U.S. Fish & Wildlife Service

Assessment of Contaminants in the Wetlands and Open Waters of the Great Salt Lake, Utah

1996-2000

USFWS Contaminant Investigations

Report Number: R6/C-01-U/0

U.S. FISH & WILDLIFE SERVICE
REGION 6

CONTAMINANTS PROGRAM

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1996-2000

Final Report

By

Bruce Waddell, Chris Cline, Nathan Darnall, Elise Boeke and Rex Sohn

U.S. Fish and Wildlife Service Ecological Services, Utah Field Office
2369 W. Orton Circle, Salt Lake City, Utah 84119

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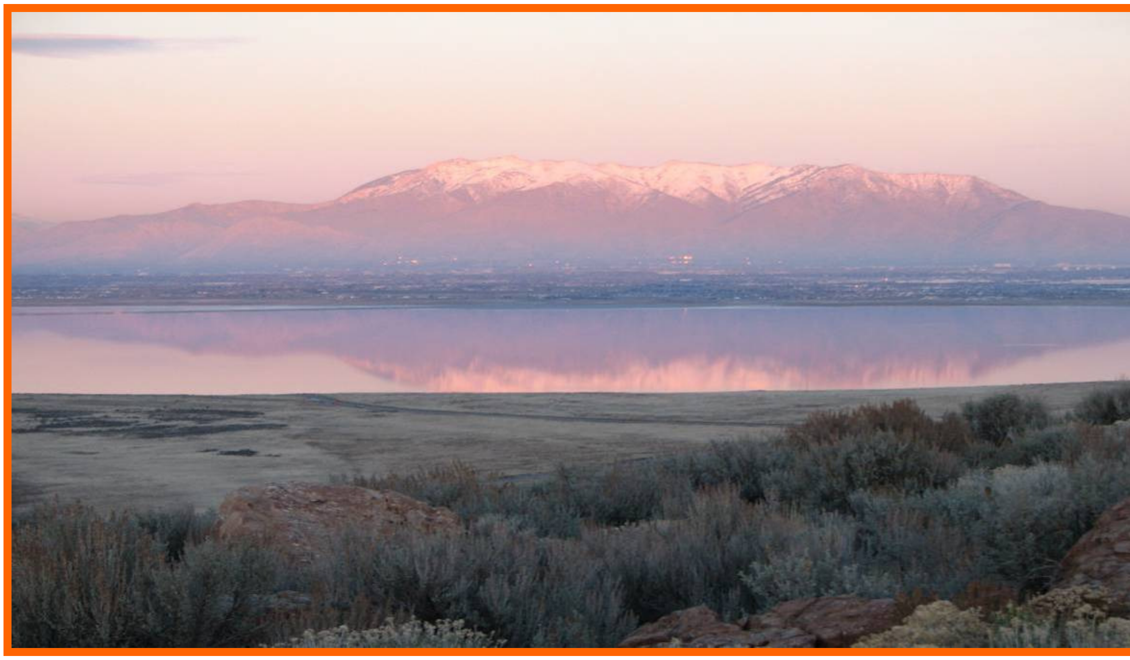

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ABSTRACT

In 1996 and 1997, the United States Fish and Wildlife Service (Service) Utah Field Office undertook a comprehensive assessment of contaminants at over 30 wetland sites around the Great Salt Lake (GSL), in northern Utah. At 4,400 km^2 (1,700 mi^2), the GSL is the 4th largest natural water body west of the Mississipi River and the largest saline lake in the continental United States. The GSL supports hemispherically significant numbers (measured in percent of global population) of a number of bird species including Wilson's phalarope (*Phalaropus tricolor*), eared grebe (*Podiceps nigricollis*), American avocet (*Recurvirostra americana*), black-necked stilt (*Hymantopus mexicanus*), snowy plover (*Charadrius alexandrinus*) and others. We assessed important avian habitats on the lake including freshwater and estuarine "transitional" wetlands on the GSL's southern and eastern shores, and the open waters of the lake. Trace metals and organic constituents were measured in over 600 samples of sediments, invertebrates, fish and avian eggs; biomarkers of exposure and/or effect (acetylcholinesterase and ethoxyresorufin-*O*-deethylase enzymes, endocrine hormones 17β-estradiol and 11-ketotestosterone, and polynuclear aromatic hydrocarbon metabolites) were measured in fish as well. In the open waters of the lake, investigation focused on sediments, brine shrimp, and liver tissue from eared grebes, which forage on the lake in the fall and winter as part of a protracted migratory stop-over where they use the lake to undergo a complete feather molt and replacement. Results of this investigation indicated that in general while a number of anthropogenically generated constituents could be observed in sediments and biota around the GSL, there were only a few locations where these constituents were present at levels of concern for the health or management of migratory bird populations. Biomarker data did not indicate that there were any consistent trends in exposure to constituents associated with the biomarkers in fish. Follow-up studies were performed in 1999 and 2000 in areas where data indicated that birds might be exposed to elevated contaminant conentrations. These included an investigation of elevated mercury concentrations in eggs of birds and contaminated sediments at the outfall of an industrial/irrigation canal in southern Farmington Bay, and sediments contaminated with metals associated with mining on the south shoreline of the GSL. These investigations concluded that sediment-foraging birds using a localized area of southern Farmington Bay may be exposed to concentrations of mercury and other contaminants that could cause adverse effects (e.g., impacts to growth, reproduction and/or survival), and that there were localized areas of elevated selenium exposure, associated with the operations and past waste management practices of a large copper smelting facility located on the south shore of the GSL. Data collected during this study also supported a hypothesis that mercury, possibly originating from atmospheric deposition, was being captured by biota within the open waters of the lake where it could be bioaccumulated by birds that use the lake as migratory stop-over habitat. Findings from this study have been used since their collection to inform additional efforts to manage and improve avian and other wildlife habitat on the GSL , including the establishment of a site-specific water quality standard for selenium in the wetlands and open waters of the GSL; and further investigation of the origin, bioavailability and effects of mercury exposure to birds in the GSL ecosystem.

KEYWORDS: Great Salt Lake Contaminants Assessment, Great Salt Lake Wetlands, Great Salt Lake Open Water, Salt Lake City, Utah, Ogden, Farmington Bay, Ogden Bay, Jordan River, Ogden River, Weber River, Bear River, Bear River Migratory Bird Refuge (BRMBR), Contaminants Investigation, sediments, invertebrates, biota, bird eggs, metals, mercury, selenium, organochlorines, petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs),

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TABLE OF CONTENTS

LIST OF APPENDICES, WITH TABLES

LIST OF TABLES IN THE REPORT

LIST OF TABLES (*continued*)

TABLE

LIST OF FIGURES IN THE REPORT

FIGURE

LIST OF FIGURES (*continued*)

FIGURE

LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYM	DEFINITION
2-PAM	2-pralidoxime
7-ER	7-ethoxyresorufin
11-KT	11-ketotestosterone
AAS	atomic absorption spectrometry
AChE	acetylcholinesterase
Al	Aluminum
ALH	Alkylated polynuclear aromatic hydrocarbon
ANOVA	analysis of variance
As	Arsenic
ASL	above sea level
B	Boron
Ba	Barium
BHC	Benzene hexachloride (also known as γ-hexachlorocyclohexane, also lindane)
BRD	Biological Research Division (USGS)
BRMBR	Bear River Migratory Bird Refuge
CCME	Canadian Council of Ministers of the Environment
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CGC	capillary gas chromatography
Cr	Chromium
Cu	Copper
DDT	dichloro-diphenyl-trichloroethane
DL	Detection limit
DTNB	5,5'-dithiobis-2-nitrobenzoate
dw	dry weight
E	Estrogen
E_2	17β-estradiol
E/T	Estrogen : Testosterone ratio
EROD	ethoxyresorufin-*O*-deethylase
FBWMA	Farmington Bay Waterfowl Management Area
FCSC	Florida Caribbean Science Center
Fe	Iron
FL/PY	fluoranthene:pyrene ratio
FWS	United States Fish and Wildlife Service
GERG	Geochemical Environmental Research Group
GMean	Geometric mean
GSI	gonadosomatic index
GSL	Great Salt Lake
HCB	Hexachlorobenzene
Hg	Mercury
HPLC	high performance liquid chromatography
HRGC	high-resolution gas chromatography
HRMS	high-resolution mass spectrometry
KUCC	Kennecott Utah Copper Corporation
LOAEL	Lowest Observed Adverse Effect Level
LOEL	Lowest Observed Effects Level
Mg	Magnesium
mg/kg	milligrams per kilogram (parts per million)
Mn	Manganese

LIST OF ACRONYMS AND ABBREVIATIONS (*continued*)

ACRONYM	DEFINITION
Mo	Molybdenum
NC	Not calculated
ND	Not detected
Ni	Nickel
NIWQP	National Irrigation Water Quality Program (U.S. Dept. of Interior)
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effects Level
NWOD	Northwest Oil Drain
OBWMA	Ogden Bay Waterfowl Management Area
OC	organochlorine
OP	organophosphate
PACF	Paxutent Analytical Control Facility
PAH	polynuclear aromatic hydrocarbon
Pb	Lead
PCB	polychlorinated biphenyl
PEC	Probable Effects Concentration
PH/AN	phenanthrene:anthracene ratio
pmol/ min·µg	picomoles of EROD reaction product per minute per migrogram of liver microsomal protein
ppm	parts per million (milligrams per kilogram)
Rn	Relative body condition
Se	Selenium
SLCWWTP	Salt Lake City Wastewater Treatment Plant (Site IS)
SQuiRT	**S**creening **Qui**ck **R**eference **T**ables
Sr	Antimony
SS	stainless steel
T	Testosterone
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin (dioxin)
TEC	Threshold Effects Concentration
TEF	Toxicity Equivalence Factor (for dioxins and dioxin-like compounds)
TPH	total petroleum hydrocarbons
USGS	United States Geological Survey
V	Vanadium
VTG	vitellogenin
ww	wet weight
Zn	Zinc

AVIAN COMMON NAME ABBREVIATIONS

AMAV	American avocet
AMCO	American coot
BNST	Black-necked stilt
CITE	Cinnamon teal
DCCO	Double-crested cormorant
EAGR	Eared grebe
FOTE	Forster's tern
GBHE	Great blue heron
MALL	Mallard duck
SNPL	Snowy plover

SPECIES REFERENCED IN THE REPORT

PLANTS

Bulrush *Scirpus* (spp.)
Cattail *Typhus* (spp.)
Canary reed grass *Phragmites* (spp.) (both native and non-native, invasive species)
Fresh-water plankton (*Daphnia* spp.)
Green alga (*Dunaliella viridis*)

INVERTEBRATES

Midges (Chironomidae)
Water boatmen (Corixidae)
Brine shrimp (*Artemia franciscana*)
Brine flies (two species: *Ephydra gracilis* and *Ephydra hians*)
Damselflies and dragonflies (Ondonata)

BIRDS

American avocet (*Recurvirostra americana*)
American coot (*Fulica americana*)
American white pelican (*Pelecanus erythrorhynchos*)
American woodcock (*Scolopax minor*)
Barn swallow (*Hirundo rustica)*
Black-crowned night heron (*Nycticorax nycticorax*)
Black-necked stilt (*Hymantopus mexicanus*)
California gull (*Larus californicus*).
Common loon (*Gavia immer*)
Eared grebe (*Podiceps nigricollis*)
Forster's tern (*Sterna forsteri*)
Great blue heron (*Ardea herodias*)
Green-winged teal (*Anas crecca*)
Mallard duck (*Anas platyrhynchos*
Northern pintail (*Anas acuta)*
Northern shoveler (*Anas clypeata*)
Pied-billed grebe (*Podilymbus podiceps*)
Snowy plover (*Charadrius alexandrinus*)
White-faced ibis (*Plegadis chihi*)
Wilson's phalarope (*Phalaropus tricolor*)

FISH

Common carp (*Cyprinus carpio*)
Utah chub (*Gila atraria*)
Western mosquitofish (*Gambusia affinis*)

LIST OF SAMPLE SITES (*by Geographic Area*)

GREAT SALT LAKE OPEN WATER

GU	Gilbert Bay- USGS Sites
GG	Gilbert Bay
GC	Gilbert Bay C7 Ditch Delta
GD	Gilbert Bay Goggin Drain Delta
GL	Gilbert Bay Goggin Drain Delta

ANTELOPE ISLAND

AE	Antelope Island East
AS	Antelope Island South
AO	Antelope Island, offshore

GREAT SALT LAKE SOUTH SHORE

LS	Saltair/GSL State Park
LC	C7 Ditch

SOUTH SHORE WETLANDS

SI	Inland Sea Shorebird Reserve
SG	Gillmor Sanctuary
SD	Goggin Drain
SN	North Point Canal
SA	Airport Mitigation Site

SOUTHEAST SHORE INDUSTRIALLY-IMPACTED WETLANDS

IP	Petrochem Ponds
IB	Beck Hot Springs
IS	Salt Lake City Wastewater Treatment Plant (Constructed) Wetlands
IO	Oil Drain Canal

FARMINGTON BAY SOUTH

FN	New State Duck Club
FP	Bountiful Pond
FS	State Canal
FC	Farmington Bay Waterfowl Management Area (WMA)- Crystal Unit
FU	Farmington Bay WMA- Unit 1
FO	Northwest Oil Drain Delta

FARMINGTON BAY NORTH

FB	Bair Creek
FK	Kaysville Marsh

OGDEN BAY

OH	Howard Slough
OC	Ogden Bay WMA- South Canal
OS	Ogden Bay WMA- South
OW	Ogden Bay WMA- Weber River
ON	Ogden Bay WMA- North

BEAR RIVER BAY

BR	Bear River Migratory Bird Refuge (BRMBR) (at old entrance gate)

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ACKNOWLEDGEMENTS:

LIST OF COOPERATORS

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- Kennecott Utah Copper Corporation
- National Audubon Society
- The Nature Conservancy
- New State Duck Club
- Salt Lake City Wastewater Treatment Plant
- U.S. Geological Survey
- Utah Division of State Parks and Recreation
- Utah Division of Wildlife Resources
- Friends of Great Salt Lake

Contaminants Assessment affecting Selected Palustrine and Lacustrine Habitats of the Great Salt Lake, 1996-2000

By
Bruce Waddell, Chris Cline, Nathan Darnall, Rex Sohn, Elise Boeke

1.0 INTRODUCTION

The Great Salt Lake (GSL) is the fourth largest natural water body, and the largest saline lake in the United States. Although its saline waters host a deceptively simple food-chain dominated by invertebrates, the biomass produced by this system annually hosts millions of birds that stop on the lake during migration to rest, molt, and re-fuel for the completion of their journeys. The GSL also sits at the downstream end of the largest city and metropolitan area in Utah, and has for the last century been the receiving water body for the waste waters generated by these communities and their supporting industries. Because of concerns regarding potential impact of these wastes on the migratory birds and their habitats that are the trust resources of the United States Fish and Wildlife Service (FWS), agency biologists undertook a comprehensive survey of contaminants and other indicators in the wetlands and open waters of the GSL between 1996 and 2000. Raw data and interim reports of the findings of this study have been used since then to inform policy discussions and to provide background information for a variety of investigations; however this report provides a comprehensive presentation and interpretation of the findings of this study, as well as management recommendations based on current conditions and concerns on the GSL.

1.1 Physical and Biological Setting of the Great Salt Lake

Hydrologic Setting—The GSL is located at the eastern edge of the Great Basin. Along with Mono Lake in California and Pyramid Lake in Nevada, the GSL is one of several vestigial remnants of large Pleistocene lakes that once filled the Great Basin between the Sierra Nevada Mountains to the west and the Wasatch Mountains to the east. As the glaciers that fed these lakes disappeared, the lakes have decreased in size and become saline, terminal basins.

Lake levels in the GSL are controlled by precipitation (inflow) and evaporation (outflow). The effective watershed of the GSL encompasses approximately 55,000 km^2 (21,000 $miles^2$) in northern Utah, southeastern Idaho and southwestern Wyoming (**Figure 1-1**) ((Environmental Management Research Group 2004))(Aldrich & Paul 2002). The majority of inflow enters the southern and eastern shores of the lake via three river systems. From north to south these are: the Bear River, which drains the northern Wasatch Mountains as well as the northern slope of the Uinta Mountains (located approximately 50 miles east of the GSL); the Weber and Ogden Rivers, which drain the central Wasatch Mountains but merge in a broad delta and floodplain on the edge of the lake; and the Jordan River, which drains the south-central Wasatch Mountains as well as the southwestern slope of the Uinta mountains via the Provo River, and then enters the Jordan River drainage system at Utah Lake. Despite these freshwater inflows, the GSL is highly saline, ranging from 12 - 15 percent salinity in the open water of the South Arm (**Figure 1-1**) and nearing saturation at 24 to 26 percent salinity in the North Arm of the lake (J. Luft, Utah Division of Wildlife Resources, pers. comm.). The high salinity is the result of the accumulation of minerals that has occurred in this closed system over the last 10,000 years. By comparison, sea water has a salinity of approximately 3.5 percent.

The GSL is very shallow for its size. The lakebed gradually slopes to a maximum depth of about 10 meters (33 ft); however, the lake's average depth is about 4 m (13 ft) when the lake is at its mean elevation of 1,281 m (4,200 ft) above sea level (ASL) (Arnow 1980). The surface area of the lake at this elevation is approximately 4,400 km^2 (1,700 mi^2) (Environmental Management Research Group 2004). Because of the shallow profile, small fluctuations in lake elevation result in large changes in size and

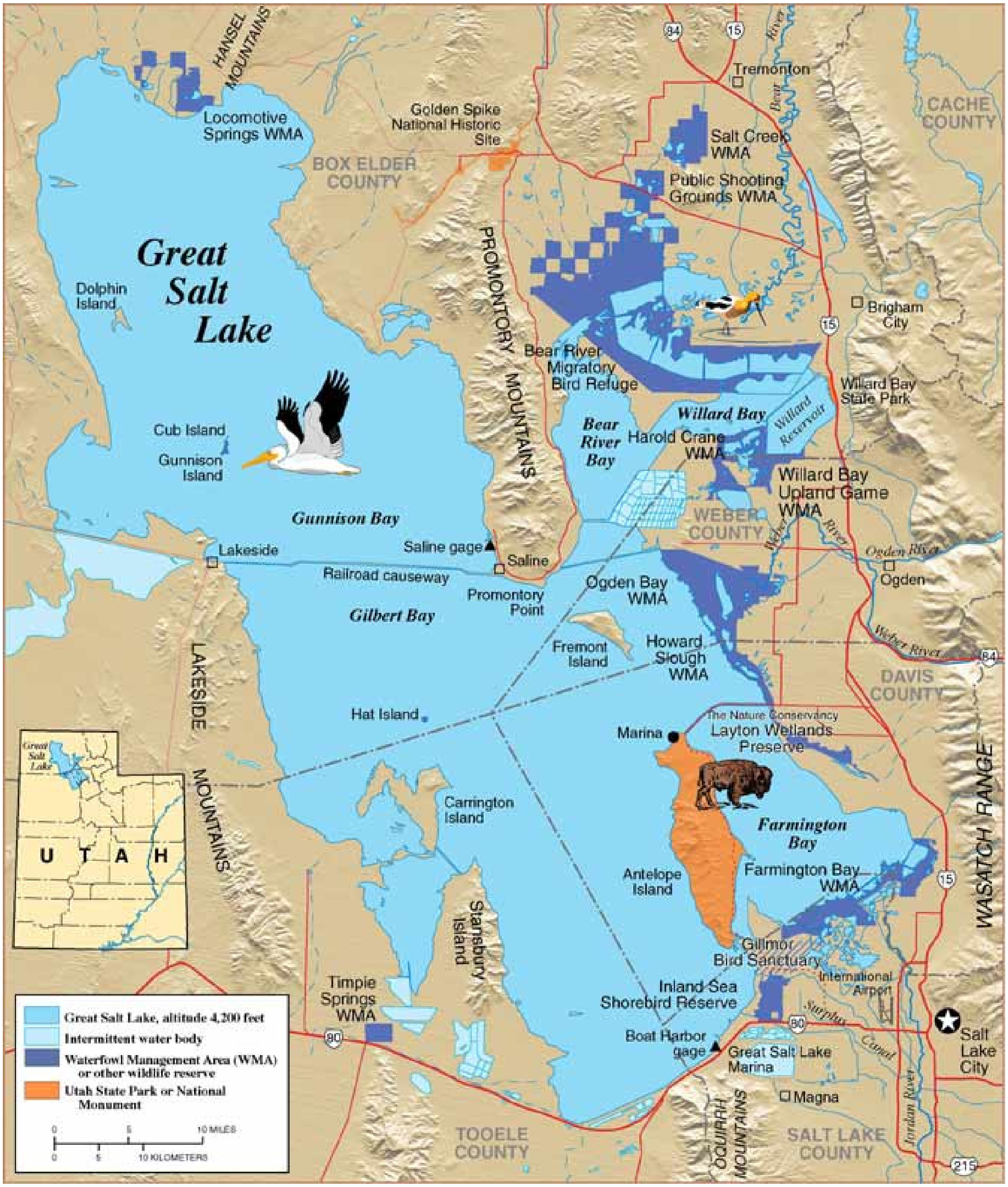

Figure 1-1 Geographic Features and Landmarks of the Great Salt Lake, Utah

habitat type in the lakeshore and delta areas. For example between 1999 and 2001,lake elevations ranged between 1280 m (4,199 ft) and 1282 m (4,205 ft) ASL, with a corresponding change in the surface area of the lake of 207 km^2 (80 mi^2) (U.S. Geological Survey 2001a). Changes in lake level are primarily caused by medium-to-long term trends in both temperature and precipitation and influence all aspects of the lake's ecology, including salinity, populations of in-lake biota, and shifts in both quantity and type of wetland vegetation around the lake.

Biological Communities—Extensive permanent and seasonal wetlands occur at the margins of the GSL, where freshwater inflows from the Jordan, Weber, and Bear Rivers enter the lake in broad alluvial deltas forming a gradient of fresh to brackish water conditions similar to marine estuaries. Dense stands of emergent wetland plant species typically ring areas of deeper open water, dominated by species including bulrush (*Scirpus* spp.) cattail (*Typhus* spp.), and both native and non-native (and invasive) species of "canary reed grass" (*Phragmites* spp.). The invertebrate community of these wetlands includes large numbers of midges (Chironomidae) and water boatment (Corixidae). While the GSL wetland communities are dominated by a relatively small number of species, they provide breeding and feeding habitat for a diverse range of avian species. Similarly, the saline open-water ecosystem of GSL itself is relatively spare, supporting one species of brine shrimp (*Artemia franciscana*) and two species of brine flies (*Ephydra gracilis* and *Ephydra hians*) (Rawley 1980). These species are in turn supported by a group of planktonic and benthic photosynthetic organisms dominated by a few species of algae (including the green alga, *Dunaliella viridis*) and diatoms (U.S. Geological Survey 2001b). However, what this system lacks in complexity it makes up for with an incredibly high volume of biomass, exemplified by a commercial brine shrimp harvesting industry that harvests up to 25 million pounds of brine shrimp eggs (cysts) each year (Utah Division of Wildlife Resources 2005).

The tremendous production of invertebrate biomass within the GSL ecosystem supports a large number of avian species throughout the year, including both migratory transients and breeding birds. On a yearly basis, the lake supports between 2 and 5 million shorebirds, up to 3 million eared grebes (*Podiceps nigricollis*), and hundred of thousands of waterfowl during spring and fall migration periods (Paton et al. 1992; Jehl et al. 1998; Fellows & Edwards 1991). Birds begin arriving in large numbers in early spring, including many migratory transients that use the wetlands as stopovers enroute to breeding areas in the northern United States and Canada, but peak avian numbers occur between April and September, which spans breeding and migratory periods. The wetlands and uplands included in the GSL ecosystem provide important nesting habitat for significant numbers of birds, particularly American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*), white-faced ibis (*Plegadis chihi*) and California gull (*Larus californicus*). The playas and mudflats surrounding the GSL are also a major nesting area for the snowy plover (*Charadrius alexandrinus*) (Paton & Edwards 1990; Paton & Edwards 1991; Paton & Edwards 1991). During the peak periods (April-September), an average of over one million birds are present on the lake or its associated wetland habitats at any one time, with average one-day species counts (recorded between 1997 and 2001) including 122,000 green-winged teal (*Anas crecca*); 93,000 eared grebe; 89,000 northern pintail (*Anas acuta*); 56,000 northern shoveler (*Anas clypeata*), 127,000 Wilson's phalarope (*Phalaropus tricolor*), 94,000 American avocet, and 80,000 California gulls (Manning & Paul 2003). However, even these numbers substantially underestimate the total avian use of the GSL as the study did not cover up to 73% of the total wetlands associated with the lake, including several high-value areas specifically managed as waterfowl habitat (Manning & Paul 2003). As a reflection of the lake's importance as a shorebird migratory staging area, the GSL was recognized in 1992 as a site of hemispheric importance to shorebirds by the Western Hemisphere Shorebird Reserve Network (Manomet Center for Conservation Science).

The GSL is vitally important to several species in which significant proportions of their total (global) population may be present on the lake at any one time. For example, up to one million Wilson's phalaropes, which is more than two-thirds of the world's population, annually migrate through GSL as they travel from their breeding grounds in the nearctic to their wintering area in the high Andes (Jehl 1988) (Colwell & Jehl 1994). Over half of the world's population of eared grebes, which exceeded 2.5 million birds on GSL in 2007 (John Luft, pers. comm.), rely on the open waters of GSL for up to four months during fall migration as a place to molt and regrow flight feathers, and feed on brine shrimp to rebuild energy reserves prior to the final leg of their migration (Jehl 1988). In addition, GSL hosts the largest nesting colony of American white pelicans (*Pelecanus erythrorhynchos*) west of the continental divide (King & Anderson 2005; King & Anderson 2005) with over 14,000 breeding adults on Gunnison Island in 2007 (John Luft pers. comm.). The Intermountain West region is the most important breeding area for the American avocet with up to 50% of the global population occurring around GSL (Sutter et al. 2005).

1.2 Contaminant Concerns on the Great Salt Lake

Approximately 1.7 million people, or about 77 percent of the current population of 2.2 million in the state of Utah, live within watersheds draining into the GSL (Fisher 2006). The convergence of rivers, and rolling uplands with the rich wetlands of the GSL shoreline drew ancestral groups to Paiute, Shoshone and other tribes into the Salt Lake valley far prior to European exploration. With the establishment of Salt Lake City and other communities by Mormon pioneers in the mid-1800's, the process of agricultural and industrial use of the valley's resources began; by the late 1800's, a thriving mineral extraction industry had grown up along the Jordan River, and emissions from smelter stacks clouded the air of the valley. Throughout the 20th century, agriculture in the Salt Lake valley was gradually replaced by industrial and urban development. By 1970, much of the current industrial infrastructure of the Great Salt Lake watershed was in place (e.g., refineries, smelters, factories, wastewater treatment plants, railroads, roads, etc.), almost all of it based on access to process water and wastewater receiving streams. These included minerals refining, industrial manufacturing, rail transportation and petroleum refining. Discharge of wastewaters directly into the Jordan River and other tributaries feeding the GSL was common until pollution controls were implemented in the 1970's and 1980's with environmental regulations such as the Clean Water Act and the Clean Air Act. Many of the earlier industrial sites later were found to be contaminated by waste management practices. In the 1980's and 1990's cleanups under the U.S. Environmental Protection Agency's "Superfund" (Comprehensive Environmental Response, Compensation and Liability Act, or CERCLA) hazardous waste cleanup program were initiated at many of these sites.

Other waterways entering the lake have also carried industrial and urban wastes into the GSL ecosystem. These include the Northwest Oil Drain (NWOD, aka Sewer Canal) and the Ogden River. The NWOD was built to carry wastewaters from the northwest industrial quadrant of Salt Lake City (including refineries, railroad yards and other heavy industries) into the GSL, and also to carry high-water flows of the Jordan River in the spring. Further north, the city of Ogden was an early railroad switching and maintenance hub, and wastes from that industry, along with wastes from large meat packing plants and other industries on the west side of town, were discharged near the confluence of the Ogden and Weber rivers upstream of Ogden Bay on the GSL.

The list of contaminants that have been discharged into the GSL is large and diverse, and includes metals from smelting and refining industries (e.g., arsenic, cadmium, copper, lead, mercury, selenium and zinc), petroleum hydrocarbons including polynuclear aromatic hydrocarbons (PAHs) from refineries, polychlorinated biphenyls (PCBs) from electrical transformers and other industrial uses, and pesticide products associated with orchards, farming, livestock, and industry. Post-war agriculture and pest control practices also contributed a variety of long-lasting organochlorine (OC) pesticide residues, including DDT, endrin and dieldrin, benzene hexcachloride (BHC; lindane), chlordane and others. Another major source of contaminants to the watersheds is municipal wastewater and stormwater, which has been increasing in volume and importance as agricultural lands around the lake have been converted to residential and light industrial development. Contaminants associated with urban development include oil, grease, particulate metals, nutrients, and a variety of herbicides and pesticides in stormwater; and nutrients, ammonia, and trace metals from sanitary wastewater treatment discharges. The latter also includes pharmaceutical residues and other "emerging contaminants" that are largely unaffected by wastewater treatment processes, and which have a newly-recognized potential for environmental disturbance to the GSL watershed. These include natural and synthetic antibiotics, hormones (e.g., estradiol from birth control pills), plasticizers, and other chemicals that may have largely uncharacterized endocrine-disrupting effects (U.S. Geological Survey 2002).

Previous Contaminant Studies—Despite the GSL's position at the receiving end of the industrial and sanitary discharges of the Salt Lake Valley, there had been no comprehensive evaluation of potential environmental contaminant issues within the wetlands surrounding the GSL or the lake itself prior to this investigation. Scattered, small-scale studies around the lake occasionally included evaluations of contaminants such as organochlorines in the late 1970's when they were first realized as a potential problem (Lindvall & Low 1979) or investigations of analyte groups that happened to include contaminants of concern to wildlife managers. Sampling by the Service in 1994 documented that some inorganic constituents, in particular selenium, were present at levels of concern in brine shrimp at certain sites within the South Arm of the Great Salt Lake (Waddell et al. 1999).

The cumulative effect of releases from industrial sites (particularly those that had been in operation prior to modern practices and regulations) around the GSL have typically been investigated in the context of CERCLA or other regulatory-directed cleanups. These investigations typically identify releases on-site or immediately down gradient, with evaluation of off-site or downstream effects usually omitted due to technical, legal and economic limitations. In most cases in the Salt Lake valley, tight clay soils which originated as lakebed sediments do not allow contaminants to travel far off site. But there have been cases where contaminant plumes have intersected active groundwater systems, adversely impacting down gradient wetlands. The most notable example of this within the GSL ecosystem is the Kennecott Utah Copper Corporation (KUCC) metals smelter and refinery on the south shore of the GSL. At this site, water-soluble metals from the refining process (including arsenic and selenium) stored in unlined lagoons or bunkers were dissolved into groundwater at the facility, which then traveled downgradient and intersected groundwater supplying a large wetland complex on the south shore of the lake. A second industrially-linked contaminant source to the GSL is the Northwest Oil Drain, discussed previously. However, even in cases where contaminant impacts to the GSL ecosystem were suspected, assessment and cleanup action boundaries were relatively tightly drawn around these facilities, and the distribution and/or effects of contaminants further downstream in the GSL ecosystem were frequently not part of the initial problem identification process.

1.3 Need and Purpose for Study

This study was initiated due to concerns regarding the potential impact of contaminants on the health of migratory birds (which are a "trust resource" of the U.S. Department of Interior and the FWS) and other species in the high quality wetland habitats surrounding the GSL. Also, as environmental cleanup investigations and actions have taken place on the lake's shore, there has been a need for better data regarding the impact of contaminants associated with these sites on the GSL wetlands. Other environmental regulatory decisions such as the development of water quality criteria to protect the GSL and its biological resources also require better characterization of baseline contaminant conditions. These needs have become more acute over the last decade as pressures from development, demand for recreation, and interest in preservation have increased. This purpose of this study was to collect data to increase the quality and quantity of data that would help to characterize the nature, extent and magnitude of contaminants within the wetlands and the open-waters of the GSL in order to support the setting of priorities regarding source control and other management activities. Since the study was initiated at the beginning of a period of accelerated economic and population growth within northern Utah, it can also provide a baseline contaminant characterization that agencies and other organizations working to preserve and mitigate wetland habitats on the lake can use to understand potential management issues or limitations in these areas. The primary purpose of the investigation was to collect data to evaluate 1) if (and where) effects of contamination in birds and or their habitats currently exist, and 2) if these effects were occurring at sufficient magnitude to warrant further study that could eventually lead to remedies such as changes in resource management or cleanup of contaminated areas.

2.0 STUDY OBJECTIVES, AREA, AND DESIGN

The overall objectives for the GSL Wetlands and Open Water study included:

1. Reconnaissance—Assess the general distribution and degree of contamination in GSL wetlands that are representative of wetland types and locations most significant to migratory birds.
2. Advanced Reconnaissance—Conduct detailed contaminant assessments of specific wetland types and locations considered at risk from contaminant sources and loading, and evaluate pathways of exposure posing significant hazards to migratory birds.
3. Analyze spatial and temporal correlations between contaminant sources, wetland types, degree of contamination, and impacts on migratory birds in the southern GSL system.

2.1 Study Area

Based on the first study objective described above, wetlands around the GSL were selected for investigation in an effort to encompass both the diversity of habitats that support Service trust resources within the GSL ecosystem and to include areas where contaminant inputs were known or suspected. The open waters of the GSL, focusing on Gilbert Bay (also referred to as the South Arm) were also included in the assessment because it is highly productive of the algae, brine shrimp and brine flies that characterize the biomass of the GSL ecosystem, and supports a large number of migrating and wintering avian species. While Gilbert Bay is not directly connected to runoff and effluents from the urban and industrial sources surrounding the GSL, lake currents and other transport processes (e.g., atmospheric deposition) bring land-based contaminants into the open water system.

Wetland habitats evaluated in this study included both riverine (associated with river floodplains) and palustrine (ponded, shallow-water, with submerged and/or emergent vegetation) types, with selected areas extending from the Great Salt Lake State Park on the southern shore to the Ogden Bay Waterfowl Management Area on the east-northeast side of the lake (**Figure 1-1**). This study area includes hundreds of square miles of wetlands which are fed by freshwater inflows to the lake. Wetlands in an industrialized area of North Salt Lake, which are remnants of a large wetland complex that had been extensively filled and altered in the early 20th century, were also included in the study. While the extent and quality of these wetlands are impaired by urbanization and development, they still provide habitat for shorebirds and waterfowl, and can potentially expose birds to contaminants associated with the industrial activities occurring near them, which include refineries, wastewater treatment plants and chemical manufacturing and storage facilities. Finally, ponds, marshes and seeps on the mainland and shore of Antelope Island, located about 7 miles off the eastern shore of the GSL, were also included in the study because there has previously been little or no characterization of these areas and because they have not been influenced by inflows from the surrounding watershed.

Within these broad geographic areas, specific study sites were chosen based on available access, recognized potential for contamination, conservation status (e.g., wildlife areas or sites being considered for wetland mitigation), and availability of proposed sample media (e.g., sediments, fish, avian eggs). The 31 study sites were grouped into 9 geographic units for analysis and reference throughout this report. Location codes for these sites are presented in **Table 2-1; Figure 2-1** shows the location of these sites around the GSL. A brief description of the habitat types and potential site-specific contaminant issues at each location is presented in Table 2-2.

2.2 Sampling Rationale for GSL Wetlands Synoptic Survey (1996-1997)

The primary objective of the initial reconnaissance phase of the GSL study (1996-1997) was to obtain a representative overview of environmental contaminants in and upstream of important GSL wetland habitats. Study sites were selected based on the history of the individual area, including known or

Table 2-1 Geographic Areas, Sample Site Designations and Location Codes for data collection sites in and around the Great Salt Lake.

Code	Site Name	Code	Site Name
GSL Open water		***Farmington Bay South (WS)***	
GU	Gilbert Bay- USGS Sites	FN	New State Duck Club
GG	Gilbert Bay	FP	Bountiful Pond
GC	Gilbert Bay C-7 Ditch Delta	FS	State Canal
GD	Gilbert Bay Goggin Drain Delta	FC	Farmington Bay WMA- Crystal Unit
GL	Gilbert Bay Lee Creek Delta	FU	Farmington Bay WMA- Unit 1
Antelope Island (WS)		FO	Northwest Oil Drain Delta
AE	Antelope Island East		
AS	Antelope Island South		
AO	Antelope Island, offshore	***Farmington Bay North (WS)***	
Great Salt Lake South Shore (WS)		FB	Bair Creek
LS	Saltair/GSL State Park	FK	Kaysville Marsh
LC	C-7 Ditch	***Ogden Bay (WS)***	
South Shore Wetlands (WS)		OH	Howard Slough
SI	Inland Sea Shorebird Reserve	OC	Ogden Bay WMA- South Canal
SG	Gillmor Sanctuary	OS	Ogden Bay WMA- South
SD	Goggin Drain	OW	Ogden Bay-Weber River
SN	North Point Canal	ON	Ogden Bay WMA- North
SA	Airport Mitigation Site		
SE Shore Industrial-area wetlands (WS)		***Bear River Bay***	
IP	Petrochem Ponds	BR	Bear River Migratory Bird Refuge entrance
IB	Beck Hot Springs		*(note: this area included only as a reference area for the study described in section 4.6)*
IS	SLC Sewage Treatment Plant		
IO	Oil Drain Canal		

WS=1996-1997 GSL Synoptic Wetlands Survey

suspected contaminants issues, which are summarized in **Table 2-2**. Factors such as access, time and funding constraints on sampling and analysis were also considered.

The general approach at each wetland location was to sample and analyze sediments, whole-body fish, bird eggs, and species of invertebrates eaten by birds for total metals and organochlorine (OC) compounds (primarily persistent chlorinated pesticides such as DDT, chlordane, dieldrin, etc.) in order to develop a weight-of-evidence approach to identify trends and/or hotspots in contaminant concentrations. In selected locations, a suite of biomarkers was analyzed in fish to look for evidence of exposure and/or effect due to certain contaminants. Subsets of samples were evaluated for location-specific or specialized contaminants, including sediments that were analyzed for total petroleum hydrocarbons (TPH), a general measure of the presence of petroleum products. A small number of sediment and tissue samples were also evaluated for dioxins and furans, which are highly toxic and bioaccumulative compounds that are by-products of industrial contamination and incomplete combustion. Sample media, numbers and analytes for the areas covered by this study are summarized in **Appendix Table A-1**, and results are presented and discussed in Section 4 (wetlands) and Section 5 (open waters)

In addition to contaminant residues, biomarkers were analyzed in carp collected from wetlands with freshwater inflows as an indirect and/or direct indicator of potential contaminant exposure to wildlife

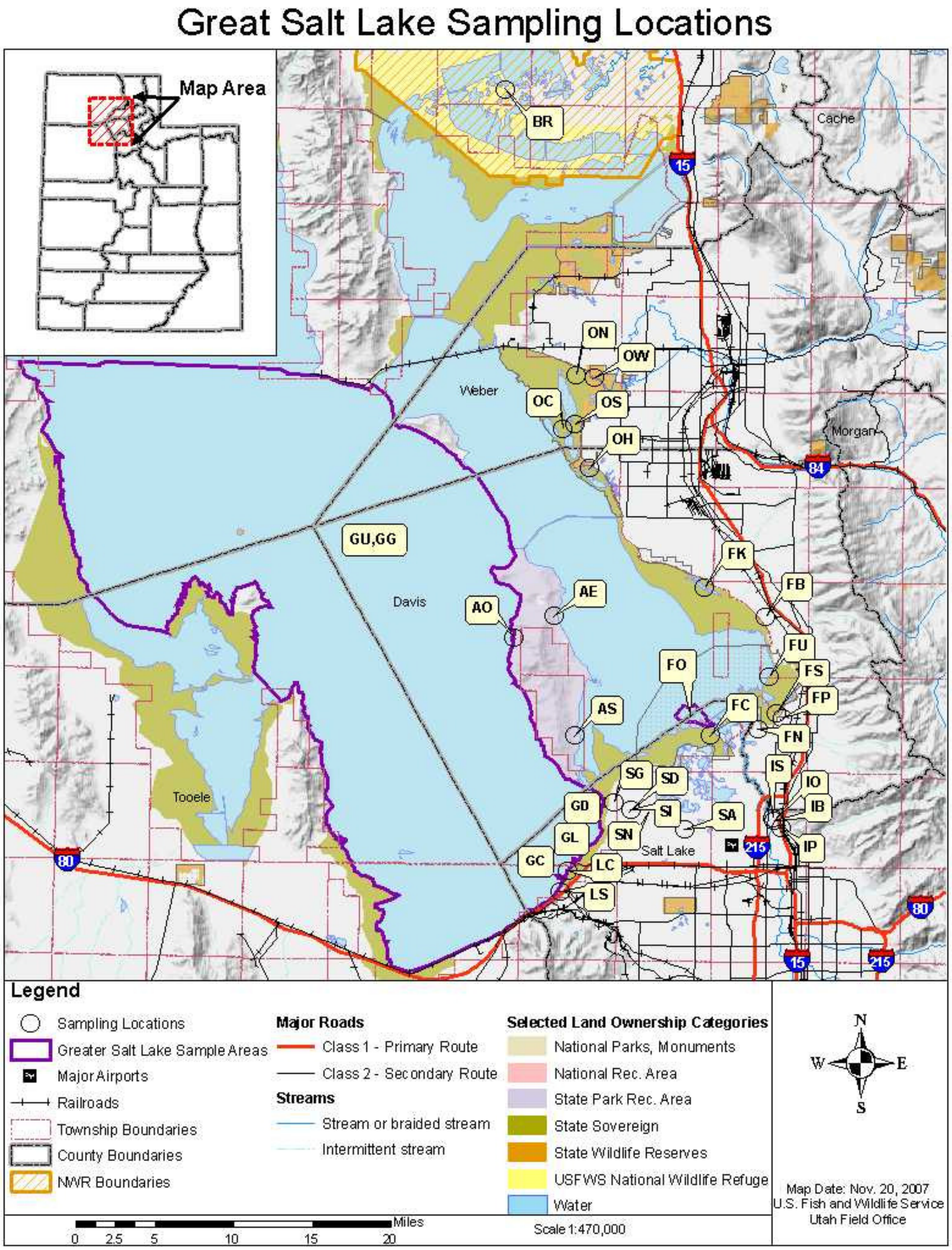

Figure 2-1 Location of Sample Sites included in Great Salt Lake Wetland and Open Water Contaminants Assessment, 1996-2000.

Table 2-2 Summary of habitat types and potential contaminant issues at wetlands and open water sites included in the Great Salt Lake Contaminants Assessment, 1996-2000 (*page 1 of 3)*

Loc. Code	Site Name	Site Description	Year(s) Sampled	Rationale for Inclusion in Study
GSL Open Water				
GU	Gilbert Bay USGS Stations	Stations (lat/long locations) in Gilbert Bay established by USGS to assess physical and biological characteristics of the lake; points randomly selected.	1996	Baseline contaminant survey of GSL open water habitat
GG	Gilbert Bay FWS Stations	Stations (lat/long locations) established by FWS.	1997, **1998, 1999**, **2000**	*same as above* (1997) FOLLOW-UP STUDISS (grebes, sediments, and brine shrimp)
GC	Gilbert Bay offshore of C-7 Ditch delta	Near outfall of copper smelter wastewater discharge on south shore of GSL.	**2000**	Assessment of potential source of contaminant exposure
GD	Gilbert Bay near Goggin Drain delta	Near delta of Goggin Drain on south shore of GSL.	**2000**	*same as above*
GL	Gilbert Bay offshore of Lee Creek delta	Near delta of stream on south shore of GSL which receives return flows from western side of Salt Lake valley and the Oquirrh Mountains.	**2000**	*same as above*
Antelope Island				
AE	Antelope Island-East	Mudflats and seasonally inundated playa on the eastern shore of Antelope Island.	1996	Baseline contaminant survey (remote, relatively undisturbed site, minimal contaminant history)
AS	Antelope Island-South	Ponded, constructed inland wetland on the southeastern side of Antelope Island.	1996	*same as above*
AO	Antelope Island-offshore	Saltflat with shallow water just off western shore of Antelope Island.	1996	*same as above*
Great Salt Lake South Shore				
LS	Saltair / Great Salt Lake State Park	Emergent spring-fed wetlands and mudflats downgradient from area with groundwater contamination.	1996, 1997	Baseline contaminant survey of GSL shoreline wetland; assessment of potential source of contaminant exposure
LC	C7 Ditch	Wastewater canal from copper smelter facility to GSL; bordered by riparian wetland habitat.	1996, 1997	Assessment of source of contaminant exposure to GSL wetland habitats and open water
South Shore Wetlands				
SI	Inland Sea Shorebird Reserve	Estuarine wetland complex; mix of naturally-occurring and created wetlands; wetland mitigation site.	1996	Baseline contaminant survey in important GSL wetland habitat
SG	Gilmore Sanctuary	Estuarine wetland complex; conservation area.	1996, 1997	*same as above*
SA	Airport Mitigation Site	Constructed palustrine wetland (ca. 100 acres) several miles SE of the GSL south shore.	1997	*same as above*
SD	Goggin Drain	Agricultural drain, water from a diversion of the Jordan River. Minimal habitat for birds or fish but forms delta on shoreline.	1996	*same as above*

Table 2-2 Summary of habitat types and potential contaminant issues at wetlands and open water sites included in the Great Salt Lake Contaminants Assessment, 1996-2000 (*page 2 of 3*)

Loc. Code	Site Name	Site Description	Year(s) Sampled	Rationale for Inclusion in Study
South Shore Wetlands (continued)				
SN	North Point Canal	Canal draining western Salt Lake Valley and receives flow from Surplus Canal. Minimal habitat for birds or fish; supplies water to Sites SI & SA.	1996, 1997	Baseline contaminant survey in important GSL wetland habitat
Great Salt Lake Southeast Shore Industrial-area Wetlands				
IP	Petrochem Ponds	Small spring-fed palustrine wetlands, <1acre. Downgradient from the Petrochem CERCLA Site and near railroad and other industrial facilities.	1996	Baseline contaminant survey of wetland with suspected contaminant exposure.
IB	Beck Hotsprings	Ephemerally wetted playa, remnant of a historically larger wetland. Geothermally warmed water is open year-round. Surrounded by heavy industry.	1996	*same as above*
IO	Northwest Oil Drain Canal (aka Sewer Canal)	Canal originating near refineries and industrial facilities in N. Salt Lake. Supplies water to Farmington Bay. Sediments of main canal remediated under CERCLA.	1996	*same as above*
IS	SLC Wastewater Treatment Plant	Constructed wetlands demonstration project at large wastewater treatment plant using effluent as water supply.	1996, 1997	*same as above* *Note: Samples in 1997 collected due to observation of deformed bird embryo in 1996*
Farmington Bay- South				
FN	New State Duck Club	Estuarine wetland located at entry of Jordan River Delta into Farmington Bay.	1996	Baseline contaminant survey in important GSL wetland habitat
FP	Bountiful Pond	Large (8-10 ac) created palustrine wetland, downgradient of urban industrial area, upgradient of important GSL wetland habitat.	1997	Baseline contaminant survey of wetland near industrialized area Assessment of potential source of contaminant exposure to downstream habitats
FS	State Canal	Estuarine wetland located at inlet of fresh water to Farmington Bay WMA (within WMA).	1996, 1997	Baseline contaminant survey in important GSL wetland habitat
FC	Farmington Bay WMA-Crystal Unit	Managed ponds, emergent wetlands and dikes within Farmington Bay WMA. Located south of the point of entry of the State Canal into the WMA.	1996, 1997, **2000**	Baseline contaminant survey in important GSL wetland habitat. *FOLLOW-UP STUDY(2000)- mercury and methyl mercury in bird eggs*
FU	Farmington Bay WMA-Unit 1	Managed ponds, emergent wetlands and dikes within Farmington Bay WMA. Is located west and north of the point of entry of the State Canal.	1997	Baseline contaminant survey of important GSL wetland habitat
FO	Oil Drain Delta	Shallow emergent sediment deposition area where Oil Drain canal enters directly into Farmington Bay; within Farmington Bay WMA.	1997, **2000**	Baseline contaminant survey of important GSL wetland habitat potentially impacted by industrial discharge. *FOLLOW-UP STUDY (2000)- petroleum-related contaminants in sediments*

Table 2-2 Summary of habitat types and potential contaminant issues at wetlands and open water sites included in the Great Salt Lake Contaminants Assessment, 1996-2000 (*page 3 of 3*)

Loc. Code	Site Name	Site Description	Year(s) Sampled	Rationale for Inclusion in Study
Farmington Bay- North				
FB	Baer Creek	Alluvial delta downstream of Central Davis County WWTP and upstream of Farmington Bay WMA. Agriculture, residential and light industrial upstream land use.	1997	Assessment of potential source of contaminant exposure to downstream habitats
FK	Kaysville Marsh	Small creek with urban/agricultural upstream land use that flows into significant conservation wetland (Layton Marsh) that forms estuary in northern Farmington Bay.	1996, 1997	Baseline contaminant survey of important GSL wetland habitat
Ogden Bay				
OH	Howard Slough	Large estuarine marsh supplied by water from Ogden and Weber rivers, flowing into northeast Gilbert Bay. Significant agricultural and increasingly urban land uses upstream.	1997	Baseline contaminant survey of important GSL wetland habitat
OC	Ogden Bay- South Canal	Canal supplying water to the southern portion of the Ogden Bay WMA. Much of the water volume is return flows from agricultural areas SE of Ogden Bay.	1996	Assessment of potential source of contaminant exposure to important GSL wetlands
OS	Ogden Bay WMA- South	A shallow estuarine wetland area in southern portion of Ogden Bay WMA, managed with dikes to form a series of shallow ponds.	1996	Baseline contaminant survey of important GSL wetland habitat
OW	Ogden Bay- Weber River	The Weber River as it flows into Ogden Bay WMA. Significant industrial upstream land use, including Ogden Railyard, a remediated CERCLA site.	1996	Assessment of potential source of contaminant exposure to important GSL wetlands
ON	Ogden Bay WMA- North	Shallow ponds and emergent wetlands in the northern portion of the Ogden Bay WMA; downstream of SiteOW	1996, 1997, **1999**	Baseline contaminant survey of important GSL wetland habitat. *FOLLOW-UP STUDY(1999)- uptake of PAHs from foodchain into barn swallows*
Bear River				
BR	Bear River Migratory Bird Refuge	Major freshwater inflow into the northeastern portion of the GSL. Similar terrain, water quality and habitat as site ON, but without industrialized upstream land use	**1999**	Reference area for study evaluating potential exposure and effects of PAHs at site ON

* NOTE: Years in **BOLD** type indicate follow-up studies

ABBREVIATIONS

CERCLA: *Comprehensive Environmental Response, Compensation & Liability Act*
WMA: *Waterfowl Management Area*
WWTP: *Wastewater treatment plant*
USGS: *United States Geological Survey*

(including migratory birds and waterfowl) in those areas. Two enzyme endpoints were evaluated, acetyl cholinesterase (AChE) enzyme activity, which is a direct indicator of exposure to organophosphate (OP) and carbamate pesticides; and ethoxyresorufin-o-deethylase (EROD) activity, which can indicate exposure to organochlorine and polynuclear aromatic hydrocarbon (PAH) compounds. Fish liver bile was also evaluated for PAH metabolites which can indicate recent exposure to PAHs--either via petroleum products (e.g., oil and fuel spills or releases) or from atmospheric deposition of incompletely combusted hydrocarbons. Finally, plasma sex steroid hormones 17β-estradiol (E_2), 11-ketotestosterone (11-KT) and vitellogenin, were measured in fish blood. In combination with other data, including both contaminant concentrations and habitat and fish health factors, these endpoints can provide evidence of exposure to contaminants that are associated with endocrine disruption which can indicate (based on evaluation of overall and relative concentrations in male and female fish) exposure to endocrine disrupting compounds. The findings of these investigations are presented in Section 4.

