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A SURVEY OF ELEMENTAL CONTAMINANTS AND ORGANOCHLORINES AT NORTH PLATTE NATIONAL WILDLIFE REFUGE, NEBRASKA, 1993.

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A Survey of Elemental Contaminants and Organochlorines at North Platte National Wildlife Refuge, Nebraska, 1993.

INTRODUCTION

The North Platte National Wildlife Refuge (Refuge) is located 8 miles northeast of Scottsbluff, in Nebraska's Panhandle. It was established by Executive Order in 1916, and was managed by the Bureau of Reclamation (BR) until 1986, when primary jurisdiction was granted to the U.S. Fish and Wildlife Service (Service). The 2,909 acre Refuge includes three reservoirs: 1) Lake Alice, 2) Winters Creek Lake, and 3) Lake Minitare (Figure 1). Water levels in all three reservoirs are managed by BR for irrigation and Lake Minitare is managed as a State Recreation Area under a lease agreement with the Nebraska Game and Parks Commission. The primary purpose of the Refuge is to provide sanctuary for migratory birds, but habitat for migrating bald eagles, waterfowl production, and compatible recreation are important management goals (USFWS, 2001). Twenty bald eagles and over 200,000 waterfowl concentrate on the Refuge during migration and over 200 species of birds have been observed on the Refuge.

Irrigation supply water from the North Platte River is the primary source of water for all three Refuge reservoirs, which are interconnected by surface water. Lake Alice receives water from the Interstate and Highline canal, and discharges to the Supply canal and Hersche drain. Winters Creek Lake is fed by the Supply canal and also discharges to the Supply canal, with the inflow and outflow separated by approximately 200 meters. Lake Minitare receives water primarily from the Supply canal with secondary input from the Highline canal and discharges into the Lowline canal and Alliance drain. Land use in the drainage is primarily agricultural; with corn, soybeans, and sugar beet production the predominant row crops. In addition, alfalfa production and grazing areas support cattle ranching within the Refuge's watershed.

