monitoring plots established in 1984 to monitor Tufted Puffin populations on Triangle Island have been resurveyed at 5-year intervals.[478, 484] Numbers of burrows in plots have varied but no overall trend was apparent.

Figure 167. In the 1970s, researchers started identifying areas on Triangle Island, BC where helicopters could land so as to minimize disturbance to nesting seabirds from the noise and prop wash from the rotors. Also, the minimum height for fly-overs was increased and it was stipulated that helicopters must approach landing sites from the sea. *Photo by Michael S. Rodway, Triangle Island, BC, July 1982.*

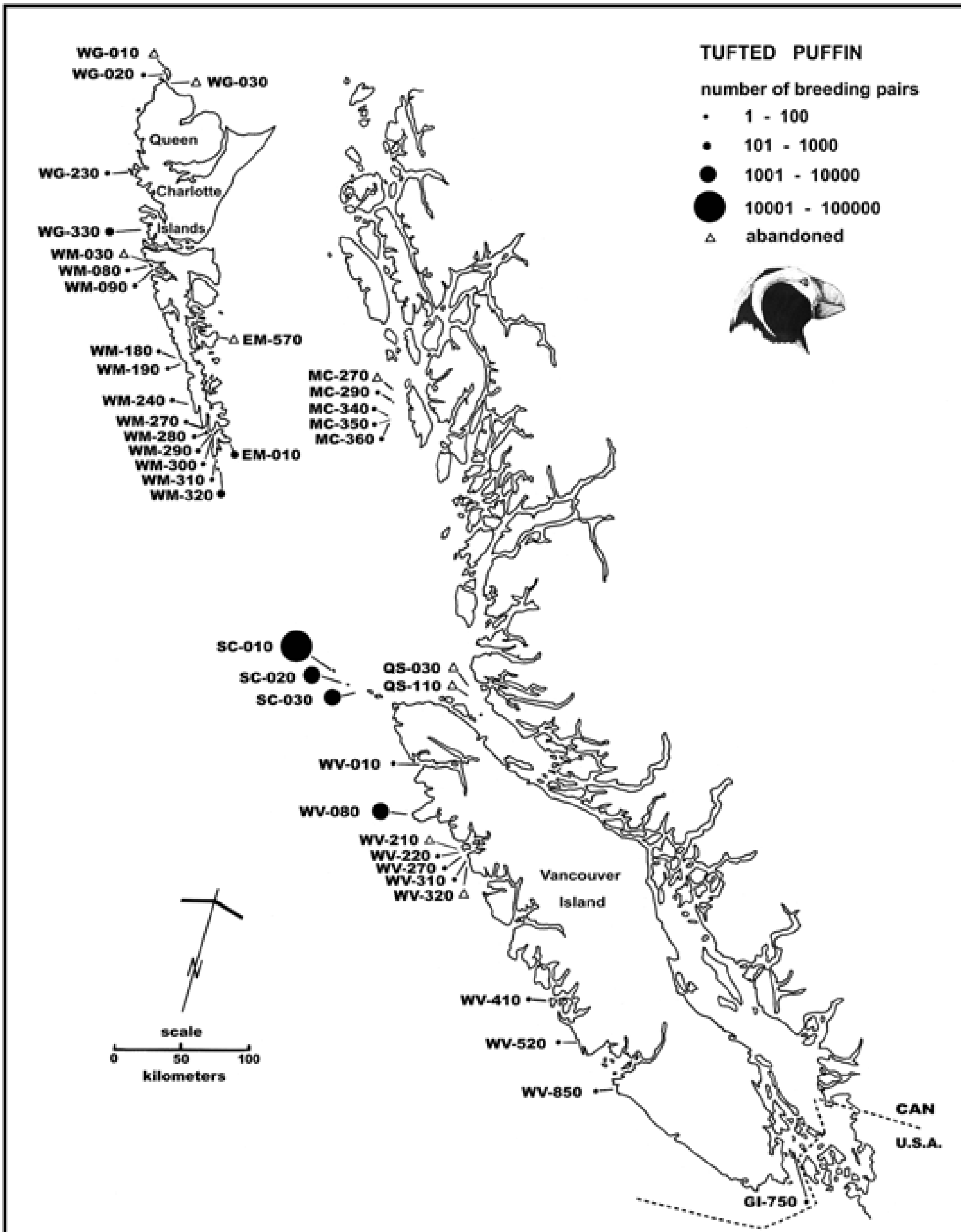


Figure 168. Tufted Puffin colonies in British Columbia. Site codes refer to colonies listed on Table 17.

Table 17. Estimates of breeding populations (pairs) of Tufted Puffins, and numbers of adult Tufted Puffins and Horned Puffins sighted at colonies in British Columbia as of 1990. See Key to Summary Tables on pages 53-56 for an explanation of the letter codes used to qualify population estimates.

			Burrow density			Burrow occupancy						
	Location	Colony area (ha)	Burrows/ha ± SE	No. of sample plots	Area sampled (%)	Percent occupancy ± SE	Sampling effort (%)	Population estimate (pairs ± SE)	TUPU birds	HOPU birds	Survey Year	Source[a]
West Coast Graham Island												
WG-010	Langara Island							E			1981	482
WG-020	Cox Island							S	23		1986	470
WG-030	Lucy Island							E			1981	482
WG-230	Hippa Island							S	40		1983	482
WG-330	Marble Island							300e	350	5	1977	134, 650
West Coast Moresby Island												
WM-030	Helgesen Island								0		1986	481
WM-080	Lihou Island							S	27		1986	481
WM-090	Bone Point							S	12		1986	481
WM-180	"Cone" Islet							S	60		1977	650
WM-190	"Between" Islet								1		1977	650
WM-240	"Keyhole" Rock							S	26		1986	470
WM-270	Adam Rocks							S	4		1986	481
WM-280	Anthony Island							20eS	32	20	1986	481
WM-290	Flatrock Island							11	16	2	1986, 88	481, 634
WM-300	Gordon Islands								1		1986	481
WM-310	St. James Island							100e	30	1	1986	481
WM-320	Kerouard Islands							600e	900	3	1986, 87	481, 634
East Coast Moresby Island												
EM-010	Kunghit Island							250e	323	3	1986, 87	480, 634
EM-570	Tuft Island							E			1982	480
Northern Mainland Coast												
MC-200	Joseph Island									0	1988	476
MC-270	Wells Rocks							0	0		1988	476
MC-290	Moore Islands							3	6		1988	476
MC-340	Byers Islands							3	6	1	1988	476
MC-350	Sinnett Islets							1S	1	0	1988	476
MC-360	Conroy Island							8	6	2	1988	476

Table 17. cont'd

	Location	Colony area (ha)	Burrow density: Burrows/ha ± SE	Burrow density: No. of sample plots	Burrow density: Area sampled (%)	Burrow occupancy: Percent occupancy ± SE	Burrow occupancy: Sampling effort (%)	Population estimate (pairs ± SE)	TUPU birds	HOPU birds	Survey Year	Source[a]
Queen Charlotte Strait												
QS-030	Storm Islands							E			1987	477
QS-110	Pine Island							E			1985	477
Scott Islands												
SC-010	Triangle Island											
	- Puffin Rock	2.3	6,092 ± 551	34	10.3	84 ± 4	0.49	11,982 ± 1,217		4	1982, 89	484
	- Main island	4.8	3,646 ± 446	12	2.9	82 ± 6	0.19	14,466 ± 2,056			1982, 89	484
	- Total	7.1		46	5.3	84 ± 4	0.33	26,448 ± 2,389		4	1982, 89	484
SC-020	Sartine Island	1.7	5,550 ± 1,230	27	0.2	M[b]		6,359 ± 1,410		6	1987,89	484
SC-030	Beresford Island	0.2	13,750 ± 3,750	8	0.3	M[b]		2,122 ± 579		7	1987	484
West Coast Vancouver Island												
WV-010	Gillam Islands							S	3		1988	475
WV-080	Solander Island	1.0	3,500 ± 376	20	0.8	90 ± 7	0.57	3,138 ± 408	700	6	1988,89	475
WV-210	Moos Islet								0		1988	475
WV-220	Thornton Islands							S	4		1988	475
WV-270	Volcanic Islets							2	2		1988	475
WV-310	Clark Island							S	5		1988	475
WV-320	McQuarrie Islets								0		1988	475
WV-410	Cleland Island							6eS	10		1988	475
WV-520	Florencia Islet							S	1		1988	475
WV-850	Seabird Rocks							4e	4		1988	170
Gulf Islands												
GI-750	Mandarte Island							1	1		1983	650

[a] Numbers refer to superscripts identifying entries in the Literature Cited and Other Sources of Information.
[b] Occupancy rate from Triangle Island was used.

Horned Puffin

Fratercula corniculata **HOPU**

(*Sea Parrot, Clown of the Sea*)

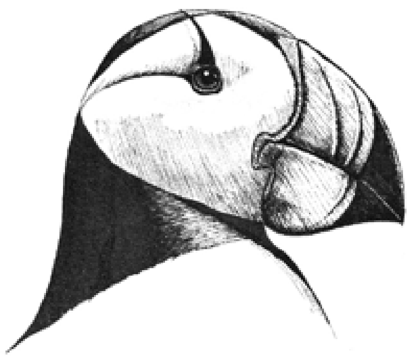


Figure 169. Horned Puffin is widespread in the North Pacific Ocean with its breeding abundance centred in the Aleutian Archipelago east to Prince William Sound in Alaska. Although confirmed nesting at only one site in British Columbia it is suspected of breeding on an additional 11 islands. *Drawing by Keith Taylor.*

This is a comical-looking bird, closely related to the smaller Atlantic Puffin. During the breeding season it usually occurs singly along coastal and pelagic waters of BC and is sometimes seen in small groups and in mixed-species flocks diving with Tufted Puffins and Rhinoceros Auklets for Pacific Sand Lance, squid, polychaete worms, and planktonic crustacea. The single chick is fed fishes, and parents may bring dozens of juvenile Pacific Sand Lance in one bill-load. Adults commonly live 20 years or more.

Large "wrecks" of Horned Puffins sometimes occur during persistent storms when they are unable to feed. In the 1940s, "windrows" of dead birds washed up on the shores of the Queen Charlotte Islands.[515]

There are over 400 records of Horned Puffin in British Columbia from every month of the year. Most are from the breeding period May through August (94%). The nearest breeding colony in Alaska is Forrester Island about 65 km northwest of Langara Island at the northwestern corner of the Queen Charlotte Islands. There is a single confirmed breeding record for BC. Most of the winter occurrences in the province are of dead birds found on beaches from Rose Spit on Graham Island south to Tofino on the central west coast of Vancouver Island.

APPEARANCE

Similar Species: In BC, Tufted Puffin and Thick-billed Murre in winter.

Size: Smaller than crow; **Length:** 36-41 cm (14-16 in); **Wingspan:** 56-58 cm (22-23 in); **Mass:** 499-754 g (1.1-1.7 lbs).

Adult breeding (Figure 170)
- black back and neck
- round white face
- huge yellow and red bill
- white underparts

Adult winter
- stocky with large head
- blackish above, white below
- dusky-grey face
- smaller, dark, reddish-tipped bill

In flight
- short, rounded wings
- grey wing linings
- bright orange legs
- flies high above water

BREEDING

An estimated 250,000 birds nest at the largest colony located along the Alaska Peninsula, but most colonies are small with a median of 48 birds. Like other puffins, birds gather on the water around the colony and fly in wheels over the nesting slopes. Courtship and copulation occurs mainly on the water. Pair bonds are likely maintained from year to year and mates may return to the breeding grounds together. Pairs occupy the nesting slopes within about one week after arrival back at the colony. Pairs claim nest sites and defend nest entrances.

Seasonal and diurnal attendance at colony: Active at colonies during the day. Attendance patterns and behaviour on the water is similar to Tufted Puffin.

Figure 170. Horned Puffin gets its name from the black "horn" above each eye that is prominent in breeding plumage. Generally, it is a chunky black-and-white seabird with a white face and massive bi-coloured bill. *Photo by Alan D. Wislon, St. Paul Island, Alaska.*

Nest: Excavates burrows with feet and bill like Tufted Puffins but more often uses rock crevices on cliffs, in talus and among beach boulders. Generally lines a nest cup with dry grasses, small twigs, and feathers.

Eggs: Subelliptical to oval. Smooth, non-glossy, off-white, unmarked or with faint pale brown to purplish spots and scrawls, becoming nest-stained. **Size:** 67 (2.6 in) x 46 mm (1.8 in); **Average clutch size (maximum clutch size):** 1(1); **Incubation period:** 38-45 days. By both sexes.

Young: Hatched with down feathers. Greyish-brown or darker brown above, greyish-white to yellowish-white below, bill and feet brownish-black. Fed 1-9 times per d, with peaks of feeding in morning and late afternoon, by both sexes. **Average number (maximum):** 1(1). **Fledging period:** 37-46 days.

Lifespan: Poorly known. Some known to survive more than 20 years.[263]

CONSERVATION

Small numbers nest in BC. Their centre of abundance is in Alaska, which supports at least 85% of the estimated world population of 1.1-1.2 million breeding birds.[84, 444] Like other diving seabirds, Horned Puffins are vulnerable to oil pollution, gill nets, introduced predators, human disturbance, and fisheries- or climate-induced changes in prey abundance and availability. They frequently ingest plastics. They are difficult to census due to their habit of nesting in rock crevices, making it hard to determine populations and monitor trends, but they are less prone to mammalian predation than burrow-nesting species. Horned Puffins were red-listed in BC in 1996 because of their limited distribution and small breeding population in BC.[55]

Population trends to 1990

In the decades leading up to 1990, Horned Puffin appeared to have been expanding its summer range along the coasts of British Columbia, Washington, and Oregon.[335, 451, 515] It has been confirmed nesting in British Columbia only at Anthony Island at the south end of the Queen Charlotte Islands,[134] but birds were sighted at 12 sites when they were last visited, and small numbers probably breed as far south as Solander Island off the west coast of Vancouver Island [475, 484] (Figure 171; Tables 5 and 17, pages 65 and 182-183). Birds were seen around two additional sites along the mainland coast in 1976,[134] but none were seen at those colonies when surveyed in the 1980s (Table 17). Total breeding population in the province is suspected to be about 30 pairs as of 1990 (Table 3, page 63).

Populations since 1990

We know of no updated records of Horned Puffins breeding along the BC coast.

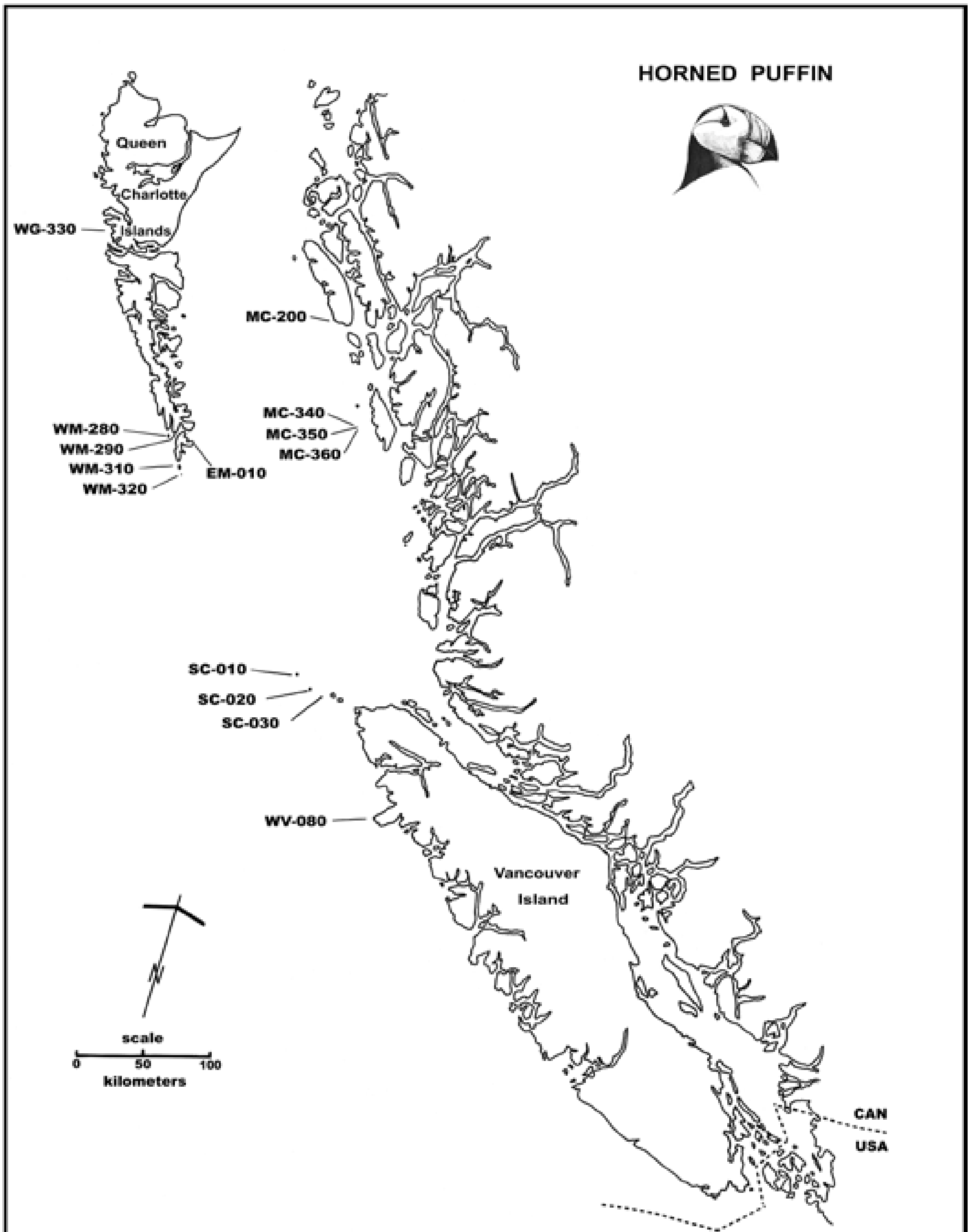


Figure 171. Colonies in British Columbia where Horned Puffins have been sighted. Site codes refer to colonies listed on Table 17.

THREATS TO SEABIRDS IN BRITISH COLUMBIA

Seabirds lived for thousands of years adapted to an environment without human interference. They nested on remote islands, sometimes in immense numbers, where they were protected from mammalian predators and were in range of abundant food supplies to feed their young. Today seabirds are the most threatened species-group of birds in the world, primarily due to the indirect and direct activities of humans. Nearly one-third of the 329 known seabird species are threatened or endangered. Concerns are global but each region has its own conservation issues.

One of the main reasons seabirds are such a threatened group is because they concentrate their numbers at breeding colonies. This behaviour can put large portions of species populations at risk from local environmental perturbations on land and at sea. Impacts occur when environmental perturbations overlap spatially and temporally with seabird activities. Knowledge of their spatial and temporal distribution and abundance on land and on the water around colonies is thus vital to their conservation.

Species that aggregate on the water around their colonies are extremely susceptible to oil pollution and other marine disturbance. In BC, this includes Common and Thick-billed murres, Pigeon Guillemots, Ancient Murrelets, Rhinoceros Auklets, Tufted Puffins, and occasionally Cassin's Auklets (see Species Accounts). In some cases, such as Common Murres on Triangle Island, almost the entire BC breeding population plus large numbers of younger, non-breeding birds may be concentrated on the water off the colony for extended periods of time.[484] Better information on when and where birds are concentrated on the water around their colonies, and on the functional importance of these staging areas to breeding birds is required to evaluate the potential risks associated with some of the threats discussed below.

Direct Exploitation

First Nations people along the northwest coast of North America traditionally harvested substantial numbers of seabirds, for food, clothing, bags, needles, and ceremonial regalia, and seabird eggs, that were used for food and trading. The latter was a good source of protein and if stored properly would keep for weeks. There was no commercial harvest of seabirds for their feathers as occurred and led to species extinctions in eastern North America.

The Haida and Tlingit indigenous peoples of the Queen Charlotte Islands and northwest mainland BC and southeast Alaska hunted and harvested 11 species of seabirds from Forrester Island for over a thousand years. Tufted Puffin (Figure 172), Common Murre, Rhinoceros Auklet, and Cassin's Auklet were the most heavily used species.[399] Although not found in middens, the eggs of Glaucous-winged Gulls were heavily harvested. Since the species is an indeterminate layer, if one or two eggs are removed from a nest more will be laid to replace those lost.

Figure 172. For several hundred years the "meaty" Tufted Puffin was the most harvested seabird on Forrester Island, AK, by Haida and Tlingit indigenous peoples from northwestern BC and southeastern Alaska. *Photo by Michael S. Rodway, Triangle Island, BC, 19 July 1985.*

Eggs of most of the larger seabirds were gathered as food by coastal peoples in BC, although specific details, such as species, islands, quantity, and techniques, are poorly known. Species-groups known to have been targeted include cormorants (probably Pelagic Cormorant as Double-crested Cormorant breed only in the Strait of Georgia and did not nest in the province until around 1920, and Brandt's Cormorant has nested only on the west coast of Vancouver Island since 1965), gulls (Glaucous-winged Gull), alcids (Common Murre, Pigeon Guillemot, Ancient Murrelet, Rhinoceros Auklet, and Tufted Puffin), and shorebirds (Black Oystercatcher). Coast Salish people utilized eggs from most of these species, although the only mention of egg use for the latter species is by the Tsimshian Peoples, specifically the Coast Tsimshian band, whose territory extended south to the vicinity of Milbanke Sound on the central mainland coast: "The eggs of sea gulls [Glaucous-winged Gull] and oystercatchers [Black Oystercatcher] were gathered in early June…" [294] (Figure 173).

Figure 173. The Southern Tsimshian, that occupied coastal areas and islands on the central mainland coast, are the only indigenous peoples that are known to have included eggs of Black Oystercatcher in their diet. *Photo by R. Wayne Campbell, Conroy Island, BC, 27 June 1978.*

Adults and eggs of Ancient Murrelets were a favourite food of the Haida in the Queen Charlotte Islands. Often they were caught by lighting fires along the upper beach below the colony to attract the birds when flying to and from nesting burrows. [90, 284] There is no information on how that harvest of Ancient Murrelets, or other alcids, affected their populations.

In the Strait of Georgia, Glaucous-winged Gull eggs were collected in large numbers by First Nations and, in the early years of the 20th century, also by many non-native fishermen.[213] Many Coast Salish bands "owned" nesting colonies of seabirds (e.g., Mitlenatch Island) and harvested eggs annually as an important source of food (Figure 174). They alternated collecting areas between years to encourage nesting in subsequent seasons. Numbers of breeding Glaucous-winged Gulls in the Strait of Georgia may have been suppressed by the intensive egg harvest.[354]

Glaucous-winged Gull eggs were harvested from major colonies in Skidegate Inlet in the Queen Charlotte Islands in 1990 [600] and more recently from Cleland Island on west coast of Vancouver Island.[184] Egging may have occurred on the Buckle Group in Queen Charlotte Strait in 1987.[477] Subsistence hunting of seabirds by First Nations is still permitted under the Migratory Birds Convention Act of 1916, and egging still occurs on a small scale in some of these areas today.

Figure 174. In the 1960s, Coast Salish peoples occasionally visited Mitlenatch Island, in the northern Strait of Georgia, BC, to gather Glaucous-winged Gull eggs as food. *Photo by R. Wayne Campbell, June 1968.*

Logging and Erosion

Logging practices, especially clear-cutting, can destroy forest habitats used by burrowing-nesting species and by Marbled Murrelets that nest on wide mossy limbs of old-growth and mature trees.[43, 513] On steep slopes, downhill erosion from the edge of logged areas can further degrade habitat. The only burrow-nesting seabird colony that has been encroached upon by logging and subsequent erosion is on Lyell Island on the east coast of Moresby Island.[480, 602]

The conservation concern related to logging activities and forest-nesting seabirds, especially alcids, really started to gain momentum with the publicity surrounding the report of the first Marbled Murrelet nest discovered in California in 1974.[37] In BC, the earliest concentrated effort to appraise the impacts of logging occurred in 1975. The BC Fish and Wildlife Branch conducted a wildlife survey in tree farm licence 24 centred on Dodge Point on Lyell Island in response to plans by Rayonier Canada to log the area. After the discovery of a large nesting colony of Ancient Murrelets (Figure 175), the area became the focus of a heated conflict between First Nations and environmentalists, and loggers. Rayonier Canada funded a more detailed survey of the Ancient Murrelet colony in 1979 [44] that was important in the eventual preservation of the colony. The conflict was used to promote the South Moresby Wilderness proposal, a local provincial ecological reserve, and other conservation initiatives. It came to a head in 1985 with protests that set the stage for many future confrontations over sustainable resource use, preservation of old-growth forests, and First Nations land issues. Current protective measures make it unlikely that logging will affect other colony sites, but only a small proportion of the remaining old-growth forest suspected to be used by Marbled Murrelets is protected.[513]

Figure 175. Protection of Ancient Murrelets nesting on Lyell Island on the east coast of Moresby Island was initiated in November 1985, when a road blockade was set up on the island by a group of Haida to protest the issuance of new cutting permits in old-growth forests. Seventy-two people were arrested over a two-week period. Twenty-one months later, on 11 July 1987, the federal and provincial governments signed a memorandum of agreement creating what is today the 1,495-square-kilometre Gwaii Haanas National Park Reserve and Haida Heritage Site.[461] *Photo by Moira J.F. Lemon, June 1980.*

Human-made Obstacles

Birds are highly visual creatures and structures built at sea and on land near the shore can become obstacles that may attract and kill hundreds, sometimes thousands, of seabirds and other species. Types of threats from human obstacles are being identified as more people become environmentally conscious and encourage mitigation efforts. Nation-wide, it has been estimated that 269 million birds, mostly land birds, are killed annually in Canada from human-related causes.[85] The two main issues are attractions to structures with artificial lights and mortality from collisions.

Substantial numbers of seabirds and many passerines are killed in BC each year flying into lighthouses and their associated buildings and guy-wires that support communication towers [404, 585] (Figure 176). Most birds are killed during spring migration [313] but deaths of birds can continue until late autumn. At the Cape St. James light station, at the south end of the Queen Charlotte Islands, from three to 15 birds were killed nightly during this seven-month period. Storm-petrels were the most common seabird killed there and at the Langara Island station. Light keepers on Pine Island in 1929 reported half a pail full of Leach's Storm-Petrels picked up at times around the light.[629] At Triple Islands station, 35 km west of Prince Rupert, land birds and Common Murres and Ancient Murrelets were killed "from flying violently against the glass [lighthouse] or against the white building upon which the light is reflected." In 1923 about 3,000 birds were killed in the month of May, mainly on misty, foggy, and rainy nights.[404] In some years in the 1970s and 1980s, lighthouse keepers reported that they collected "buckets" of dead Rhinoceros Auklets around lighthouses where large colonies exist, especially on Lucy (before the light station was dismantled) and Pine islands. Mortality of Cassin's Auklets has also been reported.[514]

In the mid-1970s, information on bird deaths from collisions with light stations was requested from 47 lighthouse keepers on the inner and outer coasts of BC.[634] Thirty-six lightkeepers (77%) reported deaths of birds and 19 specifically mentioned seabirds. There were no quantitative data kept but birds included "many" storm-petrels, mutton birds [shearwater spp.], a Pelagic Cormorant, Common Murre, Ancient Murrelet, Rhinoceros Auklets, and occasionally a Tufted Puffin. Carcasses were found between April and October but mainly during migration periods in May and September.

Figure 176. Nearly half of the lightkeepers in BC surveyed in the mid-1970s, including those at Pachena Point (shown), mentioned mortality of seabirds from flying into the lights. *Photo by R. Wayne Campbell, Pachena Point, BC, November 1967.*

A Blue Jay on a Curtain

During surveys of seabird colonies in eastern Hecate Strait in 1970, Rudi Drent, Wilf Schofield, and Wayne Campbell visited the light station on Bonilla Island to enquire about local seabird colonies. The principal light keeper was Henry MacArthur. His wife Lois was an amateur artist and bird watcher. While fresh scones were baking in the oven, tea was steeping, and fresh black salal berry jam was set on the table, we talked birds. They told us of the history of a Bald Eagle nest in the crotch of a massive Sitka spruce nearby that was at least 12 feet across and nine feet deep. Their lives were far from lonely and each had personal projects that kept them stimulated and fulfilled.

Lois enjoyed birds and mentioned that the number killed by flying into the light from the station each year was upsetting. Most were small songbirds but petrels were frequently found. She actually suggested to the federal government that changes to strobe-lighting on stations may reduce deaths.

Lois wrote unusual sightings of birds on a calendar and painted some of them on curtains around her house (Figure 177). *Wayne had started The Birds of British Columbia project earlier and immediately noticed a painting of a Blue Jay* (Cyanocitta cristata). *She also had another painting of a Steller's Jay* (C. stelleri). *When questioned further she confirmed that the bird she saw was an Eastern Blue Jay, seen on November 12, 1969, and that it stayed around for two days. This observation was the first record for the mainland coast north of Vancouver Island and only the sixth for the coast since first being recorded at Vancouver in 1948.*

Another source of mortality from human obstacles is artificial lighting on fishing boats at sea (running lights) or anchored in protected coves and bays near active colonies (boat anchorage and cabin lights). Lights, as well as bonfires, associated with the increasing presence of floating or on-shore fishing resorts in remote areas near major seabird colonies likely pose similar risks to seabirds.[187] Mortality is particularly high for some species, especially storm-petrels, murrelets, and auklets. In the 1950s and 1960s, Charlie Bellis, a commercial fisherman, often anchored in a protected bay of Langara Island, which supported a large Ancient Murrelet colony. In

Figure 177. Lois MacArthur, wife of principal light keeper Henry MacArthur, with paintings of birds identified in the vicinity of the Bonilla Island light station and drawn on the curtains in her kitchen. *Photo by R. Wayne Campbell, Bonilla Island, BC, 4 June 1970.*

a thorough letter to the commissioner of a Peregrine Falcon Inquiry in BC he wrote: "... in Cloak Bay in the 50s and 60s we used to shovel over fifty Murrelets overboard in the mornings after they had struck guywires of our fishing boat. We were not the only boat anchored in the bay, and if one multiples the number of boats anchored per night over a breeding season, say ten per night for twenty nights, killing fifty birds per night we would lose ten thousand birds per season. I believe this is a conservative estimate, and points to the seriousness of the problem".[519] Two fishing lodges, one land-based and one floating, built at the south end of Langara Island are large lighted structures and likely contribute to the disorientation and risks of collisions by seabirds in that area. In addition, light pollution from these sources may increase vulnerability of seabirds to native avian predators such as eagles, falcons, or owls.[1]

Developing threats to breeding and nonbreeding seabirds in BC include proposed at-sea structures for offshore drilling and placement of wind turbines. Seabirds are attracted to night lighting and the burning flares on oil drilling platforms, and may aggregate around offshore rigs because they create roosting refuges at sea and because they increase food availability by augmenting local ocean productivity.[621] Mortality is mainly due to direct impacts, oiling from discharged waters, and flying into the flare. For the past 45 years or so seabird colonies along the BC coast have been protected from offshore oil and gas exploration and production by a government moratorium. However, oil reserves have been identified in regions off northwest Vancouver Island and Tofino, and in Hecate Strait, Queen Charlotte Sound, Johnstone Strait, Strait of Georgia, and Juan de Fuca Strait. Reserves are estimated at 9.8 billion barrels of oil and 43.4 trillion cubic feet of natural gas, which is similar to or greater than other major oil-producing regions in northern North America. With the timber and fisheries sectors of the BC economy in decline, industry is currently lobbying to lift the moratorium on oil development.[628] Such action would pose serious additional risks for seabirds in BC.

The world's first offshore wind farms were established in Denmark and Sweden in the early 1990s and immediately attracted strong public interest.[363] The concept of wind energy as a clean renewable resource is attractive. However, the trade-offs in terms of risks to wildlife have been debated for many years and efforts to minimize the effects of turbines on seabirds have been recommended. Threats to seabirds include risks of collision, short- and long-term loss of habitat, barriers to migration, and fragmentation of ecological units.[237] Plans for wind farms are being considered in BC, with many sites already identified along the coast, including a proposed NaiKun project in Hecate Strait.[415] A 2002 proposal for a wind farm off Cape Mudge at the south end of Quadra Island in the northern Strait of Georgia was withdrawn following public opposition to the potential risks to birds, including Marbled Murrelets and Harlequin Ducks, interference with the lucrative sports fishing and other tourist activities in the area, and its visual impact. Research to develop vulnerability indices and to minimize and mitigate the immediate and long-term effects of at-sea wind energy structures on seabirds is presently being expanded in Europe,[252] and likely will be useful in North America.

Seabird Islands and Real Estate

Conflicts between nesting seabirds and residential or commercial property owners are common, especially for urban-nesting populations or colonies located on privately owned islands. Seabirds may nest on islands for safety and to avoid terrestrial predators, whereas humans live on islands for different reasons, which may include personal lifestyle and the quality of a unique experience. At times, these groups may come into conflict. Oceanfront property is preferred by both humans and seabirds but in most cases, especially on larger islands, property development does not conflict with colonial-nesting seabirds. Properties, however, with fronting steep cliffs used by Pelagic Cormorants or rocky shoreline areas used by gulls are problematic as the persistent odour from droppings of nesting cormorants and gulls is overwhelming, especially during onshore breezes. In addition, nearby roofs and structures are regularly fouled by roosting nonbreeding gulls. At such sites, a multitude of deterrents have been tried in the province, including shooting birds and hanging the carcasses in colonies, placing plastic models of owls atop cliffs, firing intermittent propane gun cannons, flying hovering predator silhouette kites, playing a loud auditory bird distress caller, and dangling monofilament fishing line over cliff faces. On several occasions when this latter deterrent has been used, nesting adults have become entangled in the monofilament and died. None of the methods worked long term, mostly because they were labour intensive and shooting or harassing a migratory species is illegal without a permit.

Occasionally entire islands that contain nesting seabirds are listed and purchased as sites for summer cottages or as a real estate investment (Figure 178). Passage Island is a 13-ha forested island with rocky outcrops located in Howe Sound about 15 km northwest of the city of Vancouver. A Pelagic Cormorant colony was established there in the late 1960s and grew to 180 pairs by 1981. Glaucous-winged Gulls have nested on top of rocky outcrops and a small grassy islet on the south end since at least 1940. Through the 1960s the gull population increased and began nesting at the edge of the forest, reaching a maximum colony size of 798 pairs in 1978 (BC Nest Record Scheme). A few Pigeon Guillemots nest around the island and infrequently a pair of Black Oystercatchers breeds on rocky outcrops.

Figure 178. William Island, a one-hectare islet near Pender Harbour on the Sunshine Coast, is currently listed at $999,800 and is promoted as "own it all for yourself and your family". There is no source of water and a generator or solar panels are needed as a source of power. Infrequently, a pair of Glaucous-winged Gulls or Black Oystercatchers may nest on the islet. *Photo by R. Wayne Campbell, 2 June 1981.*

In 1968, the island was purchased by Phil Matty, a realtor and developer, and subdivided into 61 lots. There were no amenities on the isolated island. Drinking water was barged in. Water for washing and plumbing was collected off roofs, funneled into cisterns where it was filtered by small, propane-powered pumps (Figure 179). Power also came from solar panels, wind generators, and battery banks. Nesting and roosting gulls were a constant problem. Their droppings fouled solar panels, roofs, and cisterns year-round and many were shot. Some property owners resorted to "roped roofs" to discourage gulls from roosting on their houses (Figure 180). Some carcasses were hung on ropes around the island hoping to dissuade birds but efforts were futile. In spring 1972, eggs were smashed in nests or removed. Over the years, as new houses were erected, nesting populations slowly declined and the gull colony became restricted to the grassy islet on the south end of the island. The Pelagic Cormorant population was down to 16 pairs in 1987,[596] and 21 nests were counted when the colony was surveyed in 2000.[180]

Figure 179. A retired English professor from the University of British Columbia decided that Passage Island was an ideal location to relax and write. Unknown to them, the building site they selected during the winter was located right next to a small colony of Glaucous-winged Gulls. By summer, gulls were nesting and fouling the cottage with droppings and odours. *Photo by R. Wayne Campbell, July 1978.*

Figure 180. There was no source of water on Passage Island and residents relied on rainwater collected on their roofs for washing and plumbing. While the ropes discouraged roosting gulls, birds flying over the cottage still fouled the water source. *Photo by R. Wayne Campbell, July 1974.*

Rural and urban developments have also had positive effects by creating habitat and sometimes food for nesting species. Pelagic Cormorants have colonized bridges and navigation beacons,[334] Double-crested Cormorants frequently nest atop pilings,[596] Pigeon Guillemots have adapted to nesting on beams under ferry slips and large wharves,[106] and Glaucous-winged Gulls have turned rooftops into nesting habitat through much of the urban centres of Vancouver and Victoria.[338, 601] Human refuse has been exploited for food by Glaucous-winged Gulls.[570] Seabird colonization of these man-made habitats has of course not been without conflict. Pelagic Cormorant nests were twice destroyed after they colonized the Second Narrows bridge in Vancouver,[334] and rooftop nesting gulls damage roofs, clog drains, and interfere with the servicing of air-conditioning and other equipment that is often located there.[645]

Natural and Human Disturbances

Disturbances are an everyday occurrence in the lives of seabirds. Many are natural and cannot be controlled, whereas others involving humans may be minimized with research and education. Natural disturbances might include a predator flying over or perched in a colony, a marine mammal using the colony for denning or as a feeding platform, unseasonable storms with lightning and thunder, falling trees from natural blowdowns, territorial disputes, and neighbours robbing nest materials and food. Some are realized by researchers only after years of field work but all contribute to the variety of threats to seabirds.

Natural Disturbances are Unavoidable

Arbutus Island, 3 km northwest of Swartz Bay, is a small seabird colony of mainly Pelagic Cormorants and Glaucous-winged Gulls that has been monitored by Wayne since the mid-1970s. The island's lone arbutus tree used to identify it to sailors and BC Ferries passengers but droppings from perching gulls and cormorants killed it and the icon finally fell down. The tree was used regularly as a perch for Bald Eagles, Peregrine Falcons, corvids, and occasionally by Great Blue Herons, Double-crested Cormorants, and flocking European Starlings (Sturnus vulgaris). *During an early trip to the island, Wayne noticed an adult Bald Eagle* *circling over the colony and landing on the arbutus. About the same time, three Northwestern Crows left tall trees on Piers Island and flew directly to the island. When the island was surveyed, four freshly eaten gull eggs* (Figure 181) *were found and the crows had returned home.*

Several years later it was learned from residents on Piers Island that what was witnessed was actually a regular occurrence. Between mid-May and mid-June each year, the period of peak of egg-laying for gulls, sentinel crows perch atop tall trees and keep watch around the island and offshore. When an eagle flies from Piers, where it nests, crows monitor its direction. If it lands on Arbutus Island, about 0.9 km away, they know that gulls and cormorants will leave their nests and that many will not return until the eagle has departed. The crows then head for Arbutus for a meal. It appears that eagles only use the site as a hunting perch for ocean fishing as no plucked seabirds were ever found on Arbutus. Peregrine Falcons do not illicit the same response from nesting seabirds, although nesting birds will remain alert and edgy as long as the falcon is present. Surprisingly no Pelagic Cormorant eggs were ever found preyed on by crows.

Ecotourism and other recreational activities are the source of human disturbance that most impacts nesting seabirds in BC. Disturbance from scientific investigations, some commercial sea-food harvesting operations, and Canadian Coast Guard maintenance activities can also be concerns.

For decades scientists have been concerned about investigator disturbance and the subject has been fairly well studied throughout the world. Research activities can affect the physiology, behaviour, and reproductive success of disturbed individuals (Figure 182), cause physical damage to nesting habitat, change nest distribution patterns, and impact breeding populations.[159] For example, in BC, biologists conducting surveys and research on seabird colonies may trample burrows and cause desertion.[273] Research has shown that a few seabird species, including some penguins and Laysan Albatross (*Diomedea immutabilis*) may habituate to investigator disturbances, such that some studies had little impact. Also, responses to disturbance varied greatly among species, populations, and study areas, between seasons and years, and in relation to the length of study.[159]

Figure 181. Not all freshly depredated Glaucous-winged Gull eggs found during surveys of colonies in BC can be assumed to be the result of an island's resident crows; opportunistic crows will fly in from surrounding areas. *Photo by R. Wayne Campbell, Mitlenatch Island, BC, 13 June 1970.*

Figure 182. Research into the effects of investigator disturbance on the nesting success Glaucous-winged Gulls on Colville Island, WA, 40 km east of Victoria, BC, showed that egg and chick mortality was 15-22% higher in disturbed study plots than undisturbed control plots.[276] *Photo by R. Wayne Campbell, Greater Chain Islet, BC, 9 June 1973.*

Ecotourism, and associated wildlife photography, is a burgeoning industry worldwide and poses increasing risks to colonial-nesting seabirds.[159] The International Ecotourism Society [342] defines ecotourism as, "responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education." Education is meant to be inclusive of both staff and guests. BC is an increasingly targeted destination for people who travel to experience and photograph free-ranging wildlife. Popular areas with seabird colonies include Gwaii Haanas National Park Reserve (Figures 183 and 184), Checleset Bay, Pacific Rim National Park Reserve and adjacent Barkley Sound, and the Strait of Georgia; these areas receive increasing numbers of visitors every year.

Figure 183. Most ecotourism companies in BC are responsible and employ experienced naturalists to guide guests and limit their impact during land excursions to locate and interpret discoveries such as this Black Oystercatcher nest (lower right). Still lacking, however, are scientifically defensible policies that address the variety of disturbance issues that affect seabirds. *Photo by R. Wayne Campbell, Ramsay Island, BC, 6 June 2000.*

Human disturbance on and around colonies in those areas may impact breeding birds, especially conspicuous species like cormorants, which are easily flushed from their nests, and storm-petrels or alcids, whose burrows are easily damaged by people on foot.[213, 448] Small colonies of Tufted Puffins on Anthony Island and on Seabird Rocks may have suffered from disturbance,[170, 315, 481] and declines and abandonments of Brandt's and Pelagic cormorant colonies have occurred in many areas,[470, 476, 477, 584, 596] although intermittent use of nesting sites is common in cormorants and not necessarily related to disturbance.[172] Sea Lion Rocks, the original breeding site for Brandt's Cormorant in BC, was likely abandoned due to wildlife-viewing tours landing on the colony.

Figure 184. At some seabird colonies, ecotourists witness and participate in research under the supervision of experienced volunteers. Laskeek Bay Conservation Society, a non-profit organization dedicated to conservation, education, and advocacy in marine and forest environments in the Queen Charlotte Islands, allows scheduled tours to visit their study areas. They also accept donations. This group of tourists are onlookers during the exodus of Ancient Murrelet chicks from East Limestone Island. *Photo by R. Wayne Campbell, 6 June 2000.*

There are also numerous examples of incidental disturbances by humans who visit the vicinity or land on seabird colonies for reasons other than to view, study, or photograph the birds. Some of these include sea kayakers, pleasure boaters, sports fishermen, light beacon maintenance staff, marine food gatherers, and scuba divers. Impacts depend on the length of stay and intensity and frequency of the disturbance.

Sea kayaking is a very popular activity and is growing in importance as a provincial tourist attraction (Figure 185). One of the most popular destinations is Barkley Sound, especially the Broken Group, with more than 100 islands to explore and abundant marine life, including breeding seabirds. In the past, seabird colonies were visited regularly by well-meaning but uninformed paddlers, causing significant impacts, especially on cormorants. In 1970, Pacific Rim National Park Reserve was established that included the Broken Group. Today there are eight designated campsites, regular patrols by park wardens, and at least 10 companies that provide guided kayak tours by experienced leaders. Most of the area, however, and the main seabird colonies in Barkley Sound, are outside park boundaries. There is still disturbance from small groups of independent and curious kayakers to seabirds on Baeria Rocks, Great Bear Rocks, and Starlight Reef. Other favourite kayaking locations along the BC coast include Gwaii Haanas National Park Reserve, Clayoquot Sound, Checleset Bay, Nootka Sound, Gulf Islands National Park Reserve, Desolation Sound, Johnstone Strait, and Douglas Channel – most have seabird colonies. Anne Harfenist has observed damage to burrows from kayakers and commercial and recreational fishers walking through colonies in the Queen Charlotte Islands.[187]

Figure 185. Most sea kayakers today are informed about potential threats to seabird nesting colonies and maintain a distance offshore to minimize disturbance. *Photo by R. Wayne Campbell, Oak Bay, BC, 29 May 2003.*

Recreational boaters can inadvertently impact seabird colonies. In the mid-1960s, a family on a yacht from Seattle stopped at Mitlenatch Island in June to jig for Lingcod (*Ophiodon elongates*) and rockfishes (*Sebastes* spp.) below the cormorant colony. The cormorants immediately left their nests and the resident crows took advantage of the opportunity to pilfer eggs. During the hour of fishing, the loss of eggs was substantial, many were not replaced, and productivity for the year was reduced. Wardens on Mitlenatch Island made contact with the visitors who were unaware of the consequences of fishing too close to the colony.

