FEATURE ARTICLES

Decline of Pelagic Cormorants in Barkley Sound, British Columbia

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Abstract

In 1989, a decline in numbers of nesting Pelagic Cormorants (*Phalacrocorax pelagicus*) was first reported in Barkley Sound, British Columbia. Reasons for this decline were unclear and no follow-up studies occurred. In 2006 and 2007, we resurveyed all 32 known or suspected breeding colonies and confirmed this decline which appears to have resulted in a long-term reduction in population size. By collating available nesting records since 1947, we determined that a decline of about 85% (*i.e.,* from 170 to 26 nests) occurred between about 1969 and 2006-2007, with many colonies abandoned between 1982 and 1989. Reasons for this decline are poorly known but may include reduction in prey availability, disturbance of nesting colonies, predators, and possibly other factors. More fieldwork is needed to monitor population status and protect remaining colonies in Barkley Sound and other areas along the west coast of Vancouver Island.

Introduction

In the late 1980s and 1990s, declines in Pelagic Cormorant (*Phalacrocorax pelagicus*) populations were reported throughout British Columbia, including Queen Charlotte Strait, north mainland coast, Queen Charlotte Islands, Strait of Georgia, and west coast Vancouver Island (Vermeer and Rankin 1984, Campbell et al. 1990, Rodway 1991, Vermeer et al. 1992, Fraser et al. 1999, Chatwin et al. 2002). In contrast, populations in Washington, Oregon, and California appeared roughly stable between 1975-1982 and 1988-1991 (Carter et al. 1995). Reasons for decline and colony shifting of Pelagic Cormorants in the Strait of Georgia included prey changes, disturbance of colonies, and high levels of predation (Vermeer and Rankin 1984, Rodway 1991, Chatwin et al. 2002), although population increases had been noted at some colonies earlier in the 20th century due to early protection from human disturbance (*e.g.,* Mandarte Island; Munro 1937, Drent and Guiguet 1961). Reasons for decline in other parts of British Columbia are poorly studied and understood.

Figure 1. Barkley Sound, an area of 800 km^2, is situated on the central west coast of Vancouver Island between Ucluelet and Bamfield. Hundreds of islands and partly sheltered waters provide a popular recreational area for saltwater fishing, sea kayaking, and boating. 11 August 1969 (R. Wayne Campbell).

In this paper, we assess decline in the Barkley Sound population of nesting Pelagic Cormorants (Figures 1 and 2) on the southwest coast of Vancouver Island that was first noted in 1989 (Vermeer et al. 1992). We surveyed all known nesting locations and roosts in 2006, resurveyed a portion of known colonies in 2007, and collated all known nesting records from 1947 to 2007. This region of the west coast of Vancouver Island has had the greatest survey effort over time but survey data still are incomplete or missing for most years. Regardless of these prob-

lems, Barkley Sound contains the bulk of the Pelagic Cormorant population of southwest Vancouver Island from Sooke to Estevan Point (Campbell 1976, Carter et al. 1984, Rodway 1991) and forms a discrete and accessible geographic area with similar environmental conditions for assessing status of Pelagic Cormorants in this region. Given that Pelagic Cormorants can breed intermittently at small colonies (Carter et al. 1984, Rodway et al. 1990), determination of trends is difficult without complete data over several years. We assess trends with available incomplete data, discuss possible causes of decline, identify the need for additional colony protection, and suggest future monitoring approaches. A detailed appendix of raw data provides evidence of nesting or lack of evidence obtained at each location in each year. This appendix will greatly facilitate efforts by future researchers to attempt different analysis approaches, if desired.

"In 1989, a decline in numbers of nesting Pelagic Cormorants was first reported in Barkley Sound ... Reasons for this decline are poorly known ..."

Figure 2. Over the past two and a half decades numbers of Pelagic Cormorants nesting along the British Columbia coast appear to be decreasing. Mitlenatch Island, BC. 25 August 1969 (R. Wayne Campbell).

Methods

2006 Survey

On 10 and 11 July 2006, HRC (see *Observers* on page 31 for acronyms) and PNH travelled by 4.2 m inflatable boat powered by a 20 hp. outboard engine to all 32 known or suspected nesting locations of Pelagic Cormorants in Barkley Sound between Pachena Point and Amphitrite Point (Figure 3, Table 1). At each location, we observed nesting habitats from the boat with the naked eye or binoculars and recorded numbers of visible nests, birds attending nests or roosting nearby, and chicks visible in or outside nests, and presence of guano indicative of recent roosting. Birds were aged as "breeding adults" (*i.e.,* black and green plumage with iridescence, crests, and white flank patches), "non-breeding adults" (*i.e.,* black and green plumage without white flank patches), "subadults" (*i.e.,* partial green and black plumage and partial or nearly complete and worn brownish plumage without white flank patches), or "juveniles" (*i.e.,* all brownish unworn plumage). At several cave sites, all possible nesting ledges cannot be viewed from the survey boat, although use of an inflatable boat facilitates better views than other types of boats. We ventured as far as possible into water-bottomed sea caves before rocks or shore prevented further access but this varied at some sites due to tide, sea conditions, cave shape, and boat size. At certain sites

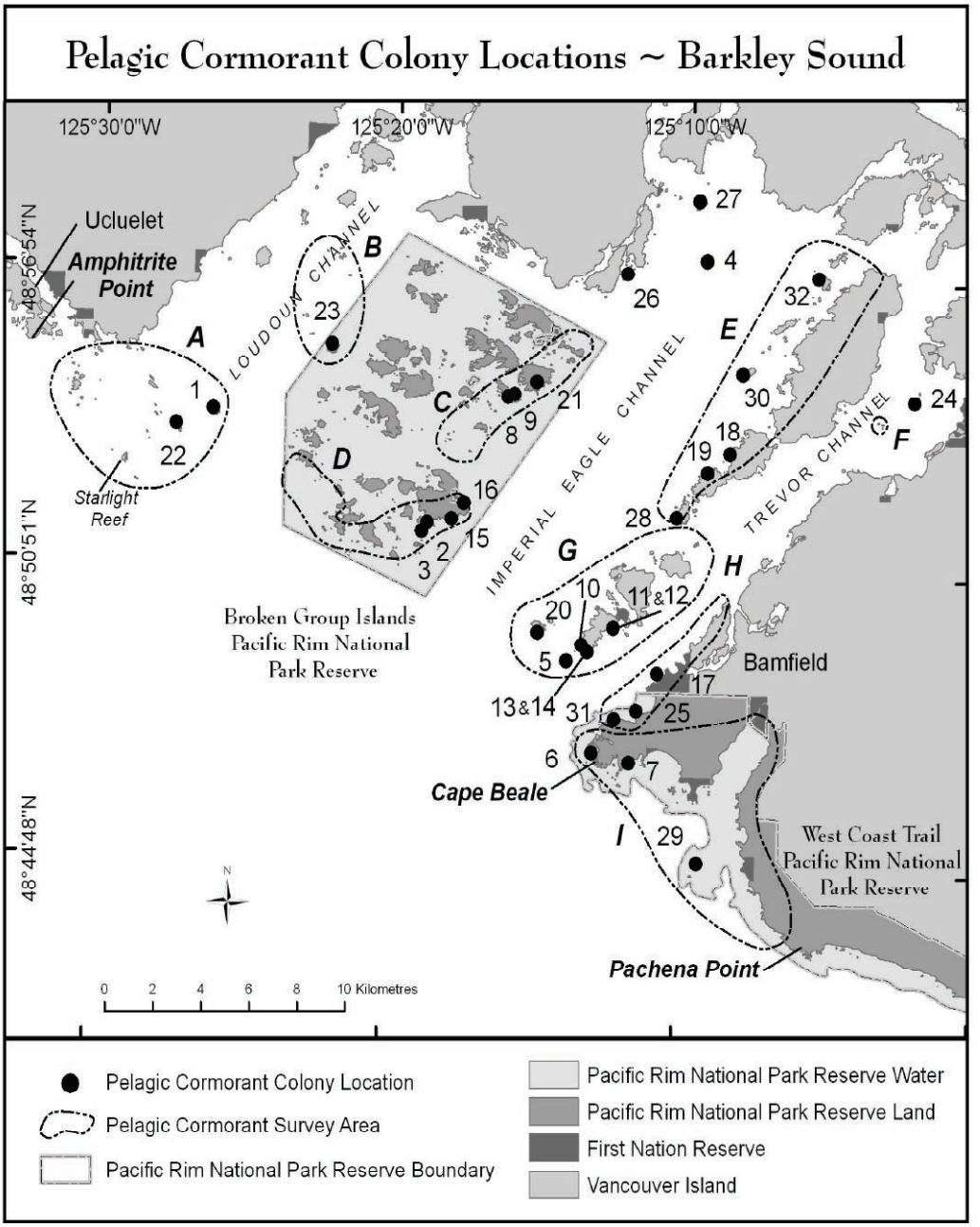

Figure 3. Known and suspected breeding colony locations of the Pelagic Cormorant in Barkley Sound, British Columbia. Numbered locations are summarized in Table 1. Lettered survey areas were searched on 10-11 July 2006 for new colonies and roosting birds (see text and Table 2).

Table 1. Numbers of Pelagic Cormorant nests at 32 known and suspected colonies in Barkley Sound, 1947-2007 (Figure 3; Appendix 1). Single annual counts or low and high multiple counts are presented for each period of years. Key: italics (suspected colony); dashes (no data); and P (presence of birds but nests may not be visible).

