

Productivity, Diet, and Environmental Contaminants in Bald Eagles Nesting Near the Wisconsin Shoreline of Lake Superior

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Abstract. Bald eagles (*Haliaeetus leucocephalus*) nesting in the Apostle Islands National Lakeshore and along the Wisconsin shoreline of Lake Superior produced an average of 0.8 young/occupied nest and had an average nest success of 57% during 1983–1988, compared to 1.3 young/occupied nest and 77% nest success in inland Wisconsin. Contaminant levels in nestling bald eagle carcasses collected from nests near Lake Superior were higher than those collected inland, suggesting local contamination. Prey remains collected at nests consisted of fish (50%); birds, primarily herring gulls (*Larus argentatus*) (48.4%); and mammals (1.2%). Organochlorine and polychlorinated biphenyl (PCB) residues were present at low levels (DDE: $\bar{x}$ = 0.07 $\mu\text{g/g}$ wet wt, PCB: $\bar{x}$ = 0.21 $\mu\text{g/g}$ wet wt) in fish. Herring gulls contained higher concentrations (DDE: $\bar{x}$ = 5.5 $\mu\text{g/g}$ wet wt, PCB: $\bar{x}$ = 16.95 $\mu\text{g/g}$ wet wt) and appear to be the major source of elevated contaminant levels in bald eagles nesting near Lake Superior.

Bald eagle populations declined substantially during the 1950s and remained depressed until the early 1970s, concurrent with the use of the persistent organochlorine pesticide DDT in North America (Broley 1958; Sprunt and Ligas 1966; Abbott 1967; Newton 1979; Gerrard 1983). Eagles nesting along the shores of the Great Lakes were severely affected; they produced an average of only 0.1 young/occupied nest and had an average nest success of 10% during 1961–1970 (Sprung *et al.* 1973). Inland production in the western Great Lake states increased soon after the ban on DDT in 1972 (Madsen *et al.* 1985; Sindelar 1983) but productivity of eagles nesting along the Wisconsin shores of Lake Superior, remains below inland averages (Sindelar 1983, 1988).

Addled eggs, collected from eagle nests in the Apostle Islands National Lakeshore (AINL) and along the south shore of Lake Superior during 1970–1982, contained significantly

higher levels of DDE, PCBs, and mercury residues than those collected from inland Wisconsin (Wiemeyer *et al.* 1984, S. Wiemeyer, unpub. data). The source of contamination was unknown. This study was conducted during 1983–1988 to monitor the reproductive success of bald eagles nesting in the AINL and to determine contaminant levels in AINL eagles and their prey.

Methods

The AINL is comprised of 21 islands and a 19-km unit of mainland shoreline located in Wisconsin, along the southwest shore of Lake Superior. Occupied nests were located by airplane in mid-April during the annual Wisconsin Bald Eagle Breeding Survey. A second aerial survey was conducted in late May to determine reproductive success, and nestlings were banded in mid-June. A paired-t test was used to compare productivity and a chi-square to compare nestling mortality between inland and Lake Superior populations.

Food habits were determined by collecting prey remains at 7 nests in the AINL and along the nearby mainland shoreline of Lake Superior during 1983–1988 and also by direct observation of 3 AINL nests during 1984–1985. Food items were identified by comparison with museum specimens; the minimum number of individual species was determined by the greatest number of identical bones of feathers per taxon (Mollhagen *et al.* 1972). Fresh food remains found at nests were wrapped in aluminum foil and frozen for contaminant analysis. Gill nets were set in eagle foraging areas and composite samples of 2–6 individuals of each fish species were collected. Adult and immature herring gulls were shot, trapped, or found dead and nestling gulls were removed from their nests or collected as eagle prey remains. Fresh food items found in nests were analyzed separately from composite samples, but pooled by species. Immature and nestling bald eagles found dead were collected for contaminant analysis. Eggshell fragments found in eagle nests near Lake Superior were measured with a micrometer graduated in units of 0.01 mm (Kranz *et al.* 1970). Shell membranes were absent from all samples; 0.13 mm was added to adjust thickness values for missing membranes (S. Wiemeyer, pers. commun.). Measurements should be considered approximations only since the position of fragments on the egg was unknown. Comparisons were made to pre-1946 norms for the same area to determine % thinning (Wiemeyer *et al.* 1984).

