Organochlorine Residues in Potential Food Items of Maine Bald Eagles *(Haliaeetus leucocephalus)*, 1966 and 1974

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Bald eagles in Maine have had a low rate of productivity for several years. From 1962 through 1970, the birds produced an average of only 0.35 young per active nest, young were produced in only 26 percent of the nesting attempts, and the population was characterized as declining (SPRUNT et al. 1973). An estimated minimum of 0.70 young per nesting attempt is needed to maintain a stable population (SPRUNT et al. 1973). TOWNSEND (1957) found indications of depressed reproduction as early as the mid-1950's. In recent years (1968-76) reproductive success has been higher in Washington County in eastern Maine (26 young produced in 98 nesting attempts) than in the area along the lower Kennebec River (0 young produced in 20 nesting attempts). High residue levels of environmental pollutants, primarily DDE, dieldrin, and polychlorinated biphenyls (PCB's), have been found in bald eagle eggs from Maine (KRANTZ et al. 1970, WIEMEYER et al. 1972).

Potential bald eagle food items were collected from several areas in Maine in both 1966 and 1974 in a preliminary effort to determine the source of organochlorine pollutants found in the eagles and their eggs, to determine whether organochlorine levels were different in areas with dissimilar rates of eagle reproductive success, and to determine whether gross changes in residue levels had occurred through time.

Methods

Fish were obtained in June-August 1966 by netting and from commercial fishermen. Additional fish were collected in September and October 1974 by netting. Herring gulls (Larus argentatus) were collected in August 1966 by shooting. All specimens were frozen before processing for chemical analysis. We were not certain that the 1966 samples would still be available and suitable for analysis until after the collection of the 1974 samples.

Fish were grouped by species and collection site. Weights of entire groups or of individuals within each group were usually recorded. Each entire group was homogenized and a subsample of each was retained for analysis. Subsamples from 1966 were placed in acetone-rinsed jars and refrozen before analysis. Subsamples

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from 1974 were analyzed immediately.

Each gull was skinned and its feet, beak, wings, brain, liver, and gastrointestinal tract were removed. Each entire carcass was then homogenized and a subsample was refrozen and retained for analysis.

Chemical analyses were conducted in late 1975. A 10-g portion of each homogenate was mixed with anhydrous sodium sulfate and extracted for 7 hours with hexane in a Soxhlet apparatus. The extract was placed on a Florisil column and eluted with 200 ml of 6% ethyl ether in hexane. The Florisil eluate was concentrated and eluted from a Silicar column to separate pesticides from PCB's.

Samples were analyzed by electron capture gas chromatography on a 4% SE-30/6% QF-1 column. Limits of sensitivity were 0.05 ppm for pesticides and 0.5 ppm for PCB's. In addition to the compounds listed in the tables (including footnotes), the samples were analyzed for toxaphene, cis-chlordane and/or trans-nonachlor; none of these three were detected.

Average recovery of spiked mallard carcass tissue ranged from 96% to 110% for all compounds listed, except for hexachlorobenzene which was 69%. Residue levels were not corrected for recovery values. Residues in 10% of the samples were confirmed on a gas chromatograph-mas spectrometer. The analytical procedure is described in more detail by CROMARTIE et al. (1975).

Results

Some dehydration of the 1966 fish samples probably took place before original homogenization and subsampling; the residue levels reported for these samples may therefore be biased upward slightly. The percentage dry weight of wet weight near the time of the original subsampling ranged from 23.6 to 37.4 for these fish samples. Those samples having a higher percentage dry weight also contained more lipid than the others. The percentage dry weight of wet weight for the gull carcass subsamples near the time the subsamples were taken ranged from 30.1 to 37.7. Dry weights were not taken on the samples collected in 1974.

