CONTAMINANT RESIDUES IN FISH FROM NORTHEASTERN OKLAHOMA

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The middle Arkansas River Basin of northeastern Oklahoma contains streams and several large reservoirs noted for their good fishing. The rivers receive industrial and municipal wastes, as well as contaminants from non-point sources. Portions of the Arkansas and Verdigris rivers have been extensively modified for navigation, and barge traffic is common. These waters also provide feeding, over-wintering and nesting habitat for animal species that are of concern to the U.S. Fish and Wildlife Service. Bald eagles (Haliaeetus leucocephalus) use habitat surrounding the reservoirs extensively during the winter for roosting and feeding, and the endangered interior least tern (Sterna antillarum) nests on sparsely vegetated sand spits and islands, and feeds on small fishes caught in the rivers. Both of these endangered species depend on a contaminant free aquatic environment to provide them with a reliable source of clean prey species.

Organochlorine compounds do not occur naturally in the environment and have been synthesized by man only in the past century. They are nonessential to life and numerous studies have shown that organochlorine compounds, including PCBs, can negatively affect fish and wildlife species (Custer and Heinz 1980, Haseltine and Prouty 1980, Helander et al. 1982, Folmer et al. 1382, Mauck et al. 1978, Mayer et al. 1977, McLane and Hughes 1980, Peakall 1975, Tori and Peterle 1983, Weis and Weis 1982, and others]. Hickey and Anderson (1968) concluded that chlorinated hydrocarbons are leading to significant decreases in reproduction for avian species that are at the top of food webs in contaminated ecosystems.

Certain elements (metals) are known to be essential for normal life processes and organisms have evolved ways to maintain homeostasis for these, within narrow limits. At slightly higher levels these same elements accumulate in the liver, kidneys, gonads and other tissues where they may interfere with normal biological processes. At even higher levels, death results through the poisoning of critical enzyme systems. At some intermediate concentration certain of the essential elements cause teratogenic effects on developing embryos (Olendorf et al. 1986). Metals are released to the environment through natural weathering of geologic formations as well as through anthropogenic means associated with mining, refining or manufacturing.

This study was undertaken to determine if aquatic organisms froz the middle Arkansas River basin in Oklahoma are accumulating metals or organochlorine compounds in body tissues.

MATERIALS AND METHODS

Fish and sediments were collected from eight locat ions in northeast Oklahoma as shown on Figure 1. Sediments were collected using an Ekman dredge. Three dredge hauls were made at each location and the top-most layer from each haul was carefully removed from the dredge with a stainless steel scoop and composited to make one sample. Sediment samples were placed on ice in the field and later frozen. The dredge and scoop were cleaned between each sample.