Sports fishermen and other recreational boaters may also disturb seabirds by fishing in or travelling through important seabird staging or feeding areas. Increasing numbers of floating or on-shore fishing lodges are located near major seabird colonies. A Vancouver Sun article, *Angling at B.C.'s Top Fishing Resorts*, from 16 May 2016,[617] listed 26 fishing resorts operating in BC, many of them located in remote locations where interactions with seabirds are likely. These included: Langara Island, Naden Harbour, near Hippa Island, and in Englefield Bay in the Queen Charlotte Islands; on the central mainland coast, some not far from the Byers- Conroy-Harvey-Sinnett and Moore-McKenney-Whitmore islands complex of seabird colonies; Kyuquot, Esperanza Inlet, Nootka Sound, Barkley Sound, and Port Renfrew along the west coast of Vancouver Island; and a number of other areas. These fly-in or drive-in resorts put large numbers of sports fishermen in areas important to breeding and foraging seabirds.

The intensity of disturbance from sports fisheries in different areas, and the potential costs to seabirds from such disturbances are unknown and need investigating. At Langara Island, boats are frequently seen within the main Ancient Murrelet staging area off McPherson Point.[644] When Ancient Murrelet populations on Langara Island were larger in the past, staging areas were more widespread around the island, including off the south end of the island [508] where the fishing lodges are now located. Seasonal opening times for lodges at sites like Langara Island occur just before the main exodus of Ancient Murrelets with their chicks. Lights and other disturbances may be disorienting to departing birds and boat traffic through waters where family groups are dispersing may be disruptive. At Hippa Island, as many as 53,000 Ancient Murrelets have been counted staging off the east side of the island from the mouth of Nesto Inlet, where a fishing lodge is located, to the north end of the island.[482] Maximum count was at 08:00 hr but large numbers of birds are gathered there for many hours of the day, especially in the morning and evening. Boats from the Nesto Inlet lodge may disturb birds if they fish in the area or travel through the area to get to offshore fishing grounds. Other concerns associated with sports fisheries include: the by-catch of seabirds, potential mortality from birds colliding with lights or other structures at fishing lodges, the alienation of seabird nesting habitat by the construction of land-based resorts, the increased risk that boats travelling to fishing lodges will transport and accidentally release rats to colony islands, spills when fueling boats, and garbage disposal that may release plastics and other contaminants in remote locations (see other sections).

Federal personnel servicing automated lights and weather stations, many of which occur on remote, exposed seabird colonies, may incidentally disturb breeding birds. Hatler et al.[315] suspected that the small population of Tufted Puffins on Seabird Rocks may have declined due to disturbance and trampling of burrows by service personnel. To service the light on Solander Island, off Brooks Peninsula, a concrete helicopter pad was built that usurped breeding habitat for seabirds as well as leaving an intrusive accumulation of garbage after inspections were complete. At some sites, supplies are brought in by a mothership and are sometimes unloaded onto fragile nesting habitats, possibly destroying burrows and disturbing nesting birds (Figure 186). Many lights are now automated and are powered with solar panels which reduce the need for regular servicing.

Figure 186. Potential impacts to nesting seabirds from the servicing of light beacons was not recognized until these sites were identified as nesting colonies during the inaugural provincial seabird survey in the 1970s. *Photo by R. Wayne Campbell, Solander Island, BC, 9 May 1976.*

New threats to nesting seabirds are constantly surfacing. In the 1960s, Gooseneck Barnacles (*Pollicepes polymerus*) were gathered by free-spirited individuals living on Wreck Beach in Florencia Bay about 8 km northwest of Ucluelet. Most were eaten for meals but a few individuals made extra money selling them to friends. The barnacle lives attached to rocks on the outer coast and is accessible at low tides (Figure 187). In the 1990s, a commercial harvest was started for restaurants in Vancouver and Toronto but did not survive. A decade later the industry has resurfaced, mainly on islands in Clayoquot Sound. An estimated 30,000 pounds of goosenecks are gathered annually bringing in as much as $1,000 a week to the harvesters.[60] At present the main conflict concerns shoreline-nesting Black Oystercatchers, but disturbance of other nesting species and accidental trampling of burrows and nests also may occur during harvesting activities on a number of seabird colony islands off the west coast of Vancouver Island.[396]

An indirect and local threat to colonial seabirds is scuba diving. Arbutus Island, near the Swartz Bay ferry terminal, is a favourite scuba diving location because of its accessibility, diversity of marine life, and clear waters, and is a dependable site to find Giant Pacific Octopus (*Enteroctopus dolfeini*). The island also has four species of breeding seabirds. Depending on weather and tidal activity, the divers often anchor their boats close to the island while they look for subtidal marine life. If diving activity and disturbance occurs at a critical period in nest-

Figure 187. The resumption of the Gooseneck Barnacle industry on the west coast of Vancouver Island increases disturbance to nesting seabirds as well as migrating rock-frequenting shorebirds. *Photo by R. Wayne Campbell, Frank Island, Chesterman Beach, BC, July 1966.*

building or early egg-laying, Pelagic Cormorants may abandon the site. This may explain the infrequent nesting attempts despite suitable available habitat. The other nesting species, Glaucous-winged Gull and Black Oystercatcher, appear less affected by this activity.

When to Sacrifice Your Offspring

Evolution is a no-holds-barred game that lasts a lifetime. Natural selection umpires the rules and the individual that has the most offspring surviving into the next generation is declared the most successful. Clearly, every surviving offspring is an important goal, but sometimes it is a better long-term strategy to sacrifice a current goal if more can be scored later. Those are the decisions that seabirds must make when they are threatened by disturbances at their colonies and face an uncertain future – they are born gamblers.

Seabirds are long-lived and only produce one or a few offspring per season. If threatened, it is a better strategy to abandon current nesting attempts if you will survive to reproduce in future years. This is a better trade-off early when you have just laid an egg than later when you have invested more in incubation and feeding. That is why birds are more likely to abandon their nests when disturbed early in the breeding season. This is a constant concern for those who survey or study seabirds. Burrowing birds like Ancient Murrelets or Tufted Puffins will sometimes abandon their eggs completely if they are disturbed in their burrows. Adapted to nest on remote islands that are generally free of mammalian predators, they must be quite shocked when their safe haven in the ground is invaded.

The severity of the reaction can be affected by many factors, including type of disturbance, species, and nesting strategy. Many surface nesting species like gulls and cormorants will flush from their nests when a threat approaches and will return to their nests once the threat goes away. We have all seen gulls wheeling and screeching over their colony when a human approaches or an eagle flies over. Gulls are more aggressive and will dive-bomb a person to try and drive them off. Unfortunately, what is one animal's bane is another's boon and other birds like crows have learned to take advantage of these responses. When cormorants flush off their nest, crows are quick to swoop in and grab eggs or small chicks. Gulls will get into the act as well if they are not worried about their own nests getting robbed. It is amazing how quickly these opportunists can decimate the breeding effort of an entire cormorant colony. Young chicks can also suffer from exposure if they are left unattended – naked cormorant chicks in the sun can die from hyperthermia in less than 10 minutes. So if you are approaching a seabird colony as a visitor and you see birds flush off their nests, you are too close.

A study in the Strait of Georgia by Trudy Chatwin recommended staying back 50-70 m from colony areas when approaching in a motorboat or kayak.[181]

Mariculture

The farming of saltwater fish first started under license in BC in 1971, and proliferated through the 1980s and 1990s.[49, 458] Currently there are 137 salmon farm tenures (Figure 188) of which 84 (61%) are along the east coast of Vancouver Island and southern mainland coast, 48 (35%) on western Vancouver Island (mainly Clayoquot Sound), and six (4%) on the central mainland coast. BC is the fourth largest farmed salmon producer in the world and in 2012 harvested 63,400 tonnes of salmon worth $344.8 million dollars.[56]

Figure 188. The first fish farm in Canada was established in Sechelt Inlet, BC. The pioneering home-made pens were built by John Slind. *Photo by R. Wayne Campbell, Sechelt Inlet, BC, 2 May 2001.*

The adverse effects of mariculture on breeding seabirds in BC are not well known. Concerns for seabirds include entanglement and drowning in net-pens while diving, displacement from traditionally-used foraging habitat, and contamination of local food supplies.[583] Fish farms and shellfish aquaculture are located in many inlets and bays where Marbled Murrelets forage. These facilities can affect up to 8% of the water surface area in some important foraging areas.[186] Impacts on Marbled Murrelets from that and other foreshore developments are difficult to assess.[228] In the past, some cormorants and gulls have been shot in BC to discourage roosting on pen structures and reduce predation on fish stocks. This approach has been effective elsewhere in North America to scare birds from fish farm tenures.[400, 634]

Commercial Fisheries Interactions

Human fishing activities have interacted with seabirds likely since humans began harvesting fish from the ocean. Human fisheries have both negative and positive effects on seabirds.[249, 393] Entrapment in fishing gear and prey depletion are the main direct and indirect negative effects of fisheries on seabirds. On the positive side, commercial fisheries generate considerable discard and offal that are readily exploited for food by many seabird species. Human fisheries also may remove larger fish predators and indirectly increase the availability of smaller prey species used by seabirds.

As top predators in ocean ecosystems, seabirds and humans exploit some of the same fish species, especially small schooling fish like anchovies (*Engraulis capensis*), capelin (*Mallotus villosus*), sandeel (*Ammodytes marinus* and other spp.), and herring (*Clupea* spp.). Human overfishing has resulted in the reduction or collapse of fish stocks with associated impacts on seabird reproduction and survival in many areas of the world.[393] For example, the fishery-induced collapse of herring (*C. harengus*) along the Norwegian coast in the late 1960s resulted in almost total breeding failures of Atlantic Puffins for the next two decades and a 14% per annum decline in their breeding populations.[13] In BC, Pacific Herring support a lucrative commercial fishery. They are an important food for Glaucous-winged Gull chicks, especially in the Strait of Georgia.[321, 560, 570, 610] They were also a principal prey species delivered to

Rhinoceros Auklet chicks during studies on Pine and Lucy islands.[31, 587] Pacific Herring stocks were depleted in the 1960s but have since recovered.[542] The effect such oscillations in herring stocks have on food availability for seabirds in BC has not been studied. Therriault et al.[546] suggested that changes in juvenile abundance, size-at-age, and in the timing and distribution of spawn may be more important to seabird predators than changes in overall biomass.

A minimum of 400,000 seabirds of 81 different species die each year in gill-nets set in coastal regions worldwide.[631] Common and Thick-billed murres are the species most frequently caught. In BC, salmon gill-net fisheries occur along most of the coast, though timing and duration of openings vary in different areas and between years.[242] Carter and Sealy [164] studied gill-net mortality in Barkley Sound, and found that Marbled Murrelets and Common Murres were the most frequently killed species. They concluded that 7.8% of the potential autumn population of Marbled Murrelets in that area died in gill-nets in the 1980 season. Large numbers of Common Murres and Ancient Murrelets have been reported killed in gill-nets in other areas (Charles Bellis – submission to the falcon enquiry),[519,585] but as of 1990 there had been no studies in other parts of the province, and data on overall seabird mortality due to gill-net drowning were lacking. Studies since 1990 have provided better documentation of fisheries-related mortality of seabirds in BC, although data were still considered preliminary.[524] Common Murres and Rhinoceros Auklets comprised more than 90% and Marbled Murrelets accounted for 2% of the gill-net bycatch reported between 1995 and 2001 in that study.

Until they were banned by a United Nations moratorium in 1993, high-seas drift nets killed in the order of half a million shallow-diving and surface feeding seabirds each year, including substantial numbers of Fork-tailed Storm-Petrels.[205, 207] About 150,000 km of salmon drift net and 2,000,000 km of squid drift net were set by the Japanese in the early 1990s.[393] Unfortunately, after they were banned, abandoned or lost drift nets continued to ensnare seabirds and other marine life in what has been called a "ghost" fishery. Derelict fishing gear in nearshore waters also catches many seabirds. Cormorants, especially Brandt's and Pelagic cormorants were the species that were most frequently caught in hundreds of derelict gillnets, fishing lines, pots, and traps that were recovered from the waters of the southern Strait of Georgia, Juan de Fuca Strait, and Puget Sound since 2002.[282]

Seabird bycatch in longline fisheries has been estimated to be at least 160,000 and potentially over 320,000 birds per year globally.[11] In BC, about 500

Figure 189. Seabirds are opportunistic feeders and many species follow ships and boats for bycatch discards and offal from at-sea cleaning. *Photo by R. Wayne Campbell, Westport, WA, 7 September 1969.*

birds are caught per year, almost a quarter of which are Black-footed Albatross (*Phoebastria nigripes*) that are listed federally as a Species of Concern.[223] Glaucous-winged Gulls are the most commonly caught of BC's breeding species.

Despite mortality to foraging marine birds at sea, there are positive effects of fisheries on seabirds in the form of providing discards and offal as food. Gill nets are not species specific and the unintended catch, called bycatch, is discarded and scavenged by many species of seabirds. This source of otherwise unavailable food is from trawlers, purse seiners, gill net fisheries, as well as individual fishers (Figure 189). For some species it is a significant source of food, especially during the breeding season. In the North Sea (Europe) the estimated discards and offal produced by fishing vessels was 945,600 tonnes of which 213,300 tonnes (37%) were consumed by seabirds.[253] For some species, like Great Skua (*Stercorarius skua*), up to 70% of its diet is from this source.[250]

Conflict with Puffins – a Quote from Willet

"Fishermen near Forrester Island, AK, detest these birds [Tufted Puffins] *because of their penchant for stealing the herring that is used as bait in trolling for salmon. After the fisherman has placed a fresh herring on the hook and lets the line out to trolling distance, the puffin will dive and neatly remove the bait from the hook. I have seen this done when the bird was forced to go down at least fifteen fathoms. Apparently a puffin will attach itself to a particular trolling boat and will follow it for hours. The fishermen attribute to the bird a surprising amount of cunning. One Norwegian assured me solemnly that the parrot* [likely referring to Atlantic Puffin] *would rise up on the crest of a wave and look into the boat in order to count the herring therein. Their eyesight is deficient at times, however, as they will sometimes dive after a spoon. Frequently the puffins will get all the herring the fisherman has and he will be obliged to cease fishing or have recourse to a spoon, which latter method is not nearly so successful as to results. As far as I was able to ascertain, this habit of stealing bait is confined to this species; the Horned Puffin apparently not having acquired it."* [625]

Oil Pollution

Oil pollution may be the most important threat to seabirds at sea in BC.[586] Local reports suggest that oil spills have been a problem for nesting seabirds on the BC coast since as far back as 1925, when one apparently devastated a Tufted Puffin colony at Hippa Island on the west coast of the Queen Charlotte Islands.[222]

There are two types of human-caused oil pollution on the ocean: accidental, catastrophic oil spills from ships or oil rig blowouts; and more chronic pollution from the dumping of oily bilge residues by ships at sea and from leakage and careless spills of oil associated with sunken ships, marinas, recreational boating, fish boats, and other small craft. Massive mortality of seabirds during major oil spills receives wide publicity but hundreds of thousands of seabirds also die from chronic oiling each year in Canada.[425, 620] About four times more oil is released onto the world's oceans from chronic pollution than occurs from more catastrophic oil spills. Legally, ships' bilge oils are disposed of at authorized port facilities, but many ship operators choose to forgo the expense and downtime required to use those facilities and instead dump oily wastes at sea. Better satellite detection methods and tougher penalties have been instituted but the practice is still widespread. Some operators use so-called "magic pipes" – detachable pipes that can route waste overboard and then be hidden when inspectors arrive – to bypass the required pollution prevention equipment. Some dump in the dark of night in international waters far from port.

The largest oil spill to date affecting the BC coast was the well-publicized *Nestucca* spill. On 23 December 1988, the tow line on the barge *Nestucca* broke while crossing Grays Harbor, Washington. In an attempt to re-establish the line the tug ripped a large gash in the barge and immediately oil spilled into the harbor. It spread along the entire west coast of Vancouver Island, and small quantities reached as far as the Moore Islands on the northcentral mainland coast 600 km away. A total of 3,568 dead, oiled birds, primarily Common Murres (42%; Figure 190) and Cassin's Auklets (32%), was found on Vancouver Island shores.[483] The total at-sea mortality in BC from this spill represented by the birds recovered on Vancouver Island shores was estimated to be 34,700 birds, 48% Common Murres and 37% Cassin's Auklets.[70] Combined mortality in BC and Washington was about 56,000 birds, 72% Common Murres.[69] This mortality was unlikely to affect world populations, but was a concern for the small, local populations of Common Murres breeding and wintering in BC and Washington.

Figure 190. In total, 1,498 Common Murres were found dead along the west coast of Vancouver Island, BC, following the *Nestuca* oil spill in Washington on 23 December 1988. The small patch of oil on the upper breast of this Common Murre was large enough that it died of hypothermia. *Photo by R. Wayne Campbell.*

Oil and Seabirds Don't Mix

Feathers are one of the many wonders of evolution. Their development allowed birds to conquer air, land, and sea and to thrive in most climates on the planet. While bird feathers are well designed for flight, their waterproofing and insulative properties may be more essential adaptations, especially for seabirds in north temperate and arctic waters. A number of seabird species, including penguins and the extinct Great Auk (Pinguinus impennis)*, relinquished flight but none can survive without the insulating protection of feathers. Outer waterproof feathers and inner down feathers keep the bird dry and warm even in cold ocean waters. The outer feathers overlap like shingles on a roof and need to be maintained in good shape to provide a waterproof coat. Birds must preen frequently to keep the intricate, interlocking barbules zipped on each feather so as to maintain their water-shedding capability. This fine-scale integrity of the feathers is what makes them waterproof. Also, most birds secrete an oily, waxy substance from a gland at the base of their tail that they spread over their feathers when preening. This serves to keep feathers supple but is not required to make a waterproof coat, although the oil does prevent water from being forced into feather barbules when birds dive deeply and helps birds shed water when they resurface.*

Contact with oil spilled from tankers or pumped out of ships' bilges ruins these life-giving adaptations. Crude oil mats the feathers, destroying their fine-scale structure, allowing water to penetrate. Birds then get wet to the skin and will suffer hypothermia in cold temperate waters like those of the BC coast. A spot of oil the size of a dime can be enough to kill a bird (see Figure 190)*. Affected birds try to preen their contaminated feathers, but to no avail. If possible they will try to get out of the water to reduce their exposure and because they are losing buoyancy as they get wet. Preening results in the bird ingesting toxic compounds in the oil, which can cause severe damage to internal organs. Inhalation of volatile compounds can cause respiratory and neurological problems and lead to cancer if birds survive. Nesting birds can transfer oil to their eggs or young causing mortality and developmental defects* (Figure 191).

One of the most important conservation measures that we can take is to prevent crude oils from being spilled or purposely pumped out of bilges in coastal waters, especially around breeding colonies or feeding areas where seabirds concentrate. The proposed increase in tanker traffic along the BC coast is a disaster waiting to happen. While resources can be mobilized and reports on oil spill response times, resources, and activities along the BC coast are available,[386] *prevention is still much better than the cure. Witnessing the purposeful discharge of bunker fuel or crude oil, whether at sea or in populated harbours, should be reported immediately to federal and provincial authorities.*

Figure 191. Oil from contaminated parents, like this brooding Common Murre, can be passed on to chicks and potentially cause developmental defects. *Photo by R. Wayne Campbell, Cleland Island, BC, August 1969.*

Oil tankers and barges ply the BC coast, and a spill during the breeding season could put major concentrations of breeding birds at risk.[586] Moratoriums against tanker traffic on the north coast and oil exploration along the entire coast are important protective measures (see below), but risks from potential oil spills remain imminent, especially in light of additional tanker traffic that would result from proposals such as the Northern Gateway, Kinder Morgan, and Eagle Spirit pipeline projects to bring oil from Alberta's oil sands to coastal BC, as well as proposals to lift the moratorium on oil exploration and development in BC waters.

Plastics and Other Pollutants

Seabirds are exposed to a suite of human debris and other contaminants in the ocean realm where they live and forage.[75] They are particularly impacted by plastics and other human trash, heavy metals, and organochlorine compounds like DDT and PCBs. The astounding concentrations of human refuse in the ocean today is a result of the long-standing habit of treating the ocean like a huge garbage can where sea-faring vessels and coastal communities can easily dispose of their waste. In addition, many pollutants are transported to the ocean from agricultural, industrial, and residential sources inland. This was not a serious problem when most human wastes were biodegradable, although it could result in eutrophication of local waters. With the development of synthetic materials and persistent chemicals, the practice today results in the accumulation of litter and marine contaminants that impact marine organisms worldwide. The federal government recognized the problem and developed Canada's Ocean Action Plan in 2005 but little progress has been made.[391]

Waste plastics and other non-biodegradable debris impact seabirds through entanglement and ingestion (Figure 192). Ingested plastics can impact seabirds through damage to, or blocking of, the digestive tract and through the release of toxic chemicals.[359, 493] Parents may deliver plastics to their chicks when they feed them, so that even nestlings are affected. Birds that become entangled in discarded or derelict fishing nets and lines, strings and ropes, balloons, plastic bags and sheets, and six-pack drink holders may be unable to feed or avoid predators and often drown.[359] Species like Double-crested Cormorants will incorporate debris into their nests where it can also pose risks of entanglement.[453] Entangled birds die from exhaustion or starvation if they cannot free themselves.[359]

Ingestion of plastic particles by seabirds was first reported in Canada in the 1960s.[489, 550] As of 2014, 25% of seabird species worldwide were known to suffer from entanglement and 40% from ingestion of plastics [359] (Figure 193). When considering just seabirds occurring in Canadian waters, results are similar: ingestion of plastic has been recorded in 43% of 91 species, including most of the species breeding in BC (except Pelagic Cormorant, Brandt's Cormorant, and Black Oystercatcher), although the incidence rate is low in many species.[459] Predictive models suggest that plastic particles will be consumed by 99% of all seabird species and 95% of the individuals of those species by the year 2050 unless waste management can reduce this threat.[623] Procellariformes, like storm-petrels, shearwaters, and fulmars, are most prone to plastic ingestion, as has been found in the few studies conducted in BC.[17, 40]

Figure 192. Black-footed Albatrosses feeding on garbage thrown into the ocean from a research vessel off the coast of Vancouver Island, BC. *Photo by R. Wayne Campbell, 29 October 1971.*

Figure 193. A sample of some of the manufactured floating plastics, and other human debris, that washes up annually on beaches around the world and pose a threat to feeding seabirds. *Photo by Christopher McNeill, Yucatán Peninsula, Mexico, January 2008.*

The Plastic Age

By-products of human industrial society have altered the condition of planet Earth. Waste products that enter the waters or the air can be distributed around the planet by oceanic and atmospheric circulation patterns. They then become global problems requiring global solutions. Climate change is one of those problems. Plastic debris spread across the oceans by both oceanic and atmospheric processes is another.

The first plastic was patented in 1856 and the first fully synthetic polymer, "Bakelite", was developed in 1907. It was not until after World War II, however, that mass production of plastics began.[547] *The use of plastics has increased exponentially since 1950, with 311 million metric tons produced worldwide in 2014.*[366] *Best estimates of the quantity of plastic littering the ocean surface range from 93,000 to 236,000 metric tons, which may seriously underestimate the total plastic burden in marine waters, given an estimated annual input of 4.8-12.7 million metric tons entering the ocean annually.*[346] *And this is only a small part of the estimated 275 million metric tons of plastic waste generated annually by human populations living within 50 km of ocean coastlines. Despite the relatively straightforward process of mechanical recycling of plastics, less than 9% in the United States and a maximum of 30% in Europe of postconsumer plastics are recovered for recycling.*[366] *Unfortunately, even some of the recycled plastic is finding its way into the oceans. Large volumes of microfibers from synthetic clothing made from recycled plastic are discharged by our washing machines and pass through sewage treatment plants into waterways and oceans where they bioaccumulate.*[62]

Most plastic particles on the ocean are less than one centimetre in size, with a peak frequency at around two millimetres.[193] *Plastic particles are ubiquitous, with concentrations as high as 580,000 plastic pieces per square kilometre observed at convergence zones and along the coastal margins near human population centers.*[367] *It has been no mystery that seabirds would encounter plastic particles while foraging, but until recently it was unclear why they would eat them. New studies have shown that after plastic weathers at sea for a month, it emits low concentrations of dimethyl sulfide, the same infochemical detected by seabirds, especially Procellariformes like petrels, to locate prey.*[500]

Stephen Rothstein found plastic particles in the stomachs of Leach's Storm-Petrels nesting in Witless Bay, Newfoundland in 1962, and recognized that seabirds, which forage over wide and remote geographic areas, can act as biological indicators of the state the world's oceans. The title of his 1973 paper, "Plastic particle pollution of the surface of the Atlantic Ocean: evidence from a seabird",[489] *identified a problem that today is considered one of the most critical challenges for the environment by the international community.*[366] *Northern Fulmars are now being used as an indicator species to monitor spatial and temporal trends in plastic pollution.*[16]

Persistent organic pollutants (POPs), like DDT and PCBs, and heavy metals like mercury that bioaccumulate in the marine environment, can have potent effects on development and the nervous system and can reduce individual survival and reproduction in seabirds.[75] Eggshell thinning was a well-publicized effect of DDT. Concentrations of many of these contaminants in seabirds and their eggs have declined in recent years following bans or reductions in their use, [220] but these persistent pollutants still impact seabird species, especially when birds are in poor condition from other stresses.[77] New compounds, such as brominated flame retardants, antifouling compounds, wood preservatives, and polycyclic aromatic hydrocarbons are continually being introduced into the marine environment and may affect seabirds. On the Pacific coast, effects of POPs were best documented for Double-crested Cormorant, with bill deformities reported in 1989 in BC, and severe egg-shell thinning and reproductive failures documented in California in 1969-72.[221]

Seabirds are also vulnerable to natural toxins that bioaccumulate in marine food chains. Paralytic shellfish poisoning (PSP) results from blooms of single-celled, dinoflagellate protozoans, or "red tides" (Figure 194). These dinoflagellates release toxins that are accumulated by fish and bi-valves that top predators like some seabirds and humans then feed on. Effects of PSP include respiratory distress, muscular paralysis, and death. Mass die-offs of shags due to PSP have been reported in Britain [14, 190] and

Figure 194. Some “red tide” blooms are colourless but this close-up shows a highly visible outbreak around Orcas Island, WA that affected summering waterbirds. *Photo by R. Wayne Campbell, 23 July 1976.*

may be under-reported elsewhere.[521] The deaths of thousands of seabirds, including Common Murre, Northern Fulmar, and many other waterbirds along the coasts of California in 2007 and Washington and Oregon in 2009 were attributed to surfactant-like substances produced by dinoflagellate blooms.[347, 443] These foams destroy the waterproof layer of feathers that keeps seabirds dry, restricting flight and leading to hypothermia, similar to the effects of oil contamination. These red tide events may be increasing in frequency in connection with climate change.

Parasites and Diseases

Seabirds are hosts to a wide diversity of parasites. A recent review [411] identified 184 taxa parasitic or pathogenic on alcids, including a multitude of endoparasitic microorganisms (21 viruses, 13 bacteria, 3 dinoflagellates, 6 protozoa, and 3 fungi), larger endoparasites (57 platyhelminths, including 34 digeneans or flukes and 23 cestodes or tapeworms, 9 acanthocephalans, and 22 nematodes or roundworms), and a number of arthropod ectoparasites (2 pentastomids or tongue worms, 14 acari or ticks and mites, and 30 insects, including lice, fleas, and flies). The colonial breeding habits of most seabird species facilitate the transfer of parasites among individuals, and many parasitic species have specialized to synchronize their life cycles with their hosts’ breeding phenology. Exposure to parasites can be a major cost of colonial nesting.[61, 627] Parasite life cycles and their impacts on seabird health are poorly studied. Only some parasites are known to cause ill effects or be pathogenic.

Ticks are the most conspicuous ectoparasite seen on seabirds at colonies. The common seabird tick *Ixodes uriae* is known to parasitize more than 50 species of seabirds, including many of those breeding in BC. All life stages of this tick live in the ground and ticks can survive 4-8 years in the protected environment of seabird burrows. They attach to birds only for a blood meal, which may last 4-10 days, and particularly target chicks that are confined to their burrow. Up to 45 ticks were counted attached to the webbed feet of young Cassin's Auklet chicks on Triangle Island,[395] 180 fully engorged ticks were removed from a dying juvenile Common Murre found in Barkley Sound,[21] 1,000 ticks have been reported on a single murre at Low Arctic colonies,[411] and thousands of ticks may infest large seabird nests.[356] Heavy tick infestation has been associated with slowed growth rates and increased mortality in chicks,[27, 395] breeding failure,[356] widespread nest desertion,[217] population decline,[50] and colony abandonment.[240] Many Cassin's Auklet chicks end up with scars or holes in the webs of their feet after ticks drop off.

Ticks are also primary vectors for many viruses and other pathogens.[423] Some tick-borne viral infections can lead to lesions in the central nervous system and possible mortality, but others have no obvious ill effect to seabird hosts. The spirochaete bacterium that causes Lyme disease in humans will cycle between seabirds and *I. uriae*, and has been found in several seabird colonies in both the Northern and Southern Hemispheres.[427] The bacterium has not yet been found in Pacific coast seabird colonies but seabird researchers throughout Canada have been advised to take precautionary measures to prevent tick attachment (Figure 195).

Figure 195. During early seabird explorations in BC little thought was given to contracting diseases and/or parasites from nesting seabirds. The potential to pick up ticks while searching burrows, especially Cassin's Auklets', however, is a reality as Dick Grinnell (left) and Brian Carter are aware of on Triangle Island. *Photo by Michael S. Rodway, summer 1989.*

Mosquitos may also spread viruses to seabirds and are the most frequent carrier of pox viruses. Avian pox causes lesions and warts on featherless parts of the body that can interfere with feeding and breathing. Large pox growths have been reported on Common Murre chicks in Barkley Sound,[4] and a Common Murre found infected with pox virus in California succumbed because it could not feed or breath adequately.[323] As long as they can continue feeding, birds can recover once the viral infection runs its course. An airborne virus causes Newcastle disease which has been epidemic in Double-crested Cormorants in the interior. An outbreak in 1995 in Saskatchewan killed 32-64% of juvenile birds.[360] Many infected birds that live suffer various degrees of paralysis and often die later.

Feather mites and lice occur in very large numbers on seabird hosts. There is little evidence that mites cause problems, but high concentrations of lice are likely costly and irritating to infected individuals and in extreme cases, such as one young Common Murre chick examined in Newfoundland that harboured 722 lice, may contribute to chick death.[233]

Many fleas have adapted to seabird hosts and seabird colonies are the only habitats for 23 species of flea [388] (Figure 196). Fleas likely occur at low

Figure 196. Fleas and mites have been found in nests of Glaucous-winged Gulls on Greater Chain Island in Oak Bay, BC, but have not been identified. There are few studies of the invertebrate fauna of bird nests but adult and larval fleas have been identified in nests of Glaucous Gull (*Larus hyperboreus*).[191] *Photo by R. Wayne Campbell, 9 June 1973.*

frequency on many seabirds without obvious ill effects, although a heavy infestation of fleas was associated with colony abandonment by Brandt's Cormorants in California.[608]

Bacterial pathogens such as *Salmonella* and the agent that causes avian cholera can kill seabirds. *Escherichia coli* is part of the natural intestinal flora but may cause disease in conjunction with other infections. When high parasite loads are found in dead birds it is difficult to determine whether birds died because of the infections or if the parasites infected birds weakened by other causes.[501] Seabirds may also act as vectors for these pathogens. Gulls that feed in areas contaminated with *Salmonella* may suffer no apparent ill effects from an infection but can act as reservoirs and a means to spread the pathogen.[392]

Fungal infections such as Aspergillosis (*Aspergillus fumigatus*) and Histoplasmosis (*Histoplasma capsulatum*) can impact seabirds and pose serious health risks to humans working near infected birds, especially birds or humans in poor condition. Captive seabirds housed in zoos, aquariums, and rehabilitation facilities are vulnerable to Aspergillosis, especially birds recovered in large numbers during oil spills.[68] These fungi flourish in nitrogen-rich soils found on seabird colonies where human visitors can be infected by breathing in airborne spores. *H. capsulatum* occurs in the central and eastern United States and areas farther south,[526] but *A. fumigatus* is common in BC and is a concern for people working with seabirds here.

Flukes, tapeworms, and roundworms are very common endoparasites of seabirds, especially gulls.[411] These organisms generally do not cause ill effects, although extreme infestations may be debilitating.[330]

Parasites often have complex life histories involving multiple hosts and their presence can reveal information about the dynamics of marine ecosystems and the behaviour of seabird hosts. For example, a study on the diversity of ticks associated with seabirds nesting on the Cape Verde islands, off the coast of West Africa, found tick lineages from wide-ranging localities, including the South Atlantic off South America, North Atlantic, and Indian oceans, and revealed previously unrecognized long-distance movements and dispersal of seabird hosts.[281] This has important implications for the dissemination of harmful pathogens that may be carried by tick or other parasitic species. Arboviruses have been transported by seabirds, either within an infected seabird or an attached tick, to widely separated regions of the globe.[423] There are also complex relationships among invertebrate and fish species that are intermediate hosts for parasites and that are fed on by seabirds. Changes in seabird diets can result in shifts in the suite of parasites to which seabirds are exposed. This is a little recognized potential consequence of climate change that, by modifying the ecology of seabird prey and the community of parasites associated with them, can result in seabirds having to contend with unfamiliar and perhaps more virulent parasite species.[251, 384]

Natural Predators

Predation is a major selective force that has helped shape the breeding behaviour and habitat use of nesting seabirds.[63, 627] Strategies developed by seabirds to minimize predation risk include nesting on inaccessible islands, colonial nesting, group behaviour, synchronous breeding, nocturnal nesting shifts, and nesting in burrows. Despite these adaptations, seabirds still suffer high mortality from natural predators.

Peregrine Falcons and Bald Eagles are the most important avian natural predators of seabirds at colonies in BC.[419, 602] Ancient Murrelets, Cassin's Auklets, and Fork-tailed and Leach's storm-petrels are the most frequent prey of Peregrine Falcons,[24, 25] though Rhinoceros Auklets are also taken.[142] Nelson and Myers [419] estimated that a family of falcons harvested about 1,000 Ancient Murrelets per year on Langara Island.

Off the central mainland coast, in the Byers-Conroy-Harvey-Sinnett and Moore-McKenney-Whitmore islands complex, a small population of Peregrine Falcons used six inactive Bald Eagle nests to breed.[142] Remains of nine species of birds were found in and beneath those nests; remains of Rhinoceros Auklet (38%) and Cassins' Auklet (19%) were the most numerous (Table 18). This was the first record for Black Turnstone (*Arenaria melanocephala*) in the diet of coastal Peregrine Falcons.[103] The Green-winged Teal (*Anas carolinensis*) and immature Bonaparte's Gulls (*Chroicocephalus philadelphia*) that were preyed on would have been migrating birds.

Table 18. Prey identified in and below six inactive Bald Eagle nests used by Peregrine Falcons for nesting in the Byers-Conroy-Harvey-Sinnett and Moore-McKenney-Whitmore islands complex, 1-3 June 1970 and 20-27 June 1976.

Species	Number
Fork-tailed Storm-Petrel	4
Leach's Storm-Petrel	1
Green-winged Teal	1
Black Turnstone	1
Bonaparte's Gull	2[1]
Pigeon Guillemot	1
Marbled Murrelet	1
Cassin's Auklet	5
Rhinoceros Auklet	10
Total	26

[1]Immatures

Bald Eagle is the most resourceful raptor in coastal BC and exploits an astonishing variety of habitats in search of prey (Figure 197). During the day, it catches much of its fish and seabird prey in offshore areas, patrols beaches for carrion, hunts estuaries for waterbirds, and searches intertidal zones at low tide for invertebrates. Eagles are opportunist hunters and individuals seem to have their own preferences. For example, one nest site on the Queen Charlotte Islands contained 357 Abalone shells and the carcasses of Sooty Shearwaters, Northern Fulmar, and Black-legged Kittiwake.[107] Breeding seabirds known as prey of Bald Eagles include Ancient Murrelet, Fork-tailed and Leach's storm-petrel, Cassin's Auklet, Rhinoceros Auklet, Tufted Puffin (Figure 198), Common Murre, Pigeon Guillemots, Glaucous-winged Gull, and Pelagic Cormorant.[289, 409]

Bald Eagle also hunts in colony areas at night.[206] In Ancient Murrelet colonies on Langara, Frederick, and Rankine islands, eagles perch low in the forest in the evening and catch incoming or outgoing birds as they scuttle across the forest floor.[480, 482, 602] They were estimated to have killed over 3,000 Ancient Murrelets on Ramsay Island, and over 8,000 on Rankine Islands in 1984.[480] Eagles frequently take Glaucous-winged Gull adults and chicks, and may prey on gull eggs in some areas.[350, 476, 477, 548]

Figure 197. Along the coast of BC, the Bald Eagle is an opportunistic and efficient predator with a varied diet that includes invertebrates, fishes, mammals, and many seabirds. *Photo by Alan D. Wilson.*

Figure 198. Prey items in this Bald Eagle nest with a newly hatched chick and egg (lower right) included Tufted Puffin (4), Rhinoceros Auklet (2), Leach's Storm-Petrel (2), and the head of a Lingcod (*Ophiodon elongates*). *Photo by R. Wayne Campbell, near Lyman Point, Kunghit Island, BC, 26 May 1996.*

Arms race on a seabird colony

Predator-prey is one of the most basic relationships in nature and a major driving force of evolution. Virtually all animals are predator or prey and, unless they are a top predator, often both – the robin catches the worm and the falcon catches the robin. Many adaptations are related to better catching prey or avoiding predators. This sets up an "arms race" between predators and prey.

Nesting on remote islands free of most mammalian predators is a good predator-avoidance strategy for seabirds. But that strategy does not protect them from avian predators. Visiting the colony only during the night is another adaptation some seabird species have evolved to avoid avian predators. Has it worked? Unfortunately for Ancient Murrelets, Bald Eagles have come up with counter strategies of their own. It is well known that Bald Eagles are diurnal predators – some owls are their nocturnal counterparts. But Bald Eagles living on Ancient Murrelet colonies in the Queen Charlotte Islands have figured out that if they perch low in the forest at night they can see Ancient Murrelets arriving under the cover of darkness scurrying across the mossy forest floor to their burrows. The black-and-white pattern of their plumage, which is likely a good adaptation for Ancient Murrelets as predators, betrays them as prey. Even humans can see that contrasting black-and-white plumage moving in the dark. Females laden with eggs may be slower in their movements and be the easiest targets for Bald Eagles. This may explain why on large Ancient Murrelet colonies evidence of thousands of depredated birds and eggs can be found. On some nocturnal vigils we have seen eagles pouncing on Ancient Murrelets from low perches on logs or stumps. And they have been flushed off freshly-killed carcasses. Eggs have even been found whole still contained within the skeletal remains of depredated birds. Eagles pluck birds they have caught on the forest floor, leaving distinctive rings of plucked feathers, often accompanied by fecal streaks from the eagle (Figure 199).

Will Ancient Murrelets respond in this arms race? Perhaps they already have. Ancient Murrelets, along with the four other congeneric, Synthliboramphus *murrelets, are the only seabird species that do not feed their chicks at the colony. Instead they take them to sea when they are only two days old. This avoids the many visits to the colony required of other species that deliver food to their young in their burrows until they fledge, and reduces the predation risk from nocturnal-hunting eagles.*

Figure 199. At some Ancient Murrelet colonies on the Queen Charlotte Islands, Bald Eagles have become nocturnal predators preying on adults as they arrive and leave burrows at night. The scattered feathers from plucked birds identify Bald Eagles as the culprit. *Photo by Moira J.F. Lemon, Frederick Island, 9 June 1980.*

Common Ravens, Northwestern Crows, and Glaucous-winged Gulls are important predators at some colonies along the entire coast. Ravens are known to feed on adult Ancient Murrelets, and ravens and crows have been observed digging up Ancient Murrelet and Rhinoceros Auklet burrows that contain chicks or eggs.[82, 476, 482, 602] Crows and gulls frequently pirate eggs or small young from cormorant nests, especially when cormorants are disturbed by passing eagles or human intruders [213, 561, 562] (Figure 200).

Northern River Otters are present on most seabird colonies, and prey on adult and young Fork-tailed and Leach's storm-petrels, Glaucous-winged

Figure 200. Northwestern Crows are quick to take advantage of natural and human disturbances at Pelagic Cormorant colonies. The depredated eggs in this photo are fresh and it is likely that a replacement clutch would have been laid. *Photo by R. Wayne Campbell, Christie Island, BC, 8 June 1981.*

Gulls, and Ancient Murrelets at some locations.[243, 482, 564, 637] They may have contributed to the abandonment of the Leach's Storm-Petrel colony on Moos Islet [475] and the demise of the Fork-tailed Storm-Petrel colony on Hoskins Islets since 1971.[480, 535] American Mink have reached Thomas and Cleland islands, and depredations of Leach's Storm-Petrels on Thomas Island and of Tufted Puffins and other burrowing species on Cleland Island have been attributed to them.[475] Wandering Garter Snake (*Thamnophis elegans vagrans*) take Pelagic Cormorant, Glaucous-winged Gull, and Pigeon Guillemot chicks on Mitlenatch Island,[94, 225] and Keen's Mouse is a known predator of Ancient Murrelet eggs and young on Reef Island.[262]

There are a few incidental records, from stomach analyses and field observations, of seabirds consumed by marine mammals. These include Brandt's Cormorant by Killer Whale (*Orcinus orca*), Common Murre by Steller Sea Lion (*Eumetopias jubatus*), adult Glaucous-winged Gull by California Sea Lion (*Zalophus californianus*), and Glaucous-winged Gull chick and Pigeon Guillemot by Harbour Seal (*Phoca vitulina*). Accidental ingestion of Cassin's Auklets, Marbled Murrelets, and Ancient Murrelets by Humpback Whales (*Megaptera novaeangliae*) has been recorded in Alaska.[209, 317]

Introduced Species

Introduced mammalian predators are the most immediate threat to nesting seabirds in the Queen Charlotte Islands. Black Rat (*Rattus rattus*; Figures 201, 202) probably reached the islands on early whaling or trading ships. They have been recorded on Langara Island, Lucy, Kunghit Island, St. James Island, Murchison Island, and Lyell Island.[298, 352, 480, 481, 482] *R. r. alexandrinus* has occurred in pure stock on Langara Island, and both *R. r. alexandrinus* and *R. r. rattus* occur on Kunghit Island.[192] The larger Norway Rat (*R. norvegicus*), first reported in the Queen Charlotte Islands in 1981, may have displaced Black Rat on Langara Island and became an even more serious threat to burrow-nesting seabirds in the following years.[32] American Marten were introduced to Lucy Island in the Queen Charlotte Islands in the 1920s,[198] and have been sighted on Langara Island.[633] Marten (subspecies *nesophila*) are indigenous to the Queen Charlotte Islands, but were historically absent from all but the largest islands.[245] Northern Raccoon (Figure 203) was introduced to the Queen Charlotte Islands in the 1940s, and have since become well established over the entire length of the archipelago.[157] They can swim far enough to reach almost all colony islands and have been detected on at least 14 islands where burrowing seabirds presently or historically nested.[306, 538]

Figure 201. Black Rat (shown) and Norway Rat, both inadvertently introduced to seabird colonies on the Queen Charlotte Islands, have greatly impacted Ancient Murrelet populations by eating eggs and killing adults. *Photo by R. Wayne Campbell.*

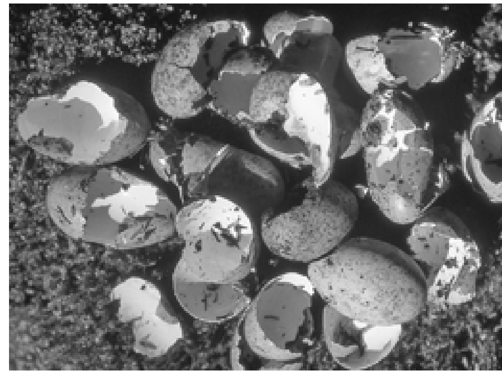


Figure 202. Shells of Ancient Murrelet eggs preyed on by Black Rat on Langara Island, gathered from an area on the ground about 3 feet x 5 feet. *Photo by Michael S. Rodway, McPherson Point, Langara Island, BC, 16 May 1977.*

Figure 203. Northern Raccoon was intentionally introduced on the Queen Charlotte Islands in the 1940s by the BC Game Commission to enhance the local fur trade. Four decades later it had spread throughout the islands. It has been estimated that 80% of the burrow-nesting seabirds on the archipelago are currently in jeopardy.[306] *Photo by R. Wayne Campbell.*

Declines in population or abandonments have occurred at all seabird colonies where introduced predators are known to occur.[538] Storm-petrels, Cassin's Auklets, Rhinoceros Auklets and Tufted Puffins have disappeared from Langara Island, and the remaining Ancient Murrelet colony is a remnant of its former size.[29, 482] Ancient Murrelet colonies have been abandoned on Lucy Island, where American Marten were introduced, and on Sea Pigeon and Boulder islands, where Northern Raccoons are now plentiful.[480, 482] The magnitude of population changes is unknown at most sites, though historical descriptions suggest an Ancient Murrelet population on Langara Island in the order of 250,000 pairs;[24, 256, 482] (see west coast Graham Island chapter). In 1986, about 11,000 Cassin's Auklet burrows and 9,000 Rhinoceros Auklet burrows on Saunders Island appeared to have been recently abandoned.[481] Suspected tracks of marten and raccoon were reported on the island in 1986 and 1987.[481, 638]

Intentional introductions of American Mink (Figure 204) to Lanz Island and raccoon to Cox Island in the Scott Islands in the 1930s may have resulted in the loss of substantial breeding populations. Although no observations of nesting populations were made prior to those introductions, abandoned burrows found in 1950 testified to the effects of the mammalian introductions.[158] In 1987, mink had killed small numbers of Cassin's Auklets that were apparently prospecting old burrows on the west end of Lanz Island.[484] The other Scott Islands are separated from Lanz Island by fast, turbulent tidal channels, and the further spread of mink or raccoon in that area is not expected to be a concern.