Colony		1947-1975			1979-1982			1989	2006	2007
No.	**Name**	**Low**	**Single**	**High**	**Low**	**Single**	**High**	**Single**	**Single**	**Single**
1	Alley Rocks	-	1	-	0	-	0	0	0	0
2	Austin Island #1	0	-	3+	0	-	6	0	0	0
3	*Austin Island #2*	-	-	-	0	-	P	0	0	0
4	Baeria Rocks	28	-	32	0	-	8	0	0	-
5	Bordelais Islets	0	-	3	0	-	0	0	0	-
6	Cape Beale	P	-	20	P	-	P	0	0	-
7	Deadman Cove	-	P	-	P	-	P	-	5-7	5
8	Dempster Island #1	0	-	14+	0	-	8	0	0	0
9	Dempster Island #2	0	-	9	0	-	5	0	0	0
10	Edward King Island Cliff	-	-	-	0	-	3	0	0	2
11	*Edward King Island #1*	P	-	P	0	-	P	0	0	0
12	*Edward King Island #2*	P	-	P	0	-	0	0	0	0
13	Edward King Island #3	P	-	P	0	-	P	0	3-5	1
14	Edward King Island #4	P	-	P	0	-	P	0	6	0
15	Effingham Island Cave	0	-	27	0	-	0	0	0	0
16	Effingham Island Arch	-	-	-	0	-	5	0	0	0
17	Execution Rock	-	P	-	0	-	4	0[1]	0[1]	0
18	Fleming Island #1	-	3-5	-	1	-	8+	0	0	-
19	Fleming Island #2	-	3-5	-	-	0	-	0	0	-
20	*Folger Island*	P[2]	-	P[2]	-	0	-	0[3]	0[3]	P
21	Gibralter Island	-	1+	-	0	-	0	0	0	0
22	Great Bear Rock	0	-	2	0	-	0	0	0	0
23	Hankin Island	-	P	-	-	-	-	-	2	-
24	*Hosie Islands*	-	P	-	-	-	-	-	0	-
25	Lawton Point	-	-	-	0	-	10	0	P	4
26	*Robinson Island*	-	-	-	-	P	-	-	0	-
27	Rutley Islands	-	-	-	-	6+	-	0	0	-
28	Sandford Island	-	-	-	0	-	0	-	0[4]	-
29	Seabird Rocks	0	-	0	0	-	0	12	0[5]	0
30	Swiss Boy Island	0	-	50	0	-	P	5	0	-
31	Tapaltous Beach	-	-	-	0	-	0	-	0[4]	-
32	Weld Island	-	0	-	0	-	18+	0	0	-

[1] Nesting in some years between 1986 and 2005.

[2] Campbell (1976) estimated 2 nests, based on presence of adults only.

[3] Birds flying into cave in some years between 1986 and 2005.

[4] Nesting noted in 2005.

[5] Nesting noted in 2003 but not in 2005.

without apparent current nesting, we did not land to search for empty nests on large exposed rocks that might not be visible from the boat (*e.g.,* Seabird Rocks, Baeria Rocks) nor did we attempt to enter deeper recesses of cave sites which could not be seen from the boat. We used the same breakdown for identifying multiple nesting locations at one island as used by Carter et al. (1984) to ensure that all locations were surveyed and effectively compared to prior data.

We also searched for new colonies and counted roosting and feeding birds in various locations in Barkley Sound. On 10 July (09:37-17:10 h [PDT]), we surveyed the east side of southern Trevor Channel (area H), Cape Beale to Pachena Point (but not including Pachena Point lighthouse; area I), southern Deer Group (area G), west side of the northern Deer Group Islands (including the Chain Group; area E), and San Jose Islets in northern Trevor Channel (area F; Figure 3). On 11 July (10:14-17:22 h), we surveyed the southern Broken Group Islands (area D), eastern Broken Group Islands (area C), southwestern Loudoun Channel (area A), and central Loudoun Channel (area B; Figure 3).

2007 Survey

On 11 July 2007, HRC and PVC travelled by 6.0 m rigid-hulled Parks Canada inflatable boat powered by twin 75 hp. outboard engines to 17 known or suspected nesting locations of Pelagic Cormorants near Cape Beale, outer Trevor Channel, southern Deer Group Islands, and along the east side of the Broken Group Islands (see Figure 3). We used the same survey methods as noted for the 2006 survey; however, nesting activities at visited colonies were noted but roosting and feeding birds were not recorded. On 5 July 2007, PVC visited Seabird Rocks, along with a group from the Bamfield Marine Station. On 27 June 2007, TC, JC, SM, and BA (unpubl. data) visited Alley Rocks, Great Bear Rock, Starlight Reef, and Heddington Reef.

Nesting Records (1947-2005)

To investigate changes in numbers of nesting birds, we collated all available nesting records of Pelagic Cormorants in Barkley Sound from 1947 to 2007 (Appendix 1). Carter et al. (1984) summarized all known records from 1947 to 1982 from published and unpublished sources (Drent and Guiguet 1961, Guiguet 1971, Campbell 1976, Hatler et al. 1978, British Columbia Provincial Museum unpubl. data, British Columbia Nest Record Scheme unpubl. data). However, HRC took details from an archived appendix and included them in Appendix 1 to ensure preservation for the historical record. Rodway and Lemon (1990) also provided additional 1975 data for certain colonies. Other than 1989 data (Vermeer et al. 1992), more recent nesting records between 1985 and 2005 were obtained from other seabird researchers (D. Bertram, A. Burger, S. Avery-Gomm, M. Lemon, and M. Rodway) and the Cape Beale light keepers (K. Brand).

Results

2006 Survey

In July 2006, nests were found at only four active colonies of 32 known or suspected colony sites in Barkley Sound, including Edward King Island #3 (three to five nests), Edward King Island #4 (six nests), Deadman Cove (five to seven nests), and Hankin Island (two nests) (Table 1). The 2006 total breeding population size for Barkley Sound was 16-20 nesting pairs. During the survey, 33 birds (28 adults, 5 subadults) were observed at three active colonies but no birds were seen at Hankin Island (Table 2). Another 47 birds were observed at or near 10 other inactive colony locations, including 23 adults, 14 subadults, three juveniles, and seven unknown. No birds were seen at 18 other inactive colonies, including two sites where nesting had been reported in 2005 (*i.e.,* Sandford Island and Tapaltous Beach; Avery-Gomm 2005; Appendix 1). Survey details for each colony surveyed in 2006 are included in Appendix 1. Only three juveniles were observed away from active colonies at Baeria Rocks. These juveniles were far from known active colonies at Edward King Island and Deadman Cove. However, fledglings were present at Deadman Cove and nesting may have been completed at Hankin Island by 11 July. Thus, a few local juveniles seemed to have moved away from active colonies by the time of the survey. There was no evidence of an influx of juveniles from areas outside Barkley Sound.

Table 2. Numbers of Pelagic Cormorants observed within different portions of Barkley Sound on 10-11 July 2006.

Survey Area	Map Area[1]	Colony Areas[2]	Non-Colony Areas	Total
Southwestern Loudoun Channel	A	5	15	20
Central Loudoun Channel	B	0	20	20
Eastern Broken Group	C	0	4	4
Southern Broken Group	D	2	2	4
North Imperial Eagle Channel[3]	None	10	-[4]	10
Northern Deer/Chain Group	E	1	0	1
Northern Trevor Channel	F	0	0	0
Southern Deer Group	G	23	1	24
Southern Trevor Channel	H	2	2	4
Cape Beale to Pachena Point	I	39	15	54
Total		**82**	**59**	**141**

[1] See Figure 3.
[2] Fledglings excluded.
[3] Includes colony areas only at Baeria, Robinson, and Rutley.
[4] Non-colony areas not surveyed.

Between Cape Beale and Pachena Point, we did not find any new Pelagic Cormorant colonies but observed 15 birds away from colonies: a) active feeding by four subadults within a multi-species feeding flock off Cape Beale; b) three breeding adults and two subadults feeding between Cape Beale and Deadman Cove; and five birds roosting on rocks and one bird feeding off the east end of Keeha Bay. No birds were seen in Pachena Bay or from the east side of Pachena Bay to Pachena Point. Including birds roosting at Seabird Rocks and attending Deadman Cove, 54 Pelagic Cormorants were observed between Cape Beale and Pachena Point, the largest concentration seen on the 2006 survey (Table 2).

During surveys in the southern Deer Group, northwestern Deer Group and Chain Group, southeastern Trevor Channel, and northern Trevor Channel, no new colonies were found and only one bird was seen away from colony sites in area "G: at a roost on the west side of Edward King Island. During surveys in the Broken Group and Loudoun Channel on 11 July, no new colonies were found and 41 roosting birds away from colonies were counted. In the southern Broken Group, two birds were noted (one roosting at rock SW of Wouwer Island and one feeding off Verbeke Reef). In the eastern Broken Group, four birds roosted on Village Reef. In southwestern Loudoun Channel, 15 birds were noted (five birds [three breeding adults, two subadults] roosting on Humphries Reef; one subadult roosting at Heddington Reef; eight birds [six breeding adults and two subadults] roosting on and one bird feeding beside Sykes Reef). In central Loudoun Channel, 20 birds were noted (one bird feeding mid channel about 1.6 km south of Page Island and 19 birds [13 breeding adults, six subadults] roosting at Pinder Rock).

Although not a focus of this survey, we did not find any nesting Brandt's Cormorants (*Phalacrocorax penicillatus*) or Common Murres (*Uria aalge*) at known colonies at Great Bear Rock and Starlight Reef (Hatler et al. 1978, Carter et al. 2006). However, we did count 186 Brandt's Cormorants roosting at the south end of Loudoun Channel (*i.e.,* 60, 48, 30, 26, 20, and two were roosting at Starlight Reef, Great Bear Rock, Heddington Reef, Alley Rocks, Sykes Reef, and Humphries Reef, respectively). The only other location in Barkley Sound where Brandt's Cormorants were recorded was at Baeria Rocks (15 roosting). Only five Common Murres were seen

Figure 4. Pelagic Cormorant nests typically include a foundation composed of a variety of seaweeds. The nest depression is frequently lined with dry plant stems and leaves and feathers of Glaucous-winged Gulls (*Larus glaucescens*) and moulted cormorant feathers. Chain Islets, BC. 19 July 1973 (R. Wayne Campbell).

during surveys, two in south Trevor Channel and three in southwestern Loudoun Channel.

2007 Survey

Nests (see Figures 2 and 4) were found at four colonies (three active and one non-active) out of 19 colonies surveyed, including Edward King Island #3 (one nest), Edward King Island cliff (two abandoned nests), Deadman Cove (five nests), and Lawton Point (four nests) (Table 1). No nests had been recorded for Edward King Island cliff and Lawton Point in 2006, although nests may have been present deep in the cave but missed at Lawton Point in 2006. Otherwise, results were similar to 2006. Roosting birds also were counted at Heddington Reef (25) and Starlight Reef (nine); in addition, Brandt's Cormorants were recorded nesting at Starlight Reef (two to three nests) but not at Great Bear Rock (T. Chatwin, unpubl. data). Details for each colony surveyed in 2007 are included in Appendix 1.

2006-2007 Summary

For general comparison to earlier surveys (see below), we combined highest available or single counts in 2006-2007 to obtain a total of 26 nests at six colonies. We are fairly certain that representative counts were obtained in 2006-2007 because similar results occurred in each year and unusual conditions were not noted. A total of 141 birds were noted in areas surveyed within Barkley Sound on 10-11 July 2006, with 59 birds counted away from colonies. The nesting population may be slightly higher than recorded in 2006-2007, if abandonment of certain colonies had occurred before the survey and nest materials were either removed by birds or not visible. Adults seen away from colonies could reflect foraging far from active colonies, or birds that had already stopped attending colonies in 2006. Small numbers of subadults seen away from colonies also could be accounted for by past local breeding and no evidence of an influx of birds from other areas was found.

