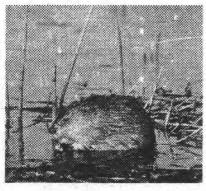
Canada Alberta Northwest Territories

Northern River Basins Study



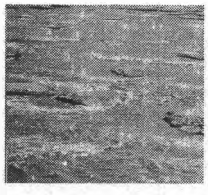


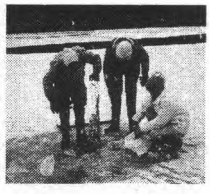





NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 64

ENVIRONMENTAL CONTAMINANTS IN MUSKRATS AND CANVASBACKS, PEACE-ATHABASCA DELTA, 1992






Prepared for the
Northern River Basins Study
under Project 2391-C1

by

Mark Wayland
Canadian Wildlife Service

Community Contributors:

Fort Chipewyan

Mr. D. Marcel
Mr. G. Marcel
Mr. E. Trip de Roche

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PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of particular work conducted as part of the Northern River Basins Study. As such, the work was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

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Whereas the above publication is the result of a project conducted under the Northern River Basins Study and the terms of reference for that project are deemed to be fulfilled,
IT IS THEREFORE REQUESTED BY THE STUDY OFFICE THAT;
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F. P. Wrona — 10 Jan 96
(Dr. Fred J. Wrona, Science Director) (Date)

Whereas it is an explicit term of reference of the Science Advisory Committee "to review, for scientific content, material for publication by the Board",
IT IS HERE ADVISED BY THE SCIENCE ADVISORY COMMITTEE THAT;
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SUPPLEMENTAL COMMENTARY HAS BEEN ADDED TO THIS PUBLICATION: [ ] Yes [✓] No

P. A. Larkin — Jan 7/96
(Dr. P. A. Larkin, Ph.D., Chair) (Date)

Whereas the Study Board is satisfied that this publication has been reviewed for scientific content and for immediate health implications,
IT IS HERE APPROVED BY THE BOARD OF DIRECTORS THAT;
this publication be released to the public, and that this publication be designated for: **[✓] STANDARD AVAILABILITY [ ] EXPANDED AVAILABILITY**

Lucille Partington — Jan. 11/96
(Lucille Partington, Co-chair) (Date)

Robert McLeod — 11/01/96
(Robert McLeod, Co-chair) (Date)

ENVIRONMENTAL CONTAMINANTS IN MUSKRATS AND CANVASBACKS, PEACE-ATHABASCA DELTA, 1992

STUDY PERSPECTIVE

In recent years, considerable concern has been expressed about the potential harmful effects of industrial and municipal discharges into the aquatic ecosystems of the northern river basins. Evaluating wildlife for exposure to contaminants originating from these sources in the Peace, Athabasca and Slave River systems has been identified as one of the objectives of the Northern River Basins Study. The Peace-Athabasca Delta is a rich, diverse ecosystem within the study area, and the local people rely extensively on its natural resources. The potential for contamination of these natural resources from industrial and municipal sources originating upstream has become a growing concern. This study examines contaminant levels in two species of wildlife that are important to the inhabitants of the Peace-Athabasca Delta, the muskrat and the canvasback duck, both of which are common to the delta environment.

Related Study Questions

4a) *What are the contents and nature of the contaminants entering the system and what are their distribution and toxicity in the aquatic ecosystem with particular reference to water, sediment and biota?*

11) *Have the riparian vegetation and riparian wildlife in the river basins been affected by exposure to organochlorines or other toxic compounds?*

14) *What long term monitoring programs and predictive models are required to provide an ongoing assessment of the state of the aquatic ecosystems? These programs must ensure that all stakeholders have the opportunity for input.*

The objective of this study was to examine contaminant burdens in juvenile (young-of-the-year) muskrats and canvasbacks collected on the Chipewyan Reserve in 1992. Contaminant residue analyses were performed for dioxins/furans, polyaromatic hydrocarbons (PAHs), organochlorine pesticides, PCBs, chlorophenolics and metals.

Laboratory analyses were performed on the adipose (fat) tissue of 12 muskrats (six male and six female), and on liver tissue of six canvasbacks (three male and three female). The muskrats were collected from Killer's Lake and Big Johnny Lake, two perched basins. Canvasbacks were collected from Flour Bay and Goose Island near the mouth of the Athabasca River and its distributary channels. Overall, levels of contaminants were at very low concentrations, or not detected at all. Although the concentrations were low, there was evidence of bleached kraft mill compounds (2,3,7,8-tetrachlorodibenzofuran, 2,3,4,7,8-pentachlorodibenzofuran, and tetra- and trichloroguaiacol) in as many as 67% of the canvasbacks that were sampled. Residues of dioxins and furans were slightly higher and detected with greater frequency in canvasbacks than muskrats. This difference suggests higher contaminant levels in Flour Bay than the perched basins, but may be explained in part by other species specific differences such as diet. Organochlorine pesticides and PCBs, known for their global distributions, were not detected in canvasbacks and were found in only one of the 12 muskrats. Most contaminants were lower in muskrats and canvasbacks from the Delta than in other North American locations. Exceptions to this rule included mercury, chromium and copper. The concentrations of these metals in Peace-Athabasca Delta canvasbacks were equal to or greater than levels in canvasbacks from other locations.

In this study, the small sample sizes and use of juvenile animals allows some interpretation of the local contaminant inputs, but does not provide information regarding the general contaminant burden and cumulative effects on the resource. Nonetheless, most of the contaminant levels in canvasbacks and muskrats from the Peace-Athabasca Delta were well below those normally associated with toxicity in these species. The results contained in this report should ease concerns regarding contaminants in muskrats occupying similar perched basin habitats in the delta. Health Canada evaluated these data and concluded that consumption of these muskrats and canvasbacks would not pose a hazard to humans.

REPORT SUMMARY

The Peace-Athabasca Delta is a rich, diverse ecosystem within the Peace and Athabasca River basins. Its inhabitants rely extensively on its natural resources. The potential for contamination of these resources from industrial and municipal sources located upstream has been one of their important concerns. This study examines pollutant burdens in two species of wildlife that are important to inhabitants of the Peace-Athabasca Delta: the fur-bearing muskrat and the canvasback duck. Juvenile (hatch-year) canvasbacks were collected from Flour Bay and near Goose Island, portions of the Athabasca Delta that can be expected to receive sediments from the Athabasca River on a regular basis. Juvenile muskrats were collected from Big Johnny Lake and Killer's Lake, two perched basins that probably receive sediments from the Athabasca River only during major floods.

Overall, contaminants, including dioxins and furans, chlorinated phenolics, polycyclic aromatic hydrocarbons, organochlorine pesticides, PCBs and heavy metals were detected infrequently and at very low concentrations in both species. There was evidence of bleached kraft mill contaminants (2,3,7,8-TCDF, 2,3,4,7,8-PeCDF, and tetra- and trichloroguaiacol) in up to 67% of the canvasbacks that were sampled, although the concentrations were low. Residues of dioxins and furans were slightly higher and detected with greater frequency in canvasbacks than in muskrats, suggesting that the Flour Bay area is slightly more polluted by these contaminants than Big Johnny Lake and Killer's Lake. However, other possible explanations, including the slightly more carnivorous nature of canvasbacks cannot be discounted when attempting to explain these differences. Organochlorine pesticides and PCBs, known for their global distributions, were not detected in canvasbacks and were detected in only one of 12 muskrats. The absence of organochlorine pesticides and PCBs coupled with the presence of dioxins/furans and chlorinated phenolics in the canvasbacks suggests that the latter originated locally within the watershed and were not the result of atmospheric transport. When compared to other North American locales, most contaminants were lower in muskrats and canvasbacks from the Peace-Athabasca Delta than in similar species elsewhere. Exceptions to this rule included mercury, chromium and copper. In Peace-Athabasca Delta canvasbacks, concentrations of these metals were equal to or greater than those in their counterparts from other locales.

In this study, the sole use of juvenile animals integrates the consequences of local contaminant inputs but does not provide information regarding the general contaminant burden in the resource. Moreover, the locations of the muskrat collections preclude definitive conclusions about general contaminant inputs in the watershed because they were sampled in basins that do not regularly receive sediment inputs from the Athabasca River. If most trapping occurs in similar areas, this report should allay concerns regarding contaminants in muskrats occupying similar habitat in the Peace-Athabasca Delta. It is probable that the concentrations of contaminants in canvasbacks and muskrats from the Peace-Athabasca delta are toxicologically irrelevant. However, this speculation is based on inadequate toxicological data. Health Canada evaluated the data and concluded that consumption of these muskrats and canvasbacks would not pose a hazard to human beings.

ACKNOWLEDGEMENTS

The following individuals assisted with the collections of waterfowl and muskrats: Mr. J. Green, Mr. D. Marcel, Mr. G. Marcel, Mr. E. Trip de Roche, and Mr. G. Wagner. Mr. J. Green and Mr. G. Wagner were especially helpful in coordinating the field collections. P. Pryor (Canadian Wildlife Service) sexed and aged the waterfowl. B. Treichel (Alberta Fish and Wildlife Division) sexed and aged the muskrats. Tissues were prepared by Enviro-Test Laboratories. Residue analyses were done by Chemex Labs Alberta (metals), Enviro-Test Laboratories (dioxins and furans) and Zenon Environmental Laboratories (chlorophenols, PAHs, PCBs and organochlorines).

B. Brownlee, R. Chabaylo and an anonymous reviewer provided helpful comments on earlier drafts of this report.

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1.0 INTRODUCTION

The Northern River Basins Study was initiated in response to concerns about municipal and industrial developments within the Peace and Athabasca River systems, especially pulp mills, oil sands projects and municipal effluents. That study formulated 16 questions, including three that specifically refer to assessing contaminant levels in aquatic biota and fish. Question 1a asks "How has the aquatic ecosystem including fish and other aquatic organisms been affected by exposure to organochlorines or other toxic compounds?". Because many species of wildlife rely on aquatic organisms for their food, they too must be considered aquatic. Question 4a asks "Describe the contents and nature of the contaminants entering the system and describe their distribution and toxicity in the aquatic ecosystem with particular reference to water, sediments and biota?". Because wildlife feed on many aquatic organisms, they must be considered as part of that ecosystem. Finally, question 11 asks "Have the riparian vegetation, riparian wildlife and domestic livestock in the river basins been affected by exposure to organochlorines or other toxic compounds?"

