Black Oystercatchers and Campsites in Western Prince William Sound, Alaska

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Abstract.—Black Oystercatchers (*Haematopus bachmani*) have been identified as a species of concern by government agencies and conservation organizations because they have small populations and are sensitive to disturbance caused by shoreline and near-shore human activity. Expanding human recreation in Prince William Sound (PWS) may have potential negative consequences on Black Oystercatcher reproduction and on the population as a whole. Almost 2000 km of shoreline in western PWS was inventoried to assess density, distribution and habitat use of breeding Black Oystercatchers each June and July from 2001 to 2004. These efforts identified 94 territories (density 0.03–0.38 pairs/km). Black Oystercatcher territories were preferentially located on wave-cut platforms and rocky islets as well as gravel beaches but they avoided salt marsh, tide flats and sheltered rocky shores. Within western PWS 186 shoreline campsites were documented and people preferred to camp on gravel beaches. The association between campsites and territories was evaluated, and although there was a positive correlation at the landscape level, direct overlap only occurred on four sites and territories were separated from campsites, on average, by 1.8 km. Impacts associated with direct overlap (e.g., trampling of nests or direct displacement of pairs) may be rare for this remote area. *Received 29 July 2008, accepted 24 February 2009.*

Key words.—habitat, human use, shoreline recreation, disturbance, Prince William Sound, Chugach National Forest, Alaska.

Waterbirds 32(3): 423-429, 2009

Black Oystercatchers (*Haematopus bachmani*) are conspicuous, long-lived shorebirds adapted to life in rocky intertidal zones along the entire Pacific Coast of North America (Andres and Falxa 1995). World-wide population estimates range from 6,800 to 11,000 individuals (Andres and Falxa 1995; Morrison *et al.* 2001). Over 65% of the world's population breeds in Alaska (Andres and Falxa 1995), with 800 to 1,200 individuals inhabiting Prince William Sound (PWS) (Isleib and Kessel 1973; Irons *et al.* 2000). Susceptible to both human and natural disturbance on the breeding grounds (Andres and Falxa 1995), this species is vulnerable to catastrophic environmental events such as oil spills and invasive predators (Andres 1997). For these reasons, the Black Oystercatcher has been listed as a species of high conservation concern in the Canadian and U.S. Shorebird Conservation Plans (Donaldson *et al.* 2000; Brown *et al.* 2001), as a priority species in the Alaska Shorebird Conservation Plan (Alaska Shorebird Working Group 2008), and as a Focal Species for the U.S. Fish & Wildlife Service.

The Chugach National Forest (CNF) designated Black Oystercatchers as a Management Indicator Species under its 2002 revised Forest Plan (U.S. Forest Service 2002). As a result of this designation, the CNF assesses habitat, monitors populations and reduces potential threats to breeding individuals for the majority of oystercatchers inhabiting the shorelines of PWS.

Following the 1989 *Exxon Valdez* oil spill, initial Black Oystercatcher research in PWS focused on basic life history and the effects of oil on nesting areas (Andres 1997). By the late 1990s, Black Oystercatchers were considered recovered from the effects of the *Exxon Valdez* oil spill (EVOS 2002) but a more recent assessment of long-term (1989-2005) waterbird monitoring efforts in PWS suggested that Black Oystercatcher populations in oiled areas had not recovered to pre-spill levels (Irons *et al.* 2000). In addition, elevated liver cytochrome P450IA levels were documented in 2004, indicating continued exposure to oil (R. Lanctot, unpublished data), which resulted in the species being downgraded to recovering (EVOS 2006; see also http://www.evostc.state.ak.us/Recovery/status_oystercatcher.cfm). Despite increased research activity related to the *Exxon Valdez* oil spill, the majority of shoreline in PWS had not been surveyed for Black Oystercatchers. Predictive habitat modeling completed by the CNF (U.S. Forest Service 2002) indicated the presence of large amounts of potential habitat in western PWS.