Figure 5. In the early 1970s Michael Shepard participated in surveys of Britiish Columbia seabird colonies by the Royal British Columbia Museum, including Barkley Sound in 1975, that also included banding activities. Sea Lion Rocks, BC. August 1970 (R. Wayne Campbell).

1947-1975 Surveys

Campbell (1976) provided a summary of "1974-1975" data on seabird nesting colonies for Vancouver Island that had been obtained by the British Columbia Provincial Museum (now Royal British Columbia Museum). A museum survey of 12 of 32 known or suspected colony sites in Barkley Sound was conducted in 1975 by MGS (Figure 5), MP, and BP (Appendix 1). By adding data presented by Campbell (1976) for 13 known or suspected colonies in Barkley Sound (*i.e.,* Alley Rocks, Austin Island [two sites], Baeria Rocks, Cape Beale, Dempster Island [two sites], Effingham Island [two sites], Folger Island, Gibralter Island, Great Bear Rock, and Seabird Rocks), a total of 107 nesting pairs can be derived. We assumed that all sites at each island had been surveyed, if no specific nesting record was available (Appendix 1).

Based on our review of available nesting records (Appendix 1), Campbell (1976) actually used highest available nest counts at these 13 colonies using historical data between 1947 and 1975, including several observations by CJG (British Columbia Provincial Museum) and DFH (Pacific Rim National Park) (Drent and Guiguet 1961, Guiguet 1971, Hatler et al. 1978, British Columbia Nest Record Scheme). We suspect that Campbell's goal was to present representative colony sizes for all known colonies, despite incomplete data in 1975 and potential intermittent breeding (Figure 6) at sites or abandonment prior to surveys that could have resulted in no nests being observed at several colonies in 1975. Rodway and Lemon (1990: Table WV-1) used a similar approach for summarizing breeding populations of Pelagic Cormorants on the west coast of Vancouver Island. We also believe that this approach was reasonable, given small colony sizes, little inter-annual variation in numbers of nests if nesting was documented, and available incomplete data. However, this approach also assumes that surveys were sufficient to obtain representative values and that no movement occurred between colonies. In any case, additional historical high count data for a minimum of 63 nests at 10 colonies (*i.e.,* Bordelais Islets, Edward King Island [five sites], Fleming Island [two sites], Swiss Boy Island, and Hankin Island) were still omitted by Campbell (1976). By assuming that highest available or single non-zero counts (hereafter "high/single counts") are generally representative of colony sizes during the 1947-1975 period, our revised total for the 1947-1975 period is 170 nesting pairs (Table 1). High/single counts during this period represent a composite of many years of counts and do not account for: a) lack of estimates of numbers of nests at six confirmed and four suspected sites; b) some suspected sites may only be roost sites; c) no nesting was assumed at five sites in areas frequented by Guiguet (1971); and three sites apparently were not surveyed. We were not able to obtain a nesting population estimate in Barkley Sound for any one year during this period, due to incomplete data.

Figure 6. For reasons unknown, small numbers of Pelagic Cormorants nest intermittently at some sites such as "White Island", off Portland Point, on the central west coast of Vancouver Island, BC. 29 August 1972 (R. Wayne Campbell).

1979-1982 Surveys

Carter et al. (1984) provided a summary of 1979-1982 data on Pelagic Cormorant colonies for Barkley Sound (Table 1, Appendix 1). These surveys were conducted opportunistically by the University of Manitoba (HRC, SGS, and KAH) during other seabird studies. A total of 29 known or suspected colonies were surveyed in at least one year; only Seabird Rocks, Hankin Island, and Hosie Islands were omitted. We obtained a total of 81 nests (high/single counts) for the 1979-1982 period. We are most certain that representative counts were obtained during this period because many sites were

surveyed several times in adjacent years and unusual conditions were not noted. Nesting at Seabird Rocks was not reported until 1988 and presumably nesting did not occur in 1979-1982. We also were not able to obtain a nesting population estimate in Barkley Sound for any one year during this period, due to incomplete data.

1989 Survey

Vermeer et al. (1992) conducted a single survey of Pelagic Cormorant colonies in Barkley Sound between 20 and 30 June 1989. This survey was conducted by the Canadian Wildlife Service as part of an investigation of the potential seabird impacts of the 1988 *Nestucca* oil spill. Few details are available for the 1989 survey because raw survey data were not archived. However, the survey was conducted rapidly over a few days of effort by KHM and PJE (KHM, pers. comm.). A total of 26 known or suspected colonies was surveyed (Table 1). We assumed that when an island or location was listed in their Table 1 that the entire island was surveyed, and when an island or location was not listed that it was not surveyed. A total of 17 nests were found at 2 active colonies (*i.e.,* Seabird Rocks and Swiss Boy Island) in 1989. We are less certain that representative counts were obtained because colonies were surveyed in only one year and unusual conditions were noted (see below).

Discussion

Aspects of Nesting Distribution

Barkley Sound hosts a relatively small breeding population of Pelagic Cormorants, contributing at most only a few hundred of the over 4,000 breeding birds reported for British Columbia (Campbell 1976, Hatler et al. 1978, Carter et al. 1984, Rodway 1991). Only one colony (Swiss Boy Island) was considered to be a "major colony" (> 50 nests) in British Columbia by Campbell et al. (1990). Small population size and small colony size are related partly to low availability of suitable nesting habitat (*i.e.,* predator free with little or no human disturbance; Figure 7) in Barkley Sound. Few rocky islands occur, most islands are accessible to predators or humans, and many Pelagic Cormorant colonies exist in sea caves on forested islands or mainland shorelines (Guiguet 1971, Carter et al. 1984). At many cave colonies, numbers of nests also can be difficult to observe and counts are minimums. Six suspected colonies (*i.e.,* Austin Island #2, Edward King Island #1, Edward King Island #2, Folger Island, Hosie Islands, and Robinson Island) also have not yet been verified as breeding colonies because attending birds may have abandoned nests prior to the survey or nested far inside caves where they were not observed. Small colonies also may lead to greater flexibility of site use over time (Carter et al. 1984). Overall, these aspects of nesting distribution have led to documentation of 32 known or suspected colony locations that are spread widely over the sound (Figure 3). Colonies in different locations are potentially exposed to different conditions of local prey availability, predators, and anthropogenic impacts. By identifying patterns of changes at different colonies and summarizing available information on factors known to affect cormorant populations in other coastal areas of western North America, we attempt to identify factors contributing to population decline.

Figure 7. Most Pelagic Cormorant colonies in Barkley Sound, BC, have been located in sea caves on forested islands, with only a few on rocky islands, such as this small colony on "White Island" near Portland Point, BC. All nest sites are relatively free from predation and inaccessible to humans. 4 August 1969 (R. Wayne Campbell).

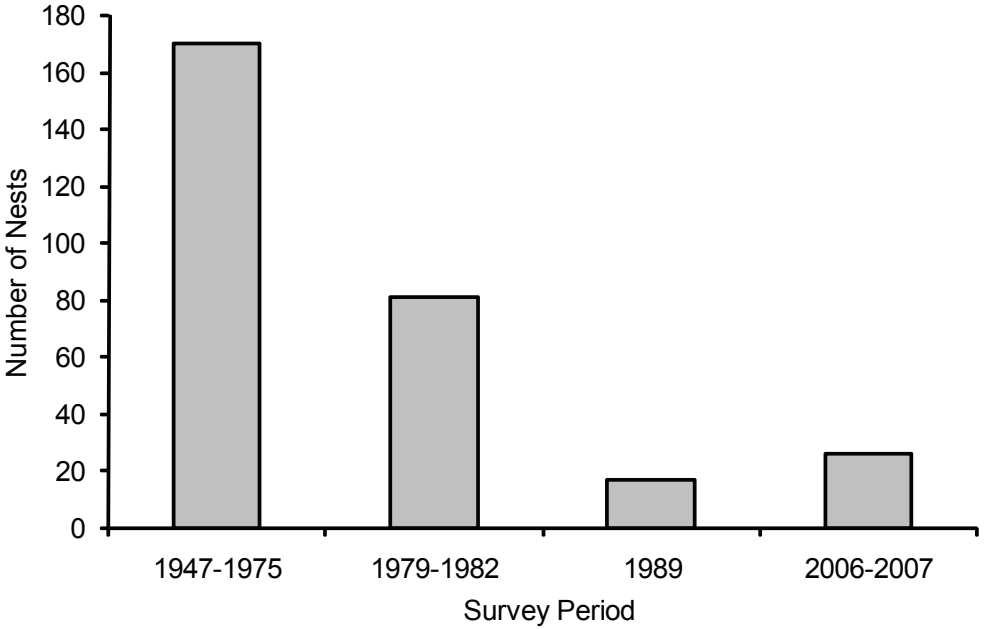

Figure 8. Changes in numbers of Pelagic Cormorant nests in Barkley Sound, British Columbia. Nest totals were derived from combinations of high or single counts for different periods noted.

Evidence of Decline

Small colony sizes, varied nesting habitats, and the dispersed nature of Pelagic Cormorant colonies in Barkley Sound have made it difficult to conduct annual surveys for most effective trend monitoring. Nonetheless, declining numbers of Pelagic Cormorant nests in Barkley Sound are still evident over time. Representative nest numbers (*i.e.,* high/single counts) and numbers of colonies with documented nests in 1947-1975 (170 nests at 13 colonies) were highest, numbers in 1989 (17 nests at two colonies) and 2006-2007 (26 nests at six colonies) were lowest, and numbers in 1979-1982 (81 nests at nine colonies) were intermediate (Figure 8). As survey methodology, coverage, frequency, and timing varied within and between years and periods, it is difficult to estimate the exact magnitude and timing of this decline. We do not believe that differing lengths of periods compared greatly affect the representativeness of numbers per colony within each period, because colonies were infrequently surveyed in 1947-1975 and most colonies were not discovered until the early 1970s (Guiguet 1971, Campbell 1976; Appendix 1). Nesting records show that decline occurred between about 1969 and 1989 and percent decline was about 85% (*i.e.,* from 170 to 26 nests). In general, we believe that this timing and degree of decline roughly accounted for various survey limitations, survey differences between periods, and annual variation in nesting effort.

