Diets of Nesting Bald Eagles, *Haliaeetus leucocephalus*, in Western Washington

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We analyzed food remains collected at Bald Eagle (*Haliaeetus leucocephalus*) nests from three regions in Washington: San Juan Islands, Olympic Peninsula, and Puget Sound. Of 1198 items collected, 53% were birds, 34% were fish, 9% were mammals, and 4% were invertebrates. Fish were more abundant at nests in the San Juan Islands and Puget Sound than at nests on the Olympic Peninsula. Overall, mammals were not important; however, the Old World Rabbit (*Oryctolagus cuniculus*) was a common food species for eagles in the San Juan Islands. Forty-two prey items were identified during 212 hours of direct observations at three eagles nests. This allowed a comparison of prey delivered to nests with prey found beneath these nests and indicated that birds were over-represented in prey collections beneath nests and fish were over-represented in prey carried to nests. Two important Bald Eagle food items, the Glaucous-winged Gull (*Larus glaucescens*) and Old World Rabbits (*Oryctolagus cuniculus*) were analyzed for DDE and PCBs; the former showed detectable levels of both.

Key Words: Bald Eagle, *Haliaeetus leucocephalus*, Washington, food habits.

The Pacific Northwest region of North America has the largest population of both nesting and wintering Bald Eagles within the species' range (Stalmaster 1987). Diets of wintering Bald Eagles in this region are well known (Stalmaster et al. 1985), but information on summer diets is either anecdotal or from studies of localized areas (Murie 1940; Imler and Kalmbach 1955; Retfalvi 1970; Ofelt 1975; Sherrod et al. 1976; Grubb and Hensel 1978; Van Daele and Van Daele 1980). Our objectives were to identify the food items of nesting Bald Eagles in Washington, to evaluate differences in food habits among three distinct geographical areas within it, and to compare two methods of diet evaluation. Finally, because Bald Eagles in the Pacific Northwest contain environmental contaminants, we examined two important prey species for DDE and PCB concentrations.

Study Area and Methods

Between 8 April-21 June 1980 and 4 June-30 July 1981, we collected prey remains below 102 nests in 68 nesting territories in western Washington. Collections were made from 34 territories on the San Juan Islands, and 17 territories each on the Olympic Peninsula and along Puget Sound. The San Juan Islands included all islands north of Whidbey Island and west of the mainland to the Canadian border (Figure 1 *in* Grubb 1976). The Olympic Peninsula included the coastline from Port Townsend west along the Strait of Juan de Fuca, around Cape Flattery, and south along the Pacific Coast to the north edge of Grays Harbor. Puget Sound included Puget Sound proper from Port Townsend south, plus Camino and Whidbey Islands and the mainland coast north to Canada.

Nests were visited just once during our study, and our visits fell within the normal nesting period of Bald Eagles (Stalmaster 1987: 63). Timing of our visits were balanced for each of the three areas. Prey remains were collected from the base of nest trees and adjacent perch trees. Prey remains were identified to the lowest taxon by comparison with museum specimens. The minimum number of individuals of each taxon in each collection was used to determine diet composition. We could not discount the possibility that some of the prey items we collected were from time periods other than the breeding season, including previous breeding seasons. Additionally, we have no way of confirming that all species listed as prey (Table 1) were indeed food items of Bald Eagles. For example, some of the invertebrates (e.g., snails) may have been in the intestines of eagle prey items.

Collections of Bald Eagles food remains may be biased in favor of items with conspicuous or

TABLE 1. Occurrence of food items collected under Bald Eagle nests and perch trees at three areas in in western Washington between April 1980 and August 1981.