The open waters of Gilbert Bay were sampled concurrently with the GSL wetland investigations, with sediments, brine shrimp and livers from eared grebes (*Podiceps nigricollis*) analyzed to characterize contaminant exposure and distribution through the open water ecosystem. Samples were primarily analyzed for metals. Eared grebes were selected for analysis because they have the potential to be highly exposed to food-chain contaminants on the GSL as they spend three to five months during fall migration on the open waters of the lake, during which they feed almost exclusively on brine shrimp. These results are presented in Section 5.

2.3 Follow-up Studies of Selected Areas (1998-2000)

Based on preliminary evaluation of the GSL wetlands and open water data collected in 1996-1997, we conducted additional sampling and/or subsequent investigations at selected sites where there was evidence of potential contaminant exposure. These efforts included:

- additional sampling of the open waters of the GSL to collect data on potential seasonal trends in contaminant exposure on the open lake, and additional sampling of sediments at three "deltas" on the south shore of the GSL formed by freshwater drains and effluents that have historically carried industrial effluents and irrigation return flows (**Section 5**);
- a follow-up evaluation of mercury in eggs of piscivorous birds in the Crystal Unit of the Farmington Bay Waterfowl Management Area (FBWMA) (**Section 6**)
- sampling of sediments at the mouth of the Northwest Oil Drain (NWOD), a canal initially built to carry industrial effluents to the GSL. This canal enters the GSL within the FBWMA, forming a depositional delta which supports a large number of sediment-foraging birds (**Section 7**)

A fourth follow-up investigation of potential uptake and effects of PAHs in barn swallows (*Hirundo rustica)* in Ogden Bay (site ON), was also conducted to evaluate potential impacts from effluents from rail yards and other industries on the Ogden Bay Waterfowl Management Area (OBWMA). A reference site at the Bear River Migratory Bird Refuge (BRMBR), located in a separate watershed north of Ogden Bay was selected as a reference site. Results of this investigation were inconclusive due to logistic and other issues, and are not reported here. However, complete PAH data for the media evaluated (sediments, benthic macroinvertebrates, and barn swallow eggs and nestlings at both sites) are presented in **Appendix E**.

3.0 MATERIALS AND METHODS

Samples of environmental media for this study were collected using procedures designed to prevent cross-contamination and were stored and transferred to preserve the integrity of the sample (e.g., cold storage, fixation and analysis within accepted sample holding times). In general, samples were collected using decontaminated and/or chemically clean collecting equipment and appropriate sample containers. Re-usable equipment (e.g., stainless steel sampling spoons, pans, etc.) was decontaminated before use by washing with a laboratory-grade detergent (e.g., Alconox™), a laboratory-grade 10% nitric acid solution, and a laboratory-grade non-polar solvent such as acetone or hexane, with each step followed by a deionized water rinse. In many cases, site water was used as a final rinse prior to equipment use.

Additional field data collected along with analytical samples included basic water quality field parameters (temperature, conductivity, pH, and dissolved oxygen), meteorological conditions, avian species composition and approximate numbers of birds. This information was recorded into field notebooks or data forms and was retained on file at the field office for later use.

3.1 Collection and Sampling Methods

Sediments – Composited grab samples of surface sediments were collected using a decontaminated stainless steel sampling spoon or a ponar dredge. Composites were formed by mixing samples from three to five sub-locations in a stainless steel pan using a spoon. Sediments were not sieved; however, attempts were made to collect only fine textured material and avoid sediments with a high prevalence of sand or coarser material. The mixed sediments were transferred to three 250 ml labeled chemically clean glass jars with Teflon® lined lids or sealable polyethylene bags if the samples were to be analyzed for inorganic elements only. A desired minimum sample mass was 200 g. Samples were transported on wet or dry ice to the Utah Field Office field lab in Salt Lake City, Utah where they were stored in commercial freezers (-12° C) until shipped on dry ice to the Geochemical and Environmental Research Group (GERG) at Texas A&M, College Station, Texas for analysis.

Invertebrates – Invertebrate samples were collected at riverine, palustrine and lacustrine sites. Preferred taxa included midge larvae (Chironomidae) and mixed benthic invertebrates, including damselfly and dragonfly larvae (Ondonata), plankton (e.g., *Daphnia* spp) and waterboatman beetles (Corixidae). The majority of samples were collected with kick-nets and transferred using forcepsto chemically clean glass jars with Teflon® lined lids. Sealable polyethylene bags were also used for samples to be analyzed for inorganic elements only. Desired minimum sample mass was 10 grams. Light traps (Espinosa and Clark 1972) were used at several sites to collect aquatic invertebrates when kick-nets proved non-productive. Brine shrimp adults and cysts were collected on the South Arm of the GSL from the top 20-30 cm of water surface by towing kick-nets or plankton nets from a boat. Samples of brine shrimp cysts were separated from adults with 500 and 106 micrometer stainless steel sieves. Flying invertebrates were collected at the Bear River MBR and Ogden Bay WMA using sweep nets from moving vehicles along the dike roads. All samples were transported on wet or dry ice to the Utah Field Office lab in Salt Lake City, Utah and stored frozen in commercial freezers (-12° C) until shipped on dry ice to GERG for analysis.

Fish – Fish were collected at major source-waters close to the Great Salt Lake or in wetlands using gill nets, Fyke nets, minnow traps or angling. Three composite, whole-body samples of five adult fish (generally common carp, *Cyprinus carpio*) were collected at most sites, though composite samples of Utah chub (*Gila atraria*) and mosquitofish (*Gambusia affinis*) were also collected. Fish were often held in live wells until processed and samples of similar-sized fish were composited. Total length, weight, sex and body condition were recorded in the field. Large whole-body fish collected for organochlorine analysis were double wrapped in aluminum foil then placed in plastic bags. Samples were stored under dry ice in the field, transported to the Utah Field Office lab and stored in commercial freezers (-12° C) until shipped to GERG for analysis. Individual fish were collected and tissues dissected for biomarker analysis at selected sites. These included:

<u>AChE Inhibition</u> –Up to six head from each site were individually wrapped in aluminum foil, frozen using dry ice and shipped to the Patuxent Wildlife Research Center (PACF) in Laurel, Maryland for analysis of brain AChE activity. Brains were dissected out of the craniums at the laboratory and prepared for quantification of AChE enzyme activity by spectrophotometry (Ellman et al. 1961).

<u>EROD Activity</u> – Six carp livers from most sites were necropsied in the field using chemically clean or single-use instruments, visually inspected for gross pathological lesions, and weighed to the nearest 0.1 g. Approximately 5 grams of tissue was stored in plastic cryovials and immediately frozen using dry ice. Samples were stored in liquid nitrogen at the Utah Field Office lab until shipped to PACF where they were subsequently prepared and analyzed for EROD activity according to standard methods described in Kennedy and Jones (1994) and Melancon (1996).

<u>PAH Metabolites</u> – Three bile samples were collected from three separate gall bladders from each of eight pre-selected sites using pre-chilled syringes and glass serum collection tubes. Samples were immediately frozen using dry ice and remained frozen until shipped to GERG for analysis of PAH metabolites benzo(a)pyrene, naphthalene, and phenanthrene.

<u>Endocrine Disruption</u> – 20 individual caudal vein blood samples (preferably ten male and ten female) were collected from each site using 25-28 gauge needles and stored in 5 cubic centimeter (cc) heparinized Vacutainer tubes on wet ice prior to transport to the Utah Field Office lab. Plasma was collected using disposable plastic pipettes and frozen at -12º C in polyethylene cryovials after each blood sample was centrifuged at 10,000 rpm (± 10% rpm) for 10 minutes. Samples were shipped frozen to the Florida Caribbean Science Center (FCSC) in Gainesville, Florida. Gonads from these fish were removed and weighed, and approximately 5 grams of gonadal tissue placed in Bouin's preservative solution and also shipped to FCSC for histopathological evaluation and determination of reproductive status.

Bird Eggs – Three to five eggs of wetland-dependent bird species were collected at each of 19 reconnaissance sites during 1996 and 1997, where possible. Black-necked stilt (*Hymantopus mexicanus*) and American coot (*Fulica americana*) were the primary species of choice; however, if these species were not available, secondary choices for egg collections were American avocet (*Recurvirostra americana*) and pied-billed grebe (*Podilymbus podiceps*), followed by other shorebirds or ducks. The two species approach (i.e., shorebirds and "ducks") permitted the evaluation of shoreline/mudflat/playa habitats and open water habitats within one sample site. One randomly selected egg was collected per nest, preferably at a late stage of development to allow for evaluation of viability and deformities in embryos. Eggs were candled (Klett et al 1986) or floated (Westerskov 1950) in the field to determine approximate age. Eggs were held at ambient temperature for a maximum of eight hours and transported to the lab where standard measurements were made, stage of development determined using the method described in Caldwell and Snart (1974) and embryos examined for viability and gross abnormalities. Following measurements, egg contents were then transferred to chemically cleaned containers and stored at -12°C prior to shipment to GERG. All egg samples were individually analyzed for chemical constituents.

Additional barn swallow eggs were collected in 1999 from Ogden Bay WMA and Bear River MBR for PAH analysis. Nests were monitored every two to four days to record clutch size and nesting success, and the approximate age of the eggs was calculated from nest chronology data. Two late-term eggs were collected per nest, prepared as above, and combined into a single composite sample.

Additional Forster's tern (*Sterna forsteri*) eggs were collected in 2000 from the Crystal Unit of Farmington Bay WMA for total and methylmercury analysis. Tern nests were marked during the egg

laying and early incubation stages and one eggs from each of 12 nests was collected and processed as described above approximately three weeks following the initiation of incubation.
Bird Livers – Eared grebes were collected on the South Arm of the Great Salt Lake in 1997, 1998 and 2000 using a shotgun and steel shot. Birds were sampled during spring migration (April and May) and fall migration and molt (September, October, November and December). Age class (young of year, juvenile, adult) for each bird was estimated by plumage and eye color (Jehl 1988). Birds were placed into plastic bags and transported on wet ice to the Utah Field Office lab where they were weighed and necropsied. Livers were removed and weighed using decontaminated instruments and body condition based on internal and subcutaneous fat deposits was recorded. Liver samples collected in 1998 and 2000 were analyzed individually for trace elements. Samples collected in 1997 were equal-weight composites analyzed for inorganic and organic constituents including dioxins and furans. One composite of eight livers came from south of Antelope Island, one composite of nine livers came from midway between Antelope Island and Stansbury Island, and one composite of 5 livers came from north of Stansbury Island.

3.2 Analytical Methods

Inorganic Constituents – Tissues were digested in heavy-walled, screw-cap Teflon® Bombs with concentrated high purity nitric acid and sediments are digested with aqua regia in glass beakers on a hotplate (Analytical Control Facility 2006). Chemical analysis for most inorganic constituents (aluminum, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, strontium, vanadium and zinc) was performed using inductively coupled plasma atomic emission spectroscopy. Arsenic was analyzed using graphite furnace atomic absorption spectrometry (AAS) while selenium was analyzed using either graphite furnace or hydride generation AAS. Mercury was analyzed by cold vapor AAS described in EPA method 245.5 with minor revisions and a modification of the method of Hatch and Ott (1968). Chemical analysis for trace elements was performed primarily by GERG though some samples were analyzed by PACF.

Organic Constituents – Tissue samples were extracted by the NOAA Status and Trends Method (MacLeod et al 1985) with minor revisions (Brooks et al. 1989; Wade et al. 1988). Sediment samples were freeze-dried and extracted in a Soxhlet extraction apparatus (Analytical Control Facility 2006). Quantitative analyses of chlorinated and non-chlorinated compounds were performed by GERG using capillary gas chromatography (CGC) with a flame ionization detector for aliphatic hydrocarbons, CGC with electron capture detector for OC pesticides and PCBs, and a mass spectrometer detector in the single ion monitoring (SIM) mode for aromatic hydrocarbons (Wade et al 1988). Endosulfan I and PCB congeners 114 and 157 co-elute with other analytes in normal CGC mode with electron capture, so in most cases samples were analyzed by CGC with a mass spectrometer detector in the SIM mode (Analytical Control Facility 2006). Aromatic hydrocarbon metabolites benzo(a)pyrene, naphthalene, and phenanthrene in bile were analyzed using high performance liquid chromatography (HPLC) and methods described in (Krahn et al 1984; Krahn et al 1986a; Krahn et al 1986b). Total petroleum hydrocarbons (TPH) were analyzed by gas chromatography-mass spectrometry. Dioxins and furans were analyzed by high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) following methods of (Tondeur 1987; USEPA 1990).

Biomarker Analyses – Brain AChE was analyzed using methods that generally followed the procedures of Ellman et al (1961). Exposure to carbamate pesticides was evaluated by incubating samples with the oxime 2-pralidoxime (2-PAM). AChE activity was quantified using a colorimetric spectrophotometer that measures the rate of production of 5,5'-dithiobis-2-nitrobenzoate produced (DTNB).
EROD enzyme activity was quantified at PACF using standard methods described in Kennedy and Jones (1994) and Melancon (1996). Blood plasma was analyzed at the FCSC for 17β-estradiol (E_2, also referenced in this report as E), 11-ketotestosterone (11-KT, also referenced in this report as T), and vitellogenin at FCSC using methods described in Goodbred et al. (1997). Histopathology of gonads was also performed at the FCSC.

Quality Assurance/Quality Control – Laboratory quality assurance/quality control was monitored by the PACF and individual labs, and also by the authors during the data analysis and reduction phase. Labs performed the required number of blanks, spikes, duplicates and use of standard reference materials according to the contract with PACF.

3.3 Data Analysis

Our objective was to determine spatial trends in contaminants in relation to wetland types or spatial trends in relation to known or suspected contaminant sources or pathways. Various methods were used depending on sample type and sample size. These included statistical comparisons between areas and sampling sites, and comparing data to accepted and relevant benchmarks (e.g., screening levels) for contaminant exposure and effects.

Statistical analysis was performed using either NCSS 2001 (Hintze 2001) or Excel (Microsoft Corp, Redland, WA). NCSS 2001 was also used to produce box plots and scatterplots while Excel was used to produce bar charts. In general, statistical comparisons were more widely used to evaluate metals concentrations due to larger sample sizes and greater detection frequency; organochlorine residues (with the exception of PCBs and DDT) were regularly below the level of detection and so were often evaluated by simple presence/absence/relative magnitude.

Assumptions of normality were tested using either the Shapiro-Wilk W test or the Martinez-Iglewicz test, data were $\log_{10}$-transformed where necessary, and critical significance value was set at $\alpha = 0.05$.

Significant differences among groups (e.g., study areas or study sites) were evaluated using analysis of variance (ANOVA) or T-tests. Differences between areas or sites were determined using the Tukey-Kramer or the Fishers Least Significant Difference tests. Linear regression was used to determine the relationship between mercury and methylmercury in tern eggs while the nonparametric Spearman Rank Correlation test was used to determine correlations between trace elements.

Data were compared to ecotoxicological screening benchmark concentrations where available, as a primary means of identifying locations where constituents could be present at levels of concern to avian species or their habitats. These are identified and discussed in the report, but in general they include (by media):

- *Sediment*- Consensus-based Threshold Effect Concentrations (TECs) and Probable Effect Concentrations (PECs) for adverse effects to fresh-water sediment-dwelling organisms, developed by MacDonald et al. (2000). These are concentrations below which adverse effects would not be expected (TECs) and above which adverse effects are probable (PECs). Although GSL wetlands are generally brackish, they are fed by fresh water, and are more ecologically similar to freshwater wetlands than they are to saline (marine) wetlands. While TECs and PECs do not directly address avian toxicity or effects, they are important to assess impacts to ecosystem and habitat resources that provide food or other services to avian species.
- *Invertebrates, Fish*- Avian dietary No Observed Adverse Effects :Levels (NOAELs) and Lowest Observed Adverse Effect Levels (LOAELS) for avian dietary exposure identified in the toxicological and/or avian resource management literature. These are cited and discussed as they are used in the report. For fish, NOAEL and LOAEL values for adverse effects in the fish themselves were also used as a measure of exposure risk to fish communities as a food source for avian species, similar to how sediment organism effects are addressed by TECs and PECs.
- *Avian eggs*- NOAEL and LOAEL values for adverse effects to avian embryonic growth, teratogenic effects, and chick hatchability and/or survivability identified in the toxicological and/or avian resource management literature. Where appropriate and available, concentrations associated with known areas where contaminants were released or were being remediated (e.g., cited in natural resource damage assessments or environmental cleanup reports) were used to compare concentrations observed in the GSL wetlands to concentrations observed at other sites.

4.0 GREAT SALT LAKE WETLANDS SYNOPTIC SURVEY (1996-1997)

A total of 480 samples of sediments, invertebrates, fish tissues and bird eggs were collected from 27 wetland locations in seven geographic areas around the GSL (**Table 2-1**) in 1996 and 1997 in an effort to systematically assess overall contaminant exposure to migratory birds that use these areas as habitat (see **Appendix Table A-1** for a summary of tissues sampled and analyses conducted at each sampling location). While the goal was to conduct the assessment synoptically—i.e., collecting all samples and all locations within the same period of time—some samples ended up being collected at different times in different locations due to logistical issues, and some sites that were sampled in 1996 were re-sampled in 1997 where preliminary results or other concerns warranted additional sample collection. Complete analytical results from all media collected at all sampling locations are in Appendix A, however the following discussion focuses on the most significant and/or noteworthy findings from the overall wetland assessment.

4.1 Sediments

A total of 34 composite sediment samples were collected from 22 of the 27 wetlands sites, in all seven of the larger geographic areas. All of these samples were split, with one portion analyzed for trace elements, and the other portion submitted for analysis of organic constituents, primarily chlorinated hydrocarbons (particularly those associated with persistent, bioaccumulative compounds such as DDTs and PCBs). Complete analytical results from these samples are presented in **Appendix Tables A-2** and **A-4**. In the following discussion, all concentrations are presented in terms of mg/kg dry weight, and all means are expressed in terms of geometric mean $\pm$ standard error (SE).

Inorganic constituents (trace elements) in Sediments

With the exception of molybdenum (Mo) and selenium (Se) most trace elements were detected in almost all samples. In general, concentrations of common elements (Al, Ba, Fe, Mg, and Mn) were within the range of background concentrations reported in (Shacklette & Boerngen 1984) for Western U.S. soils.

Table 4-1 Summary of analytical data tables contained in Appendix A, Great Salt Lake Wetlands Contaminant Assessment, 1996-1997.

Table Number	Table Title
A-1	Summary of samples collected at Great Salt Lake setlands sites, 1996-1997: Media and analytes, by site and by year
A-2	Trace elements in sediments
A-3	Organic chemicals in sediments
A-4	Trace elements in macroinvertebrates
A-5	Organic chemicals in invertebrates
A-6	Trace elements in fish
A-7	Organic chemicals in fish
A-8	Trace elements in avian eggs
A-9	Organic Chemicals in Avian Eggs
A-10	Brain acetylcholinesterase (AChE) activity in common carp
A-11	Brain ethoxyresorufin-O-deethylase (EROD) activity in common carp

Sediment threshold effect concentration (TEC) and probable effect concentrations (PEC; MacDonald et al. 2000) benchmarks (see Section 3) were exceeded in at least one location all eight of the elements most commonly associated with ecological toxicity-- arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), selenium (Se) and zinc (Zn) (**Table 4-2**). Copper and lead were most frequently present in concentrations that exceeded both TECs (> TEC in 28 of 34 samples) and PECs (Cu > PEC in 9 of 34 samples; Pb > PEC in 8 of 34 samples).

Sediment TECs, which are a more conservative, "threshold" measure of adverse effect, were frequently exceeded in many locations, such that it was difficult to make any qualitative comparisons between sites. However sediments at two sites, the Oil Drain Canal (Site IO, in the Industrially Impacted Wetlands geographic area) and the Salt Lake City Wastewater Treatment Plant (Site IS, in the same area), exceeded the TEC for each of the eight trace elements listed above. Both of these sites have a known history of contamination, with Site IO located within a canal that was historically used to transport refinery and metropolitan wastewaters to the GSL, and Site IS located in a treatment wetland (to provide tertiary treatment for wastewater) placed on land that was formerly part of an industrial site.

Sediment PECs, which are a threshold above which adverse impacts to sediment macroinvertebrates are probable, were a more useful benchmark for differentiating sites where avian populations might be impacted either directly through toxicity to the birds, or indirectly through adverse changes in the composition and abundance of invertebrate food sources. Here again, sites IO and IS had the greatest number of exceedences, with six of the eight metals (all but As and Pb) >PECs at the former and four of the eight metals (Cr, Cu, Hg, and Pb) >PECs at the latter.

Arsenic, copper and selenium- The highest overall concentrations of As and Cu were observed at the two study sites that make up the South Shore Wetland area, the C-7 Ditch (Site LC) and the Great Salt Lake State Park/Salt Aire Park (Site LS). Site LC also had the highest overall concentrations of Se observed in the GSL wetlands investigation. All (4 of 4) samples collected at Sites LC and LS exceeded the PEC for As (33 mg/kg), as did the means at these sites (47.0 $\pm$1.3 mg/kg). Copper was significantly higher at Sites LC and LS than anywhere else around the GSL (**Figure 4-1**), with the maximum observed Cu concentration in the GSL wetlands investigation (1,205 mg/kg) observed at site LC. The mean concentration for the area (914 $\pm$ 154 mg/kg) was more than six times the PEC of 149 mg/kg. Copper was also elevated at other locations around the GSL, with mean Cu concentrations > TEC in all areas except for Farmington Bay North (Figure 4-1). However, Cu was lower away from the South Shore area, with the highest Cu concentration (426 mg/kg at Site IS) lower than the lowest concentration observed at Site LS (519 mg/kg). Selenium was the least frequently detected trace element around the GSL, with observable concentrations (DL = 1.0 mg/kg) recorded in only 15 of 34 sediment samples. However, all samples collected at Sites LC and LS had detected Se; both samples from site LC exceeded the PEC[1] of 4.0 mg/kg. The Southeast Shore Industrially Impacted Wetlands, comprised of wetlands with past and/or present industrial impacts, also had Se consistently detected in sediments. However only one of the six samples collected in this area (at Site IS) had Se > PEC (**Table 4-2**).

Lead was present in all 34 sediment samples, and was present at mean concentrations that exceeded the TEC of 35.8 mg/kg in all geographic locations but Antelope Island and the wetlands in Farmington Bay North (**Table 4-2**). Lead concentrations in sediments were most elevated in the Southeast Shore Industrialized Wetlands (SE Shore Industrial area), where three of five sediment samples exceeded the PEC of 128 mg/kg, and Ogden Bay, where four of five samples were >128 mg/kg, as was the mean (163 $\pm$58.6 mg/kg). Lead in Ogden Bay sediments was significantly higher than in any other geographic area around the lake (p = 0.01).

1 The PEC for selenium (4.0 mg/kg) is an upper toxicity threshold identified by the U.S. Bureau of Reclamation's National Irrigation Water Quality Program (NIWQP, 1998), rather than a consensus-based PEC (MacDonald et al., 2000)

Table 4-2. **Summary of select trace elements (mg/kg, dry weight) in Great Salt Lake wetland sediments by geographic area and exceedances of Consensus-Based toxicity thresholds; Great Salt Lake Wetlands Synoptic Survey, 1996-1997.**

Trace Element		Antelope Island	South Shore	S. Shore Wetlands	SE Shore Industrial	Farmington Bay S	Farmington Bay N	Ogden Bay
	# of sites	*3*	*2*	*4*	*4*	*4*	*2*	*3*
	# of samples (n=)	*3*	*4*	*10*	*6*	*4*	*2*	*5*
Arsenic	*Gmean*	6.1	**<u>47.5</u>**	**16.2**	**13.2**	**10.5**	4.6	**12.2**
	Max	14.0	50.8	49.6	20.7	22.2	9.7	15.5
	#>Ref [9.8 / 33.0][1]	[0 / 0]	[4 / 4]	[7 / 1]	[5 / 0]	[3 / 0]	[0 / 0]	[4 / 0]
Cadmium	*GMean*	0.29	**1.54**	0.71	**2.27**	0.87	nc	**1.74**
	Max	0.4	3.6	0.95	8.1	1.3	1.2	2.9
	#>Ref [0.99 / 4.98	[0 / 0]	[3 / 0]	[0 / 0]	[6 / 1]	[3 / 0]	[1 / 0]	[4 / 0]
Chromium	*GMean*	13.7	28.1	18.5	**47.5**	29.3	18.9	19.3
	Max	22.6	46.1	25.8	183	41.8	30.0	25.2
	#>Ref [43.4 / 111]	[0 / 0]	[1 / 0]	[0 / 0]	[3 / 2]	[0 / 0]	[0 / 0]	[0 / 0]
Copper	*GMean*	**49.3**	**<u>914</u>**	**82.5**	**146**	**65.6**	20.5	**41.5**
	Max	58.8	1205	356	426	124	42.2	58.1
	#>Ref [31.6 / 149]	[2 / 0]	[4 / 4]	[9 / 2]	[6 / 3]	[3 / 0]	[1 / 0]	[4 / 0]
Lead	*GMean*	21.2	**65.4**	**49.7**	**127**	**70.8**	10.6	**<u>163</u>**
	Max	28	108	104	364	171	45	386
	#>Ref [35.8 / 128]	[0 / 0]	[4 / 0]	[9 / 0]	[5 / 3]	[3 / 2]	[1 / 0]	[5 / 4]
Mercury	*GMean*	0.04	0.14	0.07	**0.27**	**0.21**	nc	**0.31**
	Max	0.07	0.258	0.08	1.52	0.31	0.08	0.48
	#>Ref [0.18 / 1.06	[0 / 0]	[2 / 0]	[0 / 0]	[3 / 2]	[3 / 0]	[0 / 0]	[4 / 0]
Selenium	*GMean*	nc	**3.76**	nc	**1.58**	nc	nc	nc
	Max	nd	6.48	2.79	5	1.78	nd	1.43
	#>Ref [1.0 / 4.0]	[0 / 0]	[4 / 2]	[3 / 0]	[5 / 1]	[1 / 0]	[0 / 0]	[1 / 0]
Zinc	*GMean*	57.5	**194**	106	**292**	**157**	67.8	**256**
	Max	65.4	407	180	611	354	113	516
	#>Ref [121 / 459]	[0 / 0]	[3 / 0]	[3 / 0]	[5 / 2]	[3 / 0]	[0 / 0]	[4 / 1]

<u>KEY AND ABBREVIATIONS</u>

#>Ref [TEC / PEC]: Number of samples that exceed Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) (MacDonald et al. 2000). For Se, TEC= Se background, PEC= Se toxicity threshold (National Irrigation Water Quality Program 1998)

Gmean: Geometric mean concentration for geographic area
Gmean: Gmean>TEC
<u>Gmean:</u> Gmean>PEC

NC: Not Calculated (geometric mean not calculated because >50% of values were less than the detection limit)

ND: Not Detected (all samples were < detection limit)

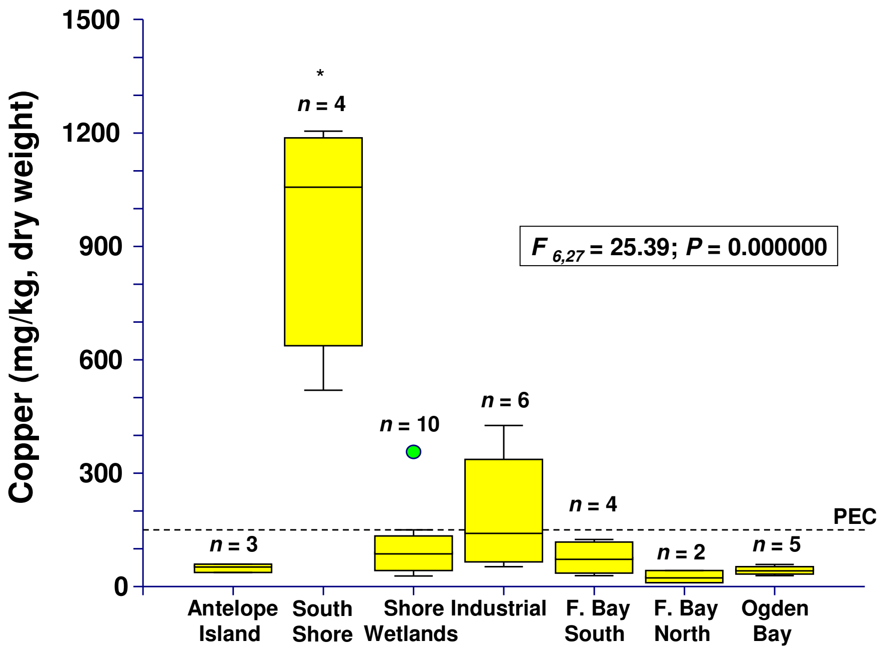

Figure 4-1 Concentrations of copper in wetland sediments by geographic area, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. "*" denotes significant difference from other areas.

Cadmium, Chromium, Mercury- The TECs for at least one of these trace elements (0.99 mg/kg Cd, 43.4 mg/kg Cr and 0.18 mg/kg Hg) were exceeded in at least one sample for all geographic areas except for Antelope Island (**Table 4-2**). However, PECs for these elements (4.98 mg/kg Cd, 111 mg/kg Cr and 1.06 mg/kg Hg) were only exceeded at the SE Shore Industrial area (10 samples from two sites, IO and IS. Cadmium was significantly higher there (p = 0.04) than at the nearby South Shore Wetlands and was elevated compared to concentrations at Antelope Island, Farmington Bay South, and Farmington Bay North. Although mean concentrations of Cr were not significantly different among areas (p = 0.07), the SE Shore Industrial area was the only place where the mean concentration of Cr exceeded the TEC and where samples with Cr >PEC were observed. Mercury was detected at mean sediment concentrations > TEC in three geographic areas (SE Shore Industrial, Farmington Bay South and Ogden Bay), but again the SE Shore Industrial area was the only one where Hg was detected in concentrations > PEC. However, the highest mean Hg concentration (0.31 $\pm$ 0.07 mg/kg) was observed in Ogden Bay. Concentrations of mercury were not significantly different among areas.

Zinc- Half of the sediment samples collected around the GSL wetlands had Zn > TEC (121 mg/kg), and mean Zn concentrations exceeded the TEC at four of the seven geographic areas evaluated. The PEC (459 mg/kg) was exceeded in the SE Shore Industrial area (both Sites IO and IS) and in Ogden Bay (at Ogden Bay South, Site OS). Mean Zn concentrations in these two geographic areas were elevated compared to the other geographic areas around the lake, but not significantly so. However mean Zn concentrations at the SE Shore Industrial area were significantly elevated (p = 0.01) compared just to the nearby Antelope Island and South Shore Wetland areas.

Organic Compounds in Sediments
Complete analytical results for the 34 sediment samples submitted for analysis are presented in **Appendix Table A-3**; this table includes only organochlorine (OC) compounds that were detected in at least one sample. Many of the constituents were present in sediments in very low concentrations, and were quantified by the laboratories in µg/kg (parts per billion). Detection limits for most compounds were in the parts per trillion range (<1 µg/kg). However, to allow easier comparison with trace element results, all concentrations in sediments discussed below are expressed in terms of mg/kg dry weight.

Three of the OCs evaluated-- α-BHC, pentachloro-anisole and toxaphene—were not detected in any of the samples. Twenty three of the 26 OCs evaluated were detected in at least one sediment sample. The most frequently detected OCs in sediment were *p,p'*-DDE (28 detections), and α- and γ-chlordanes (25 detections each). Other OCs that were detected in more than 50% of the samples were *o,p'*-DDE, *p,p'*-DDT, dieldrin, and *cis*-and *trans*-nonachlors.

DDTs (ortho (o,p'-) and para (p,p'-) isomers of DDD, DDE and DDT) – Residues of DDT-based pesticides were still detectable in sediments in GSL wetlands 20 years after their use was discontinued. In all, 12 of the 23 sites, in five of the seven geographic ranges, had detectable DDT residues. The most frequently detected isomer was p,p' DDE, which was found in 28 of the 34 samples. If p,p' DDE was not present, there were no DDT residues detected at all in the sample. One of the two sediment samples collected at Site IS had the highest observed concentration of total DDT residues, 0.207 mg/kg. However, the other sample collected at this site had only 0.004 mg/kg total DDTs. This provides an example of the potential for uneven distribution of contaminants at waste-impacted sites (i.e., "hot-spots") which translates into unevenly distributed potential for exposure (and ecological risks) at these sites. No sites (including Site IS) had sediments with total-DDT > PEC (0.052 mg/kg), however the "high" sediment sample at site IS exceeded the PECs for total DDE (*o,p'*- and *p,p'*- isomers); 0.031 mg/kg) and total DDT isomers (*o,p'*- and *p,p'*-; 0.063 mg/kg). Two other wetland sites Farmington Bay South (Site FP, a single sample) and Ogden Bay (Site ON, one sample out of two) also exceeded the PEC for total DDEs.

Non-DDT Organochlorine Pesticides/Herbicides - This diverse class of OCs includes compounds that were formerly widely used, such as dieldrin, chlordane, and mirex, and their environmental breakdown products. Trace residues of at least one of these OCs were detected at all of the wetland sites surveyed (see **Appendix Table A-4** for complete analytical results). However, concentrations exceeding TECs were detected at only seven of the sites (**Table 4-4**). The more contaminated sample from Site IS (above) also had the most non-DDT OC residues detected, and detected at the highest concentrations—this was the only site at which these compounds exceeded PECs. Site IO (the Oil Drain), also in the industrially-impacted wetlands geographic area, had six non-DDT OC's detected at concentrations > TECs, but all were less than PECs. It is relevant that both of these sites have been impacted by wastewater effluents over periods of time dating back to when non-OC pesticides were routinely applied, and it is likely that the concentrations observed at both of these sites are associated with those practices.

Polychlorinated Biphenyls (PCBs) - PCBs are a large class of OCs consisting of 209 congeners that differ by the number and position of chlorine atoms substituted on a core biphenyl ring structure. They are ubiquitous in the environment, based largely on their former widespread use and their resistance to environmental degradation. Results from the GSL wetlands were consistent with this trend, with total PCBs (t-PCB, all congeners combined) detected in all sediments sampled around the GSL, including at sites with relatively little disturbance or contamination history (e.g., site AO on Antelope Island). The highest concentrations of PCBs were observed at sites at or near known former sources such as industry or waste management. The "high" sample from Site IS (with elevated concentrations of other OCs) had 4.14 mg/kg t-PCB, well above the PEC of 0.68 mg/kg. Consistent with observed concentrations of other OCs at site IS, the other of the two samples collected had much lower t-PCB (0.004 mg/kg; see **Appendix Table A-3**). Site IO was the only other site where t-PCB > PEC (**Figure 4-2**). The TEC for t-PCB (0.060 mg/kg) was exceeded at 10 additional sites.

Table 4-3 Maximum detected concentrations of DDT isomers and total DDT residues in sediments (mg/kg, dw), compared with screening threshold concentrations, Great Salt Lake Wetlands Synoptic Survey, 1996-1997

		o,p'-DDD + *p,p'*-DDD	*o,p'*-DDE + *p,p'*-DDE	*o,p'*-DDT + *p,p'*-DDT	Total DDT [b]
Threshold Effects Concentration (TEC)[a]		**0.0049**	**0.0032**	**0.0042**	**0.005**
Probable Effects Concentration (PEC)[a]		***0.028***	***0.031***	***0.063***	***0.572***
Area #2: Antelope Island:	*(n)**				
Antelope Island offshore (AO)	*1*	0.0005	0.0005	ND	0.001
Antelope Island East (AE)	*1*	0.0003	0.0004	0.0006	0.001
Antelope Island South (AS)	*1*	ND	0.0002	ND	<0.001
Area #3: GSL South Shore:					
C7 Ditch (LC)	*1*	0.0010	0.0017	0.0003	0.003
Saltair/GSL State Park (LS)	*2*	ND	ND	ND	ND
Area #4: South Shore Wetlands:					
Airport Mitigation Site (SA)	*2*	0.0016	**0.0076**	ND	**0.009**
Gillmor Sanctuary (SG)	*5*	0.0009	0.0013	ND	0.002
Goggin Drain (SD)	*1*	0.0006	0.0005	0.0002	0.001
North Point Canal (SN)	*2*	0.0007	0.0018	**0.0046**	**0.007**
Area #5: SE Shore Industrial Wetlands:					
Beck Hot Springs (IB)	*1*	0.0017	0.0014	0.0004	0.003
Oil Drain Canal (IO)	*2*	**0.0079**	**0.0168**	**0.0489**	**0.074**
Petrochem Ponds (IP)	*1*	0.0031	0.0026	ND	**0.006**
SLC Sewage Treatment Plant (IS)	*2*	**0.0213**	***0.0458***	***0.1402***	**0.207**
Area #6: Farmington Bay South:					
Bountiful Pond (FP)	*1*	**0.0049**	***0.0335***	0.0036	**0.042**
FBWMA- Crystal Unit (FC)	*1*	0.0016	0.0010	0.0004	0.003
NW Oil Drain Delta (FO)	*1*	0.0008	0.0027	ND	0.004
State Canal (FS)	*1*	**0.0164**	**0.0194**	0.0036	**0.039**
Area #7: Farmington Bay North:					
Bair Creek (FB)	*1*	ND	ND	ND	ND
Kaysville Marsh (FK)	*2*	0.0017	**0.0096**	0.0031	**0.014**
Area #8: Ogden Bay:					
Howard Slough (OH)	*1*	0.0018	**0.0047**	ND	**0.007**
Ogden Bay WMA- North (ON)	*2*	**0.0174**	***0.0359***	0.0036	**0.057**
Ogden Bay WMA- South (OS)	*1*	0.0021	**0.0033**	0.0017	**0.007**
Ogden Bay WMA- South Canal (OC)	*1*	0.0017	0.0026	0.0021	**0.006**

KEY

0.001	Value > TEC
0.001	Value > PEC

**Values given for sample with maximum "Total DDT" concentration if > 1 sample collected at a site*

NOTES & ABBREVIATIONS:

ND = Compound not detected

(n) = number of samples per site

(a) Threshold Effects Concentrations (TEC) and Probable Effects Concentrations (PEC) from MacDonald, et al., 2000

(b) sums calculated using (0.5 x DL) for isomers that were not detected. If no DDT isomers were detected in a sample, a "total DDT isomers" sum was not calculated

Table 4-4 Maximum detected concentrations of non-DDT organochlorine pesticide residues exceeding screening benchmarks in sediments (mg/kg, dw), Great Salt Lake Wetlands Synoptic Survey, 1996-1997

	dieldrin	endrin	beta BHC	gamma BHC	alpha chlordane[a]	gamma chlordane[a]	oxy chlordane[a]	Heptachlor[b]	heptachlor epoxide
Threshold Effects Concentration (TEC)	**0.0019**	**0.0022**	**0.005**	**0.003**	**0.0032**	**0.0032**	**0.0032**	**0.0025**	**0.0025**
Probable Effects Concentration (PEC)	***0.062***	***0.207***	***0.21***	***0.005***	***0.018***	***0.018***	***0.018***	***0.016***	***0.016***
Area #2: Antelope Island:									
Antelope Island offshore (AO)	0.0004	ND	ND	0.0004	**0.004**	ND	ND	ND	ND
Antelope Island East (AE)	ND	ND	ND	0.0004	0.001	0.0002	ND	ND	ND
Antelope Island South (AS)	ND	ND	ND	0.0001	0.000	ND	ND	ND	ND
Area #3: GSL South Shore:									
C7 Ditch (LC)	0.0002	ND	ND	ND	0.001	0.0005	ND	ND	ND
Saltair/GSL State Park (LS)	ND	ND	**0.009**	ND	ND	0.001	ND	ND	ND
Area #4: South Shore Wetlands:									
Airport Mitigation Site (SA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gillmor Sanctuary (SG)	0.0002	ND	ND	0.0002	0.001	0.001	ND	ND	ND
Goggin Drain (SD)	0.0001	ND	ND	0.0001	0.000	0.0002	ND	ND	ND
North Point Canal (SN)	0.0003	ND	0.0001	0.0003	0.000	0.0003	ND	0.000	ND
Area #5: SE Shore Industrial Wetlands:									
Beck Hot Springs (IB)	0.0003	ND	0.004	0.0003	0.002	0.000	ND	ND	ND
Oil Drain Canal (IO)	**0.020**	**0.004**	ND	ND	**0.013**	**0.013**	**0.017**	**0.003**	ND
Petrochem Ponds (IP)	ND	0.0006	0.0009	ND	ND	0.001	0.0005	ND	ND
SLC Sewage Treatment Plant (IS)	***0.066***	ND	0.0004	***0.008***	***0.050***	***0.050***	ND	***0.021***	**0.008**
Area #6: Farmington Bay South:									
Bountiful Pond (FP)	0.0009	ND	ND	ND	0.001	0.001	ND	ND	ND
FBWMA- Crystal Unit (FC)	0.0002	ND	ND	ND	0.002	0.001	ND	ND	ND
NW Oil Drain Delta (FO)	0.0016	ND	ND	ND	0.002	0.003	ND	ND	ND
State Canal (FS)	**0.011**	ND	ND	ND	**0.005**	**0.007**	0.0007	ND	0.000
Area #7: Farmington Bay North:									
Bair Creek (FB)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kaysville Marsh (FK)	0.0006	ND	ND	0.0002	0.002	**0.002**	0.0002	ND	0.000
Area #8: Ogden Bay:									
Howard Slough (OH)	ND	ND	ND	ND	0.001	0.003	ND	ND	ND
Ogden Bay WMA- North (ON)	0.0008	ND	0.0008	ND	0.001	**0.002**	ND	ND	ND
Ogden Bay WMA- South (OS)	0.0005	ND	0.0002	ND	0.000	0.000	0.0002	ND	0.000
Ogden Bay WMA- South Canal (OC)	0.0004	ND	ND	ND	0.001	0.002	0.0002	ND	ND

KEY:

0.001 Maximum detected value

0.001 Maximum detected value > TEC*

0.001 Maximum detected value > PEC*

**Ingersol,et al, 2000*

NOTES AND ABBREVIATIONS:

Max: Maximum detected concentrations shown

ND: Residue not detected in samples from site.

(a): TEC and PEC for chlordane used for evaluation

(b): TEC and PEC for heptachlor expoxide used for evaluation

While one of the explanations for the broad distribution of PCBs is their environmental persistence, atmospheric deposition is also a mechanism for their distribution. Depending on the congener and its source, PCBs can be volatilized into the upper atmosphere where they can then be transported by global air currents, evidenced by observations of PCBs in arctic and Antarctic habitats (Lemmetyinen and Rantamaki 1980). This may explain their presence in wetlands in even what are perceived as relatively pristine locations, such as Antelope Island. However, another possible, closer source of PCBs to the GSL wetlands is a magnesium processing facility on the west shore of the GSL, U.S. Magnesium. This facility separates magnesium via electrolysis from highly concentrated GSL brines which contain magnesium chloride ($MgCl_2$). A by-product of the facilities' processing of GSL brines is chlorinated hydrocarbons. In limited "stack sampling" of the facility's air emissions, the U.S. EPA and others have detected a large number of highly chlorinated hydrocarbon compounds , including hydrochlorbenzene (HCB, C_6Cl_6), dioxins and furans, and "PCB-209"(decachlorobiphenyl, or $C_{10}Cl_{10}$). PCB-209 is considered rare in the environment, but it has been consistently detected in environmental media at the U.S. Magnesium facility (U.S. EPA, unpublished data), and is considered to be a "fingerprint" compound for the facility. PCB-209 is potentially less toxic than other PCB compounds due to its large molecular size (caused by the large number of chlorines substituted onto the PCB structure), but it is evident that it is bioavailable. However its ecological toxicity has not been evaluated. The distribution of PCB-209 in the GSL ecosystem beyond the boundaries of the U.S. Magnesium facility has also not been evaluated to date.

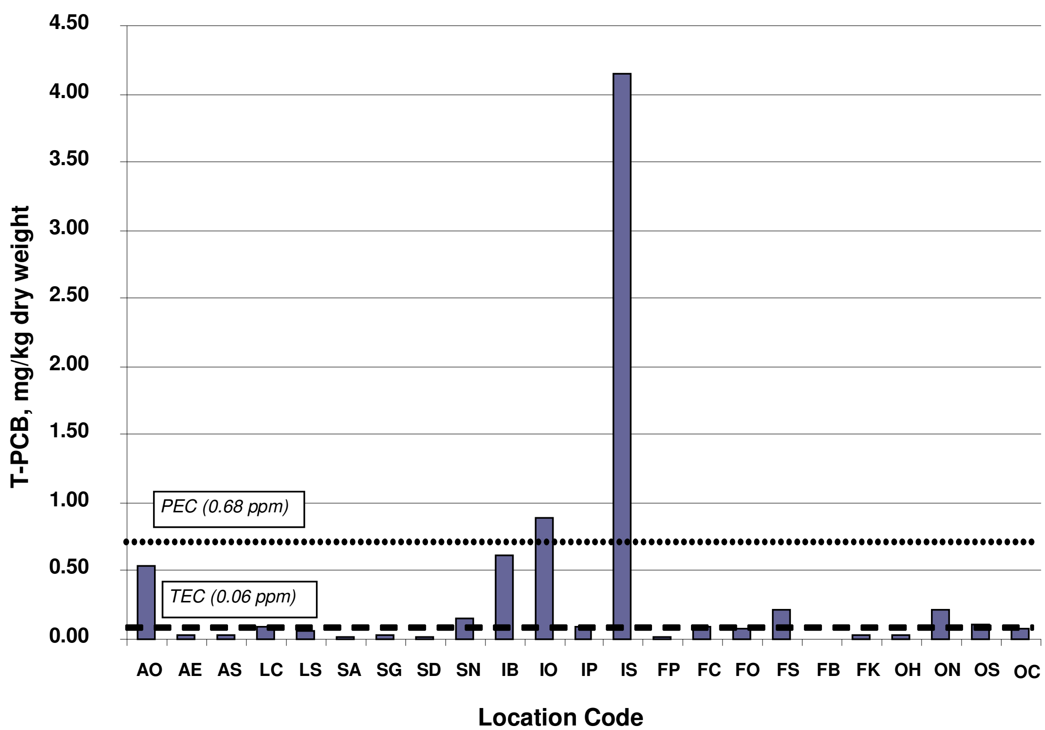

Figure 4-2 Maximum detected concentrations of total PCBs in sediments (mg/kg) compared to screening threshold concentrations, Great Salt Lake Wetlands Synoptic Survey, 1996-1997

Dioxins and Furans - Dioxins and furans can be contaminants in manufactured organochlorine compounds, such as the combination of the herbicides 2,4-D and 2,4,5-T ("agent orange"), but they are also spontaneously formed as products of incomplete combustion in the presence of chlorine. Sediment samples were collected at four locations (one each) chosen on the basis of proximity to suspected dioxin sources, including the east side of Antelope Island (Site GA, facing US Magnesium); the C-7 Ditch site on the south shore of the GSL (Site LC); a wetland mitigation site on the southeast shore of the GSL (the "Airport Mitigation" site, SA); and the State Canal (Site FS) in Farmington Bay. Seven of 17 dioxin/furans analyzed were detected in at least one sample (see **Appendix Table A-3**), at concentrations slightly above detection limits (about 1-3 parts per trillion). When these compounds were converted to toxicity-equivalent concentrations of TCDD (the most toxic of the compounds) using TCDD toxicity equivalence factors (TEFs) (Van Leeuwen 2003) and summed, the resultant total TCDD-TEF concentrations fell well below sediment benchmark concentrations (CCME 1999).

Total Petroleum Hydrocarbons (TPH) - Sediments from 31 of the wetland sites were selected for TPH analysis based on past land use at the site and/or proximity to potential sources of hydrocarbon spills and releases. All 31 had detectable concentrations of TPH ranging from 28 mg/kg at Bair Creek (Site FB) in the Farmington Bay South area to 96,560 mg/kg at Site IS (**Appendix Table A-3**). While TPH is typically used as a screening tool to identify hydrocarbon contamination, this "analyte" is actually the sum of total extractable petroleum hydrocarbons present in a sample, and consists of several hundred individual aliphatic and aromatic hydrocarbon compounds with widely varying individual toxicity characteristics. There are no ecologically derived screening benchmarks for TPH, but benchmark values ranging from 50 to 1,000 mg/kg are used by various state environmental agencies to guide cleanup of petroleum contaminated sites. The highest overall TPH concentrations in the GSL wetlands were detected in areas with a history of petroleum management operations in the upstream watershed, most notably the industrially-impacted wetlands on the southeast shore of the GSL, including site IS (with the maximum detected concentration of TPH), and Site IO, with 13,792 – 28,906 mg/kg TPH, respectively. Four of the five sediment samples collected at the industrially impacted wetlands sites had TPH >1,000 mg/kg, with far higher concentrations observed at Site IS (the sediment sample with elevated concentrations of other OCs), and Site IO (**Table 4-5**). While present at much lower concentrations than in the industrially impacted wetlands, TPH was higher than expected at the Antelope Island sites (**Table 4-5**). This may be due to spills and releases from nearby marinas.

Table 4-5. Total petroleum hydrocarbons (TPH) > 1,000 mg/kg in sediments, Great Salt Lake Wetlands Synoptic Survey, 1996-1997

Sample Site Description	TPH, mg/kg
Area #2: Antelope Island (3 sites)	
Antelope Island offshore (GA)	**2,412**
Antelope Island East (AE)	**1,173**
Area #3: GSL South Shore (2 sites)	
C7 Ditch (LC)	**1,204**
Area #4: South Shore Wetlands (4 sites)	
North Point Canal (SN)	**1,221**
Area #5: South Shore Industrially Impacted Wetlands (4 sites)	
Beck Hot Springs (IB)	**1,564**
Oil Drain Canal (IO)	**28906**
SLC Sewage Treatment Plant (IS)	**96560**
Area #6: Farmington Bay South (4 sites)	
State Canal (FS)	**6042**
Area #7: Farmington BayNorth (2 sites)	
Kaysville Marsh (FK)	**1240**
Area #8: Ogden Bay (4 sites)	
Ogden Bay WMA- North (ON)	**1305**
Ogden Bay WMA- North (ON)	**3280**
Ogden Bay WMA- South (OS)	**1058**

4.2 Invertebrates

Twenty-eight composite invertebrate samples were collected from twenty-two wetland sites within seven areas during 1996 and 1997 and evaluated for trace elements; complete analytical results are presented in **Appendix Table A-4**. At sixteen of these sites, samples were split and a representative sub-sample was submitted for analysis of OCs (typically one sample per wetland location); two OC samples were submitted for sites IS and FK. Complete results of OC analyses are presented in **Appendix Table A-5**. Where practical and achievable, invertebrate samples were collected from the same sample locations as sediment samples. Metals results were reported by the laboratory in mg/kg dry weight, and are presented here in those units. As was the case with sediments, invertebrate organochlorine analyses were reported by the laboratory in µg/kg (ppb) dry weight, but have been converted to mg/kg (dry weight) here both for comparison with metals concentrations, and also for comparison with avian dietary benchmarks, which are typically reported in mg/kg. Concentrations of constituents in invertebrates were compared with literature-based no observed adverse effects levels (NOAELs) and lowest observed adverse effects levels (LOAELs) in the diet of birds, and are identified as they are discussed below.