With these questions in mind, an important aspect of the NRBS is to focus on natural resources that are of interest to the primary resource users in the basin. The Peace-Athabasca Delta is a rich, diverse natural ecosystem within the northern river basins and its inhabitants rely extensively on its natural resources for subsistence hunting as well as for economic and social purposes. Waterfowl have traditionally been hunted by the delta's inhabitants while muskrats (*Ondatra zibethicus*) have been trapped and their furs sold to supplement incomes (Peace-Athabasca Delta Project Technical Report 1973). The potential for contamination of the delta's natural resources from industrial and municipal sources that are located upstream has been an important concern for Delta inhabitants. To address these concerns, the NRBS developed a study to examine pollutant concentrations in several components of the Delta ecosystem, including sediments, vegetation, fish, muskrats and waterfowl. This report focuses on muskrat and canvasback (*Aythya valisineria*). The latter is a species of waterfowl that is common on the Peace-Athabasca Delta (Nieman and Dirschl 1973).

Muskrats are marsh dwellers that eat primarily emergent aquatic macrophytes including cattail (*Typha* spp.) and other succulent emergents (Lacki *et al.* 1990), although they occasionally eat clams (Hanson *et al.* 1989). Canvasbacks also live in marshes and are primarily vegetarians, consuming sago pondweed (*Potamogeton pectinatus*) and other submersed aquatic plants (Bartonek and Hickey 1969, Bergman 1973). However, aquatic invertebrates, particularly caddisflies (Trichoptera), predominate in the diets of ducklings less than 40 days old and of breeding females in the weeks before and during egg-laying (Bartonek and Hickey 1969, Jarvis and Noyes 1986).

This study examines pollutant burdens in juvenile (young-of-the-year) muskrat and canvasback collected on the Chipewyan Reserve portion of the Peace-Athabasca Delta in 1992. In addition, Health Canada evaluated the safety of these samples for human consumption.

2.0 METHODS

2.1 Muskrats

Muskrats were trapped on two lakes on the Chipewyan Reserve No. 201 during December 5-8, 1992. Twenty muskrats were collected from Big Johnny Lake and ten were collected from adjacent Killer's Lake (Figure 1). Muskrats were frozen and shipped to NRBS facilities in Edmonton on Dec. 9, 1992. Details of the muskrat collection are provided in Green (1993). Subsequently, muskrats were sexed, aged (juvenile or adult) and weighed. For each specimen, adipose (fat) tissue from under the skin and around the abdomen was separated from skin and organs and placed in contaminant-free aluminum foil. The adipose tissue was thoroughly homogenized and three aliquots were then weighed. Aliquots were then refrozen and sent to the appropriate contract laboratories for contaminants analyses. Details of muskrat tissue preparations are provided by Enviro-Test Laboratories (1993*a*).

Adipose tissue from 12 juvenile muskrats, selected from the 25 that were collected, was analyzed for dioxins and furans, organochlorines and PCBs, chlorophenols, polycyclic aromatic hydrocarbons (PAHs) and heavy metals. Ten of the 12 muskrats were from Big Johny Lake, the other two were from Killer's Lake.

2.2 Canvasbacks

Between August 25-27, 1992, 18 juvenile canvasbacks were collected from the Chipewyan Reserve No. 201; 14 from a water body known as Flour Bay on the edge of Lake Athabasca and four from Goose Island (Figure 1). Samples were frozen in contaminant-free plastic bags within 12 hours of collection. They were then shipped to Edmonton where individuals were aged, sexed and weighed. Livers were dissected out, homogenized and separated into three aliquots per specimen. Details of tissue preparation are provided by Enviro-Test Laboratories (1993*a*). Liver tissues from six juvenile canvasbacks collected on Flour Bay (three male and three female) were then selected for contaminant analyses (dioxins and furans, organochlorines and PCBs, chlorophenols, PAHs and heavy metals).

2.3 Residue Analysis

2.3.1 Dioxins and Furans

Dioxins and furans were analyzed at Enviro-Test Laboratories. Tissues samples were fortified with $^{13}C_{12}$-surrogates and then Soxhlet extracted with dichloromethane/hexane (1:1). Sample cleanup consisted of extraction with concentrated sulphuric acid and multisilica followed by Florisil column chromatography, basic alumina chromatography and carbon column chromatography. The sample extracts were then analyzed using high resolution mass spectrometry/gas chromatography. Quality control guidelines as specified by Environment Canada (1989 and 1992) were followed. All samples were fortified with ^{13}C-labelled surrogates prior to analysis. A laboratory method blank and glassware proof were generated for each batch analyzed. Linearity of the mass spectrometer response was tested by analyzing five calibration solutions and noting the relative response factors for all native and

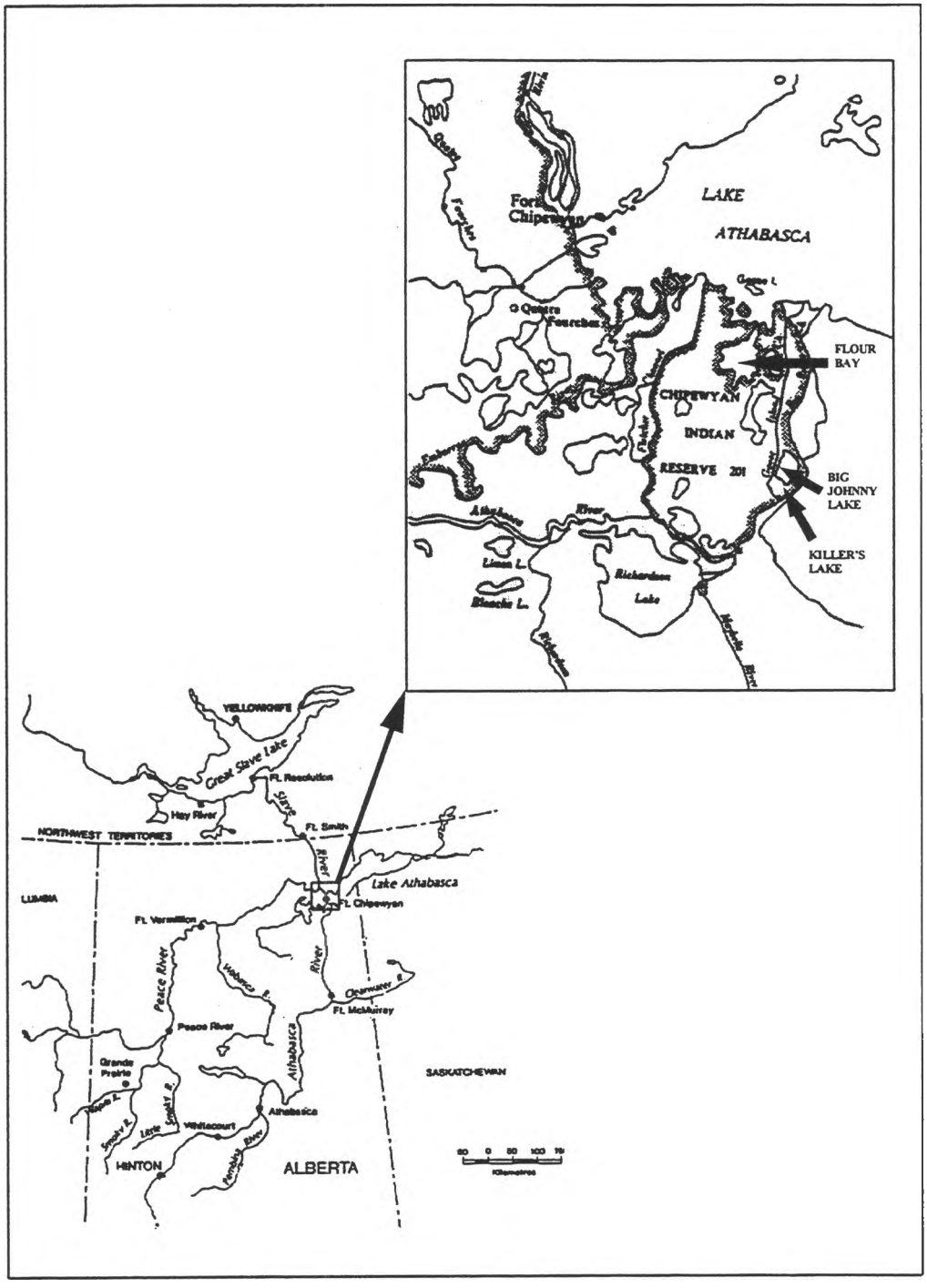

Fig. 1. Location of the Peace -Athabasca Delta and sampling locations within the Delta.

surrogate dioxins and furans. An average response factor was used when the relative response factor for any compound was constant over the five point range. Otherwise, a complete calibration curve for that compound was used over the five point range. Quantification of dioxins and furans followed procedures outlined by U.S. EPA Method 1613 (1990) and Environment Canada (1992). Further analytical details are provided by Enviro-Test Laboratories (1993*b*).

2.3.2 Polyaromatic hydrocarbons

Polyaromatic hydrocarbons (PAHs) were analyzed by Zenon Environmental Laboratories. Briefly, PAHs were liberated from the tissue by placing a subsample of the tissue homogenate in a boiling flask with ethanol, potassium hydroxide and boiling chips for two hours. The material was extracted three times with hexane. The hexane extracts were then washed four times with hot water and the washings were discarded. The hexane extract was dried through sodium sulphate and cleaned up on silica gel and concentrated to 1mL using a rotary evaporator prior to PAH analysis by gas chromatography/mass spectrometry (GC/MS) using selected ion monitoring.

2.3.3 Organochlorine Pesticides and Polychlorinated Biphenyls

Samples were ground with sodium sulphate and Soxhlet-extracted with dichloromethane. The extract was cleaned up using Florisil. Florisil column fractionation divided the extract into three fractions. Each fraction was concentrated to 1 mL using a rotary evaporator. Each extract was then analyzed using capillary gas chromatography/electron capture detection. Standard solutions of PCB congeners from the National Research Council in Halifax were run on a DB-5 capillary column to establish retention times and response factors for the PCB congeners. For the quantification and calibration of toxaphene, a US EPA reference standard and the eight most prominent toxaphene peaks were used.