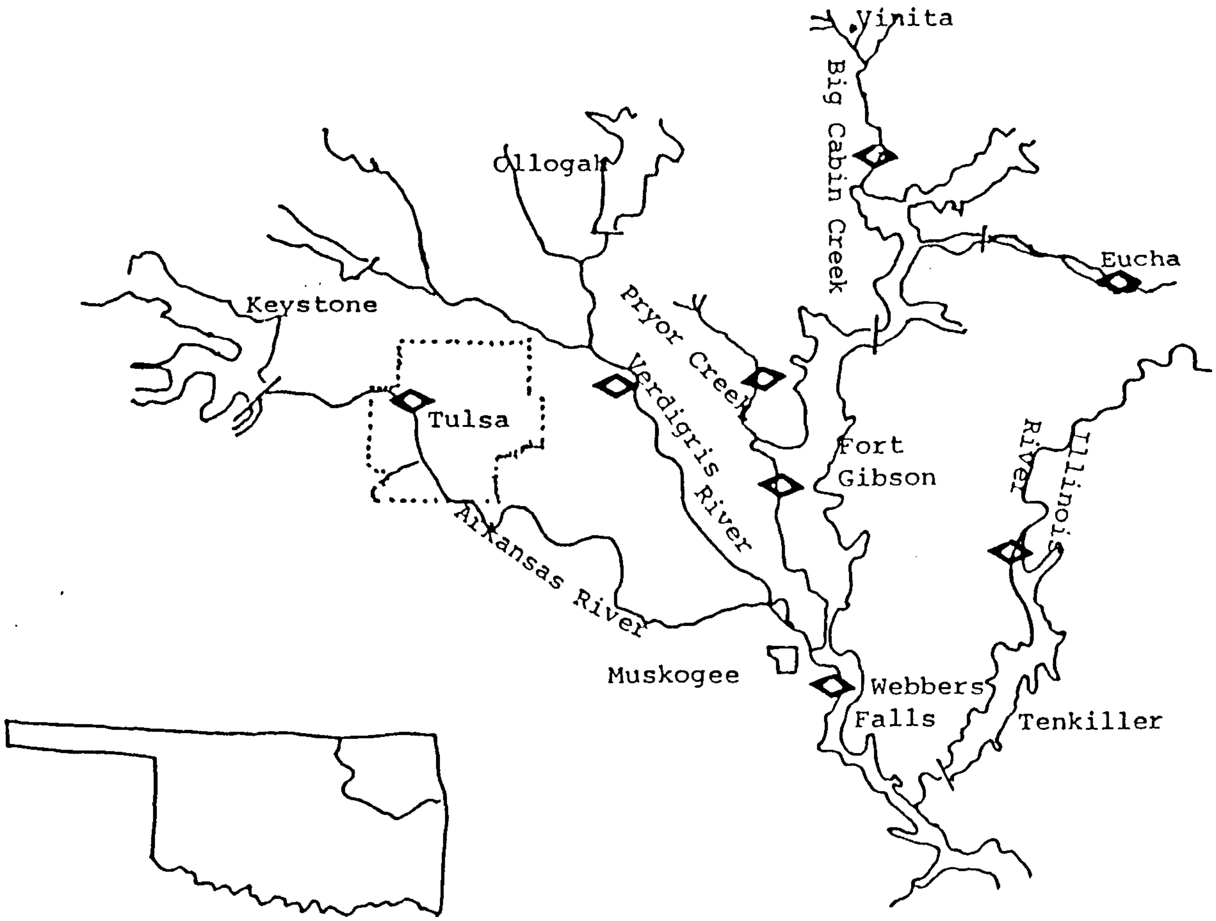

Figure 1. Location of sampling locations for contaminant study in northeastern Oklahoma. ◇ = sampling sites.

Fish were collected by electrofishing. Individual fish were weighed and measured, wrapped in aluminum foil, placed on ice in the field, and then later frozen. Five fish of the same species were cornposited to make one sample. At each sampling location efforts were made to collect two replicate samples of common carp (Cyprinus carpio), at least one sample of a predatory species, and one sample of gizzard shad (Dorosoma cepedianum).

Determination of metal residues was carried out at the Environmental Trace Substances Research Center in Columbia, Missouri'. Organochlorine compound residues were determined at Weyerhaeuser Analytical and Testing Services, Tacoma, Washington. Quality control and quality assurance were monitored by the Analytical Control Facility at the Patuxent Wildlife Research Center, Laurel, Maryland. Contaminant levels in reagent blanks, duplicate samples and unknown standards were determined as part of the QA/QC procedures. The recovery of samples spiked with known amounts of metals averaged 99 percent and analysis of standards and duplicate samples showed less than 11 percent deviation in results for both metals and organic compounds.

Data analyses were carried out using the Systat statistical analysis package on a microcomputer. Residue values were normalized by using the natural log of (x + 1) and an analysis of variance was carried out on the transformed variables. Where contaminant residues were reported as "less than" values, a value of one-half the quantitation limit (for organics) or one-half the detection limit (metals) was used in the statistical analysis. Geometric means were calculated and converted back to arithmetic values. Differences between sites and between species were determined using Tukeys HSD at the 0.05 level. Metal residues were converted to wet weight values using the average moisture content of all samples (74%).