Invertebrate groups collected within the GSL wetlands included chironomids (midge larvae), Odonates (dragonfly and damselfly larvae), *Ephydra* sp. (brine fly larvae), and Corixids (water boatman). One sample of midge larvae from the Audubon Gilmore Sanctuary site (Site SA) was only analyzed for selenium due to limited sample mass; therefore, there are only twenty-seven data points for the remaining metals. Because sediments were not depurated from the invertebrates prior to sampling, species in direct contact with sediments (i.e., chironomid larvae) were more influenced by sediment concentrations than other taxa. This was a significant factor in the comparison of metals concentrations between taxa (see below); although it was not evaluated for OC residues because of overall low detection rates, it is most likely a factor in those results as well.

Inorganic Constituents (trace elements) in Invertebrates

Most of the trace elements analyzed were detected in invertebrates, with the "essential elements" (e.g., Ca, Cu, Fe, Mg, Mn, and Zn) occurring in all samples. Trace elements associated with contamination occurred less frequently, including Hg (in 54% of samples), Be (25%), V (11%), Cd, Pb, Se (7%), As and Ni (4%). Chironomid larvae had significantly higher concentrations of a number of elements (Al, Ba, Be, Cr, Fe, Mg, Ni, Pb, and V) than other taxa ($P = 0.05$), but invertebrate type did not significantly influence trace element concentrations between areas ($P < 0.001$). With the exception of Mn, there were no significant differences in metals concentrations between geographic areas using pooled data for each element. However, concentrations of several trace elements exceeded avian dietary thresholds at specific locations, as did geometric mean concentrations at several of the geographic areas evaluated (**Table 4-6**). The discussion below highlights the trace elements observed to be at the highest concentrations or most frequently exceeding avian dietary levels of concern (LOCs). Means discussed below are geographic means; results are discussed in terms of mg/kg dry weight.

Lead- Mean concentrations of Pb exceeded the avian dietary LOC of 5 mg/kg (2000) in five of the seven geographic areas evaluated, including wetlands managed primarily for hunted waterfowl in Farmington Bay South and Ogden Bay, with the highest concentration (17.4 mg/kg) occurring in the Ogden Bay area. Mean lead > LOC was also observed in the South Shore Wetlands area and the Industrially-Impacted wetlands, with the maximum concentration (74.2 mg/kg) observed in the South Shore Wetlands. Overall, 17 of 28 invertebrate samples analyzed had Pb > LOC. Ten of these samples were of chironomid larvae, including the five highest concentrations. Most GSL wetland areas have been used by waterfowl hunters since at least the early 20th century, so lead shot is a likely source of the lead observed in both sediments and invertebrates, particularly in waterfowl management areas. Like most metals, lead compounds (i.e., lead salts) in soil are less bioavailable in neutral to alkaline soil or water environments. However, metallic lead, either in the form of shot pellets or pellet fragments, can be highly bioavailable and toxic in the digestive system, where it can be solubilized by stomach acids and immediately taken up in blood. Given that the areas where high Pb was identified are managed for waterfowl productivity and hunting, further investigation of the distribution and magnitude of lead contamination in sediments (e.g., in historically heavily hunted and/or highly productive areas) may be warranted.

Chromium- Chromium was the only other trace element for which mean concentrations greater than the avian LOC (10 mg/kg; (2000)) were observed. In all, nine of the 28 invertebrate samples exceeded the LOC. The highest concentration of Cr (31.9 mg/kg) occurred at the OH (Howard Slough) site within the Ogden Bay area; contributing to a mean concentration of 11.0 mg/kg for the Ogden Bay geographic area. Farmington Bay North also exceeded the LOC, with a mean Cr concentration of 11.6 mg/kg. Although the LOC was exceeded in these two areas, they were not significantly higher than any of the other geographic areas ($F_{6,20} = 0.74$; $P = 0.62$).

Aluminum- Geometric mean concentrations of Al were less than the avian dietary NOAEL of 5,000 mg/kg (Sparling 1990) in all seven of the GSL geographic areas evaluated (Table 4-6). However, five samples (all chironomids) exceeded this NOAEL, including at Site SI (the Inland Sea Shorebird Reserve, a wetland mitigation within the GSL South Shore wetlands area) which had the maximum observed concentration (10,707 mg/kg). Although Al is not a contaminant of concern for GSL wetlands based on past industrial activities, it may be elevated in some areas (particularly those containing GSL lakebed sediments) because of the evaporitic nature of the GSL and its sediments. This is likely the cause of elevated concentrations of other evaporates such as boron and zinc as well. High concentrations of Al

Table 4-6. Geometric mean and maximum detected concentrations of selected trace elements (mg/kg, dry weight) in invertebrates by geographic area, compared with available avian dietary effect thresholds, Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Trace Element		Antelope Island	South Shore	S. Shore Wetlands	SE Shore Industrial	Farmington Bay S	Farmington Bay N	Ogden Bay
	n=	*3*	*6*	*5**	*4*	*4*	*2*	*3*
Aluminum	Gmean	265	665	2624	958	2656	4749	2831
	Max	1348	8262	10707	2822	6009	9888	8312
[#>Ref]	[5000][1]	[0]	[1]	[2]	[0]	[1]	[1]	[2]
Arsenic	GMean	3.9	11.8	2.1	1.7	2.9	4.3	5.0
	Max	10.5	51.1	9.3	2.7	4.4	8.4	5.6
[#>Ref]	[30]	[0]	[1]	[0]	[0]	[0]	[0]	[0]
Boron	GMean	15.2	15.9	11.4	18.9	5.8	5.3	8.3
	Max	49.0	36.3	53.0	35.6	15.2	13.7	20.7
[#>Ref]	[30]	[1]	[3]	[1]	[1]	[0]	[0]	[0]
Cadmium	GMean	0.14	0.3	0.8	0.49	0.53	0.57	0.3
	Max	0.3	1.6	1.14	0.85	1.3	1.5	0.5
[#>Ref]	[20]	[0]	[0]	[0]	[0]	[0]	[0]	[0]
Chromium	GMean	1.76	5.55	6.70	8.0	9.15	**11.6**	**11.0**
	Max	3.59	23.6	14.9	28.1	19.5	16.9	31.9
[#>Ref]	[10]	[0]	[1]	[2]	[2]	[2]	[1]	[1]
Copper	GMean	13.2	81.8	30.5	44.4	27.8	21.4	22.0
	Max	17.9	377	60.4	73.4	41.4	26.6	53.1
[#>Ref]	[200]	[0]	[2]	[0]	[0]	[0]	[0]	[0]
Lead	GMean	1.6	4.9	**8.5**	**10.7**	**10.9**	**8.4**	**17.4**
	Max	10.1	26.5	74.2	53.6	33.9	22.6	49.3
[#>Ref]	[5]	[1]	[3]	[3]	[2]	[3]	[1]	[3]
Mercury	GMean	0.14	NC	NC	NC	NC	NC	0.10
	Max	0.19	0.09	0.07	0.11	1.13	0.09	0.23
[#>Ref]	[0.4]	[0]	[0]	[0]	[0]	[1]	[0]	[0]
Selenium*	GMean	1.08	2.17	2.51	1.66	2.78	1.42	2.20
	Max	1.40	5.99	5.13	6.46	4.31	1.83	6.35
[#>Ref]	[3]	[0]	[3]	[1]	[2]	[3]	[0]	[1]
Zinc	GMean	59.9	105	108	130	128	112	112
	Max	74.8	282	169	156	175	134	150
[#>Ref]	[178]	[0]	[1]	[0]	[0]	[0]	[0]	[0]

KEY AND ABBREVIATIONS

Gmean: Geometric mean concentration for geographic area

Gmean: Gmean>referenced toxicity value

Max: Maximum detected value (among samples in geographic area)

[#>Ref]: number of individual (composite) samples per geographic area exceeding the referenced threshold (citations given in discussion in text).

NC: geometric mean not calculated (more than 50% of values <detection limit)

(e.g., above the NOAEL) can interfere with phosphate metabolism, which in turn interferes with calcium deposition into bones and eggshells. However, this effect has been seen primarily in areas with low acidic buffering capability (e.g., lakes with pH in the range of 4.0 – 4.6), which may also be limited in the amount of dietary calcium and phosphorous available (Miles et al. 1993). In an estuarine environment with mean dietary Al concentrations of 2,384 mg/kg, no differences could be seen in the mechanical properties of bones in American coot (*Fulica americana*) foraging in the area, which was also very enriched in calcium (> 70,000 mg/kg; (Hui & O. Ellers 1998).

Arsenic and Copper- The maximum detected concentrations of both of these elements (51 mg/kg and 377 mg/kg, respectively) were observed at site LS; exceeding their respective levels of concern: 30 mg/kg for As (Camardese et al. 1990) and 200 mg/kg for Cu (2000). The LOC for Cu was also exceeded at site LC (377 mg/kg). The geometric mean concentration of Cu at the GSL South Shore area (81.8 mg/kg) was substantially higher than at the other geographic areas (though < LOC), but this difference was not statistically significant ($P = 0.18$). These two sites are either in or adjacent to mining-impacted areas associated with the copper smelter and refinery located on the south shore of the GSL. No other locations sampled exceeded LOC concentrations for either As or Cu.

Mercury and Selenium- Mercury was only detected in 12 of 27 invertebrate samples (DL = > 0.2 mg/kg). Because of the low detection rate, geometric mean concentrations were not calculated for the geographic areas. Where it was detected, Hg was < 0.3 mg/kg in invertebrates from all locations except for site FC (the Crystal Unit within FBWMA, in the Farmington Bay South geographic area) which had a sample with 1.13 mg/kg Hg, exceeding the LOC of 0.4 mg/kg. Selenium was detected more frequently, in 26 of 28 samples, with 10 samples exceeding the LOC of 3.0 mg/kg (Lemly 1996) The highest concentration of Se (6.46 mg/kg) occurred at site IS within the SE Shore Industrial area, followed closely by a sample at site OH within the Ogden Bay area with 6.35 mg/kg Se. The greatest frequency of exceedances of the avian dietary LOC for Se occurred at the Farmington Bay South area (75%) and at the GSL South Shore and SE Shore Industrial areas (50%). Geometric means did not exceed the LOC at any of the geographic areas, however this level was approached at the Farmington Bay South area (geometric mean Se = 2.78 mg/kg).

<u>Organic Compounds in Invertebrates</u>

Nineteen invertebrate samples from 16 locations around the GSL were evaluated for OCs (DDT isomers and non-DDT OCs) and PCBs. A single sample was collected in most locations; two samples each were collected at sites IS and FK. Complete analytical results (compounds identified in at least one invertebrate sample) are presented in **Appendix Table A-5**. As with OC results in sediment samples, concentrations were reported by the laboratories in µg/kg (parts per billion) but have been converted to mg/kg (dry weight) for presentation below.

Nineteen OCs were detected in GSL invertebrate samples, compared to 23 OCs detected in sediments. This included 13 non-DDT compounds, five of the six DDT isomers, and t-PCB. Only t-PCB and *p,p'*-DDE were detected in > 50% of the samples. Oxychlordane and *p,p'*-DDT were detected in 47% of the samples. At least one OC was detected in all invertebrate samples, with the exception of sites AS (Antelope Island South) and IP (the "Petrochem Ponds") where no OCs were detected. Sites IO, FS and FK had both the greatest number of OCs detected (12 OCs at all three sites) and the highest total OC concentrations (summed concentrations of detected OCs) ranging from 0.072 mg/kg at Site FK to 0.112 mg/kg at Site IO. These sites also had a large number of OCs detected in sediment samples, and relatively high total OC and PCB concentrations compared to other sites in the GSL study. Overall OC concentrations in invertebrates, including t-PCBs which were present in the highest concentrations, were low compared to published data from contaminated sites. The maximum detected concentration of t-PCB (0.091 mg/kg at site IO) was low compared to the avian dietary NOAEL of 0.5 mg/kg (Barron et al. 1995).

Concentrations of DDTs, including "total DDTs" (t-DDT, the summed concentration of detected DDT isomers) were also relatively low, but exceeded avian LOCs at several locations. Total DDT exceeded the avian dietary NOAEL of 0.004 mg/kg (Sample et al. 1996) at nine sites (Table 4-7), with *p,p'*-DDE, being the largest contributor. The maximum detected concentration of *p,p'*-DDE (0.027 mg/kg) occurred at Site ON, contributing to the maximum detected concentration of t-DDT (0.0484 mg/kg). This concentration also exceeded the avian dietary LOAEL of 0.04 mg/kg.

Table 4-7 Comparison of total DDT residues in wetland invertebrates (mg/kg wet weight) with calculated risk-based dietary thresholds for insectivorous birds, Great Salt Lake Wetlands Synoptic Survey, 1996-1997

		Sum DDTs [b]
	NOAEL, Woodcock[a]	***0.004***
	LOAEL, Woodcock[a]	**0.04**
Geographic Area and Study Site	**Invertebrate Type**	
Antelope Island:		
Antelope Island offshore (GA)	Brine Fly Larvae	0.0016
Antelope Island East (AE)	Brine Fly Larvae	ND
Antelope Island South (AS)	Odonates	ND
GSL South Shore		
C7 Ditch (LC)	Chironomids	***0.0076***
Saltair/GSL State Park (LS)	Benthic Macroinvertebrates	ND
South Shore Wetlands		
Goggin Drain (SD)	Benthic Macroinvertebrates	0.01
Inland Sea Shorebird Reserve (SI)	Chironomids	***0.0043***
South Shore Industrially Impacted Wetlands		
Beck Hot Springs (IB)	Corixids	0.0013
Oil Drain Canal (IO)	Chironomids	0.0101
Petrochem Ponds (IP)	Chironomid	ND
SLC Sewage Treatment Plant (IS)	Chironomid	ND
SLC Sewage Treatment Plant (IS)	Benthic Macroinvertebrates	***0.0077***
Farmington Bay South		
FBWMA- Crystal Unit (FC)	Benthic Macroinvertebrates	0.0011
State Canal (FS)	Benthic Macroinvertebrates	***0.0173***
Farmington Bay North		
Kaysville Marsh (FK)	Chironomid	***0.00685***
Kaysville Marsh (FK)	Chironomid,Leech	***0.0205***
Ogden Bay		
Howard Slough (OH)	Chironomid	***0.00564***
Ogden Bay WMA- North (ON)	Chironomids	**0.0484**
Ogden Bay WMA- South (OS)	Benthic Macroinvertebrates	***0.0089***

KEY: ***VALUE*** **:** ≥ No Observed Adverse Effect Level (NOAEL)
VALUE **:** ≥ Lowest Observed Adverse Effect Level (LOAEL)

(a) (Sample et al. 1996). Calculated avian toxicity reference value assuming diet consists 100% of invertebrates
(b) Sum of measured concentrations of *ortho*- and *para*- isomers of DDD, DDE and DDT

Biomagnification of OCs from sediments to invertebrates was not quantitatively evaluated because of low detection rates for most OCs in invertebrates. However, a qualitative comparison of sediment and invertebrate OC concentrations indicates minimal uptake, except possibly at Site ON, which had relatively high DDT concentrations in both sediments (Table 4-2) and invertebrates (Table 4-7). There is also some correspondence between total PCBs in invertebrates at site IO, and sediment PCBs which were elevated (>PEC) at that site.

4.3 Fish

Whole-body composite samples of fish were collected from GSL estuarine wetland locations that are supplied by freshwater inflows. Fish were not collected at the Antelope Island sites or Site LS due to l habitat. Concentrations of inorganic and organic constituents in fish were compared to two sets of endpoints to evaluate risks to birds: first as a contributor to avian diets (i.e., for piscivorous birds), and the health of the fish themselves, as a component of the foraging habitat (i.e., the food source) of piscivorous birds. Avian dietary levels of concern (NOAELs, LOAELs, etc) were used for the first comparison, and fish health indicators were used for the latter. Common carp (*Cyprinus carpio)* were most frequently collected; Utah chub (*Gila atraria*) and western mosquitofish (*Gambusia affinis*) were collected in locations where carp could not be found. In most cases, sampling crews attempted to collect fish from the same locations as sediment and macroinvertebrate samples, but there was less linkage between these media due to logistics issues involved with sampling fish as compared to other media. However, because fish are not sessile in the same way as invertebrates, and also because their diet is not as intimately linked to a single location, there was less need for this level of correspondence in sampling. A total of 30 fish samples were collected from 12 wetland locations for evaluation of trace metals. Twenty three samples from 11 locations were analyzed for organic compounds. The number of samples collected at each site ranged from one (at sites FC, FU and ON) to four (Site LC).

Trace Elements in Fish
As was the case for sediments and macroinvertebrates, concentrations of trace elements in fish are reported here in mg/kg dry weight, both in the following discussion and in **Appendix Table A-6**, which contains complete analytical results. In cases where benchmarks were presented in the literature in terms of wet weight, they have been converted to dry weight using 75% moisture content for a conversion factor. The mean percent moisture of all fish collected at GSL sites was 74.3%.

Trace element concentrations in fish were generally low and rarely exceeded concentrations of concern either for adverse effects to piscivorous birds or to the fish themselves. The concentrations of selected elements (As, Cd, Cr, Cu, Hg, Pb, Se, and Zn) in fish are summarized by geographic area in **Table 4-8**, along with exceedences of effect thresholds identified in peer-reviewed scientific literature.

Copper - Copper was the only element in which concentrations in fish exceeded the benchmark for fish health (13.3 mg/kg; (Eisler 2000). This occurred only at the GSL South Shore area (represented by Site LC), where three of six samples slightly exceeded this concentration, with a maximum observed concentration of 16.3 mg/kg, and a mean of 11.2 mg/kg. However, these concentrations were significantly and more than two times higher than any other area evaluated (**Figure 4-3**).

Selenium - Se was detected in >50% of fish samples from all geographic areas except the Farmington Bay North area. However, the GSL South Shore area (Site LC) was the only one where Se was present in concentrations exceeding both the avian dietary LOC of 3 mg/kg and the fish effects benchmark of 4 mg/kg (National Irrigation Water Quality Program 1998). All six samples collected at Site LC exceeded 3 mg/kg Se, with a geometric mean concentration of 6.36 mg/kg, which was 2-3 times higher than the maximum detected concentrations from other geographic areas (Table 4-8). Concentrations of

Table 4-8 Summary of selected trace elements in whole body fish (mg/kg, dry weight) by geographic area, and exceedences of levels of concern, Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Trace Element		GSL South Shore	S. Shore Wetlands	SE Shore Industrial	Farmington Bay S	Farmington Bay N	Ogden Bay
	n=	6	6	3	12	1	7
Arsenic	GMean	NC	NC	NC	NC	NC	NC
	Max	1.3	0.7	ND	ND	1	0.5
#>Ref	[12 / 30][1]	[0]	[0]	[0]	[0]	[0]	[0]
Cadmium	GMean	0.17	NC	NC	NC	NC	NC
	Max	0.23	ND	ND	ND	0.1	ND
#>Ref	[NA/20]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]
Chromium	GMean	1.43	1.49	0.84	1.97	NC	2.27
	Max	4.26	5.51	1.49	4.75	7.08	3.61
#>Ref	[NA/10]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]
Copper	GMean	11.2	3.14	4.47	3.09	NC	2.87
	Max	16.3	4.89	5.51	5.98	4.83	3.79
#>Ref	[13.3/200]	[3 / 0]	[0 / 0]	[0 / 0]	[0 / 0]	[0 / 0]	[0 / 0]
Lead	GMean	0.81	NC	NC	0.59	NC	0.91
	Max	2.13	1.5	1.5	1.43	1.5	3.2
#>Ref	[NA/5]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]	[-- / 0]
Mercury	GMean	NC	0.14	0.07	NC	NC	NC
	Max	0.34	0.26	0.08	0.26	0.14	0.37
#>Ref	[0.8/1.2]	[0]	[0]	[0]	[0]	[0]	[0]
Selenium	GMean	**6.36**	1.68	2.4	1.77	NC	1.41
	Max	9.1	2.1	3.3	2.7	1.7	1.91
#>Ref	[4/3]	[5 / 6]	[0]	[0 / 1]	[0]	[0]	[0]
Zinc	GMean	**239**	**213**	164	**199**	NC	**225**
	Max	360	262	199	247	151	512
#>Ref	[NA/178]	[-- / 5]	[-- / 4]	[-- / 1]	[-- / 10]	[0]	[-- / 5]

KEY AND ABBREVIATIONS

Gmean: Geometric mean concentration for geographic area
Gmean: Gmean> referenced toxicity value
NC: geometric mean not calculated (i.e., more than 50% of values <detection limit)
ND: all samples were less than the detection limit
#>Ref: number of samples > referenced threshold value
[X / Y]: [effects to fish / avian dietary threshold];
NA: referenced value not identified in literature

Threshold values not referenced in text:

As: Fish- toxicity threshold (Sandhu 1977) / Avian dietary- Reduced weight in mallard ducklings, (Camardese et al. 1990)
Cd: Fish health- NA / Avian dietary- Level of concern (Cain et al. 1983)
Cr: Fish health- NA / Avian dietary- Level of concern (Eisler, 2000)
Cu: Fish Health-(National Irrigation Water Quality Program 1998) / Avian dietary- Level of concern (Eisler, 2000)
Pb: Fish health- NA / Avian dietary- Level of concern (Eisler, 2000)
Hg: Fish Health- Sublethal endpoints for adult and juvenile fish (Beckvar et al. 2005) / Avian dietary- Behavioral and reproductive effects in loons (Barr 1986)
Se: Fish health- Lower effects threshold (National Irrigation Water Quality Program 1998) / Avian dietary- Lower effects threshold (National Irrigation Water Quality Program 1998)
Zn: Fish health- NA; Avian dietary Level of concern (2000)

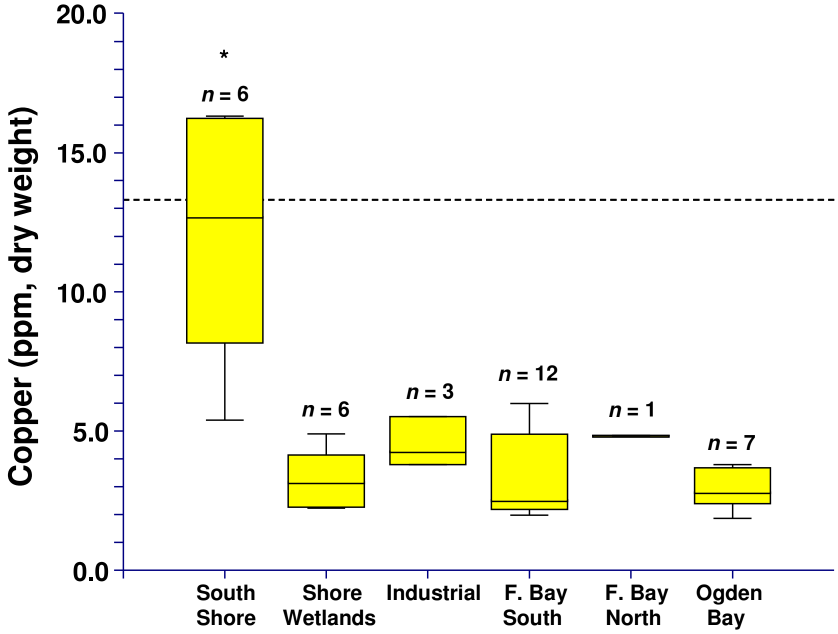

Figure 4-3. Copper in whole-body fish by geographic area, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Dashed line represents level of concern for fish health; "*" denotes significant difference (*P* < 0.001).

Se at Site LC were significantly elevated in fish compared to the other five areas ($P < 0.001$; **Figure 4-4**). The only other location where Se exceeded either the fish or avian benchmark was Site IO in the Southeast Shore Industrial Area, where one of three samples exceeded 3 mg/kg.

Mercury - Hg was detected in 20 of 35 samples but was detected in > 50% of samples in only two geographic areas: the GSL South Shore wetlands, and the SE Shore Industrial area. The highest concentration of Hg was observed in the Ogden Bay area (0.37 mg/kg). No fish samples exceeded Hg effects thresholds for either fish health (0.8 mg/kg, converted from 0.2 mg/kg wet weight; (Beckvar et al. 2005)) or avian dietary exposure for fish-eating birds (1.2 mg/kg, converted from 0.3 mg/kg wet weight;(Barr 1986)). As a point of comparison for human health, maximum detected concentrations of mercury in fish at all GSL wetland sites were well below 1.2 mg/kg dry weight, equivalent to EPA's fish consumption screening level of 0.3 mg/kg wet weight (assuming 75% moisture).

Zinc - Zinc was detected in all 35 fish samples, and exceeded the avian dietary threshold, 178 mg/kg, an avian dietary threshold concentration associated with possible immune suppression in young birds (Stahl et al. 1989), in 25 of the 35. The maximum detected concentration of Zn (512 mg/kg) was observed at Site OS in Ogden Bay. In all, zinc concentrations in 25 of the 35 fish samples exceeded this threshold, yielding geometric mean Zn concentrations that exceeded the LOC for avian dietary exposure in four of the six geographic areas (**Table 4-8**). Notably, the lowest Zn concentrations were observed in the three non-carp samples collected (two mosquito fish and one Utah chub); however, data were insufficient to evaluate whether there were species differences in Zn concentrations.

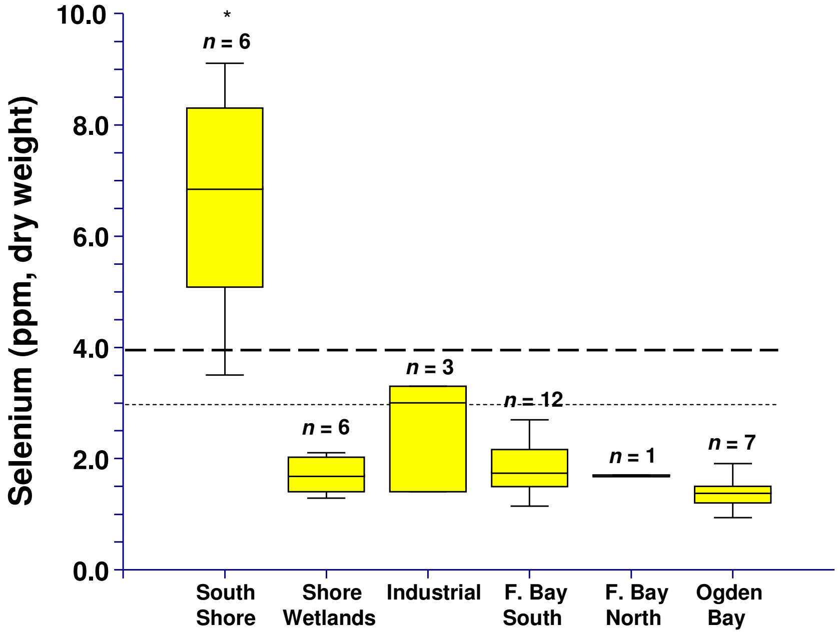

Figure 4-4. Selenium in whole-body fish by geographic area, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. The dotted and dashed lines represent avian and fish health effects levels, respectively; "*" denotes significant difference ($P < 0.001$)

The concentration of zinc in carp may be proportional to age (and therefore body mass), but this could not be evaluated (i.e., through correlation analysis) because samples were composited. However, in a study of 24 species of fish and invertebrates commonly consumed in Asia, including common carp, Zn concentrations in carp were dramatically higher than any other species evaluated (Lian-Ten Sun and Sen-Shyong Jeng 1998). This study evaluated ten different tissues (e.g., muscle and skeletal tissues, organs, gonads and digestive tract tissues) of fish and invertebrates from fresh water, brackish water and marine habitats. While most of the tissues from most of the species evaluated had on the order of 13-130 mg/kg dry weight Zn, common carp had slightly elevated Zn concentrations in muscle tissue (mean ± SD 248 ± 144 mg/kg). Concentrations in digestive tract tissues (mean 941 ± 382 mg/kg) were generally an order of magnitude greater than observed in other species. This suggests that the Zn concentrations observed in carp from the GSL may be a species characteristic, rather than an indication of Zn contamination within the ecosystem.

Arsenic, Cadmium, Chromium and Lead - Concentrations of As, Cd, Cr, and Pb were infrequently detected in whole-body fish tissues. Arsenic was detected in < 50% of samples from all geographic areas. Cadmium was not detected at all in four of the six geographic areas sampled, but was detected in > 50% of samples from the GSL South Shore area. Lead was detected in all six geographic areas, but in < 50% of samples in only three of them. Chromium was detected in all geographic areas, and in > 50% of samples at five of them. None of these metals were present in any fish samples in concentrations exceeding either fish or avian effects levels.

Organic Compounds in Fish
Complete datasets regarding the number of samples collected at each location and OC residues observed in samples are presented in **Appendix Table A-7**. In contrast to analytical results for OCs in sediments and invertebrates, residues for fish are presented as mg/kg **wet weight**. This was done as an aid for comparison with toxicity benchmarks for these compounds, which are most often presented in the literature in these terms.

All of the OC residues detected in GSL wetland sediments were detected in at least one fish sample, with the exception of aldrin and endrin. Total PCBs, *p, p'*-DDD, and *trans*-nonachlor were detected in all 23 samples. Ten other OCs (*p,p'*-DDE, *o,p'*-DDD, and *o,p'*-DDT; HCB, *cis*-nonachlor, α, γ, and oxy-chlordane isomers, heptachlor epoxide, and γ-BHC) were detected in ≥ 70% of the samples. When grouped by categories of related OC pesticides (e.g., parent compounds and metabolic or environmental break-down products), t-PCB, t-DDT, and total chlordanes were present in the highest concentrations (**Table 4-9**). None of the OCs evaluated exceeded protective benchmarks for fish health. However concentrations of t-DDT and t-PCB exceeded avian dietary NOAELs (cited in (Hinck et al. 2006) at several locations (**Figure 4-5**). The highest concentrations of t-DDT were observed in Ogden Bay, where the sample from site ON (0.238 mg/kg) exceeded the avian NOAEL (0.15 mg/kg). Fish sampled at Site OS were slightly under the NOAEL, with 0.105 mg/kg t-DDT. This was consistent with the results in sediments and invertebrates, where Site ON was one of three sites that had elevated DDTs in sediments (Table 4-3) and was the only site where DDTs in invertebrates exceeded the risk-based avian dietary NOAEL for insectivorous birds (Table 4-7). Total DDTs were also slightly elevated in portions of Farmington Bay, with 0.014 mg/kg at Site FS (the State Canal, a point where water from the Jordan River enters the GSL) and 0.101 mg/kg at Site FP (a ponded wetland complex located down-gradient from a former municipal landfill. However, t-DDT in fish at Sites FC and FU, both located within Farmington Bay Waterfowl Management Area (FBWMA) was lower, with a mean concentration of 0.025 mg/kg. The predominant isomer of DDT in fish from most sites was DDE (*o,p'*- and *p,p'*- isomers), except at Site FP where DDD predominated (but where DDD made up the smallest proportion of total DDTs in sediments; Table 4-3).

Total PCBs exceeded the avian dietary NOAEL of 0.11 mg/kg (cited in (Hinck et al. 2006) at several locations, with the highest mean concentration (0.524 mg/kg) at Ogden Bay, where fish collected from site ON had 0.640 mg/kg total PCBs (Figure 4-5). Other sites with elevated total PCBs in fish had included Sites IO, LC and SD; which all have more obvious potential than Ogden Bay for exposure to PCBs based on proximity to past or current sources. Sites IO and LC are located in industrial drainage canals and Site SD (the Goggin Drain) is located in another drainage canal that historically carried wastes from the industrialized northwest quadrant of Salt Lake City to the south shore of the GSL.

4.4 Avian Eggs

Eighty eight avian eggs from seven different species of bird were randomly collected during 1996-1997 for evaluation of trace elements and organic compounds. Eggs were collected at 19 wetland locations, within all seven of the geographic areas surveyed. In most cases, only one egg was collected from each nest. At least one egg was collected from each location, with up to five eggs collected at some locations. All eggs (n=88) were analyzed for trace elements. The contents of a subset of eggs (n=36) were split, with half of the contents submitted for analysis of trace elements and the other half submitted for th analysis of organic constituents. Egg collections were focused on species that are abundant and important in the generally brackish and shallow habitats that characterize the GSL wetlands, including American avocet (*Recurvirostra americana*; species code AMAV), black-necked stilt (*Himantopus mexicanus*; BNST) and snowy plover (*Charadrius alexandrinus*; SNPL). Four additional species collected, American coot (*Fulica americana*; AMCO), cinnamon teal (*Anas cyanoptera*; CITE), double-crested cormorant (*Phalacrocorax auritus*; DCCO) and mallard (*Anas platyrhynchos*; MALL) generally forage in and nest around freshwater environments such as palustrine wetlands.

Table 4-9 Summary of organochlorine residues in whole body fish (mg/kg, WET weight) by geographic area, and exceedences of levels of concern, Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Location Description		Total PCB	Total DDTs (a)	Total Chlordane(b)	HCB	dieldrin	gamma BHC
	Detection Frequency, All Sites	100%	NA	NA	91%	87%	70%
	Geometric Mean, All sites	0.1477	0.0565	0.0258	0.001	0.004	0.0005
LC (C7 Ditch)	*Detect. Freq*	4/4	NA	NA	4/4	4/4	4/4
	Geomean	0.150	0.056	0.016	0.001	0.003	0.0004
	Max	0.202	0.068	0.024	0.002	0.005	0.001
SA (Airport Mitigation)	*Detect. Freq*	2/2	NA	NA		ND	ND
	Geomean	0.033	0.010	NC	0.001	---	---
	Max	0.033	0.011	0.001	0.001	---	---
SG (Goggin Drain)	*Detect. Freq*	3/3	NA	NA	3/3	3/3	3/3
	Geomean	0.182	0.051	0.017	0.001	0.006	0.001
	Max	0.189	0.053	0.017	0.002	0.006	0.001
IO (Oil Drain Canal)	*Detect. Freq*	2/2	NA	NA	2/2	2/2	2/2
	Geomean	0.195	0.024	0.013	0.002	0.009	0.001
	Max	0.281	0.038	0.018	0.006	0.012	0.002
FB (Bountiful Pond)	*Detect. Freq*	2/2	NA	NA	2/2	2/2	2/2
	Geomean	0.131	0.100	0.049	0.003	0.013	0.001
	Max	0.158	0.101	0.054	0.003	0.013	0.002
FC (FBWMA- Crystal Unit)	*n=1*	0.051	0.006	NC	ND	ND	ND
FU (FBWMA- Unit 1)	*n=1*	0.253	0.097	0.022	ND	0.004	ND
FS (State Canal)	*Detect. Freq*	3/3	NA	NA	3/3	3/3	3/3
	Geomean	0.140	0.126	0.041	0.001	0.018	0.0005
	Max	0.177	0.141	0.053	0.002	0.023	0.0006
OH (Howard Slough)	*Detect. Freq*	2/2	NA	NA	2/2	2/2	ND
	Geomean	0.083	0.074	0.035	0.002	0.002	---
	Max	0.090	0.078	0.036	0.002	0.002	---
ON (Ogden Bay WMA-North)	*n=1*	0.640	0.238	0.053	0.002	0.004	ND
OS (Ogden Bay WMA-	*Detect. Freq*	2/2	NA	NA	2/2	2/2	2/2
South Canal)	*Geomean*	0.474	0.097	0.038	0.001	0.005	0.0002
	Max	0.550	0.105	0.040	0.002	0.005	0.0003
	Protective level for fish health(c)	*5.0*	*0.6*	*0.3*	*0.33*		
	Dietary threshold for piscivorous birds-low ((c)	*0.11*	*0.15*	*0.300*	*0.1*	*0.081*	
	Dietary threshold for piscivorous birds-high(c)	**5.0**(d)	**1.00**	**4.200**	**0.330**	**0.120**	

LEGEND:

Value ≥ lower level of concern, piscivorous bird dietary exposure
Value ≥ upper level of concern, piscivorous bird dietary exposure
Value maximum detected value in 1996-1997 fish samples

NOTES:

(a) sum of detected concentrations of *o,p'*- and *p,p'*- forms of DDT, DDD and DDE
(b) sum of detected concentrations of chlordane and related compounds *cis*-nonachlor, α, γ, and oxy-chlordane isomers, heptachlor epoxide
(c) cited in (Hinck et al. 2006).
(d) cited in (Kubiak et al. 1989)

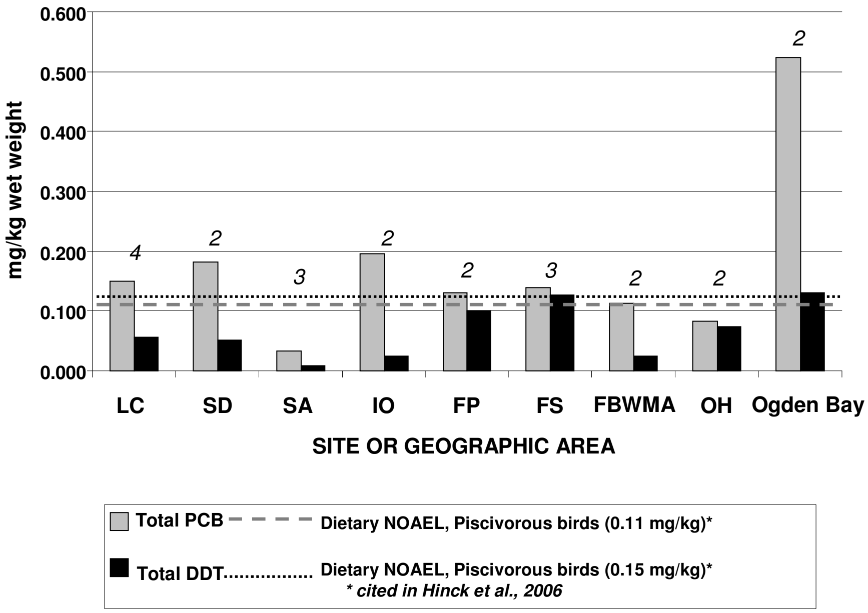

Figure 4-5 Geometric mean concentrations of total PCBs and total DDTs in whole-body fish tissues at sites and geographic locations around the Great Salt Lake, compared to avian dietary no observed adverse effect levels (NOAELs); Great Salt Lake Wetlands Synoptic Survey, 1996-1997

When both habitat types occurred within a site, eggs were collected from both groups of species if possible. The most frequently collected species were black-necked stilt (n = 41) and American coot (n = 32), and the greatest number of eggs was collected in the Farmington Bay South geographic area (**Table 4-10**).

<u>Inorganic Constituents (Trace Elements) in Avian Eggs</u>

Six trace elements (Cu, Fe, Mg, Se, Sr, and Zn) were found in all 88 eggs; Ba, Hg and Mn were found in >90% of all eggs (See **Appendix Table A-8** for complete analytical results). The least frequently detected elements (in < 5% of eggs) were B, Be, Cd, Mo and Pb. In general, trace element concentrations in eggs were low (**Table 4-11**). Of the constituents of concern for avian toxicity (As, Cd, Cu, Hg, Pb, Se, and Zn) only copper, selenium, mercury and zinc were present in concentrations that exceeded the screening benchmarks used for this evaluation (National Irrigation Water Quality Program 1998); these are discussed further below.

Copper - Copper was detected in all of the eggs sampled, which was expected because Cu is a trace nutrient. However, Cu was present at significantly higher concentrations ($P < 0.001$) at Site LS (mean Cu = 4.11 mg/kg) than at any other location around the GSL (**Figure 4-6**). This was driven by eggs collected in 1997 (n = 9) which ranged from 3.24 – 7.30 mg/kg, including three eggs that exceeded the screening value of 5.5 mg/kg. These were the only eggs out of the 88 collected that exceeded this benchmark, and represented three different species (BNST, AMCO and MALL) with different foraging preferences, indicating that Cu is available for uptake in a variety of food sources at the site.

Table 4-10 Numbers and species of avian eggs collected, for GSL Wetlands Synoptic Contaminants Survey, 1996-1997.

Geographic Area	Site Loc. Code[(a)]	Total # eggs	*Shorebird Species[(b)]* AMAV	BNST	SNPL	*Waterfowl Species[(b)]* AMCO	MALL	DCCO	CITE
Antelope Island n = 4 (2) [(c)]									
	AS	1				1*(1)*			
	AE	3		3*(1)*					
GSL South Shore n = 12 (1)									
	LS	12		9 *(1)*		1	2		
South Shore Wetlands n = 8 (5)									
	SA	6		3 *(1)*			2 *(1)*	1 *(1)*	
	SG	1	1 *(1)*						
	SI	1			1 *(1)*				
SE Shore Industrial n = 11 (7)									
	IB	3	3 *(1)*						
	IS	6				5 *(3)*	1 *(1)*		
	IP	2				1*(1)*	1 *(1)*		
Farmington Bay South n = 29 (11)									
	FN	5		3 *(1)*		2 *(1)*			
	FP	3		3 *(1)*					
	FS	7		3 *(1)*		3 *(1)*			1
	FC	12		6*(3)*		6 *(2)*			
	FO	2		2 *(1)*					
Farmington Bay North n = 7 (5)									
	FK	7		3*(3)*		4*(2)*			
Ogden Bay n = 17 (5)									
	OH	6		3*(1)*		3*(1)*			
	OS	6		3*(1)*		3*(1)*			
	ON	5				3*(1)*	2		
	TOTALS	*88 (36)*	*4 (2)*	*41 (15)*	*1 (1)*	*32 (14)*	*8 (3)*	*1 (1)*	*1*

NOTES:
(a) See Table 2-1 in text for key to Site Location Codes
(b) Species Abbreviation Codes:
AMAV: American avocet (*Recurvirostra americana*
AMCO: American coot (*Fulica americana*)
BNST: black-necked stilt (*Himantopus mexicanus*)
CITE: cinnamon teal (*Anas cyanoptera*)
DCCO: double-crested cormorant (*Phalacrocorax auritus*)
MALL: mallard (*Anas platyrhynchos*)
SNPL: snowy plover (*Charadrius alexandrinus)*
(c) All eggs analyzed for trace elements. Numbers in parentheses indicate number of eggs also analyzed for organic constituents.

Table 4-11 Summary of selected trace elements in avian eggs (mg/kg, dry weight) by geographic area, and exceedences of levels of concern, Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Trace Element		Antelope Island	GSL South Shore	S. Shore Wetland s	SE Shore Industrial	Farmington Bay S	Farmington Bay N	Ogden Bay
	# Sites Evaluated	*2*	*1*	*3*	*3*	*5*	*1*	*3*
	# eggs (n)	*4*	*12*	*8*	*11*	*29*	*7*	*17*
	# AMCO eggs	*1*	*1*	*0*	*6*	*11*	*4*	*9*
Arsenic	*Gmean*	NC	NC	NC	NC	NC	NC	NC
	Max	ND	1.1	ND	0.7	1.38	ND	0.84
#>Ref	[2.8]	--	[0]	--	[0]	[0]	--	[0]
Barium	*GMean*	1.19	2.3	2.97	1.74	3.29	4.38	5.88
	Max	1.69	5.87	17.3	3.33	11.5	5.99	17.2
#>Ref	[NA]	[--]	[--]	[--]	[--]	[--]	[--]	[--]
Cadmium	*GMean*	NC	NC	NC	NC	NC	NC	NC
	Max	ND	ND	ND	0.23	0.48	ND	ND
#>Ref	[0.15]	--	--	--	[1]	[2]	--	--
Copper	*GMean*	2.35	4.11	3.18	3.18	2.78	2.30	2.78
	Max	2.99	7.30	4.16	4.23	3.83	2.95	4.97
#>Ref	[5.5]	[0]	[3]	[0]	[0]	[0]	[0]	[0]
Lead	*GMean*	NC	NC	NC	NC	NC	NC	NC
	Max	ND	ND	ND	0.55	0.6	ND	ND
#>Ref	[NA]	--	--	--	[--]	[--]	--	--
Mercury	*GMean*	0.68	0.39	0.37	0.15	0.66	0.33	0.36
	Max	1.11	1.19	1.13	0.30	5.99	1.47	1.49
#>Ref	[3]	[0]	[0]	[0]	[0]	[3]	[0]	[0]
Selenium	*GMean*	2.6	4.8	3.6	3.2	3.1	2.0	1.6
	Max	3.6	7.5	5.3	4.4	4.6	3.1	3.2
#>Ref	[6]	[0]	[2]	[0]	[0]	[0]	[0]	[0]
Strontium	*GMean*	14.9	25.7	14.3	14.0	10.2	5.84	6.23
	Max	23.8	50.2	35.5	26.2	29.3	8.46	20.3
#>Ref	[NA]	[--]	[--]	[--]	[--]	[--]	[--]	[--]
Zinc	*GMean*	42.8	**52.4**	46.5	49.6	**51.2**	49.3	**51.4**
	Max	46.5	82.1	59.7	57.8	78.4	53.8	65.8
#>Ref	[50]	[0]	[7]	[3]	[5]	[14]	[2]	[10]

KEY AND ABBREVIATIONS

Gmean: Geometric mean concentration for geographic area
Gmean: Gmean> referenced toxicity value
NC: geometric mean not calculated (i.e., more than 50% of values <detection limit)
ND: all samples were less than the detection limit
#>Ref: number of samples > referenced threshold value it
[value]: Level of concern
As, Cu, Hg, Se, Zn: (National Irrigation Water Quality Program 1998))
Cd: background from Seiler (2003)
NA: referenced value not identified in literature

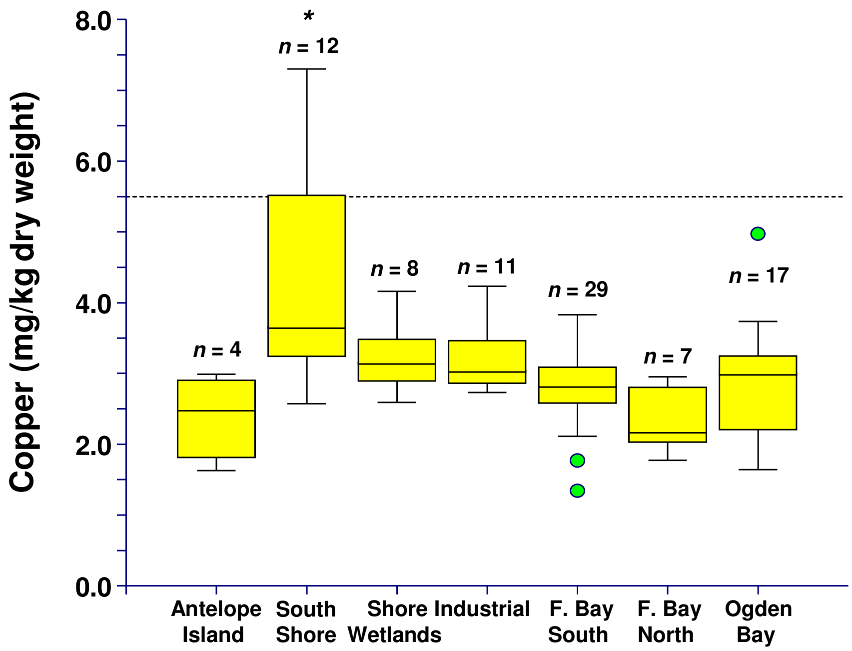

Figure 4-6 Concentrations of copper in avian eggs by geographic area, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. "*" denotes significant difference from other areas.

Selenium - Three eggs from Site LS (two BNST, one AMAV; one collected in 1996, two in 1997) exceeded the toxicity threshold for Se identified by DOI (6 mg/kg). This area had the highest geometric mean (4.8 mg/kg) and was significantly elevated ($P < 0.001$) compared to the other geographic areas (**Figure 4-7**). This was consistent with observed sediment Se concentrations (Table 4-2) and with Se uptake observed in fish (Figure 4-4) from these two sites on the GSL south shore, which are adjacent to each other and near a metals smelting and refining facility (operated by Kennecott Utah Copper Corporation, KUCC) located upgradient from the GSL. At the time that eggs were collected for this study, a preliminary investigation of contamination on and around the KUCC facility was being conducted under the auspices of the U.S. EPA and the Utah Department of Environmental Quality (UDEQ). Releases of concern included a permitted wastewater discharge to the GSL located east of Site LS (the C7 Ditch, location of Site LC), selenium-contaminated groundwater which had impacted wetlands immediately to the south of Site LS (the "I-80 Wetlands"), and wind-blown tailings originating from large (ca. 8 mi^2) tailings piles 1 mile (2km) from Sites LS and LC. The samples collected by the Service for the GSL wetlands assessment, along with more focused sampling at the I-80 wetlands in the mid 2000's eventually led to the lodging and settlement (in 2008) of a Natural Resource Damages (NRD) claim by the DOI for impacts to migratory birds from these releases.

Mercury - Mercury was detected in all 88 eggs and the maximum detected concentration was 5.99 mg/kg dry weight at site FC in the Farmington Bay South area, which is double the LOC (3 mg/kg) identified by the DOI (National Irrigation Water Quality Program 1998). While the highest mean for a geographic area occurred at the Antelope Island area (0.68 mg/kg, n = 4), the highest individual egg concentrations and the occurred at Site FC (mean = 1.86 mg/kg, n = 12). Of six eggs collected at Site FC in 1996 (two AMCO, one BNST), three exceeded 3 mg/kg. Based on these results, additional samples were collected at Site FC in 1997.