Food Item	San Juan Islands				Olympic Peninsula				Puget Sound			
	Individuals[a]		Territories[a]		Individuals		Territories		Individuals		Territories	
Birds (Aves)	N	%	N	%	N	%	N	%	N	%	N	%
Western Grebe (*Aechmophorus occidentalis*)	55	6.0	19	55.9	11	7.3	11	64.7	14	10.4	9	52.9
Common Murre (*Uria aalge*)	49	5.3	24	70.6	26	17.2	10	58.8	12	8.9	6	35.3
Glaucous-winged Gull (*Larus glaucescens*)	37	4.1	16	47.0	3	2.0	3	17.6	3	2.2	3	17.6
Gull (*Larus* spp.)	31	3.4	14	41.2	4	2.6	3	17.6	1	tr[b]	1	5.9
Pelagic Cormorant (*Phalacrocorax pelagicus*)	27	2.9	19	55.9	9	6.0	6	35.3				
Grebe (*Podicipedidae*)	26	2.8	12	35.3	5	3.3	4	23.5	2	1.5	2	11.8
White-winged Scoter (*Melanitta fusca*)	18	1.9	14	41.2	8	5.3	6	35.3	5	3.7	5	29.4
Duck (*Anatidae*)	16	1.7	10	29.4	2	1.3	2	11.8	7	5.1	5	29.4
Rhinoceros Auklet (*Cerorhinca monocerata*)	16	1.7	9	26.5	5	3.3	5	29.4	2	1.5	2	11.8
Cormorant (*Phalacrocorax* spp.)	14	1.5	12	35.3	1	tr	1	5.9				
Brandt's Cormorant (*Phalacrocorax penicillatus*)	11	1.2	8	23.5	2	1.3	2	11.8				
Pigeon Guillemot (*Cepphus columba*)	10	1.1	7	20.6	1	tr	1	5.9	2	1.5	2	11.8
Duck (*Anas* spp.)	9	1.0	7	20.6	1	tr	1	5.9	1	tr	1	5.9
Surf Scoter (*Melanitta perspicillata*)	9	1.0	6	17.6	4	2.6	3	17.6	3	2.2	3	17.6
Red-breasted Merganser (*Mergus serrator*)	9	1.0	8	23.5								
Mallard (*Anas platyrhynchos*)	5	tr	4	11.8	1	tr	1	5.9	1	tr	1	5.9
Greater Scaup (*Aythya marila*)	5	tr	5	14.7					1	tr	1	5.9
Bufflehead (*Bucephala albeola*)	5	tr	5	14.7								
Western Gull (*Larus occidentalis*)	5	tr	3	8.8								
Scaup (*Aythya* spp.)	5	tr	4	11.8	1	tr	1	5.9				
Brant (*Branta bernicla*)	4	tr	2	5.9								
Common Merganser (*Mergus merganser*)	4	tr	3	8.8								
Crow (*Corvus* spp.)	4	tr	4	11.8	1	tr	1	5.9				
Red-throated Loon (*Gavia stellata*)	3	tr	2	5.9	1	tr	1	5.9				
Horned Grebe (*Podiceps auritus*)	3	tr	3	8.8								
Red-necked Grebe (*Podiceps grisegena*)	3	tr	3	8.8	1	tr	1	5.9				
California Gull (*Larus californicus*)	3	tr	2	5.9	2	1.3	2	11.8	1	tr	1	5.9
American Crow (*Corvus brachyrhynchos*)	3	tr	3	8.8	1	tr	1	5.9				
Northwestern Crow (*Corvus caurinus*)	3	tr	2	5.9								
Common Raven (*Corvus corax*)	3	tr	3	8.8								
Duck (*Bucephala* spp.)	3	tr	3	8.8	1	tr	1	5.9				
Arctic Loon (*Gavia arctica*)	2	tr	2	5.9					2	1.5	1	5.9
Common Loon (*Gavia immer*)	2	tr	2	5.9								
Great Blue Heron (*Ardea herodias*)	2	tr	1	2.9	1	tr	1	5.9	2	1.5	1	5.9
Northern Pintail (*Anas acuta*)	2	tr	2	5.9								

TABLE 1. (continued).