RESULTS AND DISCUSSION

Bottom feeders (common carp) were collected at all locations except Lake Eucha where only gizzard shad (planktivores) were caught due to extremely high water levels. Predatory species collected were either white crappie (Pomoxis annularis) or largemouth bass (Micropterus salmoides), except at the Arkansas River site where small striped bass (Morone saxatilis) were the only predatory species found. At Pryor Creek, Webbers Falls and Fort Gibson sufficient white crappie were collected so that three composite samples of fillets were submitted for residue analysis. Channel catfish (Ictalurus punctatus) were collected only from Pryor Creek. All sediment samples consisted mostly of sand with little organic material.

Tissue levels of 38 organochlorine contaminants and 10 metals were quantified in the samples (Table 1). However, residues of many of these were below the detection limits of the analytical instruments and techniques used, and only

[1]. Mention of commercial laboratories or products is for identification only and does not signify endorsement by the U.S. Fish and Wildlife Service.

Table 1. Fish tissue and sediments were examined for the following environmental contaminants.

Organochlorine Compounds:

oxychlordane	endrin	tetradifon
cis-chlordane	dieldrin	arochlor 1221
trans-chlordane	aldrin	arochlor 1016
cis-nonachlor	alpha BHC	arochlor 1232
trans-nonachlor	beta BHC	arochlor 1242
0 P' DDE	gama BHC	arochlor 1248
P P' DDE	delta BHC	arochlor 1254
0 P' DDD	hexachlorobenzene	arochlor 1260
P P' DDD	endosulfan I	arochlor 1262
0 P' DDT	endosulfan II	toxaphene
P P' DDT	mirex	heptachlor
dicof ol	DCPA	heptachlor epoxide
		methoxychlor

Metals:

cadmium	nickel	thallium
copper	lead	vanadium
iron	selenium	zinc
molybdenum		

the contaminants listed in Tables 2 and 3 were subjected to statistical analysis. In order to make this report comparable to other data collected in Oklahoma, the values for all the chlordane isomers (oxychlordane, cis- and trans-chlordane and cis- and trans-nonachlor) were summed to a single value and repor ted as "chlordane." PP' DDE was the most common isomer of DDT and was found in all samples. The value "DDT" reported in Table 2 is the sum of all the DDT isomer values. Similarly, values for all the Arochlor values were totaled and reported as PCBs. Values for iron, lead and tellurium are not included in the statistical analysis of the metals data.

The National Contaminant Biomonitoring Program (NCBP) is a nationwide effort by the U.S. Fish and Wildlife Service that tracks levels of environmental contaminants in fish tissue. Results from the most recent study of organic contaminants, 1980-81 (Schmitt et al. 1985), were used for comparison to determine if residues from northeast Oklahoma are elevated. Table 2 lists the geometric means, ug/g wet weight (ppm), for each location and for each species (trophic level) for chlordane, total DDT, dieldrin and total PCBs.

Except for PCBs, organic contaminant residues in fish from the eight study lakes were generally low.

Chlordane is readily accumulated from water by aquatic organisms. Veith et al. (1979, as cited in Environmental Protection Agency 1980) found that fathead minnows (<u>Pimephales promelas</u>) concentrated chlordane in their body tissues 37,800 times greater than the water concentration (bioconcentration factor). Chlordane is not as acutely toxic as other pesticides and reports on biological effects other than death were not found in the literature. Technical chlordane is a complex mixture that may contain some 45 different components. Until 1988, it was widely used for termite control. Laboratory tests indicate chlordane is an animal carcinogen, and this fact, coupled with finding large residues of chlordane in fish tissue in the Missouri River basin, led to a ban on further use of the chemical. The NCBP geometric mean for chlordane, adjusted to include the total of all isomers, is 0.12 ug/g. This value is equalled or exceeded in bottom feeders from the Verdigris River, in predators from Big Cabin Creek, and in all trophic levels from Pryor Creek. The analysis of variance showed a significant difference between locations in tissue residues for chlordane and Tukeys test showed that the concentrations in the samples from Pryor Creek, without regard to species, are significantly different than concentrations at the other sample sites. The Food and Drug Administration has set an action level of 0.3 ug/mg of total chlordane for fish products (table ready fish or fillets) in interstate commerce. Carp from Pryor Creek would probably exceed this value.

