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BIOLOGY OF BLACK OYSTERCATCHERS BREEDING ON TRIANGLE ISLAND, BRITISH COLUMBIA, 2003–2011

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ABSTRACT—The breeding biology of the Black Oystercatcher (*Haemotopus bachmani*) was studied on Triangle Island, British Columbia, Canada in 2003–2011. Breeding density at this remote site was relatively high, ranging from 2.23 to 3.72 pairs/km of shoreline in the 9 y. Most clutches were initiated in the last 2 wk of May, and the annual mean 1st clutch size ranged from 2.1 to 2.8 eggs/nest, values similar to those recorded at other sites. Egg size differed little in clutches of 1, 2, and 3 eggs. Hatching success at Triangle Island ranged from 55 to 87% in 5 y, which is on the high end of the range compared to other sites. Limited data suggested that adult survival rates exceeded 90% per annum, and 43% of individuals banded just prior to fledging survived through at least their 1st winter. Oystercatchers are reliable indicators of the health of coastal ecosystems, and these data comprise a baseline against which future changes at Triangle Island can be assessed.

Key words: Black Oystercatcher, clutch size, egg size, *Haematopus bachmani*, hatching success, survival, timing of laying, Triangle Island

The Black Oystercatcher (*Haematopus bachmani*) is a large shorebird of rocky intertidal habitats, in which it is a top predator. Despite being widely distributed along the Pacific coast of North America from the western Aleutian Islands of Alaska east and south to Baja California, this highly conspicuous coastal species remains poorly studied (Andres and Falxa 1995). Previous work has examined adult time budgets (Purdy and Miller 1988); habitat use (Andres 1998; Hazlitt and Butler 2001; Poe and others 2009); diets and foraging ecology (Hartwick 1976; Butler and Kirbyson 1979; Frank 1982); timing of breeding, clutch size, and chick growth (Groves 1984; L'Hyver and Miller 1991); and the effects of natural (Vermeer and others 1992a; Hazlitt 2001; Gill and others 2004) and anthropogenic (Andres 1999; Morse and others 2006) factors on breeding success. A recent study tracked large-scale movements by deploying satellite tags (Johnson and others 2010). However, few comprehensive studies of the breeding biology of the Black Oystercatcher have spanned more than 1 or 2 y.

Oystercatchers as a group are considered reliable indicators of the health of coastal ecosystems (Carlson-Bremer and others 2010). These systems are under threat from environmental stressors such as sea-level rise (Chu-Agor and others 2011); increases in the frequency and severity of extreme climate events (van de Pol and others 2010), acidification of the ocean (Gaylord and others 2011); oiling of beaches (Lance and others 2001); shellfish fisheries (Verhulst and others 2004); eutrophication (Garcia and others 2010); and human disturbance (Goss-Custard and others 2006). To predict the future impacts of these stressors, baseline information on the biology of coastal species is needed, especially from relatively pristine sites. Here we report on a 9-y study of Black Oystercatcher breeding biology on Triangle Island, British Columbia, the outermost of the Scott Islands. Our aims are to make comparisons with oystercatcher biology at other sites, and to provide a baseline of information against which future changes at Triangle Island can be evaluated.

METHODS

Field work on Triangle Island (UTM: Zone 09, 0494480E, 5634395N, WGS84) was conducted from late March to late August in 2003–2007, mid-May to late August in 2008, mid-May to mid-August in 2009, and mid-May to early July in 2010 and 2011. Observations spanned all (2003–2007) or much (2008–2011) of the Black Oystercatcher breeding season.

Accessible shoreline areas of Triangle Island totaling 4.03 km in length (Fig. 1) were searched at 1- to 5-d intervals from soon after arrival of field crews on the island. When an oystercatcher nest initially contained an egg, a marker such as a colored fishing float was placed at the top of the beach above the nest. The markers enabled crews to quickly locate the nest later and otherwise to avoid the area. After 5 d, crews returned to get a GPS reading at the nest, record the final clutch size, then measure (length and maximum breadth, ±0.1 mm, with dial calipers), weigh (±1 g with a 100 g spring scale), and number (with a permanent marker) all eggs. Because eggs were not always fresh when they were weighed, we used an index of volume (length × breadth^2) as a measure of egg size.