Figure 204. Widely distributed naturally along the BC mainland coast, American Mink (shown) and Northern Raccoon were intentionally introduced to the two larger islands in the Scott Island chain off northwestern Vancouver Island, where they eliminated seabird breeding populations. *Photo by Alan D. Wilson.*

Black-tailed Deer (*Odocoileus hemionus sitkensis*; Figure 205) was introduced several times to the Queen Charlotte Islands between 1878 and 1925.[157, 200, 280] In the absence of large predators it has proliferated and now occurs on almost every island in the area. It is an excellent swimmer. Their impact on nesting seabirds is difficult to assess. On storm-petrel colonies with luxuriant, herbaceous vegetation and fragile soil, browsing and trampling by deer may reduce available nesting habitat. They may have contributed to the disappearance of the storm-petrel colony on Willie Island off the west coast of Moresby Island. In other areas where deer have severely browsed and removed thick shrub cover, they may have enhanced the habitat for burrowing birds. There has been debate on the degree to which invading deer have modified the vegetation structure on these islands. [297, 454, 582] However, studies since 1990 have demonstrated pervasive impacts of introduced deer on forest ecology of the Queen Charlotte Islands.[269]

Figure 205. Effects of introduced Sitka Black-tailed Deer on nesting seabirds in the Queen Charlotte Islands remain conjecture. *Photo by R. Wayne Campbell, Lawn Point, Graham Island, BC, 4 June 2000.*

European Rabbits (*Oryctolagus cuniculus*) were brought to Triangle Island by lighthouse keepers in the 1920s [158] and small numbers are still present in all parts of the island.[484] There is no evidence that they impact nesting seabirds or have significantly altered habitats.[328]

Evidence linking introduced species to declines and abandonments of seabird breeding populations in the Queen Charlotte Islands was circumstantial in 1990, although rats were known predators of Ancient Murrelet eggs and adults on Langara Island,[29, 89, 482, 508, 602] and their impact on nesting seabirds was well documented in other parts of the world.[15, 341, 394] Raccoon and marten are known predators of birds,[192, 538] but they were not known to be present on any extant seabird colonies, and direct evidence of predation or harassment of nesting species was lacking. Since 1990, the completion of Lisa Hartman's studies on raccoons in the Queen Charlotte Islands,[307] continued monitoring of raccoon presence and associated predation rates on Ancient Murrelets on East Limestone Island by the Laskeek Bay Conservation Society,[59] and additional survey work in Englefield Bay documenting further spread of raccoons and concurrent abandonment of nesting areas [266] has left little doubt that raccoons and ground-nesting seabirds are incompatible.[300] Much of the seabird population in the Queen Charlotte Islands is at risk, including a large portion of the world population of Ancient Murrelets.[306]

Food Shortage, Ocean Anomalies and Climate Change

Seabirds are well adapted for foraging but finding food can still be a challenge [518] (Figure 206). Prey is patchily distributed in the ocean and birds need skill and information to locate it. Seabirds have evolved life history strategies to accommodate spatial and temporal variability in the availability of prey and time their reproductive schedules to coincide with periods when prey is normally available within foraging range of colonies. Migratory and winter movements also track food supplies. However, major or abrupt changes in the abundance and distribution of prey that birds depend on can tax individuals beyond their ability to cope. As a result, reproductive failures are common and many birds starve to death.[501]

Figure 206. About 58% of young Glaucous-winged Gulls die in their first year of life, many from starvation from lack of foraging experience. The tennis ball picked up by the juvenile Glaucous-winged Gull in this photo will not satisfy its hunger. *Photo by R. Wayne Campbell, Esquimalt Lagoon, BC, 21 September 2003.*

Food shortage for seabirds can be caused by many factors, including: collapse of fishing stocks due to overfishing or other environmental changes; prolonged stormy weather that interferes with birds' ability to find food; changes in ocean currents that disrupt upwelling systems and reduce ocean productivity; and changes in sea surface temperatures that impact abundance, distribution, and temporal availability of prey species.[18, 33, 462, 540, 588] Recurring, anomalous weather patterns like El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation cause changes to ocean currents, circulation patterns, and sea surface temperatures and are often associated with reproductive failures and massive die-offs of seabirds, such as the thousands of Common Murres that starved to death in the Gulf of Alaska in 1993.[447] In the severe ENSO of 1982-1983, populations of guano birds in Peruvian waters were decimated, declining from eight million to one million birds within the year.[3] On the other side of the globe, 30,000 auks washed ashore in the North Sea.[304] The recent mass mortality of 50,000 to 100,000 Cassin's Auklets along the Pacific coast from BC to California was associated with an anomalous warm water "blob", perhaps combined with a series of winter storms that impacted the coast during the autumn of 2014 [177, 322] (Figure 207). Climate change

Figure 207. Finding food year-round is a constant challenge for seabirds. When ocean current circulation patterns and sea-surface temperatures change due to natural or anthropogenic causes, food may become scarce and hundreds of thousands of birds may starve. Beaches become littered with carcasses of birds, as in 2014 when thousands of Cassin's Auklets washed ashore from Alaska to California. *Photo courtesy End Times Headlines.*

presents a pervasive and persistent perturbation in ocean ecosystems worldwide.

Climate change was not on the radar of threats to breeding seabird populations in 1990, although anomalous weather patterns were known to be associated with seabird reproductive failures in BC.[484, 566, 588] There was no mention of climate change in the 1991 ICBP publication on the status and conservation of the world's seabirds.[197] Today it is apparent that climate change can disrupt or modify marine food webs and compromise seabird survival and reproductive success.[277, 326] The apparent loss in BC of more than 20% of the world's population of Cassin's Auklets is likely related to climate change and the increasing frequency and severity of extreme climate events.[397, 478] Rising ocean levels associated with climate change would impact Black Oystercatchers and Glaucous-winged Gulls that sometimes nest just above high tide on low-lying rocks. The ability or inability of seabirds to adapt to anthropogenic climate change is a subject of much current research.[19, 287, 492, 501]

Subsidiary Threats and Mortality

There are many sources of subsidiary mortality in seabirds that do not fit into the more well- categorized natural and human impacts discussed previously, yet the combined effects locally may be considerable. Awareness of these various threats can enhance peoples' understanding of seabirds and in some cases may serve as precautions and guidelines that will help minimize human impacts. Most subsidiary instances of mortality are rarely reported and seldom discussed.

Sports fisheries pose threats to fish-eating seabirds as they can become entangled in fishing lines and caught on hooks. Numbers of sports fishermen in BC is increasing, and the proliferation of fly-in, floating, or shore-based fishing resorts place large numbers of fisherman in remote areas near major seabird breeding and foraging areas. The species most affected are pursuit divers that hunt by chasing prey underwater, sometimes to depths of 30 m or more, and plunge divers, like Glaucous-winged Gull, that feed nearer the surface. Breeding seabirds caught inadvertently by fishermen in BC include Pelagic Cormorant, Glaucous-winged Gull, Common Murre, Pigeon Guillemot, Marbled Murrelet, Rhinoceros Auklet, and Tufted Puffin. The most reported species is Glaucous-winged Gull.[87] Reports of seabirds accidentally caught by recreational fishermen are from along the entire coast, from Langara Island to Race Rocks, including the Strait of Georgia. Birds are caught by ingesting hooks (Figure 208) or are snagged by the wings or feet (Figure 209).

The by-catch problem in sports fisheries has received more attention in the United States. As part of their seabird protection program, the National Oceanic and Atmospheric Administration has provided helpful instructions for removing fish hooks and lines from birds.[416]

Shooting, illegal and authorized, has impacted seabirds for centuries. Birds have been killed for personal subsistence and for commercial markets, and as nuisances, such as when they come into conflict with salmon hatchery programs or when human lives are endangered by birds flying into airplanes. Some species, like Great Auk, became extinct.[224] In BC, all seabirds are protected by federal and provincial laws from shooting and harassing, and

Figure 208. Barry Edwards holding an adult Glaucous-winged Gull found dead on Mitlenatch Island, BC, with a fish hook embedded in its esophagus. *Photo by R. Wayne Campbell, August 1968.*

Figure 209. Fish hooks with weights embedded on the wings or feet (shown) can usually be removed successfully and the bird can be released immediately. *Photo by R. Wayne Campbell, Long Beach, BC, 31 August 1968.*

during the past three decades public awareness has greatly reduced the frequency of illegal incidents (Figures 210 and 211). There are, however, still instances of shooting, netting, trapping, scaring, and oiling eggs when some seabirds, especially Glaucous-winged Gulls, pollute drinking water, foul buildings, congregate on popular recreational beaches, build nests on roofs of urban buildings, and conflict with fisheries programs. Currently, a massive cull of Double-crested Cormorants, by shooting and oiling eggs, is underway at the mouth of the Columbia River in Oregon. The management plan is to reduce the breeding population (the largest colony in the world) from 13,000 breeding pairs to 5,600 pairs (57%).[553] The controversial cull could impact breeding populations in BC.

Figure 210. In the 1950s and 1960s, birds that endangered arriving and departing airplanes at the Vancouver International Airport on Sea Island were frequently shot to discourage roosting on runways. Wayne developed a program to save carcasses for scientific research (e.g., moult and food studies) and museum specimens. *Photo by R. Wayne Campbell, Burnaby, BC, March 1964.*

Figure 211. In the past, residents on Passage Island, a seabird colony 8 km north of Vancouver, BC, shot adult Glaucous-winged Gulls and hung their carcasses (centre right) in boat platforms and yards to discourage fouling. *Photo by R. Wayne Campbell, Passage Island, BC, 2 June 1981.*

Figure 212. These two- to three-day old Glaucous-winged Gull chicks succumbed to an unseasonable storm that lashed Merry Island for several days during the critical period of hatching and early growth. *Photo by R. Wayne Campbell, 6 July 1974.*

Activities that alter the shoreline during the nesting season, such as log-salvage operations, may destroy shoreline nests of species like Black Oystercatcher, Glaucous-winged Gull, Pigeon Guillemot, and a small percentage of Cassin's Auklets that nest in piles of driftwood.[187]

In addition to loss of nesting habitat due to real estate developments discussed above, some habitat is alienated by the construction of shore-based fishing lodges, such as the land-based resort on Langara Island that was built in an area that used to be densely burrowed by Ancient Murrelets [508] before their populations were decimated by introduced rats.

Summer and winter storms can inflict tolls on breeding birds and their nesting habitat. Unseasonable weather, including strong winds, lasting rain, and hail during the breeding season can impact productivity and cause mortality on colonies. For example, in 1974, a heavy rain and wind storm killed about 35% of Glaucous-winged Gull chicks that were hatching or still small and downy on Merry Island, 12 km west of Sechelt (Figure 212). On Triangle Island in 1949, Cassin's Auklets were found cowering and soaking wet at the mouths of their burrows after a night of howling winds and rain, and a high mortality of birds was suspected.[158] Burrows can become flooded during heavy rains early in the season, and if prolonged, result in mortality or abandonment of eggs and even small chicks.

More violent winter storms often blow down swathes of mature forest, destroying nesting habitat on colony islands (Figure 213). For example, sometime before 2006 strong winds destroyed extensive habitat on Rankine Islands and Anthony Island, falling trees in four of the 16 permanent plots that had been set up to monitor Ancient Murrelet and Cassin's Auklet populations on Rankine Islands,[373] and obliterating one permanent monitoring plot for Rhinoceros Auklets on Anthony Island.[478] On Limestone and Reef islands, large swaths of trees in the main colony areas, including much of the areas used as study plots in the extensive work conducted by the Laskeek Bay Conservation Society on Limestone Island and by Tony Gaston and colleagues on Reef Island,[256] blew down in multiple storms over the winter of 2010.[437] Such habitat alterations are a dynamic and ongoing process on BC's west coast islands. Birds will sometimes continue to use blowdown areas, digging burrows under upturned roots or fallen trunks. Often there is a period that birds abandon parts of the area while forests regenerate, only to recolonize the area again once young trees have grown larger.[373] Blowdowns can also alter adjacent habitat by changing the light regime and stimulating a dense growth of saplings that make those areas unsuitable for burrow-nesters for a time.

Heavy rains may also trigger slides that wipe out burrowing habitat. On Triangle Island, a landslide

Figure 213. Windfall within an Ancient Murrelet permanent monitoring plot on George Island. *Photo by Moira J.F. Lemon, June 13, 2008.*

occurring sometime between 1989 and 1994 destroyed part of a grassy nesting slopes used by Rhinoceros and Cassin's auklets. That slide also obliterated one of the permanent monitoring plots for Rhinoceros Auklets. Over time, that area regenerated with thick salmonberry, and Rhinoceros Auklets were once again nesting there under the tall salmonberry by 2009.[478]

Agonistic defence of nesting territories is a regular source of mortality for some species. It can be direct or indirect and usually involves chicks that are less than two weeks old. The best examples for BC are from territorial disputes of Glaucous-winged Gulls documented on Mandarte Island off southern Vancouver Island in 1961 and 1962 and Mitlenatch Island in the northern Strait of Georgia between 1964 and 1966.[118, 119, 120] During five seasons of observations, 186 chicks were identified as being killed on the two islands by pecks on the head (Table 19; Figure 214). Some of the 269 chicks whose cause of mortality was unknown may also have been killed from territorial disputes (Table 19).

Mitlenatch Island is one of the few seabird colonies in the Strait of Georgia with extensive patches of brittle prickly-pear cactus (*Opuntia fragilis*) that was responsible for the deaths of at least 22 Glaucous-winged Gull chicks by ensnarement from 1964 to 1966 (Figure 215).

Figure 214. Although Glaucous-winged Gulls vigorously defend territories from pre-incubation through fledging, agonistic behaviour increases about two weeks after hatching when mortality of chicks is highest. *Photo by R. Wayne Campbell, Rose Islets, BC, July 1974.*

Table 19. Early post-hatching mortality of Glaucous-winged Gull chicks on Mandarte Island and Mitlenatch Island, BC, 1961-1966.

	Mandarte Island		Mitlenatch Island		
Cause of Mortality	**1961**	**1962**	**1964**	**1965**	**1966**
Pecked to death	12	90	13	19	52[1]
Cause unknown, found dead	43	64	33	46	83[1]
Leg band caught in vegetation	-	3	3	3	5
Dropped down cliff	2	2	-	-	-
Impaled by cactus	-	-	3	7	19[2]
Caught in deep crevice	-	1	-	-	1
Eaten by Northwestern Crow	-	3	1	2	4
Eaten by Wandering Garter Snake	-	-	1	2	1
Wandering from territory	-	3	4	3	6
Dwarfism (Runt)	-	1	-	-	-
Stepped on by researcher	1	-	-	-	-
Total	**58**	**167**	**58**	**82**	**171[2]**

[1]Large number likely due to frequent disturbance by Bald Eagles and Northern River Otters.
[2]Includes seven, half-grown live birds with cacti removed from legs.

Figure 215. Small numbers of Glaucous-winged Gull chicks become entrapped and die on patches of cacti on Mitlenatch Island each nesting season. *Photo by R. Wayne Campbell, Mitlenatch Island, BC, 25 August 1966.*

Entanglement of nestlings or recently fledged young in vegetation used as nesting materials or growing near a nest can kill young. On a banding trip to Sea Lion Rocks off Long Beach, three nestling Brandt's Cormorants, half-grown (two in the same nest), were found entangled by the legs in surf-grass (*Phyllospadix* sp.). When dried, the long leaves of the plant, the principal nest material, curl and wrap around the tarsi, restricting movement. We cut the strands to free the birds and pruned several nests to prevent potential entanglements. During disturbances or territorial clashes, young Black Oystercatchers and Glaucous-winged Gulls escape into cover near their nest. At some colonies, like Cleland Island, this includes blue wild rye (*Elymus glaucus*), a tall perennial bunch grass (Figure 216). The base of the plants is a tangle of dead vegetation and some young birds cannot escape the maze and become entrapped and die.

Figure 216. Dense vegetation, like blue wild rye, can ensnare young seabirds when they take cover to escape impending danger. *Photo by R. Wayne Campbell, Sandhill Creek, BC, September, 1968.*

CONSERVATION MEASURES AND RECOMMENDATIONS

Seabirds are challenging to study and monitor, but especially to conserve. Each species has its own unique set of traits that allows it to coexist with other species on the ocean and on land when nesting. Different reproductive, foraging, and dispersal behaviours mean that threats and appropriate management actions vary among breeding seabird species. It is a daunting task to identify conservation concerns and provide clear and comprehensive guidelines to protect these diverse species.

Research that provides a good understanding of seabird biology is prerequisite to effective conservation. Such research also has broad scale interpretive value because seabirds can serve as effective monitors of the health of oceanic ecosystems.[539] Seabirds are ideal indicators because they are easy to detect and identify compared to other marine species, are entirely dependent on marine systems for food, are long lived, and are highly mobile. Studies of at-sea distribution, diet, and foraging behaviour provide ecological information that can be integrated over large spatial and temporal scales.[20] Because they range widely and occupy the upper trophic level in marine food webs, seabirds are often the first indicators of oil and plastic particle pollution, dangerous levels of organochlorines and mercury, and occurrence of toxic chemicals, as evidenced by unexplained abnormalities (Figure 217).

International efforts to conserve biodiversity often focus conservation efforts on seabirds because of their vulnerable status worldwide. Images of struggling and dead, oil-soaked seabirds in the media also have increased public awareness, sympathy, and conservation efforts for seabirds. Although efforts to mitigate threats to seabird populations, including many successful programs to remove introduced predators from seabird colonies, have improved prospects for the future survival of seabird populations, the types and severity of many threats to seabirds continue to increase. Concerns about the future health of seabird populations thus remain paramount. The following topics still require informed thought and attendant action in BC.

Figure 217. Bill, foot, toenail, and leg deformities are being reported more frequently in Glaucous-winged Gulls (shown) and Double-crested and Pelagic cormorants in BC. The cause remains unknown. *Photo by R. Wayne Campbell, Esquimalt Lagoon, BC, 17 August 2003.*

Legislation

All seabirds nesting in BC are protected by federal and provincial laws [408] (Table 20). Thirteen of the 16 species (81%) are addressed by the federal Migratory Bird Convention Act (MBCA) of 1916, an environmental treaty between Canada and the United States that formally became a Canadian law in 1917. The Act was updated in June 1994 with additional

Figure 218. Through 1990, there were seven federal Migratory Bird Sanctuaries in BC. Christie Islet, the first, was primarily established to conserve nesting Double-crested Cormorants and is the only one of the seven to protect nesting seabirds.[136] *Photo by R. Wayne Campbell, Christie Islet, BC, 8 June 1981.*

regulations to protect migratory birds, their eggs, and their nests from hunting, trafficking, and commercialization. A permit is required to engage in any of these activities, although subsistence hunting by First Nations is still permitted in the modified legislation.[227] One major outcome of the federal act was the creation of a new category of protective land status known as Migratory Bird Sanctuaries (MBS; Figure 218).

In late 2002, the Species at Risk Act (SARA) became law in Canada. This law was developed to meet Canada's previous commitments under the International Convention on Biological Diversity, which was held in Nairobi, Kenya, in 1992. The Convention was conceived earlier as an interdisciplinary United Nations Environmental Program when conservation of biological biodiversity was deemed "a common concern of humankind." The goal of SARA is to protect endangered or threatened wildlife and their habitats. SARA allows for an independent group of wildlife professionals, brought together under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), to recommend to the federal government species or habitats that should be given protected status. There are penalties for failure to obey the law for designated species and/or habitats.

Additional federal legislation that may affect the protection of seabirds is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Although administration is shared by federal and provincial governments, the Canadian Wildlife Service and the Department of Fisheries and Oceans are responsible for managing CITES species federally. This legislation has been relevant to seabirds in BC in the past, for example, when the illegal trade in puffin beaks, used for rattles and adornments on First Nation peoples' clothing, became an issue.

Provincially, the British Columbia Wildlife Act (BCWA) protects virtually all vertebrate animals (amphibians, reptiles, birds, and mammals) from direct harm, except as allowed by regulation (e.g., hunting or trapping). BC does not have specific endangered species legislation and provisions for species-at-risk are included in the provincial Wildlife Act. The legislation allows any vertebrate species to be legally designated as endangered or threatened and can authorize direct management of wildlife. Cormorant species are legally protected only by the provincial BCWA as they are absent from the MBCA, although Double-crested Cormorant has been assessed by COSEWIC (most recently in 1978), likely because of its wide distribution nationally (Table 20; Figure 219). Additional provincial acts that address nesting seabirds in their legislation include the Provincial Museum Act that permits research related to natural history but provides no protection. The Parks Act and Ecological Reserves Act protect habitats and restrict harassment of wildlife within defined park and reserve boundaries.[408]

Figure 219. Double-crested (shown), Brandt's, and Pelagic cormorants are the only three of the 16 species of seabirds breeding in BC that are protected solely by the British Columbia Wildlife Act. *Photo by R. Wayne Campbell.*

Federal COSEWIC designations for assessed wildlife species include: Extinct (no longer exists); Extirpated (no longer exists in the wild in Canada, but exists elsewhere); Endangered (facing imminent extirpation or extinction); Threatened (likely to become an endangered if nothing is done to reverse the factors leading to its extirpation or extinction); Special Concern (may become threatened or endangered because of a combination of biological characteristics and identified threats); Data Deficient (applies when the available information is insufficient (a) to resolve a wildlife species' eligibility for assessment or (b) to permit an assessment of the wildlife species' risk of extinction); and Not At Risk (has been evaluated and found to be not at risk of extinction given the current circumstances).[188] In BC, a colour-coded, three-tier system is used to designate conservation levels for wildlife: Red is a species or ecosystem at risk of being lost (extirpated, endangered, or threatened); Blue is of special concern, and Yellow has the least risk of being lost [55] (Table 20).

Opinions differ on the criteria that should be used to prioritize conservation concern and to allocate resources for the protection of wildlife species. Table 20 shows differences in federal and provincial ranking systems for 16 species of seabirds nesting in BC. COSEWIC lists three species: Marbled Murrelet, that depends on mature and old-growth forest, is ranked as "Threatened", one level below "Endangered"; Ancient Murrelet and Cassin's Auklet are both ranked "Special Concern", partly because most of the world's population (74% and 80% respectively) breed in BC. Provincially, these three species are blue-listed as species of special concern. Marbled Murrelets were formally red-listed in BC and it is unclear why its ranking in BC has been lowered to Blue and why it now has a lower protective status provincially than federally. Double-crested Cormorant in BC also has been down-listed from Red to Blue. Rationale for these changes is not presented on the BC Conservation Data Centre's website. The five highest-priority, red-listed species

Table 20. Current protected status under federal and provincial legislation of the 16 species of seabirds breeding in British Columbia.

	Government of Canada		Province of British Columbia			
Species	MBCA[1]	COSEWIC[2]	BCWA[3]	Red[4]	Blue[4]	Yellow[4]
Fork-tailed Storm-Petrel	X	/	X			X
Leach's Storm-Petrel	X	/	X			X
Double-crested Cormorant		NAR	X		X	
Brandt's Cormorant		/	X	X		
Pelagic Cormorant		/	X	X[5]		
Black Oystercatcher	X	/	X			X
Glaucous-winged Gull	X	/	X			X
Common Murre	X	/	X	X		
Thick-billed Murre	X	/	X	X		
Pigeon Guillemot	X	/	X			X
Marbled Murrelet	X	T	X		X	
Ancient Murrelet	X	SC	X		X	
Cassin's Auklet	X	SC	X		X	
Rhinoceros Auklet	X	/	X			X
Tufted Puffin	X	/	X		X	
Horned Puffin	X	/	X	X		

[1]Species protected federally by the Migratory Birds Convention Act.
[2]Species listed by the Committee on the Status of Endangered Wildlife in Canada: T (Threatened); SC (Special Concern); NAR (Not at risk). A slash indicates species that have not been assessed.
[3]Species protected provincially by the British Columbia Wildlife Act.
[4]Provincial ranking system.
[5]Only includes northern subspecies of Pelagic Cormroant, *Phalacrocorx pelagicus pelagicus*. The southern subspecies is listed yellow.

in BC include three species, Brandt's Cormorant, Thick-billed Murre (Figure 220), and Horned Puffin, which are peripheral in the province; one subspecies, Pelagic Cormorant (*P. p. pelagicus*), of uncertain taxonomic status; and Common Murre, for which BC colonies support a small proportion of a large, continuously-distributed population along the Pacific coast. Common Murres nesting in BC may represent the northern limit of the poorly defined subspecies *U. a. californica*.[382] The status of these red-listed species warrants reconsideration.

The provincial red and blue lists guide conservation actions and COSEWIC considers provincial and territorial recommendations for species listings before initiating the detailed assessment process. However, peripheral taxa comprise a larger number of "at risk" bird species provincially than on the SARA list. In fact, peripheral species comprise about 40-100% of species red-listed by the BC government in different wildlife taxa.[66, 67] Because of the geographic location of BC and its topography, small tongues of continuously distributed species

Figure 220. Thick-billed Murre, a peripheral disjunct species in the province, is presently included in the red list on the provincial conservation rating system. *Photo by Alan D. Wilson, St. Paul Island, AK.*

enter the province from all directions as extensions of much larger populations and ranges, and thus occur only peripherally in BC. Eighty-six bird taxa are listed on the province's red and blue lists of which 59 (69%) are peripheral. Part of the scientific reason to list peripheral species is to sustain genetic variability across the population, but in most cases it is unlikely they are genetically diverse, and time and resources spent to protect these peripheral species' populations may be better allocated elsewhere.

We suggest that the three peripheral seabird species currently red-listed in BC should be given much lower priority ratings (Table 21). The small numbers of Thick-billed Murres and Horned Puffins breeding in BC represent recent range extensions from their main breeding areas in Alaska. Brandt's Cormorants that breed intermittently in BC are immigrants from southern colonies in the United States. The nearest Brandt's Cormorant and Horned Puffin colonies to BC are 90 km (Willoughby Rocks, WA) and 65 km (Forrester Island, AK) away, respectively. Thick-billed Murre has a disjunct distribution; the closest colony in Alaska is about 800 km north of the Triangle Island colony. World population of Thick-billed Murre is estimated at 15-20 million.[261] The Alaskan Thick-billed Murre population is about 2.2 million birds at 174 colonies and is listed as "Not at Risk". About 85% of the world's population of over one million Horned Puffins breeds in Alaska at 608 breeding colonies.[444] The conservation status there is listed as "moderate concern." California supports most of the world's breeding population of Brandt's Cormorant and overall populations throughout its range have generally increased since the 1970s.[608] The species is rated "Least Concern" by The International Union for Conservation of Nature (IUCN). Protection of these peripheral populations is important, but directing conservation resources towards the few pairs of Thick-billed Murre that sometimes nest on Triangle Island, the as-of-yet single pair of Horned Puffins that has been confirmed nesting in BC, and the few Brandt's Cormorants that nest intermittently in southern BC would be unwarranted. This is especially true because: resources are limited; protection of species, including Marbled Murrelet, Ancient Murrelet, Cassin's Auklet, and Rhinoceros Auklet, for which BC has stewardship responsibility for large portions of world populations, must take higher priority; and measures to protect higher-priority species likely will extend benefits to peripheral species as well.

We also recommend reassessment of the currently red-listed Pelagic Cormorant subspecies *P. p. pelagicus*. *P. p. pelagicus* is the northern of two subspecies along the Pacific coast of North America. Distinction and geographic limits of the two subspecies are poorly defined. Dorst and Mougin [211] listed the two subspecies, but without further examination of the source, published in 1811.[430] Hobson [331] cautions, however, that the precise boundary between subspecies is not clear and that the taxonomy should be confirmed. It has been suggested that the northern subspecies extends south to Langara Island in BC [9] and that the southern subspecies, *P. p. respléndens,* occurs from Mandarte Island, BC, south to Baja California.[213] The BC Conservation Data Centre has included birds breeding at all colonies in the Queen Charlotte Islands and along the northern mainland coast in the *P. p. pelagicus* population.[55] As of 1990, 476 birds were estimated nesting at those colonies. About 100,000 birds breed at colonies in Alaska, and overall populations of *P. p. pelagicus* are much larger than those of *P. p. respléndens*. Given the uncertainty in their taxonomic status, and the fact that most of the population breeds to the north in Alaska, we recommend that *P. p. pelagicus* not be given specific red-listed status in BC. The IUCN lists the entire species as "Least Concern", but given apparent population declines in BC and the vulnerability of breeding birds to disturbance, we suggest that the entire species be elevated to Blue status in BC (Table 21).

Common Murres is another species that should be reassessed. Although these birds suffer high oil- and fisheries-related mortality throughout their range, BC colonies support a very small proportion of Pacific and world populations and we recommend that their status in BC be revised to Blue. Global populations are considered secure and the species is rated "Least Concern" by the IUCN.

We propose a new system to assist in setting conservation priorities in BC (modified from Bunnell et al.[66]). In general it gives lower rankings to peripheral species, unless those species are vulnerable and threatened in other parts of their range. It uses six criteria listed in order of importance:

(1) Endemics (species and subspecies) (e.g., Vancouver Island Marmot);
(2) Significant world populations in BC (e.g., Rhinoceros Auklet; Figure 221);
(3) Significant world ranges in BC (e.g., Rufous Hummingbird);
(4) Population trends (e.g., Caspian Tern);
(5) Species vulnerability and threats (e.g., Spotted Owl); and
(6) Peripheral species (continuous and disjunct) (e.g., Arctic Tern; Figure 222).

Table 21. Suggested revised provincial ranking system and recommended conservation status for seabird species breeding in British Columbia.

	Province of British Columbia			
Species	**Red[1]**	**Blue[1]**	**Yellow[1]**	**Grey[1]**
Fork-tailed Storm-Petrel		X		
Leach's Storm-Petrel		X		
Double-crested Cormorant		X		
Brandt's Cormorant				X
Pelagic Cormorant[2]		X		
Black Oystercatcher			X	
Glaucous-winged Gull			X	
Common Murre		X		
Thick-billed Murre				X
Pigeon Guillemot			X	
Marbled Murrelet	X			
Ancient Murrelet	X			
Cassin's Auklet	X			
Rhinoceros Auklet	X			
Tufted Puffin		X		
Horned Puffin				X

[1]Provincial ranking system with proposed addition of "Grey" category for peripheral species that are not vulnerable or threatened in other parts of their range.
[2]The subspecies status of *Phalacrocorx pelagicus pelagicus* occurring in BC is questionable pending confirmation from the record published in 1811. The subspecies *P. p. resplendens* is likely more common in BC.

Figure 221. Currently, Rhinoceros Auklet is on the provincial yellow list, the lowest for conservation priorities, despite BC having an estimated 56% of the world's breeding population of about 1.5 million birds. *Photo by R. Wayne Campbell, Cleland Island, BC, August 1974.*

Figure 222. Arctic Tern has a disjunct distribution in BC. It breeds regularly from Tatshenshini River east to Atlin Lake and south to Spatsizi Plateau. Isolated pairs also breed near Fireside/Liard River and Eagle Lake in the Chilcotin region.[151] *Photo by R. Wayne Campbell, Fireside, BC, 18 June 2007.*

If these criteria were adopted, they would elevate Ancient Murrelet, Cassin's Auklet, and Rhinoceros Auklet, for which BC supports most of the world's populations, to Red status. These species also depend on mature forest for nesting at most colonies in the province, are threatened by introduced predators in the Queen Charlotte Islands, and are at high risk from oil pollution and fisheries-related mortality. Marbled Murrelet would also be red-listed due to its dependence on old-growth forest for nesting and vulnerability to at-sea perturbations. The recommended six blue-listed species are all primary, well-distributed breeding species that are especially vulnerable to environmental perturbations. Fork-tailed and Leach's Storm-Petrels are less vulnerable to oil- and fisheries-related mortality than diving species, but the concentration of breeding populations on a few colonies and the species' vulnerability to introduced predators in the Queen Charlotte Islands makes them of special concern in BC. Populations of these six species should be monitored regularly. Black Oystercatcher, Glaucous-winged Gull, and Pigeon Guillemot would remain at Yellow status as species lowest at risk of being lost.

The BC conservation rankings that would result from adoption of the proposed criteria (Table 21) suggest some revisions to COSEWIC listings as well, including elevating Ancient Murrelet and Cassin's Auklets to "Threatened" status and initiating the assessment process for Rhinoceros Auklet.

Habitat Protection

The notion of establishing bird sanctuaries in BC outside general park reserves was first proposed by G.D. Sprot and Theed Pearse, members of the British Columbia Ornithologists' Union (BCOU), in 1922.[111] The suggestion was noted by James A. Munro, chief migratory bird officer in BC, also a BCOU member, who immediately proposed a federal bird sanctuary at Swan Lake in the northern Okanagan Valley.[112, 403] This set a precedent for the protection of important bird sites in the province, including those specifically for nesting seabirds. During the late 1950s, Rudi Drent, while compiling and writing *A Catalogue of British Columbia Sea-bird Colonies*,[213] began publicly emphasizing the vulnerability of nesting seabirds to disturbance. Government managers and conservationists paid attention and began protecting colonies using a variety of options available to them. For example, in 1959, Mitlenatch Island was purchased by the provincial government from the Manson family and in 1961 was made a Provincial Nature Park (Figure 223). A federal Migratory Bird Sanctuary was established for Christie Islet and Pam Rocks in 1962, and the province's first Ecological

Figure 223. Soon after Mitlenatch Island was formally designated a Provincial Nature Park, BC Parks Branch undertook efforts to protect nesting seabirds from visitor disturbance by hiring seasonal naturalists and later developing a volunteer warden program. In this photo, Ken Kennedy (left) is taking a group of tourists on a nature walk explaining the sensitivities of seabird colonies to disturbance while looking at the island's unique flora. *Photo by R. Wayne Campbell, Mitlenatch Island, BC, 11 June 1967.*

Reserve was established on Cleland Island in 1971. Today, over 80% of the province's breeding seabird population has some sort of land-based government protection.

Designated Provincial Ecological Reserves [358] protect 70% of the total breeding seabird population at colonies in BC. They include Triangle, Sartine and Beresford islands in the Scott Islands; Solander Island (Figure 224), Cleland Island, Baeria Rocks, and Race Rocks on the west coast of Vancouver Island; Storm Islands, Tree Islets, Pine Island and the Buckle Group at the mouth of Queen Charlotte Strait; all the major colonies in the vicinity of Moore Islands on the northern Mainland coast; and Hippa Island and "Lepas" Islet on the west coast of Graham Island. Former Ecological Reserves on the east and west coasts of Moresby Island had that status withdrawn to allow their inclusion in the Gwaii Haanas National Park Reserve. That reserve includes 13% of the total provincial breeding population. A number of small colonies are encompassed by Pacific Rim and the Gulf Islands National Park Reserves. National Park

Figure 224. Solander Island, an important seabird colony off Brooks Peninsula on the west coast of Vancouver Island, was established as a provincial ecological reserve in 1971. At least six species breed on its 7.7 hectares of steep terrain. *Photo by R. Wayne Campbell, 27 June 1975.*

Reserves, managed under the National Parks Act are areas intended to become national parks pending settlement of native land claims.

Under the BC Parks system, the Duu Guusd Heritage Site/Conservancy gives protection to Frederick Island, Langara Island and other previously unprotected seabird colonies along the west coast of Graham Island. Similarly, seabird colonies from Rennell Sound south along the west coast of Graham and Moresby Island, including all the colonies within Engelfield Bay, to Tasu Sound are protected within the Daawuuxusda Heritage Site/Conservancy. On the east coast of Moresby Island, seabird colonies north of Gwaii Haanas National Park, including Reef, Limestone and Skedans islands, are protected within K'uuna Gwaay Heritage Site/Conservancy. On the mainland coast, the Rhinoceros Auklet colony on Lucy Islands near Prince Rupert is afforded protection within the BC Parks' Lucy Islands Conservancy. Gillam and Thornton islands on the west coast of Vancouver Island have no formal protection, but are recognized as Important Bird Areas.[340]

Fortuitous protection of Marbled Murrelet nesting habitat has been provided within reserves and parks established for other reasons, but because of their solitary, dispersed nesting habits, only a small percentage of the breeding population occurs in currently protected areas.[472, 513] Loss of old-growth forest that provides potential nesting habitat for Marbled Murrelet may have exceeded 50% since European settlement.[186] As of 2011, about 34% of remaining potential breeding habitat had some form of legal protection. Since it's designation as a Threatened Species, a Recovery Strategy has been implemented for the Marbled Murrelet and Wildlife Habitat Areas (WHAs) have been planned or designated for protecting nesting habitat in forests under provincial jurisdiction. Extensive areas of suitable nesting habitat have been included within conservancies and other protected areas on the Queen Charlotte Islands and the north and central mainland coast.[228] The difficult problem of identifying and preserving important old-growth habitat remaining for this species will be a constant management issue for years to come.

Additional protection for nesting seabirds, and especially their foraging habitat, will be provided by the proposed Scott Islands Marine National Wildlife Area and the Southern Strait of Georgia National Marine Conservation Area. The Scott Islands Marine National Wildlife Area has been proposed under the authority of the Canada Wildlife Act and is being negotiated in consultation with a Steering Committee and stakeholder Advisory Group, established in 2010. The Steering Committee includes representatives from other federal departments (Fisheries and Oceans, Transport, Natural Resources), the Province of British Columbia, Quatsino First Nation and Tlatasikwala First Nation. The stakeholder Advisory Group includes representatives from local and regional governments, commercial fishing, marine transportation and shipping, non-renewable energy, marine conservation, sport fishing, and marine tourism.[232] Unfortunately, regulations currently proposed to protect foraging and staging seabirds in the Scott Islands area do not provide adequate protection for seabirds, other marine species, or the broader ecosystem of this important area. Greater restrictions are required on vessel traffic, fisheries, and human disturbance to limit three of the main mortality factors that impact seabirds, including chronic oil spills, entanglement and bycatch in fishing gear, and disruption of foraging and social activities. The Southern Strait of Georgia National Marine Conservation Area is currently being worked on by Parks Canada and the Province of BC under the authority of The Canada National Marine Conservation Areas Act passed in 2002.[435]

Reduction of Disturbance

There are many general references with recommendations to minimize disturbances to seabird colonies,[159] and specific studies in the Strait of Georgia [181] have helped set guidelines to reduce impacts of direct and indirect human disturbance to nesting seabirds in BC. Investigators studying seabirds are generally sensitive to the potential consequences of their activities and strive to minimize their impacts. For the last few decades, proposed research, especially that conducted through universities or that involves the capturing and handling of wildlife, is vetted through animal care committees and permitting agencies to ensure that impacts to study animals are minimized. However, the problems associated with managing ecotourism and other activities of the ever increasing human population continue to grow. Blanket recommendations may not be applicable locally, and threats and appropriate protective measures need to be identified, almost island by island, and species by species, to have maximum effect.

Outsmarting the Crows

Effects of investigator disturbance are often unanticipated and only avoided after researchers learn from experience. I (Moira) went through such a learning process during a study of Ancient Murrelets and Cassin's Auklets on Frederick Island in 1980 and 1981. For most study burrows, a hole had to be dug into the tunnel to access the nest. The access holes were covered with a wooden hatch of cedar shakes and great care was taken to secure the hatch with earth piled on top to maintain the integrity of the burrow. The study burrows were marked with numbered orange flagging tape attached to wooden stakes placed beside the hatch. This procedure worked well through the 1980 field season, giving us confidence that our methods were as non-invasive as possible. In 1981, we learned differently.

Northwestern Crows and Common Ravens are known predators on nesting seabirds and are capable of excavating a nesting burrow with their bills. Sometimes they seem to have an uncanny ability to dig where the tunnel ceiling is thinnest to find the actual nest. However, we underestimated their intelligence.

One morning in late May, about two weeks into the 1981 field season, I noticed a crow peering into the entrance of one of the burrows. Fearing the worst, I went to investigate and discovered a scene of utter devastation – the access holes that we had dug into the tunnels were opened, and the wood and earth hatches were tossed haphazardly about. In a few cases the nests had been exposed, but fortunately, most nests were located far enough along the tunnel that the ravens and crows had been unable to reach them. We repaired the damage and placed large rocks on top of the hatches as deterrents. Then, over the course of the next couple of days we held vigil in the early mornings, watching to see what would happen. Silent gangs of crows would systematically cruise through the forest inspecting every place where we had a flag on a stick marking a burrow. Realizing they were cueing in on our markers, we removed the conspicuous wooden stakes and flagging tape and replaced them with cryptic pieces of bark on which we had inscribed the number of the burrow. It was more difficult for us to relocate our study burrows, but at least the crows could no longer cue in on our markers. Although a humourless situation, we did manage to find a ray of amusement when we realized that the crows were also attempting to dig at the base of flagged stakes that were marking predation plucking sites, but since there was no burrow there, they were unrewarded.

Since 1990, restrictions on access to sensitive sites and protocols for visiting more robust colonies have been instituted in Gwaii Haanas National Park Reserve [592] (Figure 225). All seabird colonies in

Figure 225. Eco-tourists in Gwaii Haanas National Park Reserve today have strict guidelines to follow for visiting sensitive areas. However, government vigilance to monitor and enforce compliance by every group is unrealistic. Fortunately, tour operators usually have an experienced and responsible naturalist on board, in this case Dr. Bristol Foster (holding paddle) who has been actively involved in research and protection of land and wildlife in the Queen Charlotte Islands since the early 1960s. *Photo by R. Wayne Campbell, Thurston Harbour, Moresby Island, BC, 29 May 1996.*

Pacific Rim and Gulf Islands National Park Reserves are classified as Environmentally Sensitive Sites or are within Special Preservation Zones, and guidelines for visitor access are also in place.[432, 433] Access is also restricted at other colonies with protected status as Ecological Reserves or Conservancy Areas. Most visitors likely respect established protocols, but surveillance or enforcement only occur locally in areas of high use and are absent elsewhere.