Isomers of DDT are ubiquitous contaminants that are found in practically all animal tissues. Levels found in the present study were all lower than the NCB? mean of 0.29 ug/g. Wildlife researchers have speculated that a diet containing about 1 ug/g of DDE will probably lead to egg shell thinning in predatory birds. Levels in northeast Oklahoma fish appear to be well below that concentration. The analysis of variance showed a significant difference between trophic levels in tissue residues for DDT and Tukeys test showed that the concentrations in bottom feeders are significantly different than the

Table 2. Geometric means of organochlorine chemical residues in fish from northeastern Oklahoma. All values are ug/g wet weight, N=number of composite samples analyzed.

Trophic level or location	N	Chlordane	DDT	Dieldrin	PCBs
All locations:					
Botton feeders	17	0.09	0.11	0.03	1.12”
Predators	15	0.05	0.05	0.02	0.65*
fillet (Pryor)	3	0.03	0.02	0.02	1.96”
fillet (Webber)	3	0.01	0.02	0.003	0.17
fillet (F Gibson)	3	0.01	0.01	0.004	0.18
Shad	8	0.05	0.04	0.02	0.58*
Catfish (Pryor)	3	0.13	0.06	0.05*	3.23”
All trophic levels:					
Pryor Creek	6	0.13	0.07	0.06	3.48*
Tenkiller Res.	4	0.05	0.11	0.01	0.27
Webr Falls Res.	6	0.05	0.10	0.01	0.45
Big Cabin Crk.	4	0.08	0.06	0.02	0.09
Verdigris Riv.	3	0.11	0.05	0.02	0.54*
Ft.Gibson Res.	6	0.05	0.05	0.02	1.41
Arkansas Riv.	11	0.05	0.06	0.02	0.55*
Bottom feeders:					
Pryor Creek	2	0.26*	0.13	0.14*	8.38*
Tenkiller Res.	2	0.07	0.19	0.01	0.42
Webr Falls Res.	2	0.05	0.15	0.01	0.53
Big Cabin Crk.	2	0.07	0.06	0.01	0.03
Verdigris Riv.	2	0.12”	0.05	0.02	0.59*
Ft.Gibson Res.	2	0.07	0.10	0.03	2.61”
Arkansas Riv.	5	0.05	0.09	0.01	0.88*
Predators:					
Pryor Creek	3	0.07	0.05	0.03	2.25”
Tenkiller Res.	1	0.02	0.04	0.01	0.17
Webr Falls Res.	3	0.04	0.08	0.01	0.38
Big Cabin Crk.	1	0.12”	0.08	0.03	0.26
verdigris Riv.	0	--	--	--	--
Ft.Gibson Res.	3	0.04	0.03	0.01	0.79*
Arkansas Riv.	4	0.04	0.03	0.01	0.23
Shad:					
Pryor Creek	1	0.06	0.04	0.002	1.66*
Tenkiller Res.	1	0.02	0.03	0.01	0.09
Webr Falls Res.	1	0.06	0.08	0.02	0.47
Big Cabin Crk.	1	0.06	0.04	0.02	0.03
Verdigris Riv.	1	0.07	0.05	0.02	0.45
Ft.Gibson Res.	1	0.04	0.02	0.02	1.64*
Arkansas Riv.	2	0.06	0.05	0.02	0.51
1980-81 NCBP collection geometric mean:		0.12	0.29	0.04	0.53

* These values exceed the NCBP geometric mean.

Table 3. Geometric means of metal residues in fish from northeastern Oklahoma. All values are ug/g wet weight, N=number of composite samples analyzed.