Contaminant analyses were conducted by the Wisconsin State Lab of Hygiene, Madison, WI. Fish were homogenized whole; skin, feet, beak and wings of gulls were removed prior to grinding.

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Table 1. Productivity of bald eagles nesting along the Wisconsin shoreline of Lake Superior compared to inland, 1983–1988

	Occupied nests	Successful nests	% Nest success	No. of young	Young/ occupied nest
Lake Superior (including the AINL)					
1983	7 (4) ^a	4	57	4	0.6
1984	9 (4)	4	44	7	0.8
1985	5 (3)	3	60	4	0.8
1986	10 (5)	6	60	9	0.9
1987	12 (7)	7	58	9	0.8
1988	10 (6)	6	60	11	1.1 ^b
Inland					
1983	192	145	76	248	1.3
1984	231	165	71	272	1.2
1985	209	168	80	278	1.3
1986	235	177	75	285	1.2
1987	284	233	82	411	1.4
1988	318	244	77	421	1.3

^a () = No. of occupied nests in AINL; productivity was calculated using all Lake Superior nests to increase sample size

^b This figure includes 1 nest with an unknown number of young; 2 young were used to calculate productivity

Breast, brain, and kidney or liver samples were analyzed from bald eagles. Organochlorines were analyzed according to methods described in Interim Methods of Organic Analysis (unpub lab manual, Wisc State Lab of Hygiene, Madison); recovery ranged from 80% to 110%. Residue levels were not corrected for recovery values. Detection limits were 0.05 µg/g for *o,p'*-DDT, *p,p'*-DDT, *o,p'*-DDD, *p,p'*-DDD, *o,p'*-DDE, *p,p'*-DDE, heptachlor epoxide, cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor and methoxychlor; 0.01 µg/g for hexachlorobenzene (HCB), alpha benzene hexachloride (BHC) and gamma BHC; 0.02 µg/g for dieldrin and endrin; and 0.2 µg/g for PCBs. Toxaphene could not be quantified, because samples contained a limited number of the many possible toxaphene components; therefore, they are referred to as toxaphene-like compounds. Detection limits were 1.0 µg/g. Mercury was analyzed by cold vapor atomic absorption (Manual of Analytic Methods, unpub lab manual, Wisc State Lab of Hygiene, Madison); detection limits were 0.04 µg/g. Contaminant values below the level of detection were assigned ½ the lower limit of detection to calculate means. Means for residue data are geometric. All contaminant concentrations are reported in µg/g wet weight.

Results and Discussion

Productivity

Nest Success: Eagles nesting in the AINL and along the Wisconsin shoreline of Lake Superior produced an average of 0.8 young/occupied nest from 1983–1988 and had an average nest success of 57%. These figures fall significantly below inland averages of 1.3 young/occupied nest ($P < 0.001$) and 77% nest success ($P < 0.005$) (Table 1) (Sindelar 1988). At least 50% of nesting pairs must be successful and produce a minimum of 0.7 young/occupied nest to maintain a stable population (Sprunt *et al.* 1973). However, 1.0 young/occupied nest is more indicative of a healthy population (Wiemeyer *et al.* 1984). Productivity figures are useful indicators of population stability (Sprunt *et al.* 1973), but should be applied with caution to small populations.

Trends in reproductive success are a more accurate indicator of environmental quality than productivity within individual years (Wiemeyer *et al.* 1984). Despite increased production at inland sites in Wisconsin during the mid-1970's, nesting attempts along the Lake Superior shoreline did not increase until the early 1980s, and bald eagles (with the exception of 2 pairs) did not produce young until 1983. Since 1983, the number of nesting attempts near Lake Superior have increased, but productivity has remained below inland averages. Several factors probably contribute to the lower productivity of this population; the most important being chemical contamination. Two addled eggs, collected from the AINL in 1980 and 1982, contained elevated levels of DDE (13, 14 µg/g), dieldrin, (1.0 1.1 µg/g), PCBs (6.8, 12 µg/g) and mercury (0.4, 0.47 µg/g) (S. Wiemeyer, unpub. data). Wiemeyer *et al.* (1984) reported mean 5-year production was near normal in breeding areas where eggs contained <3.0 µg/g DDE. Production decreased substantially at levels exceeding 5.1 µg/g DDE and near complete failure occurred where DDE was >15.0 µg/g. Mean 5-year production estimates from AINL eggs were 0.29 and 0.27 young/occupied nest for 1980 and 1982, respectively. Dieldrin and mercury may decrease reproduction at egg levels >1.0 µg/g and 0.5 µg/g, respectively (Wiemeyer *et al.* 1984). Residues in bald eagle eggs collected from the AINL approached or exceeded these values. Effects of PCBs on bald eagle reproduction are unknown, as PCBs are commonly correlated with DDE residues (Wiemeyer *et al.* 1984).

