TIMING AND SUCCESS OF BREEDING IN PELAGIC CORMORANTS
AT TRIANGLE ISLAND, BRITISH COLUMBIA, 2003–2008

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Key words: breeding biology, British Columbia, interannual variability, northeast Pacific, Pelagic Cormorant, Phalacrocorax pelagicus, Triangle Island

Of the 6 cormorant species that inhabit the North Pacific, the Pelagic Cormorant (Phalacrocorax pelagicus) is the smallest and most widely distributed (Hobson 1997). Pelagic Cormorants breed from Baja California in the eastern Pacific north to the Bering and Chukchi Seas, and south across the western Pacific to southern China. North America supports an estimated one-third of the global population of 400,000 birds (Johnsgard 1993), with the bulk breeding in Alaska. Campbell and others (1990) estimated that only about 4200 pairs bred in British Columbia, mostly at small and widely dispersed sites centered within the Strait of Georgia.

Information on the population status of Pelagic Cormorants in British Columbia is limited. Populations appear to have declined over recent decades in the Haida Gwaii archipelago (Fraser and others 1999), although there is some question about the reliability of the baseline data (Harfenist and others 2002). More conclusive evidence suggests that dramatic declines have occurred in the southern Strait of Georgia (by about 50% since 1987; Chatwin and others 2002), and along the west coast of Vancouver Island (by about 85% since 1969; Carter and others 2007). The declines have been attributed to disturbance at breeding colonies by humans and Bald Eagles (Haliaeetus leucocephalus), and reductions in prey availability due to oceanographic change (Chatwin and others 2002; Carter and others 2007). Persistent contamination and mortality due to oiling and fisheries practices might also be contributing factors (Harris and others 2005; Smith and Morgan 2005).

There is at present very little information on the timing and success of Pelagic Cormorant breeding at colony sites in British Columbia, especially for regions outside of the Strait of Georgia (Drent and others 1964; Harris and others 2005). This information is pertinent to understanding causes of regional population change, and given declining population trajectories, there is a need for basic demographic measures.

Triangle Island is situated about 40 km west of Cape Scott off the northwestern tip of Vancouver Island. This site supports one of British Columbia’s largest Pelagic Cormorant breeding aggregations, comprising over 400 breeding pairs in 1989 (Rodway and others 1990). Here we report on a 6-y study (2003–2008) of the timing and success of breeding in Pelagic Cormorants at Triangle Island, through a period of extreme oceanographic variation along the British Columbia coast (Mackas and others 2007). This report constitutes the most comprehensive account of the biology of the species at this comparatively pristine site, and should provide a baseline against which future changes can be measured.

Field crews collected data on Triangle Island (UTM: Zone 09, 0494480E 5634395N, WGS84) from late March until late August in each year between 2003 and 2007, and from mid-May until mid-August in 2008. Beginning on arrival in the spring, we logged systematic, detailed observations of all cormorant nests situated within the borders of a small cliff-face plot (approximately 25 m²) established in 2002 on Puffin Rock, a small islet adjoined to the main island at low tide. Our viewing blind was situated about 50 m from and 2 m above the highest nest on the plot, and provided a good view into all nests when adults stood up.

For all active nests, we recorded initial laying dates, hatching dates, and dates when a chick
was no longer present. We used these observations to determine hatching success (the proportion of active nests in which at least 1 egg hatched), fledging success (the proportion of nests in which at least 1 nestling survived at least 30 d), and breeding success (the proportion of nests in which at least 1 nestling survived to fledge). To facilitate comparisons of overall production among colonies, however, we also report frequency distributions for clutch size (total eggs), and the number of fledglings produced per nest. Because Pelagic Cormorants often replace lost clutches, we followed failed nests and recorded the same set of parameters if a replacement clutch was laid.