Trophic level or location	N	Cd	Cu	Mo	Ni	Se	V	Zn
All locations:								
Botton feeders	17	0.04	0.47	0.01	0.08	0.26	0.05	15.3
Predators	15	0.003	0.26	0.01	0.003	0.26	0.02	11.6
fillet (Pryor)	3	0.003	0.21	0.13	0.11	0.35	0.01	5.3
fillet (Webber)	3	0.01	0.30	0.01	0.03	0.36	0.01	5.8
fillet (F Gibson)	3	0.01	0.51	0.01	0.12	0.26	0.01	5.6
Shad	8	0.02	0.69	0.01	0.29	0.26	0.08	17.6
Catfish (Pryor)	3	0.04	0.30	0.05	0.49	0.34	0.17	21.6
All trophic levels:								
Pryor Creek	6	0.03	0.59	0.05	0.48	0.44	0.14	27.7
Tenkiller Res.	4	0.03	0.55	0.03	0.30	0.35	0.05	17.3
Webr Falls Res.	6	0.03	0.69	0.03	0.26	0.40	0.12	28.0
Big Cabin Crk.	4	0.06"	0.71	0.11	0.45	0.42	0.16	29.3
Verdigris Riv.	3	0.07"	0.75	0.09	0.66	0.48	0.34	28.6
Ft.Gibson Res.	6	0.07"	0.59	0.06	0.40	0.33	0.17	30.4
Arkansas Riv.	11	0.06"	0.85	0.05	0.18	0.43	0.16	30.3
Bottom feeders:								
Pryor Creek	2	0.07"	0.92	0.07	0.78	0.67	0.11	52.7*
Tenkiller Res.	2	0.04	0.65	0.03	0.43	0.34	0.05	16.1
Webr Falls Res.	2	0.06"	0.95"	0.03	0.29	0.61	0.19	61.0*
Big Cabin Crk.	2	0.11"	1.04*	0.10	0.61	0.52	0.12	59.9*
Verdigris Riv.	2	0.06"	0.61	0.13	0.45	0.62	0.11	35.0
Ft.Gibson Res.	2	0.15"	0.93"	0.08	0.32	0.34	0.11	54.0*
Arkansas Riv.	5	0.10"	0.83	0.05	0.14	0.42	0.23	36.5
Predators:								
Pryor Creek	3	0.01	0.32	0.04	0.24	0.30	0.03	17.0
Tenkiller Res.	1	0.01	0.29	0.01	0.03	0.47	0.02	18.6
Webr Falls Res.	3	0.01	0.49	0.04	0.21	0.26	0.05	18.3
Big Cabin Crk.	1	0.004	0.29	0.13	0.08	0.42	0.03	11.5
Verdigris Riv.	0	--	--	--	--	--	--	--
Ft.Gibson Res.	3	0.02	0.32	0.05	0.22	0.26	0.04	20.6
Arkansas Riv.	4	0.04	0.78	0.07	0.15	0.46	0.09	30.8
Shad:								
Pryor Creek	1	0.03	1.11*	0.03	1.04	0.52	0.94	22.6
Tenkiller Res.	1	0.03	0.71	0.05	0.44	0.26	0.08	18.4
Webr Falls Res.	1	0.02	0.91*	0.01	0.42	0.55	0.26	21.0
Big Cabin Crk.	1	0.03	0.70	0.10	0.73	0.26	0.47	17.6
Verdigris Riv.	1	0.07*	1.13*	0.03	1.27	0.26	1.31	13.:
Ft.Gibson Res.	1	0.11"	1.11"	0.08	1.95	0.52	1.36	30.9
Arkansas Riv.	2	0.03	1.10"	0.01	0.35	0.38	0.22	19.8
1981 NCBP collection:								
geometric mean		0.03	0.68			0.47		23.8
85th percentile		0.06	0.90			0.71		40.1

* This value exceeds the 85 percentile of the NCBP samples.

concentrations in predators or gizzard shad. However, there was no significant difference between sample locations.