Sindelar (1983) reported young birds in the AINL breeding population. To a lesser extent, some nest failures may be the result of young or non-breeding pairs laying eggs but not completing incubation (Newton 1979). Eggshell fragments collected from six Lake Superior nests during 1983–1987 showed only a moderate amount of thinning (0%–8%) (Table 2). Since DDE levels are negatively correlated with eggshell thickness (Wiemeyer *et al.* 1984), DDE contamination may not have been a factor in all nest failures.

Reproductive Success of Bald Eagles

Table 2. Thickness of eggshell fragments collected from bald eagle nests in the AINL and nearby mainland shoreland of Lake Superior, 1983–1987

Nest	Year	Number of young hatched	Approximate adjusted thickness (mm)	% Change from pre-1946 norm
Outer Island	1983	1	0.64	+5
Oak Island	1984	0	0.61	0
N. Twin Island	1984	2	0.56	-8
Outer Island	1985	1	0.58	-5
Sand River	1985	2	0.60	-2
Bark River	1987	0	0.59	-3

Thinning >15–20% is associated with a declining population (Anderson and Hickey 1972; Newton 1979).

Nestling Mortality: The low productivity of eagles nesting near the Wisconsin shoreline of Lake Superior in 1984–1985 can be attributed, in part, to high nestling mortality. Significantly more young died along the Lake Superior shoreline in 1984 ($P < 0.001$) and 1985 ($P < 0.05$) than inland. In 1984, four young died from unknown causes and a fifth, died when it fell from its nest. Multiple wounds on its body suggest sibling aggression may have occurred. Two young died of unknown causes in 1985. The death of an adult may have contributed to the mortality of one of the nestlings as nest abandonment may occur after the death of one parent (Ohmart and Sell 1980). Nestling mortality among Lake Superior nests was 36% (5 of 14) in 1984 and 25% (2 of 8) in 1985. Four of the 7 dead young were from the AINL. Inland mortality in Wisconsin was 4% (10 of 274) in 1984 and 4% (11 of 283) in 1985.

All of the young produced along the Lake Superior shoreline during 1986–1988 survived to fledging, but post-fledging survival for most eagles produced near Lake Superior is unknown. An emaciated juvenile from the AINL died shortly after it was found on 4 September 1986 in Minnesota. Another juvenile from the AINL found electrocuted in Florida on 6 December 1984, appeared to be in good health; no diseases were detected and lipid levels in the carcass indicated the bird was not starving.

Contaminant Levels in Nestling and Immature Bald Eagles

While all contaminant levels in nestling bald eagles were below those diagnostic of death due to pesticide poisoning, the effects of sub-lethal pesticide levels on nestling survival or parental behavior in bald eagles is unknown and may have been a factor in the deaths of some nestlings. A dead nestling collected from the AINL (Michigan Island) in 1985 contained elevated brain and tissue levels of DDE and PCBs (Table 3), likely resulting from the heavy consumption of herring gulls at this nest (Kozie 1986). Levels of contaminants among the other dead eagles from nests near Lake Superior were low but still higher than inland (WDNR, unpub.

data). The 6-month-old juvenile from the AINL (North Twin Island) found electrocuted in Florida contained 4.4 $\mu\text{g/g}$ mercury in its kidney. The source of mercury is unknown. A 10-day-old nestling from a mainland Superior nest (Amnicon River) contained 2 $\mu\text{g/g}$ of a toxaphene-like substance in its breast muscle. The 4-month-old eagle (Devils Island) collected in Minnesota, only 2 weeks after it departed the AINL, contained 11 $\mu\text{g/g}$ of a toxaphene-like compound in its breast muscle. Toxaphene was reported more often and in higher levels in Wisconsin bald eagle eggs than elsewhere in the U.S. between 1969 and 1979 (Wiemeyer *et al.* 1984). Its sub-lethal effects on birds is not well known. Although it is a lipophilic compound, domestic poultry and black ducks (*Anas rubripes*) were able to metabolize toxaphene faster than DDT or dieldrin (Bush *et al.* 1977; Haseltine *et al.* 1980), thereby reducing deleterious effects, but Mehrle *et al.* (1979) found that ducklings fed toxaphene exhibited reduced growth and impaired back bones.