However, nesting at Lawton Point and Edward King Island cliff, and probable nesting at Folger Island, were recorded in 2007 but not 2006, indicating that nesting may not occur or may not be detected at every colony in every survey year. Thus, when possible, it is valuable to conduct surveys at these colonies in more than one year to best determine status at all locations (Carter et al. 1984, Vermeer et al. 1992). Vermeer et al. (1992) first reported an 89% decline in Barkley Sound and the Flores Island – Amphitrite Point region combined in 1989 compared to unadjusted colony totals from Campbell (1976). If they had reported a separate value for Barkley Sound, it would have been 84% (*i.e.,* 107 nests at

nine sites to 17 nests at two sites). Assuming that 2006-2007 and earlier data provided representative numbers for colonies, we confirm this large relative degree of decline and further indicate little or no recovery in Barkley Sound since 1989. However, in 1989, nesting was not recorded at 6 sites (*i.e.,* Edward King Island cliff, Edward King Island #3 and #4, Deadman Cove, Hankin Island, and Lawton Point) where nesting was noted in 2006-2007. This result may have reflected a poor breeding year in 1989 or difficulty in finding or detecting breeding at certain sites. In 2006-2007, breeding also did not occur at the two sites noted in 1989 (*i.e.,* Seabird Rocks and Swiss Boy Island), although reduced breeding was noted at Seabird as recently as 2003 (Appendix 1). A shift in nesting distribution apparently has occurred in conjunction with decline.

It appears that the decline occurred before 1989, with little change between 1989 and 2006-2007. The three largest colonies ever documented in Barkley Sound (Swiss Boy Island, 25-50 nests in 1969-75; Baeria Rocks, 28-32 nests in 1970-76; and Effingham Island cave, 27 nests in 1972) were documented over several years but Baeria Rocks and Effingham Island cave were vacated by 1989, although Effingham Island cave had not been noted after 1972 when the cave may have collapsed. Swiss Boy Island was the only one of these colonies that was still active in 1989. All nesting in the Broken Group Islands within Pacific Rim National Park had ceased by 1989. Nesting at exposed rocks in Loudoun Channel (*i.e.,* Alley Rocks in 1975; Great Bear Rock in 1974-75) and Trevor Channel (*i.e.,* Bordelais Islets in 1965) ceased before 1979-1982, with nesting recorded only once each. Nesting was also recorded or suspected in only one year at Effingham Island arch (1979), Gibralter Island (1972), Hosie Islands (1975), Robinson Island (1982), and Rutley Islands (1982). Small changes at certain colonies after 1989 likely represent annual variability or survey conditions. Greater activity by Pelagic Cormorants at Lawton Point in 2007 probably reflected better survey conditions. Greater roosting attendance at Folger Island in 2007 may have reflected better local feeding conditions in this area in 2007.

Rodway (1989) noted that numbers of Pelagic Cormorants counted during aerial and boat surveys in Barkley Sound (mainly in the western part of the sound) in March-April 1989 were much lower than found in similar surveys in 1979. The lack of historically observed concentrations of Pelagic Cormorants in spring 1989 may have reflected population decline, birds moving outside Barkley Sound because a major prey species had an unusual spawning distribution, or normal variation in numbers. No conclusions were drawn. In retrospect, we note that lower bird count numbers in 1989 than in 1979 were generally consistent with ongoing population decline better demonstrated with nest count data over this period.

Reduction of Prey Availability

Vermeer et al. (1992) noted that prey shortage may have occurred in 1989 on the outer west coast of Vancouver Island, causing later nesting after the survey or a lack of nesting. Little decline was noted between 1975 and 1988 surveys in the Quatsino Sound – Esperanza Inlet area on the northwest coast of Vancouver Island. Much lower numbers were found in this area in 1989 compared to 1975 or 1988, suggesting that 1989 was a poor year with low numbers of Pelagic Cormorants attending colonies during the survey. However, incomplete surveys on the northwest coast also contributed to lower population estimates in 1989 compared to 1988 (Rodway and Lemon 1990; M.S. Rodway, pers. comm.) and nesting numbers at the Scott Islands were higher in 1989 than previous years (Rodway et al. 1990). Unfortunately, follow up surveys were not conducted in Barkley Sound after 1989 to determine whether or not 1989 data were representative or somehow temporarily reduced during a bad year.

Given little or no recovery between 1989 and 2006-2007, we suspect that long-term reduction in prey availability has contributed to this widespread change of Pelagic Cormorants in Barkley Sound. Knowledge of diet of Pelagic Cormorants in Barkley Sound (Figure 9) is very limited but seems varied and composed mainly of small benthic and midwater fish species (Carter and McIntyre 1976, Hatler et al. 1978, Porter and Sealy 1982, Hobson and Sealy 1985, Chilton and Sealy 1987, Hobson 1997). While a varied diet (especially with a large benthic component) should make these cormorants

Figure 9. Regurgitated fishes collected at nesting and roosting sites can help develop a diet profile for the Pelagic Cormorant in Barkley Sound, British Columbia. Florencia Island, BC. 21 July 1969 (R. Wayne Campbell).

less susceptible to overall prey shortages, changes in key prey species in local areas still may lead to poor reproductive success, colony abandonments, and movements of birds to other feeding and nesting areas. In Barkley Sound, predominant midwater schooling fish include juvenile Pacific Herring (*Clupea harengus*) and to a lesser degree Pacific Sandlance (*Ammodytes hexapterus*) (Waldichuk 1956, Hourston 1959, Stevenson 1962). Adults at many colonies may have relied heavily on midwater prey, because shallow waters are limited and steep muddy substrates predominate in most of Barkley Sound (Carter 1984). In 1979-1983, Pelagic Cormorants in the Deer Group were well documented feeding in multi-species flocks that formed over mid-water prey, especially herring (Porter and Sealy 1981, 1982, Chilton and Sealy 1987). Colony locations also are clumped in eastern sound areas closer to herring rearing areas, rather than in western areas of Barkley Sound closer to herring spawning areas (Hourston 1958, 1959; Stevenson 1962). However, availability of cliff and cave nesting habitats are also greater in eastern areas of Barkley Sound (Carter et al. 1984). No data are available on the distribution and abundance of benthic fish species used for prey by Pelagic Cormorants in Barkley Sound but these fish likely are widely distributed.

Limited numbers of nesting and roosting Pelagic Cormorants in the southern Deer Group and southeastern Trevor Channel in 2006-2007 was striking to HRC compared to higher numbers found during the 1979-1982 period (Carter et al. 1984, Hobson and Sealy 1985). Reduction in availability of midwater prey (especially herring) during the pre-breeding or breeding seasons may have led to colony abandonments in many parts of Barkley Sound. We also observed few small multi-species flocks and few seabirds overall (except for Marbled Murrelets *Brachyramphus marmoratus*) on 2006-2007 surveys. Reduced seabird biomass was striking to HRC in Trevor and Imperial Eagle Channels where he worked extensively in 1979-1982, further suggesting that midwater seabird prey was reduced compared to 1979-1982. Sporadic or one-time breeding by Pelagic Cormorants at several colonies in the 1970s and 1979-1982 also may have reflected intermittent nesting or fluctuating prey availability prior to reaching lower levels of prey availability by 1989 or earlier. Long-term colony abandonments may have occurred after prey had reached lower levels for a period of time, especially following the 1982-1983 El Niño event when prey may have been further reduced. Unfortunately, Pelagic Cormorant diet in Barkley Sound is poorly known and seabird prey availability has not been measured or monitored in Barkley Sound. So, there are no direct data to support or refute our supposition that prey availability may have declined to a significant degree in many areas of Barkley Sound.

Reduced breeding by Brandt's (Figure 10) and

Figure 10. Nesting colonies of Brandt's Cormorants off the central west coast of Vancouver Island have also declined since the 1970s and 1980s. Sea Lion Rocks, BC. 27 July 1968 (R. Wayne Campbell).

Pelagic Cormorants (PVC, unpubl. data; T. Chatwin, unpubl. data) and loss of breeding Common Murres (Hatler et al. 1978, Campbell et al. 1990, Carter 2004, Carter et al. 2001) also has been noted between Cleland Island and southwestern Loudoun Channel since the 1970s and early 1980s which also might reflect more widespread reduction in prey availability and effects from several other factors. Large declines in Marbled Murrelet populations in Clayoquot and Barkley Sounds were reported between 1982 and 1992-1996 (Kelson et al. 1995, Burger 2000) but population reductions were attributed mostly to loss of old-growth forest nesting habitats from logging and mortality in gill nets (also see Sealy and Carter 1984, Carter and Sealy 1984). Reduced prey availability may have contributed to declines in all of these seabird species but the degree of effect compared to other factors is difficult to determine.

Major El Niño events in 1982-1983, 1992-93, and 1997-1998 might have caused nesting failures of remaining birds due to prey reductions or heightened mortality in Barkley Sound, although no documentation of possible impacts to Pelagic Cormorants or most other breeding seabirds in Barkley Sound occurred during these events. Marbled Murrelets were noted to disperse early in June 1993 (one to two months earlier than usual) in Barkley Sound, likely indicating very poor reproductive success, associated with poor prey availability (Burger 1995). Elsewhere, reduced reproductive success, lack of egg laying, and limited colony attendance in Pelagic Cormorants have been documented in Oregon and California during El Niño events (Hodder and Graybill 1985, Boekelheide et al. 1990). However, prey availability and reproductive success often returns to higher levels after these events and little population change over wide areas has been noted after El Niño events in Washington, Oregon, and California (Carter et al. 1995).

Human Disturbance

Vermeer et al. (1992) believed that decline in the Pelagic Cormorant population was not caused by human disturbance (Figure 11) but they provided little discussion on this topic, except that cormorant colonies were considered to be less accessible to boaters than colonies in the Strait of Georgia. We provide more information to better evaluate this topic, as follows. Potential sources of colony disturbances in Barkley Sound have included: 1) recreational fishing boats near colonies, especially in popular sports fishing areas in south Trevor Channel, north Imperial Eagle Channel, and south Loudoun Channel adjacent to Bamfield, Alberni Inlet, and Ucluelet, respectively (see Execution Rock and Baeria Rocks in Appendix 1); b) kayaks entering caves, especially in the Broken Group which is a popular kayak use area (Carter et al. 1984; see Dempster Island in Appendix 1); c) seabird researchers and resource managers at Seabird Rocks and Baeria Rocks (Appendix 1); d) seabird researchers during cormorant and other seabird surveys (Appendix 1); and e) First Nations people harvesting gull eggs at

Figure 11. Curious, uninformed visitors to Pelagic Cormorant colonies can impact nesting success. "White Island", off Portland Point, BC. August 1968 (R. Wayne Campbell).

