Bald Eagles, *Haliaeetus leucocephalus*, Feeding on Spawning Plainfin Midshipman, *Porichthys notatus*, at Crescent Beach, British Columbia

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Elliott, Kyle Hamish, Christina L. Struik, and John E. Elliott. 2003. Bald Eagles, *Haliaeetus leucocephalus*, feeding on spawning Plainfin Midshipman, *Porichthys notatus*, at Crescent Beach, British Columbia. Canadian Field-Naturalist 117(4): 601-604.

We observed Bald Eagles feeding on Plainfin Midshipman near Crescent Beach, British Columbia, in May and June 2001 and 2002. We quantified consumption rates and eagle numbers during this period, illustrating the potential importance of this food source to breeding eagles. Tide height was the only significant factor influencing consumption rates, likely because this variable reflected the availability of midshipman prey.

Nous avons observé les Pygargues à tête blanche alimenter sur les Crapauds à nageoire unie près de Crescent Beach, Colombie-Britannique, en maie et juin 2001 et 2002. Nous avons mesuré les cadences de consommation et les nombres de pygargues pendant cette période, illustrant l'importance potentielle de cette source de nourriture pour les aigles. La taille de marée était le seul facteur significatif influençant les cadences de consommation et les nombres de pygargues pendant la période d'étude, probablement parce que cette variable a reflété la disponibilité des crapauds.

Key words: Bald Eagle, *Haliaeetus leucocephalus*, foraging rates, Plainfin Midshipman, *Porichthys notatus,* British Columbia.

Bald Eagles (*Haliaeetus leucocephalus*) will travel thousands of kilometers from natal areas to congregate at large dependable food supplies (Servheen and English 1979; Buehler 2000). Well-known examples include annual congregations of eagles feeding on wintering waterfowl and spawning salmon and herring (Stalmaster 1987; Knight and Skagen 1988; Stalmaster and Kaiser 1997; Restani et al. 2000). Most such events in the Pacific Northwest occur during the non-breeding season (August-April), with breeding and non-breeding individuals dispersing throughout western North America (Servheen and English 1979; Stalmaster 1987; Buehler 2000). However, at Crescent Beach, British Columbia, we observed concentrations of up to 110 eagles feeding on spawning Plainfin Midshipman (*Porichthys notatus*) between March and June 1998-2002.

Although our observations were limited to Crescent Beach, midshipman may be an important prey item for breeding eagles at other locations in the Georgia Basin. For example, this species was the main food item delivered to young at nests near Crofton, eastern Vancouver Island (Gill and Elliott 2003). If this species is an important prey item, it could potentially be a significant vector for contaminants. Harfenist et al. (1995) sampled contaminant levels in 14 inshore fish species, and found the highest levels of some chlorinated hydrocarbon contaminants, including dioxins, in Plainfin Midshipman.

Methods and Study Area

We counted eagles along a 2.0 km stretch of waterfront around Crescent Beach, British Columbia, monthly from 1995 to 2002 (Figure 1). We used a 30× telescope at stations separated by about 200 m and situated on a railroad adjacent to and about 4 m above the shoreline. The survey extended from Crescent Beach (49º03.3N, 12º53.3W) south to 1001 Steps (49º02.0N, 123º52.5W).

To evaluate the importance of midshipman as a prey source for eagles, we observed 370 individual eagles for 10-minute intervals over 8-hour periods designed to cover all tide levels and times of day on nine days in May and June 2001. We used a 30× telescope positioned on the railroad adjacent to the shoreline at the location closest to the study subject. We noted the age (classified using Clark 2001) of each eagle, the identity and size relative to the eagle's bill length of all prey consumed, and whether any kleptoparasitism occurred. We also counted the number of eagles present every two hours.

Results and Discussion.

The two highest counts were 150 eagles in March 2001 (S. Boyd, personal communication) and 110 eagles on June 20, 1999 (KHE). The June count is the largest reported summer eagle concentration in southern British Columbia (Campbell et al. 1990).