The initiation date of each clutch was determined by one of the following methods: (1) in most cases, by direct observation of the laying date of the 1st egg; otherwise, the date was estimated either (2) from the date of appearance of subsequent eggs, assuming that eggs are laid at 2-d intervals (L'Hyver and Miller 1991); or in rare cases, (3) from the hatching date of the 1st egg, assuming that the incubation period is 27 d (Webster 1941). The latter method, however, will estimate laying dates only for successful clutches. Only clutches in which the laying dates of 1st eggs could be determined within a window of 5 d using these criteria are reported.

After eggs were measured, the nest was then left undisturbed for approximately 20 d, and then checked at approximately 1- to 3- d intervals until eggs hatched or failed. Nests were considered successful if one or more eggs hatched and unsuccessful if no eggs hatched. Failed nests were inspected regularly to determine whether a replacement clutch was laid. Crews made no effort to systematically track the fates of individual chicks, so as to minimize disturbance at this sensitive stage.

Six adult Black Oystercatchers were caught with noose carpets set above the intertidal zone late in the 2007 breeding season. These individuals were likely to be pre-breeders or failed breeders and all were at least 2-y old, judging by the absence of black bill tips. For each bird, mass (±5 g with a 1 kg spring scale), maximum flattened wing chord (±1 mm with a wing bar), and lengths of tarsus (foot rolled up) and culmen (both ±0.1 mm with dial calipers) were measured. Each bird was then banded with a USFWS stainless steel band plus a color band on the right leg, and 2 color bands on the left leg (from among 6 colors). In 2004–2008, a total of 30 oystercatcher chicks was caught by hand just prior to fledging, measured and banded with USFWS stainless steel band on the right leg plus a darvic band engraved with a unique 2-digit code on the left leg. Banded adults and juveniles were resighted throughout the season in all years from 2005 to 2011. However, many of the engraved bands placed on juveniles were illegible by as early as the 2nd y after banding, so we limit the assessment of juvenile survival to the 1st y after banding.

RESULTS

Breeding Density

In 2003–2011, Black Oystercatcher nests were found in a total of 19 discrete sites in the areas searched in each year on Triangle Island (Fig. 1). Within any single year, the number of active nests ranged from 9 to 15, giving minimum and maximum breeding densities of 2.23 and 3.72 breeding pairs/km. Individual nest sites were used in 1 to 9 y of the study, and for 5.8 y on average (Fig. 1).

Timing of Breeding

The dates of initiation of 1st clutches ranged from 10–14 May to 19–23 June, a spread of approximately 6 to 7 wk (Fig. 2). Most (75%) 1st clutches were initiated between 15 and 29 May. Replacement clutches were laid as late as 10 July in 2007 (Fig. 2); thus the overall spread in laying dates with these clutches included was up to approximately 9 wk.

Clutch Size and Egg Size

Black Oystercatchers laid clutches of 1 to 3 eggs, with annual modes of 2, and more

