FORAGING ECOLOGY OF BALD EAGLES IN THE COLUMBIA RIVER ESTUARY

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Abstract: We studied time budgets and foraging ecology of adult bald eagles (*Haliaeetus leucocephalus*) in the Columbia River Estuary from 1984 to 1986. Eagles spent most of their time perching (94%); of that time, loafing (54%), foraging (23%), and nesting activities (16%) were most frequently observed. Eagles acquired food by hunting live prey (57%), scavenging (24%), and pirating (19%). Fish were the most important food and comprised 71% of prey remains. Catostomids, cyprinids, and fish <30 cm long were most often preyed upon. Consumption of waterfowl and seabirds increased in winter as they became more abundant. Foraging was spatially dependent on the distribution of tidal flats and water <4 m deep and was most common at low tide and first daylight. Differences in diets among pairs and between seasons reflect a strategy of opportunistic foraging. Management of eagle foraging habitats in the estuary should emphasize protection and enhancement of tidal flats and prey to maximize foraging opportunities.

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Bald eagles are found throughout the Pacific Northwest in close association with freshwater, estuarine, and marine ecosystems that provide abundant prey and suitable habitat for nesting and communal roosting (Anthony et al. 1982). Foods of bald eagles have been described for freshwater systems in Oregon (Frenzel 1984) and Washington (Fitzner and Hanson 1979, Knight et al. 1979, Fielder 1982) and for marine systems in the San Juan Islands of northwest Washington (Retfalvi 1970). However, there is little information on foraging ecology of bald eagles in estuarine systems (Bayer 1987).

From 1984 to 1986, we studied the ecology of a breeding population of bald eagles in the Columbia River Estuary. We present information on the species' time budgets, foraging methods, diets, and prey selection.

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STUDY AREA

The Columbia River Estuary is composed of open water, intertidal marshes, tidal flats, and natural and man-made islands (Fig. 1). Wetlands are largely brackish below and freshwater above River Mile 18. The maximum depth of the estuary at lowest tides was 37 m. Upland habitats are dominated by a mosaic of even-aged stands of Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*). Remnant stands of old-growth conifers were preferred for perching and nesting by eagles (Garrett et al. 1988).

Ocean tides were semi-diel; each tidal cycle lasted 11–14 hours. Salinity intrusion altered diurnal and seasonal distributions of fish by creating marine, brackish, and freshwater zones (Fig. 1). The interaction of tides and river currents constantly altered sediment distribution and created broad, level tidal flats that were exposed at low tide. The 30-year mean annual temperature in January was 5.1 C (Natl. Oceanic and Atmos. Adm., Astoria, Oreg., unpubl. data).

METHODS

We collected prey remains from and below nests during May and June 1984–86 when eaglets were several weeks old. We identified fish species by scale identification (Casteel 1972,

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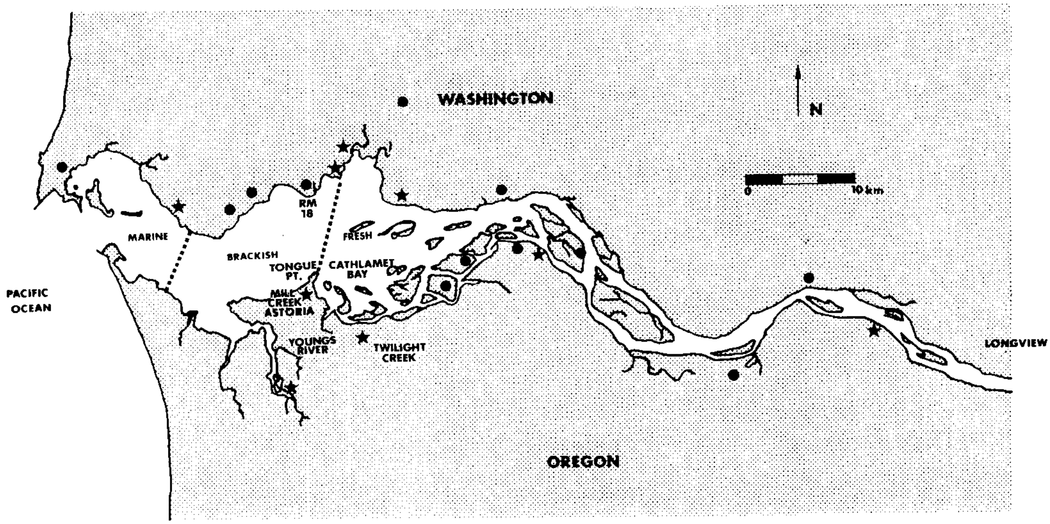