For analysis of co-planar PCBs (#'s 77, 126, 169), samples were spiked with $^{13}C_{12}$ surrogates prior to Soxhlet extraction with dichloromethane. The lipid in the extracts was removed by gel permeation chromatography. Final cleanup was done using 2% deactivated Florisil. Co-planar PCBs were separated from other PCBs on carbon. The sample was redissolved in toluene containing the internal standard D10 anthracene. Low resolution gas chromatography/mass spectrometry was used for detection of co-planar PCBs. Results for each compound were corrected for surrogate recovery of radiolabelled PCB 77.

2.3.4 Chlorophenolic Compounds

Tissues were ground with sodium sulphate and Soxhlet-extracted with dichloromethane. The extract was back extracted into an aqueous potassium carbonate solution to isolate the phenolics, and acetylated with acetic anhydride in hexane using dimethylaminopyridine to catalyze the reaction. Ascorbic acid was also added to prevent oxidation of the catechols. The hexane extract was then reduced in volume to 0.5 mL prior to analysis by gas chromatography/mass spectrometry using selected ion monitoring. A set of eight radiolabelled surrogates was used to determine the recovery of the acidic compounds.

The extract remaining after potassium carbonate extraction, which contains the anisoles and veratroles, was cleaned up by passage through Florisil deactivated with 1% water. The solvent is exchanged to hexane, concentrated to 0.5 mL and analyzed by gas chromatography/mass spectrometry using selected ion monitoring. Two surrogates were used to track the recoveries of the neutral compounds.

2.3.5 Trace Metals

For analysis of cadmium, chromium, copper, vanadium amd zinc, tissue samples were dried, ground and extracted twice with concentrated nitric acid. The sample was then subjected to a hydrogen peroxide reaction. Deoinized water was added to the sample and this solution was heated at low temperature for 30 minutes. The solution was filtered through a Whatman No. 41 filter to remove particulates. The filtrate was then analyzed for metals using an inductively coupled plasma (ICP). Tissue digestion was done as described above for analysis of lead. However, the analysis was done using graphite furnace atomic absorption spectrometry. For analysis of arsenic, tissue samples were manually digested with sulphuric and nitric acid. Using an automated system, inorganic arsenic was then reduced to its hydride. The gaseous hydride was then analyzed using atomic absorption spectrometry. For analysis of total mercury, tissue homogenates were digested with a 2:1 solution of H_2SO_4:HNO_3 mixture and oxidized with potassium permanganate. This mixture was treated with alkaline stannous hydroxylamine reducing solution and analyzed using cold vapour atomic absorption spectrometry at 253.7 nm. For analysis of inorganic mercury, tissue homogenates were digested with solutions consisting of 20% sodium chloride, 1% cyteine and 16N sulphuric acid for two hours and allowed to cool to room temperature. The digested solution was treated with strongly alkaline stannous hydroxylamine reducing solution. The elemental mercury was then analyzed by cold vapour atomic absorption spectrometry and compared to identically prepared standards. Methyl mercury was calculated from the difference between total mercury and inorganic mercury.

For analysis of all metals, standard reference material was used to determine percent recovery. Recoveries ranged from 59-110%, depending on the metal. Duplicate analyses indicated reasonable repeatability.

3.0 RESULTS

3.1 Weights and Lipids

3.1.1 Muskrats

Twelve juvenile (young-of-the-year) muskrats were analyzed for contaminants. There were six animals of each sex. Males ranged in weight from 701-924 g (mean = 818) and females from 608-937 g (mean = 754; Table 1). Lipid content of the muskrat adipose tissue that was analyzed for contaminants ranged from 15-47% (mean = 30%; Table 2).

Table 1. Fresh weights (g) of animals collected from the Peace-Athabasca Delta according to species and sex.

SPECIES	SEX	N	MEAN	1SD	MIN	MAX
Muskrat	F	6	754	±106	608	937
	M	6	818	±92	701	924
	Combined	12	786	±100	608	937
Canvasback	F	3	774	±72	696	837
	M	3	997	±56	956	1060
	Combined	6	885	±135	696	1060

Table 2. Percent lipids in homogenates of adipose tissue from muskrats (n=12) and canvasback livers (n=6) used in contaminants analyses.

SPECIES	MEAN	±1SD	MIN	MAX
Muskrat	30.1	±9.7	14.8	47.3
Canvasback	28.8	±3.1	25.0	32.3

3.1.2 Canvasbacks

Six juvenile (young-of-the-year) canvasbacks (three male and three female) were analyzed for contaminants. Males ranged from 956-1060 g (mean = 997) while females ranged from 696-837 g (mean = 774; Table 1). The lipid content of their livers averaged 29% (range 25-32%; Table 2).

3.2 Dioxins and Furans

3.2.1 Muskrats

Dioxins were detected in only one of the 12 muskrats. It contained 2,7/2,8-dichlorodibenzo-p-dioxin at 1.6 pg/g and 2,3-dichlorodibenzo-p-dioxin at 26 pg/g (Table 3). Other dioxins and furans were not detected in muskrat adipose tissue. Lipid-adjusted dioxin toxic equivalents (TEQs) were below detection limits in all samples (Table 4).

3.2.2 Canvasbacks

Three dioxin/furan isomers were detected in four of the six canvasback livers. 1,2,3,7,8-pentachlorodibenzo-p-dioxin (PeCDD), 2,3,7,8-tetrachlorodibenzofuran (TCDF) and 2,3,4,7,8-

pentachlorodibenzofuran (PeCDF) were detected in concentrations ranging from < 0.2-1.4 pg/g (Table 5). 2,3,7,8-TCDF was detected in four of six canvasback livers, making it the most common dioxin/furan detected (Table 4) and suggesting a bleached kraft mill source. Lipid-adjusted TEQs averaged 2.6 pg/g (range, ND - 3.9) in canvasback livers (Table 4).

Table 3. Concentrations (pg/g, wet wt) of dioxins and furans in adipose tissue of muskrats (n=12) collected at the Peace-Athabasca Delta, 1992.

Parameter	Detection Limit	% Detected	Min	Max
2,7/2,8 DiCDD	1.6±0.3	8	<0.4	1.6
2,3 DiCDD	1.5±0.3	8	<0.4	26.0

NOTE: Residues were below detection limits for the following compounds: 2,3,7 TriCDD (DL=1.1), 2,3,7,8 TCDD (DL=0.6), 1,2,3,7,8 PeCDD (DL=0.6), 1,2,3,4,7,8 HxCDD (DL=1.7), 1,2,3,6,7,8 HxCDD (DL=1.5), 1,2,3,7,8,9 HxCDD (DL=1.6), 1,2,3,4,6,7,8 HpCDD (DL=3.4), OCDD (DL=8.9), 2,8 DiCDF (DL=1.2), 2,3,8 TriCDF (DL=0.7), 2,3,7,8 TCDF (DL=0.6), 1,2,3,7,8 PeCDF (DL=0.5), 2,3,4,7,8 PeCDF (DL=0.6), 1,2,3,4,7,8 HxCDF (DL=1.1), 1,2,3,6,7,8 HxCDF (DL=1.1), 1,2,3,6,7,8 HxCDF (DL=1.0), 2,3,4,6,7,8 HxCDF (DL=1.3), 1,2,3,7,8,9 HxCDF (DL=1.6), 1,2,3,4,6,7,8 HpCDF (DL=1.9), 1,2,3,4,7,8,9 HpCDF (DL=4.0), OCDF (DL=6.8), where DL=average Detection Limit (pg/g).

Table 4. Comparison of lipid-adjusted dioxin Toxic Equivalents (TEQs) (pg/g) in muskrat adipose tissue and canvasback livers from the Peace-Athabasca Delta, 1992.

Species	Median	Mean[a]	±1SD[a]	Min	Max
Muskrat	ND	ND	----	ND	ND
Canvasback	2.4	2.6	0.8	ND	3.9

[a] - Means and standard deviations calculated only when ≥ 50% of the animals had detectable levels. For such calculations, concentrations below the detection limit were assigned a value of 0.5 X Detection Limit.

Male canvasbacks appeared to have lower levels of dioxins and furans than females, although sample sizes were too low for meaningful statistical analysis. On a wet weight basis, TEQs averaged 0.53±0.1 pg/g (mean±1SD) in males and 0.99±0.20 in females. The same trend was evident for lipid-adjusted TEQs; males, 2.00±0.25 and females, 3.18±0.69 pg/g, (mean±1SD).

Dioxins and furans were detected with significantly greater frequency in canvasback livers than in muskrat adipose tissue (*G*-test of independence: $P < 0.01$, Table 6).

Table 5. Concentrations (pg/g, wet wt) of dioxins and furans in canvasback livers (n=6) collected at the Peace-Athabasca Delta, 1992.

Parameter	Detection Limit	% Detected	Mean[a]	±1SD[a]	Min	Max
1,2,3,7,8 PeCDD	0.2±0.0	17	----	----	<0.2	0.5
2,3,7,8 TCDF	0.3±0.0	67	0.3	0.2	<0.2	0.6
2,3,4,7,8 PeCDF	0.4±0.1	50	0.7	0.5	<0.3	1.4

[a] - Means and standard deviations calculated only when ≥ 50% of the animals had detectable levels. For such calculations, concentrations below the detection limit were assigned a value of 0.5 X Detection Limit.
NOTE: Residues were below detection limits in all samples for the following compounds: 2,7/2,8 DiCDD (DL=2.1), 2,3 DiCDD (DL=2.1), 2,3,7 TriCDD (DL=0.8), 2,3,7,8 TCDD (DL=0.3), 1,2,3,4,7,8 HxCDD (DL=0.7), 1,2,3,6,7,8 HxCDD (DL=0.6), 1,2,3,7,8,9 HxCDD (DL=0.7), 1,2,3,4,6,7,8 HpCDD (DL=1.1), OCDD (DL=3.2), 2,8 DiCDF (DL=1.3), 2,3,8 TriCDF (DL=0.8), 1,2,3,7,8 PeCDF (DL=0.2), 1,2,3,4,7,8 HxCDF (DL=0.4), 1,2,3,6,7,8 HxCDF (DL=0.4), 2,3,4,6,7,8 HxCDF (DL=0.5), 1,2,3,7,8,9 HxCDF (DL=0.6), 1,2,3,4,6,7,8 HpCDF (DL=0.7), 1,2,3,4,7,8,9 HpCDF (DL=1.1), OCDF (DL=1.6), where DL=average detection limit for the samples (pg/g).