Dieldrin residues in northeast Oklahoma were also low. Only bottom feeders and catfish from Pryor Creek exceed the NCBP mean of 0.04 ug/g. There is no significant difference in residue levels between species but there are significant differences between some sites. Pryor Creek dieldrin residues, considered without regard to species, were higher than residues in fish from Tenkiller Reservoir, Webbers Falls Reservoir, Big Cabin Creek and the Arkansas River, but were not different than residues from the Verdigris River and Fort Gibson Reservoir.

PCBs are present at all of the locations sampled in this study. Residues equalled or exceeded the NCBP geometric mean in bottom feeders at all locations except Tenkiller Reservoir and the Verdigris River. Bottom feeders from Pryor Creek had the highest PCB residues of any location or of any species in this study, 8.38 ug/g. In the NCBP data, only fish from station 3 on the Hudson River had PCB residues that exceeded this level. Fredators from Pryor Creek with residues of 2.25 ug/g and bottom feeders from Fort Gibson with residues of 2.61 ug/g were also well above the NCBP geometric mean. Residues in shad were also highest from Pryor Creek, 1.66 ug/g, while shad from Fort Gibson were second with residues of 1.64 ug/g. The statistical tests, considering all species without regard to sample location, indicate that the differences between species is not significant. However, tests considering sample locations without regard to species, show that the difference between locations is significant and that residue concentrations at Pryor Creek are significantly different than all other locations. Residues of PCBs were lowest at Big Cabin Creek. The FDA has set a PCB action level of 2.0 ug/g for fish products in interstate commerce. Predator fillets from Pryor Creek (1.96 ug/g) are close to this number and bottom feeders fro? Pryor Creek and Fort Gibson probably exceed the FDA action limit.

The high PCB residues are of concern because a large number of bald eagles are known to feed around reservoirs in northeastern Oklahoma. Research on the effects of PCBs on raptors has demonstrated the following negative effects. Lincer and Peakall (1970) fed PCB contaminated prey to American kestrels (Falco sparverius) and compared liver activity to untreated birds. They found a dose related increase in the breakdown of es tdradiol , a hormone associated with reproduction, in the treated birds. These authors suggest that the physiological action of PCBs is similar to that of DDT and its metabolites. More recent work by Bird et al. (1983) provides further information on a possible consequence of this altered metabolism. They examined the effects of PCBs on the semen characteristics of American kestrels and found that feeding prey contaminated with 33 ppm PCBs resulted in a 22 % reduction in sperm numbers per ejaculate. Research on the prairie falcon (F. mexicanus) in Canada showed that a decrease in reproduction was significantly associated with increasing levels of PCBs and DDE (Fyfe et al. 1976). Highly contaminated individuals in this study were less aggressive in defending their nests and territories. Newton and Bogan (1978) compared clutches and nesting success of wild British sparrow hawks (Accipter nisus) and found that the PCB concentration was significantly related to the extent of egg addling and hatching failure. A decrease in shell thickness of the eggs of raptors and fish-eating birds was shown to be correlated with increased organochlorine residues (Hickey and Anderson 1968).

The one sample (gizzard shad) collected from Lake Eucha showed just traces of chlordane (0.02 ug/g), DDT (0.01 ug/g), dieldrin (0.004 ug/g) and no PCBs. Only two of the sediment samples showed contamination by organic compounds. The sample from Fort Gibson Reservoir had 0.002 ug/g of oxychlordane and the sample from Pryor Creek had the following levels: cis-chlordane 0.003, PP'DDE 0.002, and PCBs 0.19 ug/g. Most contaminants bind to small clay or colloidal particles in the water column and then settle out on the sediments. The spring of 1986 had above usual amounts of rainfall, and reservoirs and rivers were probably scoured of fine materials leaving only relatively clean sand in the sediments.