Baeria Rocks and Seabird Rocks (see Carter 2004; Appendix 1). We suspect that: 1) regularly-occurring disturbance from kayaks at Dempster Island and Gibralter Island has contributed to loss of nesting in this area; 2) annual seabird surveys (involving landing on small rocks) during the late 1960s to mid 1970s may have contributed to loss of nesting on Alley Rocks, Bordelais Islets, and Great Bear Rock; and 3) sporadic human visitation of Baeria Rocks and Seabird Rocks (involving landing) has contributed to loss of nesting at these locations. Overall, human activities and potential disturbance in Barkley Sound since the 1960s are much greater than on northwest Vancouver Island and colony disturbance levels in the 1970s and 1980s were likely similar to many areas in the Strait of Georgia. Historically, traditional harvesting within Barkley Sound by local First Nations also may have prevented breeding by Pelagic Cormorants at many locations (see Carter 2004). As such, Pelagic Cormorants may have been limited to nesting at a few relatively inaccessible locations (*e.g.,* Cape Beale). However, changing patterns of human use, including a gradual reduction in the level and type of traditional harvesting, may have provided an opportunity for an earlier expansion of nesting Pelagic Cormorants within Barkley Sound.

While seabirds are generally susceptible to human disturbance (Gotmark 1992), Pelagic Cormorants appear to be highly susceptible to disturbance and flush easily in response to boats; overall, Pelagic Cormorants do not exhibit strong nest defense behaviours (Verbeek 1982, Siegel-Causey and Hunt 1986). On the water, they also are more easily disturbed by boats than are several alcid species (Hentze 2006). As such, disturbances at colonies or on the water could have a greater effect on this species compared to many other seabirds. Geisbrecht (2001) found that Double-crested Cormorants (*P. auritus*) were not disturbed by boats (fishing, tourist, and kayak; Figure 12) at sites in the Strait of Georgia but habituation also may have occurred at these locations (see Nisbet 2000). Demarchi and Bentley (2004) noted that roosting cormorants at Race Rocks, British Columbia, were sensitive to and flushed by boats. We did not record any instances of close approach of colonies or disturbance by boats during our 2006-2007 surveys, except for our own flushing of birds from active colonies during surveys (Appendix 1). Pelagic Cormorants and Glaucous-winged Gulls flushed from Baeria Rocks in 2006 when we were still >500 m away, suggesting regular disturbance may be occurring there. We also did not find any nesting at Sandford Island on 10 July 2006, whereas nesting had been first recorded in 2005 (Avery-Gomm 2005). Close approach by boats likely occurs in this area near Bamfield and may have caused some disturbance that resulted in short-term nesting there. If many undocumented colonies disturbances have occurred, in conjunction with reduced prey availability, abandonment of large areas of Barkley Sound could have resulted rapidly over a period of a few years. To better understand potential disturbance impacts to Pelagic Cormorants at colonies and roosts, additional work is needed. A current study is being conducted on seabird disturbance by the British Columbia Ministry of Environment (T. Chatwin, unpubl. data).

Figure 12. Sea kayakers exploring sea caves at Fletcher's Beach, near Ucluelet, BC, unknowingly caused incubating Pelagic Cormorants to kick eggs from nests and take flight. July 1968 (R. Wayne Campbell).

Predators

Vermeer et al. (1992) further believed that decline in the Pelagic Cormorant population was not caused by high predation levels but they provided little discussion on this topic, except that Bald Eagles (*Haliaeetus leucocephalus*) were considered to be less abundant than in the Strait of Georgia. We provide more information to better evaluate this topic, as follows. Bald Eagles are known to prey on Pelagic Cormorants (Campbell 1969, Hatler et al. 1978, Stinson et al. 2001). Cormorants also are highly susceptible to disturbance and flush easily from colonies and roosts in response to Bald Eagle flyovers (Verbeek 1982, Siegel-Causey and Hunt 1986, Geisbrecht 2001; Figure 13). Northwestern Crows (*Corvus caurinus*) also often prey on eggs (Verbeek 1982, Siegel-Causey and Hunt 1986). Avery-Gomm (2005) suggested that reduced numbers of Pelagic Cormorants may partly reflect an increase in the Bald Eagle population in Barkley Sound. Campbell et al. (2001) reported increasing Bald Eagle populations in British Columbia. During the 2006 survey, we observed only about 15-20 eagles scattered widely throughout surveyed areas, which did not seem higher than during the 1979-1982 period to HRC. In addition, many colonies are difficult to access by large avian predators like eagles, especially those in sea caves which provide some protection to cormorants (Carter et al. 1984). Nest predators (especially Northwestern Crows; Figure 14) were noted at certain cave colonies during surveys and Glaucous-winged Gulls breed or roost on colonies located on exposed rocks. However, larger gull colonies with hundreds of nesting pairs occur only in association with Pelagic Cormorants in certain years at Baeria Rocks, Seabird Rocks, and Great Bear Rock (Drent and Guiguet 1961, Campbell 1976, Rodway 1991). Northern River Otters (*Lontra canadensis*) may affect certain colonies where cormorants breed on accessible substrates (Geisbrecht 2001). However, at many colonies, cormorants nest on cliffs or otherwise inaccessible substrates that prevent mammalian predation (Carter et al. 1984). More work is needed to assess effects of predators on Pelagic Cormorants in Barkley Sound.

Figure 13. While Bald Eagles prey directly on Pelagic Cormorants, impact at nesting colonies often comes from overflights when attending cormorants are disturbed from their nests. Sechelt, BC. 14 June 1996 (R. Wayne Campbell).

Figure 14. Northwestern Crows are a chief predator of Pelagic Cormorant eggs and obtain them when incubating cormorants are disturbed from their nests or by working together to snatch an egg from a nest. Chain Islets, BC. July 1978 (R. Wayne Campbell).

Oil Pollution

Vermeer et al. (1992) noted that the December 1988 *Nestucca* oil spill probably had little effect on decline in Pelagic Cormorants because few live or dead oiled cormorants were found. Although this spill occurred off Washington, Rodway (1989) reported tarballs in the Broken Group and oil sheen in Ucluelet Inlet months after the spill and some cormorants may have been killed but not recovered.

While decline in Pelagic Cormorants in Barkley Sound occurred before this spill, losses of small numbers of remaining cormorants could have been significant. Greater impacts likely resulted from the March 1971 *Vanlene* oil spill after a freighter lodged itself on rocks south of Effingham Island but seabird impacts were little assessed (Herlinveaux 1972). No other large oil spills have been recorded in Barkley Sound but chronic oiling from large ships and fishing boats inside and outside of Barkley Sound occurs regularly but on-shore deposition of carcasses is relatively low (O'Hara and Morgan 2006).

Environmental Contaminants

Organochlorine pesticides or polychlorinated biphenyls appear to occur at relatively low levels in Bald Eagles from Barkley Sound (Gill and Elliott 2004), suggesting that other bottom and pelagic fish-eating birds such as Pelagic Cormorants probably are not highly contaminated in this area. In the Strait of Georgia, even moderately high levels of contaminants in Pelagic Cormorants were not considered sufficient to cause reduced reproductive success and population declines observed in that area (Chatwin et al. 2002, Harris et al. 2005).

Fisheries Bycatch

Hobson (1997) mentioned that gill-net mortalities can be a potential problem for Pelagic Cormorants but none were recovered from gill nets in Trevor Channel in 1979-1980 (Carter and Sealy 1984). Accidental hooking of Pelagic Cormorants while sports fishing has not been reported in Barkley Sound but may occur on occasion, although Pelagic Cormorants often avoid boats (Hentze 2006).

Nesting Habitat Changes

Most nesting habitats are fairly stable and do not change much if at all between years (Figure 15). However, Effingham Island cave was apparently lost due to cave collapse (Carter et al. 1984; Appendix 1).

Population Shift and Colony Protection

In 1989 and 2006-2007, small numbers of breeding birds have continued to breed mainly near Cape Beale, Seabird Rocks, Lawton Point, and Edward King Island. This area has two key attributes for continued Pelagic Cormorant breeding, especially: a) suitable nesting habitat free of mammalian predators and little disturbed by humans, except at Seabird Rocks where occasional research and monitoring projects occur and possibly at Cape Beale itself where lighthouse facilities exist; and b) close access to potentially productive feeding areas with potentially diverse prey and benthic habitats between Cape Beale and Pachena Point as well as near the sill at the south entrance to Trevor Channel (Waldichuk 1956, Carter 1984). We believe that it is important to retain nesting Pelagic Cormorants in this small portion of Barkley Sound to allow for a nearby source population for potential recolonization of the remainder of the sound, if conditions change. Increased protection of colonies from disturbance could be considered but current active colonies at Edward King Island #3 and #4 do not occur within Pacific Rim National Park Reserve (Figure 3). Efforts should be made to educate various groups (*i.e.,* Pacific Rim National Park, British Columbia Ministry of Environment, Canadian Wildlife Service, Bamfield Marine Station, universities, the Bamfield Community, kayakers, and First Nations people) about potential impacts from human disturbance to these colonies and to encourage people to minimize or avoid visitations.

Figure 15. While most nesting habitats for Pelagic Cormorants are fairly stable, occupancy varies greatly between years. "White Island" near Portland Point, BC. 4 August 1968 (R. Wayne Campbell).

Future Surveys

Additional surveys along the entire west coast of Vancouver Island are needed to determine how widespread decline in breeding Pelagic Cormorants has become. However, frequent monitoring of this large area is not feasible. Long-term monitoring of the Barkley Sound population is feasible with only two to three days of effort per year and the Barkley Sound portion constitutes (and thus represents) most of the population of southwest Vancouver Island. For future monitoring purposes, we recommend a single annual survey of all known and suspected colony locations of Pelagic Cormorants in Barkley Sound in late June or early July. Carter et al. (1984) suggested two surveys per year to detect early colony abandonments and late colony initiations but we now believe that reducing colony disturbances and making monitoring less laborious are more important than maximizing information on use of every colony in each year. Surveys of caves are facilitated with small inflatable boats but care should be taken to reduce the degree of disturbances by minimizing time needed within cave entrances to count nests and birds.