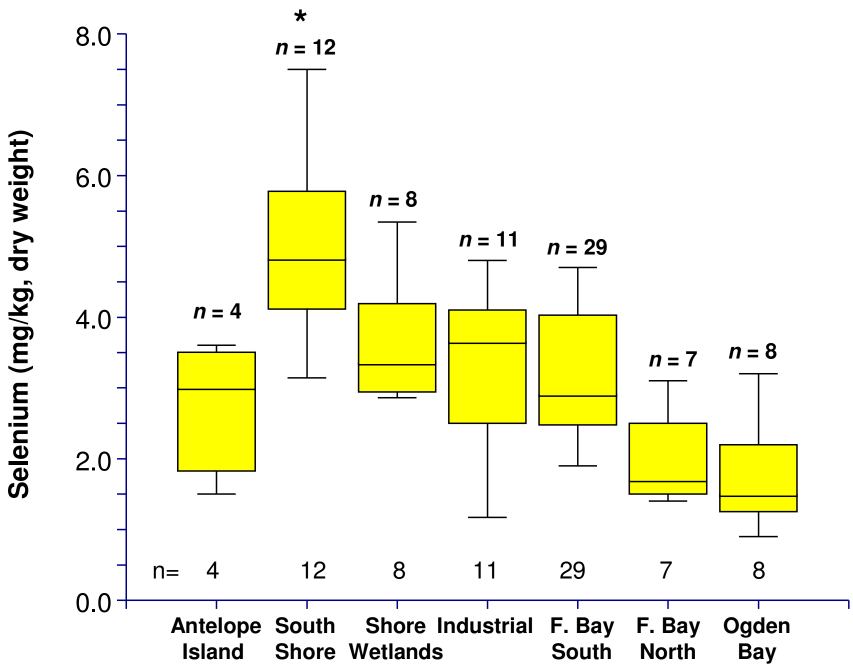

Figure 4-7. Selenium in avian eggs by geographic area, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. "*" indicates that area (GSL South Shore Wetlands) is significantly different than other areas ($P < 0.001$)

Mercury concentrations in 1997 were significantly lower than in 1996 ($P = 0.018$), but all eggs from both years at site FC had significantly higher Hg concentrations ($P = 0.005$) than at other sites within the Farmington Bay South geographic area (**Figure 4-8**). Interestingly, Hg was not elevated in eggs from sites in the SE Shore Industrial area (Sites IB, IS and IP) , which have had a long history of metals-associated activities; in fact this geographic area had the lowest mean Hg concentration of any of the geographic areas.

The Crystal Unit of Farmington Bay Waterfowl Management Area (Site FC) is immediately adjacent to the point where the Oil Drain Canal enters the waters of the GSL in Farmington Bay (see Figure 2-1). The accumulated sediments from the canal (many of which originated from refineries and other industrial facilities at the head of the canal) form a broad, shallowly inundated delta that is intensively used by birds for foraging. Based on the observed Hg concentrations and concerns for avian exposure, a follow-up study was conducted at Site FC in 2000 to further evaluate the potential for Hg uptake in piscivorous birds, which are typically subject to higher mercury exposure through food chain bioaccumulation mercury (see Section 6).

Zinc- By far the greatest number of exceedences of avian toxicity benchmarks for metals was observed with Zn, in which 41 of 88 eggs exceeded the toxicity threshold of 50 mg/kg identified by the DOI (National Irrigation Water Quality Program 1998). The only area where this benchmark was not exceeded was Antelope Island, where three BNST eggs and one AMCO egg were collected. The mean Zn concentration exceeded 50 mg/kg in three areas: the GSL South Shore, Farmington Bay South, and Ogden Bay (Table 4-10).

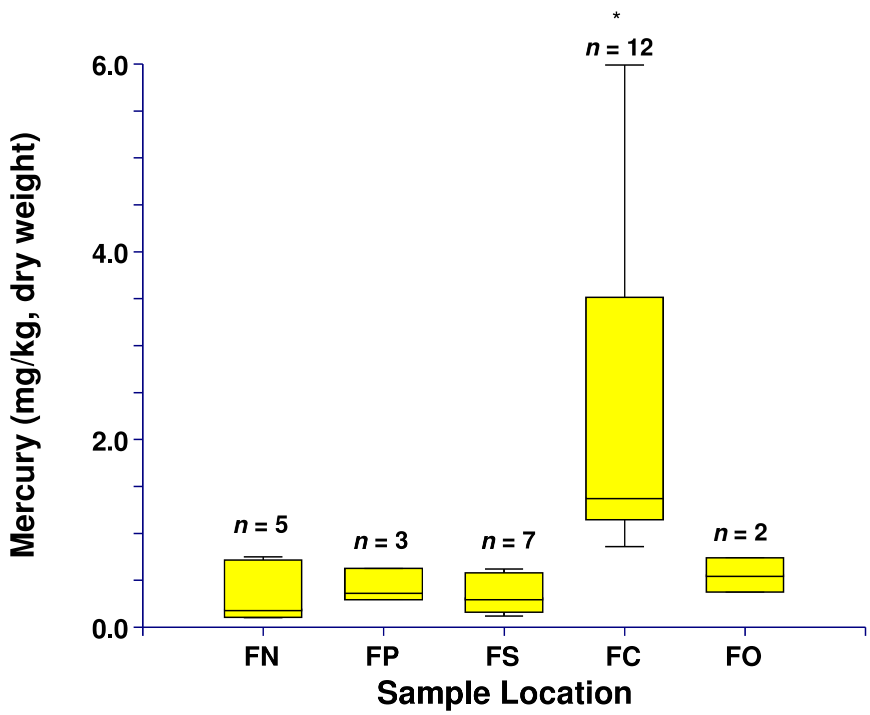

Figure 4-8. Concentrations of mercury in avian eggs from individual sites within the Farmington Bay South area, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. "*" denotes significant difference from other locations.

Zinc is a primary nutrient that is typically very well regulated, and there is almost as much literature available regarding the adverse effects of zinc deficiency as there is regarding Zn toxicity. While 50 mg/kg is identified in one reference as a no-effect level (NOAEL), there is little information regarding the effect of excess Zn in either adult or developing birds, particularly data that are linked with Zn concentrations in eggs. However, an evaluation of data retrieved from the Service's Environmental Contaminants Data Management System (ECDMS) database (accessed April 5, 2009) for the Service's "Mountain-Prairie" Region (Region 6: Utah, Colorado, Wyoming, North Dakota, South Dakota, Nebraska) indicates 1) that for any given area, American coot eggs have higher concentrations of Zn than other species evaluated around the GSL and in R6; and that 2) Zn in eggs from any given species within the GSL ecosystem is similar Zn concentrations in other states within R6 (**Figure 4-9**). Additionally, the likelihood that mean Zn concentrations for a given GSL ecosystem area exceed 50 mg/kg appears to be a function of the proportion of American coot eggs represented in the mean (see **Appendix Table A-8**). These observations indicate that 50 mg/kg is likely an overly conservative screening benchmark.

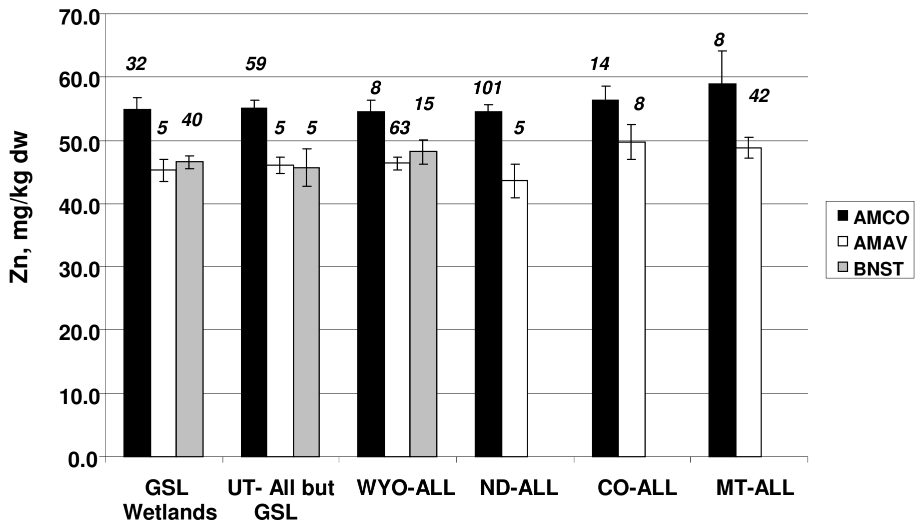

Figure 4-9 Zinc concentrations in three species, American coot (AMCO), American avocet (AMAV) and black-necked stilt (BNST) from GSL Wetlands and other locations in the western United States, 1991-2008. Data from U.S. Fish and Wildlife Service Environmental Contaminants Data Management System (ECDMS), 2009. Error bars indicate standard error; numbers above bars indicate sample size.

Organic Compounds in Avian Eggs

Similar to the results in fish, most of the OCs analyzed (23 of 26) were detected in at least one egg collected around the GSL (see complete analytical results for detected OCs in **Appendix Table A-9**). As was the case for OC concentrations in fish; all OC concentrations in eggs are presented below in terms of mg/kg wet weight. Total PCBs and DDT (at least one isomer) were observed in all eggs sampled. The predominant DDT isomer in eggs was *p,p'* DDE (observed in all eggs) versus *p, p'*-DDD which was the most frequently detected isomer in fish. However, p,p'- DDE was also frequently detected (in 65% of eggs), as were several non-DDT OCs including oxychlordane (89%), HCB (78%), and dieldrin (67%). Total DDTs (summed isomers) and t-PCB made up 80% or more of all OCs by weight in eggs (**Figure 4-10**).

Total PCBs- Although t-PCB was detected in all eggs, concentrations were generally low (**Figure 4-10**). The highest total PCB concentration measured in an individual egg was 1.39 mg/kg (ww) in a BNST egg at site FK; this was the only egg that exceeded the NOAEL (1.3 mg/kg) identified by (Wiemeyer et al. 1984). None of the eggs sampled exceeded the LOAEL of 3.5-5.0 mg/kg (Giesy et al. 1994) derived for avian eggs in the Great Lakes region.

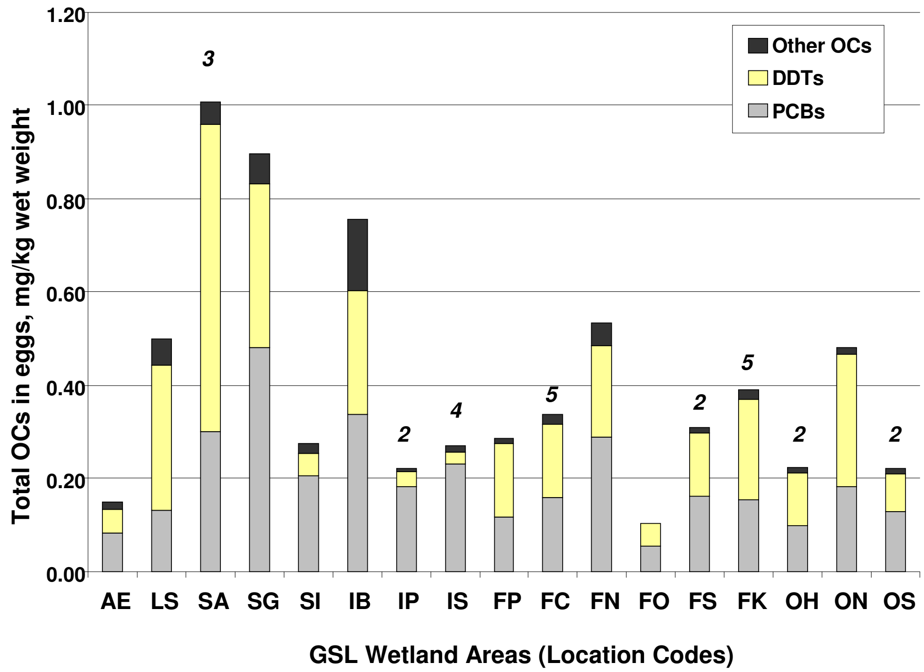

Figure 4-10 Relative contribution of total PCBs, total DDTs, and other organochlorine (OC) residues (mg/kg, ww) in avian eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Mean concentrations are presented where n>1; *n*=1 unless otherwise indicated.

Total DDTs and DDT metabolites- Summed DDT residues in eggs around the GSL ranged from 0.008 mg/kg in an AMCO egg from site IP, to 1.87 mg/kg, in a BNST from site SA collected in 1997 (**Appendix Table A-9**). This latter egg, and a BNST egg from site FK with 1.457 mg/kg total DDT, were the only two individual eggs that exceeded the lowest avian effects level found in the literature (1.0 mg/kg, (Blus 2003). Mean concentrations at sample sites (with sample numbers ranging from 1 – 5) were also < 1.0 mg/kg (**Figure 4-11**).

Despite elevated concentrations of DDTs and PCBs in a few individual eggs collected around the GSL, there were no significant concentration trends between-geographic areas (**Figure 4-12**). This was at least in part due to high within-site variability and small and uneven sample sizes. However, is interesting to note that some of the highest concentrations of both t-PCB and total DDTs in individual eggs were observed in the GSL South Shore Wetlands (i.e., Sites SA, SG and SI; see data in Appendix Table A-9). This is somewhat surprising because these sites are distant from industrial sources, and of some concern because they are wetlands being managed as conservation areas and/or wetland mitigation banks. However, these sites are all at the "bottom of the watershed" and receive water (and sediments) from industrial effluents upstream., and/or may have been previously under agricultural management or subject to mosquito abatement activities (e.g., in the case of DDT residues). As discussed above (Section 4.1), PCBs in eggs from this area may also be due to exposure to air emissions containing PCBs created by incomplete combustion of hydrocarbons from large industrial sources such as U.S. Magnesium (located approximately 30 miles (50 km) to the west-northwest of the South Shore Wetlands). Analysis of individual PCB congeners would be required to support this hypothesis.

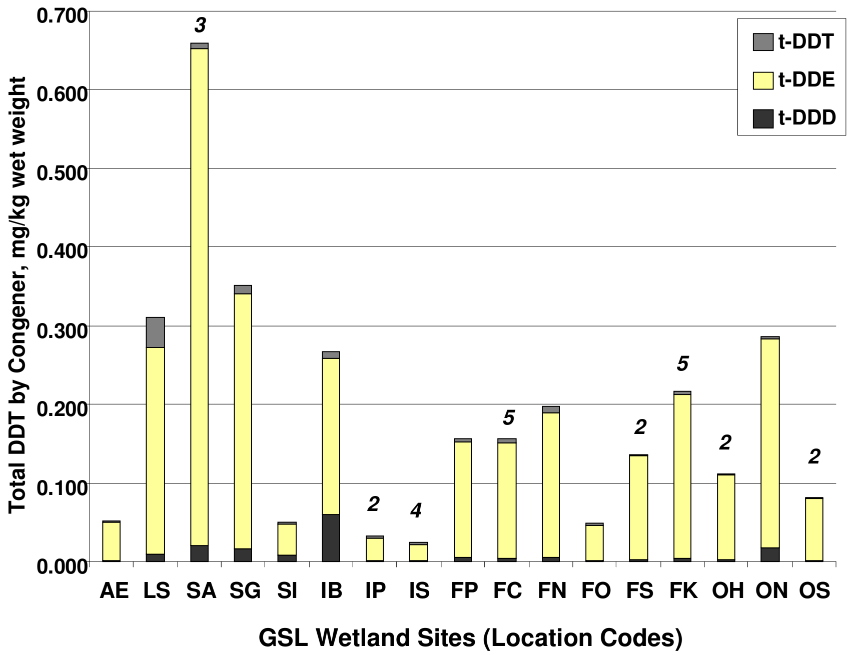

Figure 4-11. Total DDT residues (summed *o,p'-* and *p,p'-* isomers of DDD, DDE and DDT) in avian eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Mean concentrations are presented where n>1; *n*=1 unless otherwise indicated.

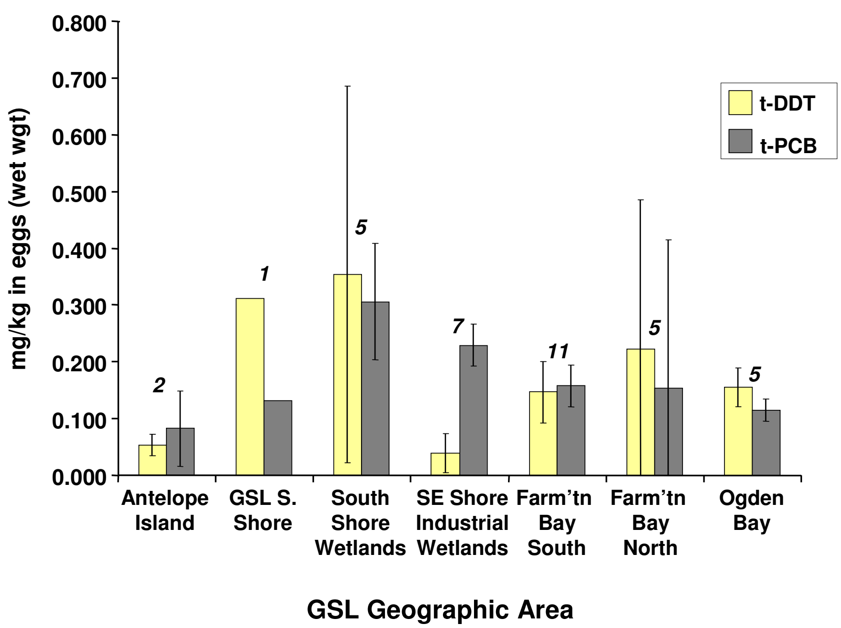

Figure 4-12. Mean concentrations of total PCBs and total DDTs in avian eggs by geographic area (mg/kg wet weight), Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Sample size (*n*) presented above bars; error bars represent standard error (±SE), .

4.5 Fish Reproductive Biomarkers and PAHs in Bile

Biomarkers of contaminant exposure in fish were included in the 1996-1997 Great Salt Lake wetlands synoptic survey because analysis of these endpoints can help to either identify specific compounds to which wildlife may be exposed, or can provide additional information that can be used in conjunction with conventional chemical analyses to interpret the effects of contaminants detected in environmental media or biological tissues. Biomarkers can range from highly specific indicators of exposure to certain compounds (e.g., depression of acetylcholinesterase (AChE) activity as an indicator of exposure to organophosphate compounds), or they can be more general measures of physiological response that can indicate a biochemical or physiological response to a less specific group of chemical that may be present. An example of this type of biomarker is the measurement of ethoxyresorufin-*O*-deethylase (EROD) activity, which is a measure of the activity of a class of metabolic enzymes (cytochrome P450) that are induced in tissues such as liver in the presence of several classes of organic chemicals, which are in turn metabolized with the aid of these enzymes. Biomarker endpoints alone will not generally indicate that a contaminant is present, but will instead, paired with accompanying chemical analytical data, indicate that chemical contaminants in the environment are present in a quantity and form that elicits a biological response from the test organism. In this respect, biomarker analyses are screening tools that are most useful to identify sites where further evaluation of possible chemical contamination might be appropriate.

A broad suite of biomarkers was assessed in fish as part of the GSL Wetlands survey. These data were evaluated as an estimator of contaminant exposure to piscivorous birds, but direct exposure to fish was also considered because fish health is a basic ecosystem indicator in aquatic habitats. Biomarker-derived evidence of contaminant exposure in fish was also considered to be a screening predictor of exposure in aquatic-dependent bird species that could be evaluated without applying the generally lethal assessment methods (e.g., collection of liver or brain tissues) to the birds themselves. Samples for biomarker analysis were generally collected at the same time that samples for chemical analysis were collected. In this section, we report results from endocrine system responses in male and female common carp and polynuclear aromatic hydrocarbon (PAH) metabolites in common carp. Results on AChE activity in common carp brain tissue and EROD activity in carp liver tissue are reported in **Appendix Tables A-10 and A-11**, respectively.

Endocrine Hormones in Common Carp

Blood serum samples from 79 male and 80 female adult common carp (*Cyprinus carpio*) collected between July 31 - August 27, 1996 and from July 23 - August 28, 1997 were analyzed for the sex steroid hormones 17β-estradiol (E_2) and 11-ketotestosterone (11-KT) and for vitellogenin (VTG), an egg yolk precursor found in female non-mammalian vertebrates. The ratio of E_2 to 11-KT (estrogen:testosterone ratio or E/T ratio) was also calculated and evaluated. The reproductive status of each fish was determined through histologic evaluation of gonadal tissue samples. The gonadosomatic index (GSI) was calculated by dividing (field-measured) gonad mass by the fish mass. Complete data from these evaluations are presented in (**Appendix Table A-12**). Four sites were sampled in 1996 and eight sites were sampled in 1997; two sites (LC and FS) were sampled in both years. Males and females were analyzed separately due to natural differences in sex steroid hormones between the sexes.

Endocrine Hormones in Male Carp - In male carp, significant differences exist between sites for concentrations of E_2, 11-KT and the E/T ratio (**Table 4-12**). A summary of key differences for E_2 include: concentrations from site OS were significantly higher than at all sites except SD, while the lowest geometric mean concentrations of E_2 occurred at FC, FU, and OH. Concentrations of testosterone in male carp were similar across all locations except site OH which had the lowest geometric mean concentration and was significantly lower than all other sites. The E/T ratio at OS was significantly higher than at FP, FC, FU, while the E/T ratios at FC and FU were significantly lower than most other sites (FP, OH, SD, LC, SA, and FS) (**Figure 4-13).** Ratios of E/T in male fish are generally expected to be less than one as concentrations of 11-KT should be greater than E_2 (Goodbred et al. 1997). Sites where ratios in male fish were >1 might suggest an unusual endocrine response and included LC (14% of male fish), SD (20%), FP (20%), FS (25%) and OS (75%). Vitellogenin was detected in one male carp at each of sites FP, LC, FS, and FU. Mean GSI (ratio of gonad mass to fish mass) was lowest at site FP (3.4%); this was significantly lower than the GSI at sites OH (8.1%) and ON (7.8%) which were the sites with the highest GSI means. The mean GSI at site OH was also significantly greater than at sites, OS, SA, and FS. GSI was significantly, but poorly correlated with weight ($r = 0.36$), length ($r = 0.34$), relative body condition ($r = 0.34$), concentrations of E_2 ($r = -0.34$), and collection date ($r = 0.38$) and not correlated with 11-KT ($r = 0.07$). Length and weight were highly correlated with each other ($r = 0.96$).

Table 4-12. Geometric mean concentrations (pg/ml) of 17β-estradiol (estrogen) and 11-keto-testosterone (testosterone), arithmetic mean E/T ratios, arithmetic mean gonadosomatic index (GSI), and detection of vitellogenin (VTG) in male common carp, Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Location (and Code)	*n*	Estrogen, pg/ml[a]		Testosterone pg/ml[a]		E/T Ratio (pg/ml)[a]		GSI[a]		VTG[b]
P-Value[(c]		*(< 0.001)*		*(<0.001)*		*(<0.001)*		*(<0.001)*		
C7 Ditch (LC)	7	473	c,d,e	954	b	0.47	b,c,d	5.4%	a,b,c	*
Goggin Drain (SD)	5	909	e,f	2,095	b	0.44	b,c,d	6.2%	a,b,c	
Airport Mitigation (SA)	10	434	b,c,d,e	815	b	0.53	c,d	4.9%	a,b	
Bountiful Pond (FP)	10	383	b,c,d	963	b	0.40	b,c	3.4%	a	*
State Canal (FS)	20	516	d,e	876	b	0.59	c,d	5.0%	a,b	*
Crystal Unit (FC)	2	124	a,b	1,775	b	0.07	a	6.5%	a,b,c	
Unit 1 (FU)	8	111	a	948	b	0.12	a	5.0%	a,b,c	*
Howard Slough (OH)	8	118	a	260	a	0.43	b,c,d	8.1%	c	
Ogden Bay South (OS)	4	2,485	f	1,527	b	1.62	d	4.5%	a,b	
Ogden Bay North (ON)	5	182	a,b,c	1,330	b	0.14	a,b	7.8%	b,c	

NOTES AND ABBREVIATIONS:

pg/ml = picogram per milliliter

(a) For each endpoint (e.g., Estrogen), means similarity (Tukey-Kramer LSD, $P \geq 0.05$) noted with letters (e.g., means noted with "a" are similar to each other)

(b) Detection of VTG noted with "*"

(c) *P* values are for ANOVA comparison between sites (1996 and 1997) with pooled data

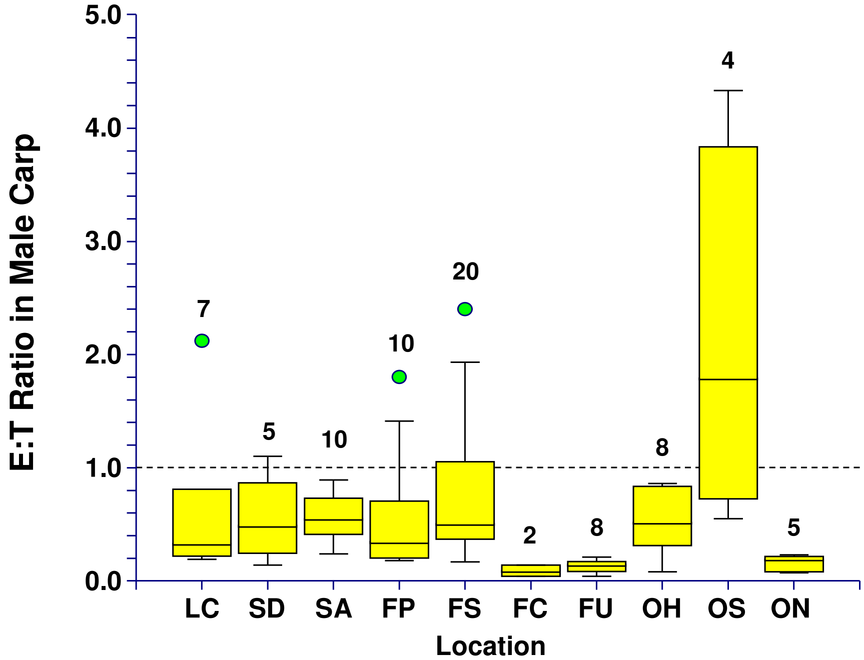

Figure 4-13. Ratio of 17β-estradiol (E) to 11-ketotestosterone (T) in male common carp, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Dashed line indicates one-to-one E/T ratio. Sample sizes are shown above box plots.

Endocrine Hormones in Female Carp - A total of 80 female common carp were collected from four locations in 1996 and eight locations in 1997, with fish being collected from sites LS and FS in both years. Data for E_2, 11-KT, E/T ratio and VTG were log-transformed prior to statistical analyses, while data for GSI met the assumption for parametric statistics.

The reproductive status of the female fish collected ranged from "undeveloped oocytes" to "late vitellogenic" based on gonad histopathology (**Table 4-13**), but the majority (72.5%) were classified as mid (n = 20) and late (n = 38) vitellogenic. Concentrations of E_2 and VTG were significantly lower in the "undeveloped oocytes" (n = 2), and "early pre-vitellogenic" (n = 6) reproductive status classes; therefore these fish were removed from further statistical analysis of hormone levels (**Table 4-13**). This eliminated site FU from further analysis (which had two fish in "undeveloped oocytes" and the remaining four fish in "early pre-vitellogenic"). Sites FP and FC were also removed from further analysis due to the reduction of sample size to n=1 by removing three fish due to sexual status (2 from FP and 1 from FC). Fish in the "pre-vitellogenic" class (n = 6) were also removed from the analysis of vitellogenin, but were included in other analyses.

Table 4-13. Influence of sexual status on geometric mean concentrations of 17β-estradiol (estrogen), 11-keto-testosterone (testosterone), mean estrogen to testosterone (E/T) ratio, vitellogenin (VTG), and mean gonadosomatic index (GSI) in female common carp, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. *P*-values are shown in parentheses. Means with similar letters are similar to each other. Sexual status was not determined for one fish.

Status	*N*	Estrogen[a] (pg/ml)		Testosterone[a] (pg/ml)		E/T Ratio[a]		VTG[a] (mg/ml)		GSI	
P-Values[b]		*(< 0.001)*		*(0.10)*		*(0.09)*		*(<0.001)*		*(<0.001)*	
Undeveloped Oocytes	2	193	a	418	--	0.46	--	0.52	a	0.0%	a
Early Pre-Vitellogenic	6	254	a	501	--	0.52	--	0.32	a	0.7%	a
Pre-Vitellogenic	6	742	b	598	--	1.24	--	0.18[c]	a	1.5%	a
Early Vitellogenic	7	1,037	b	724	--	1.43	--	2.02	b	3.7%	a,b
Mid Vitellogenic	20	512	b	305	--	1.62	--	3.13	b	6.2%	b
Late Vitellogenic	38	702	b	524	--	1.31	--	2.77[d]	b	10.3%	c

NOTES AND ABBREVIATIONS:
pg/ml = picogram per milliliter
(a) For each endpoint (e.g., Estrogen), means similarity (Tukey-Kramer LSD, $P \geq 0.05$) noted with letters (e.g., means noted with "a" are similar to each other). "--" = no significant difference observed
(b) *P* values are for ANOVA comparison between sites (1996 and 1997) with pooled data
(c) n = 5 for VTG in females in pre-vitellogenic state
(d) n = 37 for VTG in females in late-vitellogenic state

As with male carp, data for female carp from both 1996 and 1997 at site FS were evaluated for between-year differences; 1996 and 1997 data from site LC were also evaluated because sample sizes were sufficient. At both sites, concentrations of E_2 and VTG did not differ between years; however, 11-KT was significantly higher in 1997 compared to 1996 at both sites (**Table 4-14**). There were significant differences between study sites and years for concentrations of E_2, 11-KT and E/T ratio in female fish, but there was not a significant difference in VTG concentrations (**Table 4-14**). The geometric mean concentration of E_2 at site OS (1996) was significantly higher than all sites except site SD (also 1996); the lowest geometric mean occurred at site FS in 1997. Geometric mean concentrations of 11-KT at sites ON and LC (1996) were significantly higher than at sites SA and FS (1997) which had the lowest geometric mean concentrations of 11-KT for all sites and years evaluated. The higher concentrations of 11-KT observed at ON and LC (1996) also had an impact on the E/T ratio by lowering it to less than 1.0 (i.e., 11-KT > E_2) at these sites. Site ON (1996) had the lowest mean observed E/T ratio (0.44) and was significantly lower than at the other sites and years; the E/T ratio was also < 1 at sites LC (1996) and FS (1996) (**Table 4-14**). Concentrations of VTG were not significantly different among sites, but the highest and lowest means occurred at sites OH (1997) and OS (1996), respectively.

Table 4-14. Geometric mean concentrations of 17β-estradiol (estrogen), and 11-keto-testosterone (testosterone), and arithmetic mean estrogen to testosterone (E/T) ratio, vitellogenin (VTG) concentration, and gonadosomatic index (GSI) in female common carp, Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Location (Code)	*n*	Estrogen[a] (pg/ml)		Testo-sterone[a] (pg/ml)		E/T Ratio[a]		VTG[a, c] (mg/ml)		GSI[c]	
P-Values[(b)]		(< 0.001)		(< 0.001)		(< 0.001)		(0.206)		(0.001)	
C7 Ditch (LC-96)	8	726	a,b	1,110	c	0.65	a,b	1.59	--	7.9%	a,b
State Canal (FS-96)	10	583	a,b	728	b,c	0.78	a,b	2.85	--	8.6%	a,b
Goggin Drain (SD-96)	6	1,166	b,c	660	b,c	1.82	b,c	2.48	--	11.3%	a,b
Ogden B South (OS-96)	5	2,436	c	565	a,b,c	4.20	c	1.47	--	6.5%	a,b
C7 Ditch (LC-97)	5	580	a,b	481	a,b,c	1.21	a,b	2.46	--	10.3%	a,b
Airport Mitigation (SA-97)	9	535	a,b	222	a	2.40	c	3.10	--	5.7%	a
State Canal (FS-97)	10	424	a	241	a	1.73	b,c	2.69	--	5.3%	a
Howard Slough (OH-97)	9	776	a,b	314	a,b	2.44	c	4.51	--	13.1%	b
Ogden B North (ON-97)	7	512	a,b	1,180	c	0.44	a	3.08	--	7.6%	a,b

NOTES AND ABBREVIATIONS:
pg/ml = pictogram per milliliter
(a) For each endpoint (e.g., Estrogen), means similarity (Tukey-Kramer LSD, $P > 0.05$) noted with letters (e.g., means noted with "a" are similar to each other). "--" = no significant difference observed
(b) *P*- values are for ANOVA comparison between sites (1996 and 1997) with pooled data
(c) Fish in pre-vitellogenic sexual status were not used to calculate means for VTG or GSI. Sample numbers for data used to calculate means are: LC 96 = 7; LC 97 = 4; FS 96 = 9; FS 97 = 8; OS = 4; ON = 6

The mean GSI for female fish among sites and years ranged from 5.3% (site FS, 1997) to 13.1% (site OH, 1997), and differed significantly among sites, with GSI at site OH (1997) significantly higher than at sites SA and FS (both 1997). Length and weight of female fish were highly correlated with each other (r = 0.97) but both were only weakly correlated with GSI (r = 0.49 for both length and weight). GSI in female fish was even less correlated with concentrations of E_2 (r =0.12) and collection date (r =0.07) than in male fish, suggesting that GSI in female fish could not be predicted by hormone levels or that spawning (related to GSI) could not be predicted by collection date. The correlation between 11-KT and E/T ratio was relatively high (r =0.71), while the correlation between E_2 and the E/T ratio was considerably lower (r = 0.44), suggesting that 11-KT in female fish had a greater influence on the E/T ratio than E_2.

Despite between- and among-site significant differences in reproductive endpoints for both male and female carp, the impact of contaminant stressors on reproductive anatomy and physiology remains unclear. While some fish serum hormone concentrations appear abnormal and vitellogenin protein was detected in male fish populations from some locations, more data, including fish contaminant concentrations and occurrence of intersex, with higher sample sizes (allowing for more complex statistical analyses) would be required to elucidate if environmental stressors are disrupting endocrine function in GSL wetland fish.

Relative Body Condition (Male and Female Fish)- Relationships between length and weight in fish are well documented and commonly used to assess the health of fish populations; however, relative body condition *(Rn)* may be a more useful indicator because of the potential for seasonal variation in the length-weight relationship due to factors such as spawning and nutritional deficits (Osmundson et al. 1997). Relative body condition is defined as:

$$Rn = \frac{M_O}{M_E}$$

where M_O is the observed mass of an individual fish, and M_E is the "expected" mass, which has been determined by a linear regression of the log-transformed length-to-weight relationship for a given population. A relative body condition of 1.0 indicates the fish's observed mass equals the expected mass of that population.

For the population of 79 male carp collected in 1996 and 1997, the mean *Rn* was 1.00 with a range of 0.964 to 1.056 ($R^2 = 0.95$). The results from ANOVA indicate that *Rn* was significantly different between locations ($F_{9,69} = 6.87$; $P < 0.001$), and paired t-tests of observed and expected mass for each site showed observed mass was significantly higher than the expected mass at FU and OH, while at LC and ON observed mass was significantly lower than the expected.

Analysis of *Rn* for 80 female carp yielded results similar to those of the males. The mean *Rn* was 1.00 with a range of 0.957 to 1.048 ($R^2 = 0.97$). Relative body condition was significantly different between locations ($F_{9,70} = 2.79$; $P = 0.007$), and paired t-tests of observed and expected mass showed observed mass was significantly higher than the expected mass at FU and OH and significantly lower than the expected mass at LC and OS. These results are almost identical to the males.

If the *Rn* was similar across all sites, fish within each site would be equally above and below an *Rn* of 1.0. That, however, was not the case. Relative body condition in both males and females was higher than expected at sites FU and OH, possibly suggesting heavier and healthier fish, and was lower in males and females at site LC, suggesting thinner fish. The one disparity between the sexes was *Rn* was lower in males at site ON but lower at site OS for females.

<u>Polynuclear Aromatic Hydrocarbon Metabolites in Fish Bile</u>

Bile from three individual fish at each of eight different locations was analyzed for the polynuclear aromatic hydrocarbon (PAH) metabolites of benzo(a)pyrene, naphthalene and phenanthrene parent compounds. Metabolites of all three of these compounds were detected in every sample (**Table 4-15**, with complete data in **Appendix Table A-13**).

The highest mean concentrations of all three metabolites occurred at site FS in Farmington Bay, followed closely by sites ON in Ogden Bay and LC at the mouth of the C7 canal on the south shore of the GSL. Site FU, also in Farmington Bay (and near the mouth of the Oil Drain canal), had elevated concentrations of phenanthrene and moderately elevated levels of benzo(a)pyrene.

Concentrations of benzo(a)pyrene at C7 Ditch, State Canal and Ogden North are indicative of a highly PAH contaminated environment (Krahn et al. 1986; Pinkney et al. 2001), and only Airport Mitigation and Crystal Unit had consistent concentrations that might be considered background (Suzanne McDonald, Geochemical and Environmental Research Group, personal communication) (**Figure 4-14**). Similar trends appear for naphthalene (**Figure 4-15**) and for phenanthrene (**Figure 4-16**), except that phenanthrene appears to be elevated across every site. Regarding the relatively high concentrations of PAHs at C7 Ditch, this may be explained by the proximity of site LC to an interstate freeway and to KUCC's copper smelter and refining facility, both of which are likely sources of PAH emissions that can be deposited in nearby waters. Potential sources of PAHs in Ogden Bay include the Ogden Rail Yard, motor boat traffic, roadways upstream and spills.

Table 4-15. Mean concentrations (mg/kg ww) of PAH metabolites in bile from common carp, Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Location	*Sex (M,F)*	*Benzo(a)pyrene[(a)]*		*Naphthalene[(a)]*		*Phenanthrene[(a)]*	
				P-Values[(b)]			
		(<0.001)		*(< 0.001)*		*(< 0.001)*	
C7Ditch (LC)	(1,2)	***1.060***	a	***549***	a,b	***123.5***	a
Airport Mitigation (SA)	(2,1)	0.126	b	68	c,d	44.1	b
Bountiful Pond (FP)	(3,0)	0.288	b	135	c	43.2	b
Crystal Unit (FC)	(1,2)	0.159	b	74	c,d	14.7	b,c
State Canal (FS)	(1,2)	***1.366***	a	***650***	a,b	***188.6***	a,d
Unit 1 (FU)	(1,2)	0.262	b	129	c	***125.1***	a
Howard Slough (OH)	(0,3)	0.288	b	100	c	38.2	b
Ogden North (ON)	(0,3)	***1.155***	a	298	b	***76.4***	a
Means, all sites		0.405		176		***62.7***	

KEY AND NOTES:

Value: "low" level

Value: "moderate" level

Value: "high" level (see text for discussion and reference)

(a) For each endpoint (e.g., benzo(a)pyrene), means similarity (Tukey-Kramer LSD, $P > 0.05$) noted with letters (e.g., means noted with "a" are similar to each other).

(b) *P* values are for ANOVA comparison between sites

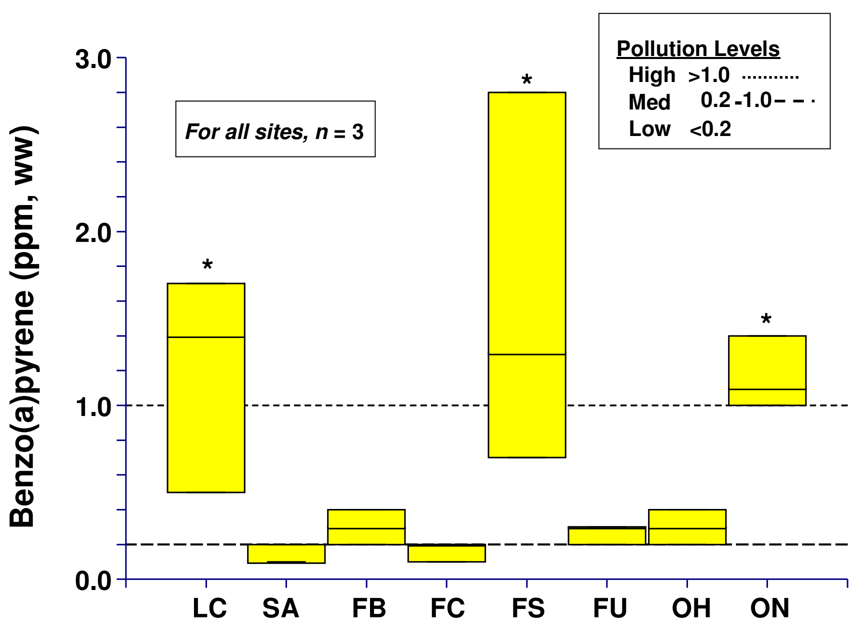

Figure 4-14. Concentrations of benzo(a)pyrene in bile from common carp (*Cyprinus carpio*) Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Sites marked with (*) are significantly elevated compared to other sites; references for threshold levels given in text.

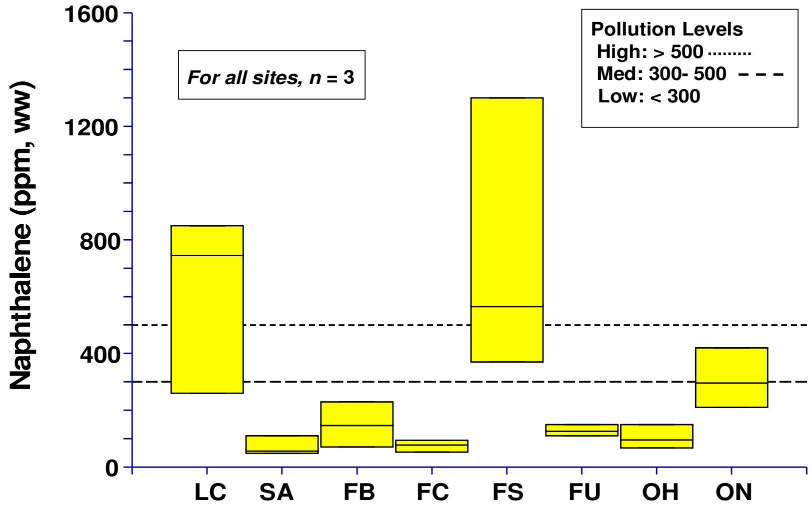

Figure 4-15. Concentrations of naphthalene in bile from common carp (*Cyprinus carpio*) Great Salt Lake Wetlands Synoptic Survey, 1996-1997. See Table 4.1-13 for results of means testing between sites (Tukey's Least Significant Difference); references for threshold levels given in text.

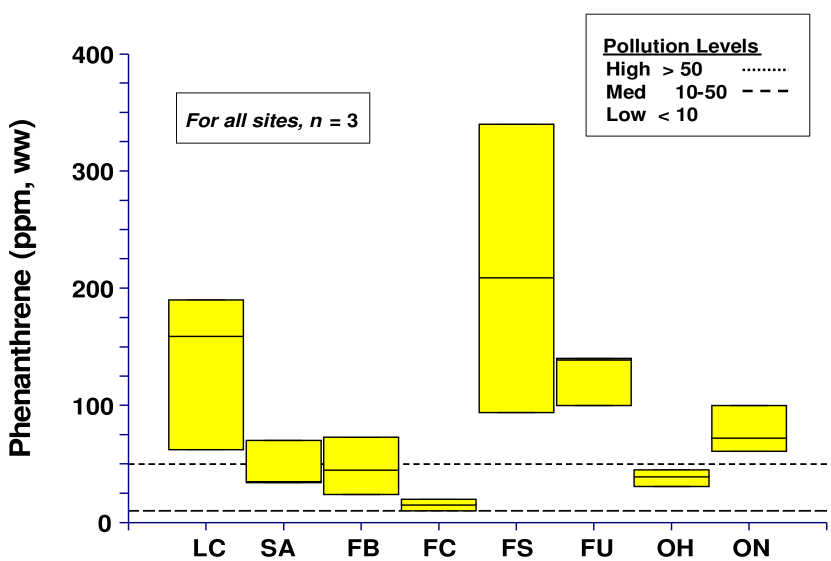

Figure 4-16. Concentrations of phenanthrene in bile from common carp (*Cyprinus carpio*) Great Salt Lake Wetlands Synoptic Survey, 1996-1997. See Table 4.1-13 for results of means testing between sites (Tukey's Least Significant Difference); references for threshold levels given in text.

Weight of evidence Analysis, Fish endocrine and body condition indicators

Table 4-16 provides a summary of responses observed within the suite of biomarkers evaluated at the GSL wetland sites, including enzyme biomarkers (AChE and EROD), endocrine hormone concentrations and ratios, and detections of elevated concentrations of PAH metabolites in bile. Because of high sample variability due to uneven sample sizes and different collection times, it was difficult to observe trends in this data; but nevertheless, three of the seven geographic areas evaluated had consistent "positive" responses (i.e., responses indicative of potential contaminant exposure) for these endpoints. Within the GSL south shore area, Site LC was the only site with aquatic habitat suitable for fish. While Farmington Bay South and Ogden Bay each contained multiple sample sites, all may be relatively homogenous with respect to fish populations, making it difficult to tie potential exposure to any particular site without further investigation. Carp at site LC had positive indications of contaminant exposure along several lines: E/T ratios were altered in female fish, vitellogenin was observed in male fish, body condition was adversely impacted in both sexes, and relatively high concentrations of PAH metabolites were observed in the subset of fish evaluated for this endpoint. However, increased EROD activity was not observed. Looking at contaminant data in fish from Site LC (Section 4.3) these findings are consistent with Cu and

Table 4-16. Weight of Evidence Summary: Responses of common carp endocrine sex hormones, vitellogenin, body condition, and enzyme biomarkers and detection of elevated concentrations of PAH compounds for the GSL South Shore, Farmington Bay South, and Ogden Bay. All data were collected from 1996-1997.

	Sites with Responses*					
	GSL South Shore		Farmington Bay South		Ogden Bay	
Endocrine:	**F**	**M**	**F**	**M**	**F**	**M**
Estrogen	--	--	FS	--	--	OS
Testosterone	--	--	--	--	ON	--
E/T Ratio	LC	--	FS	--	ON	OS
Vitellogenin	--	LC	--	FP, FS, FU	--	--
Body Condition	LC	LC	FU	FU	OS	ON
Enzyme Biomarkers:						
EROD	--	--	FU	--	--	--
AChE	LC	LC	--	--	--	--
PAH Compounds:						
Benzo(a)pyrene	LC		FS		ON	
Naphthalene	LC		FS		--	
Phenanthrene	LC		FS, FU		ON	

KEY and NOTES:

--	No response
Endocrine:	Site code indicates a response above or below expected at site
Enzyme Biomarkers:	Site code indicates activation of enzyme at site
PAH:	Site code indicates elevated concentrations of a PAH at site

* Biomarkers and presence of PAH compounds were not evaluated in the GSL Open Water, SE Industrialized Area Wetlands, Antelope Island, and Farmington Bay North. Responses were not detected in the GSL South Shore Wetlands.

Se concentrations that exceeded fish health levels of concern (**Table 4-8**) although concentrations of chlorinated organic compounds that are implicated in endocrine disruption were generally below levels of concern for fish (**Table 4-9**). An additional factor in fish health at LC, particularly regarding general indicators such as relative body condition, is overall habitat condition, which is generally impaired at the site. These factors, including high sediment and nutrient loads, occasional high biological oxygen demand and consequent low dissolved oxygen, and high summer temperatures may have as great or greater cumulative effect on fish health as contaminant-driven factors. However, these data also correspond with observations of elevated Cu (**Figure 4-6**) and Se (**Figure 4-7**) in avian eggs, indicating that these metals are both elevated and biologically available throughout the site. In total, it can be concluded that avian health and productivity may be adversely impacted by exposure at Site LC.

Within Farmington Bay South, Sites FS and FU were the most impacted with respect to fish biomarkers. Female fish from Site FS had altered estrogen levels and E:T ratios, while male fish from both sites FS and FU exhibited vitellogenin expression, and body condition of both sexes was altered at site FU. However, fish from site FU had relatively low concentrations of bile PAH metabolites with the exception of phenanthrene, while fish from Site FS had high concentrations of all three PAH metabolites. Site FS is located at the outlet of the State Canal, which contains water originating from the Jordan River. Jordan River meets water quality standards, and all environmental media collected at the site had relatively low concentrations of contaminants, with only slightly elevated concentrations of OCs in sediments and macroinvertebrates. Site FU also had relatively low concentrations of observed contaminants despite its proximity to the NWOD delta. Again, habitat quality and other biotic factors may also play a role in the observed endocrine responses, which may overshadow contaminant responses.

At Ogden Bay, female fish at Site ON had increased testosterone levels and male fish had increased estrogen levels, leading to altered E:T ratios for the respective sexes at the respective sites. However, relative body condition findings were reversed, with females from Site OS and males from Site ON having decreased relative body condition. Fish from site ON had elevated bile PAHs. Site ON was among the sites where DDT and its metabolites appeared to still be present in the food-chain, with elevated concentrations observed in sediments (**Table 4-3**), macroinvertebrates (**Table 4-7**), and fish (**Figure 4-5**), indicating that DDT was still bioavailable throughout the aquatic food chain at Site ON at the time of sampling. This was somewhat borne out in the avian egg results, where DDT concentrations at site ON were also slightly elevated, with only other sites with a history of intensive mosquito abatement activity such as Sites LS, SA and SG having higher concentrations (**Figure 4-11**).

5.0 GREAT SALT LAKE OPEN WATER (GILBERT BAY) AND SOUTH SHORE DELTAS (1996-2000)

5.1 Introduction

The open waters of the Great Salt Lake play a central role in the global ecology of many avian species. Although the biological community within the lake is quite simple (algae and other phytoplankton, brine shrimp, and brine flies), it supplies an abundant food resource for birds that stop over at the lake during migration. Several species such as northern shoveler (*Anas clypeata*) and common goldeneye (*Bucephala clangula*) spend much of the winter on the lake after the fresher waters in Farmington Bay and Bear River Bay have frozen over. One species, the eared grebe (*Podiceps nigricollis*), utilizes the lake for both food and protection from predators during a protracted fall migratory stop-over. These birds arrive on the lake in late September when brine shrimp populations are peaking, and spend up to six weeks feeding on the lake while they undergo a complete feather molt before continuing on to their wintering grounds in December-January. While the open waters of the lake are distant from the mouths of rivers that carry effluents into the lake, there is a concern regarding the accumulation of metals and other contaminants into a water body with no outlet. As discussed in Section 2.0, the objective of the GSL Open Water survey was to assess one of the important open-water areas of the lake (Gilbert Bay, located in the southern half of the GSL) by sampling over a broad area within a time frame relevant to migratory birds to get a "snapshot" of potential contaminant risks to birds.

Initial sampling of the open waters of the GSL was carried out in 1996-1997 and addressed sediments, brine shrimp and eared grebes (liver tissue); additional eared grebe liver samples were collected in 1998. Based on concerns arising from review of the results of this sampling round, combined with the identification of data gaps in discussions of lake management with other agencies, additional sediment, brine shrimp and eared grebe liver samples were collected in 2000 (see Table 2-2 for a summary of sample sites and media). Sampling locations for these are shown in **Figure 5-1 (**sediment and brine shrimp) and **Figure 5-2** (eared grebes).

Sediment samples were collected with a ponar dredge (in open water areas) or composited from an approximately 1 m^2 area (for shallowly submerged sediments) using equipment and methods described in Section 3.0. Brine shrimp, either adults or cysts (eggs) were sampled by towing plankton nets through the top meter of lake depth until sufficient sample mass had been collected. Eared grebes were collected with stainless steel shot, placed immediately in coolers on wet ice, and transported back to the Service's field laboratory in Salt Lake City where livers were dissected out. Samples of all media were stored at -10° C prior to shipment to analytical laboratories (see Section 3.0). Livers from eared grebes collected in 1997 (n=22) were composited into three samples representing distinct geographic areas of the lake (Figure 5-2), which were split and submitted separately for analysis of metals, organochlorines (OC) and dioxins/furans. Livers from eared grebes collected in 1998 and 2000 were submitted individually for analysis. Samples (all media) collected from 1998-2000 were analyzed only for metals. A complete count of sample media, numbers, types (individual vs. composite) and analytes is presented in **Table 5-1**.