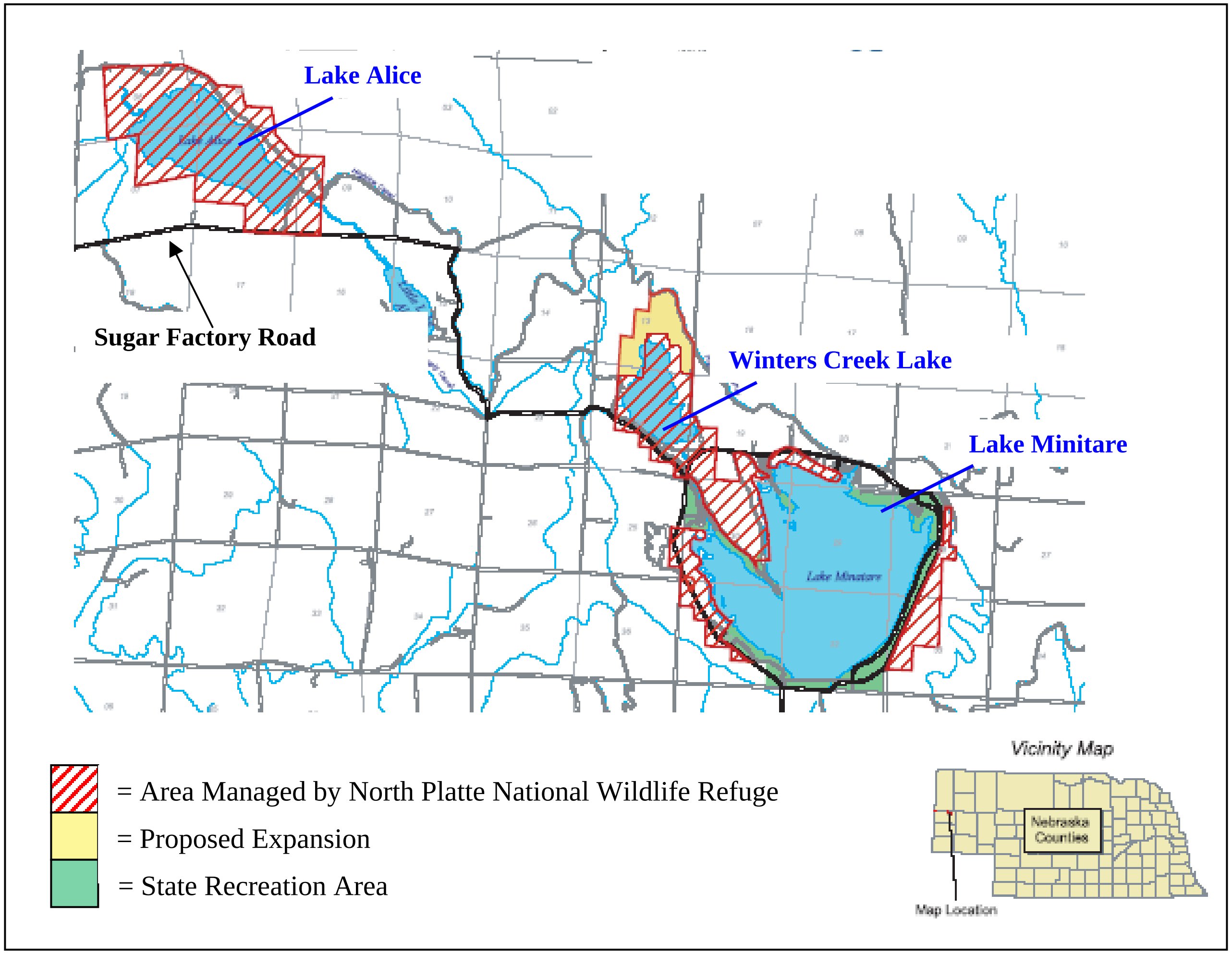

Figure 1: Location of North Platte National Wildlife Refuge. Note: This map is a modified version of Map 2 in the final Comprehensive Conservation Plan (USFWS, 2001).

OBJECTIVES AND METHODS

The objective of this research was to evaluate organochlorine and trace element exposure and effects to Refuge wildlife. This was accomplished by measuring concentrations of these contaminants in Refuge sediment, water, and common carp (*Cyprinus carpio)* samples and comparing them to literature-established background concentrations and protective guidelines.

All samples were collected by Service personnel from the Nebraska Ecological Services Field Office (NEFO). Sediments were sampled using a stainless steel spoon; both sediment and water grab samples were collected into chemically clean containers. Carp were collected by electrofishing and composited on site (one composite per waterbody with four to five fish per composite sample). All samples were kept on wet ice and transported to the NEFO lab where they were kept frozen. Samples were then submitted to the Patuxent Analytical Control Facility (PACF), since renamed the Analytical Control Facility (ACF), for analytical analysis by Hazleton Environmental Services, Inc, in Madison, WI

Concentrations of organochlorines (OCs) were determined in eleven sediment, nine water, and three carp composite samples (Appendix Table A.1). Detailed descriptions of lab methods including sample preparation, detection limits, and quality assurance/quality control (QA/QC) are provided elsewhere (PACF catalogs #s 6050040 and 6050043; ACF, 2005). In brief, gel-permeation chromatography was used to determine concentrations of hexachlorobenzene, total polychlorinated biphenyls (PCBs), hexachlorocyclohexanes (alpha, beta and gamma), chlorohexane, alpha chlordane, cis-nonachlor, dieldrin, endrin, gama chlordane, heptachlor epoxide, mirex, oxychlordane, toxaphene, trans-nonachlor, dichlorodiphenyltrichloroethane (DDT) p,p’ and o,p’ isomers and their metabolites including o,p'-DDD, o,p'-DDE, , p,p'-DDD, and p,p'-DDE. Detection limits for OC quantification ranged from 0.001 to 0.006 mg/L for water and from 0.01 to 0.05 mg/kg ww for sediments and carp.

Nine water grab samples, 18 sediment samples, and three carp whole-body composite samples were analyzed for elemental contaminants (Appendix Table A.2). Detailed descriptions of lab methods including sample digestion, detection limits, and QA/QC are provided elsewhere (PACF catalogs #s 6050029 and 6050040; ACF, 2005). In brief, inductively coupled plasma atomic emission spectrometry was used to determine concentrations of aluminum (Al), boron (B), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), strontium (Sr), vanadium (V), and zinc (Zn). Mercury (Hg) concentrations were determined by cold vapor atomic absorption and graphite furnace atomic absorption was used to measure arsenic (As), selenium (Se) and small concentrations of Pb and Cd.

Precision and accuracy of the laboratory results for OCs and elemental contaminants were confirmed by analyzing procedural blanks, duplicate analyses, test recoveries, spiked material, and reference material.

All statistical calculations were performed with JMP® Version 5 software (JMP, 2002). If 50 percent or more of the samples analyzed were above the detection limit for a particular trace element, then half the detection limit was used for those samples with concentrations below the detection limit when performing statistical analyses. Where means are provided, the "±" refers to a standard error unless otherwise noted.

RESULTS AND DISCUSSION

Organochlorine Contaminants

Concentrations of OCs were below detection limits in all water and sediment samples and only total PCBs and p,p'-DDE were detected in carp. Total PCBs were detected once at 0.05 micro-grams per gram (µg/g) wet weight (ww) in the carp sample from Lake Minitare. Concentrations of p,p'-DDE were above detection twice at 0.017 and 0.13 µg/g ww in samples from Lake Alice and Lake Minitare, respectively. There are no national pesticide or PCB tissue criteria that have been adopted for protection of wildlife. However, concentrations of total PCBs and DDE in carp were below criteria (0.1 and 0.2 µg/g ww, respectively) proposed by the state of New York for protection of fish-eating wildlife (Newell et al., 1987).