Table 6. Comparison of frequency of detectable concentrations of all dioxin and furan congeners in muskrat adipose tissue and canvasback livers from the Peace-Athabasca Delta, 1992.

Species	Number of Detections	Number of Non-Detections	Subtotal
Muskrat	2	262	264
Canvasback	7	125	132
Subtotal	9	387	396
G_{adj}=7.21, 1*df*, *P*<0.01			

3.3 Chlorophenolics

3.3.1 Muskrats

Chlorophenolics were detected in adipose tissue of four of the 12 muskrats that were analyzed. Data are presented for 38 chlorophenolic compounds, five of which were detected in muskrat adipose tissue. 2,4,6-trichlorophenol was detected in three of the 12 animals (maximum concentration: 0.0009 µg/g), while pentachlorophenol, 2,3,6-trichlorophenol, tetrachloroguaiacol and 3,4,5-trichlorocatechol were detected in one sample each (Table 7). The maximum concentrations detected were 0.0042 µg/g pentachlorophenol and 0.0042 µg/g 2,3,6-trichlorophenol (Table 7).

Table 7. Concentrations of chlorinated phenolics (µg/g, wet wt) in adipose tissue of muskrats (n=12) collected at the Peace-Athabasca Delta, 1992.

Parameter	Detection Limit	% Detected	Min	Max
Pentachlorophenol	0.0002	8	<0.0002	0.0042
2,3,6 Trichlorophenol	0.0002	8	<0.0002	0.0042
2,4,6 Trichlorophenol	0.0002	25	<0.0002	0.0009
Tetrachloroguaiacol	0.0004	8	<0.0004	0.0005
3,4,5 Trichlorocatechol	0.0004	8	<0.0004	0.0012

NOTE: Tissue residues were below detection limits (0.0002 - 0.0004 µg/g) in all samples for the following compounds: 2,3,4,6+2,3,5,6 tetrachlorophenol, 2,3,4,5 tetrachlorophenol, 2,3,4 trichlorophenol, 2,3,5 trichlorophenol, 2,4,5 trichlorophenol, 2,4 dichlorophenol, 2,6 dichlorophenol, 3,4,5 trichloroguaiacol, 3,4,6 trichloroguaiacol, 4,5,6 trichloroguaiacol, 4,5 dichloroguaiacol, 4,6 dichloroguaiacol, 4 chloroguaiacol, tetrachlorocatechol, 3,4 dichlorocatechol, 3,5 dichlorocatechol, 4,5 dichlorocatechol, 4 chlorocatechol, tetrachloroveratrole, 3,4,5 trichloroveratrole, 3,4,5 trichlorosyringol, 5,6 chlorovanillin, 6 chlorovanillin, pentachloroanisole, 2,3,4,6+2,3,5,6 tetrachloroanisole, 2,3,4,5 tetrachloroanisole, 2,3,4 trichloroanisole, 2,3,5 trichloroanisole, 2,3,6 trichloroanisole, 2,4,5 trichloroanisole, 2,4,6 trichloroanisole, 2,4 dichloroanisole, 2,6 dichloroanisole.

3.3.2 Canvasbacks

Chlorophenolics were detected in livers of five of the six canvasbacks. Four of 38 chlorophenolic compounds were detected (Table 8). Tetrachloroguaiacol and 4,5,6-trichloroguaiacol were the most frequently detected chlorophenolics, occurring in three of the six canvasbacks at concentrations ranging up to 0.014 and 0.0099 µg/g respectively. 3,4,5-trichloroguaiacol and 3,4,5-trichlorocatechol were detected in one bird each.

Table 8. Concentrations of chlorinated phenolics (µg/g, wet wt) in canvasback livers (n=6) collected at the Peace-Athabasca Delta, 1992.

Parameter	Detection Limit	% Detected	Mean[a]	±1SD[a]	Min	Max
Tetrachloroguaiacol	0.0004	50	0.0037	0.0059	<0.0004	0.014
3,4,5 Trichloroguaiacol	0.0004	17	----	----	<0.0004	0.0024
4,5,6 Trichloroguaiacol	0.0004	50	0.0025	0.0037	<0.0004	0.0099
3,4,5 Trichlorocatechol	0.0004	17	----	----	<0.0004	0.0013

[a] - Means and standard deviations calculated only when ≥ 50% of the animals had detectable levels. For such calculations, concentrations below the detection limit were assigned a value of 0.5 X Detection Limit.

NOTE: Tissue residues were below detection limits (0.0002 - 0.0004 µg/g) in all samples for the following compounds: pentachlorophenol, 2,3,4,6+2,3,5,6 tetrachlorophenol, 2,3,4,5 tetrachlorophenol, 2,3,4 trichlorophenol, 2,3,5 trichlorophenol, 2,3,6 trichlorophenol, 2,4,5 trichlorophenol, 2,4,6 trichlorophenol, 2,4 dichlorophenol, 2,6 dichlorophenol, 3,4,6 trichloroguaiacol, 4,5 dichloroguaiacol, 4,6 dichloroguaiacol, 4 chloroguaiacol, tetrachlorocatechol, 3,4 dichlorocatechol, 3,5 dichlorocatechol, 4,5 dichlorocatechol, 4 chlorocatechol, tetrachloroveratrole, 3,4,5 trichloroveratrole, 3,4,5 trichlorosyringol, 5,6 chlorovanillin, 6 chlorovanillin, pentachloroanisole, 2,3,4,6+2,3,5,6 tetrachloroanisole, 2,3,4,5 tetrachloroanisole, 2,3,4 trichloroanisole, 2,3,5 trichloroanisole, 2,3,6 trichloroanisole, 2,4,5 trichloroanisole, 2,4,6 trichloroanisole, 2,4 dichloroanisole, 2,6 dichloroanisole.

There was not a significant difference between muskrat adipose tissue and canvasback livers in the frequency of detections of chlorophenolic compounds (*G*-test of independence: $P > 0.1$, Table 9).

Table 9. Comparison of frequency of detectable concentrations of all chlorophenolics in muskrat adipose tissue and canvasback livers from the Peace-Athabasca Delta, 1992.

Species	Number of Detections	Number of Non-Detections	Subtotal
Muskrat	7	449	456
Canvasback	8	220	228
Subtotal	15	669	684
G_{adj}=2.49, 1*df*, P>0.1			

3.4. Polycyclic Aromatic Hydrocarbons (PAHs)

3.4.1 Muskrats

PAHs were detected in adipose tissue of three of 12 muskrats. Fluoranthene was detected in three animals, pyrene in two, and naphthalene, acenaphthene, phenanthrene, anthracene, and chrysene were each detected in one (Table 10). Concentrations of total PAHs in muskrat adipose tissue ranged to a maximum of 0.06 µg/g.

3.4.2 Canvasbacks

PAHs were detected in livers of 2 of 6 canvasbacks. Fluoranthene and pyrene were detected in two animals, while fluorene, phenanthrene and benzo(b+k)fluoranthene were each detected in one (Table 11). Maximum concentrations of total PAHs reached 0.016 µg/g.

The frequency of PAH detection did not differ significantly between muskrat adipose tissue and canvasback livers (*G*-test of independence: $P > 0.5$, Table 12). Flouranthene and pyrene were the most frequently detected PAHs in both species. Phenanthrene was also detected in each species (Table 11).

3.5 PCBs and Organochlorine Pesticides

3.5.1 Muskrats

PCBs were detected in adipose tissue of only one of 12 muskrats. Four congeners (101, 118, 153, 138) were detected in that animal (Table 13). The sum of all the PCBs in that animal was 0.05 µg/g.

Organochlorine pesticides were not detected in muskrats.

Table 10. Concentrations of PAHs (µg/g, wet wt) in adipose tissue from muskrats (n=12) collected at the Peace-Athabasca Delta, December, 1992.

Parameter	Detection Limit	% Detected	Min	Max
Naphthalene	0.001	8	<0.001	0.002
Acenaphthene	0.001	8	<0.001	0.01
Phenanthrene	0.001	8	<0.001	0.01
Anthracene	0.001	8	<0.001	0.01
Total low MW PAHs	0.001	17	<0.001	0.03
Fluoranthene	0.001	25	<0.001	0.011
Pyrene	0.001	17	<0.001	0.02
Chrysene	0.001	8	<0.001	0.004
Total High MW PAHs	0.005	17	<0.005	0.03
Total PAHs	0.005	17	<0.005	0.06

NOTE: The following PAHs were below detection limits (0.001 - 0.002 µg/g) in all the samples: acenaphthylene, fluorene, benz(a)anthracene, benzo(b+k)fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene, dibenz(ah)anthracene and benzo(ghi)perylene.

Table 11. Concentrations of PAHs (µg/g, wet wt) in canvasback livers (n=6) collected at the Peace-Athabasca Delta, August, 1992.

Parameter	Detection Limit	% Detected	Min	Max
Fluorene	0.001	17	<0.001	0.002
Phenanthrene	0.001	17	<0.001	0.011
Total low MW PAHs	0.001	17	<0.001	0.013
Fluoranthene	0.001	33	<0.001	0.002
Pyrene	0.001	33	<0.001	0.001
Benzo(b+k)fluoranthene	0.001	17	<0.001	0.003
Total High MW PAHs	0.005	17	<0.005	0.006
Total PAHs	0.005	33	<0.005	0.016

NOTE: The following PAHs were below detection limits (0.001-0.002 µg/g) in all the samples: naphthalene, acenaphthylene, acenaphthene, anthracene, benz(a)anthracene, chrysene, benzo(a)pyrene, indeno(123-cd)pyrene, dibenz(ah)anthracene and benzo(ghi)perylene.

Table 12. Comparison of frequency of detectable concentrations of polynuclear aromatic hydrocarbons in muskrat adipose tissue and canvasback livers from the Peace-Athabasca Delta, 1992.