Sample analysis, data reduction and statistical methods used in this study were generally the same as outlined for the GSL Wetlands assessment (Section 3), with Students T-test used to compare concentrations in in sediments collected closer to the south shore of the GSL ("on-shore", defined by a transect imposed on the data post-hoc and shown in Figure 5-1) compared to those collected further out in the lake ("off-shore"). Trace element concentrations in sediments were also compared to the same threshold effect concentrations (TECs) and probable effect concentrations (PECs) ((MacDonald et al. 2000) used in the GSL Wetlands analysis. Concentrations of selenium were compared to sediment guidelines concentrations published by the DOI's Irrigation Water Quality Program (National Irrigation Water Quality Program 1998).It is unknown how well these benchmarks predict sediment toxicity in the

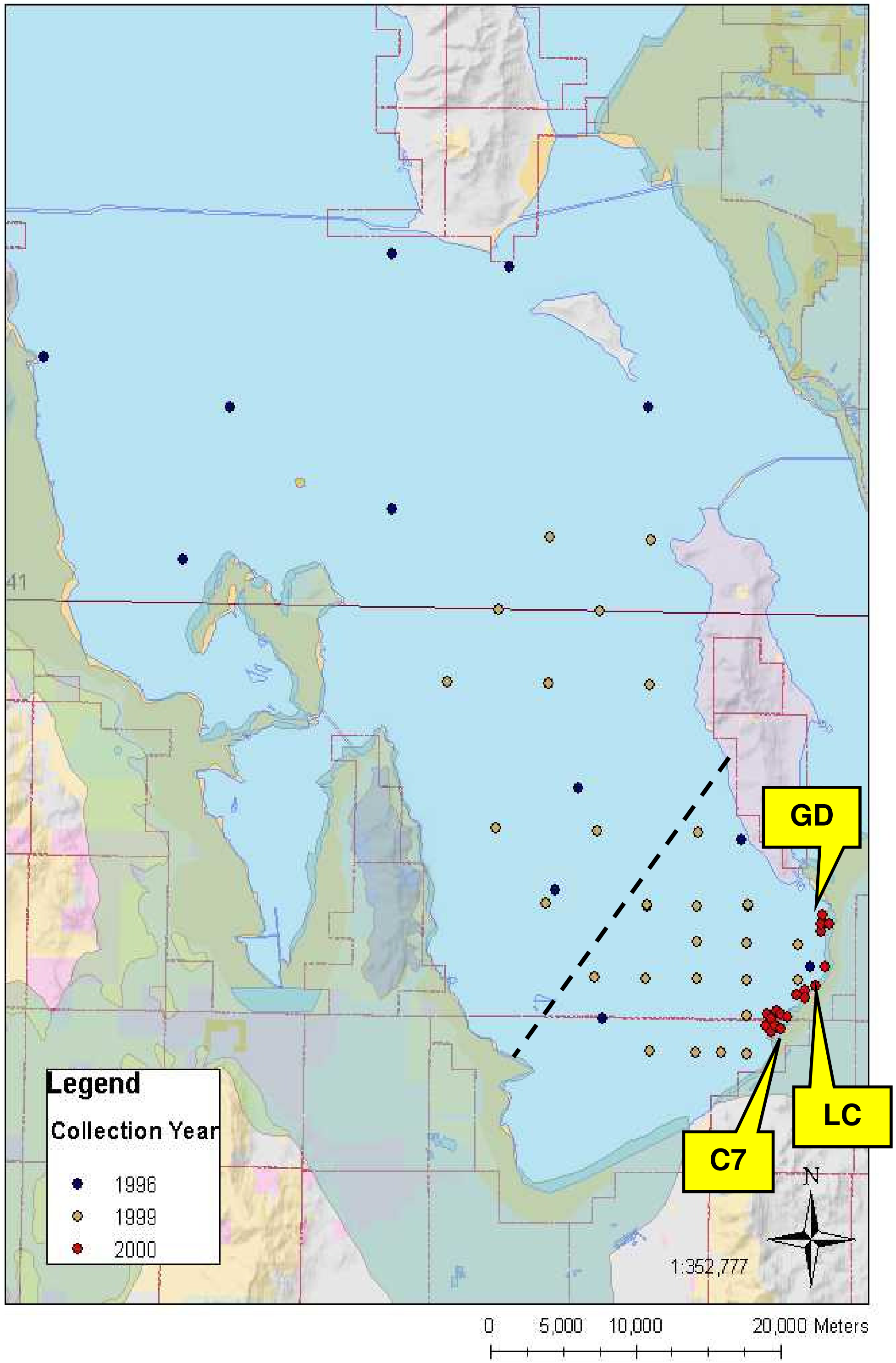

Figure 5-1 Sediment and Brine Shrimp Samples collected in Gilbert Bay (1996 and 1999) and Sediment Samples collected at South Shore Delta Locations (2000; GD = Goggin Drain, LC = Lee Creek, C7 = C7 Ditch), Great Salt Lake Open Water (Gilbert Bay) Survey (1996-2000). Dashed line is a (post-hoc) transect separating sediment samples (1996 and 1999) into "onshore" and "offshore" groups

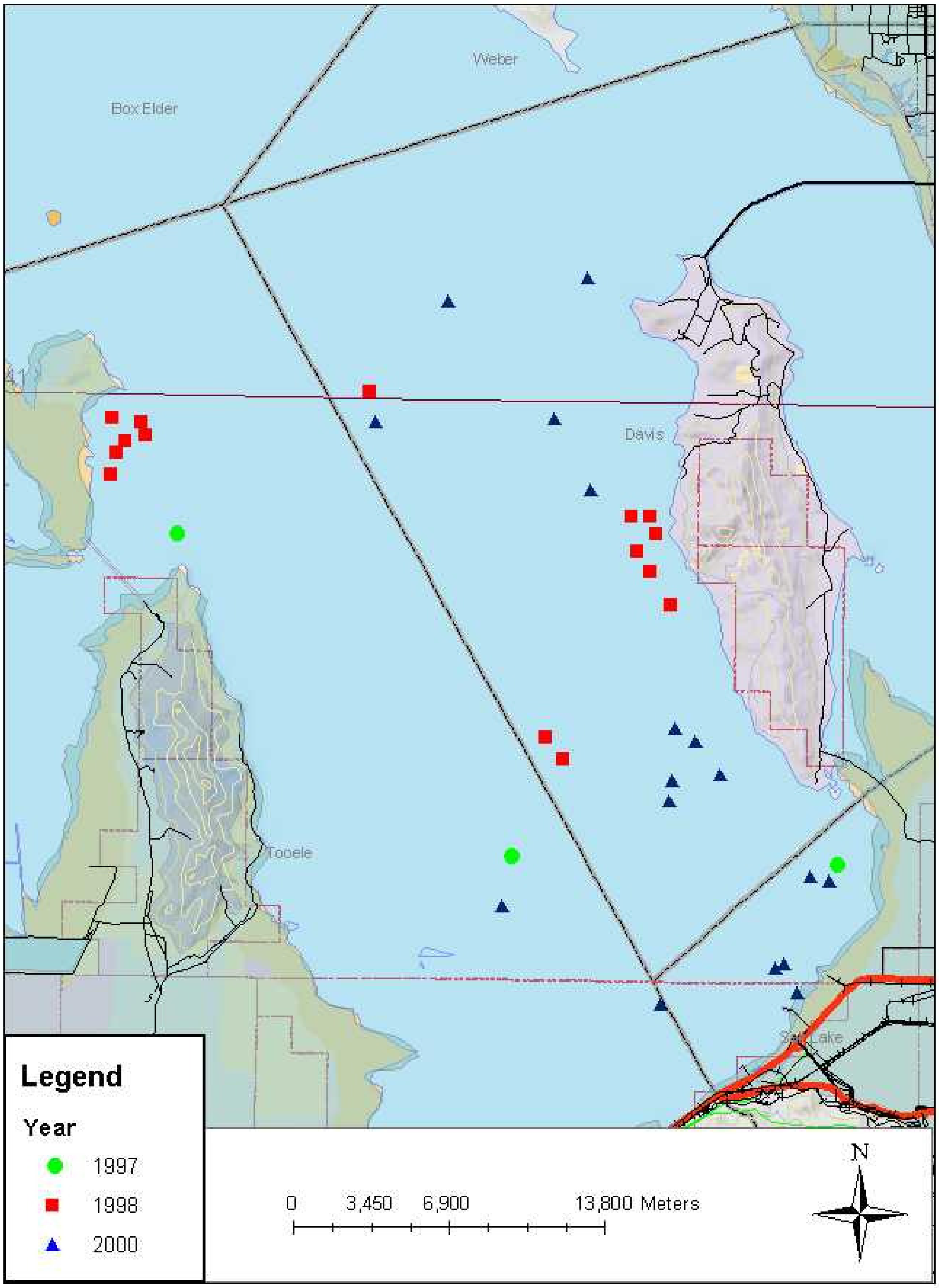

Figure 5-2 Locations of Eared Grebes (*Podiceps nigricollis*) collected in 1997 (composite samples) 1998 and 2000 (individual samples); Great Salt Lake Open Water (Gilbert Bay) Survey (1996-2000)

Table 5-1 Media, numbers and constituents analyzed, Great Salt Lake Open Water (Gilbert Bay) Survey (1996-2000)

Location	Loc. Code	Year	Sample number (*n*)	Matrix	Analytes
Gilbert Bay (Open Waters)					
USGS Sites	GU	1996	10	Sediment (indiv)	MET
	"	"	12	Brine shrimp- adult	MET
	"	"	4	Brine shrimp- cysts	MET
FWS Sites	GG	1997	3	EAGR liver (comp)	MET, D/F, OC
	"	1998	16	EAGR liver (indiv)	MET
	"	1999	28	Sediment	MET
	"	"	28	Brine shrimp- adult	MET
	"	"	4	Brine shrimp- cysts	MET
	"	2000	28	Brine shrimp- adult	MET
	"	"	24	EAGR liver (indiv)	MET
South Shore "Deltas"					
C7 Ditch Delta	GC	2000	9	Sediment (comp)	MET
Goggin Drain Delta	GG	2000	4	Sediment (comp)	MET
Lee Creek Delta	GL	2000	5	Sediment (comp)	MET

NOTES and ABBREVIATIONS:

USGS Sites: established by U.S. Geological Service Utah Water Resources Division forGreat Salt Lake Hydrologic and Limnologic Investigations

FWS Sites: established by U.S. Fish and Wildlife Service Utah Field Office for GSL Contaminants Assessment

MET: trace elements (metals)
D/F: dioxins and furans
OC: Organochlorine
EAGR: Eared grebe
Comp: composite sample
Indiv: individual sample

highly saline conditions of the GSL, but they are useful for comparability with the GSL wetlands assessment. They may also be more applicable to sediments in the GSL "delta" areas, since freshwater inflows in these areas may form fresh- or brackish-water delta systems when the GSL is below its long-term average of 1,280 meters (4,200 feet) above sea level. Concentrations of trace elements in brine shrimp were compared to relevant avian dietary levels of concerns used in the GSL wetlands assessment, and on-shore/off-shore concentrations were evaluated with Students t-test. Concentrations of trace elements and OCs (where available) were compared to concentrations in avian livers found to be associated with adverse effects to avian growth, reproduction and/or survival, including no observed adverse effects levels (NOAELs) and lowest observed adverse effects levels (LOAELS) in published scientific literature.

Complete analytical results for these samples are presented in Appendix B, as follows:

- Appendix Table B-1 Trace Elements in Sediments, GSL Open Waters and South Shore Deltas
- Appendix Table B-2 Trace Elements in Brine Shrimp Cysts and Adults, GSL Open Waters
- Appendix Table B-3 Trace Elements in Eared Grebe Livers, GSL Open Waters
- Appendix Table B-4 Organochlorines and Dioxins/Furans in Eared Grebe Livers, GSL Open Waters

All trace element analyses are presented and discussed in terms of mg/kg dry weight, organic compounds in eared grebe livers, are presented in terms of mg/kg wet weight.

5.2 Trace Elements in Sediments- GSL Open Waters and South Shore Deltas

A total of 38 sediment samples were collected from the open waters of Gilbert Bay in 1996 and 1999 at locations throughout the southern portion of the GSL. Ten samples were collected in 1996 at standardized sampling locations established by the USGS Water Resources Division (Salt Lake City, Utah). An additional 28 samples were collected in 1999 at points established by Rich (2002) to evaluate the distribution and movement of sediments in response to circulation and currents in the lake. These samples were collected at points on a systematic grid with particular emphasis along the western shore of Antelope Island, with approximately half located southwest ("onshore") of a transect (established post-hoc) centered approximately halfway along the length of Antelope Island and extending southwest (Figure 5-1). This transect was used to divide "on-shore" samples collected closer to the south shore of the GSL (of concern due to industrial and agricultural effluents that enter the GSL in this location) from "off-shore" samples more representative of the deeper waters of the open lake.

In comparison to freshwater SQGs, only copper (Cu) exceeded the upper PECs with any frequency, in one of 10 samples in 1996 and 12 of 28 samples in 1999 exceeding the PEC of 149 mg/kg (**Table 5-2**). In addition to copper, concentrations of lead, mercury and selenium frequently exceeded the lower TECs. Samples collected in 1999 tended to have higher concentrations with higher maximum and geometric mean concentrations for all elements compared to 1996 samples. However, this was biased by the fact that many of the samples collected in 1996 were collected further out in the central & northern portions of Gilbert Bay, while samples collected in 1999 were concentrated near the south shore area of the lake, near the outfall of the C7 Ditch (**Figure 5-1**). This ditch is a wastewater discharge canal that originates from the Kennecott Utah Copper Corporation (KUCC) metals smelting and refining facility, and carries process waters (after treatment at an onsite treatment plant) from the facility's tailings pile and smelting operations. The C7 Ditch has been in existence since the early-mid 20th century, and while it is currently in compliance with Clean Water Act requirements, water quality monitoring records maintained in the U.S. EPA's STORET database (accessed at http://www.epa.gov/storpubl/legacy/gateway.htm) indicate that it has historically carried wastewaters with much higher concentrations of metals associated with copper refining, including Cu, As, Cd and Se .

Copper concentrations were not significantly elevated in on-shore sediment samples (geometric mean 147 mg/kg) compared to off-shore samples (49.5 mg/kg; $P = 0.059$). However two samples collected just offshore of the C7 Ditch outfall had concentrations that were outliers compared to the rest of the on-shore samples, with 620 and 1,083 mg/kg Cu, respectively (**Figure 5-3**). The geometric mean concentration of arsenic was also higher in the on-shore samples (21.0 mg/kg) compared to off-shore (18.3 mg/kg) with the highest concentrations again concentrated around the C7 Ditch, but the difference was not significant ($P = 0.325$). Selenium exceeded the DOI background concentration of 1.0 mg/kg in all 38 samples, but did not exceed the toxicity threshold of 4.0 mg/kg. One sample with relatively high Se (3.08 mg/kg) was collected near the C7 Ditch outfall, but the maximum detected concentration of Se (3.34 mg/kg) was observed about 20 km to the northwest, just on the other side of the off-shore dividing line. Mercury was detected in only half of the off-shore samples compared to 65% of on-shore samples, and the geometric mean of on-shore samples (0.201 mg/kg) was greater than in off- shore samples (0.186[2] mg/kg). The four highest Hg concentrations (0.385 – 0.414 mg/kg) were observed in off-shore sediments, but statistical comparison was not possible because of the low Hg detection frequency in the off-shore samples.

2 Calculated using a value of 0.1 mg/kg (half of the detection limit of 0.2 mg/kg) to estimate concentrations in samples with <0.2 mg/kg

Table 5-2 Summary of selected trace elements (mg/kg, dry weight) compared to freshwater sediment screening benchmarks, Great Salt Lake Open Water (Gilbert Bay) Survey (1996-2000)

Trace Element		Gilbert Bay 1996[1]	Gilbert Bay 1999
	n=	*10*	*28*
Arsenic	Gmean	**15.8**	**21.3**
TEC / PEC	Max	29.6	45.6
[9.8 / 33.0]	#>Ref[2]	[8 / 0]	[28 / 1]
Cadmium	GMean	NC	0.32
TEC / PEC	Max	0.27	1.71
[0.99 / 4.98]	#>Ref	[0 / 0]	[1 / 0]
Chromium	GMean	7.37	10.2
TEC / PEC	Max	17.1	58.9
[43.4 / 111]	#>Ref	[0 / 0]	[1 / 0]
Copper	GMean	**36.2**	**120.**
TEC / PEC	Max	233.	1083.
[31.6 / 149]	#>Ref	[5 / 1]	[23 / 12]
Lead	GMean	**44.**	**65.7**
TEC / PEC	Max	129.	145.
[35.8 / 128]	#>Ref	[7 / 1]	[23 / 2]
Mercury	GMean	NC	**0.220**
TEC / PEC	Max	0.373	0.414
[0.18 / 1.06]	#>Ref	[2 / 0]	[20 / 0]
Selenium	GMean	**1.67**	**2.03**
BG / Toxicity	Max	2.50	3.34
[1.0 / 4.0]	#>Ref	[10 / 0]	[28 / 0]
Zinc	GMean	58.2	78.5
TEC / PEC	Max	145.	154.
[121 / 459]	#>Ref	[2 / 0]	[3 / 0]

Key and Abbreviations

#>Ref [TEC / PEC]: Number of samples that exceed Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) (MacDonald et al. 2000). For Se, BG = Se background, Toxicity = Se toxicity threshold (National Irrigation Water Quality Program 1998)

Gmean: geometric mean concentration for sample year

Gmean: Gmean>TEC

NC = geometric mean not calculated (i.e., more than 50% of values <detection limit)

ND = all samples were less than the detection limit

[1] This column includes one sample collected in 1997

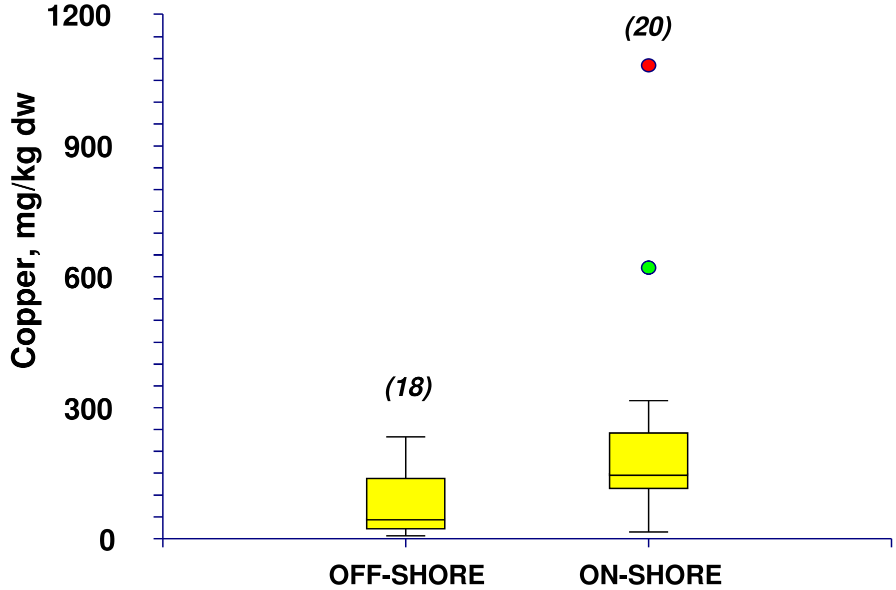

Figure 5-3. Copper in sediments from the open waters of Gilbert Bay in the Great Salt Lake, Utah, 1996-1999, "on-shore"(near the lake's south shore) compared to deeper waters. Sample numbers shown in parentheses.

South Shore Delta Sediment Samples, 2000

Based in part on the elevated concentrations of trace metals observed within and off-shore of the C7 Ditch, as well as within the nearby Goggin Drain, additional sediment samples were collected on the alluvial sediment fans (deltas) located at the mouths of these channels, as well as at a third channel located between these two, Lee Creek. While the C7 Ditch is an industrial effluent channel, the Goggin Drain and Lee Creek carry primarily irrigation return flow into the GSL, and are located within lands that are managed as wetland mitigation banks which provide high quality foraging and nesting habitat to migratory birds. Nine samples were collected on the C7 Ditch Delta (C7), while four and five samples were collected on the Goggin Drain (GD) and Lee Creek (LC) deltas, respectively (locations shown on Figure 5.1)

In general, concentrations of trace elements of concern in the deltas were lower than either the on-shore or off-shore sediments discussed above. Mean concentrations of copper were elevated compared to TECs in both the C7 and GD deltas, with one of the samples from C7 exceeding the PEC almost 10-fold (1,308 mg/kg vs. the PEC of 149 mg/kg). However, geometric mean concentrations of Cu in both deltas were lower than the on-shore open water sediment samples. Concentrations of lead were higher at the GD delta, with the geometric mean (95.6 mg/kg) and all four of the samples collected exceeding the PEC. The mean concentration of Pb at the GD delta was greater than the mean Pb concentration in the on-shore open water sediments. This may be due to past land uses at the GD site, which included waterfowl hunting the mid 1990's, when the property upland of the delta was acquired by a conservation organization as a wetland mitigation site. The Lee Creek Delta (LC) was comparatively clean, with only

Table 5.3 Concentrations of trace elements in Sediments , South Shore "Deltas" Compared to Sediment Screening Benchmark Concentrations and to Geometric Mean Concentrations of Sediments Collected in the Open Waters of Gilbert Bay, Great Salt Lake, Utah, 2000.

		As	Cd	Cu	Pb	Hg	Se	Zn
	TEC	*9.8*	*0.99*	*31.6*	*35.8*	*0.18*	*1.0*	*121*
	PEC	***33.0***	***4.98***	***149***	***128***	***1.06***	***4.0***	***459***
	Geometric Mean, off-shore	*18.4*	0.25	*49.5*	*51.0*	0.186	*1.88*	65.4
	Geometric mean, on-shore	*21.0*	0.39	*147*	*67.4*	*0.201*	*1.97*	79.6
C7 Ditch Delta; 2000								
C7, n=9	*geometric mean*	*11.9*	[---]	*86.6*	18.9	[---]	[---]	47.3
	maximum	***33.7***	0.252	***1,308***	*55.4*	ND	*2.01*	*124.*
	Det. Frequency	9/9	2/9	9/9	9/9	0/9	3/9	9/9
	% > PEC	11%	0	33%	0	0	0	0
	TEC< % <PEC	56%	0	33%	11%	0	33%	11%
Goggin Drain Delta; 2000								
GD, n=4	*geometric mean*	*16.6*	[---]	*94.8*	*95.6*	[---]	[---]	*159*
	maximum	*22.4*	0.851	***228***	***170***	ND	*1.04*	*242*
	Det. Frequency	4/4	2/4	4/4	4/4	0/4	1/4	4/4
	% > PEC	0	0	25%	50%	0	0	0
	TEC< % <PEC	100%	0	75%	50%	0	25%	75%
Lee's Creek Delta; 2000								
LC, n=5	*geometric mean*	9.25	[---]	*41.4*	22.9	[---]	[---]	27.8
	maximum	*10.5*	ND	*146*	28.9	ND	*1.2*	51.8
	Det. Frequency	5/5	0/5	5/5	5/5	0/5	1/5	5/5
	% > PEC	0	ND	0	0	ND	0	0
	TEC< % <PEC	40%	ND	20%	0	ND	20%	0

Notes and Abbreviations:

TEC: Threshold Effect Concentration
PEC: Probable Effect Concentration (both (MacDonald et al. 2000)
Value: Concentration > PEC
Value: Concentration ≥ TEC but < PEC
ND: Not Detected
[---]: Value not calculated because of insufficient detection frequency

occasional exceedences of TECs, and no exceedences of PECs. Areas upland of the LC delta are also currently being managed as a wetland mitigation bank, operated by KUCC as the "Inland Sea Shorebird Reserve." This property encompasses several hundred acres, and water from Lee Creek is being used to create and manage both ponded and emergent wetland habitat that is of high value to a large number of migratory birds, waterfowl and raptors.

5.3 Trace Elements in Brine Shrimp and Brine Shrimp Cysts, GSL Open Waters

A total of 68 samples of brine shrimp and cysts (eggs) collected between 1996 and 2000 were evaluated for trace metals, with data for those elements that exceeded avian dietary screening benchmarks summarized in **Table 5-4**. Complete analytical results are presented in **Appendix Table B-2**. Samples of adult brine shrimp and cysts were collected at the same time and location as the sediment samples discussed above, with samples collected in 1996 distributed broadly across Gilbert Bay, and samples collected in 1999 focused more tightly on the southern portion of the lake near the south shore (see Section 5.1 and **Figure 5-1**). Samples in both 1997[3] and 1999 were collected in the fall (September – October) in order to evaluate dietary exposure to birds using the lake as a fall migratory stop-over (e.g. eared grebes). However, based on concentration trends observed in those years, and also to characterize exposure to birds using the GSL during spring migration, additional samples of adult brine shrimp were collected in May 2000, at the same locations sampled the previous fall.

Viewed in total (**Table 5-4**), only boron (B), mercury (Hg) and selenium (Se) exceeded avian dietary effects levels in brine shrimp adults. Brine shrimp cysts did not exceed these levels, but are less of a food source for birds. Mean concentrations of B in brine shrimp adults exceeded the LOAEL of 30 mg/kg associated with reduced weight in mallard ducklings (Smith & Anders 1989) in samples collected in the fall (September-October) in both 1996 and 1999, but were less than the LOAEL in the spring (May 2000). Mean concentrations of Hg in the fall of 1996 nearly exceeded the LOAEL of 0.4 mg/kg associated with behavioral and reproductive effects in mallards (Heinz 1979). Mercury was not detected (DL<0.2 mg/kg) in brine shrimp collected during the spring of 2000 but was detected in all samples from 1999 (autumn) and in all but one sample in 1996. Concentrations of Hg in fall brine shrimp samples (1996 and 1999) were significantly higher than in samples collected in the spring of 2000 ($P < 0.0001$; **Figure 5-4**). Mercury was not detected in any sample of brine shrimp cysts. Mean Se concentrations were below the avian LOAEL of 3.0 mg/kg for reproductive failure in fish and wildlife; (Lemly 1996), but individual samples exceeded this level, particularly in samples collected in the fall of 1999 (10 of 28 samples). Concentrations in cysts were significantly lower than in shrimp ($P < 0.0001$) and on average contained half as much Se as adult brine shrimp.

Both Hg and Se are of concern because they are bioaccumulative, leading to an increased potential for exposure in birds that spend long periods of time on the lake feeding only on this food. To evaluate this, samples collected in September (1996 and 1999, n=20) were compared to samples collected in October (n=20). In this comparison, Se was significantly elevated in October (2.96 mg/kg) compared to September (2.56 mg/kg; $P = 0.012$, Students' T-test), but Hg was not significantly different within this interval. While Hg concentrations were significantly lower in brine shrimp collected in the spring compared to those collected in the fall, Se was not (Table 5-5).

Given that the freshwater tributaries to the south arm of the GSL are potential sources of contaminants to the open waters of the lake, a post-hoc comparison was made between the concentrations of Hg and Se in brine shrimp collected at on-shore locations and those collected from off-shore locations (See Section 5.1 above). Comparison across the entire data set was limited by small and uneven sample sizes (e.g., in September 1996, only one brine shrimp sample was collected on-shore compared to four collected off-shore, while in October 1999 there were 11 on-shore samples but only two off-shore samples). In pooled data from fall collections (1996 and 1999), mean offshore Hg and Se concentrations (0.374 mg/kg and 2.92 mg/kg) were greater than on-shore concentrations (0.320 mg/kg Hg, 2.64 mg/kg Se) but were insiginificant at α=0.05($P = 0.062$ and $P = 0.069$, respectively). Mercury could not be evaluated for onshore/offshore differences in the spring (May 2000) because all samples were <DL, and there was no

3 One sample of brine shrimp cysts collected in February 1997 was grouped with three other samples collected in October 1996 for analysis, see Table 5-4.

Table 5-4 Summary of selected trace elements (mg/kg, dry weight) in brine shrimp and brine shrimp cysts compared to avian dietary effect thresholds, Great Salt Lake Open Water (Gilbert Bay) Survey, 1996-2000.

Metal		Brine Shrimp *Sept/Oct 1996*	Brine Shrimp *Sept/Oct 1999*	Brine Shrimp *May 2000*	Cysts *Oct/Feb 1996*[1]	Cysts *Sept/Oct 1999*
	n=	*12*	*28*	*28*	*4*	*4*
Aluminum	*Gmean*	294	58.2	38.9	31.6	149
	Max	757	199	120	45.9	196
Ref = 5000	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]
Arsenic	*Gmean*	9.26	16.0	10.5	9.87	10.2
	Max	13.0	18.7	15.3	10.6	12.7
Ref= 30	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]
Boron	*Gmean*	**44.9**	**42.3**	29.4	**38.9**	**75.2**
	Max	66.7	69.5	41.5	69.1	87.2
Ref= 30	*[#>Ref]*	[5]	[28]	[12]	[3]	[4]
Chromium	*Gmean*	1.72	NC	NC	0.48	0.80
	Max	3.1	1.45	3.77	0.72	0.98
Ref = 10	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]
Copper	*Gmean*	11.2	8.58	12.7	5.58	9.17
	Max	17.8	13.9	15.2	8.94	10.8
Ref= 200	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]
Lead	*Gmean*	1.30	NC	NC	NC	1.83
	Max	2.75	1.66	ND	1.5	2.12
Ref = 5	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]
Mercury	*Gmean*	0.39	0.32	NC	NC	NC
	Max	0.60	0.38	ND	ND	ND
Ref= 0.4	*[#>Ref]*	[6]	[0]	[0]	[0]	[0]
Selenium	*Gmean*	2.42	2.85	2.63	1.74	1.42
	Max	3.81	3.59	3.05	2.15	1.63
Ref= 3	*[#>Ref]*	[2]	[10]	[2]	[0]	[0]
Zinc	*Gmean*	75.9	55.8	115	57.3	36.0
	Max	106	69.2	140	76	46.7
Ref= 178	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]

Key and Abbreviations:

Gmean geometric mean concentration for sample year
Gmean Gmean>referenced avian dietary threshold
NC Geometric mean not calculated (i.e., more than 50% of values <detection limit)
ND All samples < detection limit
#>Ref The number of samples that exceed the referenced avian dietary threshold: **Al**--No observed effect level (Sparling 1990); **As**-- Reduced weight in mallard ducklings (Camardese et al. 1990); **B**-- Reduced weight in mallard ducklings (Smith & Anders 1989); **Cr, Cu, Pb, Zn**--Levels of concern (2000); **Hg**-- Behavioral and reproductive effects in mallards (Heinz 1979); **Se**--Reproductive failure in fish and wildlife; (Lemly 1996).

[1] This column includes one sample collected in February 1997

Table 5-5 Seasonal trends in concentrations of bioaccumulative metals in adult brine shrimp from the open waters of the Great Salt Lake, 1996 – 2000. All concentrations are given in mg/kg dw,

	September (96+99)) *n=20*	**October (96+99)** *n=20*	***P =***	**FALL Sept-Oct ('96 + '99)** *n=40*	**SPRING (May 2000)** *n=28*	***P =***
Mercury	0.339	0.350	*0.698*	**0.344**	0.1 (ND)	*<0.0001**
Selenium	2.56	**2.96**	*0.012**	2.77	2.64	*0.199*

NOTES:

" * " Significant difference, Students' T-test, α=0.05 (significantly higher concentrations shown in **bold**)

ND Mercury not detected (detection limit = 0.2 mg/kg) in all samples. 0.5 x detection limit (0.1 mg/kg) used for purposes of calculation and statistical comparison.

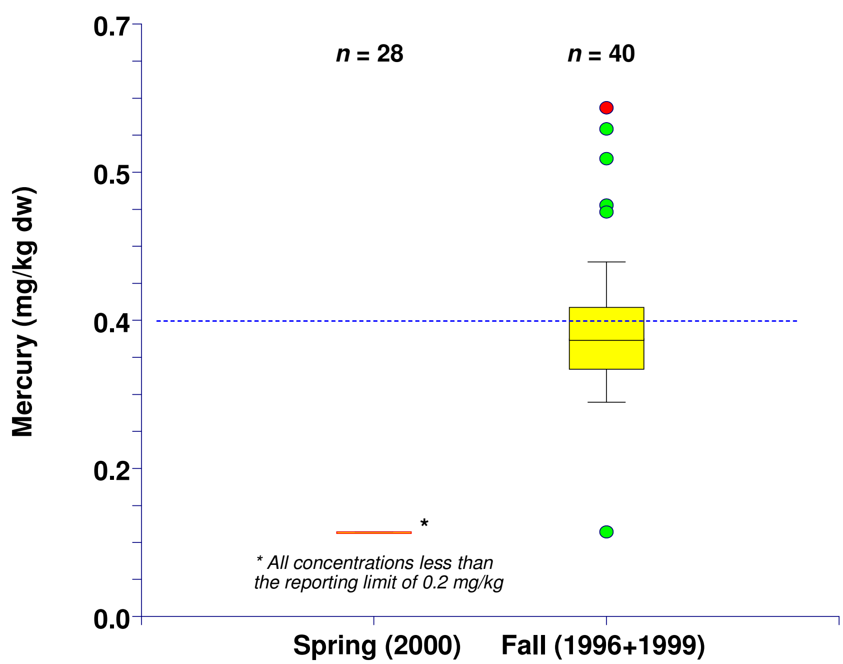

Figure 5-4 Mercury in adult brine shrimp collected from the open waters of the Great Salt Lake in Spring (May 2000) compared to Fall (September and October of 1996 and 1999). Dashed line indicates avian dietary level of concern.

difference in Se concentrations (*P* = 0.241). Based on this limited spatial analysis concentration gradients of bioaccumulative metals in brine shrimp associated with contaminant inputs cannot be ruled out, but research that has been conducted on the lake subsequent to this survey has indicated that there are several unique transport mechanisms within the GSL that may play a stronger role in distributing contaminants within the lake. These include a hypersaline "dense brine layer" at the bottom of the lake which flows along density as well as topographic gradients on the lake's bottom, and mixing events that occur across this "halocline", both of which play a major role in the distribution and availability of contaminants (particularly Hg) to organisms in the upper water column (Naftz et al. 2008).

5.4 Trace Elements and Organochlorines in Livers of Eared Grebes

With the exception of arsenic and mercury, metal concentrations in the grebe livers collected between 1997 and 2000 were less than the levels of concern identified in the literature (**Table 5-6**). Elevated arsenic concentrations were observed in one of the three composited liver samples analyzed in 1997 (6.83 mg/kg). This indicates that at least one, or some of the birds comprising the composite sample had much higher concentrations, and was one of the factors that led to the decision to submit samples collected after 1997 individually (as well as the need to characterize variability in metals concentrations). However, the maximum concentration of As observed in subsequent sampling events was much less (3.30 mg/kg, in December 1998). Mercury in grebe livers exceeded the level of concern (16.7 mg/kg) in two of four birds collected in December 1998 (19.1 and 19.3 mg/kg), and in one bird collected in May 2000 (20.5 mg/kg).

While the highest concentration of mercury was observed in a bird collected in the spring, the geometric mean concentration of all grebes (n=21) collected in May 2000 was 1.96 mg/kg, which was the lowest mean concentration for all collection periods (Figure 5-5). Concentrations of Se, the other metal of concern with regard to bioaccumulation, did not exceed the LOC of 30 mg/kg in any of the birds collected. Boron, which was present in concentrations exceeding the avian dietary LOC in brine shrimp (Section 5.2) was only detected in four samples (the three composite samples from 1997 and in one sample from December 1998), just above the detection limit of 0.2 mg/kg.

While the lowest mean concentration of Hg was observed in the spring (May 2000), the highest mean Hg concentration was observed in December 1998. These data, combined with evidence of accumulation of Hg and Se in brine shrimp (above) indicated the possibility of seasonal bioaccumulation of Hg, and to a less clearly defined extent, eared grebes foraging on the GSL. This possibility is consistent with the foraging ecology of eared grebes, which arrive on the GSL in the early fall (birds begin arriving about late September). Individual birds spend approximately 6-12 weeks on the GSL, during which time they undergo a complete feather molt, along with a complicated physiological process involving loss of flight muscle, building up of fat reserves (at about the same time new feathers are being grown) and then redevelopment of flight muscles. The birds stay on the open waters of the lake during this entire process, foraging exclusively on brine shrimp, whose annual population numbers are peaking at the same time. Peak numbers of grebes occur on the GSL from late November to mid-December, with the large majority leaving in late December to early January.

To evaluate seasonal accumulation of Hg and Se, data were grouped by seasons where possible for statistical analysis. Data from April and May 2000 were similar for both Hg and Se (Students' T-test, $P < 0.05$), and so were pooled for analysis ("Spring", n=24). Both Se and Hg data for livers collected in November (1997) and December (1998) were also similar, and so were also pooled ("Winter", n=7). Data for both Hg and Se in livers collected in September (1998) were different from both Spring and Winter, and so were treated as "Fall" (n=12) for ANOVA. The maximum detected Hg concentration observed in one of the samples collected in May 2000 was < (2 x standard deviation on the mean), and also outside the 95% upper confidence limit on all Hg data combined, and so was removed from the seasonal ANOVA. Mercury in grebe livers collected during the spring was significantly lower than either Fall or Winter ($P < 0.001$), and concentrations in Winter were significantly greater than those observed in

Table 5-6 Summary of trace elements (mg/kg, dry weight) in livers of eared grebes (*Podiceps nigricollis*) compared to levels of concern. Great Salt Lake Open Water (Gilbert Bay) Survey, 1997 – 2000.

Metal		November 1997	September 1998	December 1998	April 2000 [b]	May 2000 [b]
	n=	*3* [a]	*12*	*4*	*3*	*21*
Arsenic	*GMean*	5.91	1.31	2.24	1.18	1.62
	std. error	*(0.51)*	*(0.12)*	*(0.52)*	*(0.52)*	*(0.14)*
	Max	**6.83**	2.20	3.30	2.79	2.9
Ref= 6.6	*[#>Ref]*	[1]	[0]	[0]	[0]	[0]
Cadmium	*GMean*	1.82	1.43	1.1	3.59	4.07
	std. error	*(0.14)*	*(0.48)*	*(0.58)*	*(3.57)*	*(0.90)*
	Max	2.09	6.54	3.06	12.7	17.9
Ref- 33.3	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]
Copper	*GMean*	15.1	10.5	10.3	13.0	12.8
	std. error	*(0.67)*	*(0.34)*	*(0.70)*	*(2.83)*	*(1.16)*
	Max	16.3	12.2	11.7	19.2	30.2
Ref= NA	*[#>Ref]*	[--]	[--]	[--]	[--]	[--]
Mercury	*GMean*	11.6	6.69	13.5	4.39	1.96
	std. error	*(0.61)*	*(0.48)*	*(3.16)*	*(1.90)*	*(1.00)*
	Max	12.6	9.51	**19.3**	8.72	**20.5**
Ref= 16.7	*[#>Ref]*	[0]	[0]	[2]	[0]	[1]
Selenium	*GMean*	10.1	6.23	10.5	10.5	7.05
	std. error	*(0.60)*	*(0.39)*	*(2.62)*	*(3.76)*	*(0.69)*
	Max	11.3	8.16	15.5	18.9	17.0
Ref= 30	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]
Zinc	*GMean*	117	75.1	81.9	128	110
	std. error	*(3.28)*	*(4.08)*	*(6.77)*	*(19.5)*	*(8.56)*
	Max	122	116	99.1	169	190
Ref= 2,100	*[#>Ref]*	[0]	[0]	[0]	[0]	[0]

Key and Abbreviations

Gmean geometric mean concentration for sample year
Gmean Gmean>referenced avian threshold
NC Geometric mean not calculated (i.e., more than 50% of values <detection limit)
ND All samples < detection limit
-- no toxicity reference value available for comparison
#>Ref The number of samples that exceed the referenced avian dietary threshold:
As: Reduced weight gain in adult birds; delayed egg laying; (Stanley et al. 1994);
Cd: Probable Cd contamination; Eisler (1993);
Hg: Threshold for adult waterbirds (5 ppm, ww; assume 70% moisture for dw); (Zillioux et al. 1993);
Se: Sublethal; (National Irrigation Water Quality Program 1998);
Zn: Toxicity threshold (National Irrigation Water Quality Program 1998).
(a) composites of 22 individuals

the Fall ($P < 0.001$) (**Figure 5-5**). The highest concentration of Se also occurred in a bird collected in the spring, although not in the same bird with the maximum Hg concentration. The highest geometric mean occurred in the Winter (December 1998). Concentrations of Se did not differ between years, and there was no difference between Spring and Fall concentrations, but concentrations in Winter were significantly higher than those in Fall ($P = 0.017$) (**Figure 5-6**).

Mercury and selenium can be bound to one another in the liver, with various interpretations as to whether Hg is actively scavenged from the liver by Se, whether Se concentrations can increase in the liver in response to mercury exposure, the capacity of this mechanism is to protect against mercury, and how much Se can be accumulated in the liver before it too reaches toxic levels (Eagles-Smith et al. 2009). While a number of metals have been observed to decrease in grebe livers during migration (Rattner & Jehl 1997), it appears that both of these metals may increase in the livers of birds that use the GSL for migratory stop-over habitat, at least in the fall. Based on this data, it is not possible to determine whether Se concentrations in eared grebe livers increase in response to Hg exposure, or if it increases due to exposure to Se in brine shrimp also.

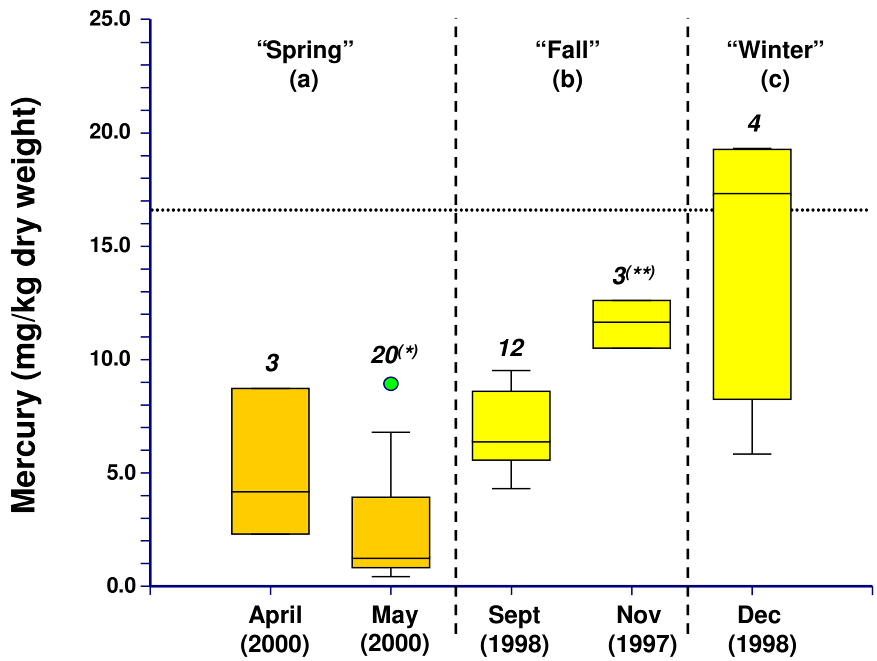

Figure 5-5 Seasonal trends in mercury in eared grebe (*Podiceps nigricollis*) livers, Great Salt Lake Open Water (Gilbert Bay) Survey, 1996-2000. Letters in parentheses indicate significantly different concentrations (P<0.05). “*”: one sample removed because of outlying value (see text); “”: composite samples.**

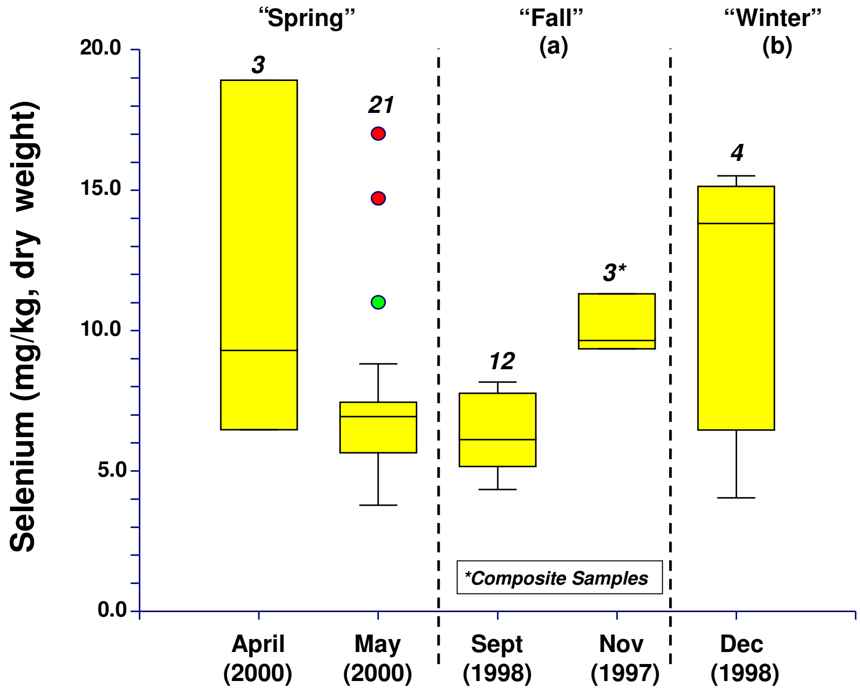

Figure 5-6 Selenium concentrations by month in eared grebe (*Podiceps nigricollis*) livers, Great Salt Lake Open Water (Gilbert Bay) Survey, 1996-2000. Letters in parentheses indicate significantly different concentrations (P<0.05).

Organochlorine Compounds in Eared Grebe Livers

Organic constituents were not routinely analyzed in the sediment samples collected in the open water (Gilbert Bay) portions of the GSL. However, due to concerns that arose surrounding the U.S. Magnesium Facility located on the west shore of the GSL, whose air emissions were reported to potentially contain elevated levels of dioxins and other chlorinated hydrocarbons (See Section 4., three composite liver samples from eared grebes that were collected in Gilbert Bay in 1997 were analyzed for organochlorines and dioxins and furans. The complete analytical results for these samples are presented in **Appendix Table B-4**.

Only two compounds, total PCBs and *p,p'*-DDE, were detected, in two of the three samples. The maximum detected concentration of t-PCB was 0.116 mg/kg (wet weight), well below a literature-based threshold effect level for PCBs in avian tissue of 4.58 mg/kg (Tillitt et al. 1992). By comparison, green-backed herons in northeastern Louisiana had 0.2 ppm total PCBs in liver tissue, along with 0.1 ppm in breast muscle (Niethammer et al. 1984), and mallards collected from a PCB-contaminated site in New York had 1.0 ppm total PCBs in liver tissue (Eisler 1986). Only one of the two isomers of DDE was detected, ranging from 0.0095 to 0.0387 mg/kg wet weight. This was well below a published threshold effect concentration of 100 mg/kg in avian liver identified as a minimum critical level at which productivity is affected (Noble and Elliot, 1990).

6.0 MERCURY IN TERNS AT FARMINGTON BAY WATERFOWL MANAGEMENT AREA, 2000

6.1 Introduction

During the 1996-1997 Great Salt Lake Wetlands Contaminant Survey (Section 4), elevated concentrations of mercury were observed in the large majority of eggs collected in the Crystal Unit of theFarmington Bay Waterfowl Management Area (FBWMA). Ten of the 12 eggs collected, from two species, American coot (AMCO, n=6) and black-necked stilt (BNST, n=6) had > 1.0 mg/kg dry weight total mercury, and 3 of the 12 exceeding the identified screening benchmark of 3.0 mg/kg. Eggs from the Crystal Unit had significantly more mercury than in other areas evaluated in Farmington Bay (Figure 4-8), with the maximum detected concentration of mercury double the screening benchmark (5.99 mg/kg in an American coot egg), and 4.6 mg/kg observed in a black-necked stilt egg. In contrast, none of the other 78 eggs collected for the 1996-1997 wetlands survey exceeded 0.75 mg/kg.

Because mercury is bioaccumulative, the greatest concern regarding exposure in birds is typically focused on piscivorous species. Although the GSL itself does not support fish, the wetland impoundments of FBWMA are supplied by fresh water from the Jordan River, and support populations of warm-water fish such as small-mouthed bass, sunfish, mosquito fish, and common carp. Piscivorous species that occur at FBWMA include several species of terns (Forster's tern, *Sterna forsteri*; Common tern, *S. hirundo*; and Caspian tern, *Hydroprogne caspia*), egrets and herons; wintering American bald eagles (*Haliaeetus leucocephalus*); and American white pelicans (*Pelecanus erythrorhynchos*), which have a large nesting colony on Gunnison Island in the northern portion of the GSL, but which make daily flights to Farmington Bay and other GSL wetlands to feed.

Based on discussions with the U.S. EPA and the Utah Department of Environmental Quality, concerns regarding avian exposure to mercury and other contaminants focused on the Northwest Oil Drain (NWOD), which drains much of the most heavily industrialized portion of Salt Lake City, and was constructed prior to the existence of water quality regulations (see discussion in Section 7). The NWOD empties into Farmington Bay on the northern boundary of the Crystal Unit, forming a delta of sediments washed down from upstream industrial and agricultural areas. Although the sediments are contaminated (with oil sheens and a noticeable hydrocarbon odor produced when they are disturbed), they support emergent and submerged aquatic wetland vegetation, as well as pollution tolerant macroinvertebrates such as chironomid larvae, which are also adapted to the saline, anoxic sediments characteristic of GSL wetlands. These concerns and discussions led to the study of mercury accumulation in a piscivorous bird species, Forster's Tern described in this section, and the study of sediments in the NWOD Delta, presented in Section 7.0.