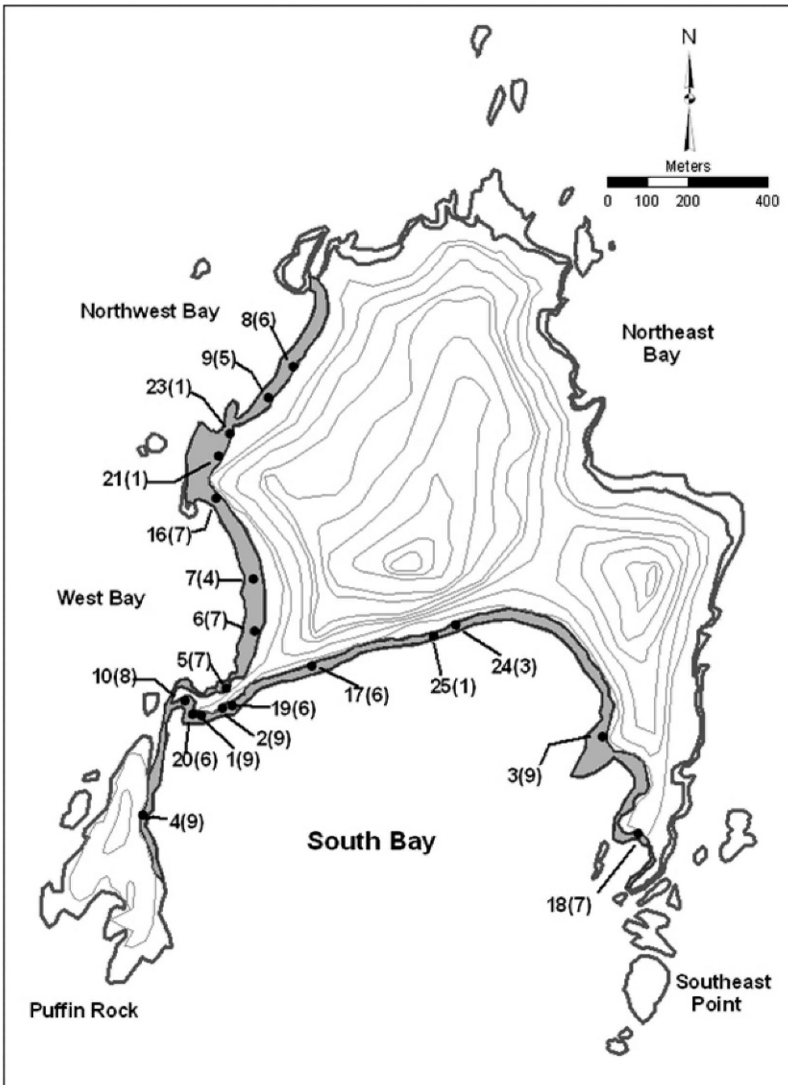

FIGURE 1. Map of Triangle Island showing locations of Black Oystercatcher nests found in the 4.03 km of shoreline areas searched in 2003–2011 (shaded in grey). Nests were numbered in the order they were found over the 9 y; nests 11–15 and 22 are located outside the area searched in all years (and not included on the map). Numbers in brackets are the number of years of the study in which the nest was active.

commonly 3 (Fig. 2). Mean 1st clutch sizes ranged from 2.1 ± 0.8 (*s*) eggs/nest in 2011 to 2.8 ± 0.4 (*s*) eggs/nest in 2010. Single-egg clutches were laid only in 2007, 2008, 2009, and 2011 (Fig. 2), and in all but 2009, these were the last clutches to be laid in the year. The 1st and replacement clutches laid in the same nest in the same year tended to be of the same size: in 3 cases, both consisted of 3 eggs (2003, 2007, 2008); while in 2 cases, both consisted of 2 eggs (2004 and 2007); in 1 case, however, there were 3 eggs in the 1st clutch but only 2 in the replacement (2008).

There was a strong peak in egg size at 80 to 86 cm^3 of volume index (Fig. 3), and the eggs in clutches of 1, 2, and 3 differed little in linear dimensions: for eggs in single-egg clutches (n = 8), mean length = 56.9 mm (min = 53.9 mm,