**Timing of Breeding**

The number of active Pelagic Cormorant nests on our monitoring plot varied from 0 (2008) to 24 (2003) across the 6 y, with lower numbers in more recent years (Table 1). The season’s 1st egg was laid as early as 15 May in 2003 (day 135) and as late as 4 June in 2007 (day 155), while median laying dates varied from 30 May in 2003 (day 150) to 19 June in 2006 (day 170)(Fig. 1). No nests were built and no eggs were laid on the breeding plot in 2008. Across all years, individual pairs initiated 1st clutches between mid-May and mid-July. Laying was especially synchronous in 2007 and especially asynchronous in 2004 and 2005 (Fig. 1). Annually, replacement clutches were laid at 0 to 25% of nests at which the 1st clutch was lost prior to hatching (Table 1), and these replacement clutches extended clutch initiation dates to as late as 3 August in 2006 (day 215)(Fig. 1).

Historical information on timing of breeding at Triangle Island is sparse. Rodway and others (1990) reported that nests contained eggs in mid-June in 1989, and in mid-July in 1982, 1984, and 1985. Chicks were seen in nests on 19 and 23 July in 1982 (days 200 and 204), with 1 chick described as “40 cm tall, starting to feather”, suggesting that it was several weeks old. In 1989, Rodway and others (1990) reported simply that “most nests held large young” in early August. In more recent years (Triangle Island Research Station, unpubl. data), no chicks were seen in 22 nests on 21 June 1998 (day 172), but 9 of these nests held chicks on 8 July (day 189). Similarly, only 1 of 65 nests held a chick on 26 June in 2001 (day 177), but 5 of these nests held chicks on 28 June (day 179). In 2002, the 1st chick of the season in 32 nests hatched between 15 and 19 June (days 166 and 170). Based on these observations, it appears that there has been little systematic change in the timing of breeding over recent decades, while timing varied markedly from year to year (Fig. 1). The same is true at other Pelagic Cormorant breeding sites (Boekelheide and others 1990).

The timing of breeding at Triangle Island is similar to that at other sites in British Columbia. Peak laying occurs between late May and mid-June at Mandarte Island (Drent and others 1964), and between early June and early July in Pacific Rim National Park (Hatler and others 1978). Timing at Triangle Island also is similar to that at the Farallon Islands, California, where laying peaks in late May (Boekelheide and others 1990), and on Middleton Island, Alaska, where laying peaks in late May to mid-June (Hatch and Hatch 1990).

**Clutch size**

Clutch sizes varied from 1 to 4 eggs in 2003, 2004, and 2005, and from 2 to 4 eggs in 2006 and 2007 (Fig. 2). Again, no eggs were laid on the

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<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>First clutches</th>
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<th>Replacement clutches</th>
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<tr>
<td></td>
<td></td>
<td>Hatch (%)</td>
<td>Fledge (%)</td>
<td>Successful (%)</td>
<td>Hatch (%)</td>
<td>Fledge (%)</td>
<td>Successful (%)</td>
<td>No. successful nests (%)</td>
<td>Chicks fledged, all nests (%)</td>
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<tr>
<td>2003</td>
<td>24</td>
<td>16 (67)</td>
<td>9 (56)</td>
<td>9 (38)</td>
<td>2 (25)</td>
<td>1 (50)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>9 (38)</td>
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<td>2004</td>
<td>20</td>
<td>16 (80)</td>
<td>13 (81)</td>
<td>13 (65)</td>
<td>2 (50)</td>
<td>2 (100)</td>
<td>2 (100)</td>
<td>2 (100)</td>
<td>15 (75)</td>
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<td>2005</td>
<td>15</td>
<td>2 (13)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>3 (23)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
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<tr>
<td>2006</td>
<td>13</td>
<td>8 (62)</td>
<td>6 (75)</td>
<td>6 (46)</td>
<td>1 (20)</td>
<td>0 (0)</td>
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<td>0 (0)</td>
<td>6 (46)</td>
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<tr>
<td>2007</td>
<td>15</td>
<td>13 (87)</td>
<td>2 (15)</td>
<td>2 (13)</td>
<td>0 (0)</td>
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<td>2 (13)</td>
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<td>2008</td>
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1 Number and percentage of active nests where the 1st clutch failed to hatch and was subsequently replaced. For example, in 2003, 24 first eggs were laid, of which 16 hatched and 8 did not. Of the 8 eggs that failed, 2 (25%) were replaced.
FIGURE 1. Timing and success of breeding for Pelagic Cormorants at Triangle Island, British Columbia, in 2003–2007. Laying dates are grouped by 5-d intervals and represent clutch initiation dates. No nests were built and no eggs were laid on the study plot in 2008.
study plot in 2008. There was little seasonal trend in clutch size, although weak seasonal declines have been reported elsewhere (Boekelheide and others 1990). The modal clutch size was 3 eggs in all 5 y from 2003 to 2007, with means between 2.3 (2005) and 3.2 (2007) eggs. Replacement clutches were somewhat smaller, consisting of 2 (in 6 of 8 cases) or occasionally 3 (2 cases) eggs. While Pelagic Cormorants occasionally lay up to 8 eggs (Campbell and others 1990), clutch sizes at Triangle Island were within the normal range for the species; means across the northeast Pacific range from 2.5 to 4 eggs, with no geographic cline evident (Hobson 1997; Sydeman and others 2001).