Food Item	San Juan Islands				Olympic Peninsula				Puget Sound			
	Individuals[a]		Territories[a]		Individuals		Territories		Individuals		Territories	
Birds (Aves) continued	N	%	N	%	N	%	N	%	N	%	N	%
American Wigeon (*Anas americana*)	2	tr	2	5.9					1	tr	1	5.9
Common Goldeneye (*Bucephala clangula*)	2	tr	2	5.9								
Turkey (*Meleagridinae*)	2	tr	2	5.9								
Herring Gull (*Larus argentatus*)	2	tr	1	2.9								
Pileated Woodpecker (*Dryocopus pileatus*)	2	tr	2	5.9	1	tr	1	5.9				
Pied-billed Grebe (*Podilymbus podiceps*)	1	tr	1	2.9								
Canada Goose (*Branta canadensis*)	1	tr	1	2.9	2	1.3	1	5.9				
Lesser Scaup (*Aythya affinis*)	1	tr	1	2.9								
Oldsquaw (*Clangula hyemalis*)	1	tr	1	2.9								
Hooded Merganser (*Lophodytes cucullatus*)	1	tr	1	2.9								
Bonaparte's Gull (*Larus philadelphia*)	1	tr	1	2.9								
Black-legged Kittiwake (*Rissa tridactyla*)	1	tr	1	2.9	1	tr	1	5.9				
Band-tailed Pigeon (*Columba fasciata*)	1	tr	1	2.9								
Belted Kingfisher (*Ceryle alcyon*)	1	tr	1	2.9								
Grouse (Tetraoninae)	1	tr	1	2.9								
Scoter (*Melanitta* spp.)	1	tr	1	2.9	4	2.6	1	5.9				
Red-tailed Hawk (*Buteo jamaicensis*)	1	tr	1	2.9								
Merganser (*Mergus* spp.)	1	tr	1	2.9								
Sooty Shearwater (*Puffinus griseus*)					6	4.0	4	23.5				
Alcid (Alcidae)	3	tr	2	5.9	2	1.3	2	11.8	2	1.5	1	5.9
Shearwater (*Puffinus* spp.)					2	1.3	2	11.8				
Northern Fulmar (*Fulmarus glacialis*)					1	tr	1	5.9				
Varied Thrush (*Ixoreus naevius*)					1	tr	1	5.9				
Gadwall (*Anas strepera*)									2	1.5	1	5.9
Ring-necked Pheasant (*Phasianus colchicus*)									3	2.2	2	11.8
Rock Dove (*Columba livia*)									1	tr	1	5.9
Unidentified	7	tr	7	20.6	4	2.6	4	23.5	7	5.1	7	41.2
Bird Subtotal	439	48.2			116	77.5			76	56.3		
Fish (Osteichthyes)												
Rockfish (*Sebastes* spp.)	134	14.7	26	76.5	11	7.2	5	29.4	8	5.9	6	35.3
Ling-cod (*Ophiodon elongatus*)	52	5.7	16	47.1	9	6.0	6	35.3	2	1.5	1	5.9
Walleye Pollock (*Theragra chalcogramma*)	36	3.9	14	41.2					1	tr	1	5.9
Pacific Hake (*Merluccius productus*)	34	3.7	11	32.3					2	1.5	2	11.8
Pacific Cod (*Gadus macrocephalus*)	21	2.3	9	26.5					1	tr	1	5.9
Cabezon (*Scorpaenichthys marmoratus*)	20	2.2	8	23.5	1	tr	1	5.9	1	tr	1	5.9

TABLE 1. (continued).