Adult Survival

Brown streaking on the head and tail plumage of adult females at 2 of the 3 active nests in the AINL in 1985 indicate these birds were young adults and therefore new pair members. The death of the adult female at the third active nest indicates a high turnover among breeding adults in the AINL during 1985. Survival rates are more important to population stability than reproductive success. A population with high productivity and survival will increase while another population with high productivity and only 10% lower survival will decrease; decreases in productivity with high survival rates show less significant declines (Grier 1980).

Population turnover may mask the loss of breeding adults. Increased productivity at individual nest sites is likely due to pair member replacement rather than decreases in contaminant loads of existing adults, as DDE loss rate in birds is slow (Stickel *et al.* 1984; Grier 1982). Grier (1982) suggested that the rapid recovery of bald eagles in northwestern Ontario, after the ban on DDT, was due to a high turnover among breeding adults. The current production in the AINL and along the mainland shoreline of Lake Superior is probably due to a younger breeding population, with low contaminant levels, dispersing from the inland population. Survival rates within the Lake Superior population need to be examined and may be the most important element of population dynamics among Lake Superior eagles.

Food Habits

Diet: Fish comprised 50% of prey remains at nests (Table 4). Common species included longnose (*Catostomus catostomus*) and white suckers (*C. commersoni*), burbot (*Lota lota*), and round whitefish (*Prosopium cylindraceum*). The average length of fish estimated from bones found among food remains was 354 mm ($N = 46$, $SD = 7.0$). Actual lengths and weights of 4 fish found in nests averaged 366 mm and 0.3 kg, respectively. Birds, primarily herring gulls, comprised 48.4% of prey remains. White-tailed deer (*Odocoileus*

Table 3. Concentrations of environmental contaminants in 6 nestling and 2 immature bald eagles from Lake Superior and inland Wisconsin nests, 1984–1986

			Residue concentration (μg/g wet weight) ^a							
Nest	age	% lipid	<i>o,p'</i> -DDT	<i>o,p'</i> -DDD	<i>p,p'</i> -DDD	<i>p,p'</i> -DDE	Dieldrin	Endrin	PCB ^e	Mercury
Lake Superior										
Michigan Is. ^b	5 wks									
Brain		na	0.18	0.16	0.28	16.0	0.97	0.17	42.0	
Breast		0.6	—	—	0.06	5.3	0.29	0.03	14.0	0.54
Kidney										
Amnicon River	10 day									
Brain		na	—	—	—	1.8	0.13	—	8.7	
Breast		0.8	—	—	0.06	1.1	0.07	—	4.4	1.0
Liver										
N. Twin Is.	5 wks									
Brain		na	na	na	na	na	na	na	na	
Breast		0.8	—	—	—	1.5	0.15	0.02	3.3	0.36
Kidney										
Devils Is. ^c	4 mon									
Brain		5.1	na	na	*d	4.6	0.71	na	12.0	
Breast		0.4	na	na	*	6.6	0.55	na	13.0	2.3
Liver										
N. Twin Is.	6 mon									
Brain		8.0	0.05	0.06	0.09	1.5	0.19	0.05	2.9	
Breast		6.2	—	—	—	0.12	0.03	—	0.27	4.4
Kidney										3.1
Liver										
Inland										
Tomahawk R.	4 wks									
Brain		5.3	—	—	—	0.09	0.04	—	0.42	
Breast		7.2	—	—	—	0.07	0.03	—	0.27	0.52
Kidney										
Big Crooked L.	5 wks									
Brain		6.0	—	—	—	—	—	—	—	
Breast		4.8	—	—	—	0.06	—	—	—	0.30
Kidney										
Wild Rice L.	9 wks									
Brain		na	na	na	—	—	—	—	—	
Breast		3.7	na	na	—	0.7	—	—	—	0.74
Liver										