Elemental Contaminants

Water. Waterborne concentrations of elemental contaminants were generally low and frequently below detection limits (Appendix table A.3). However, Al and Se were detected in water at concentrations above Nebraska Department of Environmental Quality (NDEQ) acute and chronic aquatic life water quality standards. All nine water samples had concentrations of Al above Nebraska's chronic aquatic life water quality standard of 87 micrograms per liter (µg/L) (NDEQ, 2002). The highest concentrations of total Al were at Lake Minatare where they averaged 875 ± 41 µg/L, a concentration above Nebraska's acute aquatic life standard of 750 µg/L (NDEQ, 2002). Selenium was detected once in water at 3 µg/L. This concentration did not exceed the 5.0 µg/L total recoverable aquatic life water quality standard (NDEQ, 2002), but was above the 2 µg/L total recoverable Se threshold for bioaccumulation and reproductive failure for fish and wildlife (Lemly, 1996a). It should be noted that all water samples for this study were collected on the same day in late July and concentrations of Se at a site can vary greatly by season or between years (Seiler et al., 2003). Therefore, the water concentrations of Se reported in this study should not be interpreted as representing the potential waterborne influx of Se into the Refuge.

The comparison of Al concentrations detected in this study with Nebraska water quality criteria may not accurately evaluate whether wetland plant and invertebrate species are at risk. Total recoverable Al was measured in this study, whereas Nebraska's water quality standard is for dissolved Al. Water samples are filtered before an analysis for dissolved metals, whereas total recoverable analysis includes microorganisms and suspended particulates that are not filtered and thus result in higher concentrations. Total recoverable is a more appropriate measurement than dissolved when particulate aluminum is primarily aluminum hydroxide particles; however, the total recoverable procedure also measures aluminum bound to clay particles, which might be less toxic than aluminum hydroxide (USEPA, 2002). Al toxicity and bioavailability to aquatic biota is largely dependent on its solubility and generally increases as pH decreases (Gensemer and Playle, 1999). The pH in Lake Minatare is within the Nebraska water quality standard range of 6.5 to 9.0 (NDEQ, 2002; NDEQ, 2004). Given that Al is only sparingly soluble at a pH between 6.0 and 8.0 (Sparling et al., 1997), Al bioavailability and toxicity to aquatic species on the Refuge is likely low However, future assessments of Al at the site should include pH measurements.

Sediments. Mean concentrations of elemental contaminants in sediments were below or near western background concentrations (Shakette and Boerngen, 1984) and did not exceed known toxicity thresholds (Table 1). Selenium was below detection in 11 of 18 sediment samples and all detected concentrations were within the 0.2 -2.0 mg/kg dry weight (dw) normal background range for freshwater sediments (USDOI, 1998). All sediment samples were below the detection limit for cadmium, mercury, and molybdenum.

Table 1. Mean ± SE concentrations of elemental contaminants in sediments from North Platte National Wildlife Refuge compared to western background concentrations and effects thresholds.

Trace Element	Mean concentration (mg/kg) ± standard error			Concentration mg/kg dry weight	
	Lake Alice	Winters Creek Lake	Lake Minatare	*Western U.S.	Effects Thresholds
Al	8639 ± 1147	6108 ± 1413	7175 ± 1016	74,000	58,030[A]
As	2.48 ± 1.33	0.78 ± 0.15	0.80 ± 0.06	7	9.79[B], 12.10[C]
B	7.68 ± 0.89	6.55 ± 1.64	6.31 ± 0.68	NA	No criterion
Ba	82 ± 11	68 ± 16	84 ± 11	670	No criterion
Be	0.30 ± 0.04	0.20 ± 0.05	0.24 ± 0.03	0.97	No criterion
Cd	BDL	BDL	BDL	NA	0.59[C], 0.99[B]
Cr	6.63 ± 0.51	4.90 ± 0.84	5.70 ± 0.61	56	43.4[B], 56.0[C]
Cu	5.19 ± 0.82	3.42 ± 0.77	4.23 ± 0.60	27	7.77[A], 31.6[B], 270[D]
Fe	8026 ± 556	6832 ± 1137	7521 ± 807	26,000	No criterion
Hg	BDL	BDL	BDL	NA	No criterion
Mg	2984 ± 387	2653 ± 627	2411 ± 363	NA	No criterion
Mn	126 ± 12	83 ± 17	95 ± 12	480	819.0[E], 1,081[A]; 1,673[C]
Mo	BDL	BDL	BDL	1.1	No criterion
Ni	4.49 ± 0.55	2.76 ± 0.55	3.44 ± 0.42	19	22.7[B]
Pb	4.40 ± 0.30	2.92 ± 0.62	3.62 ± 0.37	20	34.2[C], 35.8[B]
Se	BDL	BDL	BDL	0.34	4.0[E]
Sr	49 ± 7	55 ± 19	38 ± 6	NA	No criterion
V	26 ± 2	22 ± 5	25 ± 3	88	No criterion
Zn	20 ± 2	16 ± 3	18 ± 2	65	121[B], 159[C]; 1,532[A]

Note: * indicates background soil concentrations for the Western U.S. (Shacklette and Boerngen, 1984). Six samples were analyzed at each site. SE = standard error, NA = not available, BDL indicates that 50% or more of the samples analyzed were below detection limits.
A = Probable effects concentration benchmark (Jones et al., 1997).
B = Sediment quality guideline threshold effects concentration below which harmful effects are unlikely to be observed (MacDonald et al., 2000).
C = Toxic Effects Concentration benchmark below which effects are rarely expected to occur (Jones et al., 1997).
D = No Effects Concentration benchmark (Jones et al., 1997).
E = Toxicity threshold at which adverse effects on some fish and wildlife species may occur (USDOI, 1998).