We also suggest that deep recesses of caves should not be entered while active breeding is occurring to prevent excessive disturbances of nesting or roosting birds. However, in some cases, one must enter into shaded areas of caves to get an adequate view of nests in deep recesses of caves. Surveys of exposed rocks also should be conducted from distances of >100 m using binoculars to attempt to not flush birds from nests. Surveys of Pelagic Cormorants in Barkley Sound also could be conducted in two to three consecutive years followed by a hiatus of two to three years without surveys. This approach should ensure that: a) intermittent nesting and relatively high nest counts are documented at all sites in at least one of these years; b) long-term research and monitoring impacts are minimized; and c) an adequate dataset for trend monitoring of Pelagic Cormorants is developed for Pacific Rim National Park.

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Figure 16. Harry Carter first surveyed seabird colonies in BC while working as a summer student for the Royal British Columbia Museum in 1974-1978. He surveyed Pelagic Cormorants in Barkley Sound in 1979-1982, during his M.Sc. studies at the University of Manitoba, and re-surveyed colonies in 2006-2007 to confirm and investigate decline. Santa Cruz Island, CA. 8 August 2007 (Percy Hébert).

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Figure 17. Charles Guiguet, here checking for nesting Cassin's Auklets on Cleland Island, BC, conducted early seabird survey work for the Royal British Columbia Museum and first documented many Pelagic Cormorant colonies in Barkley Sound. 29 June 1970 (R. Wayne Campbell).

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Figure 18. With the Royal British Columbia Museum and Canadian Wildlife Service, Michael Rodway has contributed extensively to our knowledge of seabird colonies in British Columbia. Moore Islands, BC. 26 June 1976 (R. Wayne Campbell).

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About the Authors

Harry (see Figure 16) is a private consultant specializing in seabird research, monitoring, surveys, restoration, conservation, and injury assessments on the west coast of North America from Alaska to Baja California.

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Appendix 1. Nesting records of Pelagic Cormorants in Barkley Sound, British Columbia, 1947-2007

Below, we have listed all available nesting records for 32 known or suspected colony sites of Pelagic Cormorants in Barkley Sound, British Columbia, from 1947 to 2007. Initials of observers and other sources of information are provided at the end (see page 31).

In addition, we have provided clarifying comments about these records and reference to historical literature which assist interpretation.

Alley Rocks

1975: 13 July - one nest with two eggs (MGS - RBCM; Campbell 1976); **1976:** August - no nests (HRC, WEM; Carter et al. 1984; Appendix 1); **1979:** 10 June - no nests (HRC, SGS, JMP; Carter et al. 1984; Appendix 1); **1982:** 19 June - no nests (HRC; Carter et al. 1984: Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests but two subadults roosting (HRC, PNH; this study).; **2007:** 27 June - no nests but 11 roosting, mostly immatures (TC, JC, SM, BA; unpubl. data). **Comments:** exposed rocks. Nesting was confirmed in 1975.

Figure 19. David Hatler photographing Brandt's Cormorants on Sea Lion Rocks, BC. 27 July 1969 (R. Wayne Campbell). The first comprehensive summary for seabird colonies in Pacific Rim National Park were collated and published by Hatler et al. (1978).

Cave #1 (North)

1971: 17 September - 12 fledglings seen at and near mouth of cave (Hatler et al. 1978); **1972:** 6 July - three+ nests near the cave entrance (JB, DFH; Hatler et al. 1978; Campbell 1976; see Figure 19); **1973:** 23 July - no nests and no birds (DFH *in* BCNRS; Hatler et al. 1978); **1975:** 15 July - no nests and no birds (MGS, MP, and BP, RBCM); **1979:** 16 June - one nest and five adults flew out of cave (HRC, SGS; Carter et al. 1984; Appendix 1).; **1979:** 27 August - two empty nests (HRC; Carter et al. 1984; Appendix 1); **1980:** 1 July - six nests on cave ledges and 15 adults flew out of cave (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** June-July - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests, no birds, and no guano (HRC, PNH; this study); **2007:** 11 July - no nests, no birds, and no guano (HRC, PVC; this study).

Cave #2 (South)

1979: 16 June - one adult flew out of cave and 11 adults sitting on water outside cave entrance (HRC, SGS; Carter et al. 1984; Appendix 1); **1979:** 27 August - one subadult flew out of cave (HRC; Carter et al. 1984; Appendix 1); **1980:** 1 July - no nests and no birds (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests and no birds (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests, no birds, and no guano (HRC, PNH; this study); **2007:** 11 July - no nests, no birds and no guano (HRC, PVC; this study).

Comments: Two cave sites located on east side of Austin Island in Pacific Rim National Park. Cave #1 is northernmost; cave #2 southernmost. Nesting was confirmed in cave #1 in 1972, 1979, and 1980; cave #2 suspected nesting only. *Vanlene* oil spill occurred off Austin Island in 1971.

1960: 18 July - birds were observed from a distance and six to eight pairs were assumed nesting (ARW; Drent and Guiguet 1961); **1970:** 15 July - 28 nests (CJG, JS; Guiguet 1971); 25 July - 32 empty nests; egg harvesting suspected (RWC; Guiguet 1971; Campbell 1976); **1976:** 12 August - 25 nests with six eggs and 31 chicks (HRC, SGS; Carter et al. 1984; Appendix 1); **1977:** 30 August - six nests with 11 chicks (HRC, WEM; Carter et al. 1984; Appendix 1); **1979:** 5 June - no nests and no birds (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** 1 July - no nests but a few roosting birds present (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August – eight nests with birds in incubating postures (HRC, KAH; Carter et al.1984; Appendix 1); **1988:** 23 July - no nests (DG and ML in AB notes; Rodway and Lemon 1990); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2005:** 15 August - 122 birds (22 on north island; 100 on south island plus 20 Brandt's Cormorants (AS2, unpubl. data); **2006:** 1 February - four birds roosting (two on north island; two on south island; AS2, unpubl. data); 31 May - no nests or birds; landed on islands (AS2, unpubl. data); 11 July - no nests but nine birds (six subadults, three juveniles) roosting. Many Glaucous-winged Gulls and 15 roosting Brandt's Cormorants flushed when our boat was 500 m away, suggesting recent disturbances (HRC, PNH; this study). **Comments:** exposed rocks; designated as a British Columbia Ecological Reserve in 1971. Nesting confirmed 1970, 1976, 1977, and 1982. Disturbance is suspected from boats, First Nations people collecting gull eggs, and researchers.

Bordelais Islets

1965: 13 August - three nests on west side cliffs (CJG; Guiguet 1971); **1970:** 5 June - no nests but four pairs of adults, one carrying nest material (CJG, EL; Guiguet 1971); **1975:** no nests (Rodway and Lemon 1990); **1977:** August - no nests (SGS, KRS; Carter et al. 1984; Appendix 1); **1979:** no nests (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** no nests (HRC; Carter et al. 1984; Appendix 1); **1982:** 23 August - no nests (HRC, KAH; Carter et al. 1984; Appendix 1);

1989: 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 10 July – one breeding adult flew by area (HRC, PNH; this study); **Comments:** exposed rocks. Nesting confirmed in 1965. Colony not mentioned in Campbell (1976).

Cape Beale

1947: July - 20 nests with large chicks (JAB; Drent and Guiguet 1961; Campbell 1976; see Figure 20); **1959:** 6 July - 14 nests (nine eggs in five active nests and nine empty nests) but eggshells indicated that the colony had been recently disturbed (TW; Drent and Guiguet 1961); **1970:** 22 August - birds were noted flying in and out of cave with nesting material (CJG; Guiguet 1971); **1979:** 19 May - birds were observed flying in and out of cave (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** 14 June - birds were observed flying in and out of cave (HRC; Carter et al. 1984; Appendix 1); **1982:** 4 September - birds were observed flying in and out of the cave (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **1993-2001:** lighthouse keepers annually noted nesting on cliffs below lighthouse and adjacent to cave (KB; this study); **2002-2003:** lighthouse keepers noted nesting ceased to occur on cliffs, although some birds continued to roost (KB; this study); **2004-2006:** no nests (KB; this study); **2006**: 10 July - no nests and no birds at cave or cliffs (HRC, PNH; this study). **Comments:** mainland cave and cliffs located below lighthouse in Pacific Rim National Park. Nesting confirmed in 1947, 1959, and 1993-2001. No major changes have occurred at the lighthouse that might have disturbed birds around 2001 (K. Brand, pers. comm.).

Figure 20. When nestling Pelagic Cormorants obtain a coat of downy feathers, their chances of survival are greatly increased. Christie Islet, BC. 18 July 1970 (R. Wayne Campbell).

Deadman Cove/Keeha Bay

1970: 12 June - two adults were flushed (JBF, CJG; Guiguet 1971); **1980:** 14 June - four adults were seen flying out of cave (HRC; Carter et al. 1984; Appendix 1); **1982:** 4 September - two adults were present (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - not surveyed (KHM, PJE; Vermeer et al. 1992); **2005:** "inactive colony"; no nesting was assumed from land but site not was visited by boat (SAG; Avery-Gomm 2005; pers. comm.). **2006:** 10 July - two+ nests with attending adults about four m above water; 11+ large chicks (fledgling size) scrambled deep into cave; 14 birds (nine breeding adults, five subadults). About five to seven total nests were estimated, with three to five nests assumed for 11+ fledglings (HRC, PNH; this study). **2007:** 11 July - nests and 16 birds (10 breeding adults and six subadults/juveniles). All nests with breeding adults in incubation posture; possibly more nests present but not seen (HRC, PVC; this study). **Comments:** mainland cave located on west side of Keeha Bay (*i.e.,* cove to east of Deadman Cove) in Pacific Rim National Park. Not mapped correctly in Carter et al. (1984). Colony not mentioned in Campbell (1976) and not surveyed by Vermeer et al. (1992).

Dempster Island

1970: 12 June - 18 nests in three caves (WG, EL; Guiguet 1971).

Cave #1 (West)

1971: 8 August - 10+ nests (20 medium to large chicks in eight nests and two empty nests); (CJG, JBF; Hatler et al. 1978; Campbell 1976); **1972:** 17 June - 14+ nests (10+ eggs in four nests, three empty, and seven unchecked) (CJG, JBF; Hatler et al. 1978); **1973:** 23 July - 23 adults at cave (CJG, JBF; Hatler et al. 1978); **1975:** 15 July - no nests (MGS, MP, and BP - RBCM); **1980:** 1 July - eight nests (17 eggs in five nests, three nests unchecked) and nine adults on cliffs above cave entrance (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests, no birds, and no guano (HRC, PNH; this study); **2007:** 11 July - no nests and no birds. Some guano in right cave but probably just roosting (HRC, PVC; this study): **Comments:** Located in Pacific Rim National Park (Broken Group). Largest and westernmost of two major caves on east end of island. Cave 'a' in Hatler et al. (1978). Nesting confirmed in 1970, 1971, 1972, and 1980.