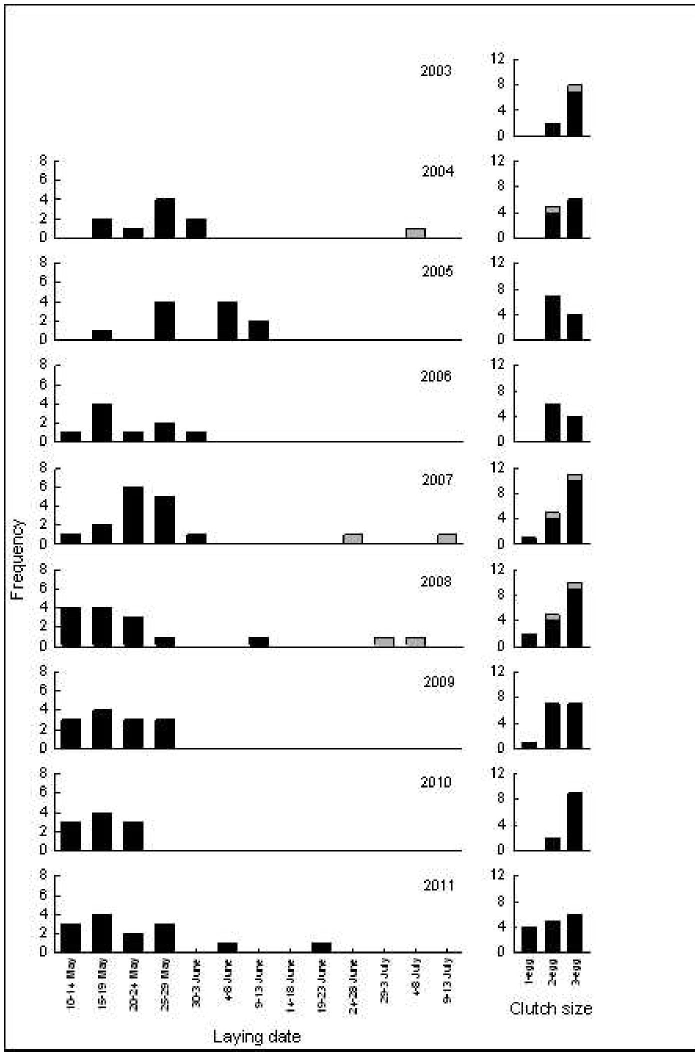

FIGURE 2. Frequency distributions for dates of initiation of 1st (black) and replacement (grey) clutches in 2004–2011 (left); and for clutch size in 1st (black) and replacement (grey) clutches in 2003–2011 (right), in Black Oystercatchers breeding at Triangle Island. Sample sizes for the 2 measures are not always the same because of uncertainty regarding laying dates in a few cases; only laying dates known to within a 5 d window are included. We have assumed that both replacement clutches in 2008 were laid after the chicks from a previous clutch had left the nest.

max = 60.4 mm), and mean breadth = 38.3 mm (36.5 to 40.0 mm); for eggs in 2-egg clutches ($n = 78$), mean length = 57.7 mm (49.9 to 66.0 mm), and mean breadth = 38.3 mm (35.6 to 40.7 mm); for eggs in 3-egg clutches ($n = 183$), mean length = 56.9 mm (50.9 to 63.6 mm), and mean breadth = 38.4 mm (36.0 to 40.5 mm); and finally, for replacement eggs ($n = 15$), mean length = 55.7 mm (51.3 to 58.5 mm), and mean breadth = 38.2 mm (36.0 to 39.7 mm).

Hatching Success

There was uncertainty about the fates of some nests in 2003–2006 due to the irregularity of nest checks around hatching in those earlier years. Consequently, we limit the analysis of Black Oystercatcher hatching success to 2007–2011. Hatching success (the percentage of nests in which at least 1 egg hatched) varied from 55%