We have identified several activities, including ecotourism, kayaking, scuba diving, and harvesting of Gooseneck Barnacles, that place people on, or near, seabird colonies during the breeding season where disturbance to nesting birds or damage to burrows is likely. Investigations are needed to determine the extent that these and other activities affect nesting birds. Disturbance or damage to seabirds or their nests are offences under the federal Migratory Birds Convention Act and the BC Wildlife Act. Under the authority of these acts, we recommend implementing a permitting process to manage visitation to all seabird colonies in BC. The intent of the permit would be to make people more aware of potential damage they might cause, encourage reporting of activities that might damage seabird colonies, and to allow access without impacting nesting birds. We also suggest that all seabird colonies, especially those with some provincial or federal protection (e.g., ecological reserves, parks, migratory bird sanctuaries, etc.) be posted with signs to identify their sensitive nature (Figure 226).

Figure 226. Signs, well-placed and easily visible, and regularly maintained, should be placed on all seabird colonies in BC. *Photo by R. Wayne Campbell, Christie Islet, BC, 18 July 1970.*

Most guidelines currently in place address nesting birds on land. The functional importance of staging areas around colonies has been poorly studied and less attention has been paid to those areas than to nesting areas on land.[510] This is understandable given the logistical difficulties of studying bird behaviour in concentrations of thousands of birds on the water. For Ancient Murrelet and other species, display and vocalization behaviour is intense on staging areas, and those areas may be important for pairs that are re-uniting, and for courtship and pair formation by non-breeding birds.[256, 510] Large proportions of breeding and non-breeding populations [510] – in some cases almost the entire BC breeding population [484] – may be aggregated on the water around colonies at any one time. Guidelines to minimize impacts of human disturbance have not adequately addressed these vulnerable concentrations. Canadian federal guidelines recommend that people on land or on the water stay a minimum distance of 300 m from colony areas and that larger boats and ships anchor no closer than 500 m from colonies.[231] They also state that concentrations of birds on the water should be avoided, but no guidance is provided as to what constitutes a "concentration", how far to stay away from concentrations, or where or when these concentrations may occur.

Recommended minimum approach distances need to be revised for species that stage on the water, including Common (Figure 227) and Thick-billed murres, Pigeon Guillemots, Ancient Murrelets, Rhinoceros Auklets, and Tufted Puffins, and should depend on the distance off the colony that birds gather and the specific time periods that birds are present. Staging areas of Ancient Murrelets sometimes extend over three kilometres offshore at some colonies.[256, 508] To avoid disturbance to those important areas, the minimum approach distance should be greater than that during the period mid-March through June when Ancient Murrelets attend their colonies. Sensitive periods extend through the summer for species like Rhinoceros Auklets and Tufted Puffins that raise their chicks ashore. Navigation lights on vessels are also concerns and nighttime travel or anchorage of boats needs to be kept well outside the areas where Ancient Murrelets or other species are present on the water at night.

Figure 227. Any aggregation of seabirds near a colony site, including Common Murres, should remain undisturbed so as not to interfere with critical courtship or pair-bonding activities, or perhaps impact adults seeking temporary respite before returning to the colony with prey to feed their young. *Photo by R. Wayne Campbell.*

The permitting process for visiting seabird colonies should also include appropriate exclusions on boat traffic through offshore and nearshore staging areas and anchorage near staging areas at night. Permitting (with instructional pamphlets) should apply to all activities, including the ecotourism industry and sports fishing lodges that are increasingly becoming established in the vicinity of major seabird colonies, especially in areas like the west coast of Graham and Moresby islands. This would require up-to-date information on the location and timing of staging concentrations around colonies. Main staging concentrations at colonies in the Queen Charlotte Islands have been identified and mapped [256, 480, 481, 482, 508, 510] and birds tend to use the same areas from year to year, but repeated, dedicated surveys are warranted to provide more reliable information on which to base recommendations and restrictions. Surveys are required to identify staging concentrations around colonies in other coastal regions, such as the large Rhinoceros Auklet colonies on Storm and Pine islands in Queen Charlotte Strait.

Studies are also required to distinguish the effects of human disturbance on cormorant colonies from normal population fluctuations and shifts in nesting locations.[172, 487]

Protection from Oil Pollution

Preventing oil contamination of the ocean is one of the most important conservation steps that we can take to protect marine-dependent bird species in BC. Federal moratoriums against tanker traffic and oil exploration along the BC coast are positive moves in that direction and need to be supported and expanded. More intensive efforts to deter the dumping of oily wastes by ships at sea and to reduce leakage and careless spillage associated with smaller craft are also needed (Figure 228).

Figure 228. A lightly oiled Marbled Murrelet found along the west coast of Vancouver Island, BC, in early January 1989 following the *Nestucca* oil spill near Grays Harbor, WA, on 23 December 1988. Even small amounts of oil on the outer plumage can be deadly. *Photo by Moira J.F. Lemon, January, 1989.*

The BC Legislature passed a resolution opposing oil tanker traffic off the west coast in 1971. A federal moratorium against crude oil tanker traffic along the north coast of BC was informally instituted in 1972, and has recently been given formal status in Bill C-48, the Oil Tanker Moratorium Act, tabled in the federal parliament on 12 May 2017. The moratorium covers the area from the Alaska/BC border down to the point on BC's mainland adjacent to the northern tip of Vancouver Island, including the Queen Charlotte Islands, and prohibits oil tankers carrying crude oil or persistent oil products as cargo from entering or leaving ports and marine installations in this area. Lighter, more volatile petroleum products, including gasoline, propane, jet fuel, and liquefied natural gas, which is shipped out of the large processing plant at Kitimat, are not covered by the moratorium. Vessels carrying less than 12,500 tonnes of crude oil or persistent oil products as cargo will be exempted from the moratorium to allow local communities and industries to continue to receive supplies of heavier heating and fuel oils. The Act also gives the Minister the authority to grant exemptions to vessels if their passage is deemed to be in the public interest or of help to local communities. The moratorium has received support from some native groups, including the Haida and Heiltsuk Nations, who as part of The Coastal First Nations declared a ban on oil tankers in their waters in 2010, but is opposed by others, such as the Woodland Cree, who are part of a consortium called Eagle Spirit Energy that has been described as "the largest First Nations endeavour in the world", and that propose construction of a $14 billion pipeline between Fort McMurray, AB and Prince Rupert, BC.

The oil tanker moratorium does not apply to southern ports and offers no protection from tanker traffic through the Strait of Georgia and Juan de Fuca Strait. Expansion of the Kinder Morgan or Trans Mountain pipeline that brings crude and semi-refined oils from Alberta to the port in Vancouver will increase tanker traffic and associated risks to nesting and wintering birds in those waters (Figure 229). The expansion was recently approved by the federal government, but is currently opposed by a coalition of NDP and Green parties in the newly-elected (9 May 2017) provincial government in BC. A number of environmental groups are also lobbying against the expansion. The Society Promoting Environmental Conservation states, "Increasing our capacity to feed dirty oil to local and overseas markets is counterproductive to our communities' efforts to mitigate climate change and build healthier, more sustainable cities".[525] It also poses greater risks to marine birds.

Figure 229. The government oil tanker moratorium does not apply to ports in southern BC where traffic is expected to increase significantly with expansion of Kinder Morgan's Trans Mountain pipeline to the port of Vancouver. *Photo by R. Wayne Campbell, Fraser River near Vancouver, BC, 20 June 1970.*

There is also a voluntary Tanker Exclusion Zone, initiated in 1977 following completion of the Trans Alaska Pipeline System, and agreed upon in 1988 by the Canadian Coast Guard, the United States Coast Guard and representatives from US tanker industry groups, that stipulates that loaded tankers travelling south from Alaska to the continental US remain 77 nautical miles (143 km) to the west of Cape St. James, 60 miles (111 km) from Triangle Island, 40 miles (74 km) from Estevan Point, and 22 miles (41 km) off the south end of Vancouver Island where tankers approach Juan de Fuca Strait to enter US waters. However, anecdotal reports suggest that low enforcement has resulted in tankers not always observing this agreement.

A moratorium against oil exploration and development was also issued by the federal government in 1972. The moratorium was a policy decision and has no formal status but the federal government has refused to issue permits for any offshore oil and gas related activity since then. Over the intervening years, a number of industry and BC provincial government studies have recommended lifting the moratorium, and lobbying on both sides continues today.[618, 628] The main areas proposed for offshore oil and gas development include Queen

Charlotte Sound , Hecate Strait, and Dixon Entrance. The moratorium was in danger of being lifted in the 1980s, pending an accord being negotiated at that time by the federal and provincial governments.[636] In the event of offshore drilling, a 20 km exclusion zone around all shoreline areas was agreed upon at that time, in part to allow time for an emergency response to prevent an oil spill reaching the coast.[226] This provides some protection in the immediate vicinity of seabird colonies, but with the experience of past spills like the *Exxon-Valdez* and *Nestucca*, the potential damage from a major spill or blowout in coastal waters is obvious.

The Nestucca Spill

In January 1989, when heavy Bunker C oil from the December 1988 sinking of the Nestucca barge began to come ashore along Long Beach in Pacific Rim National Park Reserve, a response was mounted by the Canadian Coast Guard. This soon grew to include many government agencies, and the Canadian Wildlife Service sent Michael and me (Moira) to the command center near Ucluelet to gather information about the potential impact on migratory birds. The data we gathered during many helicopter flights provided a timely picture of the abundance and distribution of waterbirds in the area and the risk to those populations from the drifting oil. While conducting our bird surveys, we were able to provide observations on the extent of oiling along the shoreline, often in areas not yet surveyed by the other agencies.

Many volunteers from numerous organizations were instrumental in the hands-on clean up along remote beaches and shorelines where large equipment could not go. The clean-up crews had to endure the nauseating odour of the oil that hung in the air and permeated everything. Michael and I also had the depressing task of identifying and counting the number of dead oiled birds that had washed ashore. Bags of birds encased in thick oily debris were gathered up and amassed at the command center, where we would have to pull them apart and separate the birds from other debris (Figure 230)*.*

Sometimes birds had only a small amount of oil on their feathers, which still was enough to kill them, but more often birds were completely encased in the thick tar-like oil. A thick oily blob, on close inspection, would turn out to be a Common Murre, and pulling this away would often reveal a smaller bird, a Cassin's Auklet within the same oily mass. We identified birds from their size, bill shape and foot details. Loons, grebes, cormorants, sea-ducks, gulls and alcids were all found to be victims of the oil spill. The most unusual casualties were Parakeet Auklets (Aethia psittacula).

The oiled birds that were found washed up on shore represented only a small percentage of the actual casualties from the oil spill. Many were simply not found by observers, or were scavenged by predators; others drifted further out to sea and sank, never ending up on shore.

Figure 230. Michael Rodway identifying bags of oiled bird carcasses collected along the west coast of Vancouver Island, BC, from the 23 December 1988 *Nestucca* oil spill near Grays Harbor, WA. *Photo by Moira J.F. Lemon, Amphitrite Point, BC, January 1989.*

In the event of an oil spill, both the United States and Canada rely on private sector response organizations to supply the majority of equipment required to deal with containment and oil cleanup. There are four response organizations in Canada that have been issued authorization certificates by the federal government. In addition, Canadian Coast Guard vessels can be equipped with oil containment and recovery equipment, and the Department of National Defense has some recovery equipment available from bases on Vancouver Island. Response times depend on many factors, but performance standards require a minimum of 500 m of affected shoreline be cleaned or protected each day, and recovery of spilled oil from sheltered or unsheltered waters be completed within 10 operational days after equipment is deployed. Even if these performance objectives are met, there is little question that a major spill in areas where marine birds concentrate would decimate bird populations before response efforts can be completed.

Efforts to limit the discharge at sea of oily bilge waste were initiated with the International Convention for the Prevention of Pollution of the Sea, signed in London on 12 May 1954 (Figure 231). The convention stipulated that within 12 months ships be outfitted with the means to prevent escape of fuel oil or heavy diesel oil into bilges, and that within three years facilities be established in all main ports for receiving oily wastes without causing undue delay to ships. That convention has been amended and superseded several times since but the same efforts are ongoing and dumping of oily waste today remains a serious source of contamination and a huge threat to marine birds. Effectiveness at combatting the practice in Canada has lagged behind other parts of the world.

Figure 231. The discharge at sea of bilges containing oil by commercial fishing factory ships was a common practice in the 20th century. Most unloading was done in international waters, without penalty. *Photo by R. Wayne Campbell.*

The problem of illegal oil dumping has been pronounced in Canada for several reasons.[436] Canada's surveillance, enforcement efforts, and penalties have historically been inadequate to provide strong punitive incentives for compliance, and port facilities have been inadequate to efficiently support the legal disposal of wastes by all visiting ships. Canada's less frequent surveillance, low marine pollution prosecution rate, and infrastructural issues has made our waters an attractive dumping ground for ship operators willing to break the law.

In the spring of 2005, Canada moved to better combat the problem of illegal waste oil dumping by passing Bill C-15, which amends the Migratory Birds Convention Act of 1994, and the Canadian Environmental Protection Act of 1999. The amendments clarify the prohibitions found in both acts against the dumping of oily bilge wastes or other pollutants into the ocean, and strengthen Canada's legal capacity to prosecute marine polluters. The bill extended the jurisdiction of existing legislation to include Canada's entire 200 nautical mile exclusive economic zone, increased maximum penalties for polluters, and holds operators of ships illegally polluting in Canadian waters individually accountable for these actions. At the same time, the Government of Canada invested more in aircraft and satellite surveillance to detect infractions (National Aerial Surveillance Program) and in enforcement to prosecute polluters. In 2008, 183 pollution spills were detected and several prosecutions resulted in fines as high as $80,000.[230] However, fines are routinely in the hundreds of thousands to million-dollar range in the USA and Europe, and surveillance and enforcement efforts in other areas are much more intensive than in Canada. Conviction in other countries also commonly results in criminal charges and the suspension of working papers for ships' operators, which has not occurred in Canada. Greater efforts to control illegal dumping of oil in Canadian waters are needed, especially given the persistent mortality of hundreds of thousands of marine birds each year off Canadian shores (Figure 232).

Smaller boats, fueling operations at marinas, passenger ships, and fishing boats cause most of the oil spills detected in BC nearshore waters by patrol flights in the National Aerial Surveillance Program.[28]

Figure 232. Most major oil spills are caused by human mistakes or carelessness, or less commonly by equipment failures. However, major storms can also wreck ships and result in the release of oil into the water. The shipwreck in the photo, the *SS Clarkesdale Victory*, was a cargo ship used during World War II to supply troops at the battle of Okinawa in Japan, with ammunition, diesel oil, and other necessities. On November 24, 1947, in 50 foot waves, it ran into a reef off Hippa Island, broke in two, and sank quickly. Forty-nine of the 53 crew were lost.[387] *Photo by R. Wayne Campbell, Hippa Island, BC, June 1988.*

The largest concentration of spills was in the busy waters of the Strait of Georgia. Most spills from these sources are due to carelessness and can be prevented. Marinas for small boats are a major source of oil contamination and many moored old boats constantly leak oil into the ocean. Public education is improving this situation and actions of concerned citizens are helping. Marine pollution incidents, including oiled seabirds found alive or dead near local marinas (Figure 233) in BC should be reported to the Canadian Coast Guard at 1-800-889-8852. Oiled live seabirds should be reported to local chapters of the Society for the Prevention of Cruelty to Animals or wildlife rehabilitation centres.

Figure 233. This dead adult Glaucous-winged Gull was covered with vegetable oil dumped at a nearby marina. *Photo by R. Wayne Campbell, Chain Islets, BC, 23 July 1973.*

Elimination or Control of Introduced Predators

Introduced mammalian predators remain the most serious conservation issue in the Queen Charlotte Islands. Since 1990, eradication programs have been completed or are underway to remove rats from Langara, Cox and Lucy islands at the northwest corner of Graham Island [352, 543] and from St. James, Arichika, Bischof, and Murchison islands along the east coast of Moresby Island,[434] providing some optimism for the future of Ancient Murrelet and other species populations at those impacted sites. Control of rats on Kunghit and Lyell islands remains an outstanding management challenge.

Northern Raccoon (Figure 234) is still the most serious threat to nesting populations throughout the Queen Charlotte Islands. During the late 1990s and early 2000s, the federal and provincial governments and the Haida Nation coordinated a program to monitor, research, and control raccoon activities on seabird colonies in the Queen Charlotte Islands.[229, 302] In Gwaii Haanas National Park Reserve, these efforts are ongoing with a focus on research into other monitoring and methods of detection, but there are only opportunistic patrols for evidence of raccoon presence on major colonies on the west coast of Graham Island and in Engelfield Bay. It has proved difficult to control invading raccoons before they damage seabird colonies.[59] Protecting extant colonies within reach of raccoons will require constant vigilance until an archipelago-wide solution can be devised.[592]

Figure 234. On the Queen Charlotte Islands, the introduced Northern Raccoon swims freely among islands and colonies, and has become a serious threat to nesting seabirds. *Photo by R. Wayne Campbell, 4 February 1997.*

The presence of American Marten on Lucy and Langara islands needs to be ascertained, and they should be removed if they are present. The risk of re-introduction of predators to Langara Island has increased due to the establishment of a fishing lodge on former Ancient Murrelet nesting habitat and careful monitoring of that colony is required. The Management Plan for the Ancient Murrelet states that the "establishment of a rat-ready bait-station program in collaboration with the fishing lodges is warranted at Langara Island." [229]

A program to control or eradicate American Mink and Northern Raccoons from Lanz and Cox islands should be developed within the framework of a management plan for the proposed Scott Islands Marine National Wildlife Area.[328]

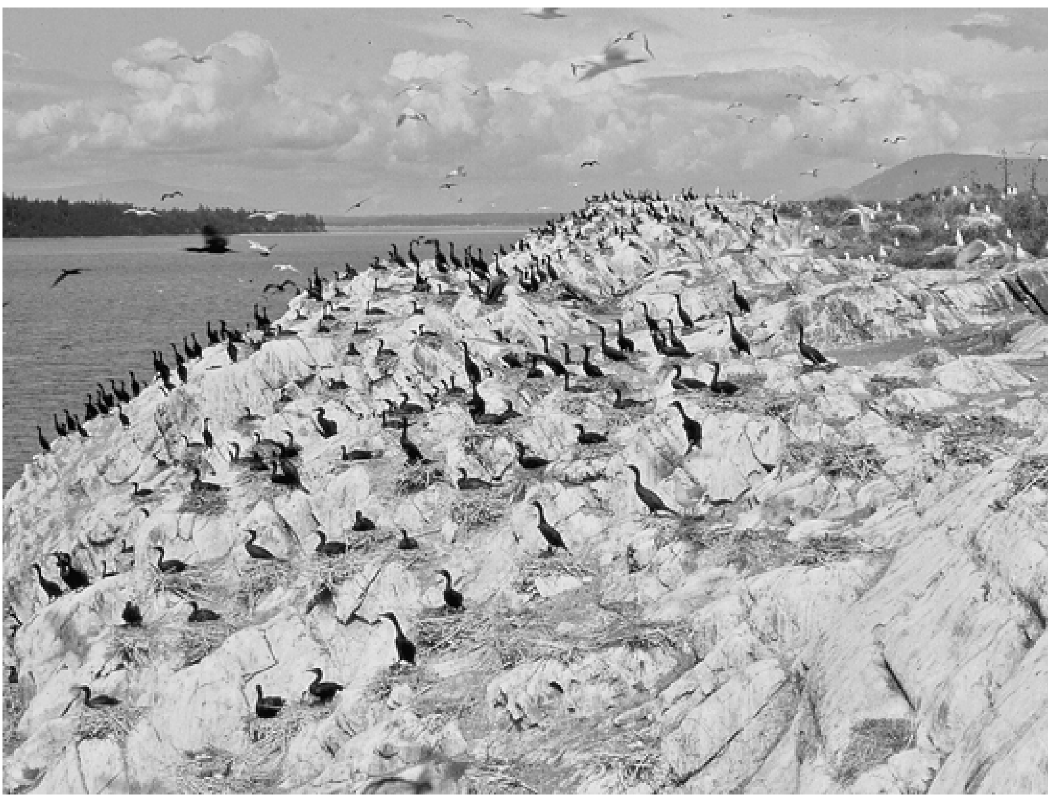


Figure 235. The earliest complete survey of Double-crested Cormorant nests in British Columbia started in 1957 by Masters of Arts student Gerry van Tets on Mandarte Island off Sidney on southern Vancouver Island.[559] The colony has been monitored ever since. *Photo by R. Wayne Campbell, Mandarte Island, BC, 10 July 1981.*

Nesting Surveys

Before province-wide surveys of nesting colonies in BC began in the 1970s, there was no standardized protocol to count surface-nesting species and estimate burrow-nesting seabirds. Methods used were personal decisions that varied greatly among observers. Consequently, trend information could only be derived for local colonies surveyed by the same individuals over many years. Some of those colonies with early trend information included: Christie Islet and Pam Rocks, repeatedly surveyed by the Vancouver Natural History Society; Mandarte (Bare) Island, surveyed by University of BC students (Figure 235); and Race Rocks, surveyed over several years by lightkeeper G.C. Odlum. Early survey work of course provided other valuable information (Figure 236).

Standardized techniques were adopted or developed for all species during the rigorous surveys conducted by CWS during the 1980s. This included line transects with quadrats for all major colonies of burrow-nesting species, adjusted counts from photographs for Common Murre, and repeated counts at periods of maximum attendance for Pigeon Guillemot. However, there are still a number of colonies and areas that have never been surveyed using standardized and repeatable methods, and for which reliable baseline population estimates are lacking.

For burrow-nesting species, rigorous surveys of some smaller storm-petrel and alcid colonies off the west coast of Graham Island and at the south end of Moresby Island still need to be conducted. Unlike other regions of the BC coast, only major colonies of burrow-nesting species were surveyed by CWS along the west coast of Graham Island.[482] Off the west coast of Graham Island, formerly extant storm-petrel colonies on "Lepas" Islet, Solide Islands, "Kiokathli" Islets, Barry Islet, and "Seal Point" Islet (Table 7), Cassin's Auklet colonies on "Lepas" Islet, Solide

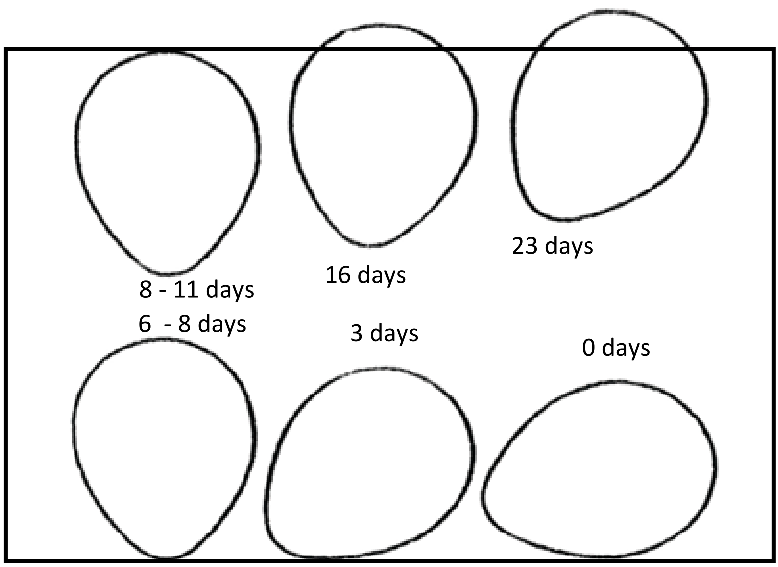


Figure 236. Value-added information can be obtained from visits to seabird colonies by using a "float test" to determine the stage of incubation. During incubation an egg loses weight through evaporation of water and gases. As the embryo develops into a chick an air pocket forms and the egg becomes more buoyant and floats. This old egg-collecting technique allows regional nesting chronologies to be developed for management recommendations, especially when determining time periods to minimize human disturbances. *From Campbell and Preston.*[122]

Islands, "Kiokathli" Islets, Barry Islet, and Marble Island (Table 15), and Ancient Murrelet (Table 14), Rhinoceros Auklet (Table 16) and Tufted Puffin colonies on Marble Island have not been visited since 1977. Colonies of storm-petrels on "Buck Channel" Island and Cassin's Auklets on "Between" Islet off the west coast of Moresby Island, and several previously extirpated storm-petrel colonies on the west coast of Graham Island, including Queen, Ogilvie, and McKenzie islands, also have not been inspected since 1977. Surveys of Ancient Murrelets and Rhinoceros Auklets on Kunghit Island were not completed with line transects during the 1980s due to lack of time.[480] Ancient Murrelet colony areas were later surveyed but surveys of some Rhinoceros Auklet colony areas there still have not been completed.[298] Tufted Puffin nesting areas at Lyman Point on Kunghit Island, and on St. James and Kerouard islands also require rigorous surveys using replicable methods.

Although total numbers of storm-petrel burrows were reliably estimated using line transects or partial counts, the proportions of Fork-tailed and Leach`s storm-petrels at 17 colonies on the east and west coasts of Moresby Island were not determined during the CWS 1980s surveys because surveys occurred before all Leach's Storm-Petrels were present. Proportions of the two species need to be assessed at the appropriate time of year (June-July) to complete baseline population estimates. Colonies where estimates of the proportion of the two species are needed include Instructor, Lihou, Luxmoore, and Rogers islands off the west coast of Moresby Island, and Rainy, Charles, Langtry, Bolkus, Skincuttle, Howay, Hotspring, Agglomerate, Kawas, Tar, Lost, Reef, and Low islands along the east coast of Moresby Island (Table 7).

At a regional scale, in-depth surveys for Pigeon Guillemots have been conducted only in Skidegate Inlet.[599] Similar repeated morning counts at all colonies are needed to provide reliable population estimates in all other coastal regions.

Population estimates and trends for Pelagic Cormorants are difficult to interpret because the species uses many nesting sites intermittently and numbers of birds nesting at particular sites can vary considerably.[172, 487] Provincial estimates, current to 1990, are based on a conglomerate of survey data from different years in different regions of the coast. Concurrent, province-wide surveys of cormorant colonies would provide better estimates of total breeding populations and, if repeated, would allow more robust determination of trends.

Since 1990, some recent surveys of Glaucous-winged Gulls and Black Oystercatchers have used different definitions for active nests and have counted only nests with eggs or young (see Survey Methods and Species Accounts). This makes comparisons with other counts that include empty nests problematical. For future surveys, we recommend that all nests be recorded and numbers of empty nests specified. For Black Oystercatcher, empty nest scrapes that are close together and appear to represent only one breeding territory should be noted.

Population Monitoring

Population surveys have provided reliable, baseline population data that are prerequisite to the conservation of breeding seabirds in BC. However, it is vital that changes in populations can be monitored on an ongoing basis so that impacts to those populations can be detected and appropriate management priorities can be identified. The most reliable method to monitor population changes would be to repeat rigorous surveys of the entire coast at regular intervals. However, approximately 10 years was required to complete baseline surveys for all seabird species breeding in BC. Repeating those surveys at regular intervals is impractical given the management resources available to federal and provincial wildlife agencies. Thus, practical surrogate methods for monitoring population changes need to be designed and instituted.

A monitoring program for burrow-nesting species (Figure 237) was designed and implemented during the CWS surveys in the 1980s.[478] Permanent monitoring plots were established on select colonies [476, 477, 480, 481, 484] and have been resurveyed at regular intervals since. Comparing trends in burrow density estimates from repeated transect surveys to those in permanent plots revealed that permanent plots can serve as reliable indicators of population change on the colonies being monitored.[478] Indicated trends likely can be extrapolated to overall populations if factors influencing populations are general at regional scales. However, local impacts to populations at unmonitored colonies could not be detected and the permanent monitoring program by itself failed to reveal major population declines at specific colonies impacted by Northern Raccoons. Thus, additional surveillance of at-risk colonies is required.

Permanent plots were not established in the 1980s on all recommended colonies. Recently, plots were established for Ancient Murrelets and Cassin's Auklets on Frederick Island,[649] but plots are still recommended for major Ancient Murrelet and Cassin's Auklet colonies on Hippa and Langara islands off the west coast of Graham Island, and on Cassin's and Rhinoceros auklet colonies on Byers and perhaps Moore islands off the central mainland coast.[478] Increasing the number of plots to monitor Rhinoceros Auklets on Lucy Islands is also recommended. Permanent plots are generally surveyed at 5-year intervals but monitoring on an annual basis on at least one colony would help to evaluate the effectiveness and sensitivity of the program.

Figure 237. We have stewardship responsibility in BC for about half of the world's population of Rhinoceros Auklets and it is important to monitor their breeding population and distribution on an on-going basis. *Photo by R. Wayne Campbell, Lucy Island, BC, 8 June 1970.*

Other components of a monitoring scheme for burrow-nesting species should include additional transect surveys of selected colonies to further validate that trends in permanent plots indicate population trends,[478] scheduled visits to colonies potentially impacted by introduced predators, and annual monitoring of breeding effort and productivity, including chick growth and diet for select species.[31, 592] Techniques for monitoring burrow occupancy rates without causing desertion should be explored for colonies in BC, especially for Ancient Murrelets, which cannot be monitored during the nestling period, and Tufted Puffins which are diurnal on their nesting colonies and thus vulnerable to disturbance during the day.[273, 448]

As with burrow-nesting species, the most reliable method to monitor population changes for surface-nesting species would be to repeat surveys of all colonies in BC. As discussed above, this may be the only means to obtain accurate trend information for cormorant species. More practically, surface-nesting species should be monitored by complete resurveys of the largest colonies in each coastal region. However, there is currently no province-wide program in place to conduct such surveys at regular intervals in BC. Various groups are conducting some monitoring of local colonies, including Parks Canada in Gwaii Haanas and Pacific Rim National Park reserves, Laskeek Bay Conservation Society in the Laskeek Bay area, the Centre for Wildlife Ecology at Simon Fraser University on Triangle Island, and the Mitlenatch Island Stewardship Team in association with BC Parks on Mitlenatch Island. The Biodiversity Centre for Wildlife Studies has been surveying surface-nesting species in the southern Strait of Georgia and Haro Strait since 2004. Their objectives have been to compare nest counts conducted from the water to those conducted on land. In addition, some repeat surveys of cormorant colonies on the east and west coasts of Vancouver Island have been conducted by Trudy Chatwin of the BC Ministry of Environment with the assistance of the late Harry Carter, and a variety of surveys have been conducted by students engaged in graduate studies at a number of universities.

There is a need to broaden the scope of these efforts, to coordinate surveys at a provincial scale, and to collate data in a central repository. CWS is the logical agency to coordinate and elaborate these efforts and to integrate them into a formal, province-wide monitoring scheme for surface-nesting species.

Preserving Seabird Colony Information in Perpetuity

The availability of information is important for scientific progress. In the environmental sciences, access to historical data is essential for identifying, understanding, and managing the rapid anthropogenic changes that are transforming the biosphere of planet Earth. Today, the problems associated with archiving and accessing the massive amounts of data generated by scientific research are staggering.[362] Digital storage is rapidly becoming the prevalent means to archive data but it is plagued with inherent pitfalls that can limit the functional longevity of such data to a few decades or less. In addition, there is a tendency for other forms of data to be lost over time. Although written records can be scanned and transformed into digital data, there is an overall trend by most public and private agencies to discard written documents, especially in the form of in-house reports, notebooks, and field data sheets. Information contained in such unpublished documents may represent a lifetime of work by scientists or naturalists, and may constitute the only existing insights into historical conditions. Adequate measures to prevent the loss of such data are needed. Making these data accessible is equally important. We recommend means to preserve, store, and make available historical data on breeding seabirds and other wildlife in BC. The following recommendations are intended to complement data collection and management programs by government and non-government agencies and private individuals. These recommendations would facilitate use by all parties with interests in wildlife.

Digital storage. Digital storage of data has many advantages if it is properly archived and updated so that it remains accessible. Data can be quickly found and distributed and storage requires minimal space. However, the effective longevity and accessibility of digital data tends to be short-lived.[606] Rapid advances in computer technology quickly outdate hardware and software used to archive data. New hardware and software are generally not compatible with preceding systems and as a result data can quickly become inaccessible unless they are continually transferred into new storage media and translated into current programs as they develop.[362] Changes in computer programs can change the way data are encrypted, and recovering data may therefore require a painstaking process of unravelling revised computer codes.[491] As noted in the Preface, recovering the initial draft portions of this book, which were prepared in the 1980s and saved on 5.25-inch computer floppy discs, was problematic and highlighted the inadequacies of digital storage for preserving information (see Figure 6, page 16). It took Michael several months to decipher the encryptions (Figure 238).

Figure 238. It was a challenging task, lasting several months, for Michael Rodway to recover files that had been stored on floppy discs in the 1980s and to correct the corrupted text so that it could be used for this catalogue. Today (2017) Michael backs up his files on thumb-sized USB flash drives, one of which holds hundreds of times as much data as all the boxes of floppy discs shown in this photo. It is unknown whether USB flash drives will still be accessible 30 years from now. *Photo by Heidi M. Regehr.*

Clearly, unless files are regularly translated into new versions of word processing or spreadsheet programs, and transferred to new storage media whenever it changes, digital storage is not a long-term solution for archiving seabird or other wildlife information. Preserving hard copies of data provides a more secure back-up and is recommended as a complement to digital storage. However, there are also concerns with the longevity of paper documents. Paper produced from wood pulp with high acidic lignin content deteriorates rapidly and, for documents printed with laser printers, the adhesion to the paper and the stability of the print is relatively short-lived.[362] Stored documents intended to last for future generations need to be printed on acid-free paper using more permanent inks. We thus recommend preservation of both digital copies and original documents, and further recommend that they are saved in a single repository to facilitate data organization, interpretation, and accessibility. Frequently updated, digital back-up copies should be stored in a second location to insure against unforeseen loss.

Preserving and accessing hard-copy data. There are several actions that can be taken to preserve written and printed seabird data and make them available to interested parties. An important initial step is to ensure that data are interpreted by those that collect them and summarized in formats such as in-house reports or peer-reviewed publications that are useable by others. Raw data and field notes should still be preserved because publications rarely contain complete data sets and notes that may be helpful to future researchers.

One of the main obstacles to the use of historical data in the conservation of seabirds and other wildlife in BC is that original field notes (Figure 239) and unpublished reports produced by researchers, students, collectors, photographers, environmentalists, wildlife consultants, and naturalists remain widely scattered and are not centralized and available for public reference. A major deterrent to updating seabird population estimates in this catalogue was that since 1990 data have been gathered by an increasingly diverse group of individuals and organizations and often are not easily available or are unknown to others. This obstacle could be overcome if researchers would be willing to contribute their data to a single repository dedicated to preserving and archiving biological information in the province.

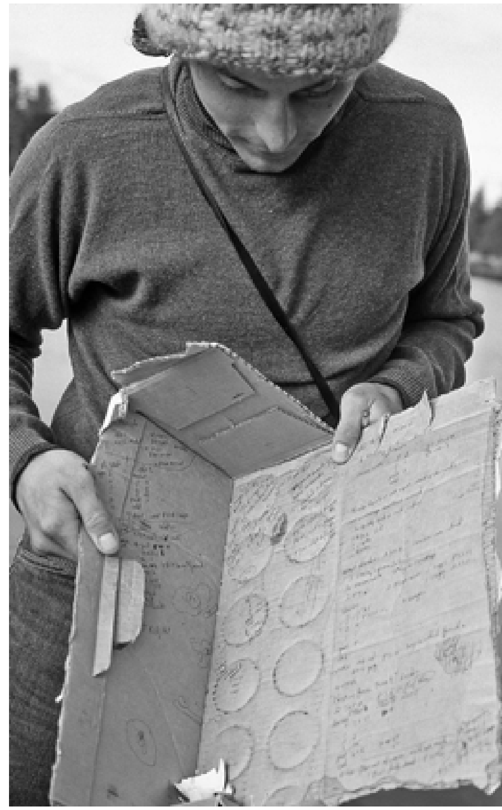


Figure 239. Original field notes are irreplaceable and cannot be duplicated if lost. Occasionally during seabird surveys, when notebooks were filled, or became very wet, results were recorded on alternate materials. Here, Harry Carter is innovating and recording his observations on cardboard boxes. He later transferred his field data to dry notebooks. *Photo by R. Wayne Campbell, Moore Islands, BC, 26 June 1976.*

A wildlife data repository for BC. In 2004, Wayne Campbell and his wife Eileen founded the Biodiversity Centre for Wildlife Studies (BCFWS), a non-profit society that fills a unique niche in the preservation of wildlife information in BC. Today the society has several hundred members. In 2017, Ron Jakimchuk created the Ronald D. Jakimchuk Foundation for Wildlife and Biodiversity Research, which established a trust fund administered by the

Victoria Foundation to ensure that the BCFWS has the funding to continue to fulfill its objectives. An important part of the mandate of the BCFWS is to preserve and archive diaries, field notebooks, raw research data, unpublished government and wildlife consultant reports, and rare and unavailable literature. Distribution and breeding records of seabirds and other wildlife are extracted from these sources, and documents which have been digitized are made available online. A permanent storage facility staffed by a knowledgeable archivist is planned. Monetary contributions to support this ongoing work can be made to the trust fund via the Victoria Foundation.

Wayne began salvaging valuable records that were in danger of being lost in the early 1970s when he obtained the diaries of Martin W. Holdom (Crescent Beach and Surrey) and Theodore and Beatrice Thacker (Hope). Over the following 32 years, another 24 data collections were saved. Today, field diaries, notebooks, original field data, and research notes dating back to 1919 have been obtained from 107 individuals. On a shelf, records from individuals occupy from a few centimetres of space to over 13 m (44 linear feet), as required for those from the late Glenn Ryder.[117] The BCFWS collection currently contains an estimated six to seven million occurrence and breeding records for birds. Also included are tens of thousands of records for amphibians, reptiles, and mammals.

The importance of these historical collections cannot be overstated.[128] Since 2004, 69 articles have been published in *Wildlife Afield*, the peer-reviewed natural history journal of the BCFWS, using these 107 historical collections. All provide significant new information for BC, and for a few species, North America.[110] Some topics included first provincial records,[113] extirpation of resident species,[125] important changes in distribution,[494] earliest provincial occurrences,[126] new (and only) breeding records,[147] changes in migration corridors,[114] new food habits,[124] BC as a haven for irruptive species [123] (Figure 240), and changes in arrival and departure dates related to climate change.[145] Hidden away in the notebooks of Glenn Ryder was an entry documenting the first discovered Marbled Murrelet nest in the world [495] (see Figure 135). That observation was made almost 20 years before any other nest was known.

Figure 240. Snowy Owl is reported annually in BC and on the coast it is a major predator of waterbirds, including seabirds, especially during years of prey shortage in the Arctic when irruptions to the south occur, which happen on average every 9.75 years. The updated account on Snowy Owls in 2009 [123] was based on 25,749 records from BCFWS collections, over 12 times as many as the number of records used 20 years earlier in the species account published in *The Birds of British Columbia*.[137] *Photo by Ervio Sian.*

The archiving and availability of historical data are also essential for detecting population trends and distributional changes. For example, while there is current local concern across southern BC that Common Nighthawk is declining as a breeding species, 120 years of documented records suggest that the breeding population may not have declined but rather has shifted northward, starting in the 1960s, likely due to loss of nesting habitat from urbanization (especially Greater Vancouver and Victoria) and climate change.[141]

Government biologists and wildlife consultants often must make management recommendations quickly and are unable to invest the time necessary to gather baseline historical information in a planned way. Recommendations may then be based on incomplete information and therefore may be inappropriate. Better understanding of species distribution and abundance through uncovering historical records can conserve government resources and allow allocation of funding and manpower to more important issues.[129] Canada Warbler is a classic example.[143] At the time that *The Birds of British Columbia* [138] was published, the species account for Canada Warbler was written using 127 occurrence and five breeding records. In 2007, after historical diaries and field notebooks were gleaned for records, an updated account [143] was published using 9,087 occurrence and 34 breeding records, which represent increases of over 7,000% and nearly 600%, respectively. Additional historical data had revealed that what was thought to be a peripheral species was in fact widely, though unevenly distributed throughout the entire northeastern portion of the province. The updated account diverted scarce government funding and resources to other projects.

Research data collected by biologists and technicians are often lost when personnel retire. We recommend a policy in all government agencies involved in managing wildlife to preserve those kinds of data by contributing them to the BCFWS. As well, university professors, their students, and wildlife consultants would make valuable contributions to future studies and management of wildlife if they made their data available to the BCFWS after studies are completed. The value of preserving original field notebooks of deceased naturalists should also be communicated as many spouses and siblings are not fully aware of the genuine historical value of the observations they contain. It is encouraging that some active naturalists and birders realize the importance of their observations and copy field notes and store them safely outside their homes. For example, naturalist Chris Siddle follows that practice and others, including Ted Hillary, Gary S. Davidson, Mark Hobson, and Errol Anderson regularly submit their field notes to the BCFWS.

We also encourage the submission to the BCFWS by government and private agencies of electronic versions of in-house reports that are not available online and thus typically have limited distributions. The BCFWS can easily post these so that they are readily accessible online. For example, all the CWS technical reports that summarize the results of seabird colony surveys in the 1980s are currently not available online, although they are accessible by request. We encourage CWS and other agencies to either provide a searchable online link to these types of documents or to release pdf versions of these reports to the BCFWS so that they can make them accessible online.

Extracting useable data from diaries and notebooks contributed to the BCFWS is a laborious process. While there were far fewer records for seabirds than for terrestrial birds, the historical field notes of collectors, bird-banders, and naturalists contributed greatly to this publication. After *A Catalogue of British Columbia Sea-bird Colonies* [213] was published in 1961, Charles Guiguet continued documenting observations of seabirds until he retired in 1980. His post-1961 field notes, copies of which are in the BCFWS library, were used extensively in this updated catalogue and other articles.[170] Often his original field notes were later typed for easy reading. The following is a sample of excerpts from summary notes of a trip to Seabird Rocks (Pachena Bay, Vancouver Island) by Charles Guiguet and Bristol Foster on 12 June 1970. Inserted check marks indicate records that have been extracted and transferred to BC Nest Record cards and the provincial seabird colony file in the BCFWS.

> *Headed for Sea Bird Rocks off Pachena Bay-- arrived after an hours run from Wower* [Island]*...Arrived in large swells at Seabird* [Rocks]*--Bristol dropped me off--about 1000 g.w. gulls on the island--nesting, most with 3 eggs--some 1, one with four--didn't count the nests but guesstimate 500+ or so pairs of glaucous wings here.* [√] *Pigeon Guillemots nesting--70-80 birds counted, nesting in heavy beach debris--nest with eggs—did not collect.*[√] *A dozen tufted puffins circling island--another dozen or so scattered over the adjacent sea--excavated 1 burrow, egg. Maybe fresh or addled--it gurgles.* [√] *Excavated*

two rhino auklet [Rhinoceros Auklet] side by side in area that could harbour a fair sized colony--more than 40 birds seen between here and Cape Beal--eggs of this species contained fully formed embryo (accidentally broken in boat). [√]

In a very few minutes excavated both boreal [Leach's] *and fork tailed petrels--collected the one adult of each and the downy fork-tailed for the records--did not disturb colony further.* [√] *Boreal petrels are on fresh eggs—one broken accidentally in boat. Black oystercatchers are on eggs...Probably 70-100 oyster catchers here--some in flocks are obviously not breeding.* [√] *Found no sign of cassin auklet or ancient murrelet.* [√]

Extracting this kind of information from historical documents is not something that most public- or private-sector biologists have the time or budget to accomplish. A non-governmental, independently-funded organization like the BCFWS can provide a valuable service to the scientific community by preserving historical documents and extracting valuable records that can then be used by other researchers and wildlife managers. We encourage collaboration with BCFWS by all public and private agencies involved in collecting and managing seabird and other wildlife data so that historical information is not lost. Unfortunately, government agencies and universities in BC and elsewhere have neither the space nor the mandate to preserve such historical records. The BCFWS is the only organization in BC that attempts to serve as a central repository for the conservation of these kinds of wildlife data.

The BCFWS has received historical books and unpublished reports being cleared from the libraries of a number of organizations, including BC Hydro (via Robert M. Bradley), Canfor (via John Deal), and Renewable Resources Consulting Services Ltd. (via Ron Jakimchuk). Although the BCFWS currently operates on funding from members and donors, their ability to process the increasing volume of historical wildlife data that exist would likely depend on additional funding contributions by users. Now that many of the BCFWS collections are better organized there is an increase in use by students, professors, wildlife consultants, and authors. The most current example is the recently completed manuscript by Adrian Dorst *Birds of Vancouver Island's West Coast* being published by UBC Press. The BCFWS's library, nest record scheme, and seabird colony files were used extensively in that publication.