Species	Number of Detections	Number of Non-Detections	Subtotal
Muskrat	10	170	180
Canvasback	7	83	90
Subtotal	17	253	270

G_{adj}=0.23, 1*df*, *P*>0.5.

Table 13. Concentrations of PCB congeners (µg/g, wet wt) that were detected in adipose tissue of muskrats (n=12) collected at the Peace-Athabasca Delta, December, 1992.

Congener	Detection Limit	% Detected	Min	Max
101	0.00003	8	<0.00003	0.015
118	0.00003	8	<0.00003	0.0065
153	0.00002	8	<0.00002	0.016
138	0.00002	8	<0.00002	0.012
Total PCBs	0.001	8	<0.001	0.05

NOTE: 49 other congeners, including the non-ortho PCBs 77, 126 and 169 were below detection limits ranging from 0.005 ng/g to 0.003 µg/g in all muskrats.

3.6.2 Canvasbacks

PCBs and organochlorine pesticides were not detected in any of the six canvasback livers. There was no significant difference in the frequency of detection of PCB congeners between muskrat adipose tissue and canvasback livers (Chi-square test of independence: $P > 0.1$; Table 14).

3.6 Trace Metals

3.6.1 Muskrats

Muskrat adipose tissue was analyzed for arsenic, lead, mercury (total and methyl), cadmium, chromium, copper, vanadium and zinc. The proportions of muskrats in which these substances were detected were as follows: arsenic, mercury and cadmium - 0 of 12; lead and vanadium - one of 12; chromium four of 12; copper 11 of 12 and zinc 12 of 12. Maximum concentrations of lead,

chromium and vanadium were below 1 µg/g while copper and zinc ranged up to 8.6 and 24.3 µg/g, respectively (Table 15).

Table 14. Comparison of frequency of detectable concentrations of polychlorinated biphenyls (PCBs) in muskrat adipose tissue and canvasback livers from the Peace-Athabasca Delta, 1992.

Species	Number of Detections	Number of Non-Detections	Subtotal
Muskrat	4	632	636
Canvasback	0	318	318
Subtotal	4	950	954

χ^2_{adj}=0.78, 1*df*, *P*>0.1

Table 15. Metal and mercury concentrations (µg/g, wet wt) in adipose tissue of muskrats (n=12) collected at the Peace-Athabasca Delta, December, 1992.

Parameter	Detection Limit	% Detected	Mean[a]	1SD[a]	Min	Max
Lead	0.2	8	----	----	<0.2	0.3
Chromium	0.2	33	----	----	<0.2	0.5
Copper	0.1	92	3.04	2.09	<0.1	8.6
Vanadium	0.2	8	----	----	<0.2	0.2
Zinc	0.1	100	18.61	4.20	12.0	24.3

[a] - Means and standard deviations calculated only when ≥ 50% of the animals had detectable levels. For such calculations, concentrations below the detection limit were assigned a value of 0.5 X Detection Limit.
NOTE: Residues of arsenic, total and methyl mercury and cadmium were below detection limits (0.2 for As, 0.02 for total Hg and methyl Hg and 0.3 for Cd) in all samples.

3.6.2 Canvasbacks

The proportions of canvasback livers in which trace metals were detected were as follows: arsenic, lead, cadmium and vanadium - 0 of 6; chromium three of six; mercury - four of six and copper and zinc - 12 of 12. Maximum concentrations were as follows: chromium - 0.7 µg/g; mercury - 1.6 µg/g; zinc - 57 µg/g and copper - 497 µg/g (Table 16).

Table 16. Concentrations of metals and mercury (µg/g, wet wt) in canvasback livers (n=6) collected at the Peace-Athabasca Delta, August, 1992.

Parameter	DL[a]	% Detected	Mean[b]	1SD[b]	Min	Max
Total Mercury	0.02	67	0.92	0.72	<0.02	1.62
Methyl Mercury	0.02	67	0.92	0.72	<0.02	1.62
Chromium	0.2	50	0.28	0.24	<0.2	0.70
Copper	0.1	100	254.7	155.5	63.2	497.0
Zinc	0.1	100	46.7	6.3	39.2	57.2

[a] - Detection Limit.

[b] - Means and standard deviations calculated only when ≥ 50% of the animals had detectable levels. For such calculations, concentrations below the detection limit were assigned a value of 0.5 X Detection Limit.

NOTE: Residues of arsenic, lead, cadmium and vanadium were below detection limits (0.2, 0.2, 0.3, and 0.2 µg/g for As, Pb, Cd and Vn respectively) in all samples.

4.0 DISCUSSION

4.1. Comparison between Muskrats and Canvasbacks

Because different tissues were analyzed,it is not possible to compare directly levels of contamination in the two species. This is especially true for non-lipophilic contaminants such as metals and may apply equally to certain chlorophenolics with low fat solubility. These substances usually occur in much higher concentrations in liver than in muscle or fat (Scheuhammer 1987, Government of Canada 1991*a*). Although muskrats and canvasbacks exhibited equally low concentrations of metals and chlorophenols in adipose tissues and livers, respectively, this should not be interpreted as indicating similarly low body burdens between the two species.

For the more lipophilic contaminants, including dioxins/furans, PCBs and organochlorine pesticides, it is probably appropriate to compare lipid-adjusted contaminant levels in the two species even though different tissues were analyzed. Such comparisons should be appropriate because it is primarily the lipid content of tissue that affects tissue partitioning of these compounds (Servos *et al.* 1994). Lipid-based liver to whole body ratios of PCBs tend to be around 0.7 in herring gulls whereas those for tetra- and penta- dioxins and furans average around 3.0 (Braune and Norstrom 1989). On a lipid-adjusted basis, canvasbacks appeared to be slightly more contaminated with dioxins/furans than muskrats in this study (Table 4). This finding may result from trophic differences between the two species and the trophic biomagnification potential of most 2378-substituted dioxins/furans with the notable exception of OCDD/F (Braune and Norstrom 1989, Broman *et al.* 1992). Young canvasbacks eat mainly invertebrates (Bartonek and Hickey 1969, Jarvis and Noyes 1986) while muskrats consume mainly plant material (Lacki *et al.* 1990). Alternatively, the possibility that these species differ in their potential for metabolizing dioxins and furans cannot be ruled out (Norstrom *et al., unpubl. manusc.*).

Another possibility is that contaminant deposition may have been greater in the Flour Bay area where the canvasbacks were collected than in Big Johny Lake or Killer's Lake where the muskrats were collected. Flour Bay likely receives sediments from Fletcher's Channel, Goose Island Channel and Big Point Channel, which are major branches of the Athabasca River. In contrast, Big Johny Lake and Killer's Lake seldom receive water and sediments from the Athabasca River. They are separated from these branches of the Athabasca River by high levees.

As for PCBs and OC pesticides, there were no differences between the two species (Table 14), as these substances were below detection limits in all but one animal. This is indicative of the extremely low level of PCB/OC contamination of the Peace-Athabasca Delta.

4.2 Comparisons with Other Studies

4.2.1 Dioxins/Furans

4.2.1.1 Muskrats

The only data on dioxins and furans in muskrats from other locations are from an industrially-polluted area near the Akwasasne Reserve near Massena, New York (Stone *et al.* 1991). Of one adult and two immature muskrats that were analyzed for dioxins and furans in adipose tissue, only the adult had detectable levels; 123478-HxCDF, 123678-HxCDF, 1234678-HpCDF and OCDF at concentrations of 13, 46, 57 and 170 ppt wet wt, respectively. These congeners were not detected in muskrats in this study. There is no indication that the DiCDDs that were detected in this study (Table 3) were considered in the New York study.

4.2.1.2 Canvasbacks

Data on dioxins and furans in canvasbacks from other areas were not found. For purposes of comparison, however, data will be presented on other species of waterfowl. In Howe Sound, British Columbia, the insectivorous Common Goldeneye duck (*Bucephala clangula*) had liver concentrations (ng/kg wet wt) of 7.1, 66.0 and 4.5 for 2378-TCDD, 2378-TCDF and total PeCDF, respectively (Whitehead *et al.* 1992). In Port Alberni, British Columbia, Greater Scaup (*Aythya marila*), an omnivorous duck, had liver levels of dioxins and furans that were approximately as follows: 5, 20 and 30 ng/kg (wet wt) for 2378-TCDD, 123678-HxCDD and 2378-TCDF, respectively (Vermeer *et al.* 1993). In the aforementioned New York study, omnivorous mallards (*Anas platyrhynchos*) and herbivorous gadwalls (*A. strepera*) contained minimum concentrations (ppt, wet wt) of 78, 15 and 120 for 2378-TCDF, 23478-PeCDF and OCDF, respectively in adipose tissue (Stone *et al.* 1991).

The concentrations of dioxins and furans reported in the above studies are substantially higher than the concentrations found in juvenile canvasbacks in this study (Table 5). One interpretation of this difference is that the Peace-Athabasca Delta ecosystem is far less contaminated with dioxins/furans than Howe Sound and Port Alberni in B.C. and the industrialized study area in New York. However, species and possible age-related differences amongst waterfowl in these studies add uncertainty to such an

interpretation.

4.2.2 Chlorophenolics

No comparable data on chlorophenolics in muskrats or canvasbacks were found. However, some data were found for chlorophenolics in bird species other than canvasback. At various locales in coastal British Columbia, pentachlorophenol (PCP) was regularly detected in waterfowl breast muscle at concentrations less than 1 ng/g (wet wt) and occasionally up to 5 ng/g. 3,4,5,6-TeCP, 5-CG and 4,5-DiCG were detected infrequently in those samples and usually at concentrations less than 1 ng/g (J.E. Elliott, Canadian Wildlife Service, Vancouver, unpubl. data). Although concentrations of chlorophenols were similar to those in the muskrats and canvasbacks in this study, the congener profile differed. Whereas the British Columbia waterfowl were contaminated most frequently with PCP, TeCP and DiCG, muskrat and canvasback from the Peace-Athabasca Delta exhibited elevated levels of TeCG as well as chlorophenolics with three chlorines (Tables 7 and 8).