Western PWS is a favorite destination for marine and shoreline recreation. Access to western PWS was improved following the opening of the Anton Anderson Memorial Tunnel to Whittier (Fig. 1) in 2000, which allows direct access for more than half of Alaska's population and supports an increasing amount of commercial tourism (Colt *et al.* 2002). As a result of easier access, Murphy *et al.* (2004) predicted an increase in the recreational use of the most sensitive shoreline habitats in PWS. The most popular months for shoreline recreation in western PWS are June and July (Murphy *et al.* 2004), also a critical period for Black Oystercatcher egg incubation and chick rearing. Because of the predicted potential for increased amounts of recreation along the shorelines of western PWS, we inventoried the western PWS shoreline to determine Black Oystercatcher distribution and general habitat associations, and then to assess the potential conflict with campsites.

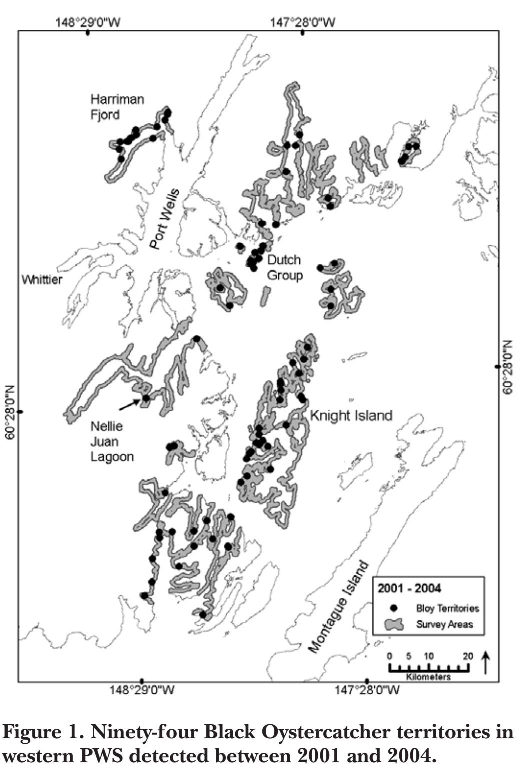

Figure 1. Ninety-four Black Oystercatcher territories in western PWS detected between 2001 and 2004.

METHODS

Study Area

Located in south-central Alaska, western PWS (~60°N, 147°W) is separated from interior Alaska in the north and west by the steep slopes of the Chugach and Kenai Mountains. Western PWS has approximately 2,030 km of mainland shoreline and 2,630 km of island shoreline. Shorelines of this region are generally steep and rocky but are punctuated by more gradually sloped beaches composed of gravel, cobble and rocky debris, which is deposited by glaciers, avalanches or streams. In addition to the many beaches, there are hundreds of small rocky islets, wave-cut platforms and emergent glacial moraines.

Under existing CNF management guidelines, most of the western half of PWS is part of the Nellie Juan-College Fjord Wilderness Study Area (U.S. Forest Service 2002). Developed recreation sites are not widely distributed, and there are no significant upland resource extraction activities, such as forestry or mining. With the exception of commercial fishing, the only widespread human activity in western PWS is recreation, both private and commercial. Activities include boating, sportfishing, kayaking, wildlife viewing and sightseeing, which are the bases for eco-tourism and charter businesses located in Whittier. Much of this activity is shoreline associated and uses primitive backcountry campsites dispersed throughout western PWS (Murphy *et al.* 2004; Colt *et al.* 2002).

Shoreline Surveys

We distributed our survey effort throughout CNF-managed western PWS based on a suite of competing objectives, such as areas with high and low human activity (eventually summarized in Murphy *et al.* 2004), the inclusion of both mainland and islands, visitation to areas with little or no previous survey effort and travel logistics. Thus, we did not select units randomly; instead we delineated survey units based on physical boundaries (topographical breaks in shoreline segments such as bays, islands and archipelagos). Because of the large area and the costs of access, we surveyed 18 units, ranging in size from 21 to 254 km in length, over four years from 2001 to 2004 (Fig. 1). We surveyed a total linear distance of 1,943 km of shoreline, approximately 64% of the western PWS shoreline managed by the CNF. Because Black Oystercatchers have a high breeding site fidelity (Tessler *et al.* 2007), surveys over multiple years along different shorelines likely encountered different (i.e. independent) breeding pairs.