Fig. 1. Location of the Columbia River Estuary. Stars represent bald eagle nest territories that we studied; dots represent additional territories.

1973; Bond 1973) and bird and mammal species by comparisons with museum specimens. The minimum number of individuals per taxon in each nest was recorded (Mollhagen et al. 1972). Prey items from nests were used to compare species occurrence within vertebrate classes but not to compare diets across vertebrate classes because prey remains at nests are not representative of all prey captured (Dunstan and Harper 1975, Ofelt 1975). Fish are more digestible, less conspicuous, and decompose faster than remains of birds and mammals (Todd et al. 1982). To assess year-round diets and to make comparisons among vertebrate classes, we conducted intensive observations of 9 pairs of adult eagles. Prey were identified by class and species when possible. We visually estimated the lengths of captured fish by comparisons to eagle length (Swenson 1978) and classified them into 4 size classes: <10 cm, 10–29 cm, 30–59 cm, and >60 cm.

Observations also were used to assess influences of tide, time of day, and season on time budgets and foraging behavior. We recorded the duration of perching and flight time in minutes and categorized activities as directional flight, soaring flight, predation flight, loafing and preening, foraging, nesting, aggression, feeding, drinking, and bathing. Foraging included hunting for live prey, scavenging, and pirating. Tide levels were recorded as (1) level 1, all tidal flats exposed (water depth <0.3 m); (2) level 2, tidal flats partially exposed (depth 0.3–0.9 m); (3) level 3, tidal flats slightly exposed (depth 1.0–1.5 m); and (4) level 4, tidal flats covered (depth >1.5 m). Information on river depths was obtained from National Oceanic and Atmospheric Administration nautical charts, 55th edition (Natl. Oceanic and Atmos. Adm., Rockville, Md.). To evaluate changes in foraging techniques in relation to tide, we defined 8 tide stages based on current velocities (Braune and Gaskin 1982). Stages lasted approximately 90 minutes and included slack low water, slow flood, fast flood, second slow flood, slack high water, slow ebb, fast ebb, and second slow ebb.

We used Chi-square analyses to assess the following: seasonal and inter-pair differences in activities, foraging methods, and prey selection; differences in foraging success among foraging methods and water depths; occurrence of foraging at spring and neap tides; changing in foraging methods at different tide levels; size variation of captured fish between seasons; changes in capture success of waterfowl in prehunting and hunting seasons; and the distribution of foraging attempts among hourly periods. Bonferroni confidence intervals (Neu et al. 1974) were used to assess the occurrence of daily foraging at different tide levels. Using simple linear regression, we determined relationships between foraging methods and river mile, and between foraging time and success.

RESULTS

Diurnal Time Budgets

Based on 3,845 hours of observation throughout the year, we found eagles spent 94.3% of their time perching. Flight time (218 hr) was partitioned into directional flights (56.0%), soaring (40.1%), and predation flights (3.9%). Most perch time was devoted to loafing (53.9%), with less time spent foraging (23.4%), nesting (16.3%), in intraspecific aggression (3.8%), feeding (2.3%), and drinking and bathing (0.3%). Activities varied between breeding and nonbreeding seasons ($\chi^2 = 523.9$, 5 df, $P < 0.001$). Nesting activity decreased by 26% in winter and was the most marked change in seasonal behavior ($\chi^2 = 962.3$, 1 df, $P < 0.001$), because eagles spent only a small portion of time constructing nests in winter. Aggression between adult eagles varied seasonally ($\chi^2 = 525.7$, 1 df, $P < 0.001$) and was observed on 6 territories; however, during winter, 2 eagle pairs on adjacent territories accounted for 95% of time spent in aggression. Variability in activity among pairs of eagles ($\chi^2 = 658.7$, 40 df, $P < 0.001$) was partly a result of these differences in aggression, a behavior that accounted for 34% of the Chi-square value. Foraging and time spent in nesting behaviors accounted for an additional 26 and 19% of the Chi-square value, respectively.