The residues found in the fish (Table 1) were difficult to interpret because (1) we were often unable to collect the same species of fish in different areas in the same year; (2) different species of fish were usually collected from different sites in the 2 years of collection; (3) the timing of collections was different in the 2 years; and (4) the scope of the collections was limited. Despite these problems in interpretation, a few generalized comparisons can be made. In 1966, residue patterns were similar in the same species from different geographic areas. In 1974, American eels (scientific names of fish sampled are given in Table 1) and white suckers from Lincoln County contained similar or higher levels of DDE

TABLE 1

Organochlorine residues in fish from Maine collected in 1966 and 1974

Collection Site and Common Name[a]	No. Fish in Group[b]	% Lipid of Wet Weight	Residue Concentration (ppm wet weight)[c] p,p'-DDE	p,p'-DDD	p,p'-DDT	PCB's
		Washington County Area - 1966				
Snowshoe Lake						
Yellow Perch	4(--)	4.4	0.11	0.05	n.d.	0.34
Third Machias Lake						
Chain Pickerel	3(580)	3.1	0.25	n.d.	0.22	0.34
Deer Island (N.B)[d]						
Sea Herring	10(69)	11.9	0.18	n.d.	0.18	1.2
Common Mackerel	10(142)	8.9	0.16	0.06	0.33	<0.5
Range			0.11-0.25	n.d.-0.06	n.d.-0.33	<0.5-1.2
		Washington County - 1974				
Boyden Lake Area						
Black Bullhead	6(395)	2.3	n.d.	n.d.	n.d.	1.1
White Sucker	6(668)	6.5	0.06	n.d.	n.d.	0.5
Smallmouth Bass	2(1429)	3.6	0.08	n.d.	n.d.	0.8
American Eel	10(186)	16.7	0.09	n.d.	n.d.	0.6
Love Lake						
Fallfish	2(410)	8.2	0.10	n.d.	n.d.	0.7
Chain Pickerel	1(221)	0.9	n.d.	n.d.	n.d.	0.6
Landlocked Salmon	5(546)	3.2	n.d.	n.d.	n.d.	0.7
Range			n.d.-0.10	n.d.	n.d.	0.5-1.1

TABLE 1 (continued)

Collection Site and Common Name[a]	No. Fish in Group[b]	% Lipid of Wet Weight	Residue Concentration (ppm wet weight)[c] p,p'-DDE	p,p'-DDD	p,p'-DDT	PCB's
		Hancock County - 1966				
(Sardine Factory)[e]						
Alewife	6(170)	5.1	0.46	0.08	0.50	1.2
Sea Herring	10(60)	13.8	0.12	n.d.	0.20	<0.5
Common Mackerel	5(139)	9.4	0.08	0.07	0.28	<0.5
Mount Desert Island						
Yellow Perch	5(--)	4.8	0.09	n.d.	n.d.	0.39
Range			0.08-0.46	n.d.-0.08	n.d.-0.50	<0.5-1.2
		Penobscot County - 1974				
Penobscot River						
American Eel[f]	5(310)	16.4	0.05	n.d.	n.d.	2.2
		Lincoln County Area - 1966				
Damariscotta Mills						
Alewife	25(216)	4.9	0.29	0.07	0.25	0.72
Pemequid Lake						
Yellow Perch	5(73)	3.1	0.22	0.08	n.d.	0.39
Chain Pickerel	1(285)	0.5	0.12	n.d.	n.d.	0.22
Eastern River						
Chain Pickerel	1(291)	0.4	n.d.	n.d.	n.d.	0.32
American Eel[g]	1(--)	5.2	0.86	0.27	0.41	1.6
White Perch	6(107)	2.9	0.43	0.12	0.25	2.0
Sunfish	5(95)	1.2	0.10	n.d.	n.d.	<0.5
(Scattered sites)						
American Eel[h]	4(368)	13.4	1.1	0.24	0.60	1.5
Range			n.d.-1.1	n.d.-0.27	n.d.-0.60	<0.5-2.0

TABLE 1 (continued)