Cave #2 (East)

1971: 8 August - nine^{+} nests (23+ eggs in seven accessible nests, one empty nest, one unchecked nest) but other nests likely present but not accessible (Hatler et al. 1978; Campbell 1976); **1973:** 23 July - 15 adults at cave (Hatler et al. 1978); **1975:** 15 July - no nests (MGS, MP, BP – RBCM); **1980:** 1 July - no nests (HRC; Carter et al. 1984; Appendix 1); **1982:** (22 August): 5 nests (1 nest with large chicks, 4 empty nests) (HRC, KAH; Carter et al. 1984: Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests, no birds, and no guano (HRC, PNH; this study); **2007:** 11 July - no nests, no birds, and no guano (HRC, PVC; this study). **Comments:** Cave #2 bifurcates into two smaller side-by-side caves but nests found in right arm only. Nesting confirmed in 1970, 1971, 1972, and 1980. Kayakers observed entering caves (Carter et al. 1984).

1964-1969: August - three caves used annually by nesting cormorants (Guiguet 1971); **1970:** June - 41 birds suspected nesting in three caves (Guiguet 1971).

Cave/Arch #1 (North a)

1979: 4 June - three adults and one non-breeder flew out of cave (HRC, SGS; Carter et al. 1984: Appendix 1); **1980:** 1 July - no nests and no birds (HRC; Carter et al. 1984; Appendix 1); **1982:** (22 August): no nests but seven to eight roosting birds (HRC, KAH; Carter et al. 1984: Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2005:** "inactive colony"; no nests observed (SAG; Avery-Gomm 2005); **2006:** 10 July - no nests and no birds (HRC, PNH; this study); **2007:** 11 July - no nests, no birds, and no guano (HRC, PVC, Figure 21; this study).

Cave/Arch #2 (North b)

1977: 21 August – one to two birds fly in and out of cave (SGS, KRS; Carter et al. 1984: Appendix 1); **1979:** 4 June - visited but no data recorded; probably no nests and no birds (HRC, SGS; Carter et al. 1984: Appendix 1); **1980:** 1 July - no nests (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2005:** "inactive colony"; no nests observed (SAG; Avery-Gomm 2005); **2006:** 10 July - no nests and no birds (HRC, PNH; this study); **2007:** 11 July - no nests, no birds, no guano (HRC, PVC; this study).

Cave #3 (South a)

1979: 10 June - one adult and one non-breeding adult flew out of cave (HRC, SGS, JMP; Carter et al. 1984; Appendix 1); **1979:** 24 June - two adults flying near cave (JMP; Carter et al. 1984; Appendix 1); **1980:** 1 July - no nests and no birds (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - six roosting birds (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et

Figure 21. Pete Clarkson holding a Black Oystercatcher (*Haematopus bachmani*) chick at Faber Islets, BC. 24 May 2007 (Dave Tessler). BC Photo 3559.

al. 1992); **2005:** "active colony"; one+ nest observed but raw data lost (SAG; Avery-Gomm 2005; pers. comm.); **2006:** 10 July – three to five nests with four breeding adults (HRC, PNH; this study); **2007:** 11 July - one nest and two breeding adults in left cave. Some guano but no old nest platforms in right cave (HRC, PVC; this study).

Cave #4 (South b)

1979: 10 June - birds flying in and out of cave (HRC; Carter et al. 1984; Appendix 1); **1980:** 1 July - no nests and no birds (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests and no birds (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2005:** "active colony"; about two to four nests observed but raw data lost (SAG; Avery-Gomm 2005; pers. comm.); **2006:** 10 July - six nests (two empty nests, two nests with incubating breeding adults, and two nests with chicks), 15 breeding adults, and 5+ fledglings (HRC, PNH; this study); **2007:** 11 July - two old nest platforms (probably from 2006) and no birds (HRC, PVC; this study).

Cliff

1979: 19 May - one nest (HRC, JMP; Carter et al. 1984; Appendix 1); **1979:** 10 June - three nests (HRC, SGS; Carter et al. 1984; Appendix 1); **1979:** 17 July - no nests and no birds (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** 1 July - no nests (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2005:** "inactive colony"; no details provided (Avery-Gomm 2005); **2006:** 10 July - no nests, no birds, but some guano on cliffs; one bird flew in the distance from this general area to roost beside another bird on rocks between Edward King Island and Bordelais Islets and may have roosted on cliff (HRC, PNH; this study); **2007:** 11 July - two empty nests and no birds; four Pelagic Cormorants and 15 Brandt's Cormorants roosting on rocks between Edward King Island and Bordelais Islet (HRC, PVC; this study).

Comments: Four caves were located on east side and a cliff on the south end of Edward King Island. Caves #1 and #2 occur near the north end and caves #3 and #4 occur near the south end. Cave #3 is composed of two smaller caves that are about three m apart. Colony not mentioned in Campbell (1976). Nesting confirmed at cliff in 1979 and 2007 and at caves #3 and #4 in 2006-2007.

Effingham Island

Cave

1972: 6 July - 27 nests (40 eggs and two chicks in 13 active nests, seven empty nests, seven inaccessible nests) (DFH *in* BCNRS; Hatler et al. 1978; Campbell 1976); **1973:** 23 July - colony not found, may be gone (DFH *in* BCNRS; Hatler et al. 1978); **1979:** 16 June - cave appears to have caved in (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** 1 July - colony site not located (HRC; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - colony site not located but four caves (one with good nesting ledges) and one collapsed cave present (HRC, PNH; this study);

2007: 11 July - colony site not located but four caves checked (HRC, PVC: this study).

Arch

1979: 16 June - five nests (one nest with incubating adult, four possibly old nests, three adults flew out of arch (HRC, SGS; Carter et al. 1984; Appendix 1); **1979:** 27 August - no nests and no birds (HRC; Carter et al. 1984; Appendix 1); **1980:** 1 July - no nests and no birds (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests and no birds (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests and no birds (HRC, PNH; this study); **2007:** 11 July - no nests, no birds but some guano seen (HRC, PVC; this study).

Comments: cave and arch sites on southeast side of Effingham Island in Pacific Rim National Park. Nesting confirmed in 1972 and 1979. Cave site apparently collapsed in 1973-1978. Sites near *Vanlene* oil spill off Austin Island in 1971.

Execution Rock

1974: nests observed but not counted (HRC; Carter et al. 1984; Appendix 1); **1979:** 16 June - no nests (HRC; Carter et al. 1984; Appendix 1); **1982:** (August - four nests (two nests with incubating adults and two nests with chicks) (KAH; Carter et al. 1984; Appendix 1); **1986-2005:** nesting noted in some years but low reproductive success likely due to disturbance by fishing boats (AB; this study); **1988:** eight nests (CWS, unpubl. data); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2005:** "inactive colony"; no nests observed (SAG; Avery-Gomm 2005; pers. comm.); **2006:** 10 July - no nests and no birds (HRC, PNH; this study); **2007:** 11 July - no nests, no birds, and no guano (HRC, PVC; this study). **Comments:** mainland cliff located on First Nations lands. Nesting confirmed in 1974, 1982, and 1986-2004. Colony not mentioned in Campbell (1976). Susceptible to boat disturbances.

Fleming Island

1967-1970: annually entering and leaving two caves (Guiguet 1971); **1970:** 11 June - three nests in one cave and five nests in the other cave; cave locations not specified (JS, RWR; Guiguet 1971); **1974:** adults seen flying in and out of cave; location not specified (HRC; Carter et al. 1984; Appendix 1).

Cave #1 (North)

1979: 14 June - eight + nests, 13 birds in cave and 12 on water and flying around outside cave (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** 1 July - eight + nests (probably more nests further in cave), 15 adults flew out of cave (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - one nest with two chicks, four to five roosting birds (Figure 22) (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006**: 10 July - no nests, no birds, and no guano (HRC, PNH; this study).

Figure 22. Rocky islands and headlands of larger islands are used for roosting by adult and nonbreeding Pelagic Cormorants each summer. At some sites, breeding also occurred in the past. Location, numbers, and ages of roosting cormorants were included in the survey. Florencia Island, BC. 27 June 2007 (Trudy Chatwin).

Cave #2 (South)

1982: 22 August - no nests and no birds noted (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (Vermeer et al. 1992); **2006:** 10 July - no nests, no birds, and no guano (HRC, PNH; this study).

Comments: two cave sites located on west side of Fleming Island. At both cave #1 and cave #2, there are two caves beside each other. Nesting confirmed in 1970, 1979, 1980, and 1982. Colony not mentioned in Campbell (1976).

Folger Island

1965-1970: cave annually harbours two or three pairs of adults (CJG; Guiguet 1971; Campbell 1976); **1975:** 16 July - seven pairs of adults (MGS, MP, BP – RBCM); **1982:** August - no nests and no birds (KAH; Carter et al. 1984; Appendix 1); **1986-2005:** birds flying into cave in some years (AB; this study); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2005:** "inactive colony"; no nests found (SAG; Avery-Gomm 2005; pers. comm.); **2006:** 10 July - no nests and no birds at Folger Island, although one bird was diving off nearby Leach Islet. (HRC, PNH; this study); **2007:** 11 July - seven birds (five breeding adults and two non-breeding adults) roosting at cave entrance and one breeding adult flew into deep part of cave. Nesting was suspected. **Comments:** cave site on northwest side of island; nesting suspected but not confirmed.

Gibralter Island

1972: 17 June - one+ nest at mouth of cave (DFH; Hatler et al. 1978; Campbell 1976); **1979:** no nests (HRC; Carter et al. 1984; Appendix 1); **1980:** 1 July - no nests (HRC; Carter et al. 1984; Appendix 1); **1982:** 23 June - no nests (HRC; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests and no birds but thick guano was present suggesting recent roosting (HRC, PNH; this study); **2007:** 11 July - no nests, no birds, and no guano (HRC, PVC; this study). **Comments:** cave site on east side of Gibralter Island in Pacific Rim National Park. Nesting confirmed in 1972.

Great Bear Rock

1969-1973: no nests, although nesting Brandt's Cormorants present (Hatler et al. 1978); **1974-1975:** two nests (Campbell 1976); **1976:** August - no nests and no birds (HRC, WEM; Carter et al. 1984; Appendix 1); **1979:** 10 August - no nests (HRC, SGS, JMP; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2003:** 10 July - no nests (PVC, AS1; this study); **2004:** 22 July - no nests (PVC, AS1; this study); **2006:** 11 July - no Pelagic or Brandt's Cormorant nests but three subadult Pelagic Cormorants roosting and 48 Brandt's Cormorants roosting (HRC, PNH; this study); **2007:** 27 June - no nests but three non-breeders roosting (TC, JC, SM, BA; unpubl. data). **Comments:** exposed rock; nesting confirmed in 1975.