The interpreted trends and historical impacts to breeding seabird populations in BC presented in this catalogue are a testament to the importance of preserving historical data and the valuable service that the BCFWS can provide. Fifty-five years in the making, the present catalogue brings together published and unpublished information on 16 species of seabirds breeding in BC through 1990. Most records used prior to the CWS surveys of the 1980s were compiled from BCFWS files. Over 450 individuals contributed to this project (Figure 241).

Figure 241. As expected, most contributed records summarized in this catalogue were for Glaucous-winged Gull, partly due to their widespread distribution, and partly because researchers and naturalists have made frequent visits to colonies during banding programs. Although the species accounts for only about one percent of the total seabird breeding population in BC, it nests on 61% of the 542 seabird nesting sites documented in the province. *Photo by Alan D. Wilson.*

ACKNOWLEDGEMENTS

Early records of nesting seabirds in BC were made by light keepers, naturalists, private egg collectors, and museum collectors, most of whom have been mentioned in the text and cited in the references. Most of those early workers were acknowledged in the first catalogue of seabird colonies by Rudolf H. Drent and Charles J. Guiguet.[213] Since that publication, numerous other people have participated in or otherwise contributed to surveys of seabird colonies in BC. Many of those people have been associated with various programs funded and organized primarily by the Royal British Columbia Museum, Canadian Wildlife Service, Parks Canada, and the British Columbia Ministry of Environment. Some individuals are known through various publications, but many remain unrecognized. We thank them all and apologize to any we may have overlooked.

The hundreds of individuals known to the authors who have made contributions to this catalogue include: Jane Algard, Mauricio Alvarez, J.O. Anvik, T.M. Anderson, G.G. Anweiler, Art Babcock, Bob Baker, John T. Ballard, Alistair Bell, Allister Bell, Desmond E.J. Belton, Dennis Belton, Douglas F. Bertram, Robin C. Best, James Biggar, Ray R. Billings, Daniel S. Bingham, Mike Biro, John Blades, Stephanie Blades, Donald A. Blood, A. Boerma, Lynne Bonner, Valerie Brown, Andrè M. Breault, Shelagh Bucknell, Frank Buffam, Alan E. Burger, Clyde H. Burton (Figure 242), David Bustard, Bruce Butler, Robert W. Butler, Sharon Butler, Lola Caldwell, Barb Campbell, Barry Campbell, Eileen C. Campbell, D. D. Sean Campbell, Tessa N. Campbell, Richard J. Cannings, G. Clifford Carl, Brian Carter (Figure 243), Harold "Doc" Carter, Harry R. Carter, Alice L.E.V. Cassidy, John R. Cassie, Sharon Chapman, Trudy A. Chatwin (Figure 244), Rosalind Chaundy, William (Bill) Chudyk, Myke J. Chutter, Gwen Colby, Marie-Aude Coleman, Allegra Collister, John Comer, John M. Cooper, G.E. Corley-Smith, M. Elizabeth Courtnall, Scott Crawford, Leo Cullen, James Currie, James T. Cuthbert, Mark K. Daly, Albert R. Davidson, Gary S. Davidson, Brian Davies, Dave Davies, Gregory Dawe, Kevin Devito, Wayne Diakow, Laurel Dick, Ron Diederichs, Adrian

Figure 242. Many of the seabird colonies off Powell River, especially Vivian Island, have been surveyed by Clyde Burton. *Photo by R. Wayne Campbell, Powell River, BC, 23 February 2007.*

Figure 243 Brian Carter, as a university student, participated in CWS seabird surveys along the northern mainland coast, in Queen Charlotte Strait, on the Scott Islands, and along the west coast of Vancouver Island from 1986 to 1989. *Photo by Michael S. Rodway, Solander Island, BC, 28 May 1989.*

Figure 244. Trudy Chatwin (formerly Carson) investigating an Ancient Murrelet burrow on Frederick Island in 1980. *Photo by Moira J.F. Lemon.*

Figure 245. Don Garnier, a student at the University of Victoria, participated in CWS coastal colony surveys in 1985, 1986 and 1988. *Photo by Michael S. Rodway, Green Rock, BC, 19 June 1986.*

Dorst, Jan J. Drent, Nel Drent, Rudolph H. Drent, Ian Dube, David Duncan, Michael Easton, Barry Edwards, Willy Egeland, Andrew Eisenhauer, David W. Ellis, Bob Emory, Simon Emms, G. Erasmus, J. Erasmus, Peter Ewins, Brent Fair, Robert G. Foottit, Michael Force, Bruce S. Ford, Barry Forer, J. Bristol Foster, Eric Foster, Victor Foster, June Franklin, R. Franklin, Douglas P. Fraser, Gwen Fraser, Lisa Fraser, D. Lorne Frost, Kim Gage, Susan Garnham, Donald Garnier (Figure 245), Heather M. Garrioch, Anthony (Tony) J. Gaston (see Figure 39), Penny Gee, Chris George, C. Gibbs, Richard E. Gibbs, Janet Gifford, Laura Giliberti, Ed Good, Janine Goodall, J.E. Victor Goodwill, Wynne Gorman, Fred Gornall, Douglas M. Goudie, Louise Goulet, Al Grass, Craig Greenwood, Lauri Greenwood, Mark Griffin, Dick Grinnell, Matthew Grinnell, Sarah Groves, Charles J. Guiguet, Susan Guiguet, Shannon Hackett, Patty Haist, David Hancock, Lyn Hancock, F. Gordon Hart, E.H. Hart, Earl Hartwick, David F. Hatler, Marietta Hatler, Ian Hatter, David M. Hawes, Myrnal A.L. Hawes, Al Hawryzki, Robert (Bob) B. Hay, Heather Hay, Bill Hays, Kathleen Heise, Kent Henderson, Denise Herlinveaux, Hilde Hesse, Werner H. Hesse (Figure 246), George Hillier, Nancy Hillis, Rick J. Hoar, Keith Hobson, M. Hodgson, Norman Holmes, Tracey D. Hooper, Dennis Horwood, Jim Hudnal, Stuart Johnston, Ian Jones (Figure 247), Kerry R. Joy, Lynn Joy, Gary W. Kaiser, Ken Kennedy, Ethel Kippin, John Kirbyson, Richard Kool, Ann Lancaster, Lin Langley, Andrea Lawrence, Debby LeBrocq, Martin C. Lee, Ewald Lemke, Eric C. Lofroth, Linda J. Loftus, John MacDonald, N.T. MacDonald, Douglas MacKay, David A. Manuwal, Murray Mark, Phyllis Mark, Peter Marshall, Donald Maxwell, Ian McGregor, Lorne D. McIntosh, William E. McIntyre, Neil McLean, George M. McKay, Michael McKay, Faye McNall, Michael C.E. McNall, William J. Merilees, Arthur L. Meugens, Alex Mills, Lynne Milnes, Colleen Moore, Keith Moore, Ken H. Morgan, Mary C. Morris, Alexander Muir, Margaret Muir, Sara Neely, Marilyn Nelson, R. Wayne Nelson, Megan Niven, David Noble, Willa Noble, Phil R. Nott, Mark Nyhof, Emily Oguss, R. Frank Oldaker, E. Orsmby, Steve Parcells, Colin Partridge, N. Patton, Marilyn A. Paul, Betty-Lou Peers, Ron Pilkey, Eleanor Perkins, Dick Pillsbury, David Powell, Damian Power, G. Allen

Figure 246. The late Werner Hesse provided observations of nesting seabirds during banding trips in the Greater Vancouver area in the late 1960s and early 1970s and especially during infrequent trips to Mandarte Island with Rudolph Drent and later Peter Arcese. His original field notes, estimated to contain 265,000 records, are in the BCFWS library. *Photo by R. Wayne Campbell, Metchosin, BC, 26 September 2008.*

Figure 247. Ian Jones assisted with surveys on Triangle Island in 1984 and completed his M.Sc. on Ancient Murrelets on Reef Island in association with Tony Gaston. He went on to study auklets in Alaska for his Ph.D. thesis and is now an internationally recognized seabird ecologist and a professor at Memorial University of Newfoundland. *Photo by Michael S. Rodway, Triangle Island, BC, July 1984.*

Poynter, Margaret Purdy, Leo J. Rankine, Jeff Reeve, Tom E. Reimchen, Al Reimer, Heidi M. Regehr, Laszlo I. Retfalvi, Randy Reusch, Donald Richards, Kathy Richards, William E. Ricker, Richard A. Ring, Robert Risebrough, Phyllida Riseborough, Syd Roberts, Ian Robertson, Terrance Robertson, Tony Robichaud, Christine M. Rodway, Donald F. Rodway, Joy Ann Rodway, Robert L. Russell, Glenn R. Ryder, Frank Sanford, Jean-Pierre L. Savard, W. Jack Schick, Zella M. Schultz, Spencer G. Sealy, Gary Seedhouse, Michael G. Shepard, Teresa Shepard, Christopher D. Shepard, George P. Sirk, Lauren Sirk, Vivian Skinner, Ian D. Smith, W.J. (Kay) Smith, James N.M. Smith, G.E. John Smith, Andy Snyder, Margaret (Peggy) J. Sowden, David A.E. Spalding, D.B. Sparling, M. Sparling, Helen Stephen, Jamie A. Stephen, Andrew C. Stewart, E. Anne Stewart (Figure 248), Geoff E. Stewart, David Stirling, Terry Sullivan, Gail Summers, Kenneth R. Summers, Douglas Swanston, Keith G. Taylor, M. Elizabeth Taylor, Howard A. Telosky, Terry W. Thormin, Diana Thompson, David Thomson, John Toochin, Neil S. Trenholme, Yves

Figure 248. The Provincial Museum, with help from BC Ecological Reserves, hired summer students, mostly from the University of Victoria, for help with seabird colony surveys in the 1970s. In this photo Anne Stewart is checking the contents of burrows in a quadrat on Hippa Island, BC. *Photo by R. Wayne Campbell, 21 July 1977.*

Turcotte, Douglas Turnbull, Anne Vallée, Gerard F. Van Tets, Nicholaas A.M. Verbeek, William Verbrugge, Kees Vermeer, Anita Vincente, Mary Wainwright, John G. Ward, G. Ross Waters, Scott Webb, Ken White, Alan Whitney, Irene Whitney, Andrew Whittaker, Thomas Widdowson, Douglas J. Wilson, Rory Wilson, Michael Wolfe, David Woolgar, Robert Wright, Gwen W. Wright, Richard T. Wright, Dave Younger, and Ian Yule.

We thank Dr. Harold Carter (Figure 249), owner and skipper of our mothership *Ted Mac* during the BCPM surveys, and Art Babcock on the *Bajo Point* and the captains and crews of numerous Canadian Coast Guard and Department of Fisheries and Oceans vessels and aircraft that assisted with transportation of CWS field crews and supplies over the years. We also thank helicopter pilots and support staff at Vancouver Island Helicopters who helped provide transport and were concerned for our wellbeing on Triangle Island. Our work in the Queen Charlotte Islands was greatly assisted by Keith Moore (Figure 250) and Rick Hoar of British Columbia Fish and Wildlife Branch. In 1986, Keith Moore was our potential saviour and the only warning we had of the possible tsunami that could have spelled the demise of the entire survey crew in Englefield Bay had it materialized.

Figure 249. The late Dr. Harold Carter, an orthopaedic surgeon in Victoria, BC, bought the *Ted Mac* to serve as a "mothership" and place of dry respite during seabird surveys along the BC coast in the 1970s. "Doc" Carter also did a lot of the cooking, boat maintenance, and assured sleeping bags were dry and aired. *Photo by R. Wayne Campbell, Moore Islands, BC, 25 June 1976.*

Figure 250. Keith Moore, a forestry consultant and resident of the Queen Charlotte Islands is involved in forestry and environmental issues in BC. He is a founding director of the Laskeek Bay Conservation Society and participated in seabird surveys on the Queen Charlotte Islands. *Photo by Michael S. Rodway, Willie Island, BC, 18 May 1986.*

Between 1975 and 1979, inventories of colonial nesting seabirds in BC were sponsored and financed in part by the BCPM and directed by Wayne Campbell. CWS directed and funded the seabird inventory program from 1980 to 1990. We thank Kees Vermeer and Gary Kaiser of CWS who, in their turn, have supervised that program. Thanks also to G.E. John Smith, Jean-Pierre Savard, and Tony Gaston for many years of technical and statistical advice at CWS. Thanks to Rob Butler, Tony Gaston, Heidi Regehr (Figure 251), Jean-Pierre Savard, and Steve Wetmore for making helpful comments at various stages in the preparation of the original document. Moira Lemon prepared the figures. Many thanks to Ken Morgan for helping to interpret data from his surveys along the west coast of Vancouver Island in 1989 and in Skidegate Inlet in 1990.

Figure 251. Heidi Regehr assisted with seabird surveys on Triangle Island in 2009 and provided sage advice and valuable editorial input into this manuscript as it evolved. *Photo by Michael S. Rodway, Triangle Island, BC, June 2009.*

Figure 252. Mark Hobson is a veteran naturalist and internationally recognized artist whose paintings have captured the essence of wildlife and landscapes of coastal BC for over 30 years. He is a passionate supporter of conservation and environmental activities in the province, including wildlife festivals and efforts to protect habitats. His delightful field notebooks, replete with sketches, have been entrusted to the collections of the Biodiversity Centre for Wildlife Studies. *Photo by Chris Pouget.*

Figure 253. For 50 years Eileen Campbell has been a volunteer supporter of preserving and organizing wildlife information in British Columbia. Her first project, in 1968, was transferring Martin W. Holdom's field notes into chronological species files for quick access for the four-volume *The Birds of British Columbia* project. The organized notes now occupy 56 cm (22 inches) of shelf space and provide the only early counts and trends for species like Brant in the Lower Mainland. Her latest project, that lasted 2½ years, was reorganizing species files into chronological order for 900,000 breeding records in the BC Nest Record Scheme. *Photo by R. Wayne Campbell, Victoria, BC, September, 2012.*

We are very grateful to wildlife and landscape artist Mark Hobson (Coastline Art Inc.; art@markhobson.com; Figure 252), who enthusiastically donated his pieces of coastal artwork despite being overwhelmed with many commissions that had spring deadlines. Head drawings that decorate the species accounts were done by artists Keith Taylor (most species) and Mark Nyhof (Black Oystercatcher and Thick-billed Murre).

Most photographs are by the authors and took months to sort and categorize. Eileen Campbell (Figure 253) helped immensely with this task by identifying hundreds of photos to specific island locations and filing them in the master seabird colony file for BC housed by the BCFWS in Victoria. Others sprinkled throughout the book, especially from Jared Hobbs (cover) and Alan D. Wilson, are acknowledged in each caption.

Reviewing this article was not easy as it dealt with so many seabird species, different breeding sites, and related references and studies for BC and the Pacific Northwest. We are very grateful to Dennis A. Demarchi, Patricia Huet, and Spencer G. Sealy for their knowledgeable comments and astute recommendations to make the manuscript more readable. Special commendation goes to Mark Nyhof (Figure 254) for the laborious and superlative job of laying out text and numerous tables, maps, and photographs to transform the manuscript into a polished published document.

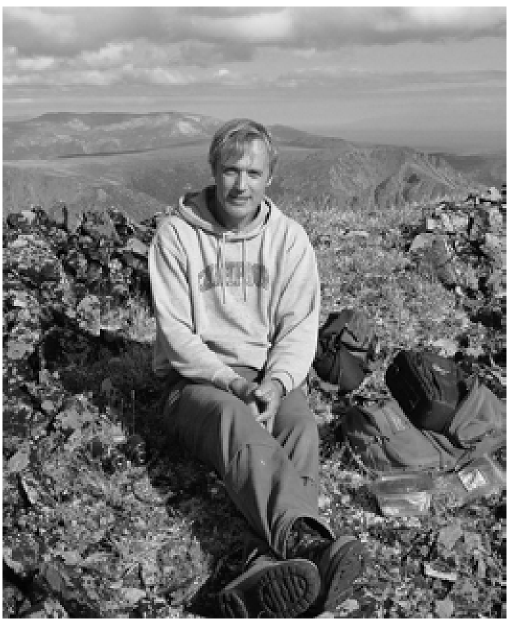


Figure 254. Mark Nyhof – wildlife artist, exemplary nest finder, experienced field naturalist, wildlife consultant, and construction worker – has, in his spare time, prepared 13 issues of *Wildlife Afield* for publication since 2010. He is self -taught and picked up publishing skills from manuals and computer programs. *Photo by Rose Nyhof, Perkins Peak, BC, 7 September 2013.*

This special issue of *Wildlife Afield* was supported by the Ronald D. Jakimchuk Foundation for Wildlife and Biodiversity Research, administered by the Victoria Foundation (Figure 255), and personal contributions from Peter Blokker, Eileen Campbell, Cyril Colonel, Dennis Demarchi, Bryan Gates, Phil Henderson, Ted Hillary, Doug Leighton, Fred McMechan, Wayne Nelson, Sylvia and Keith Pincott, Robert Puls, Andrew Reynolds, Chris Siddle, Jim Sims, Tom Stevens, Mary Taitt, Howard Telosky, and John and Mary Theberge.

Figure 255. Ron Jakimchuk, a retired wildlife consultant and keen naturalist, established the Ronald D. Jakimchuk Foundation for Wildlife and Biodiversity Research with the Victoria Foundation to assure that the preservation of field notes, historical records, and unpublished reports concerning wildlife in BC were supported into the future. Ron has maintained a special interest in marshes since exploring them as a child on the Canadian prairies. *Photo by R. Wayne Campbell, "Airport Marsh", Douglas Lake, BC, June 2014.*

LITERATURE CITED

[1]Adams, J. 2008. Cassin's Auklet (*Ptychoramphus aleuticus*). Pages 205-212 in W.D. Shuford and T. Gardali (eds.). California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento, CA.

[2]Ainley, D.G., R.J. Boekelheide, S.H. Morrell, and C.S. Strong. 1990. Pigeon Guillemot. Pages 276-305 *in* D.G. Ainley and R.J. Boekelheide (eds.). Seabirds of the Farallon Islands. Stanford University Press, Stanford, CA.

[3]Ainley, D.G., H.R. Carter, D.W. Anderson, K.T. Briggs, M.C. Coulter, F. Cruz, J.B. Cruz, C.A.Vallée, S.I. Fefer, S.A. Hatch, E.A. Schreiber, R.W. Schreiber, and N.G. Smith. 1988. Effects of the 1982-83 El Niño-Southern Oscillation on Pacific Ocean bird populations. Proceedings of the International Ornithological Congress 19:1747-1758.

Figure 256. Population trends of Common Murres are difficult to assess due to daily and seasonal fluctuations in attendance patterns, annual variation in breeding effort in relation to oceanographic conditions, and the inaccessibility of many nesting sites. *Photo by R. Wayne Campbell, Triangle Island, BC, August 1974.*

[4]Ainley, D.G., D.N. Nettleship, H.R. Carter, and A.E. Storey. 2002. Common Murre (*Uria aalge*). *In* The Birds of North America, No. 666 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. 44 pp.

[5]Ainley, D.G., L.B. Spear, and S.G. Allen. 1996. Variation in the diet of Cassin's auklet reveals spatial, seasonal, and decadal occurrence patterns of euphausiids off California, USA. Marine Ecology Progress Series 137:1-10.

[6]Ainley, D.G., W.J. Sydeman, S.A. Hatch, and U.R. Wilson. 1994. Seabird trends along the west coast of North America: causes and extent of regional concordance. Studies in Avian Biology 15:119-133. [Figure 256]

[7]Ainley, D.G., W.J. Sydeman, and J. Norton. 1995. Upper trophic level predators indicate interannual negative and positive anomalies in the California Current food web. Marine Ecology Progress Series 118:69-79.

[8]Aitchison, N.W. 1972. The Pigeon Guillemot, *Cepphus columba*: breeding biology and brood size. B.Sc. thesis, University of British Columbia, Vancouver, BC. 25 pp.

[9]American Ornithologists' Union. 1957. Check-list of North American birds, 5th Edition. American Ornithologists' Union, The Lord Baltimore Press, Baltimore, MD. 691 pp.

[10]American Ornithologists' Union. 1998. Check-list of North American birds, 7th Edition. American Ornithologists' Union, Washington, D.C. 829 pp.

[11]Anderson, O.R.J., C.J. Small, J.P. Croxall, E.K. Dunn, B.J. Sullivan, O. Yates, and A. Black. 2011. Global seabird bycatch in longline fisheries. Endangered Species Research 14:91-106.

[12]Andres, B.A. and G.A. Falxa. 1995. Black Oystercatcher (*Haematopus bachmani*). *In* The Birds of North America, No. 155 (A. Poole and F. Gill eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC. 20 pp. [Figure 257]

Figure 257. This catalogue identifies nesting sites and estimates the breeding population of Black Oystercatchers in BC. Distribution and abundance of non-breeding birds, such as this juvenile in transition plumage, has not been addressed. *Photo by R. Wayne Campbell, Esquimalt Lagoon, BC, 3 August 2003.*

[13]Anker-Nilssen, T. and O.W. Røstad. 1993. Census and monitoring of Puffins *Fratercula arctica* on Røst, N Norway, 1979-1988. Ornis Scandinavica 24:1-9.

[14]Armstrong, I.H., J.C. Coulson, P. Hawkey, and M.J. Hudson. 1978. Further mass seabird deaths from paralytic shellfish poisoning. British Birds 71:58-68.

[15]Atkinson, I.A.E. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. Pages 35-81 *in* P.J. Moors (ed.). Conservation of island birds: case studies for the management of threatened island species. International Council for Bird Preservation, Technical Publication No. 3, Cambridge, UK.

[16]Avery-Gomm, S., P.D. O'Hara, L. Kleine, V. Bowes, L.K. Wilson, and K.L. Barry. 2012. Northern Fulmars as biological monitors of trends of plastic pollution in the eastern North Pacific. Marine Pollution Bulletin 64:1776-1781.

[17]Avery-Gomm, S., J.F. Provencher, K.H. Morgan, and D.F. Bertram. 2013. Plastic ingestion in marine-associated bird species from the eastern North Pacific. Marine Pollution Bulletin 72:257-259.

[18]Bailey, E.P. and G.H. Davenport. 1972. Die-off of Common Murres on the Alaska Peninsula and Unimak Island. Condor 74:215-218.

[19]Bakun, A., B.A. Black, S.J. Bograd, M. García-Reyes, A.J. Miller, R.R. Rykaczewski, and W.J. Sydeman. 2015. Anticipated effects of climate change on coastal upwelling ecosystems. Current Climate Change Reports 1:85-93.

[20]Balance, L. 2007. Understanding seabirds at sea: why and how? Marine Ornithology 35:127-135.

[21]Ballard, J.T. and R.A. Ring. 1979. The ectoparasites of some marine birds from Bamfield Marine Station, British Colombia, with particular reference to Common Murres, *Uria aalge* (Pont.). Canadian Journal of Zoology 57:1980-1984.

[22]Banner, A., W. Mackenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Land Management Handbook No. 26, Part 1. British Columbia Ministry of Forests, Research Branch, Victoria, BC. 280 pp.

[23]Barbraud, C. and G. Gélinaud. 2005. Estimating the sizes of large gull colonies taking into account nest detection probability. Waterbirds 28:53-60.

[24]Beebe, F.L. 1960. The marine peregrines of the northwest Pacific coast. Condor 62:145-189. [Figure 258]

[25]Beebe, F.L. 1969. The known status of the Peregrine Falcon in British Columbia. Pages 53-60 *in* J.J. Hickey (ed.). Peregrine Falcon populations: their biology and decline. University of Wisconsin Press, Madison, WI. 446 pp.

[26]Beissinger. S.R. 1995. Population trends of the Marbled Murrelet projected from demographic analyses. Pages 385-394 *in* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt (eds.) Ecology and conservation of the Marbled Murrelet. United States Deprtment of Agriculture, Forest Service, General Technical Report PSW-152, Albany, CA.

Figure 258. Frank Beebe, an illustrator at the BC Provincial Museum, accompanied Charles Guiguet on early seabird surveys to the Queen Charlotte Islands. He was a falconer and wrote several classic papers and books on coastal Peregrine Falcons. He was also an accomplished wood carver and frequently entered his pieces in local competitions. In this photo, Frank, 83 years old, is looking at his carving of an American Kestrel. Frank died on 15 November 2008 at 95 years old. *Photo by R. Wayne Campbell, Sidney, BC, 12 April 1996.*

[27]Bergström, S., P.D. Haemig, and B. Olsen. 1999. Increased mortality of Black-browed Albatross chicks at a colony heavily infested with the tick *Ixodes uriae.* International Journal for Parasitology 29:1359-1361.

[28]Bertazzon, S., P.D. O'Hara, O. Barrett, and N. Serra-Sogas. 2014. Geospatial analysis of oil discharges observed by the National Aerial Surveillance Program in the Canadian Pacific Ocean. Applied Geography 52:78-89.

[29]Bertram, D.F. 1989. The status of Ancient Murrelets breeding on Langara Island, British Columbia, in 1988. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 59, Delta, BC. 67 pp.

[30]Bertram, D.F. 1995. The roles of introduced rats and commercial fishing in the decline of Ancient Murrelets on Langara Island, British Columbia. Conservation Biology 9:865-872.

[31]Bertram, D.F. and G.W. Kaiser. 1988. Monitoring growth and diet of nestling Rhinoceros Auklets to gauge prey availability. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 48, Delta, BC. 45 pp. [Figure 259]

Figure 259. Doug Bertram, an enthusiastic student on CWS surveys, went on to complete a Master's degree on Rhinoceros Auklets and a Ph.D. on fishes, and is now a research biologist with Environment and Climate Change Canada. *Photo by Michael S. Rodway, Rankine Islands, BC, 5 June 1984.*

[32]Bertram, D.F. and D.W. Nagorsen. 1995. Introduced rats, *Rattus* spp., on the Queen Charlotte Islands: implications for seabird conservation. Canadian Field-Naturalist 109:6-10.

[33]Bertram, D.F., A. Harfenist, and B.D. Smith. 2005. Ocean climate and El Niño impacts on survival of Cassin's Auklets from upwelling and downwelling domains of British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 62:2841-2853.

[34]Bertram, D.F., G.W. Kaiser, and R.C. Ydenberg. 1991. Patterns in the provisioning and growth of nestling Rhinoceros Auklets. Auk 108:842-852.

[35]Bertram, D.F., D.L. Mackas, and S.M. McKinnell. 2001. The seasonal cycle revisited: Interannual variation and ecosystem consequences. Progress in Oceanography 49:283-307.

[36]Bibby, C.J., N.D. Burgess, D.A. Hill, and S.H. Mustoe. 2000. Bird census techniques (2nd ed.). Academic Press, London, UK. 302 pp.

[37]Binford, L.C., B.G. Elliott, and S.W. Singer. 1975. Discovery of a nest and the downy young of the Marbled Murrelet. Wilson Bulletin 87:303-319.

[38]Birkhead, T. 2012. Bird sense: What it's like to be a bird. Bloomsbury, London, UK. 265 pp.

[39]Birkhead, T.R. and D.N. Nettleship. 1980. Census methods for murres, *Uria* species: a unified approach. Canadian Wildlife Service Occasional Paper No. 43, Ottawa, ON. 25 pp. [Figure 260]

[42]Blight, L.K., J.L. Ryder, and D.F. Bertram. 1999. Predation on Rhinoceros Auklet eggs by a native population of *Peromyscus*. Condor 101:871-876.

[43]Blood, D.A. and G.G. Anweiler. 1984. Forest nesting habitat of Ancient Murrelets in the Queen Charlotte Islands. Pages 297-302 *in* W.R. Meehan, T.R. Merrell, Jr., and T.A. Hanley (eds.). Fish and wildlife relationships in old-growth forests; Proceedings of a Symposium, held in Juneau, Alaska, 12-15 April 1982. American Institute of Fishery Research Biologists.

[44]Blood, D.A., G.G. Anweiller, and M.J. Chutter. 1979. Survey of Ancient Murrelet colony at Dodge Point, Lyell Island, May 1979. Donald A. Blood & Associates unpublished report, Lantzville, BC. 29 pp. [Figure 261]

Figure 260. Using standardized census methods is essential to provide comparative quantitative data for breeding seabird species like Common Murres in BC. *Photo by R. Wayne Campbell, August 1974.*

Figure 261. Susanne Guiguet participated in the BCPM surveys in the mid-1970s. Here she is helping establish a plot to determine occupancy of Ancient Murrelet burrows on Lyell Island. *Photo by Michael S. Rodway, Dodge Point, Lyell Island, BC, 18 May 1977.*

[40]Blight, L.K. and A.E. Burger. 1997. Occurrence of plastic particles in seabirds from the eastern North Pacific. Marine Pollution Bulletin 34:323-325.

[41]Blight, L.K. M.C. Drever, and P. Arcese. 2015. A century of change in Glaucous-winged Gull (*Larus glaucescens*) populations in a dynamic coastal environment. Condor 117:108-120.

[45]Boersma, P.D. 1986. Ingestion of petroleum by seabirds can serve as a monitor of water quality. Science 231:373-376.

[46]Boersma, P.D. and M.C. Silva. 2001. Fork-tailed Storm-Petrel (*Oceanodroma furcata*). *In* The Birds of North America, No. 569 (A. Poole and F. Gill eds.). The Birds of North America, Inc., Philadelphia, PA. 27 pp.

[47]Boersma, P.D., N.T. Wheelwright, M.K. Nerini, and E.S. Wheelwright. 1980. The breeding biology of the Fork-tailed Storm-Petrel (*Oceanodroma furcata*). Auk 97:268-282.

[48]Bonadonna, F., M. Villafane, C. Bajzak, and P. Jouventin. 2004. Recognition of burrow's olfactory signature in blue petrels, *Halobaena caerulea*: an efficient discrimination mechanism in the dark. Animal Behaviour 67:893-898.

[49]Booth, J.A. and H.I. Rueggeberg. 1988. Marine birds and aquaculture in British Columbia: assessment and management of interactions, Phase 1 report: description of interactions and a method for assessing habitat overlap. Hammond Bay Environmental Services, Nanaimo, BC. 27 pp.

[50]Boulinier, T. and E. Danchin. 1996. Population trends in Kittiwake *Rissa tridactyla* colonies in relation to tick infestation. Ibis 138:326-334.

[51]Boyd, M. 2015. Caspian Tern. *In* P.J.A. Davidson, R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). The atlas of the breeding birds of British Columbia, 2008-2012. Bird Studies Canada. Delta, B.C. http://www.birdatlas.bc.ca/accounts/speciesaccount,jsp?sp=CATE&lang=en [Figure 262]

[52]Boyd, W.S., L. McFarlane Tranquilla, J.L. Ryder, S.G. Shisko, and D.F. Bertram. 2008. Variation in marine distributions of Cassin's Auklets breeding at Triangle Island, British Columbia. Auk 125:158-166.

[53]Bradley, R.W. and F. Cooke. 2001. Cliff and deciduous tree nests of Marbled Murrelets in southwestern British Columbia. Northwestern Naturalist 82:52-57.

[54]Breault, A.M. 1990. Monitoring program of fish-eating birds in the Strait of Georgia. Canadian Wildlife Service, Pacific and Yukon Region, Unpublished Report. Delta, BC. 74pp.

[55]British Columbia Conservation Data Centre. 2017. Conservation status reports. British Columbia Ministry of Environment, Victoria, BC. http://a100.gov.bc.ca/pub/eswp/.

[56]British Columbia Ministry of Agriculture. 2013. Grow BC – Fish and shellfish farming in BC. British Columbia Ministry of Agriculture, Victoria, BC. 8 pp.

[57]Brooks, A. 1926. Scarcity of the Marbled Murrelet. Murrelet 7:39.

[58]Brooks, A. and H.S. Swarth. 1925. A distributional list of the birds of British Columbia. Pacific Coast Avifauna No. 17. Berkley, CA. 158 pp. [Figure 263]

Figure 262. Fifteen years after Caspian Tern was suspected of nesting in the Greater Vancouver region, a small colony was discovered on a lake in the central interior of the province.[99, 137] Recently, a small colony has become established on a metal roof of a building in the Fraser River delta. *Photo by R. Wayne Campbell, 19 June 1998.*

Figure 263. The abundance and distribution of breeding seabirds in BC was poorly investigated in the late 1800s and early 1900s as most collectors, like Allan Brooks, only visited accessible breeding sites and then only for short periods of time to collect eggs, nestlings, or adults. *Photo courtesy of Greater Vernon Museum & Archives.*

[59]Brown, A. and A.J. Gaston. 2014. History of raccoons on East Limestone Island 1990-2012. Pages 38-45 *in* A.J. Gaston (ed.). Laskeek Bay Research 17. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[60]Brown, C. 2015. Dangerous, tasty fishery resumes off B.C. coast. Canadian Broadcasting Corporation News, posted October 9, 2015. www.cbc.ca/news/canada/british-columbia/gooseneck-barnacles-havest-1.3263816.

[61]Brown, C.R. and M.B. Brown. 1986. Ectoparasitism as a cost of coloniality in Cliff Swallows (*Hirundo pyrrhonata*). Ecology 67: 1206-1218.

[62]Browne, M.A., P. Crump, S.J. Niven, E.L. Teuten, A. Tonkin, T. Galloway, and R.C. Thompson. 2011. Accumulations of microplastic on shorelines worldwide: sources and sinks. Environmental Science and Technology 45:9175-9179.

[63]Buckley, F.G. and P.A. Buckley. 1980. Habitat selection and marine birds. Pages 69-112 *in* J. Burger, B.L. Olla, and H.E. Winn (eds.). Behavior of marine animals. Volume 4. Plenum Press, New York, NY.

[64]Buffam, F.V. 1965. Wickaninnish Beach - summer 1965. British Columbia Parks Branch Unpublished Report, Vitoria, BC. 80 pp.

[65]Buffam, F.V. 1966. Wickaninnnish Provincial Park summer report, 1966. British Columbia Parks Branch Unpublished Report, Victoria, BC. 14 pp.

[66]Bunnell, F.L., R.W. Campbell, and K.A. Squires. 2004. Conservation priorities for peripheral species: the example of British Columbia. Canadian Journal of Forest Research 34:2240-2247.

[67]Bunnell, F.L., R.W. Campbell, and K. Squires. 2005. Assessing the need for species conservation in British Columbia. BC Journal of Ecosystems and Management 6:29-37.

[68]Burco, J.D., M.H. Ziccardi, K.V. Clemons, and L.A. Tell. 2012. Evaluation of plasma (1→3) β-D-glucan concentrations in birds naturally and experimentally infected with *Aspergillus fumigatus*. Avian Diseases 56:183-191.

[69]Burger, A.E. 1992. The effects of oil pollution on seabirds off the west coast of Vancouver Island. Pages 120-128 *in* K. Vermeer, R.W. Butler, and K.H. Morgan (eds.). The ecology, status, and conservation of marine and shoreline birds on the west coast of Vancouver Island. Canadian Wildlife Service Occasional Paper No. 75, Ottawa, ON.

[70]Burger, A.E. 1993. Effects of the Nestucca oil spill on seabirds along the coast of Vancouver Island in 1989. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 179. Delta, BC. 51 pp.

[71]Burger, A.E. 1993. Mortality of seabirds assessed from beach-bird surveys in southern British Columbia. Canadian Field-Naturalist 107:164-176. [Figure 264]

Figure 264. In July 1967, nine Cassin's Auklets, all juveniles, were picked up alive during vehicle surveys of five kilometres of sandy beach along Long Beach, BC. All were released at sea off Tofino. *Photo by R. Wayne Campbell, Long Beach, BC, July 1967.*

[72]Burger, A.E. 2002. Conservation assessment of Marbled Murrelets in British Columbia: a review of the biology, populations, habitat associations, and conservation. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 387, Delta, BC. 168 pp.

[73]Burger, A.E. and D.W. Powell. 1990. Diving depths and diet of Cassin's Auklet at Reef Island, British Columbia. Canadian Journal of Zoology 68:1572-1577.

[74]Burger, J. and M. Gochfeld. 1996. Family Laridae (Gulls). Pages 572-623 *in* J. del Hoyo, A. Elliot, and J. Sargatal (eds.). Handbook of the birds of the world, vol. 3, Hoatzin to Auks. Lynx Edicions, Barcelona, Spain.

[75]Burger, J. and M. Gochfeld. 2001. Effects of chemicals and pollution on seabirds. Pages 485-525 *in* E.A. Schreiber and J. Burger (eds.). Biology of marine birds. CRC Press, Boca Raton, FL.

[76]Burnett, J.A. 1999. A passion for wildlife: A history of the Canadian Wildlife Service, 1947-1997. Canadian Field-Naturalist 113:1-183.

[77]Bustnes, J.O., S. Bourgeon, E.H.K. Leat, E. Magnusdóttir, H. Strøm, S.A. Hanssen, A. Petersen, K. Olafsdóttir, K. Borgå, G.W. Gabrielsen, and R.W. Furness. 2015. Multiple stressors in a top predator seabird: potential ecological consequences of environmental contaminants, population health and breeding conditions. PLoS ONE 10(7):e0131769.

[78]Butler, R.W. 2015. Double-crested Cormorant. *In* P.J.A. Davidson, R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). The atlas of the breeding birds of British Columbia, 2008-2012. Bird Studies Canada. Delta, BC. http://www.birdatlas.bc.ca/accounts/speciesaccount.jsp?sp=DCCO&lang=en.

[79]Butler, R.W. and R.W. Campbell. 1987. The birds of the Fraser River delta: populations, ecology and international significance. Canadian Wildlife Service Occasional Paper No. 65, Ottawa, ON. 73 pp.

[80]Butler, R.W. and T.E. Golumbia. 2008. Status of breeding Black Oystercatchers, H*aematopus bachmani*, in the Strait of Georgia, British Columbia. Northwestern Naturalist 89:37-40.

[81]Butler, R.W. and J.W. Kirbyson.1979. Oyster predation by the Black Oystercatcher in British Columbia. Condor 81:433-435.

[82]Butler, R.W., M. Lemon, and M. Rodway. 1985. Northwestern Crows in a Rhinoceros Auklet colony: predators and scavengers. Murrelet 66:86-90.

[83]Butler, R.W., N.A.M. Verbeek, and R.G. Foottit. 1980. Mortality and dispersal of the Glaucous-winged Gulls of southern British Columbia. Canadian Field-Naturalist 94:315-320. [Figure 265]

Figure 265. Information for this article by Butler et al. was provided by volunteer bird-banders in the 1960s and 1970s in southern BC. An analysis of band returns showed highest mortality for one and two-year old Glaucous-winged Gulls between September and November and for adults during late summer. The mortality rate for first-year gulls was estimated at 58-59%. One first-year bird travelled 2,050 km from its breeding colony. *Photo by R. Wayne Campbell,, Esquimalt Lagoon, BC, 9 September 1995.*

[84]Byrd, G.V., E.C. Murphy, G.W. Kaiser, A.Y. Kondratyev, and Y.V. Shibaev. 1993. Status and ecology of offshore fish-feeding alcids (murres and puffins) in the North Pacific. Pages 176-186 *in* K. Vermeer, K. Briggs, K. Morgan and D. Seigel-Causey (eds.). The status, ecology, and conservation of marine birds of the North Pacific. Canadian Wildlife Service Special Publication. Ottawa, ON.

[85]Calvert, A.M., C.A. Bishop, R.D. Elliott, E.A. Krebs, T.M. Kydd, C.S. Machtans, and G.J. Robertson. 2013. A synopsis of human-related avian mortality in Canada. Avian Conservation and Ecology 8:11. http://dx.dol.org/10.5751/ACE-00581-080211.

[86]Campbell, R.W. 1966. On Black Oystercatchers "catching" oysters. Victoria Naturalist 23:26.

[87]Campbell, R.W. 1967. Fishing lures – a hazard to seabirds. Blue Jay 25:71-72.

[88]Campbell, R.W. 1967. Summer naturalist report, Wickaninnish Provincial Park – 1967. British Columbia Ministry of Recreation and Conservation, Parks Branch, Unpublished Report Victoria, BC. 163 pp.

[89]Campbell, R.W. 1968. Alexandrian Rat predation on Ancient Murrelet eggs. Murrelet 49:38.

[90]Campbell, R.W. 1968. Capturing Ancient Murrelets by night-lighting. Blue Jay 26:90-91.

[91]Campbell, R.W. 1968. Occurrence and nesting of the Black Oystercatcher near Vancouver, British Columbia. Murrelet 49:11.

[92]Campbell, R.W. 1968. Status of breeding Herring Gulls at Bridge Lake, British Columbia. Canadian Field-Naturalist 82:217-219.

Figure 266. On Mitlenatch Island, BC, the Wandering Garter Snake feeds on a wide variety of animals, including small intertidal fishes, small mammals, and nestlings of Northwestern Crows (shown), Black Oystercatchers, and Glaucous-winged Gulls. *Photo by R. Wayne Campbell, 22 June 1968.*

[93]Campbell, R.W. 1968. Summer naturalist report, Wickaninnish Provincial Park – 1968. British Columbia Ministry of Recreation and Conservation, Parks Branch, Unpublished Report Victoria, BC. 104 pp.

[94]Campbell, R.W. 1969. Notes on some foods of the Wandering Garter Snake on Mitlenatch Island, British Columbia. Syesis 2:183-187. [Figure 266]

[95]Campbell, R.W. 1969. Spring bird observations on Langara Island, British Columbia. Blue Jay 27:155-159.

[96]Campbell, R.W. 1969. Summer naturalist report, Wickaninnish Provincial Park – 1969. British Columbia Ministry of Recreation and Conservation, Parks Branch, Unpublished Report, Victoria, BC. 85 pp.

[97]Campbell, R.W. 1970. Prospectus for an annual bird report. Vancouver Natural History Society Discovery 148:9-11.

[98]Campbell, R.W. 1970. Recent information on nesting colonies of Mew Gulls on Kennedy Lake, Vancouver Island, British Columbia. Syesis 3:5-15.

[99]Campbell, R.W. 1971. Status of the Caspian Tern in British Columbia. Syesis 4:185-190.

[100]Campbell, R.W. 1975. Longevity records of a Glaucous-winged Gull. Bird-Banding 46:166.

[101]Campbell, R.W. 1975. Marginal habitat used by Glaucous-winged Gulls for nesting. Syesis 8:393.

[102]Campbell, R.W. 1975. Seabird colonies in Skidegate Inlet, Queen Charlotte Islands, British Columbia. Syesis 8:355-361. [Figure 267)

[103]Campbell, R.W. 1976. Hunting tactics of a Peregrine Falcon on Black Turnstones. Condor 77:485.

[104]Campbell, R.W. 1976. Seabirds breeding on the Canadian west coast. Pages 39-65 *in* H. Hosford (ed.). Mountains and seas: selected papers from a conference. British Columbia Provincial Museum Heritage Record No. 1, Victoria, BC. 65 pp.

[105]Campbell, R.W. 1977. Seabird colonies of Vancouver Island area. British Columbia Provincial Museum Special Publication, Victoria, BC. [Map].

Figure 267. Although hundreds of Pigeon Guillemots were counted in Skidegate Inlet during seabird surveys, few nests were actually found. This nest, containing two eggs, was located under driftwood just above high water. *Photo by R. Wayne Campbell, Bush Island, BC, 18 June 1984.*

[106]Campbell, R.W. 1977. Use of man-made structures as nest sites by Pigeon Guillemots. Canadian Field-Naturalist 91:193-194.

[107]Campbell, R.W. 1984. Wings over the water. Pages 95-117 *in* Islands Protection Society (eds.) Islands at the edge: preserving the Queen Charlotte Islands wilderness. Douglas-McIntyre, Toronto, ON. 160 pp.

[108]Campbell, R.W. 1987. Birds and mammals observed during a cruise of Moresby Island, Queen Charlotte Islands, 7 to 17 June 1987. Report for Pacific Synergies Limited, Whistler, BC. 11 pp. [Figure 268]

[109]Campbell, R.W. 2007. New longevity record of a Glaucous-winged Gull from British Columbia. Wildlife Afield 4:78-80.

[110]Campbell, R.W. 2014. Early status and life history of Northern Spotted Owl (*Strix occidentalis caurina*) in British Columbia, 1903-1965 including first breeding records for North America. Wildlife Afield 11:123-155.