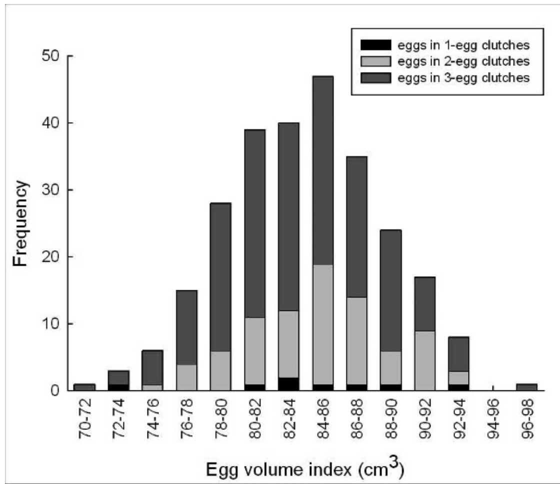

FIGURE 3. Frequency distribution of egg volume indices (length × breadth^2) in relation to clutch size (1–3 eggs).

in 2010 to 87% in 2009 (Table 1). Without daily checks, we were not always able to determine how many eggs had hatched, so we do not report on hatching success of individual eggs.

Adult and Juvenile Survival

Adult Black Oystercatchers on Triangle Island were similar in mass and linear dimensions to those in California and Alaska (Table 2). Of the 6 adults banded in 2007, 5 (83%) survived at least 3 y, and 4 (67%) survived at least 4 y (Table 3). Of the 30 chicks banded in 2004–2008, 13 (43%) survived to at least 1 y of age (Table 4), and survival was especially high for the 2004 cohort (75%).

DISCUSSION

Breeding Density

At 2.23 to 3.72 pairs/km of shoreline, Black Oystercatchers bred at relatively high density on Triangle Island. At other sites in British Columbia, Vermeer and others (1992a) reported densities ranging from 0.06 pairs/km in the Gulf Islands up to 1.61 pairs/km in Skidegate Inlet, Haida Gwaii. Along the west coast of Vancouver Island, breeding densities were 0.07 pairs/km in Barkley Sound and 0.75 pairs/km in the Cape Beale region (Vermeer and others 1992b), but density was exceptionally high at Cleland Island at approximately 38 pairs/km (calculated from data in Rodway and Lemon 1990). In Alaska, oystercatcher breeding density was approximately 0.26 pairs/km in Kenai Fjords National Park (calculated from data in Morse and others 2006); 0.03 to 0.38 pairs/km in Prince William Sound (Poe and others 2009); and up to 2.5 pairs/km on fox-free islands off the Alaska Peninsula (Byrd and others 1997). On Middleton Island, Gill and others (2004) reported a breeding density of 5.2 pairs/km following a long period of exponential population

TABLE 1. Hatching success of Black Oystercatchers at Triangle Island, 2007–2011.

Year	Number of nests	Number that hatched	Number that failed	Number undetermined[1]	Hatching success (%)[2]
2007	15 (2)[3]	11 (2)[3]	4 (0)[3]	0	73
2008	15 (2)	12 (2)	3 (0)	0	80
2009	15	13	2	0	87
2010	11	6	5	0	55
2011	15	11	2	2	85

[1] Nests that still had eggs when observations ceased in that year.
[2] Excluding nests of undetermined fate.
[3] Numbers in brackets represent replacement clutches, which were laid following loss of eggs in a 1st clutch (2 in 2007) or loss of chicks from a 1st clutch (2 in 2008). These are included in the totals. Thus in 2007, replacement clutches were laid at 2 of the 15 nests, and 2 of the 11 clutches that hatched were replacement clutches.

TABLE 2. Mass and linear measurements of Black Oystercatchers at Triangle Island, and in California (Andres and Falxa 1995) and Alaska (Guzzetti and others 2008). Values are shown as mean ± *s*.

Site	Sex	*n*	Mass (g)	Wing chord (mm)	Tarsus (mm)	Culmen (mm)
Triangle	Both	6	574 ± 18	254.8 ± 9.9[1]	52.4 ± 2.1	72.3 ± 4.1
California	Male		—	245.0 ± 6.1	51.9 ± 1.8	68.3 ± 4.2
	Female		—	247.5 ± 7.3	53.1 ± 2.0	73.6 ± 3.3
Alaska	Male	92	582 ± 31	249.7 ± 8.2	51.6 ± 1.4	68.6 ± 2.9
	Female	113	619 ± 44	251.9 ± 7.9	53.1 ± 1.8	74.7 ± 3.3

[1] Maximum flattened wing chord.

growth. Black Oystercatchers thus appear to nest at higher densities on remote, offshore islands than at protected, inshore sites.