Time spent foraging was negatively correlated ($r = -0.57$, 16 df, $P = 0.02$) with foraging success. That is, eagles that were less successful hunting spent more time hunting. The mean time spent nesting of 3 pairs that failed to hatch young was 10% of the activity time, whereas successful pairs spent 20% of their annual time budget in nesting activities.

Hunting Methods

In 715 predations, eagles hunted live prey (57%), scavenged (24%), and pirated (19%). There were no seasonal differences in foraging methods of eagles among taxonomic classes of prey ($\chi^2 = 3.0$, 2 df, $P = 0.22$) or fish taxa alone ($\chi^2 = 0.3$, 2 df, $P = 0.86$). However, there was variability among breeding pairs ($n = 9$) in the amount of prey taken using the 3 methods throughout the year ($\chi^2 = 74.7$, 16 df, $P < 0.001$). Scavenging was the most successful foraging technique (98%) and was more successful ($\chi^2 = 102.4$, 2 df, $P < 0.001$) than attempts to capture live prey (66%) or to pirate (46%). Unsuccessful scavenges resulted when eagles attempted but failed to secure dead prey from deep water. Piracies were directed at gulls (*Larus* spp.) 74% of the time ($n = 102$) and were 36% successful. The relatively low success of gull piracies was related to the frequent inability of eagles to recover prey after it was dropped by gulls in open water. Attempts to pirate other eagles accounted for 22% of the piracies ($n = 30$), and 80% were successful. Piracies of conspecifics were usually on tidal flats where prey was recovered, hence the higher success rate.

Diets

Direct observations indicated that piscine, avian, and mammalian prey comprised 90, 7, and 3%, respectively, of identified prey taken by eagles throughout the year ($n = 599$). Proportions of each prey class varied seasonally ($\chi^2 = 29.4$, 2 df, $P < 0.001$) and among pairs ($\chi^2 = 112.3$, 16 df, $P < 0.001$). Overall there was a 16% higher proportion of birds in eagle diets during the nonbreeding period and a corresponding lower proportion of fish.

Freshwater catostomids and cyprinids and anadromous clupeids and salmonids were the most frequent fish prey in nests (Table 1). The widespread distribution and consumption of these taxa were evidenced by their occurrence in 67–83% of the nests. Marine fish, including Gadidae and Embiotocidae, were less common prey because only 2 territories were located strictly in marine habitats. We did not determine seasonal changes in the species of fish selected by eagles because we could not identify a high percentage of fish species from direct observations.

Eagles displayed changes in size preferences of fish between seasons ($\chi^2 = 16.8$, 3 df, $P < 0.001$). During the breeding season, the proportion of fish <10 cm long increased in the diet from 8 to 25%, and fish >60 cm decreased from 16 to 6%. Differences resulted, in part, from the increased capture of juvenile salmonids during major movements of this age class through the estuary in June. Eagles occasionally perched on the ground beside tidal pools and captured several small fish in succession. For the entire year, 69, 25, and 6% of captured fish were <30 cm, 30–60 cm, and >60 cm long, respectively.

Waterfowl and seabirds were the primary avian prey identified in nests and comprised 92% of this prey class (Table 1). Waterfowl ac-

Table 1. Prey remains found in bald eagle nests in the Columbia River Estuary, Oregon and Washington, 1984–86.