6.2 Methods

The intitial goal of this study was to collect eggs from great blue herons (*Ardea herodias*, GBHE), which are long-lived, and tend to forage close to their nesting colonies while breeding. While a GBHE colony had been located within the Crystal Unit for several decades, it was discovered on initial sampling forays that the colony had been abandoned, likely due to flooding by the GSL during the late 1980's, which killed the trees used by the herons for nesting. Instead, a nesting colony of Forsters' terns (FOTE) was located just south of the Crystal Unit along Spring Creek (**Figure 6-1**). The nests were outside of the Crystal Unit wetland impoundment, but were located on the edge of the open waters of Farmington Bay. The birds were presumed to forage within the nearby Crystal Unit since no fish are within the highly saline, open waters of Farmington Bay. Thirteen FOTE nests were located and one egg from each nest was collected; an additional GBHE egg was opportunistically collected, as were two dead nestlings (1

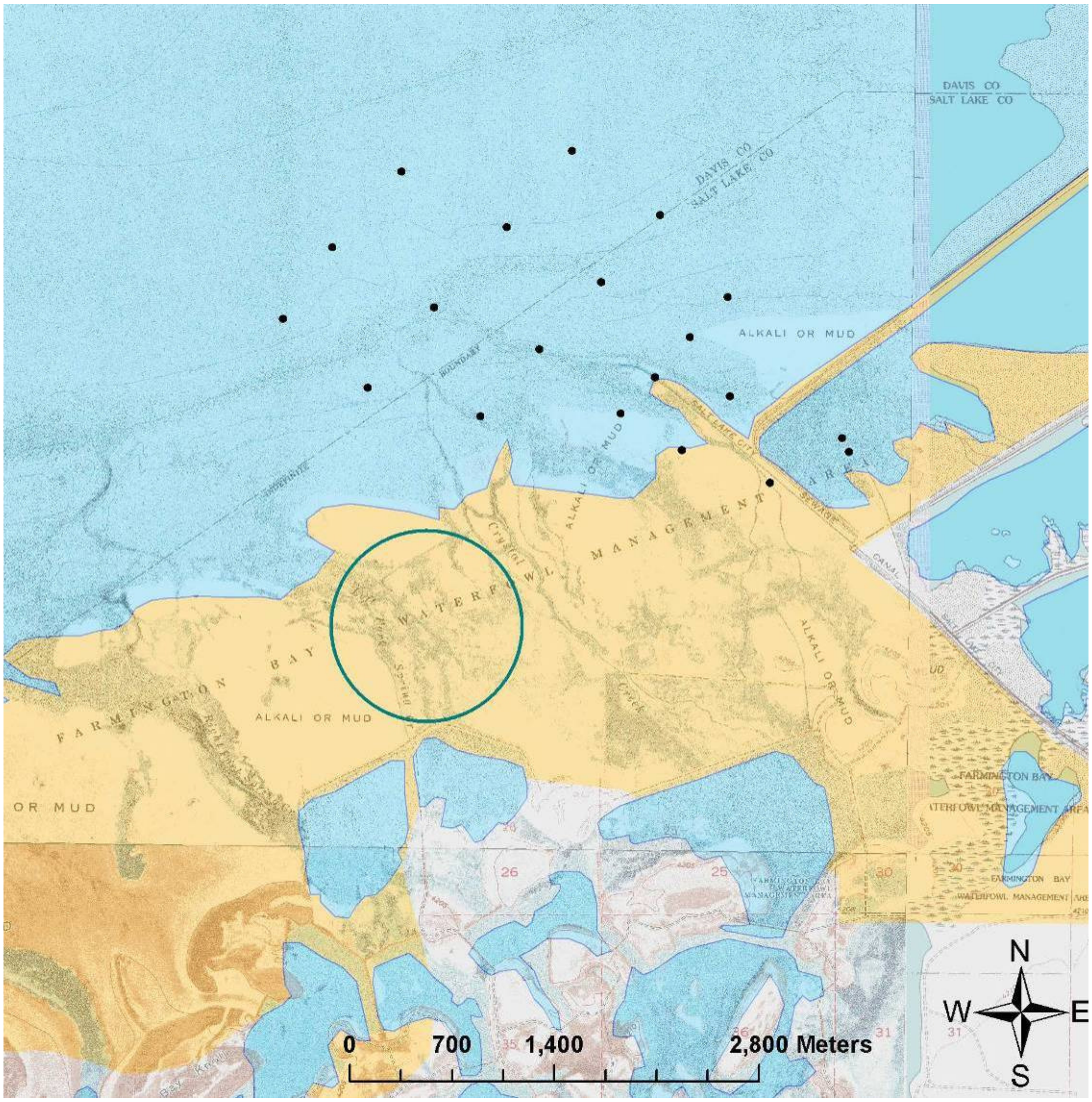

Figure 6-1. Approximate area (circled) of Forster's tern colony along Spring Creek near the Crystal Unit of Farmington Bay Waterfowl Management Area, sampled in 2000. Location of nearby sediment samples collected for the investigation of the Oil Drain Delta are also shown (black dots).

each of FOTE and GBHE). Egg and nestling collections were performed according to methods described in Section 3 of this report. All eggs and nestlings were analyzed for both total mercury (T-Hg) and Methylmercury (Me-Hg) by analytical laboratories and according to methods also described in Section 3.

6.3 Results and Discussion

Complete analytical data for both T-Hg and Me-Hg for all eggs and tisues are presented in **Appendix Table D-1**. Concentrations are presented in parts per million dry weight (mg/kg dw) to allow for comparisons between eggs and tissues with varying percent moisture content.

The geometric mean concentration of T-Hg in all 14 eggs (13 FOTE + 1 GBHE) was 1.08 mg/kg, ranging from 0.20 to 1.96 mg/kg dw. Seven of the 13 FOTE eggs had >1.0 mg/kg T-Hg. The geometric mean concentration of Me-Hg in the 14 eggs was 0.89 mg/kg, and ranged from 0.24 to 1.92 mg/kg. None of the eggs analyzed exceeded the toxicity threshold of 3.44 mg/kg T-Hg (dw, at 75% moisture) identified by Heinz (1979) associated with reproductive impairment in a generational study of mallards (*Anas platyrhynchos*), or the 5.56 mg/kg value associated with reduced nesting success in common loons (*Gavia immer*) (Barr 1986). The eggs also had significantly less t-Hg than the 12 eggs collected in 1996-1997 at the Crystal Unit ($P = 0.030$, Students' T-test).

Total Hg measured in the recovered FOTE nestling was 3.18 mg/kg, with 1.41 mg/kg, or 44.3% of that being measured as Me-Hg. Total Hg in the recovered GBHE nestling was lower, 0.31 mg/kg, but the MeHg value for that same bird (conducted on a sub-sample of the carcass) was almost a third greater, 0.41 mg/kg.

Methyl mercury values measured in the eggs had a mean concentration of 0.78 $\pm$ 0.47 mg/kg, for a mean % Me-Hg value of (0.78 / 1.08) = 72% Me-Hg, however, individual % Me-Hg values measured in eggs ranged from 45% - 147%, and the true mean of measured T-Hg/Me-Hg was 84% ($\pm$ 26%). Methyl mercury in the FOTE and GBHE carcasses were 1.41 and 0.41 mg/kg, respectively, which was equivalent to 44% and 132% of measured T-Hg.

The mean weight of the 13 FOTE eggs collected was 17.8 grams, but ranged over 6 grams (14 – 20 grams), or about $\pm$ 10%. Mean percent moisture in the 14 eggs was 77% + 2%, however, there did not appear to be any relationship between egg weight and percent moisture, which could have indicated that collected eggs were addled or had dried out, which could have affected methyl mercury concentrations within the eggs (e.g., due to decay). Percent moisture in the eggs collected for this study was actually slightly higher than the mean for the 88 eggs collected for the 1996-1997 GSL wetland survey (75% $\pm$ 4%).

To evaluate the relationship (if any) between trophic level and mercury concentrations in eggs from the Crystal Unit of FBWMA, data for all bird eggs from all years combined (1996 and 1997, 6 AMCO = 6 BNST; 2000 13 FOTE + 1 GBHE) were classified by generalized trophic level. American coots were classified as herbivores (although their diet may include a small percentage of invertebrates), BNST were classified as insectivores, and FOTE and GBHE were classified as piscivores. The resulting relationship (Figure 6-2) was the reverse of what would be expected for a compound that accumulates up the food chain, with is an inverse relationship between higher trophic level and increasing total Hg concentrations in the vicinity of the Crystal Unit (**Figure 6-2**). An example of typical mercury exposure to aquatic avian receptors was described by (Fimreite 1974) who showed that scavengers and fish eating birds had the

Table 6-1. Concentrations of mercury and methylmercury (mg/kg dry weight) in eggs and nestlings of Forster's terns (FOTE) and great blue herons (GBHE) collected near the Crystal Unit of Farmington Bay Waterfowl Management Area, 2000.

		Total Hg		Methyl Hg		% Methyl Hg
Species / Tissue	**n**	**Mean**	**Max**	**Mean**	**Max**	**Mean**
FOTE + GBHE / Egg	14	1.08	1.96	0.78	1.92	84%
FOTE / Nestling	1	--	3.18	--	1.41	44%
GBHE / Nestling	1	--	0.31	--	0.41	133%

highest Hg concentrations while species consuming primarily plant material had the lowest Hg concentrations). When the same trophic level analysis was performed using t-Hg values from other 76 eggs collected during the 1996-1997 GSL wetlands survey (i.e., for all areas but the Crystal Unit), the expected relationship was shown, with significantly lower t-Hg in herbivorous species compared to insectivorous species ($P < 0.001$). Looking just at AMCO collected at the Crystal Unit in 1996-1997 (n=6), t-Hg was significantly higher in AMCO than in the FOTE and GBHE eggs ($P = 0.027$).

While the results of this study did not support the concern that piscivorous species at FBWMA may be exposed to elevated concentrations of Hg, there are several alternative hypotheses regarding the observed mercury concentrations in AMCO and BNST eggs from the Crystal Unit. The results from the sampling of sediments in the NWOD delta confirmed that elevated mercury concentrations exist in that area (mean Hg = 0.97 mg/kg, with 7 of 20 samples > 1.06 mg/kg (the concentration associated with "probable" adverse effects to sediment organisms). The maximum detected Hg concentration in the sampling grid evaluated was 6.2 mg/kg, but more importantly, the trend for all contaminants evaluated was that the highest concentrations observed were at the downstream end of the sampling grid, indicating that it is very possible that higher concentrations of mercury and other contaminants exist further out into Farmington Bay, and/or extend over a larger area than was sampled by the Service (see Section 7). It may be that mercury exposure in FBWMA is more a function of sediment exposure (i.e., direct exposure through consumption of sediment-bearing foods and/or incidental sediment ingestion) than trophic bioaccumulation. This, along with a more complete characterization of the nature and extent of sediment contamination in the NWOD delta, is one of the higher priority follow-up actions to be identified by this investigation.

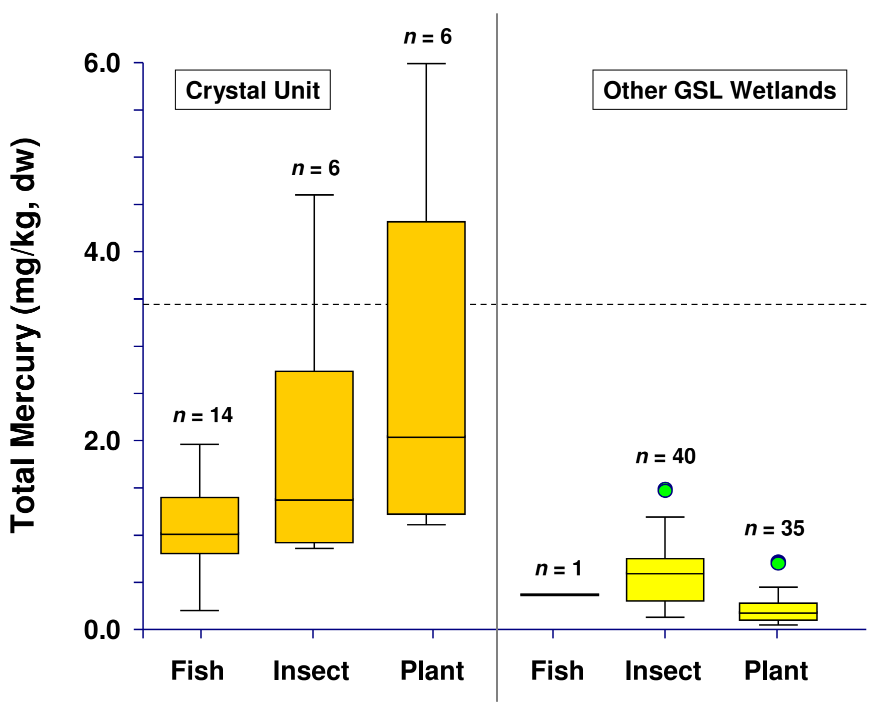

Figure 6-2. Total mercury in bird eggs from Great Salt Lake wetlands (1996 - 2000) by principal food preference and approximate trophic level (piscivore, insectivore, and herbivore).

7.0 CONTAMINANT ASSESSMENT OF SEDIMENTS IN THE NORTHWEST OIL DRAIN "DELTA", FARMINGTON BAY, 2000

7.1 Introduction

The Northwest Oil Drain (NWOD) was built in the early part of the 20th century as part of the Salt Lake City's irrigation and flood water control system and to transport waste waters from heavy industries located in the northwest quadrant of the city. Currently, flows are a combination of return flows from canals originally diverted from the Jordan River, storm waters, treated wastewater effluents from the Salt Lake City Wastewater Treatment Plant (SLC WWTP) and treated wastewaters from several refineries still in operation in the area. Prior to the implementation of controls under water quality regulations beginning with the 1972 Water Pollution Control Act, the NWOD carried untreated wastewaters from a variety of industries in the northwest quadrant, including the refineries, feed lots, tanneries, metal fabricating and plating operations, chemical manufacturing plants, and other "heavy industries." The former name of the NWOD, still currently in use, is "the Sewage Canal."

The NWOD enters the Great Salt Lake within one of the most intensely managed and productive waterfowl habitats on the GSL, the Farmington Bay Waterfowl Management Area (FBWMA) which is owned and operated by the Utah Department of Natural Resources Division of Wildlife Resources (UDNR- DWR). The outlet of the NWOD forms a delta of sediments which reach out several kilometers into the bay, and is located between two of the main waterfowl management impoundments of the FBWMA, the Turpin Unit to the north and the Crystal Unit to the south (**Figure 7-1**). Although the shoreline of the GSL varies considerably depending on lake level, the delta is typically shallowly inundated over much of its area, and is vegetated with emergent and submerged aquatic wetland plants. There are typically a large number and variety of avian species foraging and nesting in the area, with large populations of American avocets, black-necked stilts, white-faced ibis, and American coots foraging in the sediments.

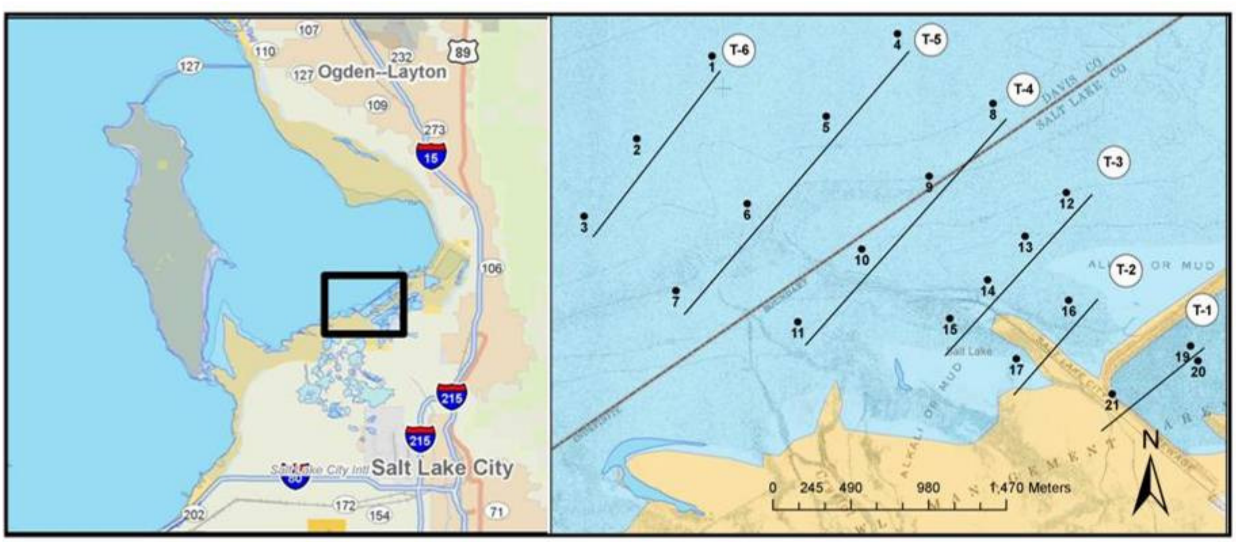

Figure 7-1. Location of the Northwest Oil Drain (NWOD) within Farmington Bay and location of sediment samples (and transects) within the NWOD delta.

Beginning in the late 1990's, the U.S. EPA and the Utah Department of Environmental Quality (UDEQ) began conducting remedial investigations of the NWOD under the Comprehensive Environmental Response, Liability and Compensation Act (CERCLA). These investigations came to the Service's attention after much of the sampling for the 1996-1997 GSL Wetlands Contaminant assessment had been completed. However, based on data that had been collected in relevant locations (summarized below, and shown in **Figure 7-2**), the Service recommended that the NWOD remedial investigation include the submerged portion in Farmington Bay to address avian exposure to contaminants in the delta and characterize risks to avian populations. The study detailed in this section was undertaken by the Service in order to gather data to help in this process. However, the regulatory agencies declined to extend the investigation due to a variety of factors. The upstream segments of the NWOD canal were cleaned up during approximately 2002 – 2005, but the delta of the NWOD remains unaddressed to date.

7.2 Study Location and Methods

Twenty sediment sampling locations were chosen for this investigation and sampled in 2000. Eighteen of the sampling points were located at the mouth of the NWOD where it empties out into Farmington bay near the southwest end of the impoundment dike between the Crystal Unit (to the south) and the Turpin Unit (to the north) in the FBWMA (**Figure 7-1**). Two additional samples were located upgradient of the shoreline of Farmington Bay as it existed in 2000, within the Turpin Unit. These samples were located to

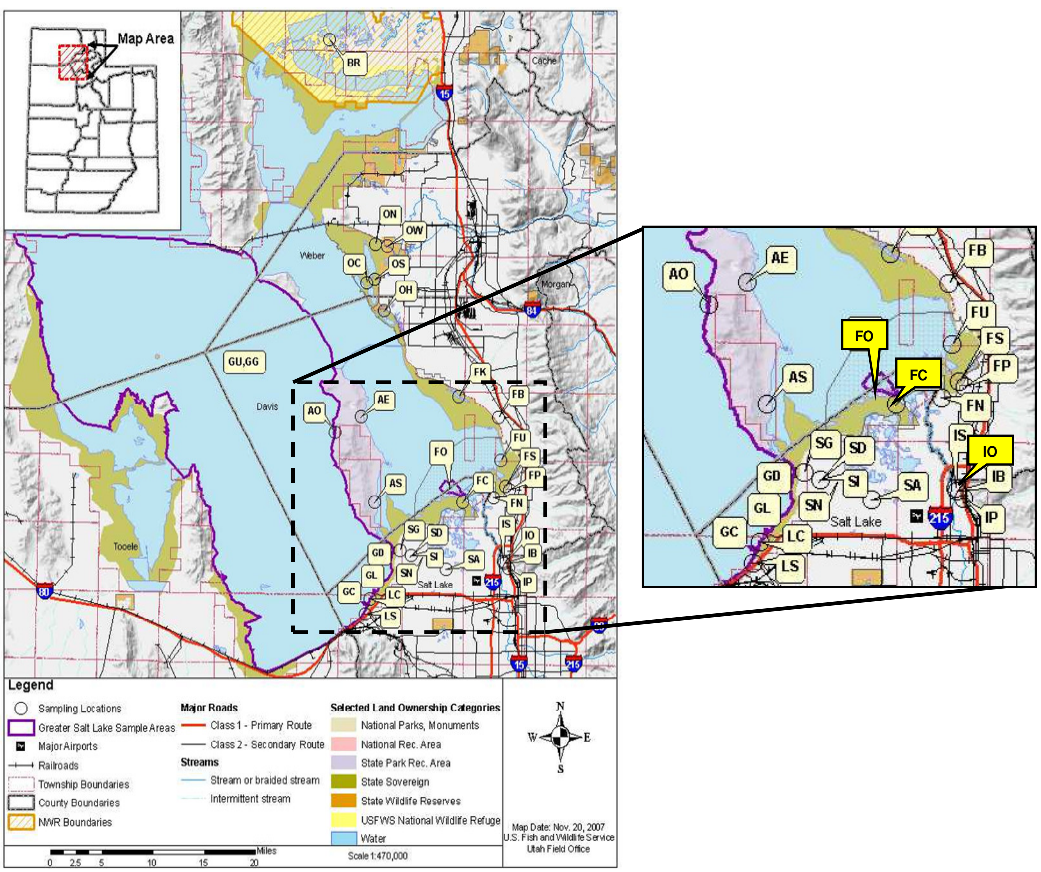

Figure 7-2. Sampling locations of 1996-1997 Great Salt Lake Wetlands Contaminants Assessment; sites relevant to the Northwest Oil Drain highlighted in yellow.

characterize contamination that may have been deposited in the Turpin Unit during the early 1980's, when several years of historically high precipitation had resulted in flooding of the GSL shoreline. The samples were arranged in transects that ran parallel to the shoreline and extended out into Farmington Bay. The first transect (T-1) included the two points within the Turpin Unit, and the second (T-2) was the first transect located within Farmington Bay. A total of six transects, spaced approximately 500 meters apart, extended about 2.5 km into Farmington Bay. Sediments in the four shore-most transects (T-1 through T-4) were located under less than 30 cm of water; these were sampled with decontaminated stainless steel scoops according to procedures outlined in Section 3. The last two transects (T-5 and T-6) were under approximately 1.0 – 1.5 meters of water, and were sampled with a stainless steel ponar dredge from a canoe. All samples were collected into chemically clean borosilicate glass jars, and handled, transported and stored as described in Section 3. Samples were analyzed for 19 metals, 25 organochlorine compounds (including total PCBs); and 25 polynuclear aromatic hydrocarbons (PAHs) including both non-alkylated and alkylated PAHs. Two isomers of tetrachlorobenzene (TCB; 1,2,3,4- and 1,2,4,5-isomers), were also included in the analysis. Analytical laboratories and methods are described in Section 3.

Analytical results were compared with the freshwater Consensus-based Sediment Screening Guidelines (CBSSG) threshold effect concentrations (TECs) and probable effect concentrations (PECs) used to evaluate the GSL wetland sediments. (MacDonald et al. 2000) and see Section 4.1). Concentrations of selenium were evaluated against the sediment guidelines in (National Irrigation Water Quality Program 1998) because these guidelines directly address adverse effects to avian species. Concentrations of Al, Ba, Mn, and V were compared with concentrations identified in "SQuiRT" (Screening Quick Reference Tables) produced by the National Oceanic and Atmospheric Administration (NOAA;(Buchman 1999). Ecologically-based screening concentrations could not be identified for Be and B, so concentrations of these elements were compared with mean "background" concentrations in western U.S soils (Shacklette & Boerngen 1984) as a way of roughly identifying elevated concentrations compared with these "background" values. No reference values were identified for Fe, Mg, Mo and Sr. For organics, available TEC and PEC concentrations (MacDonald et al., 2000 and NOAA, 1999) were used as screening benchmarks. Although these benchmarks are not available for all of the compounds that were analyzed, they are available for constituents that are typically of greatest concern for ecological toxicity. Since organic constituents tend to co-occur with each other, we believed that elevated concentrations of compounds with screening concentrations would tend to "drive" the evaluation, so no attempt was made to identify additional benchmarks for compounds not addressed by the CBSG or SQuiRT references.

7.3 Results and Discussion

Trace Elements-
All data from the metals analysis in the Oil Drain Delta sediments are presented in **Appendix Table D-1**. All elements but Hg, Mo and Se were detected in every sample, with Mo the least frequently detected, in less 50% of the samples.

The geometric means of 14 metals exceeded their respective TECs, out of the 15 metals for which TECs could be identified (**Table 7-1**). Only the geometric mean concentrations of Cr, Mn and Vn did not exceed these lower benchmarks. All 20 samples exceeded the TECs for a number of metals of concern including As, and Pb; 19 of the 20 samples exceeded the TEC for mercury (Table 7-1). The geometric mean concentration of lead (Pb) exceeded the higher threshold PEC, and a high frequency of samples exceeded the PECs for Pb and Cu. Seven of the 20 sediment samples exceeded the PEC for Hg.

In addition to the number of exceedences of the sediment benchmarks, the spatial distribution of contaminant concentrations was also of interest. Copper, Pb and Zn collectively tended to have the highest concentrations from Transect 3 (T-3) outward (**Figure 7-3**); Hg exhibited the same trend (**Figure 7-4**).

Table 7-1 Summary of trace elements (mg/kg, dry weight) and exceedences of reference values in sediments of the Northwest Oil Drain Delta(*n* = 20) in Farmington Bay, Great Salt Lake, 2000.

Constituent	Gmean[a]	max	Reference Values[c]	# > TEC	# > PEC
Aluminum	*10,882*	*16,989*	[2,600 / 25,550][1]	20	0
Arsenic	*25.8*	**43.0**	[9.8 / 33][2]	20	5
Barium	*220*	305	[48 / --][3]	20	--
Beryllium	*0.71*	1.96	[0.68 / --][4]	15	--
Boron	*100*	141	[23 / --][4]	20	--
Cadmium	*1.56*	**10.9**	[0.99 / 4.98][2]	13	3
Chromium	36.3	**310**	[43.4 / 111][2]	8	3
Copper	*137*	**268**	[31.6 / 149][2]	19	12
Iron	12,023	18,703	[--]	--	--
Lead	**193**	**453**	[35.8 / 128][2]	20	16
Magnesium	28,981	38,311	[--]	--	--
Manganese	*322*	443	[400 / 630][1]	3	0
Mercury	*0.97*	**6.17**	[0.18 / 1.06][2]	19	7
Molybdenum	NC[b]	17.4	[--]	--	--
Nickel	17.0	36.5	[22.7 / 48.6][2]	4	0
Selenium	*1.22*	2.48	[1 / 4][5]	14	0
Strontium	745	2710	[--]	--	--
Vanadium	*30.7*	112	[50 / --][1]	1	--
Zinc	*275*	**932**	[121 / 459][2]	17	5

KEY:

Value	Value exceeds TEC
Value	Value exceeds PEC

NOTES:

(a)One half the detection limit was used to calculate geometric means for Hg and Se
(b)NC = Geometric mean not calculated
(c)[--] = No reference values identified

KEY TO EFFECTS LEVELS:

1) "Background" and lowest Threshold Effect Level (Buchman 1999)
2) Threshold Effects and Probable Effects concentrations (MacDonald et al. 2000)
3) Apparent Effects Threshold in marine sediments (Buchman 1999)
4) Mean concentrations in U.S. soils (Shacklette & Boerngen 1984); not a threshold value.
5) "Background" and toxicity threshold (National Irrigation Water Quality Program 1998)

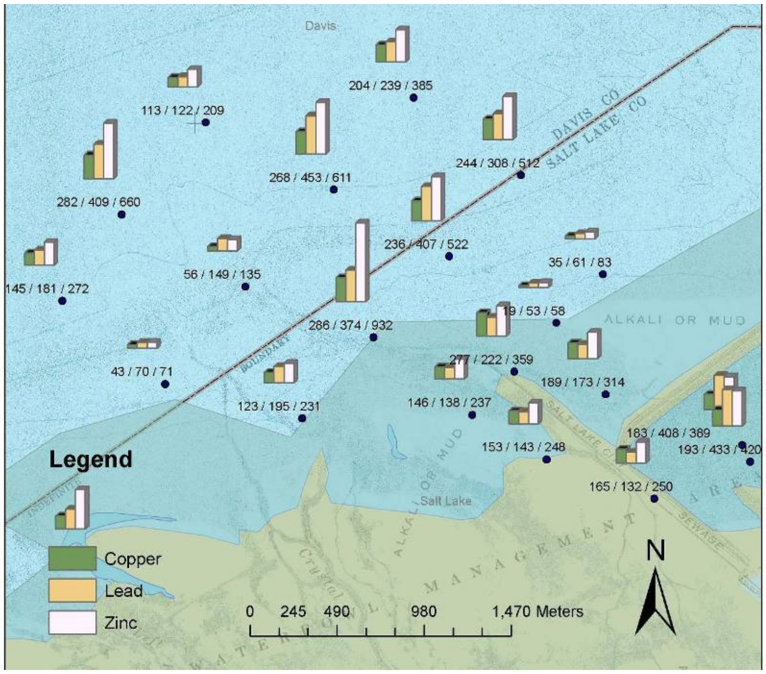

Figure 7-3. Spatial distribution of copper, lead and zinc (mg/kg dry weight) in sediments, Northwest Oil Drain Delta of the Great Salt Lake, 2000. Probable effects concentrations (PECs) = 149 mg/kg (Cu), 128 mg/kg (Pb) and 459 mg/kg (Zn).

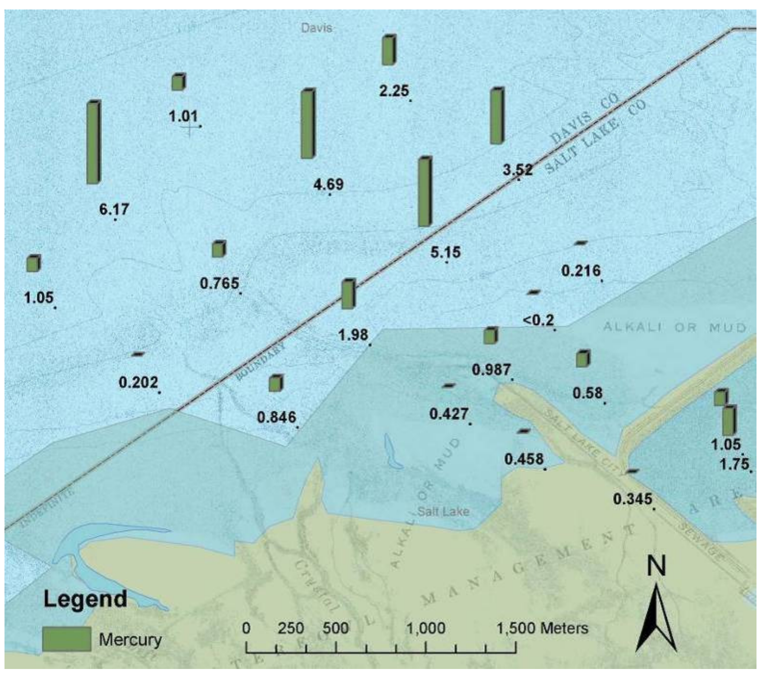

Figure 7-4. Spatial distribution of mercury (mg/kg dry weight) in sediments, Northwest Oil Drain Delta of the Great Salt Lake, 2000. Probable effects concentration (PEC) = 1.06 mg/kg.

Organics-PCBs, DDTs, other chlorinated hydrocarbons
All data from the analysis of organic constuents in the NWOD Delta sediments are presented in **Appendix Tables D-2** (OCs and PCBs), **D-3** (non-alkylated PAHs) and **D-4** (alkylated PAHs).

Total PCBs and DDTs were detected in all 20 samples. Total PCB (t-PCB) concentrations ranged from 0.043 – 5.55 mg/kg (geometric mean 0.293 mg/kg), with 19 of 20 samples exceeding the TEC of 0.060 mg/kg and five exceeding the PEC of 0.680 mg/kg. Echoing the contaminant distribution observed for trace metals, the highest detected concentrations of total PCB occurred the furthest off-shore in Transect 6 (**Figure 7-5**).

All six isomers of DDT were detected in NWOD delta sediments, with the isomers of DDD (*o,p'*-DDD and *p,p'*-DDD) the most frequently occurring, in 18 of 20 samples (**Table 7-2**). Maximum detected concentrations of all six isomers exceeded their respective PECs, and geometric mean concentrations of *o,p'*-DDD and *p,p'*-DDE exceeded their TECs (0.005 mg/kg and 0.003 mg/kg, respectively). In contrast to total PCB concentrations, which had a distinct peak in Transect 6 (furthest off-shore), concentrations of DDTs were more evenly distributed throughout the sampling grid (shown as total DDT in **Figure 7-6**).

Non-DDT organochlorines were also detected in NWOD delta sediments, with chlordanes (alpha chlordane, gamma chlordane, cis- and trans- isomers of nonachlor) present at the highest concentrations in this group. This was similar to trends observed in wetland sediments around the GSL during the 1996-1996 contaminants assessment, but concentrations tended to be higher in the NWOD delta. Geometric mean concentrations of alpha chlordane slightly exceeded the TEC (0.0033 mg/kg vs. the TEC of 0.0032 mg/kg). Spatial trends for these compounds were consistent with that seen for other constituents analyzed, with the highest concentrations being present in the furthest off-shore transect, T-6 (**Table 7-3**).

Polynuclear aromatic hydrocarbons (PAHs)
Both alkylated and non-alkylated PAHs were analyzed in NWOD delta sediments. This was done to provide data for a "fingerprint" analysis of PAHs, which can provide information as to the origin and/or source of these compounds, but this analysis was not performed. Complete data from these analyses are provided in **Appendix Tables D-3** (alkylated PAHs) and **D-4** (non-alkylated PAHs). Howver, sediment screening benchmarks are only available for non-alkylated PAHs, so only these compounds are discussed below. Total PAHs (t-PAH), calculated as the summed concentration of all PAHs (using a value of ½ the detection limit for samples with non-detected concentrations) were also evaluated. Two isomers of tetrachlorobenzene (TCB) were also evaluated; sediment screening benchmarks are not available for these compounds either.

As expected, PAHs were widely distributed in the Oil Drain delta with all 25 of the non-alkylated PAHs analyzed detected in at least one sample and with 16 of the 25 detected in all sediment samples. At least one PAH was present >TEC in each of the 20 samples. Nine PAH compounds had mean concentrations in at least one transect that exceeded their respective TECs and the mean concentration of dibenz(*a,h*)anthracene exceeded the PEC in one transect (T-5) (**Table 7-4**),. Three PAH compounds, and t-PEC had maximum detected concentrations > PEC in at least one sample. While PAH concentrations exceeded TECs throughout the sampling grid, the spatial distribution concentrations was similar to that observed previously, the highest concentrations detected at the off-shore edge of the grid (**Figure 7-7**).

Conclusions and Recommendations
The majority of trace elements of concern (e.g., Hg, Cu, Pb, Zn) as well as chlorinated OCs and PAHs were detected in NWOD delta sediments at levels that exceeded threshold sediment toxicity concentrations for individual compounds. These concentrations are known to adversely impact both sediment-dwelling organisms and birds that forage on them.

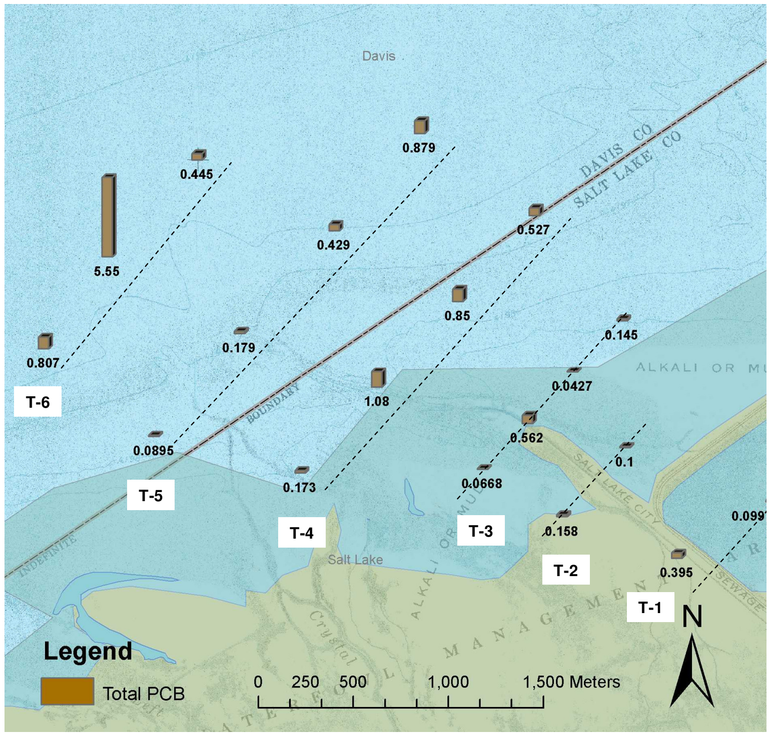

Figure 7-5. Spatial distribution of total PCBs (mg/kg dry weight) in sediments, Northwest Oil Drain Delta of the Great Salt Lake, 2000. Probable effect concentration (PEC) =0.680 mg/kg.

Table 7-2. Summary of DDT isomer concentrations (mg/kg dry weight) in sediments, Great Salt Lake Oil Drain Delta, 2000. Transects are numbered from T-1 (onshore) to T-6 (offshore).

DDT Metabolite	# Detects (of 20)	Geo. Mean Conc.	Max. Conc. (Transect #)	(#) ≥ PEC conc.	Transects ≥ PEC	(#) ≥ TEC conc.
o,p'-DDD	18	*0.006*	0.101 (T-4)	(4) ≥ 0.028	6,5,4	(10) ≥ 0.005
p,p'-DDD	18	*0.008*	0.116 (T-1)	(5) ≥ 0.028	6,5,4	(8) ≥ 0.005
o,p'-DDE	7	NC	0.059 (T-4)	(1) ≥ 0.031	4	(5) ≥ 0.003
p,p'-DDE	17	*0.004*	0.079 (T-1)	(2) ≥ 0.031	6,4	(10) ≥ 0.003
o,p'-DDT	12	0.003	0.200 (T-4)	(2) ≥ 0.063	5,4	(5) ≥ 0.004
p,p'-DDT	4	NC	0.101 (T-4)	(1) ≥ 0.063	4	(4) ≥ 0.004
Total DDTs (summed)	NA	*.0352*	0.360 (T-4)	(0) ≥ 0.572	*None*	(20) ≥ 0.005

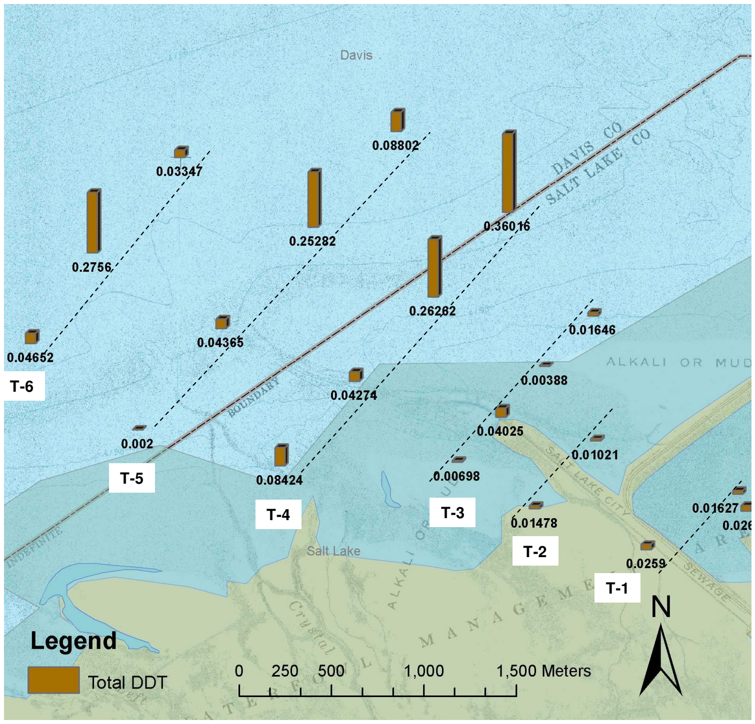

Figure 7-6. Spatial distribution of total DDTs (summed concentrations of o,p'- and p,p'-isomers of DDD, DDE and DDT; mg/kg dry weight) in sediments, Northwest Oil Drain Delta of the Great Salt Lake. Probable effect concentration (PEC) =0.572 mg/kg

Table 7-3. Concentrations of frequently detected chlorinated organic compounds in sediment samples (mg/kg dry weight) compared with sediment screening benchmarks, Northwest Oil Drain Delta, 2000.

	alpha chlordane	gamma chlordane	cis-nonachlor	trans-nonachlor
Threshold Effects Concentration (TEC)	*0.0032*	*0.0032*	*0.0025*	*0.0025*
Probable Effects Concentration (PEC)	**0.018**	**0.018**	**0.016**	**0.016**
All Data (20 samples)				
# detections	15	12	12	10
max conc.	**0.067**	**0.128**	**0.026**	**0.031**
geomean conc	*0.00334*	0.00234	0.00170	0.00160
% ≥ PEC	13%	17%	8%	10%
% ≥ TEC	73%	58%	67%	70%
Transect 6 (offshore; 3 samples)				
# detections	3	3	3	3
max conc.	**0.067**	**0.128**	**0.026**	**0.031**
geomean conc	*0.0107*	**0.0215**	*0.0052*	*0.0056*
% ≥ PEC	33%	33%	33%	33%
% ≥ TEC	100%	100%	66%	66%

Table 7-4. Geometric mean concentrations of non-alkylated PAHs in sediments by transect, Northwest Oil Drain Delta of the Great Salt Lake, 2000. All concentrations given in mg/kg (ppm) dry weight.

	onshore < < ---					*--- > >offshore*			
PAHs with SQGs	**T-1**	**T-2**	**T-3**	**T-4**	**T-5**	**T-6**	**TEC**	**PEC**	***TEC/ PEC source***
2-methylnaphthalene*	*0.073*	*0.022*	0.012	*0.051*	*0.044*	*0.038*	0.020	0.201	*(1)*
Benzo(a)anthracene	0.083	0.027	0.013	*0.078*	*0.060*	*0.148*	0.108	1.05	*(2)*
Dibenz(a,h)anthracene*	0.129	0.016	0.012	*0.074*	**0.138**	0.019	0.033	0.135	*(2)*
acenaphthalene*	*0.045*	*0.011*	*0.020*	*0.023*	*0.016*	*0.021*	0.006	0.128	*(1)*
acenaphthene	0.029	0.015	0.005	*0.007*	0.004	0.018	0.007	0.089	*(1)*
anthracene*	*0.146*	0.031	0.018	*0.137*	*0.146*	*0.123*	0.057	0.845	*(2)*
benzo(a)pyrene	0.159	0.038	0.021	0.076	0.085	0.090	0.150	1.45	*(2)*
benzo(b)fluoranthene	0.052	0.046	0.028	0.154	0.155	0.082	0.240	13.4	*(4)*
benzo(e)pyrene*	*0.221*	0.058	0.042	*0.324*	*0.473*	0.095	0.150	1.45	*(4)*
benzo(g,h,i)perylene	*0.337*	0.057	0.032	*0.219*	*0.329*	0.089	0.170	3.20	*(3)*
benzo(k)fluoranthene	0.014	0.013	0.006	0.037	0.023	0.021	0.240	13.4	*(3)*
chrysene	0.160	0.075	0.051	*0.451*	*0.308*	*0.202*	0.166	1.29	*(2)*
fluoranthene	0.087	0.051	0.017	0.086	0.038	0.105	0.423	2.23	*(2)*
fluorene	0.024	0.014	0.004	0.019	0.012	0.023	0.077	0.536	*(2)*
indeno(1,2,3-cd)pyrene	0.117	0.033	0.019	0.112	0.161	0.047	0.200	3.20	*(2)*
naphthalene	0.032	0.014	0.008	0.021	0.017	0.019	0.176	0.561	*(2)*
phenanthrene	0.103	0.043	0.019	0.106	0.057	*0.250*	0.204	1.17	*(1)*
pyrene	0.189	0.096	0.045	*0.453*	*0.268*	*0.356*	0.195	1.52	*(2)*
Total PAH (summed)	2.53	0.772	0.435	*3.38*	*2.79*	*3.07*	1.61	22.8	*(2)*
#PAH>TEC	*7*	*2*	*1*	*9*	*8*	*7*			
#PAH>PEC					**1**				

KEY:

value	value > TEC
value	value > PEC

NOTES

Threshold Effects Concentrations (TECs) and Probable Effects Concentrations (PECs) from sources as noted:

(1) Canadian Council of Ministers of the Environment (CCME, 1999)

(2) Consensus-Based Sediment Quality Guidelines (MacDonald, et al, 2000)

(3) Guidelines for the Protection and management of sediments in Ontario, Canada (Ontario, 1993

(4) TECs and PECs for benzo(e)pyrene and benzo(b)fluoranthene were assigned based on chemical structural similarity to benzo(a)pyrene (CBSQG) and benzo(k)flouranthene (CBSQG), respectively

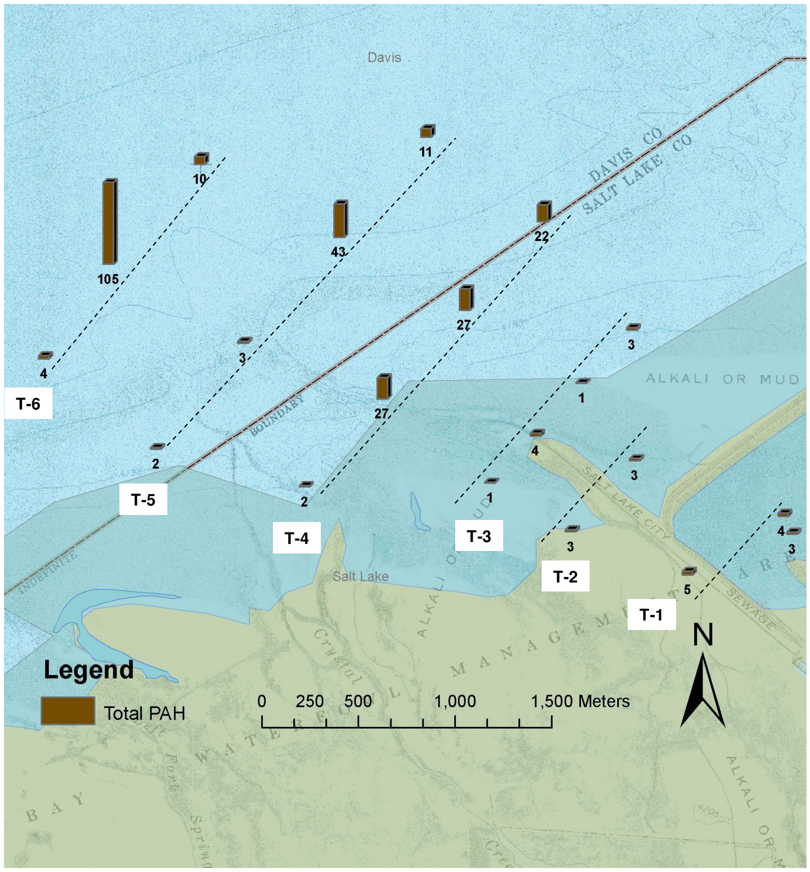

Figure 7-7. Spatial distribution of total (summed) non-alkylated PAH concentrations (mg/kg dry weight) in sediments, Northwest Oil Drain Delta of the Great Salt Lake, 2000. Threshold effect concentration (TEC) =1.61 mg/kg; probable effects concentration (PEC) =22.8 mg/kg.

While sediment TECs are commonly interpreted as conservative because adverse effects are "not expected" below them, an evaluation of the individual studies that form their basis indicates that adverse effects have been observed at or even below these thresholds in certain cases (D. Wall, USFWS, personal communication). Additionally, individual TECs/PECs do not address cumulative (additive or synergistic) toxicity. We found mean concentrations of 14 of 15 metals, and organic compounds including total PCBs, DDT isomers, chlordane and several PAHs (including total PAH) to be present above TECs, and nearly half of the samples had levels of some of the most toxic constituents (Pb, Hg, t-PAH) exceeding "probable" effects levels. Cumulatively, these data suggest that sediment-dwelling invertebrate and plant communities could be impaired in the NWOD delta. These impairments can lead to a decrease in abundance and diversity of food items for avian fauna that occur in the FBWMA, where the NWOD delta is located.

However, despite possible impairment, sediment-dwelling organisms and plants are present in the NWOD delta, because some of the most abundant species in the area, which are adapted to the difficult environmental conditions of the GSL's estuarine wetlands (e.g., high salinity, low oxygen, high temperatures) are also pollutant tolerant. Avian usage of food resources in the NWOD delta is also a function of the surrounding, less polluted habitats in the FBWMA, which are managed specifically for avian productivity. These conditions create a pathway for birds to be exposed to contaminants in the NWOD delta both through consumption of food items (e.g., the gut contents of macroinvertebrates, sediments attached to roots and other plant matter) and through consumption of sediments adhering to these food items. This "incidental" sediment ingestion can range from 3 – 10% of total dietary intake depending on species (Hui & Beyer 1998; Beyer et al. 2008).

The highest concentrations of almost all constituents were observed in the farthest off-shore transects. Thus, while the "nature" of contamination in the NWOD delta is better characterized as a result of this study, the "extent" of the contamination is not. Because the location of the GSL shoreline fluctuates greatly with small changes in lake elevation, the areas around the farthest transects may be exposed at lower lake levels, subsequently increasing exposure risk to benthic foraging birds.

Mercury concentrations in avian eggs collected in the Crystal Unit in 1996-1997 (discussed in Section 4.4) seem to indicate that birds exposed to sediments in this area would have increased risk of ecologically adverse effects. Elevated t-Hg concentrations were observed in black-necked stilt and American coot, both of which are highly sediment exposed and are commonly observed in the NWOD delta. However, in our follow-up investigation, which addressed a piscivorous species, Forsters' tern (see Section 6), elevated mercury concentrations were not observed. We believe this indicates that mercury uptake in the Farmington Bay wetlands does not occur through the food-chain (i.e., biomagnification through successive trophic levels) but is instead more an issue of direct sediment exposure.

8.0 SUMMARY CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

8.1 Introduction

This study was a first-ever comprehensive evaluation of contaminant concentrations throughout the avian food chain (and exposure pathways) in the Great Salt Lake and the wetlands surrounding it. One important conclusion supported by the data presented here is that no areas were identified where contaminants were present in acutely toxic concentrations or were widely present in concentrations associated with a high probability of harm to birds or other wildlife. However, several areas where contaminant inputs may be having more subtle impacts were identified. These inputs consist primarily of residual concentrations of "legacy" compounds such as chlorinated pesticides, or are associated with past (and also current) waste disposal practices that have resulted in the accumulation of contaminants at the "bottom of the hill" in the GSL. Our data indicated areas around the GSL where these contaminants may be present at concentrations that could cause decreases in the productivity and resource value of habitat areas used by birds (e.g., loss of diversity or abundance of foraging resources), or in some cases may be having sub-lethal effects on avian populations themselves. Data collected during this study also provided an important first glimpse at areas of the GSL where mercury is present at elevated levels and where it appears to have an annual pattern of accumulation in food chain biota and avian tissues. Finally, these data add to the previously very limited characterization of a contaminants "baseline" for the GSL, particularly in areas of the lake that were relatively undeveloped at the time that they were sampled, but which are currently receiving increased resource extraction and/or population growth-based development pressure.

The findings in this report represent a "screen" of potential contaminant issues in the wetlands and open waters of the Great Salt Lake ecosystem, not a conclusive determination of whether or not these contaminants are injuring migratory birds or other wildlife. The contaminant data presented here do not wholly characterize the nature, extent or magnitude of distribution of the constituents identified, or their effects on the health or sustainability of exposed species. In most cases only one or two locations within large and complex habitats were sampled; often with only single samples of various media. In many locations, only presence/absence could be definitively evaluated, and statistical comparisons were limited by small and uneven sample sizes, or other conditions (e.g., collections over multiple years or in dissimilar biota between areas) that limited certainty. Determinations of effect relied heavily on literature-based screening benchmark concentrations. Added to that is the fact that the laboratory conditions under which tests are commonly conducted are very different than the conditions experienced by wildlife, which likely include additional stressors such as disease, adverse weather, or lack of food. Finally, our evaluation addressed contaminants individually, ignoring potential additive, synergistic or antagonistic interactions. In some areas where a large number of constituents were identified at elevated concentrations (e.g., the Northwest Oil Drain Delta), these interactions may be an important consideration in assessing potential impacts to migratory birds.