We surveyed each unit twice per season. During each survey, two trained observers visually surveyed the entire shoreline of each survey unit from small inflatable power boats. We conducted surveys at ≤5 km/hr and ≤50 m from shoreline between 0800-1900 h (Alaska Daylight Time) at various tidal stages, although we maximized our effort during high tides to increase our likelihood of finding birds near nest sites. When we detected Black Oystercatchers, we went ashore to collect habitat information and determine breeding status. Although we recognize that detection rates may differ by observer, habitat type, tidal cycle, and within and between breeding seasons, we minimized these effects as much as possible by using techniques that were successful in previous PWS work (Andres 1997, 1998, 1999). Through these efforts, we believe we were able to detect virtually all of the Black Oystercatchers occurring on the shoreline but acknowledge that the number of territories found during our surveys is likely a minimum.

Because most Black Oystercatchers initiate breeding in May and early June in PWS (Andres and Falxa 1995), we completed our initial shoreline surveys to obtain territory and nest information within a ten-day period during late May and early June. For each bird located, we assigned status as territorial or non-territorial using a combination of behavioral observation and nest search. To reduce disturbance, we conducted these assessments for less than 30 min on each territory. We defined a reproductive pair by the presence of eggs or chicks or reproductive behaviors such as courting, nest-building, copulation or territorial aggression, and we defined non-reproductive status as individual, pair, or >2 birds not engaged in reproductive behavior. Our approach provides a conservative estimate of the number of reproductively active pairs. We geo-referenced all locations with a GPS and later developed a GIS overlay with individual territories and nest locations. We used locations of territories to estimate linear pair density (pairs/km) for each survey unit.

We assigned a shoreline type for each nest location based on the following five categories: salt marsh and tidal flat; wave-cut platform; exposed rocky shore; sheltered rocky shore; and gravel beaches. Nests were small enough that they did not overlap two categories. These shoreline types represent an aggregate of ten base shoreline types defined for an Environmental Sensitivity Index GIS layer produced for PWS by the National Atmospheric and Oceanic Administration (NOAA 2000). We calculated the total available km of each shoreline type for all survey units.

Spatial Analyses

We pooled GPS locations from all territories and survey units across years and conducted a Chi-square goodness of fit analysis to determine if Black Oystercatchers selected habitat types in proportion to their availability (Sokal and Rohlf 1995). We calculated a Jacob's D electivity index to determine preference or avoidance of particular shoreline types, and we used the following equation:

$$D = (r - p)/(r + p - 2rp)$$

where r = the proportion of nests on that shoreline type and p = the proportion of shoreline type from all survey units combined (Jacobs 1974). The Jacob's D shows habitat preference values relative to availability, from -1 (selection against) to +1 (selection for). We used an occupied territory to indicate shoreline class membership.

We used the Chugach National Forest Backcountry Ranger Program primitive campsite inventory for western PWS to determine how humans selected habitat types for camping. This layer represents a combination of known sites identified during a five-year, complete, shoreline inventory effort of western PWS (Chugach National Forest, unpublished data). We conducted a Chi-square goodness of fit test to determine if humans selected habitat types in proportion to their availability (e.g., Johnson 1980) and calculated a Jacob's D electivity index to determine preference or avoidance of particular shoreline types using the following equation: $D = (r - p)/(r + p - 2rp)$, where r = the proportion of campsites on that shoreline type and p = the proportion of shoreline type from all survey units combined (Jacobs 1974).

To evaluate the association between campsites and nest territories at the landscape scale, we used a Kolmogorov-Smirnov (KS) distribution test for continuous distributions (Zar 1999). We measured the Euclidean distance from campsites to nests and from campsites to random points and summarized nearest distance values from all known campsites and 270 random shoreline locations from the raster layer. We computed a cumulative distribution function (CDF), plotted the resulting values, and then measured the maximum distance (D_{max}) between the observed (distance-to-nest) and expected (distance-to-random) curve and compared that result to the critical value of (D_α) for the KS goodness of fit test for continuous distributions (Zar 1999).