Food Item	San Juan Islands				Olympic Peninsula				Puget Sound			
	Individuals[a]		Territories[a]		Individuals		Territories		Individuals		Territories	
Fish (Osteichthyes) continued	N	%	N	%	N	%	N	%	N	%	N	%
Red Irish Lord (*Hemilepidotus hemilepidotus*)	10	1.1	5	14.7	1	tr	1	5.9	2	1.5	2	11.8
Great Sculpin (*Myoxocephalus polyacanthocephalus*)	8	tr	8	23.5					4	2.9	2	11.8
Buffalo Sculpin (*Enophrys bison*)	5	tr	2	5.9								
Starry Flounder (*Platichthys stellatus*)	4	tr	3	8.8					10	7.4	5	29.4
True Cod (*Gadidae*)	3	tr	3	8.8					2	1.5	1	5.9
Surf Perch (Embiotocidae)	3	tr	3	8.8	1	tr	1	5.9	1	tr	1	5.9
Salmon (*Oncorhynchus* spp.)	1	tr	1	2.9					1	tr	1	5.9
Sculpin (Cottidae)	1	tr	1	2.9					1	tr	1	5.9
English Sole (*Parophrys vetulus*)	1	tr	1	2.9								
Prickleback (Stichaeidae)	1	tr	1	2.9								
Steelhead (*Salmo gairdneri*)									1	tr	1	5.9
Plainfin Midshipman (*Porichthys notatus*)									2	1.5	1	5.9
Channel Catfish (*Ictalurus punctatus*)									6	4.4	1	5.9
Flatfish (Pleuronectiformes)	1	tr	1	2.9								
Fish (Chondrichthyes)												
Spiny Dogfish (*Squalus acanthias*)	1	tr	1	2.9								
Spotted Ratfish (*Hydrolagus colliei*)	1	tr	1	2.9								
Fish Subtotal	337	36.9			23	15.2			45	33.3		
Mammals (Mammalia)												
Old World Rabbit (*Oryctolagus cuniculus*)	88	9.6	19	55.9								
Black-tailed Deer (*Odocoileus hemionus*)	3	tr	3	8.8	1	tr	1	5.9	1	tr	1	5.9
Domestic Cow	3	tr	3	8.8								
Raccoon (*Procyon lotor*)	2	tr	2	5.9	1	tr	1	5.9				
Muskrat (*Ondatra zibethicus*)	1	tr	1	2.9								
Weasel (*Mustela* spp.)	1	tr	1	2.9								
Domestic Sheep	1	tr	1	2.9								
Mountain Beaver (*Aplodontia rufa*)					1	tr	1	5.9				
Snowshoe Hare (*Lepus americanus*)									1	tr	1	5.9
Rabbit (*Leparidae*									3	2.2	3	17.6
Mammal Subtotal	99	10.8			3	2.0			5	3.7		
Invertebrates												
Abalone (*Haliotis kamtschatkana*)	17	1.9	4	11.8								
Limpet (*Acmaea* spp.)	1	tr	1	2.9								
Snail (*Lunatia pallida*)	1	tr	1	2.9								
Snail (*Nucella lamellosa*)	1	tr	1	2.9	2	1.3	1	5.9				
Snail (*Amphissa columbiana*)	1	tr	1	2.9								

TABLE 1. (concluded).

Food Item	San Juan Islands Individuals[a] N	%	Territories[a] N	%	Olympic Peninsula Individuals N	%	Territories N	%	Puget Sound Individuals N	%	Territories N	%
Invertebrates continued												
Mussel (*Mytilus edulis*)	1	tr	1	2.9					3	2.2	2	11.8
Scallop (*Chlamys hastata*)	3	tr	3	8.8								
Bivalve (*Clinocardium nuttalli*)					1	tr	1	5.9	1	tr	1	5.9
Clam (*Macoma inquinata*)									1	tr	1	5.9
Bivalve (*Protothaca staminea*)	5	tr	4	11.8	4	2.6	2	11.8	1	tr	1	5.9
Clam (*Saxidomus gigantea*)									2	1.5	1	5.9
Bivalve (*Mya arenaria*)					1	tr	1	5.9				
Piddock (*Zirfaea pilsbryi*)									1	tr	1	5.9
Snail (*Vespericola columbiana*)	1	tr	1	2.9								
Snail (*Monodenia fidelis*)	5	tr	4	11.8								
Invertebrate Subtotal	36	3.9			8	5.3			9	6.7		
GRAND TOTAL	911	100.0	34		150	100.0	17		135	100.0	17	

[a]"Individuals" refers to number of prey items; "territories" refers to the number of eagle territories in which the prey item was found.
[b]tr = < 1.0%.

unpalatable body parts (Todd et al. 1982). To examine the extent of this bias in our study, we compared diet determined by observing food items brought to three nests containing young with diet determined by collecting remains beneath the nest trees. Nest observations were made in the San Juan Islands between 2 June and 9 July 1980 and observation effort was evenly allocated among times of day and nest sites. Prey collections beneath nests were made in July 1980. Prey items were identified to class using a 15-60X telescope from a blind 160-570 m from each nest tree. We tested for differences among data collection methods for variations in diet using chi-square analysis.