In south-central Finland, chlorophenolics (with the exception of PCP) were detected infrequently in starlings (*Sturnus vulgaris*) despite fairly widespread chlorophenol contamination of the environment in the area (Paasivirta *et al.* 1985). PCP was detected in breast muscles of 45% of the starlings that were analyzed at concentrations up to 59 ng/g (detection limit = 1 ng/g). In the piscivorous white-tailed eagle (*Haliaeetus albicilla*), however, a wider range of chlorophenolic compounds was detected, usually with greater frequency and at higher concentrations (Paasivirta *et al.* 1985). For example, 2,4,6-TCP, 2,3,4,6-TeCP, PCP, 3,4,5-TCC and 4,5,6-TCG were detected with ≥ 50% frequency in their breast muscles at mean concentrations of 64, 89, 2152, 20 and 21 ng/g, respectively. Although the concentrations reported in the Finnish study are much higher than those in this study, the congener profile is similar (Tables 7 and 8), suggesting a similar source of chlorophenolic contamination.

4.2.3 Polycyclic Aromatic Hydrocarbons

4.2.3.1 Muskrats

No comparable data from other Canadian sources were found. However, PAHs were detected with significantly greater frequency (*G*-test of independence, $P < 0.05$) and at higher concentrations in carcasses of muskrats from the Elizabeth River in Virginia than in adipose tissue of muskrats in this study (Table 17) (Halbrook *et al.* 1993). Phenanthrene and naphthalene were the most frequently detected PAHs in the Virginia muskrats whereas fluoranthene and pyrene dominated in the Peace-Athabasca Delta muskrats (Table 10). PAHs in muskrats from the Elizabeth River likely originated from industrial sources (Halbrook *et al.* 1993). The source of PAHs in Delta muskrats is uncertain. However, it is noteworthy that other studies suggest that natural oil seeps may be important sourses of PAHs in northern Alberta and the Mackenzie River (Hrudey and Associates 1988, Brownlee 1990).

Table 17. Comparison of polynuclear aromatic hydrocarbons (PAHs) in carcass aliquots from muskrats on the Elizabeth River, Virginia[a] and adipose tissue of muskrats from the Peace-Athabasca Delta.

Location	Detection Limit (µg/g)	N	Percent Detections[b]	Max
Elizabeth River (Virginia)	0.008[c]	35	18	0.038[c]
Peace-Athabasca Delta	0.001	6	8	0.02
G_{adj}=3.93, 1*df*, P<0.05				

[a] - data taken from Halbrook *et al.* (1993).
[b] - based on data for naphthalene, anthracene, fluorene, chrysene, phenanthrene and pyrene.
[c] - converted from dry wt to wet wt using a conversion factor of 4 (Scanlon 1982).

4.2.3.2 Canvasbacks

No comparable data were found for this species. However, there is some published PAH data for a closely-related species of diving duck, the redhead (*Aythya americana*) from coastal Texas (Michot *et al.* 1994). PAHs were detected significantly more often (*G*-test of independence, P = 0.064) and at higher concentrations in adult male redhead carcasses from Texas than in juvenile canvasbacks from the Peace-Athabasca Delta (Table 18). It is uncertain whether the greater frequency of detection and higher concentrations of PAHs in Texas redheads resulted from higher contamination of the Texas coast with PAHs or whether it was simply a function of age or species differences in PAH accumulation patterns.

Table 18. Comparison of polycyclic aromatic hydrocarbons (PAHs) in carcass aliquots of adult male redheads[a] from coastal Texas and livers of immature canvasbacks from the Peace-Athabasca Delta.

Species	Detection Limit (µg/g)	N	Percent Detections	Max
Redhead (coastal Texas)	0.01	15	19	0.09
Canvasback (Peace-Athabasca Delta)	0.001	6	9	0.016
G_{adj}=3.54, 1*df*, P=0.064				

[a] - data taken from Michot *et al.* (1994).

The only other data on PAHs in Canadian birds is for herring gulls (*Larus argentatus*) from Lake

Ontario in the 1970s. Mean concentrations of naphthalene, acenaphthene, anthracene, fluoranthene, benzo[a]pyrene, fluorene and pyrene in gull livers were 0.05, 0.038, 0.152, 0.082, 0.038, 0.044 and 0.076 µg/kg (lipid-adjusted), respectively (Government of Canada 1994a). Gull liver is about 4% lipid, on average, (Braune and Norstrom 1989). Therefore, on a wet weight basis, levels of the above-listed PAHs were 0.002, 0.002, 0.006, 0.003, 0.002, 0.002 and 0.003 µg/kg, respectively. These concentrations are similar to maximum PAH concentrations in canvasback livers in this study (Table 11).

4.2.4 PCBs and Organochlorine Pesticides

4.2.4.1 Muskrats

PCB and organochlorine levels in muskrats from other North American locales are quite low, although they tend to be higher than levels found in muskrats from the Peace-Athabasca Delta. In Virginia, USA, three of 35 muskrats had detectable levels of PCBs and organochlorines (Halbrook *et al.* 1993). The highest total PCB level was about 0.17 µg/g (converted from dry to wet wt using a factor of 4, Scanlon 1982), higher than the maximum level of 0.05 µg/g recorded in this study. Also, dieldrin and DDE were detected in muskrats from Virginia (Halbrook *et al.* 1993). These contaminants were not detected in any of the 12 Peace-Athabasca Delta muskrats. PCBs were detected in adult muskrats from an industrialized area of New York State near the Akwasasne Reserve at concentrations ranging up to 0.8 µg/g (Stone *et al.* 1991), higher than the maximum PCB concentration of 0.05 µg/g that was detected in the Peace-Athabasca Delta muskrats (Table 13).

4.2.4.1 Canvasbacks

Mean concentrations of PCBs, DDE and dieldrin in wings of canvasbacks collected in California during 1980-81 were 0.72, 0.62 and 0.02 µg/g PCBs, DDE and dieldrin, respectively (Ohlendorf and Miller 1984). These contaminants were not detected in livers of canvasbacks from the Peace-Athabasca Delta in 1992. Differences between these studies are likely the result of a combination of regional differences in levels of organochlorine and PCB contamination (i.e. the P-A Delta is less contaminated by these global pollutants than California) and declines in OC/PCB pollution in North America between the late 1970s and late 1980s (Government of Canada 1991*b*).

4.2.5 Metals

4.2.5.1 Muskrats

It is difficult to compare concentrations of metals in Peace-Athabasca Delta muskrats to those from other regions because adipose tissue was used for metals analyses in this study, whereas liver and kidneys are used in most other studies. Metals tend to accumulate at higher levels in liver and kidney than in adipose tissue. Thus, it is not surprising that metal concentrations in livers and kidneys of muskrats from Virginia, Pennsylvania and Manitoba were higher than in adipose tissue of Peace-Athabasca Delta muskrats (Table 19).

Table 19. Mean concentrations (μg/g, dry wt) of metals and mercury in muskrat tissues from various North American locales.

Location	Organ	As	Pb	Hg-Total	MeHg	Cd	Cr	Cu	Vn	Zn
Virginia, USA[a]	Kidney	ND	1.02	0.016	----	1.36	----	11.9	0.72	83.3
Pennsyl-	Liver	----	0.04	0.046	----	0.02	----	4.0	----	49.5
vania, USA[b]	Kidney	----	----	----	----	0.59	----	2.2	----	----
Flin Flon,	Liver	----	0.54	----	----	0.30	----	11.7	----	81.7
Canada[c]	Kidney	----	0.84	----	----	1.33	----	12.8	----	75.2
P-A Delta, Canada[d]	Adipose	ND	0.12	ND	ND	ND	ND	3.0	ND	24.3

[a] - data from Halbrook *et al.* 1993.
[b] - data from Everett and Anthony 1976.
[c] - data from Radvanyi and Shaw, 1981.
[d] - data from this study.

Table 20. Mean concentrations (µg/g, dry wt) of metals and mercury in canvasback organs from various North American locales.

Location	Organ	As	Pb	Hg-Total	MeHg	Cd	Cr	Cu	Vn	Zn
Chesapeake Bay, Virginia[a]	Liver	----	0.70	0.96	----	----0.92	0.08	236	----	164
	Kidney	----	----	----	----		----	----	----	----
Chesapeake Bay, Virginia[b]	Liver	----	3.8	----	----	3.10	----	114	----	154
	Kidney	----	----	----	----	4.10	----	----	----	----
Louisiana[c]	Liver	0.43[f]	5.8	0.26	----	0.27[g]	----	135[g]	0.94[f]	133[g]
Prairies, Canada (1970s)[d]	Liver	----	----	0.17	----	----	----	----	----	----
P-A Delta, Canada[e]	Liver	ND	ND	0.92	0.92	ND	0.28	255	ND	47

[a] - data from White *et al.* 1979.
[b] - data from DiGuilio and Scanlon 1984.
[c] - data from Custer and Hohman 1994.
[d] - data from Braune *et al.* 1991.
[e] - data from this study.
[f] - maximum level.
[g] - juvenile canvasbacks.

4.2.5.2 Canvasbacks

Metal levels in livers of canvasbacks from the Peace-Athabasca Delta were generally lower than in those of canvasbacks at wintering locations in the USA (Table 20). Exceptions included mercury, chromium and copper which, in the Peace-Athabasca Delta canvasbacks, were approximately equal to or greater than their concentrations in canvasbacks from the USA. Mercury in Peace-Athabasca Delta canvasbacks was equal to that in canvasbacks from Chesapeake Bay but greater than that in canvasbacks from the Louisiana, perhaps owing to differences in feeding habits between the sites. The diet of canvasback ducklings (the Peace-Athabasca Delta canvasbacks would have recently fledged) consists mainly of animal matter (Bartonek and Hickey 1969, Jarvis and Noyes 1986) as does the diet of canvasbacks wintering in Chesapeake Bay (Perry and Uhler 1988), whereas in Louisiana canvasbacks consume primarily vegetation (Hohman *et al.* 1990). Mercury biomagnifies through food chains (Wren *et al.* 1983). Thus plant-feeding canvasbacks would be expected to have lower mercury levels than those that feed primarily on animal matter. The higher levels of chromium and copper in the Peace-Athabasca Delta canvasbacks than in those from Chesapeake Bay are not readily explainable. Chromium is often present in effluents from municipal sewage plants and pulp mills while atmospheric emissions from power generating plants also contribute significant quantities (Government of Canada 1994*b*). Perhaps some or all of these sources have contributed chromium to the Peace-Athabasca Delta.