Results from this studie identified several areas where contaminants are present at levels that approach or exceed levels of concern in avian dietary items or in avian eggs. The southern portion of Farmington Bay, potentially localized to the outlet of the Northwest Oil Drain had significantly higher concentrations of mercury in the eggs of sediment-exposed birds than other areas around the lake, and sediments in the NWOD Delta had elevated concentrations of a large number of both inorganic and organic constituents. In Ogden Bay, lead (Pb) and "legacy" organochlorine compounds such as DDT were observed in food items and in fish at higher concentrations and with more frequency than at other wetland sites around the GSL. For the most part, concentrations of these constituents were below levels of concern, but it is not known if, or why they seem to be more bioavailable in Ogden Bay than in other areas around the lake . Sediments in the area around the outfall of the C-7 Ditch on the south shore of the GSL had significantly higher concentrations of metals (e.g., copper and selenium) associated with past and present industrial activities. Avian eggs collected at South Shore wetlands sites also had elevated concentrations of these metals, particularly selenium, supporting the Service's concern regarding the rate of input of these metals to the GSL.

Within the open waters of the GSL, elevated mercury concentrations were observed in the livers of eared grebes that use the GSL for an extended migratory stop-over during fall migration, with some indication that selenium concentrations may also increase during this period. We also observed that concentrations of these metals appear to increase seasonally, potentially related to the length of time that the birds spend foraging on the open lake. In the interval between when these data were collected and the present, a unique and important mercury cycling mechanism has been identified within the GSL (Naftz et al. 2008), the dynamics of mercury uptake in eared grebes have been further evaluated (Miles and Darnall, in preparation) and elevated Hg concentrations have been documented in waterfowl species (northern shoveler, common goldeneye and cinnamon teal) that forage on the open lake during certain times of the year (Vest et al. 2008). At this time, additional studies are being conducted to evaluate avian mercury exposure in GSL wetlands compared to the lake's open waters. Because peak mercury concentrations in waterfowl on the GSL appear to occur in late winter just before birds migrate to their breeding grounds, the effect of mercury exposure in breeding birds that wintered on the lake should be investigated.

8.2 Areas and Constituents of Concern Identified in this Investigation

South Shore of the Great Salt Lake

Sediments in the this area of the GSL have elevated concentrations of As, Cu, Se, and Zn, with the latter three trace elements also above levels of concern in fish and bird eggs. The area of greatest concern with respect to avian exposure is the GSL shoreline between the Saltair marina and the GSL State Park, with particular concern regarding areas of lake shore/lakebed sediment where effluent from the C7 Ditch creates a delta of aquatic habitat (vegetation and sediment macroinvertebrates) between the outfall location and waters of the lake, which can be as long as 2-3 km depending on lake elevation.

Copper, Se and Zn are essential elements for all living organisms, but excessive amounts of these elements can also be harmful. Of these three, Se is the element of greatest concern both because it bioaccumulates and because it has a relatively steep toxicity curve, particularly in birds (NIWQP 1998). Avian dietary exposure to Cu, Se and Zn occurs primarily through incidental ingestion of sediments while foraging and through ingestion of contaminants within the invertebrates themselves. While sediment ingestion varies considerably by species depending on prey items and foraging style, it typically ranges between 3 – 10% of total ingestion (Beyer et al 1994, Beyer et al 2008) and in some species may be as high as 30% (Hui and Beyer 1998).

Selenium, Cu and Zn can be considerably toxic to aquatic and benthic invertebrates (Clements et al. 1988; Ingersoll et al. 1990), particularly to larval and pre-adult life stages (Bodar et al. 1989; Khangarot and Ray 1989). Impacts on invertebrate community abundance, diversity and structure can directly affect the diversity and abundance of avian populations that an area can then support (Hurlbut et al. 1989). On the GSL south shore, available habitat for shorebirds and waterfowl varies dramatically depending on lake levels. At lower lake levels, available habitat is extended and birds can forage over a greater area; in addition, the distance between the C7 Ditch outfall and the lake increases, increasing the foraging area which may be impacted by dissolved metals in the discharge.

Contaminant data in fish confirmed that metals and trace elements in the GSL south shore area are bioavailable. Cadmium was detected in whole-body fish samples only at site LC, and other metals including Cu, Mn, and Zn and the metalloid Se were seen in higher concentrations at LC than at most of the other sites in the 1996-1997 survey. Metals, notably Cd, may play a role in endocrine disruption, and may increase concentrations of testosterone (S. Goodbred, USGS, pers. comm.). However, endocrine biomarkers are not specific to contaminants exposure, and other factors such as the relatively poor habitat quality of the area where the fish were collected must also be considered. Site LC consists of a narrow ditch with little vegetation or diverse habitat for macroinvertebrates. Relative body condition, a measure of fish health that integrates many environmental factors, was significantly lower in both male and female fish at site LC than at any other site evaluated.

This investigation confirmed that selenium is a concern in the south shore area, with concentrations above levels of concern in all media evaluated. Selenium is a well-known teratogen in birds. Elevated egg Se concentrations can also reduce hatchability even if there is no embryonic deformation observed (Hoffman et al. 2002). The GSL south shore was the only area where we found bird eggs with Se > 6 mg/kg, a screening level associated with reduction of hatchability in some species (Skorupa et al. 1989; Skorupa and Ohlendorf 1991). The geometric mean concentration of Se in eggs from the South Shore (n = 12) was 4.8 mg/kg, while geometric means from all other areas evaluated in this study were below the 3 mg/kg background threshold. Further avian monitoring conducted in 2006 (as part of an interagency effort to establish a water quality standard for Se in the GSL) indicated Se was present in eggs at concentrations equivalent to or exceeding the concentrations we observed in this study , with a geometric mean concentration of 5.1 mg/kg Se (n = 8) and two of eight eggs exceeding 6 mg/kg (Cavitt 2006). Eggs collected from other areas of the GSL during the 2006 study had lower selenium concentrations, echoing the findings of this investigation. Concerns regarding avian Se exposure brought to light by this study resulted in intense evaluation of the wetlands impacted by Se-contaminated groundwater originating from KUCC's facility, and in 2008 resulted in a Natural Resource Damage (NRD) settlement between the U.S. Department of Interior and the facility for injuries to migratory birds at these wetlands.

Farmington Bay South and the Southeast Shore Industrial Area Wetlands
Farmington Bay contains the largest acreage of state- and privately owned wetlands managed for migratory birds and waterfowl on the GSL. The southern portion of Farmington Bay (Farmington Bay South, FBS) also receives the greatest amounts of wastewater and other anthropogenic stressors. This investigation focused on both of these facts in the number of sites evaluated (**Figure 2-1, Table 2-2**) and the number of samples collected.

The results of this investigation showed that sediments in the south shore industrially impacted wetlands contain elevated concentrations of a variety of contaminants, but that in general (with the exception of the Northwest Oil Drain Delta), concentrations of these constituents decrease with distance from the source area. Several trace elements (Cd, Cr, Cu, Hg, Pb, Se and Zn) exceeded PECs in sediments in wetlands near industrial areas, but only Pb exceeded sediment PECs in the wetlands in FBS. Lead also was elevated in macroinvertebrates from FBS, with 3 of 4 samples exceeding the avian dietary NOAEL (5 mg/kg). Chromium, Hg and Se also exceeded dietary NOAELs in FBS invertebrates, but did not exceed sediment PECs.

Site IO was the only industrially-impacted wetland site where habitat for fish occurred. Selenium and Zn exceeded levels of concern in these fish, however there is uncertainty about whether these concentrations are representative of the site because the fish could have moved upstream or downstream. However, these results imply that there is a source of metals somewhere within the watershed of Site IO.

Fish from FBS exceeded screening levels for Zn only, which also was elevated throughout the entire GSL study area. A variety of organic constituents were detected in fish from FBS but none exceeded avian dietary LOAELs with the exception of total PCBs. Total PCBs were detected in all fish from FBS sites, and exceeded the avian dietary NOAEL of 0.1 mg/kg ww at three sites, ranging from 0.13 – 0.25 mg/kg ww. Piscivorous birds foraging at site IO could be exposed to elevated concentrations of total PCBs, where the geometric mean concentration in fish was 0.2 mg/kg ww.

Mercury emerged as a contaminant of concern at the Crystal Unit of the Farmington Bay WMA (site FC) based on concentrations observed in avian eggs collected in 1996-1997. The 12 eggs collected at Site FC had the five highest detections of total Hg observed in the 88 eggs collected around the GSL, with three exceeding the LOAEL of 0.86 mg/kg ww (derived from 3.4 mg/kg dw [Heinz 1979] assuming 75% moisture). All eggs collected at site FC were in the top quartile of Hg concentrations in avian eggs from the GSL. This appeared to be localized to site FC as eggs at all other sites in FBS had significantly lower concentrations (**Figure 4.-8**). However, Hg in piscivorous bird eggs (Forster's Tern; FOTE) collected during the 2000 follow-up study (Section 6) were lower (geometric mean total Hg = 1.08 mg/kg dw) but were still elevated compared to other GSL wetlands. Species at higher trophic levels, like terns and herons, generally have higher egg Hg concentrations (Fimreite 1974), but that was not true for this study. Instead, herbivores (e.g., American coot, AMCO) had the highest concentrations followed by insectivores (e.g., black-necked stilt, BNST). If elevated Hg is limited to the NWOD Delta area adjacent to FC (as it appears based on data presented in Section 7) it may be that Hg exposure in FOTE is "diluted" by their larger foraging range (McNicholl et al., 2001) compared to AMCO (Brisbin and Mowbray 2002) and BNST (Robinson et al. 1999). This may have been exacerbated by the fact that the FOTE eggs were collected at a site about 1.5 miles (2.5 km) from the NWOD Delta and SiteFC. Additionally, it appears likely that Hg exposure in the NWOD Delta and Site FC are a function of sediment exposure through incidental ingestion, where AMCO and BNST both have relatively high sediment ingestion rates (although they have not been characterized) compared to piscivorous birds. Finally, exposure levels may differ from year to year as the lake evaluation changes, exposing or covering mudflats and shifting vegetation and nesting and foraging locations.

Although meHg in sediments was not specifically addressed in this report, subsequent investigations by the U.S. Geological Survey and others (Naftz et al. 2008) have confirmed that Hg methylation occurs to a high degree in the sediments of the GSL, both in the open waters of the lake and within the near-shore wetlands Sediments in the GSL watershed are fine-grained, contain high concentrations of organic matter, and are typically anoxic just below the sediment surface layer. They also contain high concentrations of sulfates, leading to high levels of activity by anaerobic sulfate-reducing bacteria (SRB). These bacteria are one of the major mechanisms responsible for the methylation of Hg (Compeau and Bartha 1985). Current research suggests that wetlands in general, and freshwater wetlands in particular, may play a driving role in the methylation of atmospheric Hg (Halla et al. 2008). There are likely a variety of Hg sources within the FBS system, including atmospheric deposition, urban/industrial runoff and historic contamination. Environmental factors within FBS may also lead to increased production of meHg from these sources. Intermittent wetting and drying of sediments, which occurs in FBS with the rise and fall of lake levels and can lead to increased Hg methylation by increasing the availability of sulfate, organic and/or inorganic Hg (Krabbenhoft and Fink 2000). Wind-driven resuspension of sediments, which has been shown to release meHg to the water column (Kim et al. 2006) is also a common occurrence in the shallow bay.

Eutrophication is a significant issue in FBS (Wurtsbaugh and Marcarelli 2006) due to nutrient enrichment from the numerous wastewater treatment plants and other effluents discharged into the bay. High vegetative biomass production coupled with warm summertime water temperatures on the shallowly-submerged mudflats can lead to episodes of low dissolved oxygen caused by decaying plant matter. This may impact Hg cycling positively by facilitating anoxic conditions and by providing organic matter, which has been shown to be an important contributor to Hg methylation, particularly in warm, carbon-rich wetlands such as peat wetlands in the Florida Everglades and other areas of the southeastern U.S. (Halla et al. 2008). (e.g., by increasing the amount of decaying plant matter). Alternatively, these conditions could limit mercury methylation, as excessive levels of organic carbon or sulfide can make Hg unavailable for uptake by sulfate-reducing bacteria (Bank et al. 2007). However, this remains yet to be evaluated in Farmington Bay

Sediment-linked Hg exposure is a concern for the management of migratory birds and waterfowl in Farmington Bay because much of the highest-value habitat for avian use in the area consists of large open mudflats covered by 10-30 cm (4-12 inches) of water that are heavily used by sediment foragers such as American avocet, black-necked stilt and white-faced ibis (*Plegadis chihi*). Submerged aquatic vegetation growing in and on sediments is also an important food source for herbivorous species such as American coot and dabbling ducks. Of these, cinnamon teal (*Anas cyanoptera*) are one of a relatively small number of waterfowl species that nest in the GSL wetlands, and FBS is among the most productive areas in the state for this species (J. Luft, Utah Div. Wildlife Resources, pers. comm. 2008). Because of the importance of these habitats to avian populations, and also because of human health concerns linked to the consumption of waterfowl that are harvested on the GSL (Utah Environmental Epidemiology Program 2006), the origin, fate, transport and cycling of Hg, as well as the wildlife and human health risks and impacts of Hg exposure, are currently being addressed in a series of coordinated investigations that are being undertaken by researchers and others from academia, state and federal agencies, including the Service.

An additional investigation is currently being conducted by the USEPA and the Utah Department of Environmental Quality to determine whether Farmington Bay is impaired by Hg, along with nutrients, which are also a significant concern in FBS but were not addressed by this contaminants assessment. Nutrient enrichment in FBS is primarily due to the contribution of effluents from the large municipal WWTPs located on the eastern shore of the lake (T. Miller, Utah DEQ, pers. comm. 2008). While nutrients are likely to be a contributing factor to the rich productivity of plants and macroinvertebrates that serve as the food resource for birds, the bay is already stressed by nutrients, which spur the production of large mats of filamentous algae in the summer, which in turn contribute to anoxic conditions when this vegetation dies and decays. The interaction of Hg and nutrient enrichment should be investigated, because it is possible that Hg exposure may be influenced by nutrient enrichment as the anaerobic conditions and organic carbon provided by decaying vegetation can promote the growth of sulfate-reducing bacteria which are believed to be primarily responsible for Hg methylation.

Ogden Bay

There were several concerns regarding Ogden Bay leading into this investigation, including agricultural inputs from farmland within the watershed of the Ogden Bay Waterfowl Management Area, and potential effects associated with a large railroad maintenance facility located upstream (the Union Pacific Ogden Railyard, located on the Ogden River about 8 miles upstream of Ogden Bay). However, with the exception of lead (discussed below) our investigation did not identify any major contaminant source areas or significant patterns of adverse effect in biota in this area. Persistent bioaccumulative organochlorine compounds, including DDT-metabolites, were identified more consistently across biota types in Ogden Bay than at other locations around the GSL. Concentrations in general were below the levels of concern identified in Section 4, but Site ON stood out with elevated DDT levels in macroinvertebrates, fish and bird eggs. Site ON was the only site where total DDTs in both macroinvertebrates and fish exceeded the avian dietary effect level of 0.15 mg/kg dw (Blus 1982). Total DDTs in bird eggs, as well as total PCBs, were higher at Site ON than they were at the other two sites in Ogden Bay (OS and OH), but they were comparable to those observed in Farmington Bay.

***Lead Across GSL Wetlands* -** Concentrations of Pb in invertebrates exceeded the avian dietary LOAEL of 5 mg/kg (Eisler 2000) at all wetland sites evaluated during this assessment. The highest Pb concentrations were observed at the ISSR Wetlands (Site SI, 74.2 mg/kg in chironomids), the Petrochem Ponds in the industrial area wetlands (Site IP, 53.6 mg/kg in chironomids), and northern Ogden Bay (Site ON, 49.3 mg/kg in chironomids). Several of these sites also had high sediment Pb concentrations, including Site IP (364 mg/kg; the maximum observed concentration for the assessment) and ON (242 mg/kg). Sediments with Pb exceeding the PEC (128 mg/kg) were also collected in southern Ogden Bay, (Site OS), the State Canal in Farmington Bay (site FS), and in the Oil Drain Canal (site IO).

Sources of lead may in GSL wetland sediments include atmospheric deposition, historic milling and smelting (e.g., Mildvale Slag and Sharon Steel), historic use of leaded gasoline, and industrial uses and sewage effluents (Pattee and Pain 2003). While Pb typically exists in the environment in precipitate forms that have limited bioavailability, sediment invertebrates in lead-contaminated areas can contain enough undigested sediment to provide a source of Pb to foraging birds, fish, and other wildlife. This may be the source of Pb observed in invertebrates from Sites IP and IO. However, the primary concern regarding avian Pb exposure is lead shot and angling weights which can accumulate to levels of concern in areas (Pattee and Hennes 1983, Brand and Rocke 1987, White and Stendell 1977). Lead from shot can occur in sediments either as whole pellets or as fragments, and is typically consumed by waterfowl that are either foraging in sediments for food or are ingesting the sediments themselves to supply grit for their gizzards. Once consumed, the Pb becomes highly bioavailable in the stomach. Ingestion of one or two pellets can be enough to cause serious adverse effects or mortality (Bellrose 1951; Rattner et al. 1989). Aside from an industrial area wetland (site IP), the highest concentrations of sediment Pb observed in this assessment occurred in areas that have been managed primarily for waterfowl hunting for many decades (sites ON, OS and FS). However, almost a decade has passed since these data were collected, during which the use of Pb shot has declined significantly, which, in combination with continued sedimentation, should result in a decrease in Pb exposure for waterfowl and other birds in these areas.

8.3 Areas with Little Evidence of Contaminants Impacts

Several geographic areas within the Great Salt Lake ecosystem had minimal evidence of contaminant impact, including Antelope Island, the complex of mitigation wetlands located on the GSL South Shore (e.g., sites SA, SN, SG and SI), and the northern portion of Farmington Bay. This is generally consistent with the relative lack of historic and/or current contaminant inputs to these areas.

***Antelope Island* -** The only notable contaminant-issue at Antelope Island was the presence of relatively high concentrations of total petroleum hydrocarbons in sediments (geometric mean 1,006 mg/kg; maximum 2,412 mg/kg). There are no ecologically-based benchmarks for TPH, but 1,000 mg/kg is a commonly accepted benchmark above which petroleum-impacted sites, such as underground storage tank sites, may be further evaluated for remediation (UDERR 2006). The presence of TPH at these levels at Antelope Island was unexpected, and their source is unexplained. Polychlorinated biphenyls (PCBs) were also present in Antelope Island sediment samples (as they were in all sediment samples evaluated for this study) but at low concentrations Their detection here may reflect the ubiquity of PCBs in the global environment, as they are known to be deposited in remote regions far from the site of their manufacture or use (Cleverly et al. 2007).

***South Shore Conservation Wetland s* -** This study confirmed that lands that have been reserved for Clean Water Act Section 404 wetland mitigation banking along the south shore of the GSL do not pose an exposure risk to waterfowl that are attracted to the restored/enhanced wetlands. Concentrations of Cr, Cu, Pb, Se and Zn in sediments occasionally exceeded PECs, but generally did not appear to accumulate in sediment macroinvertebrates to levels of avian dietary concern. Copper above the avian dietary LOC was observed in one macroinvertebrate sample at Site SN (the North Point canal), which is near the Kennecott Utah Copper Corp's mine tailings pile

***Farmington Bay North* –** The sites evaluated in the northern portion of Farmington Bay are also conservation/mitigation wetlands, and again there was little evidence of chemical stressors at these sites. Site FK, a freshwater marsh that is included in a wetland preserve managed by The Nature Conservancy, had one exceedence of levels of concern for Cr and Pb in macroinvertebrates. However, there was no evidence that these metals were being bioaccumulated in fish or bird eggs at the site. The average concentration of Zn in the seven bird eggs collected at site FK (49.3 mg/kg) was similar to the 50 mg/kg level of concern used for this evaluation and the mean Zn concentration of 50.8 mg/kg for all of the eggs evaluated for this study.

8.4 Management Recommendations

In the years that have passed between the collection of data for this investigation and the present (*circa* 2009), several significant management actions have taken place on the GSL, many of which were initiated or have been informed by the results of this study. These include the initiation to establish a tissue-based water quality standard for selenium for the Great Salt Lake, and an intensive study of the fate, transport and environmental effects of mercury in the GSL ecosystem. The other major potential contaminant issue that was identified by this study, the plume of contaminated sediments at the terminus of the Northwest Oil Drain in southern Farmington Bay (the NWOD Delta) is not yet being addressed by regulatory agencies, but has been brought to their attention.

Because of the GSLs unique nature, being neither a freshwater ecosystem nor a marine one, national water quality standards promulgated under the Clean Water Act have been a poor fit for determining whether the beneficial uses of the GSL (both by humans and wildlife) are "impaired" by chemical or other stressors by application of water quality standards. Consequently, regulation of water quality in the GSL by State (Utah Department of Environmental Quality, UDEQ) and Federal (U.S. EPA) has been achieved by "narrative" standards that have been difficult to evaluate if not enforce. In 2005 began to develop water quality standards for Se in the open waters of the GSL, and site-specific standards for the wetlands around the GSL. The Service has been an active participant in this process, and supports it because doing so will limit the exposure of migratory birds to environmental contaminants in point source discharges to the lake and its wetlands. The results from this investigation were used as a starting point for the development of hypotheses regarding the distribution and effects of Se on migratory birds and waterfowl. As Utah DEQ and the EPA begin to address numeric criteria for other contaminants, these results will continue to be useful.

In 2005, trace metal concentration data from grebes collected on the open waters of the GSL (Section 5) were paired with observations by the USGS of elevated Hg concentrations in the water and sediments of the GSL. The USGS's studies found that dissolved total and methyl-mercury concentrations in GSL waters in some locations were among the highest that had ever been recorded (Naftz et al., 2008). In 2006, mercury concentrations in three species of waterfowl (northern shoveler, common goldeneye and cinnamon teal) collected during hunting season (late fall-early winter) exceeded the U.S. EPA's screening value for human consumption (0.3 mg/kg fresh weight) leading to the nation's first-ever Hg consumption advisory for hunted waterfowl (Vest et al., 2008). These findings, coupled with our data in southern Farmington Bay, provided the basis for a comprehensive multi-agency investigation of mercury distribution and exposure in the wetlands and open waters of the GSL. This effort has involved the U.S. EPA, Utah DEQ, Utah Division of Wildlife Resources, USFWS, USGS, universities and others, and is a starting point to assessing whether the lake is "impaired" under the Clean Water Act for Hg, as well as management or remedial actions that would be effective in reducing exposure. The Service has been a key contributor to this effort, which is ongoing. In 2008, adults, eggs and juveniles of cinnamon teal from Farmington Bay, Ogden Bay and Bear River Bay were collected to assess Hg exposure in the wetland habitats ringing the GSL. Additional sampling of northern shovelers and goldeneye was also conducted to further characterize spatial and temporal patterns of Hg exposure in the open water system. This data is expected to provide a more complete characterization of mercury exposure to birds that nest in the GSL wetlands, but an important question that might need to be addressed. A follow-up question that is being evaluated based on the results of sampling in the open-water system is whether birds that forage on the GSL through the winter bring elevated Hg concentrations with them to breeding grounds in the spring, and whether these concentrations may be linked to adverse effects to avian productivity and growth in those areas.

A report of the findings from this investigation in the Northwest Oil Drain, the Crystal Unit of the Farmington Bay Waterfowl Management Area and other sites in southern Farmington Bay was presented to the U.S. EPA in 2009 as part of a recommendation that EPA and Utah DEQ include this area in remedial activities being conducted on upstream segments of the Northwest Oil Drain. The Service based this recommendation on the large number of constituents present in concentrations which exceed screening concentrations, the indication of localized uptake of at least one constituent (Hg) in sediment foraging birds in the area, the as-yet uncharacterized extent of the contaminated area, and its location within one of the most intensively managed and high-value avian habitat areas on the GSL. We will continue to work with the agencies involved to further characterize this area and develop management recommendations.

The purpose of this investigation was to provide a screening-level characterization of potential contaminant issues in high-value wetland areas around the GSL, associated with historic and present human activities. It was focused on the areas that were subject to the most intense human use and development at the time, primarily the southeastern quadrant of the GSL. However since then other important areas, such as the Service's Bear River Migratory Bird Refuge, and the western shores of the GSL have seen increased development pressures, raising many of the same questions that led to the assessment described in this report. The Service should support and participate in investigations of contaminant sources and their potential environmental risks in these areas.

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APPENDIX A

Great Salt Lake Wetlands Synoptic Survey,
1997-2000

Table A-1. Summary of Samples Collected by Site and by Year, Great Salt Lake Contaminants Assessment, 1996-2000 (*page 1 of 4*).

Location	Loc. Code	Year	# Samples	Matrix	Analytes
Great Salt Lake Open Water					
Gilbert Bay USGS Sites	**GU**	1996	10	SED	MET
			12	INVERT (brine shrimp)	MET
			4	INVERT (brine shrimp cysts)	MET
Gilbert Bay FWS Sites	**GG**	1997	3	EAGR liver (comp)	MET, D/F, OC
		1998	16	EAGR liver (indiv)	MET
		1999	28	SED	MET
			28	INVERT (brine shrimp)	MET
			4	INVERT (brine shrimp cysts)	MET
		2000	28	INVERT (brine shrimp)	MET
			24	EAGR (indiv)	MET
C7 Ditch "Delta"	**GC**	**2000**	9	SED	MET
Goggin Drain "Delta"	**GG**	**2000**	4	SED	MET
Lee Creek "Delta	**GL**	**2000**	5	SED	MET
Antelope Island					
Antelope Island East	**AE**	1996	1	SED	MET, OC, TPH
			1	INVERT (brine fly larvae)	MET, OC
			3	EGG	MET (3), OC (1)
Antelope Island Offshore	**AO**	1996	1	SED	MET, D/F, OC, TPH
			1	INVERT (brine fly)	MET, OC
Antelope Island South	**AS**	1996	1	SED	MET, OC, TPH
			1	INVERT (anisoptera)	MET, OC
			1	EGG	MET, OC
Great Salt Lake South Shore					
Saltair/GSL State Park	**LS**	1996	1	INVERT (m-benth)	MET, OC
			3	EGG	MET (3), OC (1)
		1997	2	SED	MET, OC, TPH
			3	INVERT (m-benth+Chiron)	MET
			9	EGG	MET
C-7 Ditch	**LC**	1996	1	SED	MET, OC, TPH
			1	INVERT (Chiron)	MET, OC
			3	FISH (carp, comp)	MET, OC
			6	FISH (carp, indiv)	AChE, EROD
			13	FISH (Carp, 8F, 5M)	ENDOCRINE
		1997	1	SED	MET
			1	INVERT (m-benth)	MET
			3	FISH (carp, comp)	MET (3), OC (1)
			6	FISH (carp, indiv)	AChE
			7	FISH (Carp, 5F, 2M)	ENDOCRINE

Location	Loc. Code	Year	# Samples	Matrix	Analytes
GSL South Shore Wetlands					
Inland Sea Shorebird	**SI**	1996	1	INVERT (Chiron)	MET, OC
Reserve		1997	1	EGG	MET, OC
Gilmore Sancturary	**SG**	1996	3	SED	MET, OC, TPH
			1	INVERT (Chiron)	Se only
			1	EGG	MET, OC
		1997	2	SED	MET, OC
Airport Mitigation Site	**SA**	1997	2	SED	MET, OC, TPH
			2	INVERT (chiron+anisopetera)	MET
			3	FISH (carp, comp)	MET (3), OC (2)
			6	FISH (carp, indiv)	AChE, EROD
			3	FISH (Carp, indiv)	PAH
			19	FISH (Carp, 9F, 10M)	ENDOCRINE
			6	EGG	MET (6) OC (3)
Goggin Drain (Inflow)	**SD**	1996	1	SED	MET, OC, TPH
			1	INVERT (m-benth)	MET, OC
			3	FISH (carp, comp)	MET (3), OC (3)
			6	FISH (carp, indiv)	AChE, EROD
			3	FISH (Carp, indiv)	PAH metab.
			11	FISH (Carp, 6F, 5M)	ENDOCRINE
North Point Canal	**SN**	1996	2	SED	MET, OC, TPH
(Inflow)		1997	1	INVERT (m-benth)	MET
GSL Industrial Area Wetlands					
Petrochem Ponds	**IP**	1997	1	SED	MET, OC, TPH
			1	INVERT (chiron)	MET, OC
			2	EGG	MET, OC
Beck Hotsprings	**IB**	1996	1	SED	MET, OC, TPH
			1	INVERT (corixids)	MET, OC
			3	EGG	MET (3), OC (1)
Northwest Oil Drain	**IO**	1996	2	SED	MET, OC, TPH
			1	INVERT (chiron)	OC
			1	FISH (Gambusia,comp)	MET, OC
			3	FISH (Carp, comp)	MET (2), OC (1)
Salt Lake City	**IS**	1996	1	SED	MET, OC, TPH
Wastewater Treatment			1	INVERT (m-benth)	MET, OC
Plant Wetlands			3	EGG	MET (3), OC (1)
		1997	1	SED	MET, OC, TPH
			1	INVERT (chiron)	MET, OC
			3	EGG	MET, OC

Table A-1. Summary of Samples Collected by Site and by Year, Great Salt Lake Contaminants Assessment, 1996-2000 (*page 3 of 4*).

Location	Loc. Code	Year	# Samples	Matrix	Analytes
Farmington Bay Wetlands- South					
New State Duck Club	**FN**	1996	5	EGG	MET (5), OC (2)
Bountiful Ponds	**FP**	1997	1	SED	MET, OC, TPH
			1	INVERT (chiron)	MET
			3	FISH (carp, comp)	MET (3), OC (2)
			6	FISH (carp, indiv)	AChE, EROD
			13	FISH (Carp, 3F, 10M)	ENDOCRINE
			3	EGG	MET (3), OC (1)
State Canal	**FS**	1996	1	SED	MET, D/F, OC, TPH
			1	INVERT (m-benth)	MET, OC
			3	FISH (carp, comp)	MET, OC
			6	FISH (carp, indiv)	AChE, EROD
			20	FISH (Carp, 10F, 10M)	ENDOCRINE
			7	EGG	MET
		1997	3	FISH (carp, indiv)	AChE, PAH metab.
			6	FISH (carp, indiv)	EROD
			20	FISH (Carp, 10F, 10M)	ENDOCRINE
Farmington Bay WMA- Crystal Unit	**FC**	1996	1	SED	MET, OC, TPH
			1	INVERT (m-benth)	MET, OC
			6	EGG	MET (6) OC (3)
		1997	3	FISH (carp, comp)	MET (3), OC (1)
			4	Fish (Carp,indiv)	AChE, EROD
			3	Fish (Carp,indiv)	PAH metab.
			4	FISH (Carp, 2F, 2M)	ENDOCRINE
			6	EGG	MET (6) OC (2)
		2000	14	EGG	T-Hg , MeHg
			2	bird carcass	T-Hg, MeHg
Farmington Bay WMA- Unit 1	**FU**	1997	3	FISH (carp, comp)	MET (3), OC (1)
			6	FISH (carp, indiv)	AChE, EROD
			14	FISH (Carp, 6F, 8M)	ENDOCRINE
Oil Drain Delta	**FO**	1997	1	SED	MET, OC, TPH
			1	INVERT (chiron)	MET, OC, TPH
			3	EGG	MET (2), OC (1)
		2000	20	SED	MET, OC, PAH, TOC
Baer Creek	**FB**	1997	1	SED	MET, OCs, TPH
			1	INVERT (m-benth)	MET
Kaysville Marsh	**FK**	1996	1	SED	MET, OC, TPH
			1	INVERT (chiron)	MET, OC
			1	FISH (Gambusia,comp)	MET
			7	EGG	MET (7), OCs (2)
		1997	1	SED	OC
			3	EGG	OC

Location	Loc. Code	Year	# Samples	Matrix	Analytes
Ogden Bay					
Howard Slough	**OH**	1997	1	SED	MET, OC, TPH
			1	INVERT (chiron)	MET, OC
			3	FISH (carp, comp)	MET (3), OC (2)
			6	FISH (Carp, indiv)	AChE, EROD
			3	FISH (Carp, indiv)	PAH metab.
			17	FISH (Carp, 9F, 8M)	ENDOCRINE
			6	EGG	MET (6), OC (2)
Ogden Bay- South Canal	**OC**	1996	1	SED	MET, D/F, OC, TPH
			3	FISH (carp, comp)	MET (3), OC (2)
			6	FISH (Carp, indiv)	AChE, EROD
Ogden Bay WMA-	**OS**	1996	1	SED	MET, OC, TPH
South			1	INVERT (m-benth)	MET, OC
			6	EGG	MET (6), OC (2)
			9	FISH (Carp, 5F, 4M)	ENDOCRINE
Ogden Bay WMA-	**ON**	1996	2	SED	MET, OC, TPH
North			1	INVERT (chiron)	MET, OC
			5	EGG	MET (5), OC (1)
		1997	1	FISH (carp, comp)	MET, OC
			12	FISH (Carp, 7F, 5M)	ENDOCRINE
		2000	3	SED	PAH, TOC
			2	INVERT (Chiron)	PAH
			15	EGG (BASW, comp)	PAH
			14	Nestling (BASW, comp)	PAH
			1	GI (BASW, comp)	PAH
Bear River					
Bear River Migratory	**BR**	2000	3	SED	PAH, TOC
Bird Refuge			4	INVERT (m-benth)	PAH
(Reference site for			15	EGG (BASW, comp)	PAH
ON 2000 samples)			16	Nestling (BASW, comp)	PAH

ABBREVIATIONS:

Matrices/Species sampled

SED= Sediments

INVERT= Invertebrate
m-benth=Mixed Benthic
Chiron=Chironomids
EGG= Avian Egg
EAGR= Eared Grebe
BASW=Barn Swallow

Sample Types

Comp=Composite Sample
Indiv= Individual Sample

(#F, #M)=Number of females, number of males

GI= Gastrointestinal Tract Contents

Analytes

D/F=Dioxins & Furans

OC=Organochlorines

TPH= Total Petroleum Hydrocarbons

PAH=Polyaromatic Hydrocarbons
T-Hg=Total Mercury

MeHg=Methyl Mercury
Se= Selenium

Biomarkers

AChE= Acetyl Cholinesterase (in brain)
EROD= ethoxyresorufin-O-deethylase (in liver)
ENDOCRINE= Endocrine endpoints (E2, 11KT, VIT, Gonad wgt.) (in blood)
E2=17β-estradiol
11KT=11-ketotestosterone
VIT= Vitellogenin

PAH metab= PAH metabolites (in bile)

Table A-2. Trace Elements in Sediments, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements in samples shown in *italics*. *(Page 1 of 3)*

Sample Number	Sample Site Description	Sample Weight (grams)	Collection Date	% moisture	Al	As	B	Ba
Area #2: Antelope Island								
AISE2	Antelope Isl. Offshore (GA)	747	6/26/1996	69.8	2789	14.	175.	185.
AISE3	Antelope Island South (AS)	1062	6/26/1996	26.8	6743	1.8	11.3	32.4
AISE4	Antelope Island East (AE)	433	7/18/1996	50.5	6251	9.1	45.4	116.
Area #3: GSL South Shore								
C7SE1	C7 Ditch (LC)	877	5/5/1996	58.5	16260	46.7	51.7	182.
97C7SE1	C7 Ditch (LC)	1040	7/24/1997	38.1	11428	50.8	52.1	204.
97GSSE1	Saltair/GSL State Park (LS)	892	6/16/1997	63.2	4806	46.3	115.	198.
97SPSE2	Saltair/GSL State Park (LS)	808	6/23/1997	78.3	7320	44.6	46.	159.
Area #4: South Shore Wetlands								
97AMSE1	Airport Mitigation Site (SA)	945	6/18/1997	49.6	11252	6.34	33.3	129.
97AMSE2	Airport Mitigation Site (SA)	1107	6/18/1997	28.7	12839	7.63	36.	133.
NGSE1	Gillmor Sanctuary (SG)	1005	6/11/1996	38.9	15711	22.3	140.	196.
AUSE1	Gillmor Sanctuary (SG)	900	6/27/1996	45.0	18061	16.8	86.6	162.
AUSE2	Gillmor Sanctuary (SG)	610	6/27/1996	34.3	16499	25.7	268.	149.
97AUSE1	Gillmor Sanctuary (SG)	947	7/18/1997	38.7	17890	31.1	269.	149.
97AUSE2	Gillmor Sanctuary (SG)	888	7/22/1997	51.9	13469	18.	156.	118.
GDSE1	Goggin Drain (SD)	1018	6/11/1996	30.1	5683	8.4	< *10*	92.
NPSE1	North Point Canal (SN)	1033	6/27/1996	33.9	13148	11.2	38.6	125.
GSASE1	North Point Canal (SN)	790	7/29/1996	64.6	3807	49.6	151.	198.
Area #5: South Shore Industrially Impacted Wetlands								
BHSE1	Beck Hot Springs (IB)	819	6/11/1996	66.9	8268	16.8	74.	153.
ODSE1	Oil Drain Canal (IO)	766	8/21/1996	73.4	9125	12.3	31.8	379.
ODSE2	Oil Drain Canal (IO)	744	8/21/1996	70.5	11891	13.2	24.3	351.
WPSE1	SLC Sewage Treatment Plant (IS)	682	6/13/1996	81.6	10791	16.3	47.3	603.
97WPSE1	SLC Sewage Treatment Plant (IS)	888	6/24/1997	41.2	5402	5.74	13.3	91.1
97PCSE1	Petrochem Ponds (IP)	847	6/10/1997	51.4	7209	20.7	29.	124.
Area #6: Farmington Bay South								
CUSE1	FBWMA- Crystal Unit (FC)	927	6/10/1996	47.4	10956	22.2	129.	239.
SCSE1	State Canal (FS)	843	6/17/1996	60.7	16524	14.3	30.9	190.
97BPSE1	Bountiful Pond (FP)	913	8/8/1997	33.9	10875	3.47	15.8	100.
97OMSE1	NW Oil Drain Delta (FO)	1028	7/1/1997	41.0	7994	11.1	36.8	213.
Area #7: Farmington BayNorth								
KCSE1	Kaysville Marsh (FK)	957	8/20/1996	46.6	18360	9.7	28.3	173.
97BCSE1	Bair Creek (FB)	1118	7/7/1997	29.7	6645	2.15	12.5	54.2
Area #8: Ogden Bay								
97HSSE1	Howard Slough (OH)	803	6/30/1997	66.4	13311	14.2	25.8	246.
OSSE1	Ogden Bay WMA- So. (OS)	875	6/24/1996	50.8	10840	12.6	46.5	145.
OSSE2	Ogden Bay WMA- So. (OS)	854	6/7/1996	48.7	14213	10.3	34.1	168.
OBSE1	Ogden Bay WMA- N.h (ON)	769	6/7/1996	61.3	7279	9.4	13.5	138.
OBSE2	Ogden Bay WMA- N. (ON)	385	7/17/1996	73.6	12185	15.5	31.8	148.

Table A-2. (continued) (*page 2 of 3*)

Sample	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni
Area #2: Antelope Island										
AISE2	0.25	0.6	8.26	55.5	4034	0.07	16847	291	< *5.0*	18.4
AISE3	1.22	< *0.2*	22.6	58.8	18062	0.02	4456	182	< *5.0*	9.62
AISE4	0.77	0.4	13.7	36.6	14383	0.05	11817	285	< *5.0*	13.1
Area #3: GSL South Shore										
C7SE1	1.54	3.6	46.1	990.	19057	0.08	18366	397	48.8	30.3
97C7SE1	1.46	3.58	40.7	1205.	13514	0.201	18612	278	73.4	23.
97GSSE1	0.61	0.4	15.2	519.	6396	< *0.2*	20701	281	24.6	8.22
97SPSE2	0.906	1.09	21.8	1131.	12421	0.258	16771	234	77.5	12.1
Area #4: South Shore Wetlands										
97AMSE1	1.23	0.69	14.9	35.6	12401	< *0.2*	12105	293	< *5.0*	12.2
97AMSE2	1.38	0.35	15.3	27.9	13695	< *0.2*	18931	367	< *5.0*	14.7
NGSE1	1.46	0.8	20.8	89.7	16603	0.06	61689	440	< *5.0*	18.4
AUSE1	1.49	0.9	25.8	98.6	18405	0.08	39560	406	< *5.0*	19.2
AUSE2	1.36	0.6	21.3	149.	14953	0.06	64584	339	< *5.0*	16.4
97AUSE1	1.91	0.95	21.4	128.	16545	< *0.2*	64913	346	5.61	16.4
97AUSE2	1.56	0.78	17.5	90.3	13147	< *0.2*	54570	295	7.32	14.7
GDSE1	0.57	0.9	15.6	44.7	10506	0.04	9842	184	< *5.0*	9.61
NPSE1	1.3	0.9	22.2	60.4	16237	0.03	16892	379	< *5.0*	17.8
GSASE1	0.39	0.5	14.1	356.	5463	0.07	15048	226	16.7	12.1
Area #5: South Shore Industrially Impacted Wetlands										
BHSE1	1.18	1.2	16.3	68.9	9845	0.06	6975	520	< *5.0*	11.5
ODSE1	3.09	1.2	43.8	126.	12217	0.15	11202	312	< *5.0*	17.7
ODSE2	1.51	4	160.	306.	16290	1.52	11119	259	6.92	39.
WPSE1	0.91	8.1	183.	426.	14030	1.46	8500	236	101	56.
97WPSE1	0.691	1.06	24.5	52.3	8684	< *0.2*	7187	170	12.3	12.2
97PCSE1	2.37	2.77	22.4	162.	12450	0.208	21511	277	5.34	14.1
Area #6: Farmington Bay South										
CUSE1	0.92	1.3	25.	98.5	10513	0.31	45823	403	< *5.0*	13.9
SCSE1	1.74	1.2	41.8	124.	21527	0.28	18621	349	< *5.0*	26.6
97BPSE1	1.32	0.29	29.7	28.6	16255	< 0.2	11017	237	< *5.0*	21.1
97OMSE1	1.03	1.24	23.7	53.1	10252	0.232	18371	253	< *5.0*	13.5
Area #7: Farmington BayNorth										
KCSE1	1.77	1.2	30.	42.2	20577	0.08	12730	522	< *5.0*	21.
97BCSE1	0.782	<0.2	11.9	9.98	11919	< 0.2	6153	274	< *5.0*	9.58
Area #8: Ogden Bay										
97HSSE1	1.59	0.78	20.	28.7	13871	< 0.2	18817	452	< *5.0*	16.
OSSE1	1.07	2.9	18.5	58.1	12415	0.48	14387	499	< *5.0*	14.3
OSSE2	1.49	1.4	25.2	45.7	16705	0.27	14413	413	< *5.0*	18.4
OBSE1	0.8	2.2	14.5	36.	10846	0.46	9447	302	< *5.0*	12.2
OBSE2	1.33	2.3	20.	44.7	16315	0.47	14928	579	< *5.0*	19.1

Table A-2. Trace Elements in Sediments, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements in samples shown in italics. ***(Page 3 of 3)***

Sample Number	Sample Site Description	Pb	Se	Sr	V	Zn
Area #2: Antelope Island						
AISE2	Antelope Island Offshore (GA)	34.	< *1*	1903.	9.21	58.9
AISE3	Antelope Island South (AS)	10.	< *1*	75.4	17.2	49.8
AISE4	Antelope Island East (AE)	28.	< *1*	570.	14.5	65.4
	Area #3: GSL South Shore					
C7SE1	C7 Ditch (LC)	58.	4	346.	45.6	407.
97C7SE1	C7 Ditch (LC)	62.6	6.48	1303.	33.9	342.
97GSSE1	Saltair/GSL State Park (LS)	46.7	2.17	2759.	13.	80.7
97SPSE2	Saltair/GSL State Park (LS)	108.	3.56	1001.	17.9	126.
Area #4: South Shore Wetlands						
97AMSE1	Airport Mitigation Site (SA)	38.1	< *1*	235.	18.6	88.7
97AMSE2	Airport Mitigation Site (SA)	13.2	< *1*	207.	21.8	61.3
NGSE1	Gillmor Sanctuary (SG)	99.	< *1*	269.	32.3	138.
AUSE1	Gillmor Sanctuary (SG)	104.	< *1*	343.	33.8	180.
AUSE2	Gillmor Sanctuary (SG)	62.	< *1*	265.	30.9	106.
97AUSE1	Gillmor Sanctuary (SG)	44.1	1.79	138.	29.7	99.7
97AUSE2	Gillmor Sanctuary (SG)	57.5	2.79	249.	23.8	92.5
GDSE1	Goggin Drain (SD)	63.	< *1*	109.	18.4	159.
NPSE1	North Point Canal (SN)	46.	< *1*	217.	28.4	111.
GSASE1	North Point Canal (SN)	39.	1	2394.	13.1	75.1
Area #5: South Shore Industrially Impacted Wetlands				1903.	9.21	58.9
BHSE1	Beck Hot Springs (IB)	106.	< *1*	1503.	16.5	154.
ODSE1	Oil Drain Canal (IO)	162.	1	1129.	19.1	289.
ODSE2	Oil Drain Canal (IO)	155.	2	357.	24.4	394.
WPSE1	SLC Sewage Treatment Plant (IS)	116.	5	560.	24.1	611.
97WPSE1	SLC Sewage Treatment Plant (IS)	37.4	1.2	205.	14.5	98.9
97PCSE1	Petrochem Ponds (IP)	364.	1.29	676.	16.8	588.
Area #6: Farmington Bay South						
CUSE1	FBWMA- Crystal Unit (FC)	126.	< *1*	1172.	27.6	160.
SCSE1	State Canal (FS)	171.	1	253.	33.6	354.
97BPSE1	Bountiful Pond (FP)	19.5	< *1*	164.	25.9	73.6
97OMSE1	NW Oil Drain Delta (FO)	59.7	1.78	1316.	15.5	147.
Area #7: Farmington BayNorth						
KCSE1	Kaysville Marsh (FK)	45.	< *1*	112.	30.1	113.
97BCSE1	Bair Creek (FB)	5.	< *1*	22.4	14.	40.4
Area #8: Ogden Bay						
97HSSE1	Howard Slough (OH)	38.	1.43	222.	17.4	105.
OSSE1	Ogden Bay WMA- South (OS)	386.	< *1*	131.	17.2	516.
OSSE2	Ogden Bay WMA- South (OS)	134.	< *1*	99.8	22.7	224.
OBSE1	Ogden Bay WMA- North (ON)	255.	< *1*	86.6	14.4	313.
OBSE2	Ogden Bay WMA- North (ON)	229.	< *1*	117.	21.5	288.

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Table A-3. Organic Chemicals in Sediments, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines, Polychlorinated Biphenyls (PCBs), Total Petroleum Hydrocarbons (TPH), and Dioxins/Furans. ***(Page 1 of 6)***

Sample Number	Sample Site Description	Collection Date	Sample Weight (grams)	% moisture	Aldrin	dieldrin
	Area #2: Antelope Island:					
AISE2	Antelope Island offshore (GA)	06/26/96	747	73.6	< 0.000187	**0.0004**
AISE4	Antelope Island East (AE)	07/18/96	433	52.9	< 0.000106	< 0.000106
AISE3	Antelope Island South (AS)	06/26/96	1062	28.3	< 6.85E-05	< 6.85E-05
	Area #3: GSL South Shore:					
C7SE1	C7 Ditch (LC)	05/05/96	877	59.5	< 0.000122	**0.0002**
97GSSE1	Saltair/GSL State Park (LS)	06/16/97	892	63.2	< 0.000677	< 0.000677
97SPSE2	Saltair/GSL State Park (LS)	06/23/97	808	78.3	< 0.00115	< 0.00115
	Area #4: South Shore Wetlands:					
97AMSE1	Airport Mitigation Site (SA)	06/18/97	945	49.6	< 0.000491	< 0.000491
97AMSE2	Airport Mitigation Site (SA)	06/18/97	1107	28.7	< 0.000346	< 0.000346
AUSE1	Gillmor Sanctuary (SG)	06/27/96	900	46.2	< 9.27E-05	0.000186
AUSE2	Gillmor Sanctuary (SG)	06/27/96	610	33.6	< 0.000075	< 0.000075
NGSE1	Gillmor Sanctuary (SG)	06/11/96	1005	42.1	< 8.57E-05	**0.0002**
97AUSE1	Gillmor Sanctuary (SG)	07/18/97	947	38.3	< 0.000404	< 0.000404
97AUSE2	Gillmor Sanctuary (SG)	07/22/97	888	51.9	< 0.000519	< 0.000519
GDSE1	Goggin Drain (SD)	06/11/96	1018	31.1	< 7.14E-05	**0.0001**
GSASE1	North Point Canal (SN)	07/29/96	790	65.1	< 0.000143	**0.0003**
NPSE1	North Point Canal (SN)	06/27/96	1033	39.4	< 8.13E-05	**0.0003**
	Area #5: South Shore Industrially Impacted Wetlands:					
BHSE1	Beck Hot Springs (IB)	06/11/96	819	70.9	< 0.000171	**0.0003**
ODSE1	Oil Drain Canal (IO)	08/21/96	766	77	< 0.00216	**0.0235**
ODSE2	Oil Drain Canal (IO)	08/21/96	744	66.4	< 0.00148	**0.0137**
97PCSE1	Petrochem Ponds (IP)	06/10/97	847	51.4	< 0.000509	< 0.000509
WPSE1	SLC Sewage Treatment Plant (IS)	06/13/96	682	89	< 0.00447	**0.0664**
97WPSE1	SLC Sewage Treatment Plant (IS)	06/24/97	888	41.2	< 0.000421	**0.0008**
	Area #6: Farmington Bay South:					
97BPSE1	Bountiful Pond (FP)	08/08/97	913	33.9	**0.0005**	**0.0009**
CUSE1	FBWMA- Crystal Unit (FC)	06/10/96	927	48.7	< 9.61E-05	**0.0002**
97OMSE1	NW Oil Drain Delta (FO)	07/01/97	1028	41	< 0.000423	**0.0016**
SCSE1	State Canal (FS)	06/17/96	843	69.5	< 0.000162	**0.0111**
	Area #7: Farmington BayNorth:					
97BCSE1	Bair Creek (FB)	07/07/97	1118	29.7	< 0.000354	< 0.000354
KCSE1	Kaysville Marsh (FK)	08/20/96	957	54.2	< 0.000107	**0.0011**
97KCSE1	Kaysville Marsh (FK)	06/04/97	871	50.5	< 0.000501	**0.0006**
	Area #8: Ogden Bay:					
97HSSE1	Howard Slough (OH)	06/30/97	803	66.4	< 0.000741	< 0.000741
OBSE1	Ogden Bay WMA- North (ON)	06/07/96	769	67.2	**0.0003**	**0.0003**
OBSE2	Ogden Bay WMA- North (ON)	07/17/96	385	74	< 0.000192	**0.0008**
OSSE1	Ogden Bay WMA- South (OS)	06/24/96	875	57	< 0.000116	**0.0005**
OSSE2	Ogden Bay WMA- South Canal (OC)	06/07/96	854	46.7	< 9.36E-05	**0.0004**

All values milligram per kilogram (parts per million) on a dry-weight basis

detected values are in presented in bold face type.