Nine Glaucous-winged Gulls (scientific names appear in Table 1) and four Old World Rabbits were collected on San Juan Island on 22 and 23 June 1980. Gulls were weighed whole, then liver, breast muscle, and heart were removed and frozen for chlorinated hydrocarbon analysis. Rabbits were weighed whole, then livers were dissected for analysis. Chemical contaminants were analyzed according to Stanley and LeFavoure (1965), Murphy (1972), and Webb and McCall (1973).

Results and Discussion

Regional diet composition

We collected 1198 food items representing 83 prey species: 49 species of birds, 15 species of fish, 8 species of mammals, and 14 species of invertebrates (Table 1). The diet of Bald Eagles as measured by the frequency of occurrence of individuals in major food classes varied regionally ($\chi^2 = 56.9$, df = 6, $P < 0.001$; Figure 1). Birds comprised 78% of all prey remains at Olympic Peninsula nests; more fish and fewer birds were found at territories in the San Juan Islands. Mammals comprised 11% of total prey items in the San Juan Islands, which was much higher when compared to the other regions ($\chi^2 = 167.2$, df = 1, $P < 0.001$).

At nests in the San Juan Islands, grebes, murres, gulls, and cormorants were the most important avian prey items, both in terms of numbers and biomass, occurring in over half of all territories (Table 1). Rockfish, Ling-cod, Walleye Pollock, and Pacific Hake were the most important fish prey species and were found on at least 75% of all territories. The Old World Rabbit comprised 89% of all mammalian foods items and were found on over half of all territories.

At nests on the Olympic Peninsula, grebes, scoters, cormorants, and murres were the principle bird prey (Table 1). Rockfish and Ling-cod made up 87% of all fish remains and were each found at almost one-third of all territories. Mammals and invertebrates together were much less important, comprising only 7% of the total food items.

Grebes, murres, and scoters were the most common bird prey items at nests along Puget

Sound. Rockfish and Starry Flounder were the principle fish prey items, while mammals and invertebrates were poorly represented.

Our findings agree with the generalization that coastal nesting Bald Eagles feed more on birds than on other taxa, and that nests located in other than coastal areas show a higher proportion of fish remains (Chrest 1964; Retfalvi 1970; DeGrange and Nelson 1982; *references in* Todd et al. 1982; Cash et al. 1985; *but see* Grubb and Hensel 1978). Seabirds made up a majority of the bird species found in prey remains and Bald Eagles use a variety of methods to capture them, including team-hunting, excavating nesting burrows, surprise, and pirating (*references in* Todd et al. 1982; DeGrange and Nelson 1982; Angell and Balcomb 1982).

Our fish collections contained few vertebrae but a large number of skulls. This suggests eagles fed on fish heads discarded by fishermen, a behavior that has been reported elsewhere (Dunstan and Harper 1975; Todd et al. 1982; Cash et al. 1985). Alternatively, fish skulls may have appeared in the collections more often because they were less digestible and persisted longer than vertebrae. However, many of the fish species were bottom-dwelling species which would not normally be available to eagles. We suggest that these fish were discarded by sport or commercial fisherman who consider some species of bottom fish undesirable.