^a — = none detected; na = not analyzed^b Sample also contained 0.07 $\mu\text{g/g}$ t-chlordane in the brain^c Sample also contained 0.36 $\mu\text{g/g}$ and 0.22 $\mu\text{g/g}$ of heptachlor epoxide in the brain and breast, respectively^d * = interference, not able to quantify^e PCB = polychlorobiphenyls

virginianus) and snowshoe hare (*Lepus americanus*) were the only mammals (1.2%) represented, although 4 small rodents were observed being brought to a nest in 1984. Eagles nesting near Lake Superior consumed a higher percentage of birds than inland eagles. P. Keasling and C. Sindelar (unpub. data) found birds comprised only 6% of prey remains at 80 nests in inland Wisconsin while fish and mammals comprised 84% and 7%, respectively. Dunstan and Harper (1975) reported similar findings in the Chippewa National Forest in Minnesota where birds comprised 8%, fish 90%, and mammals 1% of prey remains. Food collections are a relatively accurate indicator of the variety of animals consumed, but tend to underestimate fish whose parts are easily digested and decompose more rapidly than birds or mammals

(Imler and Kalbach 1955; Dunstan and Harper 1975; Ofelt 1975; Todd *et al.* 1982). Actual consumption of fish was probably higher; fish represented 97% of observations at 3 nests in the AINL during 1984–1985; birds and mammals each accounted for only 1.5%.

Early spring food habits for bald eagles nesting in the AINL are unknown and may be a source of additional contamination. Prey selection just prior to egg laying is especially important, since increased body burdens at that time may result in excessive contamination of eggs and eggshell thinning (S. Wiemeyer, pers. commun.). Herring gulls may be an available prey item in early spring when eagles return to breeding territories. Herring gull remains were present at 2 Lake Superior eagle nests that failed during early incubation.

Table 3. (cont'd)

Residue concentration ($\mu\text{g/g}$ wet weight) ^a						
c-chlordane	c-nonachlor	t-nonachlor	Hexachloro- benzene	q-benzene hexachloride	Methoxychlor	Toxaphene- like compound
0.17	0.39	0.46	0.10	—	0.14	*
—	0.07	0.14	0.03	—	—	*
—	—	—	—	—	—	—
—	—	0.07	—	—	—	2.0
na	na	na	na	na	na	na
—	—	0.12	0.02	—	—	*
0.24	na	0.46	0.07	—	—	13.0
0.20	na	0.59	0.04	—	—	11.0
0.07	0.10	0.11	0.02	0.01	—	*
—	—	—	—	—	—	—
—	—	—	—	—	—	—
—	—	—	—	—	—	—
—	—	—	—	—	—	—
—	—	—	—	—	—	—

tion. Rough fish, discarded by commercial fishermen, may also be used prior to ice-out. The occurrence of migratory birds in the diet may increase during spring since Lake Superior acts as a geographic barrier during migration, funneling birds along the shoreline or congregating them on the islands (Temple and Harris 1985). Migratory birds, that winter in areas where DDT or other organochlorine pesticides are still used, may add additional contaminants to the eagle food chain. Eagle wintering areas are also a potential source of contamination. However, it is doubtful that the Lake Superior eagle population winters in areas different from inland birds, which are generally not experiencing reproductive problems (Bent 1937; Brown and Amadon 1968).

Contaminants in Eagle Food Items: Eagles from the AINL were heavily dependent on fish during the breeding season, implicating Lake Superior as a potential source of contamination. However, a comparison of contaminant concentrations in fish from Lake Superior with those reported in prey items of bald and white-tailed eagles (*H. albicilla*) from

Maine, Oregon, and Finland (Koivurasaari *et al.* 1976; Wiemeyer *et al.* 1978; Frenzel 1984; Risebrough and Jarman 1985) indicated chemical concentrations in fish from the AINL were low (Table 5). DDE levels in AINL fish were lower than those found to cause eggshell thinning in American kestrels (*Falco sparverius*) (2.8 $\mu\text{g/g}$) (Wiemeyer and Porter 1970) and also below 0.5 $\mu\text{g/g}$ which would represent the lower limit of concern for eggshell thinning in bald eagles (US Fish Wildlife Service 1986).