4.3 Toxic Potential of Contaminants to Muskrats and Canvasbacks

There exists some knowledge concerning the toxic potential of some of these contaminants for certain species of wild mammals and birds. However, interpreting tissue residues in Peace-Athabasca Delta canvasbacks and muskrats in terms of tissue concentrations known to be associated with toxic effects should be done with great caution for a number of reasons. First, species vary widely in their sensitivity to contaminants and there are no instances where canvasbacks or muskrats have been used for toxicity testing. Second, experimental conditions and dosing regimes that animals are subjected to in toxicity testing are often far different from those that wild animals experience. Third, toxicity information is often based on residue levels in tissues that are different from those analyzed in this study. Nevertheless, I have attempted, below, to interpret tissue residue levels in Peace-Athabasca Delta muskrats and canvasbacks in terms of residue levels that have been associated with toxicity in experimental and non-experimental wild birds and mammals.

Most of the contaminants in canvasbacks and muskrats from the Peace-Athabasca Delta were well below those associated with toxicity. Table 21 provides data on tissue residue levels associated with toxic effects in various birds and mammals for contaminants that were detected in the Peace-Athabasca Delta canvasbacks and muskrats. It is possible to directly compare the residue levels for some contaminants in the canvasback and muskrats to known or suggested threshold effects levels listed in Table 21. In those cases, with the exception of copper, it is clear that residues in the Peace-Athabasca Delta animals were far below toxicity thresholds. However, for other contaminants such as dioxins/furans and PAHs, a direct comparison is not possible because different tissues were analyzed.

It is possible to convert egg concentrations of PCDD/DFs associated with toxicity to liver concentrations

and then compare the result of that conversion to actual concentrations in Peace-Athabasca Delta canvasback livers as a means of assessing the potential toxicity of these substances in Peace-Athabasca Delta canvasbacks. For example, the liver:egg ratio of 2,3,7,8-TCDD in Herring Gulls averages 1.54 (Braune and Norstrom 1989). Extrapolating this figure to the egg concentration associated with developmental problems in Great-Blue Heron embryos (135 ppt, see Table 21), one can estimate that a female bird with 210 ppt 2,3,7,8-TCDD in its liver might encounter reproductive problems. This is far greater than the maximum 2,3,7,8-TCDD toxic equivalents concentration of 3.9 ppt observed in this study.

PAHs are extremely toxic to bird embryos (Table 21). However, the route of exposure is through contact with oil-contaminated belly feathers of the incubating parent. Metabolic transfers of PAHs from parental tissues to eggs is not considered to be an important source of PAHs in eggs. Thus, PAHs in livers or adipose tissue of adult birds probably has little, if any, effect on embryo development. Information on the toxic consequences of PAH residues in adult birds and mammals appears to be lacking. Apparently, it is the high molecular weight fraction of PAHs that are toxic to birds, whereas the low molecular weight PAHs are not toxic (Peakall *et al.* 1982). In this study canvasbacks and muskrats were exposed to low concentrations of low and high molecular weight PAHs. Toxicity studies are needed before the toxic significance of those concentrations can be confidently assessed.

Copper concentrations in canvasback livers were similar to those in Canada geese that died from copper poisoning (Henderson and Winterfield 1975). This does not indicate that copper levels in Peace-Athabasca Delta canvasbacks were high enough to be considered toxic. Rather, it may serve to illustrate the inadequacy of comparing contaminant concentrations in tissues of different species subjected to different exposure scenarios. The Canada geese that died from copper poisoning drank water that had been treated with copper sulphate to kill algae. Thus their exposure was acute. The canvasbacks in this study probably experienced a chronic exposure, but at lower concentrations. Copper is an essential dietary element. Presumably, the levels of copper in P-A Delta canvasbacks reflected dietary requirements rather than toxic exposure. It is interesting that copper concentrations in canvasbacks are similar at several geographic locations in North America (Table 20), a phenomenon that supports the above statement.

Table 21. Toxicity thresholds or guidelines for birds and or mammals for some of the contaminants that were detected in muskrat or canvasbacks in this study.

Contaminant	Tissue	Concentration	Effect	Details	Reference
2,3,7,8,-TCDD	Egg	1300 - 2200 ppt wet wt	Embryo LD_{50}	injected into pheasant eggs	Nosek *et al. 1993*
2,3,7,8-TCDD	Egg	135 ppt wet wt	Impaired embryonic development	environmental concentration in Great-Blue Heron eggs near Vancouver	Hart *et al. 1991*
PCBs	Egg	16 ppm wet wt		Criterion for protecting birds	Eisler 1986*b*
	Brain	54 ppm wet wt		"	"
	Liver	2 ppm wet wt	reduced reproductive output	Aroclor 1254 fed to captive mink	Wren 1991
PAHs	Egg	0.04-0.18 ppb wet wt	sublethal toxic effects	Toxic range for various PAHs applied to surface of eggshell	Eisler 1987
	Whole body	1mL Prudoe Bay Crude oil administered orally per bird	reduced growth rate and survival	only high molecular weight fraction was toxic	Peakall *et al.* 1982
PCP	Liver	46 ppm wet wt	death	Snail kites found dead	Eisler 1989
Mercury	Liver	2-3 ppm	poor reproductive success	experimental feeding of MeHg to pheasants	Fimreite 1971
	Liver	>40 ppm	death	experimental feeding to blackbirds	Finley *et al.* 1979
	Liver	3.6 - 6.5 ppm (dry wt)	reduced reproductive success	experimental feeding to mallards.	Heinz 1979
	Liver	21.3 ppm	death	experimental feeding to mink	Wobeser *et al.* 1976
Chromium	Tissue Residue	<200 ppb (wet wt)		Proposed criteria for protection of animals	Eisler 1986*a*

Contaminant	Tissue	Concentration	Effect	Details	Reference
Cadmium	Kidney	100-200 ppm wet wt.	nephro-toxicity	birds	Scheuhammer 1987
		100 ppm (wet wt)		critical tissue concentration-birds	Outeridge *et al.* 1994
		30 ppm wet wt		critical tissue concentration-mammals	Outeridge *et al.* 1994
Lead	liver or kidney	>15 ppm, wet wt		Biologically hazardous level for vertebrates	Eisler 1985
	Liver	>8 ppm, wet wt	lead poisoning in waterfowl		Eisler 1988
Copper	Liver	56 - 97 ppm wet wt	death	residues in Canada geese that died from drinking water contaminated with copper sulphate	Henderson and Winterfield, 1975
Zinc	Liver	2100 ppm, dry wt	zinc poisoning in birds		Eisler 1993
	Liver	465 ppm, dry wt	zinc poisoning in mammals		Eisler 1993

NOTE: Wet wt values in livers can be converted to approximate dry wt values by multiplying by 4.0 (Scanlon 1982).

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APPENDIX A: Terms of Reference

No contractual Terms of Reference were prepared for the work documented in this report. The work was done by the author as a contribution in kind from his employing agency and represents a part of his responsibilities to the working committee of the Contaminants Component of the Northern River Basins Study.

APPENDIX B: Health Canada's Assessment of These Samples for Human Consumption

Health and Welfare Canada | Santé et Bien-être social Canada
Health Protection Branch | Direction générale de la protection de la santé

Bureau of Chemical Safety
Room 309B
Banting Building
Postal Locator: 2203G2
Ottawa, Ontario
K1A 0L2

April 27, 1995

Our Reference Number: 95-08

Mr. Mark Wayland
Ecosystem Quality Division
Environmental Conservation
Environment Canada
Saskatoon, Sask.

Dear Mr. Wayland:

This will refer to your memo of December 9, 1994 and of the accompanying package of organochlorine and trace metal residue data from muskrat and duck samples. These samples were collected from the Peace-Athabasca area in northern Alberta.

Our review of the submitted data has now been completed. Based on the information provided, consumption of these muskrat adipose tissue and canvasback duck liver samples is not considered to pose any hazard to the health of the consumer.

I trust the above is acceptable to you.

Yours truly,

H.B.S. Conacher, Ph.D.
A/Director
Bureau of Chemical Safety

Canada

APPENDIX C: Contaminants Data

P-A Delta Wildlife Contaminants

SAMPLE ID	SPECIES	LOCATION	ENVIROTESTSAMP	ZENONSAMP	CHEMEXSAMP	DATE	AGE	SEX
JL1	MUSKRAT	JOHNIES L	E3-08-379-01A	E3-03-118-05A	E3-03-118-05A	DEC 5/ 92	J	F
JL2	MUSKRAT	JOHNIES L	E3-08-379-02A	E3-03-118-06A	E3-03-118-06A	DEC 6/92	J	F
JL3	MUSKRAT	JOHNIES L	E3-08-379-03A	E3-03-118-07A	E3-03-118-07A	DEC 6/92	J	F
JL1	MUSKRAT	JOHNIES L	E3-08-379-04A	E3-03-118-08A	E3-03-118-08A	DEC 6/92	J	F
JL2	MUSKRAT	JOHNIES L	E3-08-379-05A	E3-03-118-09A	E3-03-118-09A	DEC 5/92	J	M
JL3	MUSKRAT	JOHNIES L	E3-08-379-06A	E3-03-118-10A	E3-03-118-10A	DEC 6/92	J	F
JL4	MUSKRAT	JOHNIES L	E3-08-379-07A	E3-03-118-11A	E3-03-118-11A	DEC 6/92	J	M
JL5	MUSKRAT	JOHNIES L	E3-08-379-08A	E3-03-118-12A	E3-03-118-12A	DEC 6/92	J	M
JL6	MUSKRAT	JOHNIES L	E3-08-379-09A	E3-03-118-13A	E3-03-118-13A	DEC 6/92	J	M
JL7	MUSKRAT	JOHNIES L	E3-08-379-10A	E3-03-118-14A	E3-03-118-14A	DEC 6/92	J	M
KL1	MUSKRAT	KILLERS L	E3-08-379-11A	E3-03-118-18A	E3-03-118-18A	DEC 5/92	J	F
KL2	MUSKRAT	KILLERS L	E3-08-379-12A	E3-03-118-19A	E3-03-118-19A	DEC 5/92	J	M
CAN2-FB	CANVASBACK	FLOUR BAY	E3-08-379-13A	E3-03-118-36A	E3-03-118-36A	AUG 26/92	J	M
CAN3-FB	CANVASBACK	FLOUR BAY	E3-08-379-14A	E3-03-118-37A	E3-03-118-37A	AUG 26/92	J	M
CAN4-FB	CANVASBACK	FLOUR BAY	E3-08-379-15A	E3-03-118-38A	E3-03-118-38A	AUG 26/92	J	F
CAN5-FB	CANVASBACK	FLOUR BAY	E3-08-379-16A	E3-03-118-39A	E3-03-118-39A	AUG 26/92	J	M
CAN7-FB	CANVASBACK	FLOUR BAY	E3-08-379-17A	E3-03-118-41A	E3-03-118-41A	AUG 26/92	J	F
CAN10-FB	CANVASBACK	FLOUR BAY	E3-08-379-18A	E3-03-118-44A	E3-03-118-44A	AUG 26/92	J	F