Classification	Individuals		% of class	Nests where prey identified	
	No.	%		No.	%
Fish					
Catostomidae				15	83
largescale sucker (*Catostomus macrocheilus*)	32	17.3	24.2		
Clupeidae				13	72
American shad (*Alosa sapidissima*)	24	13.0	20.2		
Cyprinidae				12	67
common carp (*Cyprinus carpio*)	20	10.8	15.2		
peamouth (*Mylocheilus caurinus*)	18	9.7	13.6		
other cyprinids	8	4.3	6.7		
Salmonidae				12	67
salmon (*Oncorhynchus* spp.) and steelhead (*Salmo gairdneri*)	16	8.6	12.1		
Centrarchidae				5	27
black crappie (*Pomoxis nigromaculatus*)	2	1.0	1.5		
other centrarchids	3	1.6	2.3		
Percidae				2	11
yellow perch (*Perca flavescens*)	2	1.0	1.5		
Acipenseridae				3	17
sturgeon (*Acipenser* spp.)	3	1.6	2.3		
Gadidae				2	11
unidentified	3	1.6	2.3		
Embiotocidae				1	6
shiner perch (*Cymatogaster aggregata*)	1	0.5	0.8		
Subtotal	132	71.0			
Birds					
Anatidae				12	67
mallard (*Anas platyrhynchos*)	9	4.9	18.4		
green-winged teal (*A. crecca*)	4	2.2	8.2		
northern pintail (*A. acuta*)	2	1.0	4.1		
American wigeon (*A. americana*)	2	1.0	4.1		
Canada goose (imm.) (*Branta canadensis*)	3	1.6	6.1		
other anatids (*Aythya* spp.)	2	1.0	4.0		
Podicipedidae				6	33
western grebe (*Aechmophorus occidentalis*)	8	4.3	16.3		
Phalacrocoracidae				3	17
cormorant (*Phalacrocorax* spp.)	5	2.7	10.2		
Laridae				4	22
gull (*Larus* spp.)	5	2.7	10.2		
other	2	1.0	4.0		
Alcidae				1	6
common murre (*Uria aalge*)	2	1.0	4.1		
Other birds	5	2.7	10.1	3	17
Subtotal	49	26.1			
Mammals					
Leporidae				2	11
brush rabbit (*Sylvilagus bachmani*)	2	1.0	50.0		
Other mammals	2	1.0	50.0	2	11
Subtotal	4	2.0			

counted for 41% of avian prey taken during the nesting period and 60% in winter. Waterfowl surveys conducted in winter 1984–85 throughout the Columbia River Estuary revealed peak populations from November through January with declines thereafter (J. B. Atkinson, U.S. Fish Wildl. Serv., unpubl. data). Sixty-two percent of 42 attempted predations of eagles on waterfowl occurred during the waterfowl hunting seasons (Oct–Jan). There was no difference in the capture success of waterfowl during hunting and prehunting seasons ($\chi^2 = 1.3$, 1 df, $P > 0.25$). Three of 9 breeding pairs accounted for 71% of all waterfowl predations, and foraging

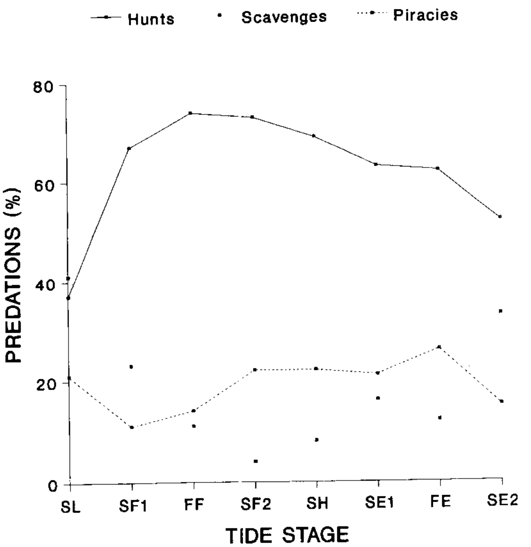

Fig. 2. Distribution of different foraging methods by adult bald eagles among tidal stages in the Columbia River Estuary, 1984–86. SL = slack low water, $SF_{1,2}$ = slow flood, FF = fast flood, SH = slack high water, $SE_{1,2}$ = slow ebb, FE = fast ebb.