**Breeding success**

Breeding success at Triangle Island varied dramatically over the 5 y of our study: 13 to
87% of egg-laying pairs hatched 1 or more eggs, and 0 to 65% of pairs that hatched at least 1 egg had 1 or more chick survive to fledge (Table 1). Overall, at least 1 chick fledged from 0 to 65% of 1st clutches, depending on year. Only 2 of 8 pairs that re-laid after losing their 1st clutch fledged a chick, both in 2004. Including replacement clutches, 0 to 75% of pairs succeeded annually (Table 1). Of note, no pairs bred successfully in 2005, a year of widespread failure for seabird breeding across the California Current system (Sydeman and others 2006). In addition, the lack of breeding on the study plot in 2008 apparently was due to constant disturbance from Bald Eagles, possibly associated with inactivity at a Peregrine Falcon (*Falco peregrinus*) eyrie near the cormorant plot. In other years, the falcon parents kept Bald Eagles out of the area.

We rarely knew the cause of breeding failure. Most failures occurred after hatching (Table 1), possibly because chicks simply starved to death or were evicted by older and stronger nestmates. Except in 2004, when all 12 clutches laid on or before the median laying date were successful compared to only 3 of 8 laid after the median date, there was little systematic within-season variation in breeding success (Fig. 1). The modal number of fledglings produced per nest was 0 in 4 of 5 y; however, in 2004 the modal number was 2 and 1 nest fledged 3 chicks (Fig. 2). In total, 0 to 26 fledgling cormorants were produced annually (Fig. 1). The modal number of fledglings produced per nest was 0 in 4 of 5 y; however, in 2004 the modal number was 2 and 1 nest fledged 3 chicks (Fig. 2). In total, 0 to 26 fledgling cormorants were produced annually from within the borders of our monitoring plot.

Such extreme interannual variation in breeding success appears to be typical of Pelagic Cormorants throughout their northeast Pacific range. At the Farallon Islands, California, Pelagic Cormorants produced 0 to 2.4 fledglings per active nest in 11 y (Boekelheide and others 1990). More recent analyses suggest little temporal change since then (Sydeman and others 2001). Further north, Pelagic Cormorants produced 0.1 to 1.4 fledglings per active nest on the Semidi Islands, Alaska, over 5 y (Hatch and Hatch 1990). Success was more consistent in just 2 y at Mandarte Island, British Columbia in the late 1950s where 74 and 79% of active nests were successful (Drent and others 1964). However, Harris and others (2005) reported considerably greater variance in reproductive success (0 to 2.0 fledglings per active nest) at Mandarte Island and other colonies in the Strait of Georgia between 1989 and 1994. On the whole, it appears that Pelagic Cormorant breeding success at Triangle Island during the 5 y of this study was fairly typical of the species.

Acknowledgments.—We thank many field workers for their efforts collecting these data. Funding was provided by the Nestucca Oil Spill Trust Fund, the Centre for Wildlife Ecology (Simon Fraser University and the Canadian Wildlife Service), World Wildlife Fund Canada, and the Migratory Birds and Science Horizons program of Environment Canada. We received invaluable ship and helicopter support from the Canadian Coast Guard. Thanks to M Court, J Higham, and C Smith for logistical support from Vancouver.

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