Dioxins and furans are in pg/g (wet)
Total and methyl mercury are in micrograms per kilogram (dry)
As, Pb, Cd, Cu, Vn, Zn, Cr are in micrograms per gram (dry)
All other compounds are in micrograms per gram (wet)

SAMPLE ID	WEIGHT	TISSUE	DiCDD-27/28	DICDD-23	TriCDD-237	TCDD-2378	PCDD-12378	HxCDD-123478
JL1	937	ADIPOSE	ND	ND	ND	ND	ND	ND
JL2	720	ADIPOSE	1.6	ND	ND	ND	ND	ND
JL3	737	ADIPOSE	ND	ND	ND	ND	ND	ND
JL1	608	ADIPOSE	ND	ND	ND	ND	ND	ND
JL2	797	ADIPOSE	ND	ND	ND	ND	ND	ND
JL3	771	ADIPOSE	ND	ND	ND	ND	ND	ND
JL4	726	ADIPOSE	ND	ND	ND	ND	ND	ND
JL5	904	ADIPOSE	ND	ND	ND	ND	ND	ND
JL6	857	ADIPOSE	ND	ND	ND	ND	ND	ND
JL7	924	ADIPOSE	ND	ND	ND	ND	ND	ND
KL1	749	ADIPOSE	ND	(26)	ND	ND	ND	ND
KL2	701	ADIPOSE	ND	ND	ND	ND	ND	ND
CAN2-FB	956	LIVER	ND	ND	ND	ND	ND	ND
CAN3-FB	974	LIVER	ND	ND	ND	ND	ND	ND
CAN4-FB	696	LIVER	ND	ND	ND	ND	0.5	ND
CAN5-FB	1060	LIVER	ND	ND	ND	ND	ND	ND
CAN7-FB	789	LIVER	ND	ND	ND	ND	ND	ND
CAN10-FB	837	LIVER	ND	ND	ND	ND	ND	ND

P-A Delta Wildlife Contaminants

SAMPLE ID	HxCDD-123678	HxCDD-123789	HpCDD-1234678	OCDD	DiCDF-28	TriCDF-238	TCDF-2378
JL1	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	0.6
CAN5-FB	ND	ND	ND	ND	ND	ND	0.2
CAN7-FB	ND	ND	ND	ND	ND	ND	0.4
CAN10-FB	ND	ND	ND	ND	ND	ND	0.4

SAMPLE ID	PCDF-23478	HxCDF-123478	HxCDF-123678	HxCDF-234678	HxCDF-123789	HpCDF-1234678
JL1	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND
CAN5-FB	0.5	ND	ND	ND	ND	ND
CAN7-FB	1.3	ND	ND	ND	ND	ND
CAN10-FB	1.4	ND	ND	ND	ND	ND

P-A Delta Wildlife Contaminants

SAMPLE ID	HpCDF-1234789	OCDF	PCP	TeCP-2346+2356	TeCP-2345	TCP-234	TCP-235	TCP-236
JL1	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	0.0042
JL3	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	0.0042	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	TCP-245	TCP-246	DiCP-24	DCP-26	TeCG	TCG-345	TCG-346	TCG-456	DiCG-45	DiCG-46
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	0.0009	ND	ND	0.0005	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	0.0006	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	0.0006	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	0.011	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	0.014	0.0024	ND	0.0099	ND	ND
CAN7-FB	ND	ND	ND	ND	0.0028	ND	ND	0.0017	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	0.0029	ND	ND

P-A Delta Wildlife Contaminants

SAMPLE ID	CG-4	TECC	TCC-345	DiCC-34	DiCC-35	DiCC-45	CC-4	TeCV	TCV-345	DCV-45
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	0.0012	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	0.0013	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	TCS-345	DiCVan-56	CVan-6	PeCA	TeCA-2346+2356	TeCA-2345	TCA-234	TCA-235
JL1	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND

P-A Delta Wildlife Contaminants

SAMPLE ID	TCA-236	TCA-245	TCA-246	DiCA-24	DiCA-26	PCB5/8	PCB18	PCB15	PCB16/32
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	TCA-236	TCA-245	TCA-246	DiCA-24	DiCA-26	PCB5/8	PCB18	PCB15	PCB16/32
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND

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SAMPLE ID	PCB31	PCB28	PCB33	PCB22	PCB52	PCB49	PCB44	PCB40	PCB70/76	PCB66/95
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	PCB56/60	PCB84	PCB89	PCB101	PCB87	PCB85	PCB110	PCB151	PCB149	PCB118
JL1	ND	ND	ND	0.015	ND	ND	ND	ND	ND	0.0065
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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SAMPLE ID	PCB146	PCB153	PCB105	PCB141	PCB137	PCB138	PCB129	PCB182/187	PCB183	PCB128
JL1	ND	0.016	ND	ND	ND	0.012	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	PCB185	PCB174	PCB177	PCB171/202	PCB180	PCB191	PCB170	PCB201	PCB196/203
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND

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SAMPLE ID	PCB189	PCB195/208	PCB207	PCB194	PCB205	PCB206	PCB209	TOTPCB	PCB77	PCB126
JL1	ND	ND	ND	ND	ND	ND	ND	0.05	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	PCB169	NAPHTHALENE	ACENAPHTHALENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	ANTHRACENE
JL1	ND	ND	ND	0.01	ND	0.01	0.01
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND
KL2	ND	0.002	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	0.002	0.001	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND

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SAMPLE ID	LMW-PAH	FLUORANTHENE	PYRENE	BENZ(A)ANTHRACENE	CHRYSENE	BENZO(B+K)FLUORANTHENE
JL1	0.03	0.01	0.02	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND
KL1	ND	0.001	ND	ND	ND	ND
KL2	0.002	0.011	0.011	ND	0.004	ND
CAN2-FB	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	0.002	0.001	ND	ND	0.003
CAN7-FB	0.013	0.002	0.001	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND

SAMPLE ID	BENZO(A)PYRENE	INDENO(123-CD)PYRENE	DIBENZ(AH)ANTHRACENE	BENZO(GHI)PERYLENE	HMW-PAH
JL1	ND	ND	ND	ND	0.03
JL2	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	0.026
CAN2-FB	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	0.006	0.006
CAN7-FB	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND

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SAMPLE ID	TOTPAH	ALDRIN	BHC-Alpha	BHC-Beta	BHC-Delta	CHLORDANE-Alpha	CHLORDANE-Gamma	DDE-pp
JL1	0.06	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND
KL2	0.028	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	0.016	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	DDD-pp	DDT-pp	ENDOSULFAN I	ENDOSULFAN II	ENDOSULFAN SULPHATE	DDT-op	DIELDRIN
JL1	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND

P-A Delta Wildlife Contaminants

SAMPLE ID	ENDRIN	HCB	HEPTACHLOR	HEPTACHLOR EPOXIDE	LINDANE	METHOXYCHLOR	MIREX
JL1	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	ND	ND
CAN4-FB	ND	ND	ND	ND	ND	ND	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	ND	ND
CAN10-FB	ND	ND	ND	ND	ND	ND	ND

SAMPLE ID	NONACHLOR-Trans	OXYCHLODANE	TOXAPHENE	As	Pb	Hg-Tot	Hg-Methyl	Cd
JL1	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND
JL1	ND	ND	ND	ND	ND	ND	ND	ND
JL2	ND	ND	ND	ND	ND	ND	ND	ND
JL3	ND	ND	ND	ND	ND	ND	ND	ND
JL4	ND	ND	ND	ND	ND	ND	ND	ND
JL5	ND	ND	ND	ND	ND	ND	ND	ND
JL6	ND	ND	ND	ND	ND	ND	ND	ND
JL7	ND	ND	ND	ND	0.3	ND	ND	ND
KL1	ND	ND	ND	ND	ND	ND	ND	ND
KL2	ND	ND	ND	ND	ND	ND	ND	ND
CAN2-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN3-FB	ND	ND	ND	ND	ND	67	67	ND
CAN4-FB	ND	ND	ND	ND	ND	152	152	ND
CAN5-FB	ND	ND	ND	ND	ND	ND	ND	ND
CAN7-FB	ND	ND	ND	ND	ND	150	150	ND
CAN10-FB	ND	ND	ND	ND	ND	162	162	ND

P-A Delta Wildlife Contaminants

SAMPLE ID	Cr	Cu	Vn	Zn
JL1	ND	2.1	ND	19.1
JL2	ND	2.1	ND	22.3
JL3	ND	3.7	ND	24.3
JL1	ND	4.4	ND	16.3
JL2	ND	2.9	ND	12
JL3	0.4	3.6	ND	22
JL4	ND	2.6	ND	23.2
JL5	ND	ND	ND	16.7
JL6	0.3	2.6	ND	12.3
JL7	0.5	8.6	ND	21.4
KL1	0.4	2.7	0.2	14.8
KL2		1.1	ND	18.9
CAN2-FB	ND	306	ND	39.2
CAN3-FB	0.3	63.2	ND	57.2
CAN4-FB	0.4	330	ND	48.6
CAN5-FB	ND	139	ND	47.6
CAN7-FB	0.7	193	ND	41.9
CAN10-FB	ND	497	ND	45.5