Fish Tissue

Several elemental contaminants (As, Cu, Pb, Se, and Zn) were detected at concentrations that exceeded the 85^{th} percentile concentration for carp as determined by a national fish tissue monitoring program (Schmitt and Brumbaugh, 1990) (Table 2). However, only concentrations of Se in carp were above known toxicity thresholds for protecting wildlife. Carp from all three reservoirs had tissue concentrations of Se above the 4.0 µg/g dw effects threshold for protecting fish health and reproduction (Lemly, 1996a). At the two larger reservoirs (Lake Alice and Lake Minitare), carp also had concentrations of selenium above a 2 mg/kg wet weight (ww) human health advisory concentration for no consumption by children and pregnant women (Fan et al, 1988).

An irrigation drainage water quality survey conducted within the Refuge's watershed since this study was performed further indicates that Se may be hazardous to Refuge wildlife (Druliner et al., 1999). The survey was conducted in 1995 and found that concentrations of Se in surface water and fish tissue exceeded toxicity thresholds aimed at protecting wildlife (Druliner et al., 1999). Concentrations of Se in 17 of 19 water samples exceeded the 2 µg/L threshold concentration above which Se has been documented to produce adverse effects in biota through bioaccumulation. In addition, eight of thirteen composite fish samples had concentrations of Se that exceeded the 4.0 µg/g dw level of concern for protection against juvenile mortality and reproductive failure (Lemly, 1996a). Although no fish samples were collected from the Lake Alice site, the only site within the Refuge's border, the Se concentration in a surface water sample equaled 5 µg/L.

Reproductive effects to fish and waterfowl from exposure to Se are well documented by laboratory and field investigations (reviewed by USDOI, 1998). Fish and aquatic birds are the most sensitive animals to Se toxicity and they are most vulnerable at early life stages (Ohlendorf, 2003). Selenium exposure to fish and/or avian species can result in teratogenic defects in developing offspring, decreased hatchability, reduced growth, reproductive failure, and mortality (Lemly, 1996a; USDOI, 1998).

Table 2. Concentrations of elemental contaminants in mg/kg dry weight (dw) and wet weight (ww) for whole-body carp (*Cyprinus carpio)* composite samples from North Platte NWR, Nebraska, 1993.

Trace Element	Lake Alice		Lake Minitare		Winters Creek Lake	
	dw	ww	dw	ww	dw	ww
Aluminum	360	94.4	72.3	20.9	76.8	20.5
Arsenic	0.65	0.17	0.97	0.28 [a]	0.82	0.22
Boron	<1.52	0.4	<1.37	<0.39	<1.48	<0.39
Barium	4.85	1.27	7.02	2.03	9.29	2.48
Beryllium	<0.08	<0.02	<0.07	<0.02	<0.07	<0.02
Cadmium	<0.23	<0.06	<0.2	<0.06	<0.22	<0.06
Chromium	1.48	0.39	1.48	0.43	1.31	0.35
Copper	8.93	1.41 [a]	4.88	1.41 [a]	18.6	4.97 [a]
Iron	222	58.1	179	51.7	181	48.4
Mercury	0.344	0.09	0.197	0.057	0.071	0.019
Magnesium	1122	294	1156	334	1056	282
Manganese	7.21	1.89	8.13	2.35	6.93	1.85
Molybdenum	<1.52	<0.4	<1.37	<0.39	<1.48	<0.39
Nickel	0.73	0.19	0.99	0.29	1.61	0.43
Lead	<1.89	<0.5	<1.71	<0.49	3.42	0.91 [a]
Selenium	11.5 [b]	3.02 [a,c]	7.3 [b]	2.11 [a,c]	5.06 [b]	1.35 [a]
Strontium	93.9	24.6	115	33.3	204	54.4
Vanadium	0.77	0.2	0.63	0.18	0.48	0.13
Zinc	223	58.4 [a]	235	67.9 [a]	160	42.7 [a]

Note: All samples were composites of 4-5 fish, "<" indicates a concentration below the detection limit (value equals the detection limit). Underlined values exceeded benchmark values or known toxicity thresholds as defined below:

a. Above the 85th percentile mg/kg ww concentration for either As (0.27),Cu (1.0), Pb (0.22), Se (0.73), or Zn (34.2) (Schmitt and Brumbaugh, 1990).
b. 4 mg/kg Se dw threshold for reproductive effects in perch and bluegill (USDOI, 1998).
c. Above a 2 mg/kg ww consumption advisory for the protection of human health (USDOI, 1998).

Selenium exposure can decrease Refuge game-fish abundance by causing decreased reproduction or survival. Game fish including bluegill (*Lepomis macrochirus*) and yellow perch (*Perca flavescens*) are stocked for recreational purposes into Winters Creek Lake and Lake Minitare (USFWS, 2001). The estimated Se threshold for reproductive impairment by 10 percent for bluegill and perch is 4 to 6 µg/g dw in fish tissue (USDOI, 1998). Selenium accumulation can be similar between bluegill and carp (Lemly, 1997). Therefore, the results of this study (i.e., all three carp composite samples having concentrations of Se above 4 µg/g dw) indicate that natural reproduction of bluegill and perhaps other game fish species in Lake Minitare and Winters Creek Lake may be impaired by Se. This potential reproductive impairment is less important if game fish abundance for fishing purposes relies on frequent stocking efforts. Selenium exposure in combination with low water temperature also can result in Winter Stress Syndrome (WSS), a condition where reduced feeding and activity results in severe lipid depletion and increased mortality (Lemly, 1993; Lemly 1996b).