Timing of Breeding

Egg-laying by Black Oystercatchers on Triangle Island spanned 6 to 7 wk, but up to 9 wk with replacement clutches included, with a peak in laying in mid- to late May. Timing is similar at other sites in British Columbia. At Mandarte Island, laying peaked between 15 and 23 May in 1956–1961, with a spread in 1st egg dates from 7–30 May (Drent and others 1964). On Cleland Island, L'Hyver and Miller (1991) found 1st eggs on 13 and 10 May in 1982 and 1983, respectively, and the spreads in clutch initiation dates were 44 and 55 d; Vermeer and others (1992b) reported that 72% of clutches were initiated on Cleland Island between 15 May and 4 June in 1989. In Skidegate Inlet, Haida Gwaii, the mean clutch initiation date was 23 May in 1990 (Vermeer and others 1992a). To the south, egg-laying began about 20 April in 1946 in southern California (Kenyon 1949). To the north, in Alaska, the 1st clutch was laid on 9 May in 1941 on Kayak Island (Webster 1941); mean dates of clutch initiation on Middleton Island were 16 May and 19 May in 2001 and 2002, respectively (Gill and others 2004); and in Kenai Fjords National Park, the peak of hatching was 8–15 June in 5 y, suggesting peak laying about 12–19 May (Morse and others 2006). As suggested previously (L'Hyver and Miller 1991), there is no consistent latitudinal trend in the timing of laying by Black Oystercatchers.

Clutch Size and Egg Size

At Triangle Island, Black Oystercatchers laid clutches of 1 to 3 eggs, with annual means of 2.1 to 2.8 eggs/nest. Clutches of 4 (L'Hyver and Miller 1991) and 5 (Zerlang and Fraser 1940) eggs have been recorded elsewhere. At other sites in British Columbia, the mean clutch size was 2.6 eggs/nest at Mandarte Island in 1956–1961 (Drent and others 1964); 2.3 eggs/nest in Skidegate Inlet in 1990 (Vermeer and others 1992a); and 1.9 to 2.2 eggs/nest, with a consistent modal value of 2, at Cleland Island in 9 y (Hartwick 1974; Groves 1984; L'Hyver and Miller 1991; Vermeer and others 1992b). In Alaska, the mean clutch size was 2.6 eggs/nest at sites unaffected by oiling in Prince William Sound in 2 y (Andres 1999); 2.5 to 2.7 eggs/nest in 5 y in Kenai Fjords National Park (Morse and others 2006); and 2.5 and 2.8 eggs/nest in 2 y on Middleton Island (Gill and others 2004). With the exception of Cleland Island, where clutch sizes were unusually small (perhaps due to the exceptionally high nesting density), clutch sizes

TABLE 3. Resightings of 6 adult Black Oystercatchers banded with a code of 3 colors (Y = Yellow; G = Green; W = White; B = Blue) on Triangle Island in 2007.

	Resighting year			
Band combination	2008	2009	2010	2011
YGG	Yes	Yes	Yes	Yes
WBW	Yes	Yes	Yes	Yes
GWB	Yes	No	Yes	Yes
BGY	Yes	Yes	No	Yes
YWY	Yes	No	No	No
WBG	Yes	No	Yes	No

TABLE 4. Numbers of juvenile Black Oystercatchers banded (2004–2008) and resighted 1 or more y later on Triangle Island.

Year banded	Number banded	Number resighted
2004	8	6
2005	11	3[1]
2006	4	1
2007	5	2[1]
2008	2	1

[1] Single individuals banded in 2005 and 2007 were first resighted in their 2nd y after banding, but not in their 1st y after banding.

at Triangle Island were similar to those at other sites. L'Huyver and Miller (1991) reported that mean clutch sizes in museum collections ranged from 2.3 to 2.7 eggs/nest at sites from southern California to Alaska, with little latitudinal trend.