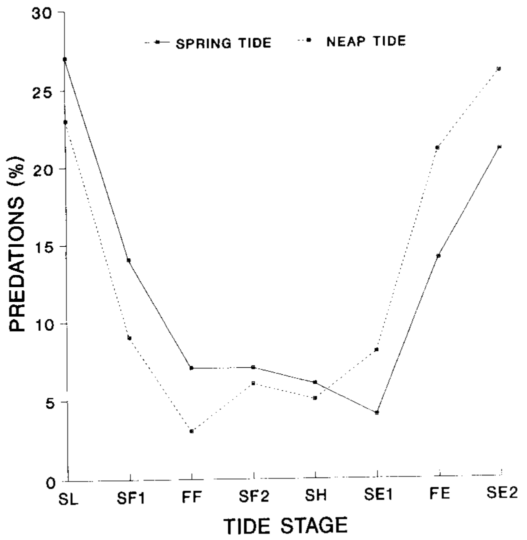

Fig. 3. Predation attempts by adult bald eagles among tidal stages during spring tides (n = 346) and neap tides (n = 411) in the Columbia River Estuary, 1984–86. SL = slack low water, $SF_{1,2}$ = slow flood, FF = fast flood, SH = slack high water, $SE_{1,2}$ = slow ebb, FE = fast ebb.

territories of these 3 pairs were associated with 58% of all waterfowl in the estuary (J. B. Atkinson, unpubl. data).

Mammals were infrequent prey of eagles, based on nest collections (Table 1). Direct observations showed that the occurrence of mammals in diets varied little (2–3%) throughout the year.

Influences on Foraging Behavior

Water Depth.—Eagles used shallow water to hunt for fish; of 292 attempts to capture live prey, 70% occurred in water <4 m deep. This increased to 84% when 173 scavenges at 0 m were included. Eagles were equally successful at hunting live prey in water <4 m deep (69%) versus >4 m (66%) (χ^2 = 0.32, 1 df, P = 0.57).

Tide.—Foraging attempts were not distributed among tide cycles in proportion to the amount of time eagles were observed during each tide cycle. Eagles foraged more than expected during low tides and less than expected during high tides (Table 2). In addition, use of different foraging methods varied among the 4 tide levels (χ^2 = 115.1, 6 df, P < 0.001). Eagles scavenged more at low tide stages and hunted live prey during high tides (Fig. 2). The proportions of piracies varied <20% throughout the tidal cycle and increased as high tides receded. Forty percent of all predation attempts at low tide occurred during the slow ebb, 41% at slack low water, and 19% at slow flood stage as water depths increased.

Foraging methods also varied among eagle pairs in relation to the degree of tidal influence (i.e., the range of tides) along the river. Tidal influence decreased progressively from the river mouth upstream. The proportion of scavenges for each eagle pair was negatively correlated (r = −0.83, 8 df, P = 0.01) with river mile location of each nesting territory. Proportionally fewer scavenges were attempted upriver where the tidal influence was less and there was less exposure of tidal flats. In contrast, live kills increased progressively from the mouth of the river upstream (r = 0.79, 8 df, P = 0.01).

Eagles foraged with different intensities (χ^2 = 26.3, 7 df, P < 0.001) during spring tides (max. tidal flux during new or full moon which resulted in lower low tides and higher high tides) and neap tides (min. tidal flux during quarter moons which resulted in average tides). During spring tides, lower-than-average low tides created expansive tidal flats that provided greater opportunities for scavenging (Fig. 3).

Time of Day.—Foraging attempts were not evenly distributed among hourly periods between dawn and dusk (χ^2 = 86.7, 15 df, P < 0.001). Predations peaked from 0500 to 0600 hours at 4 predations per 10 hours of observation, declined until 1100 hours, and remained

Table 2. Bald eagle predation attempts at different tide levels in the Columbia River Estuary, 1984–86.