Reproductive impairment in avian species also may result from Se exposure at the Refuge. Diets containing 3 to 8 mg/kg Se can result in reproductive impairment (USDOI, 1998), indicating that piscivorous avian species, such as the bald eagle and osprey that feed on the Refuge, may be at risk to Se toxicity. Although Se exposure to waterfowl could not be adequately evaluated from the results of this study, waterfowl can be especially sensitive to Se toxicity. Concentrations of Se in food items for waterfowl (i.e., invertebrates and plants) and in waterfowl eggs need to be determined in future Se assessments on the Refuge. Waterfowl eggs are one of the best biotic matrices for evaluating Se risk to birds and researchers have identified a toxicity threshold of approximately 6 to 10 µg/g dw (Heinz, 1996; USDOI, 1998; Hamilton, 2004). Duck egg concentrations greater than 10 µg/g are associated with a 3.2 percent rate of teratogenesis (Skorupa, 1998) and egg hatchability is an even more sensitive endpoint with an impairment threshold of 6 µg/g dw (Seiler et al., 2003).

Recommendations

Data from this study and more current research by others (Druliner et al., 1999) indicate that Se toxicity from food-chain bioaccumulation may be impairing reproduction of waterfowl and fish on the Refuge. However, a more detailed assessment of Se that includes invertebrate, avian, and plant receptors is needed to further evaluate Se bioaccumulation and potential effects to Refuge wildlife. It is recommended that the Service conduct an aquatic hazard assessment for Se as described by Lemly (1995). This assessment includes measuring concentrations of Se in five ecosystem components (water, sediment, benthic invertebrates, fish eggs, and bird eggs) to incorporate into a hazard assessment model. Risk to waterfowl from Se exposure should be evaluated further by determining Se concentrations in waterfowl plant food items. In addition, concentrations of Se in game fish fillets should be determined to evaluate human health risks.

Conclusions

With the exception of Se, concentrations of OCs and elemental contaminants measured in water, sediment, and fish tissues were below literature established toxicity thresholds and do not appear to be an issue on the Refuge. Although concentrations of Se were generally low in water and sediments, in carp they exceeded literature established toxicity thresholds for the protection of fish and wildlife. High biotic uptake of Se is a concern and important Refuge species that may be adversely affected by Se include game fish, piscivorous avian species, and waterfowl. Information on Se accumulation in plants, invertebrates, fish, and duck eggs is needed to better evaluate Se bioaccumulation and toxicity at the Refuge.

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APPENDIX: RAW DATA TABLES

Table A.1. Samples analyzed for organochlorine contaminants at the North Platte National Wildlife Refuge, 1993.

PACF Catalog	Sample ID	Samle Matrix	Site	Date Collected	Sample mass* (g)	Percent Moisture	Percent Lipid
6050040	NPASM2	Sediments	Lake Alice	7/21/1993	900	19.8	NA
6050040	NPASM3	Sediments	Lake Alice	7/21/1993	900	24.9	NA
6050043	NPASO1	Sediments	Lake Alice	7/21/1993	1800	24.5	NA
6050043	NPASO2	Sediments	Lake Alice	7/21/1993	1800	21.4	NA
6050043	NPASO3	Sediments	Lake Alice	7/21/1993	1800	16.8	NA
6050043	NPMSO1	Sediments	Lake Minitare	7/21/1993	1800	23.6	NA
6050043	NPMSO2	Sediments	Lake Minitare	7/21/1993	1800	19	NA
6050043	NPMSO3	Sediments	Lake Minitare	7/21/1993	1800	23.2	NA
6050043	NPWSO1	Sediments	Winters Creek Lake	7/21/1993	1800	28.3	NA
6050043	NPWSO2	Sediments	Winters Creek Lake	7/21/1993	1800	24.1	NA
6050043	NPWSO3	Sediments	Winters Creek Lake	7/21/1993	1800	16	NA
6050043	NPAWO1	Water	Lake Alice	7/21/1993	930	NA	NA
6050043	NPAWO2	Water	Lake Alice	7/21/1993	930	NA	NA
6050043	NPAWO3	Water	Lake Alice	7/21/1993	950	NA	NA
6050043	NPMWO1	Water	Lake Minitare	7/21/1993	940	NA	NA
6050043	NPMWO2	Water	Lake Minitare	7/21/1993	920	NA	NA
6050043	NPMWO3	Water	Lake Minitare	7/21/1993	910	NA	NA
6050043	NPWWO1	Water	Winters Creek Lake	7/21/1993	950	NA	NA
6050043	NPWWO2	Water	Winters Creek Lake	7/21/1993	930	NA	NA
6050043	NPWWO3	Water	Winters Creek Lake	7/21/1993	940	NA	NA
6050043	NPAFO	Whole Body	Lake Alice	7/27/1993	20276	73.4	7.2
6050043	NPMFO	Whole Body	Lake Minitare	7/27/1993	13672	69.8	9.69
6050043	NPWFO	Whole Body	Winters Creek Lake	7/27/1993	5772	72.2	9.3

Note: Sample mass = mass of the sample analyzed, NA = not applicable, PACF = the Patuxent Analytical Control Facility. The PACF catalog number identifies the original data output which contains additional information on laboratory methods and results.