Contamination in Lake Superior fish is due almost entirely to atmospheric transport (International Joint Commission 1977; Murphy 1984; Schmidt and Andren 1984), although some local input has occurred (International Joint Commission 1977, Parismo *et al.* 1984, Shear 1984). Chemical contaminants in Lake Superior have decreased since the late 1960s. The average DDE concentration in fish collected in 1967–1968 was 0.46 $\mu\text{g/g}$ (range = 0.23–1.44) (Henderson *et al.* 1969), but DDE concentrations in this study averaged 0.07 $\mu\text{g/g}$ (range = N.D. – 0.14) (Table 5). Contaminant concentrations in herring gull eggs also indicate a

Table 4. Food remains collected at bald eagle nest and perch trees in the AINL and nearby mainland shoreline, 1983–1988

Food Item	N	%
Fish		
Longnose sucker	24	15.4
Burbot	21	13.5
Sucker (<i>Catostomus spp.</i>)	10	6.4
White sucker	9	5.8
Round whitefish	6	3.8
Carp (<i>Cyprinus carpio</i>)	3	1.9
Lake trout (<i>Salvelinus namaycush</i>)	2	1.3
Whitefish, chub or herring (<i>Coregonus spp.</i>)	2	1.3
Bloater chub (<i>Coregonus hoyi</i>)	1	0.6
Sub-total	78	50
Birds		
Herring gull	34	21.8
Blue jay (<i>Cyanocitta cristata</i>)	10	6.4
Northern flicker (<i>Colaptes auratus</i>)	5	3.2
American bittern (<i>Botaurus lentiginosus</i>)	3	1.9
American coot (<i>Fulica americana</i>)	3	1.9
Broad-winged hawk (<i>Buteo platynerus</i>)	3	1.9
Sharp-shinned hawk (<i>Accipiter striatus</i>)	3	1.9
Common crow (<i>Corvus brachyrhynchos</i>)	2	1.3
Belted kingfisher (<i>Ceryle alcyon</i>)	2	1.3
Red-tailed hawk (<i>Buteo jamaicensis</i>)	1	0.6
Canvasback (<i>Aythya valisineria</i>)	1	0.6
Common merganser (<i>Mergus merganser</i>)	1	0.6
Wood duck (<i>Aix sponsa</i>)	1	0.6
Lesser golden plover (<i>Pluvialis dominica</i>)	1	0.6
Red-winged blackbird (<i>Agelaius phoeniceus</i>)	1	0.6
Hairy woodpecker (<i>Picoides villosus</i>)	1	0.6
Unidentified birds	4	2.6
Sub-total	76	48.4
Mammals		
White-tailed deer	1	0.6
Snowshoe hare	1	0.6
Sub-total	2	1.2
Total	156	99.6

downward trend in DDT, DDE, DDD, HCB, BHC, mirex and PCBs, and lake trout showed a decline in total DDT, PCBs and mercury; dieldrin levels have remained consistently low (International Joint Commission 1985). The highly oligotrophic nature of Lake Superior however, retards the decomposition of contaminants. Thus, while contaminant levels are declining, residues of chemicals used in the past persist.

Bioaccumulated contaminants in the fish-eating herring gull probably contribute to the poor reproductive history of AINL eagles. Herring gull eggs collected from the AINL in 1983 contained high levels of DDE (4.65 µg/g), dieldrin (0.47 µg/g), and PCBs (28.4 µg/g) (Struger 1985). A similar collection in 1979 also contained eggs with elevated levels of DDE ($\bar{x}$ = 17.7 µg/g, range = 8.8–40.4) and PCBs ($\bar{x}$ = 27.6 µg/g, range = 13.4–61.6) (Matteson 1979). High levels of contaminants were attributed to the seasonal movements of some Lake Superior herring gulls to Lake Michigan, where their foods are more contaminated (Matteson 1979; Gilman *et al.* 1977). Some gulls may also accumulate contaminants by feeding on the entrails of larger fish discarded by commercial fishermen at dumps near the AINL.