Tide level (m)	Hr observed		Predations				90% CI[a]
			Observed		Expected		
	n	Proportion	*n*	Proportion	*n*	Proportion	
<0.3	583	0.151	191	0.272	106	0.151	0.234–0.310+[b]
0.3–0.9	912	0.237	210	0.300	166	0.237	0.261–0.310+
1.0–1.5	1,122	0.292	166	0.237	205	0.292	0.201–0.273–[c]
>1.5	1,228	0.319	134	0.191	224	0.320	0.158–0.224–
Total	3,845		701		701		

[a] Bonferroni confidence interval.
[b] More predations than expected.
[c] Less predations than expected.

at approximately 1 predation per 10 hours of observation until 1800 hours.

DISCUSSION

Foraging of breeding bald eagles in the Columbia River Estuary was opportunistic; prey selection was largely determined by the distribution and vulnerability of fish and waterfowl as influenced by location, season, and tides. Eagles on territories associated with shallow bays consumed comparatively high amounts of waterfowl. Todd et al. (1982) and LeFranc and Cline (1983) noted similar relationships between the incidence of waterfowl and seabird remains in bald eagles' nests and their local abundance.

Tidal flats and shallow water that increased the availability of fish carrion and live fish contributed to the relatively high proportion of fish taken in the Columbia River Estuary (71%). Proportions of fish in diets of bald eagles nesting in other coastal regions varied from 41% in Chesapeake Bay (LeFranc and Cline 1983) to 42% in southern Louisiana (Dugoni et al. 1986) and 76–85% in southeast Alaska (Ofelt 1975). That catostomids and cyprinids were most often eaten by Columbia River Estuary eagles is noteworthy because benthic-feeding fish were predominant in diets of inland bald eagles in several studies (Haywood and Ohmart 1986). Seventy-five percent of fish in these 2 families are available in intertidal and nearshore waters in the Columbia River Estuary, whereas only 23% of the remaining fish species captured by eagles are found in these habitats (G. T. McCabe, Natl. Mar. Fish. Serv., unpubl. data). Haywood and Ohmart (1986) found that benthic-feeding fish in Arizona rivers were most vulnerable to predation because they fed in shallows and riffles. Swenson (1979) also suggested that benthic-feeding fish direct their sight downward and are poor swimmers, making them more vulnerable to aerial attack by osprey (*Pandion haliaetus*).

Low tide was the major influence on the daily activity cycle. Eagles foraged most intensively in the morning and at ebb through slack tide. Early morning foraging, also noted in other eagle populations (Harmata 1984), is promoted by morning hunger and relatively low levels of human activity on the Columbia River Estuary (McGarigal et al. 1991). Intensified foraging at early ebb tide provides an opportunity to avoid competing for prey. Also, the onset of ebb tide may have triggered foraging behavior that gradually declined throughout the tide cycle. As scavengers fed, prey was depleted on tidal flats and eagles became satiated, which reduced foraging activity. At slack tide, no new prey were exposed, and the advancing flood tide covered any remaining prey and reduced foraging opportunities. The influence of tide on bald eagle foraging habits has been documented in southeast Alaska (Ofelt 1975) and in British Columbia (Hancock 1964), and it appears to be characteristic of eagle populations on the west coast of North America. This is in contrast to breeding eagles on inland rivers in Arizona, where daily foraging was a continual process because fish were available throughout the day (Haywood and Ohmart 1986).

Foraging ability and prey specialization were additional influences on prey selection. Time spent foraging among eagle pairs was related to foraging success. The varied ability of eagles to capture waterfowl (Southern 1963, Hancock 1964, McClelland 1973, Frenzel 1984) is related to the age of eagles and the abundance and vulnerability of waterfowl. In the Tongue Point area (Fig. 1), nonbreeding eagles, of which 69%

were subadults, fed on dead fish 98% of the time during winter 1983–84 (n = 101) and were never observed to capture live waterfowl.