Table A.2. Samples analyzed for trace element contaminants at the North Platte National Wildlife Refuge, 1992 to 1993.

PACF Catalog	Sample ID	Samle Matrix	Site	Date Collected	Sample Mass* (g)	Percent Moisture
6050029	la-1-s	Sediments	Lake Alice	8/18/1992	877.23	38.1
6050029	la-2-s	Sediments	Lake Alice	8/18/1992	998.47	31.3
6050029	la-3-s	Sediments	Lake Alice	8/18/1992	878.88	28.1
6050029	lm-1-s	Sediments	Lake Minitare	8/18/1992	920.62	30.4
6050029	lm-2-s	Sediments	Lake Minitare	8/18/1992	806.63	23.2
6050029	lm-3-s	Sediments	Lake Minitare	8/18/1992	912.77	31.2
6050029	wc-1-s	Sediments	Winters Creek Lake	8/18/1992	801.46	26.9
6050029	wc-2-s	Sediments	Winters Creek Lake	8/18/1992	1030	28.3
6050029	wc-3-s	Sediments	Winters Creek Lake	8/18/1992	771.36	56.4
6050040	NPASM1	Sediments	Lake Alice	7/21/1993	499.56	33.2
6050040	NPASM2	Sediments	Lake Alice	7/21/1993	389.92	24.5
6050040	NPASM3	Sediments	Lake Alice	7/21/1993	377.42	19.3
6050040	NPMSM1	Sediments	Lake Minitare	7/21/1993	486.45	26.4
6050040	NPMSM2	Sediments	Lake Minitare	7/21/1993	575.82	19.8
6050040	NPMSM3	Sediments	Lake Minitare	7/21/1993	505.74	26.8
6050040	NPWSM1	Sediments	Winters Creek Lake	7/21/1993	492.85	25.4
6050040	NPWSM2	Sediments	Winters Creek Lake	7/21/1993	476.6	27.5
6050040	NPWSM3	Sediments	Winters Creek Lake	7/21/1993	549.91	20
6050040	NPAWM1	Water	Lake Alice	7/21/1993	979.08	NA
6050040	NPAWM2	Water	Lake Alice	7/21/1993	1010	NA
6050040	NPAWM3	Water	Lake Alice	7/21/1993	977.21	NA
6050040	NPMWM1	Water	Lake Minitare	7/21/1993	940.85	NA
6050040	NPMWM2	Water	Lake Minitare	7/21/1993	990.4	NA
6050040	NPMWM3	Water	Lake Minitare	7/21/1993	1010	NA
6050040	NPWWM1	Water	Winters Creek Lake	7/21/1993	1000	NA
6050040	NPWWM2	Water	Winters Creek Lake	7/21/1993	1000	NA
6050040	NPWWM3	Water	Winters Creek Lake	7/21/1993	1020	NA
6050040	NPAFM	Whole Body	Lake Alice	7/27/1993	295.47	73.8
6050040	NPMFM	Whole Body	Lake Minitare	7/27/1993	191.07	71.1
6050040	NPWFM	Whole Body	Winters Creek Lake	7/27/1993	235.1	73.3

Note: Sample mass equals the mass of the sample analyzed, NA = not applicable, PACF = the Patuxent Analytical Control Facility. The PACF catalog number identifies the original data output which contains additional information on laboratory methods and results.

Table A.3. Concentrations of trace elements in water samples collected from North Platte National Wildlife Refuge, Nebraska, 1993.

	Trace Element Concentration in µg/L					
Sample ID	Al	As	B	Ba	Cu	Fe
NPAWM1	612	2	198	67	4	509
NPAWM2	224	2	101	57	<2	182
NPAWM3	224	2	92	56	<2	186
NPMWM1	1660	3	134	97	<2	1190
NPMWM2	700	3	106	76	<2	553
NPMWM3	265	2	111	66	<2	180
NPWWM1	186	2	161	46	<2	116
NPWWM2	156	2	122	50	<2	126
NPWWM3	115	1	117	45	<2	115
	Mg	Mn	Se	Sr	V	Zn
NPAWM1	21400	25	3	505	4	21
NPAWM2	19200	11	<2	464	3	8
NPAWM3	18600	12	<2	453	2	7
NPMWM1	22000	57	<2	539	8	12
NPMWM2	21100	26	<2	510	6	11
NPMWM3	20500	14	<2	513	4	9
NPWWM1	21400	8	<2	471	4	5
NPWWM2	22500	8	<2	493	4	6
NPWWM3	20700	11	<2	459	4	9

Results are from PACF catalog 6050040. Trace elements that were below detection limits in all samples analyzed are not provided in the table. These elements and their minimum detection limits in mg/L include Mo (0.008), Cd (0.001), Be (0.001), Ni (0.002), Cr (0.002), Pb (0.01) and Hg (0.0001).

Table A.4. Concentrations of trace elements in sediment samples collected from North Platte National Wildlife Refuge, Nebraska, 1992 and 1993.