During 90 hours of observation in May-June 2001 and 2002, the Plainfin Midshipman was the only prey item we observed eagles consuming at this location. This is a demersal fish that spawns in British Columbia's intertidal and high subtidal between May and

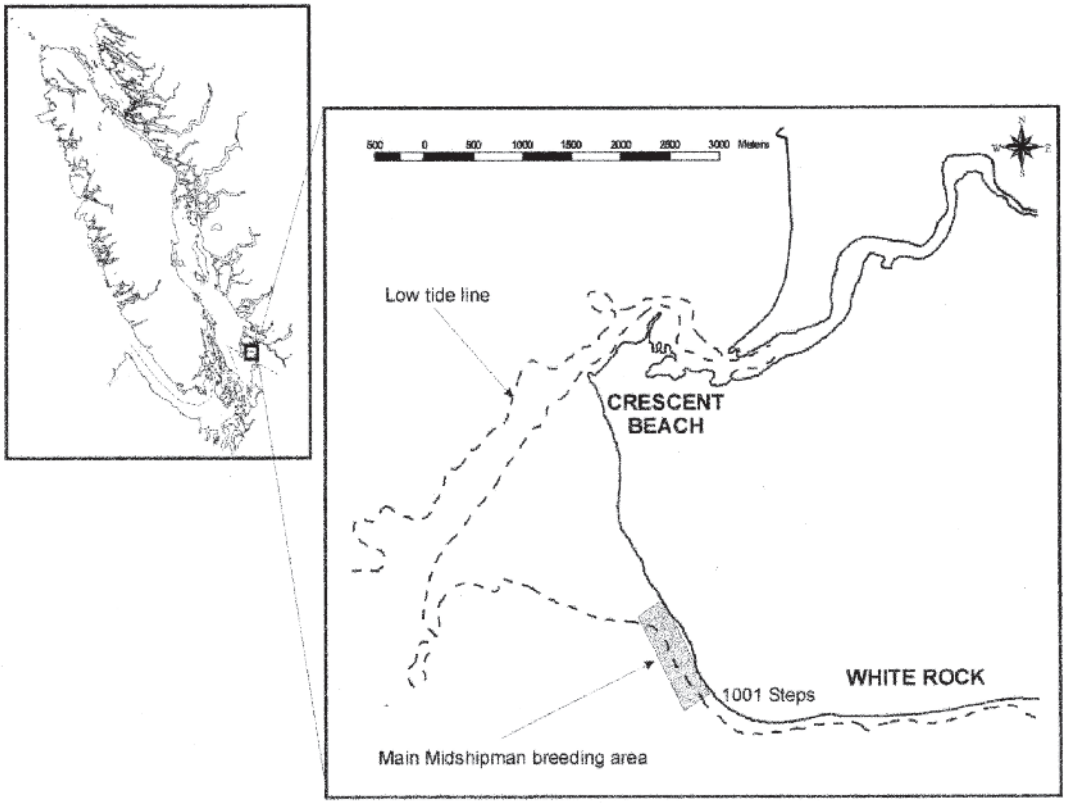

FIGURE 1. Location where Bald Eagles were observed to congregate and feed on Plainfin Midshipman, *Porichthys notatus,* from 1995 to 2002 near Crescent Beach, British Columbia.

July (Hart 1973; Elliott 2002). Most females and Type I (egg-guarding) males die after breeding (Demartini 1990; Elliott 2002). In addition to capturing emaciated post-breeders, the eagles also caught midshipman that were exposed on the beach or in shallow water by the receding tide, prior to breeding.