Ramifications of increased time spent foraging, such as increased energy expenditures or lower productivity, could be important in eagle populations where prey is limited, competition is high, or weather is stressful. These factors were not obvious in the Columbia River Estuary. Food shortage has been identified as the main reason raptors leave breeding areas and migrate in winter (Newton 1979), and nonbreeding eagles tend to concentrate in rich foraging areas (Stalmaster 1976) or in areas with favorable climates (Harmata 1984). For bald eagles, reduced prey availability results from the freeze-up of lakes and rivers in northern areas of their range (Stalmaster 1987). In the Columbia River Estuary, waterways remained ice-free, thereby exposing fish and waterfowl to predation throughout the year and allowing breeding eagles to remain as year-round residents. On other rivers of the Pacific Northwest where migrant eagles take advantage of abundant dead and dying salmon by scavenging (Knight and Knight 1983), foraging behaviors that promote inactivity are important to winter survival (Stalmaster and Gessaman 1984). However, in the Columbia River Estuary, we did not detect seasonal changes in use of different foraging methods by breeding eagles. Also, numerous subadult eagles were attracted to the Columbia River Estuary in winter and outnumbered resident adults by about 3:1 during their peak abundance (Garrett et al. 1988).

MANAGEMENT RECOMMENDATIONS

Because foraging is a key behavior that influences daily and seasonal activity budgets of bald eagles and has implications for survival and reproduction, foraging habitats should be maintained and enhanced. Shallow-water areas <4 m deep (i.e., tidal flats) and waterfowl habitats should be protected in estuaries or tidally influenced coastal areas that support eagle populations. Loss of these habitats could affect breeding eagles by increasing competition for foraging sites and flight distances between nests and feeding areas. Dredged channels should be aligned to avoid foraging areas, and side-slopes of channels should be angled to prevent erosion of tidal flats. Monitoring of dredged sites should take place to ensure that foraging sites are not affected negatively. Clam and oyster farming, sand shrimp harvesting, net-pen rearing of salmon, and recreational boating and fishing near high-use foraging areas could negatively affect eagle foraging patterns in estuaries. McGarigal et al. (1991) provide recommendations to minimize potential boating disturbances on eagle foraging areas in the Columbia River Estuary. Morning and slack low tide periods are times when human disturbance should be minimized.

Foraging habitats should be created. Dredge spoils within some eagle territories in the Columbia River Estuary are used as foraging sites, so deposition of new spoils could be an effective means of creating foraging habitat. If such practices are initiated, care should be taken to avoid filling existing foraging sites and exposing any contaminants contained in river sediments. Eagle use of tidal flats or shallow waters could be enhanced by erecting pilings or artificial perches in open expanses of water to increase the effective eagle foraging area. Perches should extend at least 5 m above ground and be located 400 m apart to maximize use (J. Watson and K. McGarigal, Oreg. Coop. Wildl. Res. Unit, unpubl. data). Hatchery-reared salmon smolts, released above 2 eagle territories in the Columbia River Estuary, provided an important prey resource and should be maintained.

LITERATURE CITED

ANTHONY, R. G., R. L. KNIGHT, G. T. ALLEN, B. R. MCCLELLAND, AND J. I. HODGES. 1982. Habitat use by nesting and roosting bald eagles in the Pacific Northwest. Trans. North Am. Wildl. Nat. Resour. Conf. 47:332–342.

BAYER, R. D. 1987. Winter observations of bald eagles at Yaquina estuary, Oregon. Murrelet 68: 39–44.

BOND, C. E. 1973. Key to freshwater fishes. Tech. Bull. 58. Oregon State Univ., Corvallis. 42pp.

BRAUNE, B. M., AND D. E. GASKIN. 1982. Feeding ecology of nonbreeding populations of larids off Deer Island, New Brunswick. Auk 99:67–76.

CASTEEL, R. R. 1972. A key, based on scales, to the families of native California freshwater fishes. Proc. Calif. Acad. Sci. 39:25–76.

———. 1973. The scales of native freshwater fish families of Washington. Northwest Sci. 47:230–238.

DUGONI, J. A., P. J. ZWANK, AND G. C. FURMAN. 1986. Food of nesting bald eagles in Louisiana. Raptor Res. 20:124–125.

DUNSTAN, T. C., AND J. F. HARPER. 1975. Food habits of bald eagles in north-central Minnesota. J. Wildl. Manage. 39:140–143.