Collection Site and Common Name[a]	No. Fish in Group[b]	% Lipid of Wet Weight	Residue Concentration (ppm wet weight)[c] p,p'-DDE	p,p'-DDD	p,p'-DDT	PCB's
		Lincoln County Area - 1974				
Kennebec - Eastern Rivers						
American Eel	2(477)	13.7	0.19	0.05	n.d.	4.2
American Eel	2(485)	13.4	0.36	n.d.	0.11	4.2
White Perch	9(251)	7.7	0.14	0.10	0.24	4.2
White Sucker	6(31)	3.4	n.d.	n.d.	n.d.	1.8
Carp	2(58)	6.5	n.d.	n.d.	n.d.	3.0
Range			n.d.-0.36	n.d.-0.10	n.d.-0.24	1.8-4.2

a/ Scientific names of fish species collected are as follows: yellow perch - Perca flavescens; chain pickerel - Esox niger; sea herring - Clupea harengus; common mackerel - Scomber scombrus; black bullhead - Ictalurus melas; white sucker - Catostomus commersoni; smallmouth bass - Micropterus dolomieui; American eel - Anguilla rostrata; fallfish - Semotilus corporalis; landlocked salmon - Salmo salar sebago; alewife - Alosa pseudoharengus; white perch - Morone americana; sunfish - Lepomis sp.; carp - Cyprinus carpio.

b/ Figures in parentheses are average weight in grams per fish in each sample.

c/ PCB's = polychlorinated biphenyls; n.d. = not detected.

d/ From New Brunswick, Canada near Maine border.

e/ Sites of actual catch unknown.

f/ Also contained 0.07 ppm dieldrin, 0.06 ppm mirex, and 0.10 ppm hexachlorobenzene.

g/ Also contained 0.07 ppm dieldrin.

h/ One from Pemequid Lake; three from Sheepscot River. Also contained 0.08 ppm dieldrin.

and consistently higher levels of PCB's than were found in these two species from Washington County. Levels of DDT plus its metabolites usually were more than 50 percent lower in 1974 than 1966 for chain pickerel from Washington County and for American eel and white perch in Lincoln County; levels of PCB's in these same samples were at least twice as high in 1974 than in 1966.

PCB's in fish collected in 1966 most nearly resembled Aroclor 1254, as did the residues in the fish samples collected in Washington County in 1974. PCB's in the fish from Penobscot and Lincoln Counties collected in 1974 most nearly resembled Aroclor 1248.

Residue levels of DDT and its metabolites were higher in gulls collected in 1966 than in fish collected in either 1966 or 1974 (Table 2). In addition, all of the gulls also contained dieldrin, and some contained heptachlor epoxide, mirex, and oxychlordane. These pollutants were rarely detected in any of the fish samples from either year. PCB's in four of the five gulls were higher than levels found in the fish collected in either year. PCB's in the gulls most nearly resembled Aroclor 1254 or 1260.

Discussion

TOWNSEND (1957) stated that the primary foods of Maine bald eagles were fish and eels, but also mentioned that a rabbit was observed in one nest. Most fish were of small nongame species. WRIGHT (1953) provided information on the feeding habits of bald eagles on the St. John River estuary in nearby New Brunswick during the months of March through November. His direct observations of feeding eagles and his data from prey remains revealed that 90 percent of the food eaten consisted of fish, including perch, brown bullhead (Ictalurus nebulosus), alewife, chain pickerel, chub, white sucker, and others. Birds, primarily ducks, made up most of the remainder of the foods eaten, whereas mammals were rarely taken. NORTON (1907) mentioned that an eagle was observed killing two herring gulls at a breeding colony in Maine. We have found the remains of ducks, including a merganser, and herring gulls under active nests of Maine bald eagles. The items that have been analyzed here are therefore reasonably representative of the major food items of Maine bald eagles, although we have not collected any ducks for analysis.

The few recoveries of bald eagles banded in Maine suggest that they generally move for only limited distances. All recoveries (n = 7) of bald eagles banded in Maine before 1960 with butt-end bands (six were banded as nestlings) occurred in Maine or in an adjacent state or Canadian province within 2 years of the time they were banded (TOWNSEND 1957, COOKE 1941). Band retention may have been poor because of the type of bands used. Two of three recent (1975-76) recoveries of bald eagles banded with rivet bands as nestlings in Maine occurred in Maine within 2 years of the time they were banded; the third was recovered in

TABLE 2

Organochlorine residues (ppm wet weight) in carcasses of individual herring gulls from Maine, collected in 1966