Between the first week in May and the last week in June, over 40 eagles (mean ± SE = 48.3 ± 1.3, n = 22) were consistently present at low tide (below 1.5 m). Eagles were not present along the foreshore at tides higher than 3 m, although some eagles were usually present in adjacent trees. Between 0.5 and 3 m, eagle counts decreased as tide height increased (Figure 2), with no difference between outgoing and incoming tides (ANCOVA, $P > 0.6$). Eagle counts did not vary with temperature, precipitation, time of day, or Julian date (correlation, $P > 0.6$). The overall ratio of subadults to adults was 1.19 to 1 and the proportions of subadults in each age class were 0.33 (1st years), 0.44 (2nd years), 0.15 (3rd years) and 0.08 (4th years). There was no difference in the timing of adult and juvenile counts (ANCOVA, $P > 0.6$).

The consumption rate also decreased at higher tide levels although consumption peaked between 1 and 2 m during outgoing tides, with no consumption occurring above 3 m (Figure 2). The overall consumption rate during outgoing tides was significantly higher than incoming tides only between 1 and 2 m (ANOVA, $F = 7.0$, $P = 0.03$). Consumption rate did not vary with temperature, precipitation, time of day, Julian date (correlation, $P > 0.6$) or individual's age (χ^2, $P > 0.6$). As predicted by Restani et al. (2000), we observed a significantly higher handling time by subadults (mean ± SE = 4.3 ± 0.8 min, n = 24) than adults (2.3 ± 0.4 min, n = 27). Handling time was independent of fish size (correlation, $P > 0.6$). Of fish consumed, 21% were pirated from conspecifics while 7% were pirated from Northwestern Crows (*Corvus caurinus*). There was no significant difference between adults and subadults in the proportion of fish pirated or the success of either age group at pirating one another (χ^2, $P > 0.6$). Overall, piracy was less successful (32% of all attempts successful, n = 62) than capturing prey (91% successful, n = 85).

Clearly, tide is the dominant environmental factor influencing the consumption rate and number of eagles at this location, as is also the case in the Columbia River estuary (Watson et al. 1991). The high con-

sumption rate between 1-2 m on outgoing tides reflects the consumption of midshipman exposed by the receding tide; most midshipman nest under boulders at the 1-2 m tide line. Assuming the consumption rates shown in Figure 2, an analysis of tide heights between sunrise and sunset from 10 May to 20 June in 2001 suggested that the average number of midshipman consumed per day per eagle was 14.2 ± 2.1, well above the amount needed for a neutral energy budget (Stalmaster and Gessaman 1984). This may explain why the eagles choose to conserve energy by loafing along the foreshore at low tide. We estimate that eagles consumed 22700 ± 3400 midshipman between 10 May and 20 June 2001, using the eagle counts from Figure 2. This would represent a large amount of nitrogen being transferred into nearby roost trees and may enhance community productivity along the shoreline, as has been observed near salmon spawns (Cederholm et al. 2000). The handling time for midshipman was shorter than that reported for Kokanee Salmon (*Oncorhynchus nerka*), where there was no difference in handling time between adults and juveniles (Restani et al. 2000). Although Bennetts and McClelland (1997) and Brown (1993) found lower foraging efficiencies in subadults than adults and Restani et al. (2000) found higher consumption rates in subadults, we found no difference in consumption rates, suggesting that experience plays a minor role in this system. Likewise, although the use of piracy decreases with age among eagles feeding on salmon (Bennetts and McClelland 1997), we found no difference in use of piracy between age classes. Hansen (1986) and Knight and Skagen (1988) showed that the success of eagles foraging on spawning salmon depends on the frequency of various strategies utilized at spawning sites. A similar analysis for eagles foraging on midshipman may elucidate some of the patterns described by other researchers that we were unable to find in our system, such as a relationship between age and consumption rates.