FIELDER, P. C. 1982. Food habits of bald eagles along the mid-Columbia River, Washington, Murrelet 63:46–50.

FITZNER, R. E., AND W. C. HANSON. 1979. A congregation of wintering bald eagles. Condor 81: 311–313.

FRENZEL, R. W. 1984. Environmental contaminants and ecology of bald eagles in southcentral Oregon. Ph.D. Thesis, Oregon State Univ., Corvallis. 143pp.

GARRETT, M., R. G. ANTHONY, J. W. WATSON, AND K. MCGARIGAL. 1988. Ecology of bald eagles on the lower Columbia River. U.S. Army Corps Eng., Portland, Oreg. 191pp.

HANCOCK, D. 1964. Bald eagles wintering in the southern Gulf Islands, British Columbia. Wilson Bull. 76:117–120.

HARMATA, A. R. 1984. Bald eagles of the San Luis Valley, Colorado: their winter ecology and spring migration. Ph.D. Thesis, Montana State Univ., Bozeman. 222pp.

HAYWOOD, D. D., AND R. D. OHMART. 1986. Utilization of benthic-feeding fish by inland breeding bald eagles. Condor 88:35–42.

KNIGHT, R. L., J. B. ATHERN, J. L. BRUGGEMAN, AND A. W. ERICKSON. 1979. Observations on wintering bald and golden eagles on the Columbia River, Washington. Murrelet 60:99–105.

KNIGHT, S. K., AND R. L. KNIGHT. 1983. Aspects of food finding by wintering bald eagles. Auk 100:477–484.

LEFRANC, M. N., AND K. W. CLINE. 1983. The occurrence of birds as prey at active bald eagle nests in the Chesapeake Bay Region. Pages 79–86 *in* D. M. Bird, N. R. Seymour, and J. M. Gerrard, eds. Biology and management of bald eagles and ospreys. Harpell Press, Ste. Anne-de-Bellevue, Quebec.

MCCLELLAND, B. R. 1973. Autumn concentrations of bald eagles in Glacier National Park. Condor 75:121–123.

MCGARIGAL, K., R. G. ANTHONY, AND F. B. ISAACS. 1991. Interactions of humans and bald eagles on the Columbia River Estuary. Wildl. Monogr. 115:1–47.

MOLLHAGEN, T. R., R. W. WILEY, AND R. L. PACKARD. 1972. Prey remains in golden eagle nests: Texas and New Mexico. J. Wildl. Manage. 36: 784–792.

NEU, C. W., C. R. BYERS, AND J. M. PEEK. 1974. A techniques for analysis of utilization-availability data. J. Wildl. Manage. 38:541–545.

NEWTON, I. 1979. Population ecology of raptors. Buteo Books, Vermillon, S.D. 339pp.

OFELT, C. H. 1975. Food habits of nesting bald eagles in southeast Alaska. Condor 77:337–339.

RETFALVI, L. 1970. Food of nesting bald eagles on San Juan Island, Washington. Condor 72:358–361.

SOUTHERN W. E. 1963. Winter populations, behavior, and seasonal dispersal of bald eagles in northeastern Illinois. Wilson Bull. 75:42–55.

STALMASTER, M. V. 1976. Winter ecology and effects of human activity on bald eagles in the Nooksack River Valley, Washington. M.S. Thesis, Western Washington State Coll., Bellingham. 100pp.

———. 1987. The bald eagle. Universe Books, New York, N.Y. 227pp.

———, AND J. A. GESSAMAN. 1984. Ecological energetics and foraging behavior of overwintering bald eagles. Ecol. Monogr. 54:407–428.

SWENSON, J. E. 1978. Prey and foraging behavior of ospreys on Yellowstone Lake, Wyoming. J. Wildl. Manage. 42:87–90.

———. 1979. The relationship between prey species ecology and dive success in ospreys. Auk 96: 408–412.

TODD, C. S., L. S. YOUNG, R. B. OWEN, JR., AND F. J. GRAMLICH. 1982. Food habits of bald eagles in Maine. J. Wildl. Manage. 46:636–645.

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