PACF Catalog	Sample ID	Al D.W.	Al W.W.	As D.W.	As W.W.	B D.W.	B W.W.	Ba D.W.	Ba W.W.
		Trace Element Concentration in mg/kg							
6050040	NPASM1	9626	6430	1.18	0.79	9.18	6.13	81.1	54.2
6050040	NPASM2	6874	5190	0.91	0.69	6.83	5.16	59.1	44.6
6050040	NPASM3	5551	4480	0.87	0.7	5.14	4.15	49.8	40.2
6050040	NPMSM1	7459	5490	0.73	0.54	7.84	5.77	78.7	57.9
6050040	NPMSM2	2431	1950	0.64	0.51	3.34	2.68	34.5	27.7
6050040	NPMSM3	8033	5880	0.7	0.51	5.93	4.34	82.2	60.2
6050040	NPWSM1	7775	5800	0.54	0.4	7.9	5.89	86.5	64.5
6050040	NPWSM2	6662	4830	0.59	0.43	4.72	3.42	59.4	43.1
6050040	NPWSM3	1056	845	0.43	0.34	2.25	1.8	20	16
6050043	NPASO1	8650	5940	1.18	0.81	7.53	5.17	80.5	55.3
6050029	la-1-s	8998	5570	9.1	5.63	8.26	5.11	100	62
6050029	la-2-s	7263	4990	1.18	0.81	5.78	3.97	80.1	55
6050029	la-3-s	13519	9720	1.63	1.17	10.9	7.83	124	89.4
6050029	lm-1-s	7945	5530	0.75	0.52	6.77	4.71	107	74.5
6050029	lm-2-s	7357	5650	1.02	0.78	6.2	4.76	89.6	68.8
6050029	lm-3-s	9826	6760	0.93	0.64	7.79	5.36	114	78.1
6050029	wc-1-s	6389	4670	1.15	0.84	6.91	5.05	78.8	57.6
6050029	wc-2-s	3640	2610	0.59	0.42	3.93	2.82	38.2	27.4
6050029	wc-3-s	11124	4850	1.35	0.59	13.6	5.93	128	55.8

PACF Catalog	Sample ID	Be D.W.	Be W.W.	Cr D.W.	Cr W.W.	Cu D.W.	Cu W.W.	Fe D.W.	Fe W.W.
6050040	NPASM1	0.32	0.22	7.34	4.9	5.27	3.52	8039	5370
6050040	NPASM2	0.24	0.18	5.83	4.4	3.47	2.62	6477	4890
6050040	NPASM3	0.21	0.17	6.77	5.46	3.33	2.69	8525	6880
6050040	NPMSM1	0.25	0.18	7.19	5.29	3.97	2.92	8573	6310
6050040	NPMSM2	0.09	0.07	2.93	2.35	1.65	1.32	3591	2880
6050040	NPMSM3	0.28	0.21	6.67	4.88	4.14	3.03	8484	6210
6050040	NPWSM1	0.26	0.19	5.54	4.13	3.87	2.89	7507	5600
6050040	NPWSM2	0.25	0.18	5.1	3.7	3.59	2.6	6772	4910
6050040	NPWSM3	<0.06	<0.05	1.3	1.04	0.85	0.68	2088	1670
6050029	la-1-s	0.31	0.19	5.93	3.67	5.96	3.69	7722	4780
6050029	la-2-s	0.24	0.16	5.24	3.6	4.37	3	7016	4820
6050029	la-3-s	0.45	0.32	8.65	6.22	8.73	6.28	10376	7460
6050029	lm-1-s	0.27	0.19	6.12	4.26	5.98	4.16	8865	6170
6050029	lm-2-s	0.22	0.17	5.42	4.16	4.45	3.42	7591	5830
6050029	lm-3-s	0.3	0.21	5.87	4.04	5.2	3.58	8023	5520
6050029	wc-1-s	0.2	0.14	5.46	3.99	3.53	2.58	7633	5580
6050029	wc-2-s	0.12	0.08	4.37	3.13	2.16	1.55	6304	4520
6050029	wc-3-s	0.34	0.15	7.61	3.32	6.49	2.83	10688	4660

Table A.4. Continued

PACF Catalog	Sample ID	Mg D.W.	Mg W.W.	Mn D.W.	Mn W.W.	Ni D.W.	Ni W.W.	Pb D.W.	Pb W.W.
		Trace Element Concentration in mg/kg							
6050040	NPASM1	3174	2120	111	74.1	4.72	3.15	4.21	2.81
6050040	NPASM2	2291	1730	109	82.2	3.44	2.6	3.71	2.8
6050040	NPASM3	1958	1580	98.6	79.6	3.4	2.74	4.52	3.65
6050040	NPMSM1	2255	1660	101	74.2	3.11	2.29	3.56	2.62
6050040	NPMSM2	736	590	34	27.3	1.52	1.22	1.86	1.49
6050040	NPMSM3	2787	2040	104	76.4	4.03	2.95	4.02	2.94
6050040	NPWSM1	3123	2330	90.9	67.8	2.92	2.18	2.75	2.05
6050040	NPWSM2	2607	1890	79	57.3	2.92	2.12	2.99	2.17
6050040	NPWSM3	395	316	20.8	16.6	0.74	0.59	<1.53	1.22
6050029	la-1-s	3328	2060	151	93.6	4.67	2.89	4.75	2.94
6050029	la-2-s	2547	1750	110	75.6	3.71	2.55	3.6	2.47
6050029	la-3-s	4604	3310	175	126	6.97	5.01	5.58	4.01
6050029	lm-1-s	2902	2020	111	77.3	4.22	2.94	4.45	3.1
6050029	lm-2-s	2513	1930	101	77.4	3.75	2.88	4.08	3.13
6050029	lm-3-s	3270	2250	118	81	4.01	2.76	3.72	2.56
6050029	wc-1-s	3037	2220	91	66.5	3.04	2.22	3.46	2.53
6050029	wc-2-s	1757	1260	67.8	48.6	2.05	1.47	2.2	1.58
6050029	wc-3-s	5000	2180	148	64.7	4.86	2.12	5.37	2.34