The concentrations of elements (metals) in fish are also measured as part of the NCBP. The latest results are for samples collected in 1980-81 (Lowe et al. 1985). The 85th percentile, an arbitrary point distinguishing stations with high concentratons of metals, is calculated for NCBP station geometric mean concentrations (May and McKinney 1981). These numbers were used to compare results from the northeast Oklahoma samples. If concentrations exceed the 85th percentile, those residues are greater than 85% of the values reported in the 1980-81 nationwide sampling.

NCBP results since 1976 have shown that fish from station 78, Verdigris River at Oologah Reservoir, consistently have the highest, or next to highest, cadmium residues of all stations that are surveyed. Data from the present study show that cadmium residues are above the 85th percentile for all bottom feeders except those from Tenkiller Reservoir. Residues in gizzard shad from the Verdigris River and Fort Gibson are also above the 85th percentile. The analysis of variance showed that there is a significant difference in residue concentrations between trophic groups, but no significant difference between locations. Tukeys test showed that each trophic group is different from the other two. The cadmium level in the single gizzard shad sample from Lake Eucha was not different from the residues in fish from Fort Gibson Reservoir. Sublethal effects of cadmium exposure in fish and birds are similar and include retarded growth, anemia, and testicular damage (Eisler 1985). The toxicity of cadmium to fish is confounded by complex interactions between water hardness, salinity, exposure concentration and time, and temperature. The significance of low tissue concentrations in fish and wildlife is not fully understood (Eisler 1985). Cadmium is closely associated with zinc in geological formations and nearly all cadmium in this country is produced as a by product of zinc smelting (May and McKinney 1981). Cadmium is used in large quantities in the electroplating industry and formerly was a common contaminant in plating wastewaters treated at municipal sewage plants. Sewage treatment plant sludge in Tulsa contains elevated levels of cadmium and cannot be disposed of by land farming (personal communication, Frank Canahl). One of the primary zinc producers in the country is located in Bartlesville, Oklahoma, but the source of cadmium contamination in northeastern Oklahoma has not been determined,.

Copper is the only element measured in the NCBP that declined significantly from 1978-79 to 1980-81 (Lowe et al. 1985). In the samples from northeastern Oklahoma concentrations of copper in bottom feeders from Pryor Creek, Webbers Falls Reservoir, Big Cabin Creek and Fort Gibson Reservoir exceeded the 85th percentile. All gizzard shad samples except Tenkiller Reservoir and Big Cabin Creek were above the 85th percentile. However, none of the samples approach the maximum residue concentration of 38.75 ug/g reported in the NCBP (Lowe et al. 1985). Statistical analysis showed there are significant differences between the trophic levels but no difference between sample locations. Because copper is a required element for animal nutrition, the significance of copper residues has not been established, and few tests have been conducted for the purpose of estimating the bioconcentration factor (Environmental Protection Agency 1983).

There has been much interest in selenium as a contaminant of fresh water ecosystems since the Service first became aware of the problems at Kesterson National Wildlife Refuge (Anon. 1986). Lowe et al. (1985) reported a range of selenium values of from 0.09 to 2.47 ug/g in whole fish tissue for the 1980-81 NCBP samples. They state that the highest values consistantly come from the Colorado River system, an area of highly seleniferous soils. Saiki (1986) reported selenium residue values in mosquitofish (Gambusia affinis) from a clean pond of 0.29 ug/g selenium while mosquitofish from contaminanted ponds contained residues of from 26.0 to 31 ug/g. Bauaann and Gillespie (1986) found that selenium concentrated in the gonads of fish and led to reproductive failure in sunfishes when residues reached about 4 ug/g. Examination of the data from northeastern Oklahoma with an analysis of variance shows that the residues *are* not significantly different between locations but they are different between trophic groups. Residues in predators are different from residues of both bottom feeders and gizzard shad. Judging from the values reported in Table 3, it appears that selenium levels in fish from northeastern Oklahoma are not a cause for concern at this time.