Hankin Island

1972: colony of unknown size present (Hatler et al. 1978); **2006:** (11 July - two old nests and guano but no birds; nesting apparently completed (HRC, PNH; this study); **Comments:** cave site on east side of Hankin Island. Nesting confirmed in 1972 and 2006. Colony not mentioned in Campbell (1976) and not surveyed by Carter et al. (1984) or Vermeer et al. (1992).

Hosie Islands

1975: 16 July - three pairs in breeding plumage flushed from cave (MGS, MP, BP – RBCM); **2006:** 10 July - no nests at cave but some guano on cliffs at southwest corner indicating roosting (HRC, PNH; this study); **Comments:** cave site on south side of the largest Hosie Islet. Nesting suspected but not confirmed. Colony not mentioned in Campbell (1976) and not surveyed by Carter et al. (1984) or Vermeer et al. (1992).

Lawton Point

1979: 19 May - one adult carrying nest material into cave (HRC, JMP; Carter et al. 1984; Appendix 1); **1979:** 4 June - seven nests, 20 adults, and one non-breeding adult flew out of cave, more flew farther into cave (HRC, SGS; Carter et al. 1984; Appendix 1); **1979:** 13 June - birds using cave (HRC, SGS; Carter et al. 1984; Appendix 1); 28 June - 10 nests (5 nests with 19 eggs, four empty nests; one nest missing since 4 June) (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** 14 June - nests seen but not counted (HRC; Carter et al. 1984; Appendix 1); **1982:** 4 September - no nests seen at entrance to cave but two pairs suspected nesting farther in cave (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 10 July - no nests, no guano; one bird flew out of cave and one bird feeding off outer Lawton Point (HRC, PNH; this study); **2007:** 11 July - four nests with incubating breeding adults in deep inner part of cave – this part of the cave was not visible in 2006 (HRC, PVC; this study). **Comments:** mainland cave site located in Pacific Rim National Park. Nesting confirmed in 1979, 1980, and 2007. Colony not mentioned in Campbell (1976).

Robinson Island

1982: 23 June - one adult with nesting material at cave entrance and two birds without white flank patches (HRC; Carter et al. 1984; Appendix 1); **2006:** 11 July - no nests and no birds (HRC, PNH; this study); **Comments:** cave site on east side of Robinson Island, located on First Nations lands. Nesting suspected but not confirmed. Colony not mentioned in Campbell (1976) and not surveyed by Vermeer et al. (1992).

Rutley Islands

1982: 24 June - six+ nests, 15 adults and three non-breeding birds on cliffs, one adult carrying nest material (HRC; Carter et al. 1984; Appendix 1); **1982:** 22 August - one nest with three chicks, nest located under overhanging tree foliage (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 11 July - no nests and no birds; one bird on water flushed and flew towards Baeria Rocks (HRC, PNH; this study). **Comments:** cliff site; nesting confirmed in 1982. Colony not mentioned in Campbell (1976).

Sandford Island

1979-1982: no nests found but birds observed roosting on cliffs in this area (HRC; this study); **2005:** "active colony"; seven+ nests in photograph but raw data lost (SAG; Avery-Gomm 2005; pers. comm.); **2006**: 10 July - no nests and no birds (HRC, PNH; this study). **Comments:** cliff site on southwest side of Sandford Island. Nesting confirmed in 2005.

Seabird Rocks

1960: no nesting records (Drent and Guiguet 1961); **1974-1975:** no nests (Campbell 1976); **1979-1982:** no nests (HRC, SGS, unpubl. observations); **1988:** 26 July - 16 nests (DG, AB; Rodway and Lemon 1990); **1989:** 20-30 June - 12 nests (KHM, PJE; Vermeer et al. 1992); **1992:** 19 June - no nests (AB notes; this study); **2003:** 1 August - eight nests; some eggs were eaten by Northwestern Crows when incubating adults flushed (PVC; this study); **2005:** 6 July - no nests (PVC; this study); **2006:** 10 July - no nests and 25 birds roosting (22 breeding adults, three subadults); gulls flushed as we passed by, possibly due to undetected Northern River Otter presence (HRC, PNH; this study); 19 July - no nests (PVC, TC; this study); **2007:** 5 July - no nests (PVC; this study). **Comments:** exposed rocks within Pacific Rim National Park; nesting confirmed in 1988 and 2003. Northern River Otter scat and many carcasses of Leach's Storm-Petrels (*Oceanodroma leucorhoa*) and Rhinoceros Auklets (*Cerorhinca monocerata*) were found in 2005 and 2006, indicating mammalian predator presence (PVC, unpubl. data). Pelagic Cormorants may have been depredated or disturbed. Also disturbed on occasion by researchers and possibly by First Nations people collecting gull eggs (Figure 23). Colony was not surveyed by Carter et al. (1984). (see Appendix 1).

Figure 23. Occasionally an egg of a Pelagic Cormorant was found in a Glaucous-winged Gull nest when First Nations people collected gull eggs for eating. Chain Islets, BC. June 1973 (R. Wayne Campbell).

Figure 24. Many Pelagic Cormorant nests contain an assortment of varying stages of incubation and nestling development due to natural and human disturbances. Chain Islets, BC. 23 July 1973 (R. Wayne Campbell).

Swiss Boy Island

1969: 11 August - nests contained large downy young, 50 pairs assumed nesting (JS, EL; Guiguet 1971); **1970:** 11 July - no nests (JS, RWR; Guiguet 1971); **1975:** 17 July - no nests but 25 pairs assumed nesting (MGS, MP, BP – RBCM); **1979:** 30 June - birds flying in and out of cave (HRC, SGS; Carter et al. 1984; Appendix 1); **1982:** 22 August - no nests and no birds (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - five nests (KHM, PJE; Vermeer et al. 1992); **2006:** 10 July - no nests and no birds, but some guano at southern cave indicates roosting (HRC, PNH; this study). **Comments:** two caves on west side of Swiss Boy Island; nesting confirmed in 1969. Colony not mentioned in Campbell (1976).

Tapaltous Beach

1979-1982: no nests found but birds were observed roosting at caves in this area (HRC; this study); **2005:** "active colony"; one + nest observed but raw data lost (SAG; Avery-Gomm 2005; pers. comm.); **2006:** 10 July - no nests and no birds (HRC, PNH; this study). **Comments:** mainland cave site on the south side of Tapaltous Bay in Pacific Rim National Park. Nesting was first suspected in 2005. With no details provided, we considered this as a suspected colony because birds may have been roosting at site without breeding or cave site location may have been confused with the nearby Lawton Point colony which was not reported surveyed.

Weld Island

1975: 17 July - no nests (MGS, MP, BP – RBCM); **1979:** 30 June - 18+ nests (10 nests with 29 eggs and four chicks (Figure 24), three empty nests, five inaccessible), 29 birds flushed (HRC, SGS; Carter et al. 1984; Appendix 1); **1980:** 1 July - two + nests visible from water, 13 adults flew out of cave (HRC; Carter et al. 1984; Appendix 1); **1982:** 4 September - no nests and no birds (HRC, KAH; Carter et al. 1984; Appendix 1); **1989:** 20-30 June - no nests (KHM, PJE; Vermeer et al. 1992); **2006:** 10 July - no nests and no birds, but 1 subadult roosted on north side of island (HRC, PNH; this study). **Comments:** two caves on south and west sides of Weld Island; nesting was confirmed 1979 and 1980. Colony not mentioned in Campbell (1976).

Observers

Abbreviated individual observers noted above include: Ben Alderman (**BA**), Stephanie Avery-Gomm (**SAG**), Jim Biggar (**B**), Kathy Brand (**KB**); J. A. Brooks (**JAB**), Alan Burger (**AB**), R. Wayne Campbell (**RWC**), Harry R. Carter (**HRC**), Trudy Chatwin (**TC**), Peter V. Clarkson (**PVC**), Jenna

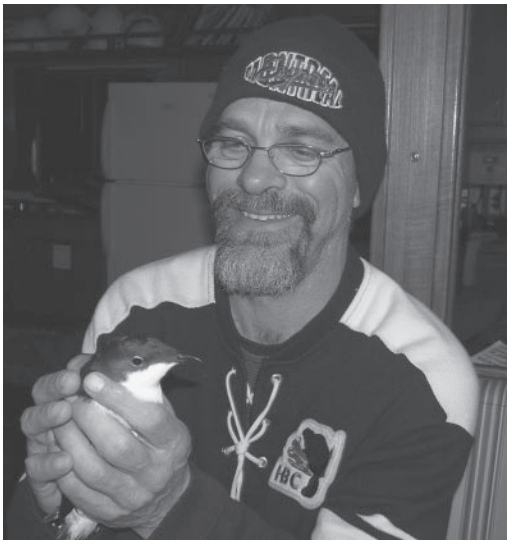

Figure 25. Percy Hébert, holding a Xantus's Murrelet (*Synthliboramphus hypoleucus*), participated in the survey of nesting and roosting Pelagic Cormorants in Barkley Sound in 2006. San Miguel Island, CA. 24 April 2007 (Harry Carter).

Cragg (JC), Peter J. Ewins (**PJE**), J. Bristol Foster (**JBF**), D. Garnier (**DG**), Charles J. Guiguet (**CJG**), David F. Hatler (**DFH**), Percy N. Hébert (**PNH**; Figure 25), Keith A. Hobson (**KAH**), Ewald Lemke (**EL**), Moira Lemon (**ML**), Sebastian Marcoux (**SM**), William E. McIntyre (**WEM**), Ken H. Morgan (**KHM**), Marilyn A. Paul (**MP**), Betty-Lou Peers (**BP**), Julie M. Porter (**JMP**), Robert W. Risebrough (**RWR**), Joan D. Rosebergh (**JDR**), Jack Schick (**JS**), Spencer G. Sealy (**SGS**), Michael G. Shepard (**MGS**), A. Spooner (**AS1**), Ann Stewart (**AS2**), Ken R. Summers (**KRS**), T. Widdowson (**TW**), and A. R. Wooton (**ARW**).

Other abbreviations: **BCNRS** (British Columbia Nest Record Scheme operated and housed by the Biodiversity Centre for Wildlife Studies in Victoria, BC), **RBCM** (Royal British Columbia Museum), and **CWS** (Canadian Wildlife Service).