Single-egg clutches were laid by Black Oystercatchers in just 4 of the 9 y of study, and they tended to be laid late. The combination of late laying and small size suggests that these single-egg clutches were laid by 1st-time breeders, and in fact, 3 of the 4 pairs that laid single-egg clutches in 2011 included an individual of unknown sex banded as a chick in 2004–2008 and not seen breeding in any earlier year. As in some (L'Hyver and Miller 1991) but not all (Webster 1941) previous studies, replacement clutches at Triangle Island tended to be the same size as 1st clutches laid by the same females.

Black Oystercatcher egg size at Triangle Island differed little between clutches of 1, 2, and 3 eggs, with a frequency peak at 80 to 86 cm^3 of volume index. Egg size at Triangle Island thus was similar to that in Prince William Sound, where the mean egg volume was 43.4 cm^3 (Andres 1999), equivalent to 84.9 cm^3 of volume index.

Hatching Success

Hatching success for Black Oystercatchers at Triangle Island ranged from a low of 55% (in the El Niño year of 2010) up to a high of 87%. We rarely knew the causes of failure, but they included: (1) inviability of eggs, as reported elsewhere (Gill and others 2004); (2) nests inundated at extreme high tides and during storms (Morse and others 2006); (3) nests abandoned when Steller's (*Eumetopias jubatus*) or California (*Zalophus californianus*) Sea Lions encroached too closely (Warheit and others 2004); (4) a nest abandoned after an adult bird was depredated by a Peregrine Falcon (*Falco peregrinus*); and (5) depredation of eggs by Northwestern Crows (*Corvus caurinus*), which we suspect was the commonest cause of failure.

At other sites in British Columbia, just 23% of pairs hatched at least 1 egg at Cleland Island in 1976 and 1977 (Groves 1984) and 45% in 1989 (Vermeer and others 1992b), while 62 (1996) and 44% (1997) of breeding pairs hatched at least 1 egg in the Gulf Islands (Hazlitt and Butler 2001). Data were reported on a per egg basis, rather than a per nest basis, on Mandarte Island (Drent and others 1964) and in Skidegate Inlet (Vermeer and others 1992a), precluding comparison. In Alaska, 31% of pairs hatched at least 1 egg in Prince William Sound in 1992 and 1993 (Andres 1999); 20 to 51% of pairs hatched at least 1 egg in Kenai Fjords National Park in 5 y (Morse and others 2006); and 92 and 93% of pairs hatched at least 1 egg on Middleton Island in 2 y. It is interesting that hatching success was higher at the most remote of the sites where data were available (Triangle and Middleton islands).

Adult and Juvenile Survival

Body mass of Black Oystercatchers at Triangle Island was similar to that at sites in Alaska. While there have been no formal assessments to date, owing to the limited amount of banding that has been done, resighting rates in Alaska and British Columbia suggest that the typical adult survival rate for Black Oystercatchers is in excess of 90% per annum (Andres and Falxa 1995; Hazlitt and Butler 2001; this study). At Triangle Island, 43% of banded juveniles survived to at least 1 y of age, comparable to the 53% that survived to 1 y of age on Cleland Island (Groves 1984). Most juveniles were resighted on Triangle Island in late March and early April in the year after they were banded, in flocks with adult birds. Satellite-tagged Black Oystercatchers started their spring migration very early in April (Johnson and others 2010), so it is possible that adult and juvenile oystercatchers reside on Triangle Island through the winter.

Conclusions

Several facets of Black Oystercatcher biology on Triangle Island appear to be typical for the species: timing of laying, clutch and egg size, and adult and juvenile survival rates. But nesting density and hatching success are relatively high at this remote site. We hope that this report can provide a baseline of information against which future changes in the marine system at Triangle Island can be measured.

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