Zinc residues are elevated in bottom feeders from Pryor Creek, Webbers Falls Reservoir and Big Cabin Creek when compared to the 85th percentile: however, the maximum value from northeastern Oklahoma fish is well below the value of 103.2 ug/g recorded from the NCBP. Tukeys test shows there are significant differences in zinc residues between trophic groups, with bottom feeders being higher than the other groups.

Vanadium, molybdenum and nickel are not measured as part of the NCB?; therefore, comparison values for residues are not available. Vanadium residues were highest in gizzard shad with shad from the Verdigris River and Fort Gibson Reservoir showing the highest accumulation, 1.31 and 1.36 ug/g respectively. Molybdenum residues were low (0.03 to 0.09 ug/g for all trophic levels) and the analysis of variance showed that differences in residue concentrations between species and between sites were nonsignificant. Tong et al. (1974) found that molybdenum residues in lake trout (Salvelinus naymaycush) ranged from 0.0022 up to 0.0085 ug/g and that residues decreased with fish age. Nickel residues are low in most fishes from northeast Oklahoma, 0.03 to 1.95 ug/g, but residues in gizzard shad are significantly higher than the other trophic groups. Nickel, as nickel carbonyl, is toxic to mammals when inhaled (Environment Protection Agency 1980), but no research has been conducted on effects from ingesting contaminated prey.

Lead residues were not analyzed statistically because only 10 of the reported values are above the detection limit. Five of the values above detection are from the Arkansas River. Values for Arkansas River predators were all below detection, values for Arkansas River gizzard shad were 0.13 and 0.18, and values for bottom feeders were 0.18, 0.36, 0.52, and 0.70 ug/g. The 1980-81 NCBP geometric mean for lead is 0.17 and the 85th percentile is 0.25 ug/g. The Arkansas River collecting site is in a major metropolitian area, receives large amounts of run-off from city streets, and is bordered by highways. This may explain the high lead residues.

Results from the metals analyses of the sediment samples showed no consistent patterns and results do not appear to correlate with fish tissue residues. The absence of fine materials in the sediment samples may explain the low values for metal contaminants.

The residue values for sampling locations, without regard for species, were examined and scored for all 11 measured variables. The values were scored either 1, 2, or 3, depending on whether the residue for that variable was the lowest, medium or highest value recorded for these samples. The scores were then summed. A location that had the lowest value for all contaminant residues would receive a score of 11; the maximum score would be 33. The scores ranged from 14 to 26. The lowest score, and therefore the “cleanest” location sampled, was Tenkiller Reservoir. Samples at this location were collected above the reservoir in the Illinois River and, evaluated subjectively, this location would be ranked as the best location in northeastern Oklahoma. A put and take rainbow trout fishery is maintained below the dam, the river flows through rough, hilly limestone terrain, and the water is cold and very clear. The highest score, and therefore the “dirtiest” location sampled, was Pryor Creek. This stream drains an industrial area, stream banks are eroded, and suspended sediment loads are high. In addition, an old industrial disposal site heavily contaminated with PCBs is located on the stream bank. Additional studies on PCB contamination from this site are currently underway.

Most of the locations from which samples were analyzed appear to be free of contaminants at levels which have been shown in the literature to cause problems in fish or wildlife. Data from fish collected from the Arkansas River did not indicate that food items of the interior least tern were contaminated. However, this was a limited sample and additional specimens from other locations and species should be collected and analyzed. Fish, especially bottom feeders from Pryor Creek and Fort Gibson, do have high body residues of PCBs. Consumption of fish by eagles from Pryor Creek and/or Fort Gibson Reservoir may constitute a threat to the successful reproduction of these birds at their northern breeding sites. Oklahoma is participating in a “hacking” program to reintroduce captive reared southern bald eagles into their former range. Consumption of contaminated fish by these birds on a regular basis may lead to reproductive failure when they begin to nest in Oklahoma. Continued reproductive success of fish eating birds that nest in northeastern Oklahoma, herons, egrets, and their allies, may also be jeopardized. More follow up studies are needed. This study also provides baseline data that will allow future comparisons to be made and determine if the threat from environmental contaminants decreases over time.

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