Compound	Lincoln Co. Pemequid Lake[a]	Sagadahoc Co. Bath Dump[a]	Washington County Eastport Dumb[b]	Washington County Eastport Dump[a]	Washington County Cutler[a]
% lipid of wet weight	6.5	2.2	7.4	4.7	6.5
p,p'-DDE	2.6	1.7	5.9	3.6	3.7
p,p'-DDD	0.16	n.d.	0.23	0.20	0.09
p,p'-DDT	0.32	n.d.	n.d.	0.07	n.d.
Dieldrin	0.05	0.24	0.14	0.05	0.11
Heptachlor epoxide	n.d.	n.d.	0.09	0.17	0.05
Mirex	n.d.	n.d.	0.19	0.11	0.08
Oxychlordane	0.11	n.d.	0.10	0.09	0.07
cis-nonachlor	n.d.	n.d.	n.d.	0.07	n.d.
PCB's	2.8	17.	6.8	4.9	14.

[a] Adult - male.
[b] Immatue - sex unknown.

South Carolina within 6 months of the time it was banded. PALMER (1949) reported that many bald eagles winter along the coast of Maine, probably including some from more northerly and easterly areas. In extremely cold weather some of the birds may move out of the state. In recent years adult bald eagles commonly have been observed on or near their coastal nesting territories throughout the winter. It therefore seems likely that the major portion of the residue burden carried by Maine bald eagles is accumulated from food sources in that state.

DIMOND et al. (1968a and b, 1970, 1971, 1975), DIMOND and SHERBURNE (1969), and SHERBURNE and DIMOND (1969) have reported on declining residues of DDT plus its metabolites in invertebrates, fish, amphibians, birds and mammals in Maine following cessation of the use of DDT for forest insect control. Moderate to high residues of DDT plus its metabolites were found in ravens (Corvus corax) from both DDT-treated and untreated forests (DIMOND et al. 1975) and in other species of fish-eating birds, including mergansers, from treated forests (DIMOND et al. 1971). ZITKO et al. (1974) found an average of only 0.089 ppm (wet weight) PCB in muscle of yellow perch collected in May 1972 from Grand Falls on the St. Croix River, a point on the border of Washington County, Maine, and New Brunswick; DDE was not detected. WHITE and HEATH (1976) reported that levels of DDT plus its metabolites and dieldrin in wing pools of black ducks (Anas rubripes) shot by hunters in Maine were considerably lower in 1972 than in 1969; the level of PCB's remained relatively unchanged. These declining trends in residues of DDT and its metabolites are similar to those we found for several species of fish reported here. Little DDT or dieldrin has been used in Maine since 1970.

KOIVUSAARI et al. (1976) analyzed a number of prey species of white-tailed eagles (Haliaeetus albicilla) from the Gulf of Bothnia, Finland, where reproductive success of the eagles has been poor due to high levels of various environmental pollutants. Average residue levels (ppm wet weight) of DDE (0.01-0.04) and PCB's (0.08-0.19) in fish were much lower than the levels we have reported here; average DDT levels were below 0.03 ppm and DDD was not detected. Average PCB's in ducks ranged from 0.03 to 4.89 ppm and DDE levels ranged from 0.01 to 1.21 ppm; DDT and DDD were seldom detected. They believed that the high residue levels in the white-tailed eagles came primarily from fish-eating species in their prey. The high levels of pollutants found in the gulls from Maine indicate that fish-eating birds may also be an important source of pollutants for Maine bald eagles.

Residues of DDE in the gulls approached or exceeded the relatively low dietary levels of DDE (2.8 and 3.0 ppm wet weight) found to cause significant eggshell thinning in captive American kestrels (Falco sparverius) (WIEMEYER and PORTER 1970, LINCER 1975). The eggshells of Maine bald eagles are considerably thinner than normal.

No obvious change in DDE levels in eggs of Maine bald eagles has been noted since 1968. Levels of DDD plus DDT appear to have declined slightly, as have dieldrin levels. PCB levels appear to be increasing in their eggs.

Additional information is needed on the food habits of Maine bald eagles, on movements of the birds during different seasons and stages of their lives, and on residue levels in all major portions of their diet throughout the year before an adequate understanding of the source of pollutants in their tissues and eggs can be determined.

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