PACF Catalog	Sample ID	Se D.W.	Se W.W.	Sr D.W.	Sr W.W.	V D.W.	V W.W.	Zn D.W.	Zn W.W.
6050040	NPASM1	0.4	0.27	46.9	31.3	23.2	15.5	20.1	13.4
6050040	NPASM2	<0.26	<0.2	40.4	30.5	18.8	14.2	15.6	11.8
6050040	NPASM3	<0.25	<0.2	28	22.6	28.1	22.7	17.5	14.1
6050040	NPMSM1	<0.27	<0.2	36.4	26.8	28.3	20.8	19.7	14.5
6050040	NPMSM2	<0.25	<0.2	12.7	10.2	10.8	8.65	7.99	6.41
6050040	NPMSM3	<0.27	<0.2	36.5	26.7	24.6	18	19.5	14.3
6050040	NPWSM1	<0.27	<0.2	58.6	43.7	18.8	14	17.7	13.2
6050040	NPWSM2	<0.28	<0.2	35.7	25.9	16.1	11.7	16.4	11.9
6050040	NPWSM3	<0.25	<0.2	7.61	6.09	4.1	3.28	3.51	2.81
6050029	la-1-s	0.52	0.32	57.2	35.4	26.2	16.2	20.4	12.6
6050029	la-2-s	< 0.290	<0.2	44.4	30.5	24.8	17	16.9	11.6
6050029	la-3-s	0.56	0.4	77	55.4	36.4	26.2	29.1	20.9
6050029	lm-1-s	0.29	0.2	51.3	35.7	31.2	21.7	22.4	15.6
6050029	lm-2-s	0.61	0.47	45.7	35.1	29.3	22.5	18.6	14.3
6050029	lm-3-s	< 0.290	<0.2	46.2	31.8	26	17.9	19.8	13.6
6050029	wc-1-s	0.34	0.25	59.9	43.8	30	21.9	18.3	13.4
6050029	wc-2-s	< 0.280	<0.2	28.7	20.6	27.9	20	12.7	9.08
6050029	wc-3-s	0.57	0.25	140	61.1	37.6	16.4	27.8	12.1

Note: D.W. = dry weight, W.W. = wet weight. PACF = the Patuxent Analytical Control Facility. The PACF catalog number identifies the original data output which contains additional information on laboratory methods and results. Trace elements that were below detection limits in all samples analyzed are not provided in the table. These elements and their minimum detection limits in mg/kg wet weight include Cd (0.14), Hg (0.01), and Mo (0.94).

Table A.5. Concentrations of trace elements in whole-body River Carp Sucker (*Carpiodes carpio*) samples from North Platte National Wildlife Refuge, Nebraska, 1993.

	Trace Element Concentration in mg/kg dry weight (D.W.) and wet weight (W.W.)									
	Al		As		Ba		Cr		Cu	
Sample ID	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.
NPAFM	360	94.4	0.65	0.17	4.85	1.27	1.48	0.39	8.93	2.34
NPMFM	72.3	20.9	0.97	0.28	7.02	2.03	1.48	0.43	4.88	1.41
NPWFM	76.8	20.5	0.82	0.22	9.29	2.48	1.31	0.35	18.6	4.97

	Fe		Hg		Mg		Mn		Ni	
Sample ID	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.
NPAFM	222	58.1	0.344	0.09	1122	294	7.21	1.89	0.73	0.19
NPMFM	179	51.7	0.197	0.057	1156	334	8.13	2.35	0.99	0.29
NPWFM	181	48.4	0.071	0.019	1056	282	6.93	1.85	1.61	0.43

	Pb		Se		Sr		V		Zn	
Sample ID	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.	D.W.	W.W.
NPAFM	<1.89	0.5	11.5	3.02	93.9	24.6	0.77	0.2	223	58.4
NPMFM	<1.71	0.49	7.3	2.11	115	33.3	0.63	0.18	235	67.9
NPWFM	3.42	0.91	5.06	1.35	204	54.4	0.48	0.13	160	42.7

Results are from PACF catalog 6050040. Trace elements that were below detection limits in all samples analyzed are not provided in the table. These elements and their minimum detection limits in mg/kg wet weight include B (0.04), Mo (0.04), Be (0.02), and Cd (0.06).