Lower chemical concentrations in nestlings (Table 6), compared to eggs, reflects a dilution of contaminants caused by rapid growth and low deposition rates of fat in nestlings (Anderson and Hickey 1976). These levels were lower than expected given the young age of the nestlings and the relatively high concentrations of contaminants in eggs (D. Weseloh, Canadian Fish & Wildlife Service, pers. commun.). Concentrations of DDE ($\bar{x}$ = 5.5 µg/g) and PCBs ($\bar{x}$ = 16.95 µg/g) in adult and immature herring gulls were high. A composite sample of 1 adult and 2 immature gulls collected on Isle Royale in 1983 contained 10.6 µg/g DDE and 28.8 µg/g PCBs (National Park Service 1984). Both this study and the Isle Royale sample show that adult and immature herring gulls from Lake Superior contained contaminant concentrations that were high enough (>2.8 µg/g DDE) (Wiemeyer

Table 5. Concentrations of environmental contaminants in fish from eagle foraging areas in the AINL, 1984–1985

Species	Number of individuals per sample	% lipid	Residue concentration (µg/g wet weight) ^a			
			p,p'-DDE	Dieldrin	PCB ^c	Mercury
Longnose sucker	5	3.4	0.14	0.02	0.34	0.09
Longnose sucker	5	2.8	—	—	—	—
Longnose sucker	5	3.9	0.11	0.03	—	0.10
Longnose sucker ^b	3	2.5	0.12	0.02	0.3	0.32
Round whitefish	6	4.6	0.03	—	—	0.03
Round whitefish ^c	2	1.6	0.06	—	—	0.08
Round whitefish	1	3.2	—	—	—	0.07
Burbot	2	4.4	0.10	0.02	0.38	0.29
Burbot ^d	2	6.0	0.13	0.03	0.50	0.45

^a — = none detected

^b Partially eaten fish from eagle nest; samples are from 1/2 fish

^c Sample is from eagle nest and also contained 1 µg/g of a toxaphene-like compound

^d Sample is from eagle nest

^e PCB = polychlorobiphenyls

Table 6. Concentrations of environmental contaminants in herring gulls from the AINL, 1985–1986

Sample	Number of individuals per sample	% lipid	Residue concentration ($\mu\text{g/g}$ wet weight) ^a							
			<i>p,p'</i> -DDE	Dieldrin	PCB ^c	<i>t</i> -nonachlor	Hexachlorobenzene	Heptachlor-epoxide	Toxaphene-like compound	Mercury
Nestling	2	7.3	0.31	—	0.5	—	—	—	na	0.08
Nestling	5	11.0	0.26	0.09	1.2	—	—	—	—	0.23
Immature ^b	1	18.0	5.2	0.25	14.0	0.11	0.06	—	5.0	0.32
Immature ^c	1	18.0	6.9	0.39	20.0	0.18	0.06	0.59	4.0	0.46
Immature	1	8.8	5.8	0.10	31.0	—	0.04	0.34	2.0	0.23
Adult	1	4.6	2.9	—	10.0	—	—	—	—	0.29
Adult	1	3.2	5.2	0.03	7.4	—	0.04	—	—	0.16
Adult	1	2.2	8.0	0.04	9.6	—	0.02	—	—	0.96
Adult	5	6.8	5.7	0.32	33.0	0.07	0.03	0.38	3.0	na
Adult	5	6.8	5.7	0.33	34.0	0.07	0.03	0.36	3.0	na

^a — = none detected; na = not analyzed

^b Sample also contained 0.09 $\mu\text{g/g}$ of *c*-nonachlor and 0.07 $\mu\text{g/g}$ *p,p'*-DDD

^c Sample also contained 0.13 $\mu\text{g/g}$ of *c*-nonachlor

^e PCB = polychlorobiphenyls

and Porter 1970) to contribute to the reproductive failure of bald eagles.

Acknowledgments. We thank the National Park Service and the University of Wisconsin-Stevens Point for funding this study. The Wisconsin Department of Natural Resources donated the cost of and performed all contaminant analyses, and provided unpublished data. We thank C. Sindelar for flying aerial surveys; and R. Eckstein and D. Evans for their climbing expertise; and A. Bath, J. Rautio, L. Keggi, J. Foote, and S. Okey for their field work. M. Colburn identified fish bones. S. Wiemeyer, Patuxent Wildlife Research Center, provided unpublished data. He and D. Best measured eggshell fragments. J. Wood, P. Gogan and D. Kuehn reviewed this manuscript; and C. Sindelar, R. Frenzel, and A. Harmata reviewed earlier drafts.

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Manuscript received June 20, 1989 and in revised form January 23, 1990.