RESULTS

Between 2001 and 2004, we identified 291 Black Oystercatchers and 94 unique breeding territories along 1,943 km of shoreline (Table 1). Linear pair density ranged from 0.03 to 0.38 pairs per km with Harriman Fjord and the Dutch Group having the highest density of nesting Black Oystercatchers (Fig. 1). Of the 94 territories evaluated, 50% were on gravel beaches, 21% were on sheltered rocky shores, 15% were on exposed rocky shores, 14% were on wave-cut platforms and rocky islets, and none were in either salt marsh or tide flats. Nest territories were not distributed in proportion to available habitat (χ^2 = 9.20; critical value = 9.488; df = 4; P = 0.059). Using Jacob's D Electivity Index, Black Oystercatchers selected for wave-cut platforms and gravel beaches and selected against salt marsh and tide flats, sheltered rocky shores and exposed rocky shores (Table 2).

Table 1. Summary of the Black Oystercatchers detected in western Prince William Sound from 2001 to 2004.

Year	Survey (km)	Total Birds	Territorial Pairs	Percent[1]
2001	498	81	22	54%
2002	421	53	18	68%
2003	296	75	24	64%
2004	728	82	30	73%
Total	1,943	291	94	65%

[1]Percent of birds found in confirmed territories.

We assessed the five shoreline types for the 186 primitive campsites within our study area. Campsites were not distributed in proportion to available shoreline type (χ^2 = 58.396; critical value = 9.488; df = 4; $P < 0.0001$). The Jacob's D Electivity Index showed that camps were on gravel beaches and not on exposed or sheltered rocky shores, nor on wave-cut platforms (Table 3).

Black Oystercatcher territories averaged 1,775 m away from shoreline campsites (SD = 1,426; range 60-5,865 m). Four of the territories occurred <100 m of campsites but the majority (74%) occurred >500 m from campsites. Territories on gravel beaches (n = 47) averaged 1,596 m from campsites (SD =1,603; range 60-5,843 m). Four territories occurred <100 m of campsites; of the 24 territories <500 m from campsites, 17 (71%) were on gravel beaches. When evaluated at the landscape scale, nest sites were positively associated with shoreline campsites (D_{max} = 0.179; critical value = 0.168; $P < 0.01$). Random points averaged 2,329 m from campsites (SD = 1,700; range 85-7,388 m).

DISCUSSION

We documented the distribution of Black Oystercatcher nest territories on nearly 2,000 km of shoreline in western PWS. We recognize the limitations of this information, particularly the trade-off between covering a greater extent of available shoreline and being able to compute detection rates by running survey segments multiple times. Our results provide a baseline inventory for the distribution of territories in Western PWS and identify the Harriman Fiord/Barry Arm complex, the Dutch Group archipelago

Table 2. Chi-square and Jacob's D electivity index for Black Oystercatcher territories relative to available shoreline type in western PWS, based on surveys completed from 2001 to 2004.

Shoreline type	Shoreline Length (km)	Proportion of study area (%)	Number of territories expected	Number of territories observed	Jacob's D
Salt marsh and tide flat	46	2%	2.3	0	-1
Wave cut platform	164	8%	8.0	13	0.24
Exposed rocky shore	309	16%	15.1	14	-0.04
Sheltered rocky shore	583	30%	28.5	20	-0.18
Gravel beach	841	43%	40.7	47	0.08
Total	1,943	100%	94.0	94	

Table 3. Chi-square and Jacob's D electivity index for primitive campsites relative to available shoreline type in western PWS, based on surveys completed from 2001 to 2004.

Shoreline type	Shoreline Length (km)	Proportion of study area (%)	Number of campsites expected	Number of campsites Observed	Jacob's D
Salt marsh and tide flat	46	2%	4.4	4	-0.05
Wave cut platform	164	8%	15.7	11	-0.18
Exposed rocky shore	309	16%	29.6	4	-0.76
Sheltered rocky shore	583	30%	55.8	19	-0.49
Gravel beach	841	43%	80.5	148	0.30
Total	1,943	100%	186.0	186	

and the Nellie Juan Lagoon as important breeding areas for Black Oystercatchers in PWS, in addition to Montague and Green islands identified earlier (Andres 1997, 1998).