Eagle numbers in the Pacific Northwest have increased since the 1970s (Dunwiddie and Kuntz 2001; www.ecoinfo.org/env_ind/region/baldeagle/eagle_e.cfm [Buehler 2000]) and increased eagle predation may be contribute to low Great Blue Heron (*Ardea herodias*)

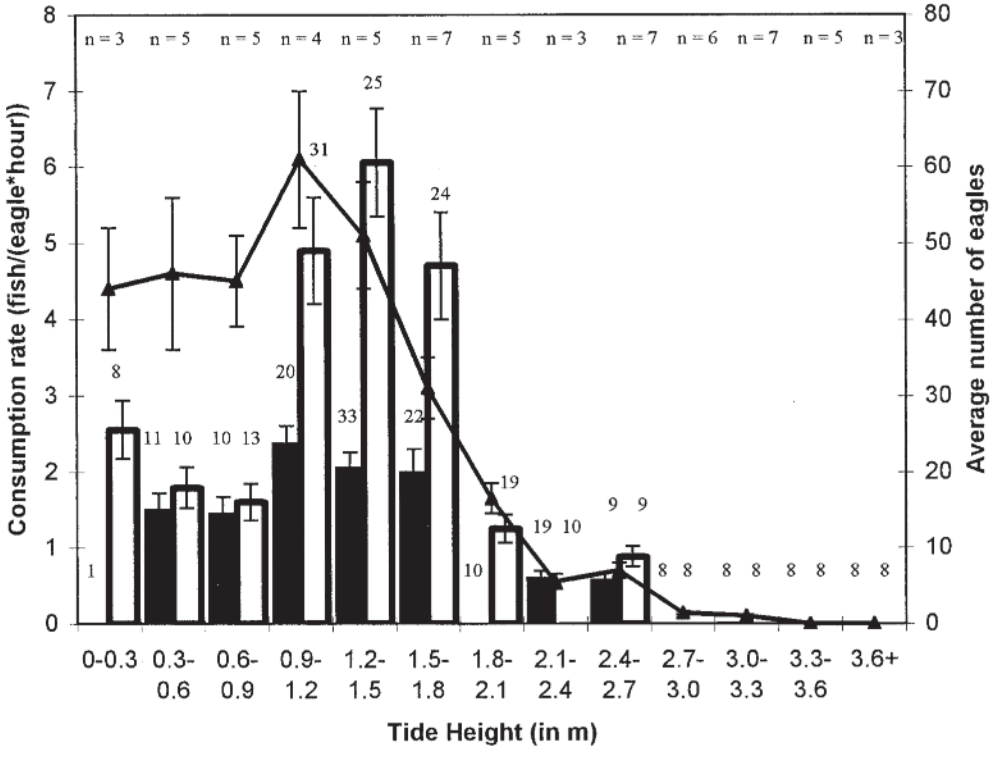

FIGURE 2. Consumption rate (black column = outgoing tide; white column = incoming tide) and average number of eagles on waterfront (line) as a function of tide height, at Crescent Beach, British Columbia, 1995–2002. Correlations on the unpooled data (tide height measured to the closest 10 cm) for all parameters are significant $P < 0.05$ (incoming consumption rate $r^2 = 0.66$, outgoing consumption rate $r^2 = 0.37$, average number of eagles $r^2 = 0.80$). Sample size shown above columns for consumption rates, top sample sizes are for counts. Error bars are ± SE.

reproductive success at some colonies (Vennesland 2000). Anecdotal evidence from naturalists familiar with the area suggests that while midshipman have bred at Crescent Beach since at least the 1960s (J. D. Macphail, personal communication), large numbers of eagles were not observed until the mid-1990s (F. Cooke, personal communication). It is unclear if the increase in eagle predation has affected midshipman reproductive success, or if the eagles are replacing or competing with other predators; Northwestern crows, Glaucous-winged Gulls (*Larus glaucescens*) and Great Blue Herons also congregate to feed on spawning midshipman at Crescent Beach.

Acknowledgments

We would like to thank Fred Cooke for organizing the original waterbird surveys along Crescent Beach and J. Don Macphail for the original identification and basic natural history of the Plainfin Midshipman. Eric Taylor also provided information on the natural history of this species. Gary Bortolotti, and S. Lee created the map in Figure 1. A. J. Erskine and Rob Butler provided helpful comments on earlier drafts of this manuscript. In addition, we thank Clare Struik and Laura Jordison for their enthusiastic help in the field.

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Received 11 October 2002
Accepted 12 January 2004