[111]Campbell, R.W. (compiler). 2014. The British Columbia Ornithologists' Union (1922-1925): *The Migrant* (Volume 1, Part 1). Wildlife Afield 11:60-78.

[112]Campbell, R.W. (compiler). 2014. The British Columbia Ornithologists' Union (1922-1925): *The Migrant* (Volume 1, Part 2). Wildlife Afield 11:232-256.

Figure 268. One of the perks of exploring remote coastal areas of the province was the chance discovery of historical native villages and middens. In this photo, Anne Stewart has just examined the "Mosquito Pole" on Chaatl Island located between Graham and Moresby islands. Over 500 Haida lived in the ancient village before fire, and possible disease, caused abandonment. *Photo by R. Wayne Campbell, Chaatl, BC, 18 June 1977.*

[113]Campbell, R.W. 2015. Earliest confirmed records of Chestnut-sided Warbler (*Setophaga pensylvanica*) for British Columbia and the Pacific Northwest. Wildlife Afield 12:78-81.

[114]Campbell, R.W. 2015. Inland occurrences of Brant (*Branta bernicla*) in British Columbia, 1865–1989. Wildlife Afield 12:70-77.

[115]Campbell, R.W. and H.M. Garrioch. 1979. Seabird colonies of the Queen Charlotte Islands. British Columbia Provincial Museum Special Publication, Victoria, BC. [Map].

[116]Campbell, R.W. and V. Gibbard. 1973. British Columbia nest records scheme eighteenth annual report, 1972. Federation of British Columbia Naturalists Newsletter 11:3-5.

[117]Campbell, R.W. and P.S. Henderson. 2013. An old-school naturalist – Glenn Roderick Ryder (1938-2013). Wildlife Afield 10:84-256.

[118]Campbell, R.W. and K. Kennedy. 1965. Summer naturalist report, Mitlenatch Island Nature Park. Report for British Columbia Ministry of Recreation and Conservation, Parks Branch, Victoria, BC. 101 pp.

[119]Campbell, R.W. and K. Kennedy. 1966. Summer naturalist report, Mitlenatch Island Nature Park. Report for British Columbia Ministry of Recreation and Conservation, Parks Branch, Victoria, BC. 172 pp.

[120]Campbell, R.W. and W.J. Merilees. 1964. Summer naturalist report, Mitlenatch Island Nature Park. Report for British Columbia Ministry of Recreation and Conservation, Parks Branch, Victoria, BC. 82 pp.

[121]Campbell, R.W. and M. Preston. 1988. British Columbia nest records scheme. Thirty-first and thirty-second annual report 1986-1987. B.C. Naturalist 26:12-13.

[122]Campbell, R.W. and M.I. Preston. 2008. British Columbia nest record scheme instruction manual. Biodiversity Centre for Wildlife Studies Report No. 1 (2nd editon), Victoria, BC. 47 pp.

[123]Campbell, R.W. and M.I. Preston. 2009. Featured species – Snowy Owl. Wildlife Afield 6:173-255.

[124]Campbell, R.W. and G.R. Ryder. 2005. Field observations of Bullfrog (*Rana catesbeina*) prey in British Columbia. Wildlife Afield 1:61-62.

[125]Campbell, R.W. and G.R. Ryder. 2010. Greater Sage-Grouse (*Centrocercus urophasianus*) in British Columbia: History, translocation, breeding, and current status. Wildlife Afield 7:3-11.

[126]Campbell, R.W. and G.R. Ryder. 2013. Earliest interior occurrence of Eurasian Wigeon (*Anas penelope*) in British Columbia. Wildlife Afield 10:38-39. [Figure 269]

[127]Campbell, R.W. and J.G. Sarles. 1966. Glaucous-winged Gull movements: A Pacific International Chapter project. Western Bird-Bander 41:6.

Figure 269. Glenn Ryder observed European Wigeon near Kelowna in the interior of BC on 16 April 1944, 23 years earlier than previous interior records. Archived historical field notes, such as those of the late Glenn Ryder, have added new information on the avifauna of the province, including seabirds. *Photo by R. Wayne Campbell, Esquimalt Lagoon, BC, 19 February 2009.*

[128]Campbell, R.W. and S.G. Sealy. 2012. From the editors: Keeping memories alive – a legacy in field notes. Wildlife Afield 9:2.

[129]Campbell, R.W. and S.G. Sealy. 2014. From the editors: Stepping back to move forward. Wildlife Afield 11:2.

[130]Campbell, R.W. and D. Stirling. 1968. Notes on the natural history of Cleland Island, British Columbia, with emphasis on the breeding bird fauna. Pages HH25-HH43 *in* Provincial Museum of Natural History and Anthropology Report for the year 1967. Victoria, BC.

[131]Campbell, R.W. and D. Stirling. 1968. Notes on the vertebrate fauna associated with a Brandt's Cormorant colony in British Columbia. Murrelet 49:7-9.

[132]Campbell, R.W. and D. Stirling. 1971. A photoduplicate file for British Columbia vertebrate records. Syesis 4:217-222.

[133]Campbell, R.W. and K.R. Summers. 1997. Vertebrates of Brooks Peninsula. Pages 12.1-12.39 *in* R.J. Hebda and J.C. Haggarty (eds.). Brooks Peninsula: An Ice Age Refugium on Vancouver Island. British Columbia Parks Branch Occasional Paper No. 5, Victoria, BC.

[134]Campbell, R.W., H.R. Carter, and S.G. Sealy. 1979. Nesting of Horned Puffins in British Columbia. Canadian Field-Naturalist 93:84-86.

[135]Campbell, R.W., H.R. Carter, C.D. Shepard, and C.J. Guiguet. 1979. A bibliography of British Columbia ornithology – Volume 1. British Columbia Provincial Museum Heritage Record Number 7, Victoria, BC. 185 pp.

[136]Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990. The birds of British Columbia: Volume 1 – nonpasserines (introduction, loons through waterfowl). Royal British Columbia Museum, Victoria, BC. 514 pp.

[137]Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990. The birds of British Columbia: Volume 2 – nonpasserines (diurnal birds of prey through woodpeckers). Royal British Columbia Museum, Victoria, BC. 636 pp.

[138]Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, A.C. Stewart, and M.C.E. McNall. 2001. The birds of British Columbia: Volume 4 – wood warblers through old world sparrows. UBC Press, Vancouver, BC. 741 pp.

[139]Campbell, R.W., M.L. Funk, L. Davis, and J.V. Kimm. 1999. British Columbia nest records scheme: 44th annual report – 1998 nesting season. WBT Wild Bird Trust of British Columbia Wildlife Report Number 5, West Vancouver, BC. 24 pp.

[140]Campbell, R.W., T.D. Hooper, and N.K. Dawe. 1988. A bibliography of British Columbia ornithology, Volume 2. Royal British Columbia Museum Heritage Record Number 19, Victoria, BC. 591 pp.

[141]Campbell, R.W., M.K. McNicholl, R.M. Brigham, and J. Ng. 2006. Featured species – Common Nighthawk. Wildlife Afield 3:32-71.

[142]Campbell, R.W., M.A. Paul, M.S. Rodway, and H.R. Carter. 1977. Tree- nesting Peregrine Falcons in British Columbia. Condor 79:500-501. [Figure 270]

[143]Campbell, R.W., M.I. Preston, M. Phinney, C. Siddle, and J. Deal. 2007. Featured species – Canada Warbler. Wildlife Afield 4:91-155.

Figure 270. While being part of a team that found the first tree-nesting Peregrine Falcons in BC was exciting for Marilyn Paul (now Lambert), equally thrilling was beachcombing for glass fishing floats that arrived from Japan after years at sea. *Photo by R. Wayne Campbell, McKenney Islands, BC, 25 June 1976.*

[144]Campbell, R.W., M.I. Preston, L.M. Van Damme, T. Greenfield, and M.K. McNicholl. 2007. Wildlife checklists of British Columbia – The birds of British Columbia. Biodiversity Centre for Wildlife Studies Special Publication No. 3, Victoria, BC. 14 pp.

[145]Campbell, R.W., M.I. Preston, L.M. Van Damme, D.C. Evers, A. Roberts, and K. Andrews. 2008. Featured species – Common Loon. Wildlife Afield 5:54-146.

[146]Campbell, R.W., M.I. Preston, L.M. Van Damme, and M. Nyhof. 2009. British Columbia nest record scheme 54th annual report – 2008 nesting season. Biodiversity Centre for Wildlife Studies Report No. 10, Victoria, BC. 73 pp.

[147]Campbell, R.W., S.G. Sealy, T.J. Underwood, and G.W. Breault. 2014. An updated account of the Yellow-billed Cuckoo in British Columbia, 1881-2013: Status and distribution, first breeding, habitat, and conservation. Wildlife Afield 11:190-231.

[148]Campbell, R.W., M.G. Shepard, and R.H. Drent. 1972. Status of birds in the Vancouver area in 1970. Syesis 5:180-220.

[149]Campbell, R.W., M.G. Shepard, B.A. MacDonald, and W.C. Weber. 1974. Vancouver birds in 1972. Vancouver Natural History Society Publication Number 5, Vancouver, BC. 96 pp.

[150]Campbell, R.W., M.G. Shepard, and W.C. Weber. 1972. Vancouver birds in 1971. Vancouver Natural History Society Special Publication Number 2, Vancouver, British Columbia. 88 pp.

[151]Campbell, R.W., J. Sims, P. Ranson, and S. Proulx. 2009. Two disjunct breeding locations for Arctic Tern in British Columbia. Wildlife Afield 6:15-19.

[152]Campbell, R.W., L.M. Van Damme, M. Nyhof, and P. Huet. 2011. British Columbia nest record scheme 56th annual report – 2010 nesting season. Biodiversity Centre for Wildlife Studies Report No. 13, Victoria, BC. 104 pp.

[153]Campbell, R.W., L.M. Van Damme, M. Nyhof, and P. Huet. 2012. British Columbia nest record scheme 57th annual report – 2011 nesting season. Biodiversity Centre for Wildlife Studies Report No. 15, Victoria, BC. 110 pp.

[154]Campbell, R.W., L.M. Van Damme, M. Nyhof, and P. Huet. 2013. British Columbia nest record scheme 58th annual report – 2012 nesting season. Biodiversity Centre for Wildlife Studies Report No. 16, Victoria, BC. 112 pp.

[155]Campbell, R.W., L.M. Van Damme, M. Nyhof, and M.I. Preston. 2010. British Columbia nest record scheme 55th annual report – 2009 nesting season. Biodiversity Centre for Wildlife Studies Report No. 12, Victoria, BC. 92 pp.

[156]Campbell, R.W., J.G. Ward, and M.G. Shepard. 1975. A new Common Murre colony in British Columbia. Canadian Field-Naturalist 89:244-248.

[157]Carl, G.C. and C.J. Guiguet. 1972. Alien animals in British Columbia. British Columbia Provincial Museum Handbook No. 14, Victoria, BC. 103 pp.

[158]Carl, G.C., C.J. Guiguet, and G.A. Hardy. 1951. Biology of the Scott Island group, British Columbia. Pages B21-B53 *in* Provincial Museum Natural History and Anthropology Report for the year 1950, Victoria, BC.

[159]Carney, K.M. and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68-79. [Figure 271]

Figure 271. Tourists visiting seabird colonies like Cleland Island without an experienced guide can impact fragile nesting habitats and cause unnecessary disturbance to nesting birds. *Photo by R. Wayne Campbell, 4 June 1975.*

[160]Carter, H.R. 2004. Temporary colonization of Cleland Island, British Columbia, by Common Murres from 1969-82. Wildlife Afield 1:39-45.

[161]Carter, H.R. 2014. Survey of seabird breeding colonies between Powell River and Vancouver, British Columbia, on 13-16 July 2014. Carter Biological Consulting, Victoria, BC.

[162]Carter, H.R. and K.A. Hobson. 1988. Creching behavior of Brandt's Cormorant chicks. Condor 90:395-400.

[163]Carter, H.R. and E.L. McClaren. 2016. Decline of the Pelagic Cormorant in western Queen Charlotte Strait, British Columbia, 1975-2014. Northwestern Naturalist 97:24-35.

[164]Carter, H.R. and S.G. Sealy. 1984. Marbled Murrelet mortality due to gill-net fishing in Barkley Sound, British Columbia. Pages 212-220 *in* D.N. Nettleship, G.A. Sanger, and P.F. Singer (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Proceedings of the Pacific Seabird Group Special Symposium, Seattle, Washington, 6-9 Jan. 1982. Canadian Wildlife Service Special Publication, Ottawa, ON.

[165]Carter, H.R. and S.G. Sealy. 1987. Inland records of downy young and fledgling Marbled Murrelets in North America. Murrelet 68:58-63.

[166]Carter, H.R. and S.G. Sealy. 2008. Ancient Murrelets breeding at Triangle Island, British Columbia, in 1949. Wildlife Afield 5:201-211.

[167]Carter, H.R. and S.G. Sealy. 2011. Earliest breeding records of Black Oystercatcher and Pigeon Guillemot in British Columbia, 1858-1896. Wildlife Afield 8:195-201.

[168]Carter, H.R. and S.G. Sealy. 2011. Earliest breeding records of storm-petrels in British Columbia, 1909-1927: Triangle Island, Tree Islets, Cox Island, Cleland Island, Lepas Bay Islands, and Tian Islets. Wildlife Afield 8:167-194.

[169]Carter, H.R. and S.G. Sealy. 2011. Historical breeding records of four species of alcid in British Columbia and southeast Alaska, 1858-1910. Northwestern Naturalist 92:37-49.

[170]Carter, H.R., A.E. Burger, P.V. Clarkson, Y. Zharikov, M.S. Rodway, S.G. Sealy, R.W. Campbell, and D.F. Hatler. 2012. Historical colony status and recent extirpations of burrow-nesting seabirds at Seabird Rocks, British Columbia. Wildlife Afield 9:13-48.

[171]Carter, H.R., P.N. Hébert, and P.V. Clarkson. 2007. Decline of Pelagic Cormorants in Barkley Sound, British Columbia. Wildlife Afield 4:3-32.

[172]Carter, H.R., K.A. Hobson, and S.G. Sealy. 1984. Colony-site selection by Pelagic Cormorants (*Phalacrocorax pelagicus*) in Barkley Sound, British Columbia. Colonial Waterbirds 7:25-34.

[173]Carter, H.R., M.A. Lambert, and D. Donnecke. 2014. Breeding of Brandt's Cormorant at Mandarte Island in 2013. Victoria Naturalist 70:6-7.

[174]Carter, H.R., K.H. Morgan, T. Chatwin, and F. Bruhwiler. 2006. Notes on recent breeding of Common Murres on Starlight Reef and Cleland Island, British Columbia. Wildlife Afield 3:117-121.

[175]Carter, H.R., A.L. Sowls, M.S. Rodway, U.W. Wilson, R.W. Lowe, G.J. McChesney, F. Gress, and D.W. Anderson. 1995. Population size, trends, and conservation problems of the Double-crested Cormorant on the Pacific coast of North America. Colonial Waterbirds 18 (Special Publication 1):189-215. [Figure 272]

Figure 272. The tree-nesting colony of Double-crested Cormorants on Ballingal Islets in the southern Strait of Georgia is being surveyed by Marilyn Paul (now Lambert). Cormorants abandoned the colony when visitors collected the juniper trees for ornaments. *Photo by R. Wayne Campbell, 27 July 1978.*

[176]Carter, H.R., U.W. Wilson, R.W. Lowe, M.S. Rodway, D.A. Manuwal, J.E. Takekawa, and J.L. Yee. 2001. Population trends of the Common Murre (*Uria aalge californica*). Pages 33-132 *in* D.A. Manuwal, H.R. Carter, T.S. Zimmerman and D.L. Orthmeyer (eds.). Biology and conservation of the Common Murre in California, Oregon, Washington, and British Columbia. Volume 1: Natural history and population trends. Information and Technology Report USGS/BRD/ITR-2000-0012. United States Geological Survey, Biological Resources Division. Washington, DC.

[177]Cavole, L.M., A.M. Demko, R.E. Diner, A. Giddings, I. Koester, C.M.L.S. Pagniello, M.-L. Paulsen, A. Ramirez-Valdez, S.M. Schwenck, N.K. Yen, M.E. Zill, and P.J.S. Franks. 2016. Biological impacts of the 2013-2015 warm-water anomaly in the Northeast Pacific: winners, losers, and the future. Oceanography 29:273-285.

[178]Charest, S. and C. Epners. 2004. East Limestone Island field station: report on the 2004 field season. *In* A.J. Gaston (ed.). Laskeek Bay Research 13:19-33. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[179]Charest, S., J. Fournier, and C. Tarver. 2004. East Limestone Island field station: report on the 2003 field season. *In* A.J. Gaston (ed.). Laskeek Bay Research 13:1-18. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[180]Chatwin, T.A., M.H. Mather, and T.D. Giesbrecht. 2002. Changes in Pelagic and Double-Crested Cormorant nesting populations in the Strait of Georgia, British Columbia. Northwestern Naturalist 83:109-117.

[181]Chatwin, T.A., J. Ruth, and A.E. Burger. 2013. Set-back distances to protect nesting and roosting seabirds off Vancouver Island from boat disturbance. Waterbirds 36:43-52.

[182]Chesser, R.T., K.J. Burns, C. Cicero, J.L. Dunn, A.W. Kratter, I.J. Lovette, P.C. Rasmussen, J.V. Remsen, Jr., J.D. Rising, D.F. Stotz, and K. Winker. 2016. Fifty-seventh supplement to the American Ornithologists' Union Check-list of North American birds. Auk 133:544-560.

[183]Clapp, R.B., M.K. Klimkiewicz, and J.H. Kennard. 1982. Longevity records of North American birds: Gavidae through Alcidae. Journal of Field Ornithology 53:81-208.

[184]Clarkson, P., F. Bruhwiler, and T. Hunter. 2004. Ground nest survey of Cleland Island and Murre Reef, 2004. Parks Canada Unpublished report, Ucluelet, BC. 5 pp.

[185]Committee on the Status of Endangered Wildlife in Canada. 2004. COSEWIC assessment and update status report on the Ancient Murrelet *Synthliboramphus antiquus* in Canada. Ottawa, ON. 31 pp. www.registrelep-sararegistry.gc.ca/default_e.cfm. [Figure 273]

Figure 273. Ancient Murrelet is the only seabird in BC that rears its young entirely at sea. Parents lead their downy chicks offshore when they are only two days old. It is listed by COSEWIC as a "Species of Special Concern", partly because the majority of the world's population breeds in BC. Visitors to islands with nesting Ancient Murrelets must be alert when young are scrambling to the sea. *Photo by Al and Irene Whitney, Frederick Island, BC, June 1988.*

[186]Committee on the Status of Endangered Wildlife in Canada. 2012. COSEWIC assessment and status report on the Marbled Murrelet *Brachyramphus marmoratus* in Canada. Ottawa, ON. 82 pp. www.registrelep-sararegistry.gc.ca/default_e.cfm.

[187]Committee on the Status of Endangered Wildlife in Canada. 2014. COSEWIC assessment and status report on the Cassin's Auklet *Ptychoramphus aleuticus* in Canada. Ottawa, ON. 69 pp.www.registrelep-sararegistry.gc.ca/default_e.cfm.

[188]Committee on the Status of Endangered Wildlife in Canada. 2017. Wildlife species assessment. Ottawa, ON. http://www.cosewic.gc.ca/default.asp?lang=En&n=ED199D3B-1.

[189]Cooper, J.M. and E.H. Miller. 1997. Populations, status, and biology of shorebirds breeding near Masset, Queen Charlotte Islands. Pages 123-130 *in* K. Vermeer and K.H. Morgan (eds.). The ecology, status and conservation of marine and shoreline birds of the Queen Charlotte Islands. Canadian Wildlife Service Occasional Paper 93, Ottawa, ON.

[190]Coulson, J.C, G.R. Potts, I.R. Deans, and D.M. Fraser. 1968. Exceptional mortality of Shags and other seabirds caused by paralytic shellfish poison. British Birds 61:381-404.

[191]Coulson, S.J., B. Moe, F. Monson, and G.W. Gabrielson. 2009. The invertebrate fauna of High Arctic seabird nests: the microarthropod community inhabiting nests on Spitsbergen, Svalbard. Polar Biology 32:1041-1046.

[192]Cowan, I.McT. and C.J. Guiguet. 1965. The mammals of British Columbia. British Columbia Provincial Museum Handbook No. 11, Victoria, BC. 414 pp.

[193]Cózar, A., F. Echevarría, J.I. González-Gordillo, X. Irigoien, B. Úbeda, S. Hernández-León, Á.T. Palma, S. Navarro, J. García-de-Lomas, A. Ruiz, M.L. Fernández-de-Puelles, and C.M. Duarte. 2014. Plastic debris in the open ocean. Proceedings of the National Academy of Science 111:10239-44.

[194]Craik, J.C.A. 2010. Mixed clutches at seabird colonies in west Scotland, 1996-2009. Seabird 23:41-52.

[195]Creston Valley Wildlife Management Area. 2016. Creston Valley Wildlife Management Area. Wetlander (fall newsletter), Creston, BC. 12 pp.

[196]Croll, D.A., A.J. Gaston, A.E. Burger, and D. Konnoff. 1992. Foraging behavior and physiological adaptation for diving in Thick-billed Murres. Ecology 73:344-356.

[197]Croxall, J.P. 1991. Seabird status and conservation: a supplement. International Council for Bird Preservation, Technical Publication No. 11, Cambridge, UK. 316 pp.

[198]Cumming, R.A. 1931. Some birds observed in the Queen Charlotte Islands, British Columbia. Murrelet 12:15-17.

[199]Cuthbert, F.J. and L.R. Wires. 1999. Caspian Tern (*Sterna caspia*). *In* The Birds of North America, No. 403 (A. Poole and F. Gill eds.). The Birds of North America, Inc., Philadelphia, PA. 31 pp.

[200]Dalzell, K.E. 1968. The Queen Charlotte Islands. Volume 1:1774-1966. Fleming Printing Ltd. Victoria, BC. 340 pp.

[201]Darcus, S.J. 1930. Notes on birds of the northern part of the Queen Charlotte Islands in 1927. Canadian Field-Naturalist 44:45-49.

[202]Davis, M.L., J.E. Elliott, and T.D. Williams. 2015. Spatial and temporal variation in the dietary ecology of the Glaucous-winged Gull *Larus glaucescens* in the Pacific Northwest. Marine Ornithology 43:189-198.

[203]Davoren, G.K. and A.E. Burger. 1999. Differences in prey selection and behaviour during self-feeding and chick provisioning in rhinoceros auklets. Animal Behaviour 58:853-863.

[204]De Beer, S. 2007. Pigeon Guillemots breeding on a moving vessel. Wildlife Afield 4:259-262.

[205]DeGange, A.R. and R.H. Day. 1991. Mortality of seabirds in the Japanese land-based gillnet fishery for salmon. Condor 93:251-258.

[206]DeGange, A.R. and J.W. Nelson. 1982. Bald Eagle predation on nocturnal seabirds. Journal of Field Ornithology 53:407-409. [Figure 274]

[207]DeGange, A.R., R.H. Day, J.E. Takekawa, and V.M. Mendenhall. 1993. Losses of seabirds in gill nets in the North Pacific. Pages 204-211 *in* K. Vermeer, K.T. Briggs, K.H. Morgan, and D. Siegel-Causey (eds.). The status, ecology, and conservation of marine birds of the North Pacific. Canadian Wildlife Service Special Publication. Ottawa, ON.

[208]Denlinger, L.M. 2006. Alaska Seabird Information Series. Unpublished Report, U.S. Fish and Wildlife Service, Migratory Bird Management, Nongame Program, Anchorage, AK. 92 pp.

[209]Dolphin, W.F. and D. McSweeney. 1983. Incidental ingestion of Cassin's Auklets by Humpback Whales. Auk 100:214.

[210]Dorst, A. *In press*. Birds of Vancouver Island's west coast. UBC Press, Vancouver, BC.

Figure 274. This Bald Eagle nest was built low in a wind-pruned Sitka spruce (lower left branch). Prey remains in the vicinity of the nest included auklets that were probably nesting on the Copper Islands, located about one kilometre to the north. *Photo by Michael S. Rodway, Slug Islet, BC, 19 June 1986.*

[211]Dorst, J. and J-L Mougin. 1979. Pelecaniformes. Page 163 *in* E. Mayr and G.W. Cottrell (eds.). Check-list of birds of the world, Volume 1. Museum of Comparative Zoology, Cambridge, MA.

[212]Drent, R.H. 1965. Breeding biology of the Pigeon Guillemot, *Cepphus columba*. Ardea 53:99-160.

Figure 275. A decade after *A Catalogue of British Columbia Sea-bird Colonies* was published, Rudi was still committed to updating the book and was exploring new colonies along the central mainland coast. In this photo, Rudi has just pulled an incubating Rhinoceros Auklet from its burrow on the Moore Islands, located in Hecate Strait west of Aristazabal Island. *Photo by R. Wayne Campbell, June 1970.*

[213]Drent, R.H. and C.J. Guiguet. 1961. A catalogue of British Columbia sea-bird colonies. Occasional Papers of the British Columbia Provincial Museum, No. 12. Victoria, BC. 173 pp. [Figure 275]

[214]Drent, R., G.F. Van Tets, F. Tompa, and K. Vermeer. 1964. The breeding birds of Mandarte Island, British Columbia. Canadian Field-Naturalist 78:208-263.

[215]Drever, M.C. 2002. Status of Ancient Murrelets (*Synthliboramphus antiquus*) and upland birds following eradication of Norway Rats (*Rattus norvegicus*) from Langara Island, Haida Gwaii. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 385, Delta, BC. 35 pp.

[216]Drever, M. 2014. Surveys of permanent seabird monitoring plots on Ramsay Island, Gwaii Haanas National Park Reserve and Haida Heritage Site, June 2012. *In* A.J. Gaston (ed.). Laskeek Bay Research 17:50-59. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[217]Duffy, D.C. 1983. The ecology of tick parasitism on densely nesting Peruvian seabirds. Ecology 64:110-119.

[218]Edwards, R.Y. 1965. Birds seen in Active Pass, British Columbia. Pages 19-23 *in* Provincial Museum of Natural History and Anthropology Report for the year 1964, Victoria, BC.

[219]Edwards, R.Y. 2000. A tribute to Charles Joseph Guiguet. Canadian Field-Naturalist 14:712-715. [Figure 276]

[220]Elliott, J.E. and K.H. Elliott. 2013. Tracking marine pollution. Science 340:556-558.

[221]Elliott, J.E. and D.G. Noble. 1993. Chlorinated hydrocarbon contaminants in marine birds of the temperate North Pacific. Pages 241-253 *in* K. Vermeer, K.T. Briggs, K.H. Morgan, and D. Siegel-Causey (eds.). The status, ecology, and conservation of marine birds of the North Pacific. Canadian Wildlife Service Special Publication. Ottawa, ON.

[222]Ellis, D.W. 1991. The living resources of the Haida: birds. Unpublished manuscript on file with the Haida Gwaii Museum, Skidegate, BC. 67 pp.

Figure 276. Charles Guiguet, curator of the Birds and Mammals Division at the Provincial Museum from 1943 to 1980, had a passion for nesting seabirds. In this photo, Charles is walking on driftwood to explore a sensitive Leach's Storm-Petrel and Rhinoceros Auklet colony on Cleland Island, BC. *Photo by R. Wayne* Campbell, *29 June 1970.*

[223]Ellis, J.I., S.I. Wilhelm, A. Hedd, G.S. Fraser, G.J. Robertson, J.-F. Rail, M. Fowler, and K.H. Morgan. 2013. Mortality of migratory birds from marine commercial fisheries and offshore oil and gas production in Canada. Avian Conservation and Ecology 8:4. http://dx.doi.org/10.5751/ACE-00589-080204.

[224]Ellis, R. 2004. No turning back: The life and death of animal species. Harper Collins, New York, NY. 428 pp.

[225]Emms, S.K. and K.H. Morgan. 1989. The breeding biology and distribution of the Pigeon Guillemot (*Cepphus columba*), in the Strait of Georgia. Pages 100-106 *in* K. Vermeer and R.W. Butler (eds.). The status and ecology of marine and shoreline birds in the Strait of Georgia, British Columbia. Canadian Wildlife Service Special Publication No. 4, Ottawa, ON.

[226]Energy, Mines and Resources Canada and Ministry of Energy, Mines and Petroleum Resources. 1987. Responses and comments on the report of the west coast offshore exploration environment assessment panel. Ministry of Energy, Mines and Petroleum Resources, Victoria and Energy, Mines and Resources, Ottawa, ON.

[227]Environment Canada. 1995. Canadian biodiversity strategy: Canada's response to the convention on biological diversity. Environment Canada Report, Hull, QC. 84 pp.

[228]Environment Canada. 2014. Recovery Strategy for the Marbled Murrelet (*Brachyramphus marmoratus*) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa, ON. 49 pp.

[229]Environment Canada. 2015. Management plan for the Ancient Murrelet (*Synthliboramphus antiquus*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment Canada, Ottawa, ON. 33 pp. http://sararegistry.gc.ca/virtual_sara/files/plans/mp_ancient_murrelet_e_proposed.pdf.

[230]Environment and Climate Change Canada. 2016. Birds oiled at sea. https://www.ec.gc.ca/mbc-com/default.asp?lang=En&n=C6E52970-1.

[231]Environment and Climate Change Canada. 2017. Guidelines to avoid disturbance to seabird and waterbird colonies in Canada. https://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=E3167D46-1#_009. [Figure 277]

Figure 277. Slug Island, on the east coast of Moresby Island, is a popular site for tourists because of calm waters, easy access, and the variety of seabirds, nesting Bald Eagles, and flowering plants present on the island. Northwestern Crows, however, are quick to take advantage of the disturbance caused by visitors and prey on Glaucous-winged Gull eggs. *Photo by R. Wayne Campbell, 6 July 1977.*

[232]Environment and Climate Change Canada. 2017. The Scott Islands: A Proposed Marine National Wildlife Area. https://ec.gc.ca/ap-pa/default.asp?lang=En&n=90605DDB-1.
[233]Eveleigh, E.S. and W. Threlfall. 1976. Population dynamics of lice (Mallophaga) on auks (Alcidae) from Newfoundland. Canadian Journal of Zoology 54:1694-1711.
[234]Ewins, P.J. 1993. Pigeon Guillemot (*Cepphus Columba*). *In* The Birds of North America, No. 49. (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC. 24 pp.
[235]Ewins, P.J., H.R. Carter, and Y.V. Shibaev. 1993. The status, distribution and ecology of inshore fish-feeding Alcids (*Cepphus* guillemots and *Brachyramphus* murrelets) in the North Pacific. Pages 164-175 *in* K. Vermeer, K.T. Briggs, K.H. Morgan, and D. Siegel-Causey (eds.). The status, ecology, and conservation of marine birds of the North Pacific. Canadian Wildlife Service Special Publication. Ottawa, ON.
[236]Ewins, P.J., K.H. Morgan, and K. Vermeer. 1994. Distribution of Pigeon Guillemots (*Cepphus columba*) breeding on the west coast of Vancouver Island, British Columbia, in 1989. Northwestern Naturalist 75:54-62.
[237]Exo, K.-M., O. Hüppop, and S. Garthe. 2003. Birds and offshore wind farms: a hot topic in marine ecology. Wader Study Group Bulletin 100:50-53.
[238]Fannin, J. 1891. Check list of British Columbia birds. Queen's Printer, Victoria, BC. 49 pp.
[239]Fannin, J. 1898. A preliminary catalogue of the collections of natural history and ethnology of the Provincial Museum, Victoria, B.C. British Columbia Provincial Museum, Victoria, BC. 196 pp.
[240]Feare, C.J. 1976. Desertion and abnormal development in a colony of Sooty Terns *Sterna fuscata* infested by virus-infected ticks. Ibis 118:112-115.
[241]Fischer, J.B. and C.R. Griffin. 2000. Can burrow-nesting seabirds be identified from their burrows? Wildlife Society Bulletin 28:586-591.
[242]Fisheries and Oceans Canada. 1987. British Columbia commercial catch statistics: salmon. Department of Fisheries and Oceans, Pacific Region, Vancouver, BC. 29 pp.
[243]Foottit, R.G. and R.W. Butler. 1977. Predation on nesting Glaucous-winged Gulls by River Otter. Canadian Field-Naturalist 91:189-190.
[244]Foottit, R.G., R.W. Butler, and W.J. Merilees. 1973. Additional nesting sites of sea birds in northern Georgia Strait, B.C. Murrelet 54:39-40.
[245]Foster, J.B. 1965. The evolution of mammals of the Queen Charlotte Islands, British Columbia. British Columbia Provincial Museum Occasional Paper No. 14, Victoria, BC. 130 pp.
[246]Fraser, D.F. 2015. Parasitic Jaeger. *In* P.J.A. Davidson, R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). The atlas of the breeding birds of British Columbia, 2008-2012. Bird Studies Canada. Delta, B.C. http://www.birdatlas.bc.ca/accounts/speciesaccount.jsp?sp=PAJA&lang=en
[247]Fujimaki, Y. 1986. Seabird colonies on Hokkaido Island. *In* N.M. Litvinenko (ed.). Seabirds of the far east: collection of scientific papers. USSR Academy of Sciences, Vladivstok. Translation for Environment Canada.
[248]Furness, R.W. 1985. Plastic particle pollution: accumulation by Procellariiform seabirds at Scottish colonies. Marine Pollution Bulletin 16:103-106.
[249]Furness, R.W. and D.G. Ainley. 1984. Threat to seabird populations presented by commercial fisheries. Pages 701-708 *in* J.P. Croxall, P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Preservation, Technical Publication No. 2, Cambridge, England.
[250]Furness, R.W. and J.R.G. Hislop. 1981. Diets and feeding of Great Skua *Catharacta skua* during the breeding season in Shetland. Journal of Zoology 195:1-23.
[251]Galaktionov, K. 2017. Patterns and processes influencing helminth parasites of Arctic coastal communities during climate change. Journal of Helminthology 1-22. doi:10.1017/S0022149X17000232.

[252]Garthe, S. and O. Hüppop. 2004. Scaling possible adverse effects of marine farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology 41:724-734.

[253]Garthe, S., C.J. Camphuysen, and R.W. Furness. 1996. Amounts of discards by commercial fishes and their significance as food for seabirds in the North Sea. Marine Ecology Program Series 136:1-11.

[254]Gaston, A.J. 1991. Laskeek Bay Conservation Society Report on Scientific Activities in 1990. Laskeek Bay Conservation Society, Queen Charlotte City, BC. 24 pp.

[255]Gaston, A.J. 1992. Annual survival of breeding Cassin's Auklets in the Queen Charlotte Islands, British Columbia. Condor 94:1019-1021.

[256]Gaston, A.J. 1992. The Ancient Murrelet: A natural history in the Queen Charlotte Islands. T and A D Poyser, London. 267 pp.

[257]Gaston, A.J. 1993. COSEWIC Status report on the Ancient Murrelet *Synthliboramphus antiquus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. 46 pp.

[258]Gaston, A.J. 1994. Ancient Murrelet (*Sythliboramphus antiquus*). *In* The Birds of North America, No. 132 (A. Poole and F. Gill eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC. 20 pp.

[259]Gaston, A.J. and S.B.C. Dechesne. 1996. Rhinoceros Auklet (*Cerorhinca monocerata*). *In* The Birds of North America, No. 212 (A. Poole and F. Gill eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC. 20 pp. [Figure 278]

[260]Gaston, A.J. and K. Heise. 1994. Laskeek Bay Conservation Society Annual Scientific Report, 1993. Laskeek Bay Conservation Society, Queen Charlotte City, BC. 103 pp.

[261]Gaston, A.J. and J.M. Hipfner. 2000. Thick-billed Murre (*Uria lomvia*). *In* The Birds of North America, No. 497 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. 32 pp.

Figure 278. The *Birds of North America* species accounts are an invaluable source of information on breeding seabird species like Rhinoceros Auklets, especially when the authors have done their research in BC. This adult was incubating. The single egg (right) often becomes soiled in the burrow. *Photo by R. Wayne Campbell, Lucy Island, BC, 8 July 1970.*

[262]Gaston, A.J. and I.L. Jones. 1984. Studies of Ancient Murrelets on Reef Island, British Columbia. Canadian Wildlife Service Progress Report, Ottawa, ON. 2l pp.

[263]Gaston, A.J. and I.L. Jones. 1998. The auks (Alcidae). Oxford University Press, New York, NY. 388 pp.

[264]Gaston, A.J. and A. Lawrence. 1993. Laskeek Bay Conservation Society Report on Scientific Activities in 1992. Laskeek Bay Conservation Society, Queen Charlotte City, BC. 71 pp.

[265]Gaston, A.J. and M.J. Lemon. 1996. A tale of two islands: comparisons of population dynamics of Ancient Murrelets at two colonies in Haida Gwaii, British Columbia. *In* A.J. Gaston (ed.). Report of Scientific Activities for 1995. Laskeek Bay Research 6:29-38. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[266]Gaston, A.J. and M. Masselink. 1997. The impact of Raccoons *Procyon lotor* on breeding seabirds at Englefield Bay, Haida Gwaii, Canada. Bird Conservation International 7:35-51.

[267]Gaston, A.J. and D.G. Noble. 1985. Studies of Ancient Murrelets at Reef Island, 1985. Canadian Wildlife Service Progress Report, Ottawa, ON. 30 pp.

[268]Gaston, A.J., J. Brown, and K. Heise. 1995. Laskeek Bay Research 5. Laskeek Bay Conservation Society Annual Scientific Report, 1994. Laskeek Bay Conservation Society, Queen Charlotte City, BC. 82 pp.

[269]Gaston, A.J., T.E. Golumbia, J.-L. Martin, and S.T. Sharpe. 2008. Lessons from the Islands: introduced species and what they tell us about how ecosystems work. Proceedings from the Research Group on Introduced Species 2002 Symposium, Queen Charlotte City, Queen Charlotte Islands, British Columbia. Canadian Wildlife Service, Environment Canada, Ottawa, ON. 192 pp.

[270]Gaston, A.J., Y. Hashimoto, and L. Wilson. 2015. First evidence of east-west migration across the North Pacific in a marine bird. Ibis 157: 877-882.

[271]Gaston, A.J., Y. Hashimoto, and L. Wilson. 2017. Post-breeding movements of Ancient Murrelet *Synthliboramphus antiquus* family groups, subsequent migration of adults and implication for management. PLoS ONE 12(2):eo171726. https://doi.org/10.137/journal.pone 0171726.

[272]Gaston, A.J., K. Heise and A. Lawrence. 1989. Report on census carried out at Reef Island, 1989. Canadian Wildlife Service Unpublished Report. Ottawa, ON. 8 pp.

[273]Gaston, A.J., I.L. Jones, and D.G. Noble. 1988. Monitoring Ancient Murrelet breeding populations. Colonial Waterbirds 11:58-66.

[274]Gaston, A.J., A. Lawrence, and C. French. 1992. Laskeek Bay Conservation Society Report on Scientific Activities in 1991. Laskeek Bay Conservation Society, Queen Charlotte City, BC. 46 pp.

[275]Gazeteer of Canada: British Columbia. 1985. Energy, Mines and Resources, Ottawa, ON. 739 pp.

[276]Gillet, W.H., J.L. Hayward, and J.F. Stout. 1975. Effects of human activity on egg and chick mortality in a Glaucous-winged Gull colony. Condor 77:492-495.

[277]Gjerdrum, C., A.M.J. Vallée, C. Cassady St. Clair, D.F. Bertram, J.L. Ryder, and G.S. Blackburn. 2003. Tufted puffin reproduction reveals ocean climate variability. Proceedings of the National Academy of Science 100:9377-9382.

[278]Golet, G.H., K.J. Kuletz, D.D. Roby, and D.B. Irons. 2000. Adult prey choice affects chick growth and reproductive success in Pigeon Guillemots. Auk 117:82-91.

[279]Golovkin, A.N. 1984. Seabirds nesting in the USSR: the status and protection of populations. Pages 473-486 *in* J.P. Croxall, P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Protection, Technical Publication No. 2. Cambridge, England.

[280]Golumbia, T., L. Bland, K. Moore, and P. Bartier. 2008. History and current status of introduced vertebrates on Haida Gwaii. Pages 8-31 *in* A.J. Gaston, T.E. Golumbia, J.-L. Martin, and S.T. Sharpe (eds.). Lessons from the islands: introduced species and what they tell us about how ecosystems work. Proceedings from the Research Group on Introduced Species 2002 Symposium, Queen Charlotte City, Queen Charlotte Islands, British Columbia. Canadian Wildlife Service Special Publication, Environment Canada, Ottawa.

[281]Gómez-Díaz, E., J.A. Morris-Pocock, J. González-Solís, and K.D. McCoy. 2012. Trans-oceanic host dispersal explains high seabird tick diversity on Cape Verde islands. Biology Letters 8:616-619. doi: 10.1098/rsbl. 2012.0179.

[282]Good, T.P., J.A. June, M.A. Etnier, and G. Broadhurst. 2009. Ghosts of the Salish Sea: threats to marine birds in Puget Sound and the Northwest Straits from derelict fishing gear. Marine Ornithology 37:67-76.

[283]Gray, J. 2000. East Limestone Island camp: report on the 1999 field season. *In* A.J. Gaston (ed.). Laskeek Bay Research 10:2-8. Annual Scientific Reports, 1999 and 2000. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[284]Green, C. de B. 1916. Note on the distribution and nesting-habits of *Falco peregrinus peali*. Ibis 4:473-476.

[285]Green, R.N. and K. Klinka. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. Land Management Handbook No. 28. British Columbia Ministry of Forests, Research Branch, Victoria, BC. 285 pp.

[286]Greenwood, A. and V. Pattison. 2014. East Limestone Island field station: field season report 2014. Laskeek Bay Conservation Society, Queen Charlotte City, BC. 23 pp.

[287]Grémillet, D. and T. Boulinier. 2009. Spatial ecology and conservation of seabirds facing global climate change: a review. Marine Ecology Progress Series 391:121-137.

[288]Groves, S. 1982. Aspects of foraging in Black Oystercatchers (Aves: Haematopodidae). Ph.D. Thesis, University of British Columbia, Vancuver, BC. 123 pp. [Figure 279]

Figure 279. It is rare to find dump nests for seabirds. Less than 0.1% of oystercatcher and gull nests in BC contain eggs of more than one species. This nest, containing two Black Oystercatcher eggs (bottom) and a single Glaucous-winged Gull egg was found on Adam Rocks, on the west coast of Moresby Island, BC. *Photo by Michael S. Rodway, 17 June 1986.*

[289]Grubb, T.G. and R.J. Hensel. 1978. Food habits of nesting Bald Eagles on Kodiak Island, Alaska. Murrelet 59:70-73.

[290]Guiguet, C.J. 1950. Notes on Common Murres nesting in British Columbia. Murrelet 31:14-15.

[291]Guiguet, C.J. 1953. An ecological study of Goose Island, British Columbia, with special reference to mammals and birds. British Columbia Provincial Museum Occasional Paper No. 10. Victoria, BC. 78 pp.

[292]Guiguet, C.J. 1956. Enigma of the Pacific. Audubon Magazine 58:164-167, 174.

[293]Guiguet, C.J. 1971. A list of seabird nesting sites in Barkley Sound, British Columbia. Syesis 4:253-259.

[294]Halpin, M.M. and M. Seguin. 1990. Tsimshian peoples: Southern Tsimshian, coast Tsimshian, Nishga, and Gitksan. Pages 267-284 *in* W. Suttles and W.C. Sturtevant (eds.). Handbook of North American Indians, Volume 7: Northwest Coast. Smithsonian Institution Scholarly Press, Washington, DC. 796 pp.

[295]Hancock, D. 1970. New Rhinoceros Auklet colony for British Columbia. Condor 72:491.

[296]Hancock, D. 1971. New Common Murre colonies for British Columbia. Canadian Field-Naturalist 85:70-71.

[297]Hanley, T.A. 1987. Physical and chemical response of understory vegetation to deer use in southeastern Alaska. Canadian Journal of Forest Research 17:185-199.

[298]Harfenist, A. 1994. Effects of introduced rats on nesting seabirds of Haida Gwaii. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 218. Delta, BC. 52 pp.

[299]Harfenist, A. 2003. Seabird colonies background report for the Haida Gwaii/Queen Charlotte Islands land use plan. British Columbia Ministry of Water, Land and Air Protection, Queen Charlotte City, BC. 56 pp.