Competing management objectives and logistical constraints (e.g. cost and access) limited our ability for 100% coverage of western PWS. We surveyed 64% of the shoreline managed by the CNF and subsequent monitoring efforts should consider these limitations. Not computing detection rates could have resulted in underestimating total territories, potentially complicating our ability to rigorously identify preference of shoreline types. Detection rates by habitat type likely vary most significantly when attempting to answer *nest* distribution questions and thus we limited our analyses to *territories*. The relative preference identified from such a large survey area and the fact that it was characterized conservatively (five general shoreline categories) make our results representative of use patterns by this species in PWS. The relative associations of territories with campsites will aid in prioritizing management questions and improving long-term species monitoring.

The selection of habitat by shorebirds in general (del Hoyo *et al.* 1996), and Black Oystercatchers in particular (Nysewander 1977; Hockey 1987; Andres 1998) is driven by direct and indirect human influences. Our results indicate that campers recreating in this backcountry are seeking the same general beach shoreline type as ~50% of nesting Black Oystercatchers detected in our study. However, the distances between campsites and nest territories are great, averaging 1.8 km, and the overall direct influences may not be a concern. Further, it is not immediately clear that shoreline camping has direct disturbance potential in south-central Alaska, whereas it may in areas of higher human population. Kayak camping disturbance trials did not reach thresholds that lowered productivity of Black Oystercatchers nesting in Kenai Fjords National Park (Morse *et al.* 2006), but nest failure has been attributed to human disturbance in Oregon (E. Elliot-Smith, cited as personal communication in Tessler *et al.* 2007).

We did not attempt to analyze the effect of human activity on the distribution of Black Oystercatchers. Our method limited our ability to evaluate nest success and prevented an assessment of variance in distribution relative to human activity. Studies using either regular repeat visits to territories (Morse *et al.* 2006) or continuous videography (Spiegel 2009) have found assigning nest failure to human activity to be difficult. Quantifying human use in a measure meaningful to correlate it with nest success has not yet been accomplished for this species. The intensity, type and duration (including seasonality) of human activity should be measured for a complete picture of human disturbance as a function of nest success. For example, although Morse *et al.* (2006) found little evidence that shoreline campsite use affected brood survival in Kenai Fjords National Park, we cannot be certain the same thresholds exist in nearby PWS. One possible difference may be in the somewhat longer season of use in PWS resulting from a greater range of recreation (including spring hunters and power-boaters). Spring hunts in PWS start prior to the Black Oystercatcher breeding season whereas shoreline human activity (principally sea kayakers) in Kenai Fiords is restricted more to the brooding period.

Depending on the mechanism of disturbance, greater impacts may result from the indirect effects of human activity (e.g., boat wakes during high tides or increased predation) within the vicinity of nests. Increased predator density and high intensity of boating activity resulted in greater vigilance of foraging American Oystercatchers (*Haematopus palliatus*), thereby reducing fitness (Peters and Otis 2005). Additionally, given that ravens, bald eagles and scavenging gulls are attracted to even temporary human settlements in PWS, densities of these nest predators may temporarily increase in shoreline areas with regular human use. Predation may be a special concern for large scale fish harvest and processing operations like hatcheries and set-net sites. and also mobile fish processing vessels anchored in fixed locations for prolonged periods.

Future research should focus on the mechanisms of nest disturbance which correlate with rigorously characterized human recreation. These efforts will have to be implemented in the context of rising sea levels which will alter nest habitat, campsite availability and intertidal forage sites. Potential climate-change related impacts such as closer nest proximity to upland woody vegetation, which provides cover for nest predators, as well as the loss of rocky islets and beaches historically used by this species will complicate research and monitoring of Black Oystercatchers.

ACKNOWLEDGMENTS

The Chugach National Forest provided the funding for this study. Babkin Charters provided safe and comfortable accommodations as well as logistical support to complete the surveys. J. Urbanus, J. Booz, C. Heaton, M. Krick, J. Garrard and R. Venable assisted with field data collection. Comments from P. Guertin, F. Huettmann, R. Lanctot, D. Nysewander and an anonymous reviewer improved this manuscript.

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