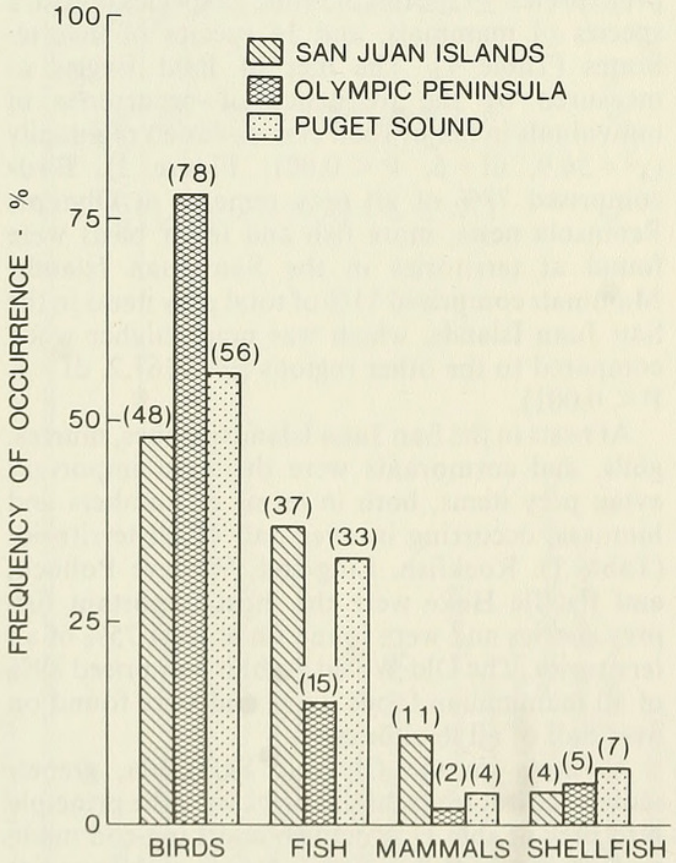

FIGURE 1. Frequency of occurrence of food items collected below nests and at perch trees of Bald Eagles in the San Juan Islands, Olympic Peninsula and Puget Sound in western Washington, 1980-1981. Numbers in parentheses are the percentages of each taxa that occur in each area.

Retfalvi (1970) found that Old World Rabbits were a common food item at two nests he studied on San Juan Island. He suggested that eagles scavenged rabbits killed by cars or farm machinery. Platt (1976) observed that wintering Bald Eagles in a Utah desert subsisted on Black-tailed Jackrabbits (*Lepus californicus*) killed by hunters or automobiles.

Analysis of methodology

We observed the delivery of 47 items during 247 hours of observations (0.19 items/hour). Diets determined from observation of food deliveries contrasted sharply with food debris found beneath nests ($\chi^2 = 397.23$, df = 1, $P < 0.001$). One Old World Rabbit was found in collections while no mammals were seen in direct observations. Birds were heavily represented in collections (55%) but were seldom observed being brought to nests (8%), while fish were commonly seen being brought to nests (92%), but were less prevalent in collections (44%).

Our observations suggest that food collections taken from the base of eagle nests do not accurately reflect prey brought to nests. Retfalvi (1965: 138) compared food information from direct observation with collections underneath one nest on San Juan Island and found that birds were under-represented in observations. Todd et al. (1982) documented a similar bias between observations and collections at nests in coastal Maine. Our results suggest a more accurate assessment of food habits is possible when nest observations are supplemented with food debris collections (Collopy 1983).

Chemical contamination

Glaucous-winged Gulls had detectable levels of DDE in liver ($\bar{x} \pm SD$ ppm: wet weight - 0.63 ± 0.48, n = 9; lipid weight - 13.54 ± 8.23, n = 9) and breast tissue samples (wet weight - 0.72 ± 0.24, n = 5; lipid weight - 20.4 ± 3.13, n = 5). PCBs were found in gull liver (wet weight - 1.54 ± 1.05, n = 9; lipid weight - 30.49 ± 22.60) and breast tissue (wet weight - 1.86 ± 0.61, n = 5; lipid weight - 52.4 ± 6.84). Tissues from three of the four rabbits contained neither DDE or PCBs, while one rabbit had a detectable level of DDE (lipid weight - 0.20 ppm).

These levels of DDE and PCBs are within the range found in prey items of Bald Eagles in Maine and in White-tailed Eagles (*Haliaeetus albicilla*) in Finland and within the values known to suppress eagle productivity (Koivusaari et al. 1976; Wiemeyer et al. 1978; Grier 1982; Wiemeyer et al. 1984). Bald Eagles in our study area contain DDE and PCBs (Kaiser et al. 1980; Angell and Balcomb

1982; Reichel et al. 1984; Washington Department of Wildlife, unpublished data), and our results indicate a potential source of this contamination.

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