[300]Harfenist, A. and G.W. Kaiser. 1997. Effects of introduced predators on the nesting seabirds of the Queen Charlotte Islands. Pages 132-136 *in* K. Vermeer and K.H. Morgan (eds.). The ecology, status and conservation of marine and shoreline birds of the Queen Charlotte Islands. Canadian Wildlife Service Occasional Paper 93. Ottawa, ON.

[301]Harfenist, A. and R.C. Ydenberg. 1995. Parental provisioning and predation risk in Rhinoceros Auklets (*Cerorhinca monocerata*): effects on nestling growth and fledging. Behavioral Ecology 6:82-86.

[302]Harfenist, A., K.R. MacDowell, T. Golumbia, G. Schultze, and Laskeek Bay Conservation Society. 2000. Monitoring and control of raccoons on seabird colonies in Haida Gwaii (Queen Charlotte Islands). Pages 333-339 *in* L.M. Darling (ed.). At risk: Proceedings of a conference on the biology and management of species and habitats at risk. British Columbia Ministry of Environment, Lands and Parks, Victoria, B.C.

[303]Harfenist, A., N.A. Sloan, and P.M. Bartier. 2002. Living marine legacy of Gwaii Haanas. iii: Marine bird baseline to 2000 and marine bird-related management issues throughout the Haida Gwaii region. Technical Reports in Ecosystem Science No. 36. Parks Canada, Ottawa, ON.

[304]Harris, M.P. and S. Wanless. 1984. The effect of the wreck of seabirds in February 1983 on auk populations on the Isle of May (Fife). Bird Study 31:103-110.

[305]Harris, R.D. 1971. Further evidence of tree nesting in the Marbled Murrelet. Canadian Field-Naturalist 85:67-68.

[306]Hartman, L.H. and D.S. Eastman. 1999. Distribution of introduced Raccoons *Procyon lotor* on the Queen Charlotte Islands: Implications for burrow nesting seabirds. Biological Conservation 88:1-13.

[307]Hartman, L., A.J. Gaston, and D. Eastman. 1997. Raccoon predation on Ancient Murrelets on East Limestone Island, British Columbia. Journal of Wildlife Management 61:377-388.

[308]Hartwick, E.B. 1973. Foraging strategy of the Black Oystercatcher. Ph.D Thesis, University of British Columbia, Vancouver, BC. 138 pp. [Figure 280]

Figure 280. Brian Hartwick's pioneering research on Black Oystercatchers encouraged other students to further study the bird's breeding biology and ecology. This nest contained two chicks and a pipped egg. *Photo by R. Wayne Campbell, Munsie Rocks, BC, 24 June 1975.*

[309]Hasegawa, H. 1984. Status and conservation of seabirds in Japan, with special attention to the Short-tailed Albatross. Pages 487-500 *in* J.P. Croxall, P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Protection, Technical Publication No. 2, Cambridge, England.

[310]Hatch, J.J. and D.V. Weseloh. 1999. Double-crested Cormorant (*Phalacrocorax auritus*). *In* The Birds of North America, No. 441 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. 36 pp.

[311]Hatler, D.F. 1972. The mammals of Pacific Rim National Park. Canadian Wildlife Service Unpublished Report, Edmonton, AB. 223 pp.

[312]Hatler, D.F. 1976. The coastal Mink on Vancouver Island, British Columbia. Ph.D. Thesis, University of British Columbia, Vancouver, BC. 360 pp.

[313]Hatler, D.F. and R.W.Campbell. 1975. Notes on spring migration, including sex segregation, of some western Savannah Sparrows. Syesis 8:401-402.

[314]Hatler, D.F., R.W. Campbell, and A. Dorst. 1973. Birds of Pacific Rim National Park, British Columbia. CanadianWildlife Service Unpublished Report, Edmonton, AB. 383 pp.

[315]Hatler, D.F., R.W. Campbell, and A. Dorst. 1978. Birds of Pacific Rim National Park. British Columbia Provincial Museum Occasional Paper No. 20, Victoria, BC. 194 pp.
[316]Hatler, D.F., D.W. Nagorsen, and A.M. Beal. 2008. Carnivores of British Columbia. Royal BC Museum, Victoria, BC. 407 pp.
[317]Haynes, T.B., M.A. Campbell, J.A. Neilson, and J.A. López. 2013. Molecular identification of seabird remains found in Humpback Whale feces. Marine Ornithology 41:161-166.
[318]Hazlitt, S.L. 1999. Territory quality and parental behaviour of the Black Oystercatcher in the Strait of Georgia, British Columbia. M.Sc. Thesis, Simon Fraser University, Burnaby, BC. 109 pp.
[319]Hearne, M.E. 2015. Black-legged Kittiwake. *in* P.J.A. Davidson, R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). The atlas of the breeding birds of British Columbia, 2008-2012. Bird Studies Canada. Delta, BC.http://www.birdatlas.bc.ca/accounts/speciesaccounts/.jsp?sp=BLK&lang=en
[320]Hedd, A., J.L. Ryder, L. Cowen, and D.F. Bertram. 2002. Inter-annual variation in the diet, provisioning and growth of Cassin's Auklet at Triangle Island, British Columbia: Responses to variation in ocean climate. Marine Ecology Progress Series 229:221-232.
[321]Henderson, B.C. 1972. The control and organization of parental feeding and its relationship to the food supply of the Glaucous-winged Gull, *Larus glaucescens*. M.Sc. Thesis, University of British Columbia. Vancouver, BC. 99 pp.
[322]Henkel, L., J. Dolliver, J. Roletto, J. Beck, B. Bodenstein, V. Bowes, D. Bradley, R. Bradley, J. Burco, C. Cumberworth, M. Flannery, J. Jahncke, S. Knowles, J. Lankton, K. Lindquist, J.K. Parrish, W. Ritchie, and L. Wilson. 2015. Investigation of Cassin's Auklet mortality in the eastern Pacific during the 2014 post-breeding season. Poster presentation at Pacific Seabird Group meeting, February 2015, San Jose, CA.
[323]Hill, J.R. and G. Bogue. 1978. Natural pox infection in a Common Murre (*Uria aalge*). Journal of Wildlife Diseases 14:337-338. (http://montereybay.noaa.gov/research/techreports/trhenkel2015.html)
[324]Hipfner, J.M. 2004. Surveys of permanent seabird monitoring plots on Ramsay Island, Gwaii Haanas in June 2002. *In* A.J. Gaston (ed.). Laskeek Bay Research 13:35-39. Laskeek Bay Conservation Society, Queen Charlotte City, BC.
[325]Hipfner, J.M. 2005. Population status of the Common Murre *Uria aalge* in British Columbia, Canada. Marine Ornithology 33:67-69.
[326]Hipfner, J.M. 2008. Matches and mismatches: Ocean climate, prey phenology and breeding success in a zooplanktivorous seabird. Marine Ecology Progress Series 368:295-304.
[327]Hipfner, J.M. and J.L. Greenwood. 2008. Breeding biology of the Common Murre at Triangle Island, British Columbia, Canada, 2002-2007. Northwestern Naturalist 89:76-84. [Figure 281]

Figure 281. Research on species like Common Murre provides information that aids conservation efforts and helps set priorities for the management of seabird populations in BC. *Photo by R. Wayne Campbell, Triangle Island, BC, August 1974.*

[328]Hipfner, J.M., M.J.F. Lemon, and M.S. Rodway. 2010. Introduced mammals, vegetation changes and seabird conservation on the Scott Islands, British Columbia, Canada. Bird Conservation International 20:295-305.

[329]Hipfner, J.M., K.W. Morrison, and A.-L. Kouwenberg. 2012. Biology of Black Oystercatchers breeding on Triangle Island, British Columbia, 2003-2011. Northwestern Naturalist 93:145-153.

[330]Hoberg, E.P. and P.G. Ryan. 1989. Ecology of helminth parasitism in *Puffinus gravis* (Procellariiformes) on the breeding grounds at Gough Island. Canadian Journal of Zoology 67:220-225.

[331]Hobson, K.A. 1997. Pelagic Cormorant (*Phalacrocorax pelagicus*). *In* The Birds of North America, No. 282. (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, D.C. 28 pp.

[332]Hobson, K.A. and J.C. Driver. 1989. Archaeological evidence for use of the Strait of Georgia by marine birds. Pages 168-173 *in* K. Vermeer, and R.W. Butler (eds.). The status and ecology of marine and shoreline birds in the Strait of Georgia, British Columbia. Canadian Wildlife Service Special Publication. Ottawa, ON.

[333]Hobson, K.A. and S.G. Sealy. 1985. Diving rhythms and diurnal roosting times of Pelagic Cormorants. Wilson Bulletin 97:116-119.

[334]Hobson, K.A. and D. Wilson. 1985. Colony establishment by Pelagic Cormorants on man-made structures in southwest coastal British Columbia. Murrelet 66:84-86.

[335]Hoffman, W., W.P. Elliott, and J.M. Scott. 1975. The occurrence and status of the Horned Puffin in the western United States. Western Birds 6:87-94.

[336]Hoffman, W., J.A. Wiens, and J.M. Scott. 1978. Hybridization between gulls (*Larus glaucescens* and *L. occidentalis*) in the Pacific Northwest. Auk 95:441-458.

[337]Holland, S.S. 1964. Landforms of British Columbia: A physiographic outline. British Columbia Department of Mines and Petroleum Resources Bulletin 48, Ottawa, ON. 138 pp.

[338]Hooper, T.D. 1988. Habitat, reproductive parameters, and nest-site tenacity of urban-nesting Glaucous-winged Gulls at Victoria, British Columbia. Murrelet 69:10-14.

[339]Huntington, C.E, R.G. Butler, and R.A. Mauck. 1996. Leach's Storm-Petrel (*Oceanodroma leucorhoa*). *In* The Birds of North America, No. 233 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC. 32 pp.

[340]IBA Canada. 2017. Important Bird and Biodiversity Areas in Canada. http://www.ibacanada.com/.

[341]Imber, M.J. 1984. Exploitation by rats *Rattus* of eggs neglected by Gadfly Petrels *Pterodroma*. Cormorant 12:82-93.

[342]International Ecotourism Society. 2015. What is ecotourism? http://www.ecotourism.org/what-is-ecotourism.

[343]Irons, D.B., S.J. Kendall, W.P. Erickson, L.L. McDonald, and B.K. Lance. 2000. Nine years after the Exxon Valdez oil spill: Effects on marine bird populations in Prince William Sound, Alaska. Condor 102:723-737.

[344]Islands Protection Society. 1984. Islands at the edge: Preserving the Queen Charlotte Islands wilderness. Douglas & McIntyre, Vancouver, BC.

[345]Jakimchuk, R.D., R.W. Campbell, and D.A. Demarchi. 2015. Ian McTaggart-Cowan: The legacy of a pioneering biologist, educator and conservationist. Harbour Publishing, Madeira Park, BC.

[346]Jambeck, J.R., R. Geyer, C. Wilcox, T.R. Siegler, M. Perryman, A. Andrady, R. Narayan, and K.L. Law. 2015. Plastic waste inputs from land into the ocean. Science 347:768-771.

[347]Jessup, D.A., M.A. Miller, J.P. Ryan, H.M. Nevins, and H.A. Kerkering. 2009. Mass stranding of marine birds caused by a surfactant-producing red tide. PLoS ONE 4(2):e4550.

[348]Jones, I.L, J.B. Falls, and A.J. Gaston. 1987. Colony departure of family groups of Ancient Murrelets. Condor 89:940-943.
[349]Jones, I.L, J.B. Falls, and A.J. Gaston. 1989. The vocal repertoire of the Ancient Murrelet. Condor 91:699-710.
[350]Kaiser, G.W. 1989. Nightly concentration of Bald Eagles at an auklet colony. Northwestern Naturalist 70:12-13.
[351]Kaiser, G.W., D. Bertram, and D. Powell. 1984. A band recovery for the Rhinoceros Auklet. Murrelet 65:57.
[352]Kaiser, G.W., R.H. Taylor, P.D. Buck, J.E. Elliott, G.R. Howald, and M.C. Drever. 1997. The Langara Island seabird habitat recovery project: eradication of Norway rats – 1993-1997. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 304, Delta, BC. 86 pp.
[353]Kelson, J.D., I.A. Manley, and H.R. Carter. 1995. At-sea population size and distribution of Marbled Murrelets in Clayoquot Sound, British Columbia: 1992 and 1993 versus 1982. Pages 90-98 *in* S.K. Nelson and S.G. Sealy (eds.). Biology of the Marbled Murrelet: Inland and at sea. Northwestern Naturalist (Symposium Issue) 76(1), Corvallis, OR.
[354]Kermode, F. 1917. Bare Island bird sanctuary. Report of the Provincial Museum of Natural History for the year 1916. Victoria, B.C.
[355]Kermode, F. 1918. Bare Island bird sanctuary. Report of the Provincial Museum of Natural History for the year 1917. Victoria, B.C.
[356]King, K.A., D.R. Blankinship, and R.T. Paul. 1977. Ticks as a factor in the 1975 nesting failure of Texas Brown Pelicans. Wilson Bulletin 89:157-158.
[357]Krajina, V.J. 1970. Ecology of forest trees in British Columbia. *In* V.J. Krajina and R.C. Brooke (eds.). Ecology of western North America. Volume 2:1-146.
[358]Krajina, V.J. 1973. The conservation of natural ecosystems in British Columbia. Syesis 6:17-31.
[359]Kühn, S., E.L. Bravo Rebolledo, and J.A. van Franeker. 2015. Deleterious effects of litter on marine life. Pages 75-116 *in* M. Bergmann, L. Gutow, and M. Klages (eds.). Marine anthropogenic litter. Springer, Heidelberg, Germany.
[360]Kuiken T., F.A. Leighton, G. Wobeser, K.L. Danesik, J. Riva, and R.A. Heckert. 1998. An epidemic of Newcastle disease in Double-crested Cormorants from Saskatchewan. Journal of Wildlife Diseases 34:457-471.
[361]Lack, D. and R.M. Lockley. 1938. Skokholm Bird Observatory homing experiments 1. 1936-37. Puffins, Storm-Petrels and Manx Shearwaters. British Birds 31:242 248.
[362]Larsen, P.S. 1999. Books and bytes: preserving documents for posterity. Journal of the American Society for Information Science 50:1020-1027.
[363]Larsson, A.K. 1994. The environmental impact from an offshore plant. Wind Engineering 18:213-218.
[364]Laskeek Bay Conservation Society. 2017. Research & publications. http://www.laskeekbay.org/laskeek-bay-publications.
[365]Latgé, J.-P. 1999. *Aspergillus fumigatus* and Aspergillosis. Clinical Microbiology Reviews 12:310-350.
[366]Law, K.L. 2017. Plastics in the marine environment. Annual Review of Marine Science 9:205-229.
[367]Law, K.L., S.E. Morét-Ferguson, N.A. Maximenko, G. Proskurowski, E.E. Peacock, J. Hafner, and C.M. Reddy. 2010. Plastic accumulation in the North Atlantic subtropical gyre. Science 329:1185-1188.
[368]Lemon, M.J.F. 1992. Survey of permanent seabird monitoring plots in Skincuttle Inlet. Pages 25-28 *in* A.J. Gaston, A. Lawrence, and C. French (eds.). Laskeek Bay Conservation Society Report on Scientific Activities in 1991. Laskeek Bay Conservation Society, Queen Charlotte City, BC. [Figure 282]

Figure 282. Moira Lemon was instrumental in establishing the first permanent seabird monitoring plots in the province and has been primarily responsible for follow-up monitoring. *Photo by Michael S. Rodway, Triangle Island, BC, summer 2009.*

[369]Lemon, M.J.F. 1993. Survey of Ancient Murrelet colony at Dodge Point on Lyell Island in 1992. Pages 38-51 *in* A.J. Gaston and A. Lawrence (eds.). Laskeek Bay Conservation Society Report on Scientific Activities No. 3, 1992. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[370]Lemon, M.J.F. 1993. Survey of permanent seabird monitoring plots on Ramsay Island. Pages 52-55 *in* A.J. Gaston and A. Lawrence (eds.). Laskeek Bay Conservation Society Report on Scientific Activities No. 3, 1992. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[371]Lemon, M.J.F. 1997. Seabird colony monitoring on George Island, 1996. *In* A.J. Gaston (ed.). Report on scientific Activities for 1996. Laskeek Bay Research 7:27-48. Laskeek Bay Conservation Society, Queen Charlotte City, B.C.

[372]Lemon, M.J.F. 2003. Surveys of permanent seabird monitoring plots on George Island and East Copper Island, Gwaii Haanas National Park, June 2003. Unpublished report to Parks Canada, December, 2003. Canadian Wildlife Service, Delta, BC. 21 pp.

[373]Lemon, M.J.F. 2005. Surveys of permanent seabird monitoring plots on Rankine Island, Gwaii Haanas National Park, June 2005. Unpublished report to Parks Canada, February, 2006. Canadian Wildlife Service, Delta, BC. 27 pp.

[374]Lemon, M.J.F. 2007. East Limestone Island Ancient Murrelet colony survey, June 2006. *In* A.J. Gaston (ed.). Laskeek Bay Conservation Society Scientific Report, 2006 and 2007. Laskeek Bay Research 15:67-86. Laskeek Bay Conservation Society, Queen Charlotte City, B.C.

[375]Lemon, M.J.F. and A.J. Gaston. 2000. Trends in Ancient Murrelet populations in Haida Gwaii since 1980. *In* A.J. Gaston (ed.). Laskeek Bay Research 9:22-26. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[376]Lockley, R.M. 1953. On the movements of the Manx Shearwater at sea during the breeding season. British Birds 46: Special Supplement.

[377]Lord, J.K. 1866. The naturalist in Vancouver Island and British Columbia, Volumes I and II. Richard Bentley, London, UK. 733 pp.

[378]Lutmerding, J.A. and A.S. Love. 2016. Longevity records of North American birds. Version 2016.1. Patuxent Wildlife Research Center, Bird Banding Laboratory, Laurel, MD. https://www.pwrc.usgs.gov/bbl/longevity/longevity_main.cfm.

[379]Mackas. D.L., S. Batten, and M. Trudel. 2007. Effects on zooplankton of a warmer ocean: recent evidence from the northeast Pacific. Progress in Oceanography 75:223-252.

[380]Madow, W.G. and L.H. Madow. 1944. On the theory of systematic sampling, I. Annals of Mathematical Statistics 15:1-24.

[381]Manuwal, D.A. and R.W. Campbell. 1979. Status and distribution of breeding seabirds of southeastern Alaska, British Columbia, and Washington. Pages 73-91 *in* J.C. Bartonek and D.N.Nettleship (eds.). Conservation of marine birds of northern North America, United States Department of the Interior Fish and Wildlife Service, Wildlife Research Report No. 11, Washington, DC. 315 pp.

[382]Manuwal, D.A. and H.R. Carter. 2001. Natural history of the Common Murre (*Uria aalge californica*). Pages 1-32 *in* D.A. Manuwal, H.R. Carter, T.S. Zimmerman, and D.L. Orthmeyer (eds.). Biology and conservation of the Common Murre in California, Oregon, Washington, and British Columbia. Volume 1: Natural history and population trends. Information and Technology Report USGS/BRD/ITR-2000-0012. United States Geological Survey, Biological Resources Division. Washington, DC.

[383]Manuwal, D.A. and A.C. Thoresen. 1993. Cassin's Auklet (*Ptychoramphus aleuticus*). *In* The Birds of North America, No. 50 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC. 20 pp.

[384]Marcogliese, D.J. 2001. Implications of climate change for parasitism of animals in the aquatic environment. Canadian Journal of Zoology 79:1331-1352.

[385]Martin, P.W. and M.T. Myres. 1969. Observations on the distribution and migration of some seabirds off the outer coasts of British Columbia and Washington State, 1946-1949. Syesis 2:241-256.

[386]Mattox, A. 2013. West coast spill response study. Volume 1: Assessment of British Columbia marine oil spill prevention & response regime. Nuka Research & Planning Group report for British Columbia Ministry of Environment, Victoria, BC. 78 pp.

[387]McCurdy, H.W. 1977. Marine history of the Pacific Northwest 1966 to 1976. Superior Publishing Company, Seattle, WA. 255 pp.

[388]Mehl, R. 1992. Fleas (Siphonaptera) from seabirds and their nests in mainland Norway and Spitzbergen. National Institute of Public Health Annals 15:3-15.

[389]Melville, D.S. 1984. Seabirds of China and the surrounding seas. Pages 501-511 *in* J.P. Croxall, P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Preservation, Technical Publication No. 2, Cambridge, UK.

[390]Merilees, W.J. 1974. A Glaucous-winged Gull mated to a Herring Gull on Okanagan Lake, British Columbia. Canadian Field-Naturalist 88:485-486.

[391]Molnar, M. and N. Koshure. 2009. Cleaning up our ocean: A report on pollution from shipping-related sources in the Pacific north coast integrated management area (Pncima) on the British Columbia coast. David Suzuki Foundation Report, Vancouver, BC. 39 pp.

[392]Monaghan, D.J., C.B. Shedden, K. Ensor, C.R. Fricker, and R.W.A. Girdwood, 1985. Salmonella carriage by Herring Gulls in the Clyde area of Scotland in relation to feeding ecology. Journal of Applied Ecology 22:669-680.

[393]Montevecchi, W.A. 2001. Interactions between fisheries and seabirds. Pages 527-557 *in* E.A. Schreiber and J. Burger (eds.). Biology of marine birds. CRC Press, Boca Raton, FL.

[394]Moors, P.J. and I.A.E. Atkinson. 1984. Predation on seabirds by introduced animals, and factors affecting its severity. Pages 667-690 *in* J.P. Croxall, J.P., P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Preservation, Technical Publication No. 2, Cambridge, UK.

[395]Morbey, Y.E. 1996. The abundance and effects of ticks *(Ixodes uriae)* on nestling Cassin's Auklets *(Ptychoramphus aleuticus)* at Triangle Island, British Columbia. Canadian Journal of Zoology 74:1585-1589.

[396]Morgan, K.H., R.W. Butler, and K. Vermeer. 1992. Environmental disturbance and conservation of marine and shoreline birds on the west coast of Vancouver Island. Pages 129-133 *in* K. Vermeer, R.W. Butler, and K.H. Morgan (eds.). The ecology, status, and conservation of marine and shoreline birds on the west coast of Vancouver Island. Canadian Wildlife Service Occasional Paper No. 75, Ottawa, ON. [Figure 283]

Figure 283. Robert W. Butler worked on Mitlenatch Island in the early 1970s and, as a CWS biologist and Senior Research Scientist, has maintained an active interest in the province's seabirds. Here Rob is scaling rock cliffs during seabird surveys on Triangle Island, BC. *Photo by Michael S. Rodway, 1984.*

[397]Morrison, K.W., J.M. Hipfner, G.S. Blackburn, and D.J. Green. 2011. Effects of extreme climate events on adult survival of three Pacific auks. Auk 128:707-715.

[398]Moskoff, W. and L.R. Bevier. 2002. Mew Gull (*Larus canus*). *In* The Birds of North America, No. 687 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. 28 pp.

[399]Moss, M.L. 2007. Haida and Tlingit use of seabirds from the Forrester Islands, southeast Alaska. Journal of Ethnobiology 27:28-45.

[400]Mott, D.E. and F.L. Boyd. 1995. A review of techniques for preventing cormorant depredations at aquaculture facilities in the southeastern United States. Colonial Waterbirds 18:176-180.

[401]Moul, I.E. and M.B. Gebauer. 2002. Status of the Double-crested Cormorant in British Columbia. British Columbia Ministry of Water, Land and Air Protection, Biodiversity Branch, Wildlife Working Report No. WR-105. Victoria, BC. 36 pp.

[402]Mouritsen, H., D. Heyers, and O. Güntürkün. 2016. The neural basis of long-distance navigation in birds. Annual Review of Physiology 78:133-54.

[403]Munro, J.A. 1922. A proposed bird sanctuary in British Columbia, Okanagan Landing, Swan Lake. Canadian Field-Naturalist 36:26-30.

[404]Munro, J.A. 1924. A preliminary report on the destruction of birds at lighthouses on the coast of British Columbia. Canadian Field-Naturalist 38:141-145,171-175.

[405]Munro, J.A. 1928. Cormorants nesting on Bare Island, British Columbia. Condor 30:327-328.

[406]Munro, J.A. 1937. Nesting colonies of the Double-crested Cormorant in British Columbia. Pages 26-30 *in* Provincial Museum of Natural History Report for the year 1936, Victoria, BC.

[407]Munro, J.A. and I.McT. Cowan. 1947. A review of the bird fauna of British Columbia. British Columbia Provincial Museum Special Publication 2, Victoria, BC. 285 pp.

[408]Munro, W.T. and R.W. Campbell. 1979. Programs and authorities of the province of British Columbia related to marine bird conservation. Pages 247-250 *in* J.C. Bartonek, J.C. and D.N. Nettleship (eds.). Conservation of marine birds of northern North America. United States Fish and Wildlife Service, Wildlife Research Report No. 11, Washington, DC. 315 pp.

[409]Murie, O.J. 1940. Food habits of the northern Bald Eagle in the Aleutian Islands, Alaska. Condor 42:198-202. [Figure 284]

[410]Murphy, S.M., R.H. Day, J.A. Wiens, and K.R. Parker. 1997. Effects of the Exxon Valdez oil spill on birds: Comparisons of pre-and post-spill surveys in Prince William Sound, Alaska. Condor 99:299-313.

[411]Muzaffar, S.B. and Jones, I.L. 2004. Parasites and diseases of the auks (Alcidae) of the world and their ecology – a review. Marine Ornithology 32:121-146.

[412]Myres, M.T. 1955. British Columbia Nest Records Scheme: 1st annual report. University of British Columbia Department of Zoology, Vancouver, BC. Mimeograph. 8 pp.

Figure 284. Although marine birds constitute the majority of the Bald Eagle's diet along the north coast, new discoveries during the BC seabird surveys revealed the adaptability of the species. This healthy, young Bald Eagle was found on the ground and prey remains nearby indicated that it had been raised primarily on Northern Abalone (*Haliotis kamtschatkana*). Avian prey remains were also found, including Sooty Shearwater, Harlequin Duck, Glaucous-winged Gull, Common Murre, Tufted Puffin, and Ancient Murrelet. *Photo by R. Wayne Campbell, Rock Islet, BC, 6 July 1977.*

[413]Myres, M.T., I.McT. Cowan, and M.D.F Udvardy. 1957. The British Columbia nest records scheme. Condor 59:308-310.

[414]Nagorsen, D.W. 2005. Rodents and Lagomorphs of British Columbia. Royal BC Museum, Victoria, BC. 410 pp.

[415]NaiKun Wind Energy Group. 2015. Proposed NaiKon project. http://naikum.ca/the project-description.

[416]National Oceanic and Atmospheric Administration. 2017. Seabird protection & avoidance tips. http://www.nmfs.noaa.gov/sfa/management/recreational/documents/seabird_protection_avoidance.pdf.

[417]Nelson, D.A. 1991. Demography of the Pigeon Guillemot on southeast Farrollon Island, California. Condor 93:765-768.

[418]Nelson, R.W. 1990. Status of the Peregrine Falcon, *Falco peregrinus peali*, on Langara Island, British Columbia, 1968-1989. Canadian Field-Naturalist 104:193-199.

[419]Nelson, R.W. and M.T. Myres. 1976. Declines in populations of Peregrine Falcons and their seabird prey at Langara Island, British Columbia. Condor 78:281-293. [Figure 285]

Figure 285. Lighthouse keepers along the BC coast have provided support and local information to biologists like Wayne Nelson for many decades. In this photo, head keeper Charles Redhead's wife Joan (left), Harry Carter, and Martin Lee are enjoying a tour of the Langara Point lighthouse. *Photo by R. Wayne Campbell, Langara Point, BC, 28 July 1977.*

[420]Nettleship, D.N. 1976. Census techniques for seabirds of arctic and eastern Canada. Canadian Wildlife Service Occassional Paper 25. Ottawa, ON. 33 pp.

[421]Newcombe, C.F. 1923. Menzies' journal of Vancouver's voyage. [Including biographical note by J. Forsyth.]. Archives of British Columbia, Memoir No. 5. Victoria, BC. 171 pp.

[422]Nuszdorfer, F.C., K. Klinka, and D.A. Demarchi. 1991. Coastal Douglas-Fir zone. Pages 81-93 *in* D. Meidinger and J. Pojar (compilers and editors). Ecosystems of British Columbia. Special Report Series 6. British Columbia Ministry of Forests, Research Branch, Victoria, BC. 330 pp.

[423]Nuttall, P.A. 1984. Tick-borne viruses in seabird colonies. Seabird 7:31-41.

[424]O'Connell, M.J., J.C. Coulson, S. Raven, and S. Joyce. 1997. Nonbreeding and nests without eggs in the Lesser Black-backed Gull *Larus fuscus*. Ibis 139:252-258.
[425]O'Hara, P.D. and K.H. Morgan. 2006. Do low rates of oiled carcass recovery in beached bird surveys indicate low rates of ship-source oil spills? Marine Ornithology 34:133-140.
[426]Oldaker, F. 1963. Unusual nest site of the Glaucous-winged Gull. Canadian Field-Naturalist 77:65-66.
[427]Olsen, B., D.C. Duffy, T.G. Jaenson, A. Gylfe, J. Bonnedahl, and S. Bergström. 1995. Transhemispheric exchange of Lyme disease spirochetes by seabirds. Journal of Clinical Microbiology 33:3270-3274.
[428]ORNIS. 2014. http://ornis2.ornisnet.org/ (accessed 13 January 2014).
[429]Osgood, W.H. 1901. Natural history of the Queen Charlotte Islands, British Columbia and natural history of the Cook Inlet region, Alaska. United States Department of Agriculture Division of Biological Survey, North American Fauna No. 21:1-87.
[430]Pallas, P.S. 1811. Zoographia Rosso Asiatica, Volume 2 (*Phalacrocorax pelagicus pelagicus*, page 303). Berlin, Germany.
[431]Parks Canada. 2008. State of the parks report - Pacific Rim National Park Reserve of Canada. 62 pp. (http://publications.gc.ca/collections/collection_2011/pc/R63-370-2008-eng.pdf).
[432]Parks Canada. 2010. Pacific Rim National Park Reserve of Canada management plan 2010. (www.pc.gc.ca/eng/pn-np/bc/pacificrim/~/media/pn.../pacificrim/.../2010-plan_e.ashx)
[433]Parks Canada. 2013 Gulf Islands National Park Reserve of Canada Draft Management Plan April, 2013. www.pc.gc.ca/pn-np/bc/gulf/~/.../gulf/.../GINPR_Draft_Plan_E_April_25_2013.ashx
[434]Parks Canada. 2015. Ecosystem restoration in Gwaii Haanas. http://www.pc.gc.ca/eng/pn-np/bc/gwaiihaanas/plan/Plan5/Plan5A.aspx.
[435]Parks Canada. 2017. Feasibility study for the proposed southern Strait of Georgia National Marine Conservation Area Reserve. https://www.pc.gc.ca/en/amnc-nmca/cnamnc-cnnmca/dgs-ssg.
[436]Paton, S. and R. Rangeley. 2006. Bilge oil blues. http://www.elements.nb.ca/theme/oceans06/sarah/sarah.htm.
[437]Pattison, J. and A. Brown. 2013. East Limestone Island field station: Field season reports 2010-2012. *In* A.J. Gaston (ed.). Laskeek Bay Research 17:1-32. Laskeek Bay Conservation Society, Queen Charlotte City, BC.
[438]Pattison, J. and V. Pattison. 2013. East Limestone Island field station: Field season report 2013. Laskeek Bay Conservation Society, Queen Charlotte City, BC. 21 pp.
[439]Pearse, T. 1946. Nesting of Western Gull off the coast of Vancouver Island, British Columbia, and possible hybridization with Glaucous-winged Gull. Murrelet 27:39-40.
[440]Pearse, T. 1946. Notes on changes in bird populations in the vicinity of Comox, British Columbia – 1917 to 1944. Murrelet 27:4-9.
[441]Pearse, T. 1956. Changes in breeding populations of pelagic birds in the Gulf of Georgia, B.C. Murrelet 37:22-23.
[442]Pearson, M. and M.C. Healey. 2012. Species at risk and local government: a primer for BC. Stewardship Centre of British Columbia, Courtenay, BC. http://www.speciesatriskbc.ca/node/8045.
[443]Phillips, E.M., J.E. Zamon, H.M. Nevins, C.M. Gibble, R.S. Duerr, and L.H. Kerr. 2011. Summary of birds killed by a harmful algal bloom along south Washington and north Oregon coasts during October 2009. Northwestern Naturalist 92:120-126.
[444]Piatt, J.F. and A.S. Kitaysky. 2002. Horned Puffin (*Fratercula corniculata*). *In* The Birds of North America, No. 603 (A. Poole and F. Gill eds.). The Birds of North America, Inc., Philadelphia, PA. 27 pp.

[445]Piatt, J.F. and A.S. Kitaysky. 2002. Tufted Puffin (*Fratercula cirrhata*). *In* The Birds of North America, No. 708 (A. Poole and F. Gill eds.). The Birds of North America, Inc., Philadelphia, PA. 32 pp. [Figure 286]

Figure 286. Tufted Puffin is widespread in the North Pacific Ocean. Over 80% of the world population breeds in North America. Starvation, predation, oil pollution, and fisheries by-catch are major sources of mortality that need better assessment. *Photo by Liam Singh*.

[446]Piatt, J.F and D.N. Nettleship. 1985. Diving depths of four alcids. Auk 102:293-297.
[447]Piatt, J.F. and T.I. van Pelt. 1997. Mass mortality of guillemots (*Uria aalge*) in the Gulf of Alaska in 1993. Marine Pollution Bulletin 34:656-662.
[448]Pierce, D.J. and T.R. Simons. 1986. The influence of human disturbance on Tufted Puffin breeding success. Auk 103:214-216.
[449]Pierotti, R.J. and T.P. Good. 1994. Herring Gull (*Larus argentatus*). *In* The Birds of North America, No. 124 (A. Poole and F. Gill eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC. 28 pp.
[450]Pierson, E.C., C.E. Huntington, and N.T. Wheelwright. 1989. Homing experiment with Leach's Storm-Petrels. Auk 106:148-150.
[451]Pitman, R.L. and M.R. Graybill. 1985. Horned Puffin sightings in the eastern Pacific. Western Birds 16:99-102.
[452]Pitman, R.L., J. Hodder, M.R. Graybill, and D.H. Varoujean. 1985. Catalog of Oregon seabird colonies. United States Fish and Wildlife Service Unpublished Report, Portland, OR.
[453]Podolski, R.H. and S.W. Kress. 1989. Plastic debris incorporated into Double-crested Cormorant nests in the Gulf of Maine. Journal of Field Ornithology 60:248-250.
[454]Pojar, J. and A. Banner. 1984. Old-growth forests and introduced Black-tailed Deer on the Queen Charlotte Islands, British Columbia. Pages 247-257 *in* W.R. Meehan, T.R. Merrell, and T.A. Hanley (eds.) Fish and wildlife relationships in old-growth forests. American Institute of Fisheries Research Biologists. Morehead City, NC.
[455]Pojar, J., K. Klinka, and D.A. Demarchi. 1991. Coastal Western Hemlock Zone. Pages 95-111 *in* D. Meidinger and J. Pojar (compilers and editors). Ecosystems of British Columbia. Special Report Series 6. British Columbia Ministry of Forests, Research Branch, Victoria, BC. 330 pp.
[456]Pollonara, E., P. Luschi, T. Guilford, M. Wikelski, F. Bonadonna, and A. Gagliardo. 2015. Olfaction and topography, but not magnetic cues, control navigation in a pelagic seabird: displacements with shearwaters in the Mediterranean Sea. Scientific Report 5:16486; doi: 10.1038/srep16486.
[457]Poynter, A. 1976. Glaucous-winged Gull – unusual nesting sites. Discovery 5:8-10.
[458]Price, I.M. and J.G. Nickum. 1995. Aquaculture and birds: the context for controversy. Colonial Waterbirds 18 (Special Publication 1):33-45.
[459]Provencher, J.F., A.L. Bond, and M.L. Mallory. 2014. Marine birds and plastic debris in Canada: a national synthesis and a way forward. Environmental Review 23:1-13.

[460]Purdy, M.A. 1985. Parental behaviour and role differentiation in the Black Oystercatcher *Haematopus bachmani*. Master's thesis, University of Victoria, Victoria, BC. 239 pp.

[461]Pynn, L. 2010. Lyell Island: 25 years later. Vancouver Sun newspaper, Wednesday, November 17.

[462]Regehr, H.M. and W.A. Montevecchi. 1997. Interactive effects of food shortage and predation on breeding failure of Black-legged Kittiwakes: indirect effects of fisheries activities and implications for indicator species. Marine Ecology Progress Series 155:249-260.

[463]Regehr, H.M., M.S. Rodway, M.J.F. Lemon, and J.M. Hipfner. 2007. Recovery of the Ancient Murrelet *Synthliboramphus antiquus* colony on Langara Island, British Columbia, following eradication of invasive rats. Marine Ornithology 35:137-144.

[464]Reid, W.V. 1988. Population dynamics of the Glaucous-winged Gull. Journal of Wildlife Management 52:763-770.

[465]Resources Inventory Committee. 1997. Inventory Methods for seabirds: cormorants, gulls, murres, storm-petrels, Ancient Murrelet, auklets, puffins, and Pigeon Guillemot. Standards for Components of British Columbia's Biodiversity No. 13. British Columbia Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force. Victoria, BC. 54 pp. [Figure 287]

Figure 287. Recording exactly what is found during seabird surveys, such as the two one-quarter-grown young and addled egg shown in this Glaucous-winged Gull nest, is valuable for later analysis. *Photo by R. Wayne Campbell, Langara Point, BC, 28 June 1977.*

[466]Robertson, I. 1971. Influence of brood-size on reproductive success of two species of cormorant, *Phalacrocorax auritus* & *P. pelagicus*, and its relation to the problem of clutch-size. Ph.D. Thesis, University of British Columbia, Vancouver, BC.

[467]Robertson, I. 1974. The food of nesting double-crested and pelagic cormorants at Mandarte Island, British Columbia, with notes on feeding ecology. Condor 76:346-348.

[468]Rock, J. 2006. East Limestone Island field station: report on the 2005 field season. *In* A.J. Gaston (ed.). Laskeek Bay Research 14:13-23. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[469]Rock, J. and J. Pattison. 2007. East Limestone Island field station: report on the 2006 field season. *In* A.J. Gaston (ed.). Laskeek Bay Conservation Society Scientific Report, 2006 and 2007. Laskeek Bay Research 15:1-13. Laskeek Bay Conservation Society, Queen Charlotte City, B.C.

[470]Rodway, M.S. 1988. British Columbia seabird colony inventory: Report #3 – Census of Glaucous-winged Gulls, Pelagic Cormorants, Black Oystercatchers, and Pigeon Guillemots in the Queen Charlotte Islands, 1986. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 43, Delta, BC. 95 pp.

[471]Rodway, M.S. 1990. Attendance patterns, hatching chronology and breeding population of Common Murres on Triangle Island, British Columbia following the Nestucca oil spill. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 87, Delta, BC.46 pp.

[472]Rodway, M.S. 1990. COSEWIC assessment and status report on the Marbled Murrelet *Brachyramphus marmoratus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. 82 pp.

[473]Rodway, M.S. 1991. Status and conservation of breeding seabirds in British Columbia. Pages 43-102 *in* J.P. Croxall (ed.). Seabird status and conservation: a supplement. International Council for Bird Preservation, Technical Publication No. 11, Cambridge, UK.

[474]Rodway, M.S. and R.W. Campbell. 1977. Natural history theme study of marine bird and mammal habitat in the Gulf Islands, British Columbia. Parks Canada Unpublished Project Report, Ottawa, ON. 107 pp.

[475]Rodway, M.S. and M.J.F. Lemon. 1990. British Columbia seabird colony inventory: Report #5 – west coast Vancouver Island. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 94, Delta, BC.87 pp.

[476]Rodway, M.S. and M.J.F. Lemon. 1991. British Columbia seabird colony inventory: Report #7 – northern mainland coast. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 121, Delta, BC. 182 pp.

[477]Rodway, M.S. and M.J.F. Lemon. 1991. British Columbia seabird colony inventory: Report #8 – Queen Charlotte Strait and Johnstone Strait. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 123, Delta, BC. 82 pp.

[478]Rodway, M.S. and M.J.F. Lemon. 2011. Use of permanent plots to monitor trends in burrow-nesting seabird populations in British Columbia. Marine Ornithology 39:243-253.

[479]Rodway, M.S., H.R. Carter, S.G. Sealy, and R.W. Campbell. 1992. Status of the Marbled Murrelet in British Columbia. Pages 17-41 *in* H.R. Carter and M.L. Morrison (eds.). Status and Conservation of the Marbled Murrelet in North America, Proceedings of the Western Foundation of Vertebrate Zoology Volume 5, No. 1, Camarillo, CA.

[480]Rodway, M.S., M.J.F. Lemon, and G.W. Kaiser. 1988. British Columbia seabird colony inventory: Report #1 – east coast Moresby Island. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 50, Delta, BC. 276 pp. [Figure 288]

[481]Rodway, M.S., M.J.F. Lemon, and G.W. Kaiser. 1990. British Columbia seabird colony inventory: Report #2 – west coast Moresby Island. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 65, Delta, BC. 163 pp.

Figure 288. Norman Holmes (right) and Heather Hay helped with CWS surveys during the 1980s. They are two of over 400 individuals who helped with surveys of seabird colonies in the province since 1961. *Photo by Michael S. Rodway, Kunghit Island, BC, summer 1986.*

[482]Rodway, M.S., M.J.F. Lemon, and G.W. Kaiser. 1994. British Columbia seabird colony inventory: Report #6 – major colonies on the west coast of Graham Island. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 95, Delta, BC. 108 pp. [Figure 289]

Figure 289. Michael Rodway, looking at Hippa Island from nearby Nesto Inlet, BC, is here enjoying a few minutes of reflection during seabird surveys. Difficult weather conditions, and the intense period of activity required to take advantage of the brief seabird breeding season, make such musings a rare event for seabird biologists. *Photo by Moira J.F. Lemon, 30 June 1983.*

[483]Rodway, M.S., M.J.F. Lemon, J-P. Savard, and R. McKelvey. 1989. Nestucca oil spill: impact assessment on avian populations and habitat. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 66., Delta, BC. 48 pp.

[484]Rodway, M.S., M.J.F. Lemon, and K.R. Summers. 1990. British Columbia seabird colony inventory: Report #4 – Scott Islands. Census results from 1982 to 1989 with reference to the Nestucca oil spill. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report Series No. 86, Delta, BC. 109 pp. [Figure 290]

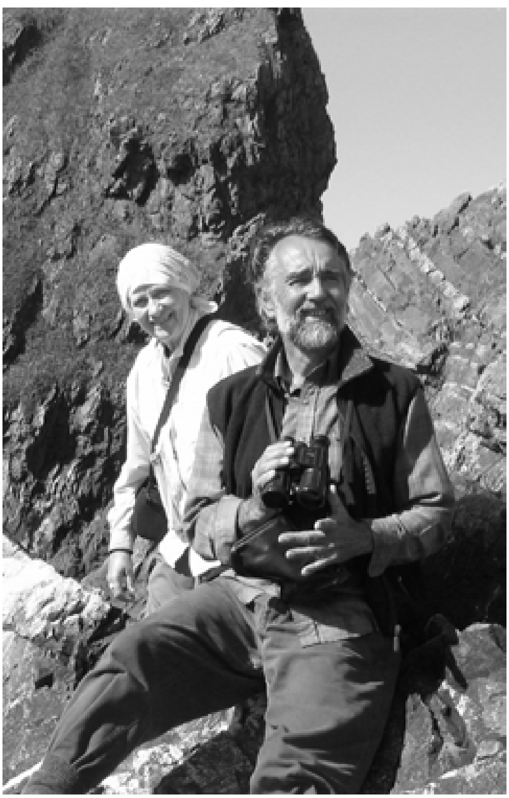


Figure 290. Moira Lemon (left) and Michael Rodway conducted seabird colony inventory and monitoring together throughout the 1980s and in some years since. *Photo by Heidi M. Regehr, Triangle Island, BC, June 2009.*

[485]Rodway, M.S., M.J.F. Lemon, and K.R. Summers. 1992. Seabird breeding populations in the Scott Islands on the west coast of Vancouver Island. Pages 52-59 *in* K. Vermeer, R.W. Butler, and K.H. Morgan (eds.). The ecology, status, and conservation of marine and shoreline birds on the west coast of Vancouver Island. Canadian Wildlife Service Occasional Paper No. 75, Ottawa, ON.

[486]Rodway, M.S., J.A. Sedgwick, and N.C. Sedgwick. 1992. First record of Mew Gulls breeding in the Queen Charlotte Islands, British Columbia. Northwestern Naturalist 73:61-62.

[487]Rodway, M.S., K.R. Summers, J.M. Hipfner, J.C. van Rooyen, and R.W. Campbell. 2011. Changes in abundance and distribution of Pelagic Cormorants nesting on Triangle Island, British Columbia, 1949-2010. Wildlife Afield 8:147-166.

[488]Rodway, M.S., L.K. Wilson, M.J.F. Lemon, and R.L. Millikin. 2017. The ups and downs of ecosystem engineering by burrow-nesting seabirds on Triangle Island, British Columbia. Marine Ornithology 45:47-55. [Figure 291]

Figure 291. The vegetated steep slopes where Cassin's Auklets nest in West Bay on Triangle Island, BC, pose a physical challenge for seabird surveyors. *Photo by Michael S. Rodway, 16 July 1985.*

[489]Rothstein, S.I. 1973. Plastic particle pollution of the surface of the Atlantic Ocean: Evidence from a seabird colony. Condor 75:344-345.

[490]Royal British Columbia Museum. 2014. http://search-collections.royalbcmuseum.bc.ca Ornithology (accessed 13 January 2014).

[491]Rumsey, A.S. 2016. When we are no more: how digital memory is shaping our future. Bloomsbury Press, London, UK. 240 pp.

[492]Russell, D.J.F., S. Wanless, Y.C. Collingham, B. Huntley, and K.C. Hamer. 2015. Predicting future European breeding distributions of British seabird species under climate change and unlimited/no dispersal scenarios. Diversity 7:342-359. doi:10.3390/d7040342.

[493]Ryan P.G. 1987. The effects of ingested plastic on seabirds: correlations between plastic load and body condition. Environmental Pollution 46:119-125.

[494]Ryder, G. and R.W. Campbell. 2004. First occurrence of Wandering Salamander on the Sunshine Coast of British Columbia. Wildlife Afield 1:5-6.

[495]Ryder, G.R., R.W. Campbell, H.R. Carter, and S.G. Sealy. 2012. Earliest well-described tree nest of the Marbled Murrelet: Elk Creek, British Columbia, 1955. Wildlife Afield 9:49-58.

[496]Ryder, J.M. and J.J. Claque. 1989. British Columbia Quaternary stratigraphy and history, Cordilleran Ice Sheet. Pages 48-58 *in* J.J. Clague (compiler). Quaternary geology of the Canadian Cordillera. Chapter One pages 15-96 *in* R.J. Fulton (editor). Quaternary Geology of Canada and Greenland. Geology of Canada No. 1. Geological Survey of Canada, Ottawa, ON, 839 pp.

[497]Sanford, F.J. 1974. An instance of gull predation. Discovery 2:120.

[498]Sanford, F.J. 1974. Gulls nesting on Water Street – 1972-73. Discovery 2:119-120.

[499]Savard, J.-P.L. and G.E.J. Smith. 1985. Comparison of survey techniques for burrow-nesting seabirds. Canadian Wildlife Service progress report No. 151, Ottawa, ON. 7 pp.

[500]Savoca, M.S., M.E. Wohlfeil, S.E. Ebeler, and G.A. Nevitt. 2016. Marine plastic debris emits a keystone infochemical for olfactory foraging seabirds. Science Advances 2:e1600395.

[501]Schreiber, E.A. 2001. Climate and weather effects on seabirds. Pages 179-215 *in* E.A. Schreiber and J. Burger (eds.). Biology of marine birds. CRC Press, Boca Raton, FL.

[502]Sealy, S.G. 1973. Adaptive significance of post-hatching developmental patterns and growth rates in the Alcidae. Ornis Scandinavica 4:113-121.

[503]Sealy, S.G., 1973. Interspecific feeding assemblages of marine birds off British Columbia. Auk 90:796-802.

[504]Sealy, S.G. 1974. Breeding phenology and clutch size in the Marbled Murrelet. Auk 91:10-23.

[505]Sealy, S.G. 1975. Aspects of the breeding biology of the Marbled Murrelet in British Columbia. Bird-banding 46:141-154.

[506]Sealy, S.G. 1975. Egg size of murrelets. Condor 77:500-501.

[507]Sealy, S.G. 1975. Feeding ecology of the Ancient and Marbled Murrelets near Langara Island, British Columbia. Canadian Journal of Zoology 53:418-433.

[508]Sealy, S.G. 1976. Biology of nesting Ancient Murrelets. Condor 78:294-306.

[509]Sealy, S.G. 1984. Interruptions extend incubation by Ancient Murrelets, Crested Auklets, and Least Auklets. Murrelet 65:53-56.

[510]Sealy, S.G. 2015. Breeding status of Ancient Murrelets attending gathering grounds near Langara Island, British Columbia, 1970-1971. Northwestern Naturalist 96:87-92.

[511]Sealy, S.G. *In press*. Observations of birds at Langara Island, Haida Gwaii (formerly Queen Charlotte Islands), British Columbia, 1970 and 1971. Wildlife Afield. [Figure 292]

[512]Sealy, S.G. and R.W. Campbell. 1979. Post-hatching movements of young Ancient Murrelets. Western Birds 10:25-30.

[513]Sealy, S.G. and H.R. Carter. 1984. At-sea distribution and nesting habitat of the Marbled Murrelet in British Columbia: problems in the conservation of a solitarily nesting seabird. Pages 737-756 *in* J.P. Croxall, P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Preservation, Technical Report No. 2, Cambridge, UK.

[514]Sealy, S.G. and H.R. Carter. 2016. Non-breeding female Cassin's Auklets killed at a lighthouse at Pine Island, British Columbia, 1976 and 1977. Northwestern Naturalist 97:135-138.

Figure 292. Spencer Sealy, professor emeritus at the University of Manitoba and editor of *Wildlife Afield*, has maintained his early interest in BC's seabirds and has published extensively on their biology and ecology. In this photo, seabird biologists Victor Zubakin (left), Spencer Sealy, and Ian Rose, are walking back to Gambell, on St. Lawrence Island, AK, from the cloud-shrouded Sevuokuk Mountain. *Photo by Lisa Sheffield, August 2004.*

[515]Sealy, S.G. and R.W. Nelson. 1973. The occurrence and status of the Horned Puffin in British Columbia. Syesis 6:51-55.

[516]Sealy, S.G., H.R. Carter, R.E. Thomson, and K.H. Morgan. 2013. Movements of Ancient Murrelet family groups to northern Vancouver Island, British Columbia. Northwestern Naturalist 94:209-226.

[517]Sealy, S.G., P. Pyle, and H.R. Carter. 2015. Ancient Murrelets molt flight feathers after the precocial young become independent. Northwestern Naturalist 96:212-221.

[518]Shealer, D.A. 2001. Foraging behavior and food of seabirds. Pages 137-177 *in* E.A. Schreiber and J. Burger (eds.). Biology of marine birds. CRC Press, Boca Raton, FL.

[519]Shelford, C.M. 1988. The falcon is telling us something. Report of the Committee of Inquiry on Falcons. Queen's Printer, Victoria, BC. 60 pp.

[520]Shoji, A. 2013. Using a video camera to study colony attendance and feeding rates of crevice-nesting Pigeon Guillemots. *In* A.J. Gaston (ed.). Laskeek Bay Research 17:46-49. Laskeek Bay Conservation Society, Queen Charlotte City, BC.

[521]Shumway, S.E., S.M. Allen, and P.D. Boersma. 2003. Marine birds and harmful algal blooms: sporadic victims or under-reported events? Harmful Algae 2:1-17.

[522]Shuntov, V.P. 1986. Seabirds in the Sea of Okhotsk. *In* N.M. Litvinenko (ed.). Seabirds of the Far East: collection of scientific papers. Union of Soviet Socialist Republics Academy of Sciences, Vladivstok, USSR. (Translation for Environment Canada).

[523]Smith, J. 2003. East Limestone Island field station: report on the 2002 field season. *In* A.J. Gaston (ed.). Laskeek Bay Research 12:1-18. Laskeek Bay Conservation Society, Queen Charlotte City, BC. [Figure 293]

Figure 293. For over 25 years, the Laskeek Bay Conservation Society, a volunteer group, has continued Tony Gaston's research on Ancient Murrelets through monitoring programs that include banding and measuring departing chicks. Plastic barriers are set up to funnel chicks into catchment areas. *Photo by R. Wayne Campbell, East Limestone Island, BC, 5 June 2000.*

[524]Smith, J. and K. Morgan. 2005. An assessment of seabird bycatch in longline and net fisheries in British Columbia. Canadian Wildlife Service, Pacific and Yukon Region, Technical Report No. 401, Sidney, BC. 51 pp.

[525]Society Promoting Environmental Conservation. 2010. A history of oil off our coast. http://www.spec.bc.ca/Resources/Documents/Land%20%20Water%20Conservation/A_History_of_oil_off_our_coast.pdf.

[526]Southern, W.E. 1986. Histoplasmosis associated with a gull colony: health concerns and precautions. Colonial Waterbirds 9:121-123.

[527]Sowls, A.L., A.R. DeGange, J.W. Nelson, and G.S. Lester. 1980. Catalog of California seabird colonies. Bureau of Land Management, Fish and Wildlife Service, United States Department of the Interior, Biological Services Program FWS/OBS-80/37, Washington, DC. 371 pp.

[528]Sowls, A.L., S.A. Hatch, and C.J. Lensink. 1978. Catalog of Alaskan seabird colonies. United States Fish and Wildlife Service, Biological Services Program, FWS/OBS 78/78, Anchorage, AK.

[529]Sowls, A.L., D.R. Nysewander, J.L. Trapp, and J.W. Nelson. 1982. Marine bird and mammal survey of the outer coast of southeast Alaska. United States Fish and Wildlife Service Unpublished Report, Anchorage, AK. 162 pp.

[530]Speich, S.M. and T.R. Wahl. 1989. Catalog of Washington seabird colonies. United States Fish and Wildlife Service and Minerals Management Service Biological Report 88(6), Washington, DC. 510 pp.

[531]Spiegel, C.S., S.M. Haig, M.I. Goldstein, and M. Huso. 2012. Factors affecting incubation patterns and sex roles of Black Oystercatchers in Alaska. Condor 114:123-134.

[532]Stirling, D. and F. Buffam. 1966. The first breeding record of Brandt's Cormorant in Canada. Canadian Field-Naturalist 80:117-118.

[533]Sullivan, T.M. 1989. Double-crested and Pelagic Cormorants in the Strait of Georgia. Canadian Wildlife Service Unpublished report, Delta, BC. 28pp.

[534]Sullivan, T.M., S.L. Hazlitt and M.J.F. Lemon. 2002. Population trends of nesting Glaucous-winged Gulls, *Larus glaucescens*, in the southern Strait of Georgia, British Columbia. Canadian Field Naturalist 116:603-606.

[535]Summers, K.R. 1974. Seabirds breeding along the east coast of Moresby Island, Queen Charlotte Islands, British Columbia. Syesis 7:1-12. [Figure 294]

Figure 294. Boats cannot be safely landed or anchored at many seabird colonies. Checking headlands on Lost Islands, off the east coast of Moresby Island, for nesting Glaucous-winged Gulls requires at least two people – one to keep the boat offshore and one to conduct the survey. *Photo by J. Bristol Foster, 11 July 1977.*

[536]Summers, K.R. and R.W. Campbell. 1978. Natural history theme study of bird and mammal habitats of Canada's Pacific coast and adjacent coastal waters. Parks Canada Unpublished Project Report. Ottawa, ON. 239 pp. [Figure 295]

[537]Summers, K.R. and R.H. Drent. 1979. Breeding biology and twinning experiments of Rhinoceros Auklets on Cleland Island, British Columbia. Murrelet 66:16-22.

[538]Summers, K. and M.S. Rodway. 1988. Raccoon-seabird interactions (with notes on rats and Marten) on Moresby Island, Queen Charlotte Islands: a problem analysis. British Columbia Ministry of Environment and Parks Unpublished Report, Smithers, BC. 62 pp.

Figure 295. In wet seepage areas and meadows, patches of the attractive yellow monkey-flower *Mimulus guttatus* (left) and scarlet paintbrush *Castilleja miniata* bring a riot of colour to many seabird colonies. *Photo by R. Wayne Campbell, Grassy Island, BC, 23 June 1975.*

[539]Tasker, M.L. and R.W. Furness (eds.). 2003. Seabirds as monitors of the marine environment. International Council for the Exploration of the Sea Cooperative Research Report No. 258, Copenhagen, DK. 73 pp.

[540]Tasker, M.L., C.J. Camphuysen, J. Cooper, S. Garthe, W.A. Montevecchi, and S.J.M. Blaber. 2000. The impacts of fishing on marine birds. ICES Journal of Marine Science 57:531-547.

[541]Taverner, P.A. 1928. Birds of western Canada (second revised edition). Canada Department of Mines Museum Bulletin No. 41, Ottawa, ON. 379 pp.

[542]Taylor, F.H.C. 1985. Introduction to the international symposium on the characteristics of herring and their implications for management. Canadian Journal of Fisheries and Aquatic Sciences 42:2.

[543]Taylor, R.H., G.W. Kaiser, and M.C. Drever. 2000. Eradication of Norway Rats for recovery of seabird habitat on Langara Island, British Columbia. Restoration Ecology 8:151-160.

[544]Tessler, D.F., J.A. Johnson, B.A. Andres, S. Thomas, and R.B. Lanctot. 2010. Black Oystercatcher (*Haematopus bachmani*) conservation action plan. Version 1.1. International Black Oystercatcher Working Group, Alaska Department of Fish and Game, Anchorage, AK, United States Fish and Wildlife Service, Anchorage, AK and Manomet Center for Conservation Sciences, Manomet, MA. 115 pp. http://www.whsrn.org/conservation-plan.

[545]Tessler, D.F., J.A. Johnson, B.A. Andres, S. Thomas, and R.B. Lanctot. 2014. A global assessment of the conservation status of the Black Oystercatcher *Haematopus bachmani*. International Wader Studies 20:83-96.

[546]Therriault, T.W., D.E. Hay, and J.F. Schweigert. 2009. Biologic overview and trends in pelagic forage fish abundance in the Salish Sea (Strait of Georgia, British Columbia). Marine Ornithology 37:3-8.

[547]Thompson, R.C., S.H. Swan, C.J. Moore, and F.S. vom Saal. 2009. Our plastic age. Philosophical Transactions of the Royal Society of London B: Biological Sciences 364:1973-1976

[548]Thompson, S.P. 1989. Observations of Bald Eagles eating Glaucous-winged Gull eggs in western Washington. Northwestern Naturalist 70:13-14.

[549]Thomson, R.E. 1981. Oceanography of the British Columbia coast. Canadian Special Publication of Fisheries and Aquatic Sciences 56, Ottawa, ON. 291 pp.

[550]Threlfall, W. 1968. The food of three species of gulls in Newfoundland. Canadian Field-Naturalist 82:176-180.

[551]Tinbergen, J.M. 2009. Rudolf Herman Drent (1937-2008). Ardea 97:1-6.

[552]Tuck, L.M. 1961. The murres: their distribution, population and biology – a study of the genus *Uria*. Canadian Wildlife Service Monograph No. 1, Ottawa, ON. 260 pp.

[553]United States Army Corps of Engineers. 2015. Final EIS: Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. www.nwp.usace.army.mil/Missions/Current/Cormorant-EIS.

[554]United States Department of the Interior, Fish and Wildlife Service. 1988. Catalog of Alaskan Seabird Colonies - computer database. United States Department of the Interior, Fish and Wildlife Service, Anchorage, Alaska.

[555]Vallée, A. and R.J. Cannings. 1983. Nesting of the Thick-billed Murre, *Uria lomvia*, in British Columbia. Canadian Field-Naturalist 97:450-451.

[556]Vallée, A. and H.R. Carter. 1987. Breeding phenology of Common Murres on Triangle Island, British Columbia, in 1980 and 1981. Pacific Seabird Group Bulletin 14:71.

[557]Van Damme, L.M. 2004. First breeding record of the Double-crested Cormorant in the Creston Valley, British Columbia. Blue Jay 62:79-83. [Figure 296]

[558]Van Damme, L.M. 2012. Creston Valley birds - when and where to find them. Biodiversity Centre for Wildlife Studies Special Publication No. 14, Victoria, BC. 35 pp.

Figure 296. In 2003, Linda Van Damme discovered Double-crested Cormorants nesting in large riparian black cottonwood trees at Leach Lake in the Creston valley. This was the second breeding colony found in the BC interior. *Photo by Linda Van Damme, 30 July 2011.*

[559]Van Tets, G.F. 1959. A comparative study of the reproductive behaviour and natural history of three sympatric species of cormorants (*Phalacrcorax auritus*, *Phalacrcorax penicillatus, and Phalacrcorax pelagicus*) at Mandarte Island, B.C. M.A. Thesis, University of British Columbia, Vancouver, BC. 86 pp.

[560]Verbeek, N.A.M. 1979. Timing of primary molt and egg-laying in Glaucous-winged Gulls. Wilson Bulletin 91:420-425.

[561]Verbeek, N.A.M. 1982. Egg predation by Northwestern Crows: its association with human and Bald Eagle activity. Auk 99:347-352.

[562]Verbeek, N.A.M. 1988. Differential predation of eggs in clutches of Glaucous-winged Gulls *Larus glaucescens*. Ibis 130:512-518.

[563]Verbeek, N.A.M. 1993. Glaucous-winged Gull (*Larus glaucescens*). *In* The Birds of North America, No. 59 (A. Poole and F. Gill eds.). The Academy of Natural Sciences, Philadelphia, PA. and The American Ornithologists' Union, Washington, D.C. 19 pp.

[564]Verbeek, N.A.M. and J.L. Morgan. 1978. River Otter predation on Glaucous-winged Gulls on Mandarte Island, B.C. Murrelet 59:92-95.

[565]Vermeer, K. 1963. The breeding ecology of the Glaucous-winged Gull (*Larus glaucescens*) on Mandarte Island, B.C. British Columbia Provincial Museum Occassional Paper No. 13, Victoria, BC. 104 pp. [Figure 297]

Figure 297. Glaucous-winged Gull nests in BC have been found to contain one to five eggs. Four-egg clutches are rare and account for less than one percent of all nests with eggs recorded. *Photo by Michael S. Rodway, Garcin Rocks, BC, 18 June 1986.*

[566]Vermeer, K. 1978. Extensive reproductive failure of Rhinoceros Auklets and Tufted Puffins. Ibis 120:112.

[567]Vermeer, K. 1979. Nesting requirements, food and breeding distribution of Rhinoceros Auklets, *Cerorhinca monocerata*, and Tufted Puffins, *Lunda cirrhata*. Ardea 67:101-110.
[568]Vermeer, K. 1980. The importance of timing and type of prey to reproductive success of Rhinoceros Auklets *Cerorhinca monocerata*. Ibis 122:343-350.
[569]Vermeer, K. 1981. The importance of plankton to Cassin's Auklets during breeding. Journal of Plankton Research 3:315-329.
[570]Vermeer, K. 1982. Comparison of the diet of the Glaucous-winged Gull on the east and west coasts of Vancouver Island. Murrelet 63:80-85.
[571]Vermeer, K. 1983. Marine bird populations in the Strait of Georgia; comparison with the west coast of Vancouver Island. Canadian Hydrographic and Ocean Sciences, Technical Report No. 19, Ottawa, ON. 18 pp.
[572]Vermeer, K. 1984. The diet and food consumption of nestling Cassin's Auklets during summer, and a comparison with other plankton-feeding alcids. Murrelet 65:65-77.
[573]Vermeer, K. 1985. A five-year summary (1978-1982) of the nestling diet of Cassin's Auklets in British Columbia. Canadian Hydrography and Ocean Sciences, Technical Report No. 56, Sidney, BC. 15 pp.
[574]Vermeer, K. 1989. Introduction to the nesting seabirds of the Strait of Georgia. Pages 84-87 *in* K. Vermeer and R.W. Butler (eds.). The status and ecology of marine and shoreline birds in the Strait of Georgia, British Columbia. Canadian Wildlife Service Special Publication No. 4, Ottawa, ON.
[575]Vermeer, K. 1992. Population growth of the Glaucous-winged Gull *Larus glaucescens* in the Strait of Georgia, British Columbia, Canada. Ardea 80:181-185.
[576]Vermeer, K. and L. Cullen. 1979. Growth of Rhinoceros Auklets and Tufted Puffins, Triangle Island, British Columbia. Ardea 67:22-27.
[577]Vermeer, K. and L. Cullen. 1982. Growth comparison of a plankton- and a fish- feeding alcid. Murrelet 63:34-39.
[578]Vermeer, K. and K. Devito. 1986. Size, caloric content, and association of prey fishes in meals of nestling Rhinoceros Auklets. Murrelet 67:1-9.
[579]Vermeer, K. and K. Devito. 1987. Habitat and nest-site selection of Mew and Glaucous-winged gulls in coastal British Columbia. *In* J.I. Hand, W.E. Southern, and K. Vermeer (eds.). Ecology and behavior of gulls. Proceedings of an international symposium of the Colonial Waterbird Group and the Pacific Seabird Group, San Francisco, 1985. Studies in Avian Biology No. 10:105-118.
[580]Vermeer, K. and K. Devito. 1988. The importance of *Paracallisoma coecus* and myctophid fishes to nesting Fork-tailed and Leach's storm-petrels in the Queen Charlotte Islands, British Columbia. Journal of Plankton Research 10:63-75.
[581]Vermeer, K. and K. Devito. 1989. Population trend of nesting Glaucous-winged Gulls in the Strait of Georgia. Pages 88-93 *in* K. Vermeer and R.W. Butler (eds.). The status and ecology of marine and shoreline birds in the Strait of Georgia, British Columbia. Canadian Wildlife Service Special Publication No. 4, Ottawa, ON.
[582]Vermeer, K. and M. Lemon. 1986. Nesting habits and habitats of Ancient Murrelets and Cassin's Auklets in the Queen Charlotte Islands, British Columbia. Murrelet 67:33-44.
[583]Vermeer, K. and K.H. Morgan. 1989. Mariculture and bird interactions in the Strait of Georgia. Pages 174-176 *in* K. Vermeer and R.W. Butler (eds.). The status and ecology of marine and shoreline birds in the Strait of Georgia, British Columbia. Canadian Wildlife Service Special Publication No. 4, Ottawa, ON.
[584]Vermeer, K. and L. Rankin. 1984. Population trends in nesting Double-crested and Pelagic Cormorants in Canada. Murrelet 65:1-9. [Figure 298]

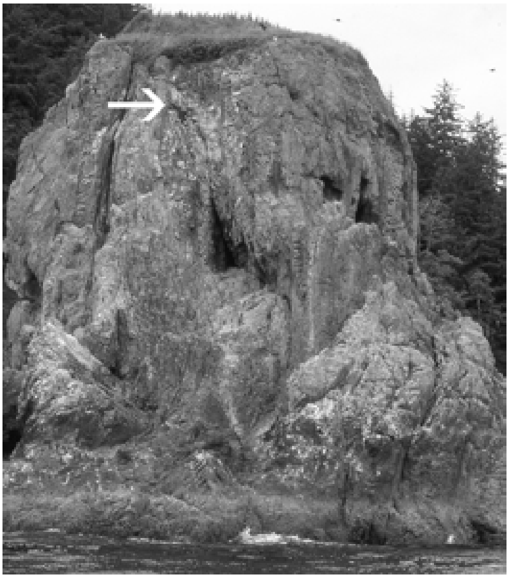


Figure 298. Rock-climbing skills are useful for surveying some Pelagic Cormorant colonies in BC. Once the cormorant nests were counted, this surveyor (top centre) continued to the top to count nesting Glaucous-winged Gulls. *Photo by R. Wayne Campbell, Crombie Point, Ramsay Island, BC, 9 July 1977.*

[585]Vermeer, K. and S.G. Sealy. 1984. Status of the nesting seabirds of British Columbia. Pages 29-40 *in* J.P. Croxall, P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Protection, Technical Publication No. 2, Cambridge, UK.

[586]Vermeer, K. and R. Vermeer. 1975. Oil threat to birds on the Canadian west coast. Canadian Field-Naturalist 89:278-298.

[587]Vermeer, K. and S.J. Westrheim. 1984. Fish changes in diets of nestling Rhinoceros Auklets and their implications. Pages 96-105 *in* D.N. Nettleship, G.A. Sanger, and P.F. Singer (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Proceedings of the Pacific Seabird Group Special Symposium, Seattle, WA, 6-9 Jan. 1982. Special Publication, Canadian Wildlife Service, Ottawa, ON.

[588]Vermeer, K., L. Cullen, and M. Porter. 1979. A provisional explanation of the reproductive failure of Tufted Puffins *Lunda cirrhata* on Triangle Island, British Columbia. Ibis 121:348-354.

[589]Vermeer, K., K. Devito, and L. Rankin. 1988. Comparison of nesting biology of Fork-tailed and Leach's storm-petrels. Colonial Waterbirds 11:46-57.

[590]Vermeer, K., P.J. Ewins, K.H. Morgan, and G.E.J. Smith. 1992. Population, nesting habitat, and reproductive success of American Black Oystercatchers on the west coast of Vancouver Island. Pages 65-70 *in* K. Vermeer, R.W. Butler, and K.H. Morgan (eds.). The ecology, status, and conservation of marine and shoreline birds on the west coast of Vancouver Island. Canadian Wildlife Service Occasional Paper No. 75, Ottawa, ON.

[591]Vermeer, K., J.D. Fulton, and S.G. Sealy. 1985. Differential use of zooplankton prey by Ancient Murrelets and Cassin's Auklets in the Queen Charlotte Islands. Journal of Plankton Research 7:443-459.

[592]Vermeer, K., A. Harfenist, G.W. Kaiser, and D.N. Nettleship. 1997. The reproductive biology, status, and conservation of seabirds breeding in the Queen Charlotte Islands: a summary. Pages 58-77 *in* K. Vermeer, K. and K.H. Morgan (eds.). The ecology, status and conservation of marine and shoreline birds of the Queen Charlotte Islands. Canadian Wildlife Service Occasional Paper 93, Ottawa, ON.

[593]Vermeer, K., D.A. Manuwal, and D.S. Bingham. 1976. Seabirds and pinnipeds of Sartine Island, Scott Island group, British Columbia. Murrelet 57:14-16. [Figure 299]

[594]Vermeer, K., K.H. Morgan, and P.J. Ewins. 1992. Population trends of Pelagic Cormorants and Glaucous-winged Gulls on the west coast of Vancouver Island. Pages 60-64 *in* K. Vermeer, R.W. Butler, and K.H. Morgan (eds.). The ecology, status, and conservation of marine and shoreline birds on the west coast of Vancouver Island. Canadian Wildlife Service Occasional Paper No. 75, Ottawa, ON.

Figure 299. Sartine Island, encompassing 1,091 ha in the Scott Islands, was established in 1971 as a provincial Ecological Reserve to protect internationally important nesting sites and terrestrial habitat for breeding birds. *Photo by Michael S. Rodway, August, 1987.*

[595]Vermeer, K., K.H. Morgan, and G.E.J. Smith. 1989. Population and nesting habitat of American Black Oystercatchers in the Strait of Georgia. Pages 118-122 *in* K. Vermeer and R.W. Butler (eds.). The status and ecology of marine and shoreline birds in the Strait of Georgia, British Columbia. Canadian Wildlife Service Special Publication No. 4, Ottawa, ON.

[596]Vermeer, K., K.H. Morgan, and G.E.J. Smith. 1989. Population trends and nesting habitat of Double-crested and Pelagic cormorants in the Strait of Georgia. Pages 94-99 *in* K. Vermeer and R.W. Butler (eds.). The status and ecology of marine and shoreline birds in the Strait of Georgia, British Columbia. Canadian Wildlife Service Special Publication No. 4, Ottawa, ON.

[597]Vermeer, K., K.H. Morgan, and G.E.J. Smith. 1992. Black Oystercatcher habitat selection, reproductive success, and their relationship with Glaucous-winged Gulls. Colonial Waterbirds 15:14-23.

[598]Vermeer, K., K.H. Morgan, and G.E.J. Smith. 1993. Colony attendance of Pigeon Guillemots as related to tide height and time of day. Colonial Waterbirds 16:1-8.

[599]Vermeer, K., K.H. Morgan, and G.E.J. Smith. 1993. Nesting biology and predation of Pigeon Guillemots in the Queen Charlotte Islands, British Columbia. Colonial Waterbirds 16:119-129.

[600]Vermeer, K., K.H. Morgan, G.E.J. Smith, and B.A. York. 1991. Effects of egging on the reproductive success of Glaucous-winged Gulls. Colonial Waterbirds 14:158-165.

[601]Vermeer, K., D. Power, and G.E.J. Smith. 1988. Habitat selection and nesting biology of roof-nesting Glaucous-winged Gulls. Colonial Waterbirds 11:189-201.

[602]Vermeer, K., S.G. Sealy, M. Lemon, and M.S. Rodway. 1984. Predation and potential environmental perturbances on Ancient Murrelets nesting in British Columbia. Pages 757-770 *in* J.P. Croxall, P.G.H. Evans, and R.W. Schreiber (eds.). Status and conservation of the world's seabirds. International Council for Bird Protection, Technical Publication No. 2, Cambridge, UK.

[603]Vermeer, K., K.R. Summers, and D.S. Bingham. 1976. Birds observed at Triangle Island, British Columbia, 1974 and 1975. Murrelet 57:35-42. [Figure 300]

Figure 300. Rarely do seabird biologists record and publish lists of animals seen incidental to their main research. An Eastern Kingbird seen on Triangle Island, BC, on 5 July 1974, was the first record on the west coast of Vancouver Island of this very rare vagrant. *Photo by R. Wayne Campbell.*

[604]Vermeer, K., I. Szabo, and P. Greisman. 1987. The relationship between plankton- feeding Bonaparte's and Mew Gulls and tidal upwelling at Active Pass, British Columbia. Journal Plankton Research 9:483-501.

[605]Vermeer, K., R.A. Vermeer, K.R. Summers, and R.R. Billings. 1979. Numbers and habitat selection of Cassin's Auklet breeding on Triangle Island, British Columbia. Auk 96:143-151.

[606]Vines, T.H., A.Y.K. Albert, R.L. Andrew, F. Débarre, D.G. Bock, M.T. Franklin, K.J. Gilbert, J.-S. Moore, S. Renaut, and D.J. Rennison. 2014. The availability of research data declines rapidly with article age. Current Biology 24:94-97.

[607]Vyatkin, P.S. 1986. Nesting cadastres of colonial birds in the Kamchatka region. *In* N.M. Litvinenko, (ed.). Seabirds of the Far East: Collection of scientific papers. Union of Soviet Socialist Republics Academy of Sciences, Vladivstok, USSR. (Translation for Environment Canada).

[608]Wallace, E.A.H. and G.E. Wallace. 1998. Brandt's Cormorant (*Phalacrocorax penicillatus*). *In* The Birds of North America, No. 362 (A. Poole and F. Gill eds.). The Birds of North America, Inc., Philadelphia, PA. 28 pp.

[609]Wallace, G.E., B. Collier, and W.J. Sydeman. 1992. Interspecific nest-site competition among cavity-nesting alcids on southeast Farallon Island, California. Waterbirds 15:241-244.

[610]Ward, J.G. 1973. Reproductive success, food supply, and the evolution of clutch-size in the Glaucous-winged Gull. Ph.D. thesis, University of British Columbia, Vancouver, BC. 119 pp.

[611]Warzybok, P.M., M. Johns, and R.W. Bradley. 2014. Status of seabirds on southeast Farallon Island during the 2014 breeding season. United States Fish and Wildlife Service Unpublished Report. Point Blue Conservation Science Contribution Number 2013. Point Blue Conservation Science, Petaluma, CA. 13 pp.

[612]Watanuki, Y. 1990. Daily activity pattern of Rhinoceros Auklets and kleptoparasitism by Black-tailed Gulls. Ornis Scandinavica 21:28-36.

[613]Watanuki, Y., M. Aotsuka, and T. Terasawa. 1986. Status of seabirds breeding on Teuri Island. Tori 34:146-150.

[614]Watt, A. 2002. The Last Island. Harbour Publishing, Madeira Park, BC.

[615]Wehle, D.H.S. 1982. Food of adult and subadult Tufted and Horned puffins. Murrelet 63:51-58.

[616]Wehle, D.H.S. 1983. The food, feeding and development of young Tufted and Horned puffins in Alaska. Condor 85:427-442.

[617]Wei, D. and S. Clouthier. 2016. Angling at B.C.'s top fishing resorts. Vancouver Sun article, 16 May 2016. http://vancouversun.com/travel/angling-at-b-c-s-top-fishing-resorts.

[618]West Coast Offshore Exploration Environmental Assessment Panel. 1986. Offshore hydrocarbon exploration: report and recommendations. Energy, Mines and Resources Canada, Ottawa, ON and British Columbia Ministry of Energy, Mines and Petroleum Resources, Victoria, BC.

[619]White, A.F., J.P. Heath, and B. Gisborne. 2006. Seasonal timing of Bald Eagle attendance and influence on activity budgets of Glaucous-winged Gulls in Barkley Sound, British Columbia. Waterbirds 29:497-500.

[620]Wiese, F. and G. Robertson. 2004. Assessing seabird mortality from chronic oil discharges at sea. Journal of Wildlife Management 68:627-638.

[621]Wiese, F.K, W.A. Montevecchi, G.K. Davoren, F. Huettmann, A.W. Diamond, and J. Limke. 2001. Seabirds at risk around offshore oil platforms in the north-west Atlantic. Marine Pollution Bulletin 42:1285-1290.

[622]Wilbur, H.M. 1969. The breeding biology of Leach's Petrel *Oceanodroma leucorhoa*. Auk 86:433-442. [Figure 301]

[623]Wilcox C, E. van Sebille, and B.D. Hardesty. 2015. Threat of plastic pollution to seabirds is global, pervasive, and increasing. Proceedings of the National Academy of Science 112:11899-904.

[624]Wild Bird Society of Japan. 1985. The count of Rhinoceros Auklet nests on Matsumaekojima Island. Strix 4:26-32.

[625]Willett, G. 1915. Summer birds of Forrester Island, Alaska. Auk 32:295-305.

Figure 301. Michael Rodway with two adult Leach's Storm-Petrels extracted from the same burrow on Gillam Islands on the west coast of Vancouver Island, BC. No egg had yet been laid. *Photo by R. Wayne Campbell, 28 June 1975.*

[626]Wiltschko, R. and W. Wiltschko. 2013. The magnetite-based receptors in the beak of birds and their role in avian navigation. Journal of Comparative Physiology A Neuroethology, Sensory, Neural, and Behavioral Physiology 199:89-98. (doc 10.1007/s00359-012-0769-3).

[627]Wittenberger, J.F. and G.L. Hunt, Jr. 1985. The adaptive significance of coloniality in birds. Avian Biology 8:1-78.

[628]Wood, J. 2012. Open B.C.'s offshore. Financial Post newspaper, September 27, Toronto, ON.

[629]Young, Rev. C.J. 1930. A study of the Rhinoceros Auklet and other birds in British Columbia, 1929. *In* Report of the Provincial Museum of Natural History for the year 1929. King's Printer, Victoria, BC. p. F16-F19.

[630]Zhao-qing, C. 1988. Niche selection of breeding seabirds on Chenlushan Island in the Yellow Sea, China. Colonial Waterbirds 11:306-307.

[631]Žydelis, R., C. Small, and G. French. 2013. The incidental catch of seabirds in gillnet fisheries: a global review. Biological Conservation 162:76-88.

OTHER SOURCES OF INFORMATION

Personal Communications and Unpublished Data

[632]Andre Breault, Canadian Wildlife Service.
[633]Kenneth Bruun, lighthouse keeper at Langara Point.
[634]Wayne Campbell, Biodiversity Centre for Wildlife Studies.
[635]Myke Chutter, BC Ministry of Water, Land and Air Protection (reported to Anne Harfenist [303]).
[636]Michael Dunn, Canadian Wildlife Service.
[637]Tony Gaston, Canadian Wildlife Service.
[638]Rick Hoar, BC Conservation Officer Service.
[639]Paul Lehman, Leader, Wings Birding Tours Worldwide.
[640]Moria Lemon, Canadian Wildlife Service.
[641]Roy Lowe, U.S. Fish and Wildlife Service.
[642]Dave Mark, Professor, State University of New York, Buffalo.
[643]Ken Morgan, Canadian Wildlife Service (reported to Michael Rodway [475]).
[644]Heidi Regehr, under contract to Canadian Wildlife Service.
[645]Dan Rodway, air conditioning specialist.
[646]Peggy Sowden, Mitlenatch Island Stewardship Team.
[647]Julie Steciw, BC Forest, Land and Natural Resources Operations, Fish & Wildlife.
[648]Terry Sullivan, under contract to Canadian Wildlife Service.
[649]Laurie Wilson, Canadian Wildlife Service.

Other Sources

[650]BCNRS (British Columbia Nest Record Scheme).

About the Authors

Michael's childhood home was at the end of a small gravel road in the remote village of Coquitlam, 24 km from downtown Vancouver. The property sat on the edge of miles and miles of wild forest that was a wonderful playground for small boys growing up. However, the idyllic rural existence wasn't to last long. Coquitlam turned out to be one of the fastest growing suburbs of Vancouver and Michael witnessed throughout his childhood the rapid transformation of treasured wild places into paved-over suburbia.

After leaving home at seventeen, and working, travelling, and taking some college courses, Michael ventured back into the wilderness and began homesteading for several years in Port Neville, a small fiord on the BC mainland coast north of Campbell River. Michael's passion for seabirds was ignited in 1975 when he met Wayne Campbell while they were both taking courses at the University of Victoria. After participating in some course projects together, Wayne invited Michael to join him for the upcoming summer in the first provincial survey of seabird colonies that Wayne had initiated through the BCPM. That was one of those moments where your life changes.

Seabird surveys with the BCPM lasted four amazing years, during which Michael got to visit almost every island and rock along the outer coast of BC, learned how to maneuver inflatable zodiacs through rough seas and to land on rocky shores off the crests of large waves, and most of all became addicted to the wonder and intensity of life on seabird colonies that are like no other place on earth. Those experiences cemented a life-long friendship with Wayne, who continues to inspire Michael with his passion and commitment today.

After that exhilarating four years, Michael decided to try his hand at teaching. That wasn't a good fit, and during his first year of teaching Michael found that he was spending more time than his pupils gazing out the window dreaming about outdoor adventures. So it wasn't a difficult decision when in 1981 Kees Vermeer from Canadian Wildlife Service (CWS) phoned and asked Michael if he would be willing to survey the seabird colony on Langara Island at the northwest tip of the Queen Charlotte Islands. It meant leaving before the school year was out, but Michael managed to find a replacement teacher approved by the local school board, packed away his school curriculum books, and headed off to begin the second phase of his seabird career.

In the second year of conducting seabird surveys under contract with CWS, Michael was partnered with Moira Lemon. They formed a dynamic duo. Over a period of 10 years, and with the help of many summer students, they conducted rigorous surveys of almost all colonies of burrow-nesting seabirds in BC, re-counted almost all colonies of surface-nesting species in northern BC, assessed the immediate seabird mortality and subsequent impact of the *Nestucca* oil spill, and conducted some of the first studies on Marbled Murrelets in the Queen Charlotte Islands. They also formed a life-long friendship, and continue to share the passion for wilderness and a fascination with seabirds today.

Michael at the base of the old lighthouse on Triangle Island, BC, during surveys of seabird monitoring plots in 2009. *Photo by Heidi M. Regehr, 29 July 2009.*

Wayne retired in 2000, having spent most of his professional life as a curator of vertebrates with the Cowan Vertebrate Museum at the University of British Columbia in Vancouver and Provincial Museum (now Royal British Columbia Museum) in Victoria. He finished the last few years of his career as a senior research scientist with the British Columbia Ministry of Environment in Victoria, completing the four-volume set *The Birds of British Columbia* as lead author.

He is an award-winning writer and has authored, co-authored, or contributed chapters to over 45 books and has penned an additional 560 articles on molluscs, echinoderms, amphibians, reptiles, birds, and mammals. He has been honored for his work with many awards including the Award of Excellence in Biology (now the Ian McTaggart-Cowan Award) from the Association of Professional Biologists of British Columbia (1989), the Order of British Columbia (1992), and two Commemorative Medals of Canada. He also received a Lifetime Achievement Award from the Federation of BC Naturalists (now Nature BC) and is an Honorary Life Member of the Vancouver Natural History Society.

He is co-founder of the non-profit organization *Biodiversity Centre for Wildlife Studies* (www.wildlifebc.org) and has served as associate editor of its bi-annual journal *Wildlife Afield* since its inception in 2004. This latest book, *Seabird Colonies of British Columbia: A Century of Changes,* a co-operative undertaking with Michael Rodway and Moira Lemon, has been a four-decade project.

Fifty years after surveying his first seabird colony on Christie Island in Howe Sound, Wayne is still monitoring and counting nesting seabirds off southern Vancouver Island. In this photo, Wayne has just located a Black Oystercatcher nest with two eggs (bottom centre). *Photo by Ronald D. Jakimchuk, Arbutus Island, BC, 31 May 2014.*

Moira grew up in the West Point Grey area of Vancouver with the trails of Pacific Spirit Park (then known as the University of BC Endowment Lands) and the surrounding beaches as a "backyard" playground. Summer holidays at Roberts Creek on the Sechelt Peninsula further instilled a keen interest in the natural world, with many happy hours spent investigating tide pools and watching the daily activities of the marine birds that frequented the area. The view from the beach of the White Islets, a seabird colony, was perhaps the first glimpse of the places where a future career would take her.

She graduated with a Bachelor of Science degree in Zoology from the University of British Columbia (UBC) in 1975. Outdoor skills and experiences gained while an active member of the Varsity Outdoor Club at UBC led to a career as a wildlife technician with the Canadian Wildlife Service (CWS) of Environment Canada beginning as a casual employee in 1977. In the early years, projects included waterfowl surveys in the Yukon and the lower mainland, and Caribou behaviour studies in the north.

Once on permanent status, from 1980 onwards, her main project was surveying seabird colonies in the remote areas of the coast, a demanding but very rewarding experience. Her introduction to seabirds began with Ancient Murrelets and Cassin's Auklets of Frederick Island in Haida Gwaii, when she and Trudy Chatwin (Carson), a veteran of the Provincial Museum seabird program, worked on a project there for CWS research scientist, Kees Vermeer. This then led into the 1980s CWS survey and monitoring program of all BC seabird colonies which she and co-leader Michael Rodway conducted with a team of eager students. Participation in some of the inaugural surveys of Marbled Murrelets in BC, sandpiper migration studies on the Fraser River delta and the sand spit on Sidney Island, and continuing a monitoring program on selected seabird colonies were the focus of the rest of her career with CWS.

Moira retired in 2014 after more than 34 years. She remains in close contact with the CWS seabird team and accompanies them on a few of their surveys most field seasons. Over the course of several decades, the passage of time is evident, particularly when visiting colony areas that were once majestic forests but are now fallen victims of intense storms, or seeing areas that were a tangle of windfall in the 1980s, but are now transformed into impenetrable jungles of thick regenerating saplings and small trees.

Currently living in Ladner with husband, Chris McNeill, hiking, sailing, skiing, and traveling take up much of their time, often sharing these adventures with Michael Rodway, (a friendship forged through the shared experiences exploring those seabird islands), and his wife Heidi.

Moira hiking to the next permanent seabird monitoring plot on Triangle Island, BC, during surveys in 2009. Strapped to her pack are extra aluminum poles to replace those that mark the corners of monitoring plots and that may have been lost since the last survey five years previously. *Photo by Michael S. Rodway, 6 August 2009.*

Overleaf: Glaucous-winged Gull. *Photo by Alan D. Wilson.*

Reprinting funded by SERVICE CANADIEN DE LA FAUNE CANADIAN WILDLIFE SERVICE

Southern Coast, British Columbia

ISSN 1712-2880