NA: Constituent not analyzed

Table A-3. (continued) *(page 2of 6)*

Sample Number	endrin	alpha BHC	beta BHC	delta BHC	gamma BHC	alpha chlordane	gamma chlordane
AISE2	< 0.000187	< 0.000187	< 0.000187	< 0.000187	**0.0004**	**0.0042**	< 0.000187
AISE4	< 0.000106	< 0.000106	< 0.000106	< 0.000106	**0.0004**	**0.0013**	**0.0002**
AISE3	< 6.85E-05	< 6.85E-05	< 6.85E-05	< 6.85E-05	**0.0001**	**0.0001**	< 6.85E-05
C7SE1	< 0.000122	< 0.000122	< 0.000122	< 0.000122	< 0.000122	**0.0010**	**0.0005**
97GSSE1	< 0.000677	< 0.000677	< 0.000677	< 0.000677	< 0.000677	< 0.000677	< 0.000677
97SPSE2	< 0.00115	< 0.00115	**0.0090**	< 0.00115	< 0.00115	< 0.00115	**0.0012**
97AMSE1	< 0.000491	< 0.000491	< 0.000491	< 0.000491	< 0.000491	< 0.000491	< 0.000491
97AMSE2	< 0.000346	< 0.000346	< 0.000346	< 0.000346	< 0.000346	< 0.000346	< 0.000346
AUSE1	< 9.27E-05	< 9.27E-05	< 9.27E-05	**0.0002**	**0.0002**	**0.0006**	**0.0009**
AUSE2	< 0.000075	< 0.000075	< 0.000075	< 0.000075	**0.0002**	**0.0002**	**0.0002**
NGSE1	< 8.57E-05	< 8.57E-05	< 8.57E-05	< 8.57E-05	< 8.57E-05	**0.0002**	**0.0003**
97AUSE1	< 0.000404	< 0.000404	< 0.000404	< 0.000404	< 0.000404	< 0.000404	< 0.000404
97AUSE2	< 0.000519	< 0.000519	< 0.000519	< 0.000519	< 0.000519	< 0.000519	< 0.000519
GDSE1	< 7.14E-05	< 7.14E-05	< 7.14E-05	< 7.14E-05	**0.0001**	**0.0001**	**0.0001**
GSASE1	< 0.000143	< 0.000143	**0.0003**	< 0.000143	**0.0003**	< 0.000143	< 0.000143
NPSE1	< 8.13E-05	< 8.13E-05	< 8.13E-05	< 8.13E-05	< 8.13E-05	**0.0002**	**0.0003**
BHSE1	< 0.000171	< 0.000171	**0.0038**	< 0.000171	**0.0003**	**0.0017**	**0.0003**
ODSE1	< 0.00216	< 0.00216	< 0.00216	< 0.00216	< 0.00216	**0.0113**	**0.0117**
ODSE2	**0.0042**	< 0.00148	< 0.00148	< 0.00148	< 0.00148	**0.0125**	**0.0107**
97PCSE1	**0.0006**	< 0.000509	**0.0009**	< 0.000509	< 0.000509	< 0.000509	**0.0010**
WPSE1	< 0.00447	< 0.00447	< 0.00447	**0.0200**	**0.0082**	**0.0500**	**0.0591**
97WPSE1	< 0.000421	< 0.000421	**0.0004**	< 0.000421	< 0.000421	**0.0016**	**0.0017**
97BPSE1	< 0.000378	< 0.000378	< 0.000378	< 0.000378	< 0.000378	**0.0011**	**0.0015**
CUSE1	< 9.61E-05	< 9.61E-05	< 9.61E-05	< 9.61E-05	< 9.61E-05	**0.0016**	**0.0008**
97OMSE1	< 0.000423	< 0.000423	< 0.000423	< 0.000423	< 0.000423	**0.0019**	**0.0027**
SCSE1	< 0.000162	< 0.000162	< 0.000162	< 0.000162	< 0.000162	**0.0052**	**0.0069**
97BCSE1	< 0.000354	< 0.000354	< 0.000354	< 0.000354	< 0.000354	< 0.000354	< 0.000354
KCSE1	< 0.000107	< 0.000107	< 0.000107	< 0.000107	**0.0002**	**0.0018**	**0.0026**
97KCSE1	< 0.000501	< 0.000501	< 0.000501	< 0.000501	< 0.000501	**0.0015**	**0.0023**
97HSSE1	< 0.000741	< 0.000741	< 0.000741	< 0.000741	< 0.000741	**0.0014**	**0.0025**
OBSE1	< 0.000153	< 0.000153	**0.0003**	< 0.000153	< 0.000153	**0.0006**	**0.0012**
OBSE2	< 0.000192	< 0.000192	**0.0008**	< 0.000192	< 0.000192	**0.0008**	**0.0023**
OSSE1	< 0.000116	< 0.000116	**0.0002**	< 0.000116	< 0.000116	**0.0005**	**0.0005**
OSSE2	< 9.36E-05	< 9.36E-05	< 9.36E-05	< 9.36E-05	< 9.36E-05	**0.0009**	**0.0015**

Table A-3. Organic Chemicals in Sediments, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines, Polychlorinated Biphenyls (PCBs), Total Petroleum Hydrocarbons (TPH), and Dioxins/Furans. ***(Page 3 of 6)***

Sample Site Description		oxy chlordane		Heptachlor		heptachlor epoxide		cis-nonachlor		trans-nonachlor		endosulfan II
Area #2: Antelope Island:												
Antelope Island offshore (GA)	<	0.000187	<	0.000187	<	0.000187	<	0.000187		**0.0004**	<	0.000374
Antelope Island East (AE)	<	0.000106	<	0.000106	<	0.000106	<	0.000106		**0.0002**		**0.0002**
Antelope Island South (AS)	<	6.85E-05	<	6.85E-05	<	6.85E-05	<	6.85E-05	<	6.85E-05	<	0.000137
Area #3: GSL South Shore:												
C7 Ditch (LC)	<	0.000122	<	0.000122	<	0.000122		**0.0002**		**0.0005**		**0.0002**
Saltair/GSL State Park (LS)	<	0.000677	<	0.000677	<	0.000677	<	0.000677	<	0.000677	<	0.000677
Saltair/GSL State Park (LS)	<	0.00115		0.00195	<	0.00115	<	0.00115	<	0.00115	<	0.00115
Area #4: South Shore Wetlands:												
Airport Mitigation Site (SA)	<	0.000491	<	0.000491	<	0.000491	<	0.000491	<	0.000491	<	0.000491
Airport Mitigation Site (SA)	<	0.000346	<	0.000346	<	0.000346	<	0.000346	<	0.000346	<	0.000346
Gillmor Sanctuary (SG)	<	9.27E-05	<	9.27E-05	<	9.27E-05		**0.0002**		0.000557		**0.0002**
Gillmor Sanctuary (SG)	<	0.000075	<	0.000075	<	0.000075	<	0.000075	<	0.000075	<	0.00015
Gillmor Sanctuary (SG)	<	8.57E-05	<	8.57E-05	<	8.57E-05		**0.0002**		**0.0002**	<	0.000171
Gillmor Sanctuary (SG)	<	0.000404	<	0.000404	<	0.000404	<	0.000404	<	0.000404	<	0.000404
Gillmor Sanctuary (SG)	<	0.000519	<	0.000519	<	0.000519	<	0.000519	<	0.000519	<	0.000519
Goggin Drain (SD)	<	7.14E-05	<	7.14E-05	<	7.14E-05		**0.0001**		**0.0003**	<	0.000143
North Point Canal (SN)	<	0.000143		**0.0003**	<	0.000143	<	0.000143	<	0.000143	<	0.000286
North Point Canal (SN)	<	8.13E-05	<	8.13E-05	<	8.13E-05		**0.0002**		**0.0002**		**0.0002**
Area #5: South Shore Industrially Impacted Wetlands:												
Beck Hot Springs (IB)	<	0.000171	<	0.000171	<	0.000171		**0.0003**		**0.0003**		**0.0003**
Oil Drain Canal (IO)		**0.0174**		**0.0026**	<	0.00216		**0.0343**		**0.0078**		**0.0061**
Oil Drain Canal (IO)		**0.0033**	<	0.00148	<	0.00148		**0.0045**		**0.0074**		**0.0104**
Petrochem Ponds (IP)		**0.0005**	<	0.000509	<	0.000509	<	0.000509	<	0.000509	<	0.000509
SLC Sewage Treatment Plant (IS)	<	0.00447		**0.0209**		**0.0082**		**0.0136**		**0.0473**	<	0.00893
SLC Sewage Treatment Plant (IS)	<	0.000421	<	0.000421	<	0.000421		**0.0005**		**0.0010**	<	0.000421
Area #6: Farmington Bay South:												
Bountiful Pond (FP)	<	0.000378	<	0.000378	<	0.000378		**0.0004**		**0.0012**	<	0.000378
FBWMA- Crystal Unit (FC)	<	9.61E-05	<	9.61E-05	<	9.61E-05		**0.0004**		**0.0006**		**0.0004**
NW Oil Drain Delta (FO)	<	0.000423	<	0.000423	<	0.000423		**0.0006**		**0.0011**	<	0.000423
State Canal (FS)		**0.0007**	<	0.000162		**0.0003**		**0.0020**		**0.0039**		**0.0007**
Area #7: Farmington BayNorth:												
Bair Creek (FB)	<	0.000354	<	0.000354	<	0.000354	<	0.000354	<	0.000354	<	0.000354
Kaysville Marsh (FK)		**0.0002**	<	0.000107		**0.0004**		**0.0009**		**0.0020**	<	0.000215
Kaysville Marsh (FK)	<	0.000501	<	0.000501	<	0.000501		**0.0006**		**0.0014**	<	0.000501
Area #8: Ogden Bay:												
Howard Slough (OH)	<	0.000741	<	0.000741	<	0.000741	<	0.000741		**0.0011**	<	0.000741
Ogden Bay WMA- North (ON)	<	0.000153	<	0.000153	<	0.000153		**0.0003**		**0.0003**	<	0.000305
Ogden Bay WMA- North (ON)	<	0.000192	<	0.000192	<	0.000192		**0.0004**		**0.0004**		**0.0004**
Ogden Bay WMA- South (OS)		**0.0002**	<	0.000116		**0.0002**		**0.0002**	<	0.000116		**0.0002**
Ogden Bay WMA- South Canal (OC)		**0.0002**	<	9.36E-05	<	9.36E-05		**0.0006**		**0.0009**		**0.0006**

Table A-3. (continued) *(page 4 of 6)*

Sample Number		HCB		mirex		toxaphene		o,p'-DDD		p,p'-DDD		o,p'-DDE		p,p'-DDE
AISE2	<	0.000187		**0.0004**		NA	<	0.000187		**0.0004**	<	0.000187		**0.0004**
AISE4	<	0.000106		**0.0002**		NA	<	0.000106		**0.0002**		**0.0002**		**0.0002**
AISE3	<	6.85E-05		**0.0001**		NA	<	6.85E-05	<	6.85E-05	<	6.85E-05		**0.0001**
C7SE1		**0.0002**	<	0.000122		NA		**0.0002**		**0.0007**		**0.0002**		**0.0015**
97GSSE1	<	0.000677	<	0.000677	<	0.00339	<	0.000677	<	0.000677	<	0.000677	<	0.000677
97SPSE2	<	0.00115		**0.0038**	<	0.00574	<	0.00115	<	0.00115	<	0.00115	<	0.00115
97AMSE1	<	0.000491	<	0.000491	<	0.00246	<	0.000491		**0.0014**	<	0.000491		**0.0074**
97AMSE2	<	0.000346	<	0.000346	<	0.00173	<	0.000346	<	0.000346	<	0.000346	<	0.000346
AUSE1		**0.0004**		**0.0002**		NA		**0.0004**		**0.0006**	<	9.27E-05		**0.0013**
AUSE2		**0.0005**		**0.0002**		NA		**0.0002**		**0.0003**	<	0.000075		**0.0002**
NGSE1		**0.0003**	<	8.57E-05		NA		**0.0002**		**0.0002**	<	8.57E-05		**0.0005**
97AUSE1	<	0.000404	<	0.000404	<	0.00202	<	0.000404	<	0.000404	<	0.000404	<	0.000404
97AUSE2	<	0.000519	<	0.000519	<	0.00259	<	0.000519	<	0.000519	<	0.000519	<	0.000519
GDSE1	<	7.14E-05	<	7.14E-05		NA		**0.0001**		**0.0004**	<	7.14E-05		**0.0004**
GSASE1		**0.0003**	<	0.000143		NA	<	0.000143	<	0.000143	<	0.000143		**0.0003**
NPSE1		**0.0002**	<	8.13E-05		NA		**0.0002**		**0.0005**		**0.0002**		**0.0017**
BHSE1	<	0.000171		**0.0003**		NA		**0.0007**		**0.0010**		**0.0003**		**0.0010**
ODSE1		**0.0057**	<	0.00216		NA		**0.0096**		**0.0143**	<	0.00216		**0.0109**
ODSE2		**0.0068**		**0.0027**		NA		**0.0071**	<	0.00148	<	0.00148		**0.0161**
97PCSE1	<	0.000509	<	0.000509	<	0.00255		**0.0015**		**0.0016**	<	0.000509		**0.0024**
WPSE1		**0.0182**	<	0.00447		NA		**0.0191**	<	0.00447	<	0.00447		**0.0436**
97WPSE1	<	0.000421		**0.0004**	<	0.00211	<	0.000421		**0.0009**	<	0.000421		**0.0027**
97BPSE1	<	0.000378	<	0.000378	<	0.00189		**0.0016**		**0.0032**		**0.0008**		**0.0327**
CUSE1		**0.0002**		**0.0002**		NA		**0.0006**		**0.0010**		**0.0002**		**0.0008**
97OMSE1	<	0.000423	<	0.000423	<	0.00211		**0.0006**	<	0.000423	<	0.000423		**0.0025**
SCSE1		**0.0007**	<	0.000162		NA		**0.0043**		**0.0121**		**0.0007**		**0.0187**
97BCSE1	<	0.000354	<	0.000354	<	0.00177	<	0.000354	<	0.000354	<	0.000354	<	0.000354
KCSE1		**0.0022**	<	0.000107		NA		**0.0007**		**0.0011**		**0.0002**		**0.0094**
97KCSE1	<	0.000501	<	0.000501	<	0.0025	<	0.000501		**0.0009**	<	0.000501		**0.0036**
97HSSE1	<	0.000741	<	0.000741	<	0.0037	<	0.000741		**0.0015**	<	0.000741		**0.0043**
OBSE1	<	0.000153	<	0.000153		NA		**0.0018**		**0.0052**		**0.0003**		**0.0073**
OBSE2	<	0.000192	<	0.000192		NA		**0.0066**		**0.0108**		**0.0012**		**0.0347**
OSSE1		**0.0002**	<	0.000116		NA		**0.0009**		**0.0012**		**0.0002**		**0.0030**
OSSE2		**0.0004**	<	9.36E-05		NA		**0.0006**		**0.0011**		**0.0002**		**0.0024**

Table A-3. Organic Chemicals in Sediments, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines, Polychlorinated Biphenyls (PCBs), Total Petroleum Hydrocarbons (TPH), and Dioxins/Furans. ***(Page 5 of 6)***

Sample Site Description		o,p'-DDT		p,p'-DDT	Total DDTs[1]	total PCBs	TPH
Area #2: Antelope Island:							
Antelope Island offshore (GA)	<	0.000187	<	0.000187	**0.0008**	**0.545**	**2412**
Antelope Island East (AE)		**0.0002**		**0.0004**	**0.0013**	**0.034**	**1173**
Antelope Island South (AS)	<	6.85E-05	<	6.85E-05	**0.0001**	**0.035**	**360**
Area #3: GSL South Shore:							
C7 Ditch (LC)	<	0.000122		**0.0002**	**0.0030**	**0.098**	**1204**
Saltair/GSL State Park (LS)	<	0.000677	<	0.000677	ND	**0.011**	**952**
Saltair/GSL State Park (LS)	<	0.00115	<	0.00115	ND	**0.056**	**247**
Area #4: South Shore Wetlands:							
Airport Mitigation Site (SA)	<	0.000491	<	0.000491	**0.0088**	**0.009**	**457**
Airport Mitigation Site (SA)	<	0.000346	<	0.000346	ND	**0.002**	**116**
Gillmor Sanctuary (SG)	<	9.27E-05	<	9.27E-05	**0.0023**	**0.028**	**334**
Gillmor Sanctuary (SG)	<	0.000075		**0.0002**	**0.0008**	**0.033**	**382**
Gillmor Sanctuary (SG)	<	8.57E-05		**0.0005**	**0.0015**	**0.030**	**154**
Gillmor Sanctuary (SG)	<	0.000404	<	0.000404	ND	**0.002**	**NS**
Gillmor Sanctuary (SG)	<	0.000519	<	0.000519	ND	**0.003**	**NS**
Goggin Drain (SD)	<	7.14E-05		**0.0001**	**0.0012**	**0.015**	**246**
North Point Canal (SN)	<	0.000143	<	0.000143	**0.0003**	**0.159**	**1221**
North Point Canal (SN)		**0.0012**		**0.0035**	**0.0071**	**0.007**	**207**
Area #5: South Shore Industrially Impacted Wetlands:							
Beck Hot Springs (IB)	<	0.000171		**0.0003**	**0.0035**	**0.611**	**1564**
Oil Drain Canal (IO)	<	0.00216	<	0.00216	**0.0348**	**0.388**	**28906**
Oil Drain Canal (IO)		**0.0482**	<	0.00148	**0.0737**	**0.887**	**13792**
Petrochem Ponds (IP)	<	0.000509	<	0.000509	**0.0057**	**0.098**	**713**
SLC Sewage Treatment Plant (IS)		**0.1380**	<	0.00447	**0.2074**	**4.14**	**96560**
SLC Sewage Treatment Plant (IS)	<	0.000421	<	0.000421	**0.004**	**0.044**	**577**
Area #6: Farmington Bay South:							
Bountiful Pond (FP)		**0.0009**		**0.0027**	**0.0419**	**0.018**	**197**
FBWMA- Crystal Unit (FC)		**0.0002**		**0.0002**	**0.0029**	**0.085**	**922**
NW Oil Drain Delta (FO)	<	0.000423	<	0.000423	**0.0035**	**0.074**	**205**
State Canal (FS)		**0.0010**		**0.0026**	**0.0393**	**0.214**	**6042**
Area #7: Farmington BayNorth:							
Bair Creek (FB)	<	0.000354	<	0.000354	ND	**0.003**	**28.4**
Kaysville Marsh (FK)		**0.0007**		**0.0024**	**0.0144**	**0.037**	**1240**
Kaysville Marsh (FK)	<	0.000501	<	0.000501	**0.0050**	**0.036**	
Area #8: Ogden Bay:							
Howard Slough (OH)	<	0.000741	<	0.000741	**0.0065**	**0.029**	**787**
Ogden Bay WMA- North (ON)	<	0.000153		**0.0024**	**0.0172**	**0.063**	**1305**
Ogden Bay WMA- North (ON)	<	0.000192		**0.0035**	**0.0568**	**0.211**	**3280**
Ogden Bay WMA- South (OS)	<	0.000116		**0.0016**	**0.0070**	**0.110**	**1058**
Ogden Bay WMA- South Canal (OC)		**0.0008**		**0.0013**	**0.0064**	**0.082**	**899**

All values mg/kg dry-weight basis; detected values are in presented in bold type.

(1) Total DDTs: Summed DDT residues in cases where at least one isomer was detected; non-detected isomers included in sum as 0.5 x Detection limit

Sample Number	1,2,3,4,6,7,8 -HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,6,7,8-HxCDD	2,3,7,8-TCDD	2,3,7,8-TCDF	OCDD	OCDF
AISE2	< 0.000003	< 0.000003	< 0.000003	< 0.000001	< 0.000001	**0.000014**	**0.000009**
AISE4	NA	NA	NA	NA	NA	NA	NA
AISE3	NA	NA	NA	NA	NA	NA	NA
C7SE1	**0.000059**	**0.000015**	**0.000003**	< 0.000001	**0.000001**	**0.000368**	**0.000034**
97GSSE1	NA	NA	NA	NA	NA	NA	NA
97SPSE2	NA	NA	NA	NA	NA	NA	NA
97AMSE1	NA	NA	NA	NA	NA	NA	NA
97AMSE2	NA	NA	NA	NA	NA	NA	NA
AUSE1	NA	NA	NA	NA	NA	NA	NA
AUSE2	NA	NA	NA	NA	NA	NA	NA
NGSE1	NA	NA	NA	NA	NA	NA	NA
97AUSE1	NA	NA	NA	NA	NA	NA	NA
97AUSE2	NA	NA	NA	NA	NA	NA	NA
GDSE1	NA	NA	NA	NA	NA	NA	NA
GSASE1	NA	NA	NA	NA	NA	NA	NA
NPSE1	NA	NA	NA	NA	NA	NA	NA
BHSE1	NA	NA	NA	NA	NA	NA	NA
ODSE1	NA	NA	NA	NA	NA	NA	NA
ODSE2	NA	NA	NA	NA	NA	NA	NA
97PCSE1	NA	NA	NA	NA	NA	NA	NA
WPSE1	NA	NA	NA	NA	NA	NA	NA
97WPSE1	NA	NA	NA	NA	NA	NA	NA
97BPSE1	NA	NA	NA	NA	NA	NA	NA
CUSE1	NA	NA	NA	NA	NA	NA	NA
97OMSE1	NA	NA	NA	NA	NA	NA	NA
SCSE1	**0.000059**	**0.000012**	**0.000003**	**0.000015**	**0.000001**	**0.000551**	**0.000025**
97BCSE1	NA	NA	NA	NA	NA	NA	NA
KCSE1	NA	NA	NA	NA	NA	NA	NA
97KCSE1	NA	NA	NA	NA	NA	NA	NA
97HSSE1	NA	NA	NA	NA	NA	NA	NA
OBSE1	NA	NA	NA	NA	NA	NA	NA
OBSE2	NA	NA	NA	NA	NA	NA	NA
OSSE1	NA	NA	NA	NA	NA	NA	NA
OSSE2	**0.000036**	**0.000011**	**0.000002**	**0.000000**	**0.000001**	**0.000270**	**0.000020**

TCDD: Tetrachlorodibenzo-p-dioxin
HxCDD: Hexachlorodibenzo-p-dioxin
HpCDD: Heptachlorodibenzo-p-dioxin
OCDD: Octachlorodibenzo-p-dioxin
OCDF: Octachlorodibenzofuran
NA: Constituent not analyzed

Table A-4. Trace Elements in Macroinvertebrates, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements in samples shown in italics. ***(Page 1 of 3)***

Sample Number	Sample Site Description	Species Code[(a)]	Collection Date	Sample Weight (grams)	% moisture	Al		As	B
	Area #2: Antelope Island								
AIBF1	Antelope Island Offshore (GA)	BFL	7/18/1996	12	64.5	162		2.3	26.7
AIBF2	Antelope Island East (AE)	BFL	7/18/1996	12	86.1	1348		10.5	49.
AIBI1	Antelope Island South (AS)	OD	7/18/1996	13	84.3	85.4		2.4	2.67
	Area #3: GSL South Shore								
C7CH1	C7 Ditch (LC)	CH	7/29/1996	11	84.1	8262		20.9	30.4
97C7CI2	C7 Ditch (LC)	BMI	7/24/1997	6	85.6	672		6.46	11.1
GSABI1	Saltair/GSL State Park (LS)	BMI	7/19/1996	12	85.1	581		24.2	32.
97GSCH1	Saltair/GSL State Park (LS)	CH	6/25/1997	12	85.5	535		5.	36.3
97SPCH1	Saltair/GSL State Park (LS)	CH	7/8/1997	10	80.0	2981		51.1	18.4
97SPCI2	Saltair/GSL State Park (LS)	BMI	8/4/1997	11	81.4	16.8		3.17	2.27
	Area #4: South Shore Wetlands								
97AMCH1	Airport Mitigation Site (SA)	CH	6/18/1997	15	86.7	8698		2.57	16.2
97AMDM1	Airport Mitigation Site (SA)	DF	6/18/1997	16	86.4	607		1.84	9.83
AUCH1	Gillmor Sanctuary (SG)	CH	6/27/1996	2	70.9				
GDCI1	Goggin Drain (SD)	BMI	7/10/1996	16	84.7	2901		4.	5.59
NGCH1	Inland Sea Shorebird Reserve (SI)	CH	7/1/1996	11	80.6	10707		9.3	53.
97NPBI1	North Point Canal (SN)	BMI	7/22/1997	12	79.9	758	<	*0.5*	4.07
	Area #5: South Shore Industrially Impacted Wetlands								
BHCO2	Beck Hot Springs (IB)	CO	7/10/1996	28	85.7	115		2.7	35.6
97PCCH1	Petrochem Ponds (IP)	CH	6/10/1997	11	82.9	1765		1.04	20.4
STBI1	SLC Sewage Treatment Plant (IS)	BMI	7/16/1996	12	87.5	1472		1.8	16.
97WPCH1	SLC Sewage Treatment Plant (IS)	CH	6/17/1997	10	87.3	2822		1.47	11.
	Area #6: Farmington Bay South								
97BPCH1	Bountiful Pond (FP)	CH	7/15/1997	10	86.2	6009		2.31	2.48
CUBI1	FBWMA- Crystal Unit (FC)	BMI	7/15/1996	12	84.6	1138		4.4	12.7
97OMCH1	NW Oil Drain Delta (FO)	CH	7/1/1997	18	87.5	2833		1.66	15.2
SCBI1	State Canal (FS)	BMI	7/15/1996	12	83.9	2568		4.2	2.34
	Area #7: Farmington BayNorth								
97BCCI1	Bair Creek (FB)	BMI	7/10/1997	14	84.9	2281		2.22	2.04
KCBI1	Kaysville Marsh (FK)	CH	8/20/1996	10	82.6	9888		8.4	13.7
	Area #8: Ogden Bay								
97HSCH1	Howard Slough (OH)	CH	6/30/1997	19	90.2	8312		5.64	20.7
OBCH1	Ogden Bay WMA- North (ON)	CH	7/17/1996	14	87.0	5259		4.5	12.4
OSBI1	Ogden Bay WMA- South (OS)	BMI	7/17/1996	13	84.0	519		4.9	2.24

NOTES:

(a) Invertebrate Species Codes:

BFL= Brine Fly Larvae | CO = Corixids
BMI = Benthic Macroinvertebrates | DF = Damselfly
CH = Chironomid | OD = Odonates

Table A-4. (continued) *(page 2 of 3)*

Sample Number	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
AIBF1	13.9	< *0.1*	0.2	1.61	8.21	155	0.19	5659	53.5	< *2*
AIBF2	38.3	0.2	0.3	3.59	17.9	2423	0.08	5820	53.3	< *2*
AIBI1	8.92	< *0.1*	< 0.1	0.95	15.6	172	0.17	977	44.5	< *2*
C7CH1	73.4	0.78	1.6	23.6	377.	6763	0.09	6569	129.	17.1
97C7CI2	11.5	< *0.1*	0.41	3.16	61.3	764	< *0.2*	2544	259.	5.1
GSABI1	17.4	< *0.1*	0.3	4.4	67.8	840	0.08	3014	43.7	2.84
97GSCH1	21.4	< *0.1*	< 0.1	4.35	50.6	783	< *0.2*	2947	43.	3.19
97SPCH1	53.5	0.311	0.31	9.97	228.	2900	< *0.2*	6868	108.	4.53
97SPCI2	3.12	< *0.1*	0.13	2.05	16.6	215	< *0.2*	976	16.5	2.14
97AMCH1	70.2	0.85	0.5	14.7	29.4	7485	< *0.2*	6740	173.	< *2*
97AMDM1	28.9	< *0.1*	1.14	3.37	13.6	568	< *0.2*	1726	38.7	< *2*
AUCH1										
GDCI1	38.2	0.26	0.6	5.72	45.7	2707	< *0.05*	2323	177.	< *2*
NGCH1	75.6	1	1	14.9	60.4	7149	0.07	13199	147.	< *2*
97NPBI1	7.63	< *0.1*	0.8	3.21	23.8	677	< *0.2*	1574	44.4	< *2*
BHCO2	2.94	0.19	0.2	1.78	32.4	202	< *0.05*	1749	15.1	< *2*
97PCCH1	36.2	0.971	0.55	7.07	41.8	2056	< *0.2*	3223	54.7	< *2*
STBI1	37.8	0.25	0.6	11.5	39.2	1521	0.11	1870	24.	7.02
97WPCH1	95.9	0.284	0.85	28.1	73.4	2498	< *0.2*	2310	47.7	7.38
97BPCH1	91.	0.67	0.35	19.5	24.5	8121	< *0.2*	4296	135.	< *2*
CUBI1	22.9	0.13	0.9	6.27	41.4	834	1.13	3425	36.2	< *2*
97OMCH1	55.	0.311	1.3	12.2	40.8	2815	< *0.2*	3671	57.8	< *2*
SCBI1	21.8	0.46	0.2	4.69	14.5	2434	0.08	1992	48.9	< *2*
97BCCI1	37.7	0.241	0.22	8.01	17.2	3344	< *0.2*	2290	507.	< *2*
KCBI1	119.	0.81	1.5	16.9	26.6	7131	0.09	5106	210.	< *2*
97HSCH1	92.6	0.833	0.37	31.9	53.1	6775	< *0.2*	7090	178.	< *2*
OBCH1	33.1	0.46	0.5	7.01	15.7	3540	0.12	3602	123.	< *2*
OSBI1	17.4	0.35	0.2	5.97	12.8	692	0.23	1431	128.	< *2*

Table A-4. Trace Elements in Macroinvertebrates, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements in samples shown in italics. ***(page 3 of 3)***

Sample Number	Sample Site Description	Species Code[a]	Ni	Pb	Se	Sr	V	Zn
	Area #2: Antelope Island							
AIBF1	Antelope Island Offshore (GA)	BFL	1.01	1.7	1.3	148.	< *0.5*	47.5
AIBF2	Antelope Island East (AE)	BFL	2.91	10.1	0.7	329.	3.62	74.8
AIBI1	Antelope Island South (AS)	OD	1.05	< *0.5*	1.4	59.9	1.02	60.4
	Area #3: GSL South Shore							
C7CH1	C7 Ditch (LC)	CH	11.3	26.5	4.5	204.	20.	282.
97C7CI2	C7 Ditch (LC)	BMI	0.83	6.74	5.99	110.	1.06	99.
GSABI1	Saltair/GSL State Park (LS)	BMI	0.64	4.9	1.2	141.	< *0.5*	86.1
97GSCH1	Saltair/GSL State Park (LS)	CH	1.03	4.75	< *0.5*	318.	2.96	50.8
97SPCH1	Saltair/GSL State Park (LS)	CH	3.47	12.6	1.74	287.	5.91	107.
97SPCI2	Saltair/GSL State Park (LS)	BMI	< *0.5*	< *0.5*	3.74	30.2	< *0.5*	102.
	Area #4: South Shore Wetlands							
97AMCH1	Airport Mitigation Site (SA)	CH	8.21	13.2	5.13	102.	14.7	103.
97AMDM1	Airport Mitigation Site (SA)	DF	0.69	0.69	1.54	31.	< *0.5*	65.7
AUCH1	Gillmor Sanctuary (SG)	CH			1.9			
GDCI1	Goggin Drain (SD)	BMI	4.21	19.5	2.8	95.8	6.85	169.
NGCH1	Inland Sea Shorebird Reserve (SI)	CH	7.36	74.2	2.7	144.	17.6	108.
97NPBI1	North Point Canal (SN)	BMI	1.72	3.35	2.19	41.	1.98	120.
	Area #5: South Shore Industrially Impacted Wetlands							
BHCO2	Beck Hot Springs (IB)	CO	0.65	2.5	0.9	199.	1.	156.
97PCCH1	Petrochem Ponds (IP)	CH	4.83	53.6	< *0.5*	253.	5.42	136.
STBI1	SLC Sewage Treatment Plant (IS)	BMI	2.79	7.6	5.2	43.9	2.64	104.
97WPCH1	SLC Sewage Treatment Plant (IS)	CH	5.84	12.7	6.46	90.8	4.3	128.
	Area #6: Farmington Bay South							
97BPCH1	Bountiful Pond (FP)	CH	10.1	3.24	0.966	25.2	14.1	120.
CUBI1	FBWMA- Crystal Unit (FC)	BMI	1.03	11.5	3.5	111.	3.46	101.
97OMCH1	NW Oil Drain Delta (FO)	CH	3.8	33.9	4.31	82.5	6.18	128.
SCBI1	State Canal (FS)	BMI	3.73	11.2	4.1	18.3	3.98	175.
	Area #7: Farmington BayNorth							
97BCCI1	Bair Creek (FB)	BMI	3.59	3.45	1.83	12.3	3.33	134.
KCBI1	Kaysville Marsh (FK)	CH	7.04	22.6	1.1	52.2	14.1	93.2
	Area #8: Ogden Bay							
97HSCH1	Howard Slough (OH)	CH	7.04	13.5	6.35	92.1	13.3	101.
OBCH1	Ogden Bay WMA- North (ON)	CH	3.28	49.3	1.2	23.5	7.21	92.2
OSBI1	Ogden Bay WMA- South (OS)	BMI	1.38	7.9	1.4	45.3	1.06	150.

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Table A-5. Organic Chemicals in Invertebrates, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs) *(Page 1 of 5)*

Sample Number	Sample Site Description	Species Composition (Common Name)	Collection Date	Sample Weight (grams)	% Lipid	% Moisture
	Area #2: Antelope Island					
AIBF1	Antelope Island offshore (GA)	Brine Fly Larvae	7/18/1996	12	5.5	66
AIBF2	Antelope Island East (AE)	Brine Fly Larvae	7/18/1996	12	0.06	87.6
AIBI1	Antelope Island South (AS)	Odonates	7/18/1996	13	0.76	86.6
	Area #3: GSL South Shore					
C7CH1	C7 Ditch (LC)	Chironomids	7/29/1996	11	0.5	82.7
GSABI1	Saltair/GSL State Park (LS)	Benthic Macroinverts	7/19/1996	12	0.4	86.4
	Area #4: South Shore Wetlands					
GDCI1	Goggin Drain (SD)	Benthic Macroinverts	7/10/1996	16	0.8	84.9
NGCH1	Inland Sea Shorebird Reserve (SI)	Chironomids	7/1/1996	11	0.3	81.4
	Area #5: South Shore Industrially Impacted Wetlands					
BHCO2	Beck Hot Springs (IB)	Corixids	7/10/1996	28	1.2	87.2
ODCH2	Oil Drain Canal (IO)	Chironomids	7/11/1996	4	1.1	83.5
97PCCH1	Petrochem Ponds (IP)	Chironomid	6/10/1997	11	0.76	85.9
97WPCH1	SLC Sewage Treatment Plant (IS)	Chironomid	6/17/1997	10	0.59	90.4
STBI1	SLC Sewage Treatment Plant (IS)	Benthic Macroinverts	7/16/1996	12	0.8	87.7
	Area #6: Farmington Bay South					
CUBI1	FBWMA- Crystal Unit (FC)	Benthic Macroinverts	7/15/1996	12	1.7	86.5
SCBI1	State Canal (FS)	Benthic Macroinverts	7/15/1996	12	1	85
	Area #7: Farmington Bay North					
97KCCH1	Kaysville Marsh (FK)	Chironomid	6/4/1997	19	0.67	83
KCBI1	Kaysville Marsh (FK)	Chironomid,Leech	8/20/1996	10	0.6	83.8
	Area #8: Ogden Bay					
97HSCH1	Howard Slough (OH)	Chironomid	6/30/1997	19	0.28	91.9
OBCH1	Ogden Bay WMA- North (ON)	Chironomids	7/17/1996	14	0.6	87.5
OSBI1	Ogden Bay WMA- South (OS)	Benthic Macroinverts	7/17/1996	13	0.9	84.9

All values milligram per kilogram (parts per million) on a wet-weight basis
detected values are in presented in bold face type.

Analyzed but not detected (not shown on table): Aldrin, Heptachlor, Endosulfan II, Mirex, o,p'-DDE, Toxaphene

Not analyzed: pentachloro-anisole

Sample Number	dieldrin	endrin	alpha BHC	beta BHC	delta BHC	gamma BHC	alpha chlordane
AIBF1	< 0.00048	< 0.00048	).0006	.0009	< 0.00048	< 0.00048	<).00048
AIBF2	< 0.000818	< 0.000818	<).000818	< .000818	< 0.000818	0.009	<).000818
AIBI1	< 0.000478	< 0.000478	<).000478	< .000478	< 0.000478	< 0.000478	<).000478
C7CH1	< 0.000883	< 0.000883	<).000883	< .000883	< 0.000883	< 0.000883	<).000883
GSABI1	< 0.000923	< 0.000923	<).000923	.0019	< 0.000923	< 0.000923	<).000923
GDCI1	0.0024	< 0.000476	<).000476	< .000476	< 0.000476	< 0.000476	).0015
NGCH1	< 0.000813	0.0009	<).000813	< .000813	< 0.000813	< 0.000813	<).000813
BHCO2	< 0.0005	< 0.0005	<).0005	< .0005	< 0.0005	< 0.0005	<).0005
ODCH2	0.0019	< 0.000893	<).000893	.0025	0.001	< 0.000893	).0012
97PCCH1	< 0.00476	< 0.00476	<).00476	< .00476	< 0.00476	< 0.00476	<).00476
97WPCH1	< 0.00485	< 0.00485	<).00485	< .00485	< 0.00485	< 0.00485	<).00485
STBI1	0.0028	0.0024	<).000952	< .000952	< 0.000952	< 0.000952	<).000952
CUBI1	< 0.000842	< 0.000842	<).000842	< .000842	< 0.000842	< 0.000842	<).000842
SCBI1	0.0042	< 0.000498	<).000498	.0005	< 0.000498	< 0.000498	).0023
97KCCH1	< 0.00472	< 0.00472	<).00472	< .00472	< 0.00472	< 0.00472	<).00472
KCBI1	0.004	< 0.000858	<).000858	< .000858	< 0.000858	< 0.000858	).0018
97HSCH1	< 0.00472	< 0.00472	<).00472	< .00472	< 0.00472	< 0.00472	<).00472
OBCH1	< 0.000933	0.0012	<).000933	< .000933	< 0.000933	< 0.000933	<).000933
OSBI1	< 0.000799	< 0.000799	<).000799	< .000799	< 0.000799	< 0.000799	).001

Table A-5. Organic Chemicals in Invertebrates, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs) ***(Page 3 of 5)***

Sample Number	Sample Site Description	gamma chlordane	oxy chlordane	heptachlor epoxide	cis-nonachlor
	Area #2: Antelope Island				
AIBF1	Antelope Island offshore (GA)	< 0.00048	**0.0009**	< 0.00048	< 0.00048
AIBF2	Antelope Island East (AE)	< 0.000818	**0.0009**	< 0.000818	< 0.000818
AIBI1	Antelope Island South (AS)	< 0.000478	< 0.000478	< 0.000478	< 0.000478
	Area #3: GSL South Shore				
C7CH1	C7 Ditch (LC)	< 0.000883	**0.0012**	< 0.000883	< 0.000883
GSABI1	Saltair/GSL State Park (LS)	< 0.000923	< 0.000923	< 0.000923	< 0.000923
	Area #4: South Shore Wetlands				
GDCI1	Goggin Drain (SD)	**0.0005**	**0.0016**	< 0.000476	**0.0008**
NGCH1	Inland Sea Shorebird Reserve (SI)	< 0.000813	< 0.000813	< 0.000813	< 0.000813
	Area #5: South Shore Industrially Impacted Wetlands				
BHCO2	Beck Hot Springs (IB)	< 0.0005	**0.0012**	< 0.0005	< 0.0005
ODCH2	Oil Drain Canal (IO)	**0.0012**	**0.0017**	< 0.000893	< 0.000893
97PCCH1	Petrochem Ponds (IP)	< 0.00476	< 0.00476	< 0.00476	< 0.00476
97WPCH1	SLC Sewage Treatment Plant (IS)	< 0.00485	< 0.00485	< 0.00485	< 0.00485
STBI1	SLC Sewage Treatment Plant (IS)	< 0.000952	**0.0023**	< 0.000952	< 0.000952
	Area #6: Farmington Bay South				
CUBI1	FBWMA- Crystal Unit (FC)	< 0.000842	< 0.000842	< 0.000842	< 0.000842
SCBI1	State Canal (FS)	**0.0022**	**0.0011**	< 0.000498	**0.0011**
	Area #7: Farmington Bay North				
97KCCH1	Kaysville Marsh (FK)	< 0.00472	< 0.00472	< 0.00472	< 0.00472
KCBI1	Kaysville Marsh (FK)	**0.0022**	**0.0022**	**0.0021**	**0.0013**
	Area #8: Ogden Bay				
97HSCH1	Howard Slough (OH)	< 0.00472	< 0.00472	< 0.00472	< 0.00472
OBCH1	Ogden Bay WMA- North (ON)	< 0.000933	< 0.000933	< 0.000933	< 0.000933
OSBI1	Ogden Bay WMA- South (OS)	< 0.000799	< 0.000799	< 0.000799	< 0.000799

Table A-5. (Continued) *(Page 4 of 5)*

Sample Number	trans-nonachlor	HCB	o,p'-DDD	o,p'-DDT	p,p'-DDD	p,p'-DDE
AIBF1	< 0.00048	< 0.00048	< 0.00048	< 0.00048	**0.0011**	**0.0005**
AIBF2	< 0.000818	< 0.000818	< 0.000818	< 0.000818	< 0.000818	< 0.000818
AIBI1	< 0.000478	< 0.000478	< 0.000478	< 0.000478	< 0.000478	< 0.000478
C7CH1	< 0.000883	< 0.000883	**0.0013**	< 0.000883	**0.0024**	**0.0039**
GSABI1	< 0.000923	< 0.000923	< 0.000923	< 0.000923	< 0.000923	< 0.000923
GDCI1	**0.0017**	< 0.000476	< 0.000476	< 0.000476	**0.0007**	**0.0093**
NGCH1	**0.001**	< 0.000813	< 0.000813	< 0.000813	**0.0014**	**0.0029**
BHCO2	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	**0.0013**
ODCH2	**0.0009**	**0.0011**	**0.0042**	< 0.000893	**0.0039**	**0.002**
97PCCH1	< 0.00476	< 0.00476	< 0.00476	< 0.00476	< 0.00476	< 0.00476
97WPCH1	< 0.00485	< 0.00485	< 0.00485	< 0.00485	< 0.00485	< 0.00485
STBI1	< 0.000952	**0.002**	< 0.000952	**0.0066**	< 0.000952	**0.0011**
CUBI1	< 0.000842	< 0.000842	< 0.000842	< 0.000842	< 0.000842	**0.0011**
SCBI1	**0.0032**	**0.0005**	**0.0023**	< 0.000498	**0.0052**	**0.0098**
97KCCH1	< 0.00472	< 0.00472	< 0.00472	< 0.00472	< 0.00472	**0.00685**
KCBI1	**0.0039**	**0.0031**	**0.0024**	< 0.000858	**0.0029**	**0.0152**
97HSCH1	< 0.00472	< 0.00472	< 0.00472	< 0.00472	< 0.00472	**0.00564**
OBCH1	< 0.000933	< 0.000933	**0.0105**	< 0.000933	**0.011**	**0.0269**
OSBI1	< 0.000799	< 0.000799	< 0.000799	< 0.000799	**0.003**	**0.0059**

Table A-5. Organic Chemicals in Invertebrates, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs) ***(Page 5 of 5)***

Sample Number	Sample Site Description		p,p'-DDT	Total DDTs (1)		Total PCBs
	Area #2: Antelope Island					
AIBF1	Antelope Island offshore (GA)	<	0.00048	0.0016		**0.0124**
AIBF2	Antelope Island East (AE)	<	0.000818			**0.0696**
AIBI1	Antelope Island South (AS)	<	0.000478		<	0.00478
	Area #3: GSL South Shore					
C7CH1	C7 Ditch (LC)	<	0.000883	0.0076		**0.0359**
GSABI1	Saltair/GSL State Park (LS)	<	0.000923			**0.0231**
	Area #4: South Shore Wetlands					
GDCI1	Goggin Drain (SD)		**0.0011**	0.0111		**0.0571**
NGCH1	Inland Sea Shorebird Reserve (SI)	<	0.000813	0.0043		**0.0261**
	Area #5: South Shore Industrially Impacted Wetlands					
BHCO2	Beck Hot Springs (IB)	<	0.0005	0.0013		**0.0289**
ODCH2	Oil Drain Canal (IO)	<	0.000893	0.0101		**0.0907**
97PCCH1	Petrochem Ponds (IP)	<	0.00476		<	0.0238
97WPCH1	SLC Sewage Treatment Plant (IS)	<	0.00485			**0.0254**
STBI1	SLC Sewage Treatment Plant (IS)	<	0.000952	0.0077		**0.0618**
	Area #6: Farmington Bay South					
CUBI1	FBWMA- Crystal Unit (FC)	<	0.000842	0.0011		**0.0264**
SCBI1	State Canal (FS)	<	0.000498	0.0173		**0.0485**
	Area #7: Farmington Bay North					
97KCCH1	Kaysville Marsh (FK)	<	0.00472	0.00685	<	0.0236
KCBI1	Kaysville Marsh (FK)	<	0.000858	0.0205		**0.0313**
	Area #8: Ogden Bay					
97HSCH1	Howard Slough (OH)	<	0.00472	0.00564	<	0.0236
OBCH1	Ogden Bay WMA- North (ON)	<	0.000933	0.0484		**0.0329**
OSBI1	Ogden Bay WMA- South (OS)	<	0.000799	0.0089		**0.0178**

(1) Total DDTs: Summed DDT residues in cases where at least one isomer was detected; non-detected isomers included in sum as 0.5 x Detection limit

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Table A-6. Trace Elements in Fish from Freshwater Inflows, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. ***(Page 1 of 3)***

Sample Number	Sample Site Description	Species Code[(a)]	Sample Weight (grams)	Collection Date	% moisture	Al	As	B
	Area #3: GSL South Shore							
C7CW1	C7 Ditch (LC)	CC	1103	7/30/1996	76.0	287.	0.5	< *2.0*
C7CW2	C7 Ditch (LC)	CC	3900	7/30/1996	72.6	36.5	1.3	< *2.0*
C7CW3	C7 Ditch (LC)	CC	10762	7/30/1996	75.3	33.9	0.8	< *2.0*
97C7CW1	C7 Ditch (LC)	CC	1829	7/23/1997	75.0	14.6	< *0.5*	< *2.0*
97C7CW2	C7 Ditch (LC)	CC	6771	7/23/1997	74.6	12.2	< *0.5*	< *2.0*
97C7WB3	C7 Ditch (LC)	UC	95	7/23/1997	73.3	27.3	< *0.5*	< *2.0*
	Area #4: South Shore Wetlands							
GDCW1	Goggin Drain (SD)	CC	2359	8/15/1996	73.1	188.	0.7	< *2.0*
GDCW2	Goggin Drain (SD)	CC	1657	8/16/1996	74.2	28.9	< *0.5*	< *2.0*
GDCW3	Goggin Drain (SD)	CC	1288	8/16/1996	74.4	65.5	< *0.5*	< *2.0*
97AMCW1	Airport Mitigation Site (SA)	CC	4734	7/16/1997	73.8	53.4	< *0.5*	< *2.0*
97AMCW2	Airport Mitigation Site (SA)	CC	10322	7/16/1997	72.0	64.4	< *0.5*	< *2.0*
97AMCW3	Airport Mitigation Site (SA)	CC	9295	7/16/1997	69.3	45.1	< *0.5*	< *2.0*
	Area #5: South Shore Industrially Impacted Wetlands							
ODCW1	NW Oil Drain (IO)	CC	262	8/13/1996	75.4	59.6	< *0.5*	< *2.0*
ODCW2	NW Oil Drain (IO)	CC	142	8/13/1996	75.3	56.8	< *0.5*	< *2.0*
ODGM2	NW Oil Drain (IO)	WM	32	7/11/1996	77.8	121.	< *0.5*	< *2.0*
	Area #6: Farmington Bay South							
SCCW1	State Canal (FS)	CC	1837	8/5/1996	78.8	185.	< *0.5*	< *2.0*
SCCW2	State Canal (FS)	CC	1831	8/6/1996	76.6	76.9	< *0.5*	< *2.0*
SCCW3	State Canal (FS)	CC	1371	8/7/1996	74.6	42.	< *0.5*	< *2.0*
97BPCW1	Bountiful Pond (FP)	CC	4449	7/15/1997	76.0	346.	< *0.5*	< *2.0*
97BPCW2	Bountiful Pond (FP)	CC	5886	7/15/1997	71.6	79.3	< *0.5*	< *2.0*
97BPCW3	Bountiful Pond (FP)	CC	6469	7/15/1997	70.0	206.	< *0.5*	< *2.0*
97CUCW1	FBWMA- Crystal Unit (FC)	CC	2074	8/19/1997	76.9	11.4	< *0.5*	< *2.0*
97CUCW2	FBWMA- Crystal Unit (FC)	CC	1773	8/19/1997	77.2	13.1	< *0.5*	< *2.0*
97CUCW3	FBWMA- Crystal Unit (FC)	CC	1338	8/19/1997	80.7	17.5	< *0.5*	< *2.0*
97F1CW1	FBWMA- Unit 1 (FU)	CC	6994	7/31/1997	72.8	62.3	< *0.5*	< *2.0*
97F1CW2	FBWMA- Unit 1 (FU)	CC	5386	7/31/1997	70.6	107.	< *0.5*	< *2.0*
97F1CW3	FBWMA- Unit 1 (FU)	CC	5624	7/31/1997	75.5	121.	< *0.5*	< *2.0*
	Area #7: Farmington BayNorth							
KCFI1	Kaysville Marsh (FK)	WM	16	8/20/1996	75.3	1092.	1.0	< *2.0*
	Area #8: Ogden Bay							
97HSCW1	Howard Slough (OH)	CC	7278	8/22/1997	70.2	61.7	< *0.5*	< *2.0*
97HSCW2	Howard Slough (OH)	CC	4983	8/22/1997	70.9	64.5	< *0.5*	< *2.0*
97HSCW3	Howard Slough (OH)	CC	2142	8/22/1997	77.6	263.	< *0.5*	< *2.0*
OBCW1	Ogden Bay WMA- South (OS)	CC	4378	8/26/1996	73.4	132.	0.5	< *2.0*
OBCW2	Ogden Bay WMA- South (OS)	CC	9811	8/27/1996	73.5	187.	< *0.5*	< *2.0*
OBCW3	Ogden Bay WMA- South (OS)	CC	13782	8/27/1996	72.8	131.	< *0.5*	< *2.0*
97OBCW1	Ogden Bay WMA- North (ON)	CC	8778	8/26/1997	68.7	62.5	< *0.5*	< *2.0*

NOTES:

(a) Fish Species Codes: CC = common carp UC = Utah Chub WM = Western Mosquitofish

Table A-6. (continued) ***(page 2 of 3)***

Sample Number	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
C7CW1	6.48	< *0.1*	0.3	1.51	16.2	340.	0.31	1431	15.6	< *2.0*
C7CW2	4.87	< *0.1*	0.4	0.77	16.3	119.	0.31	1472	10.4	< *2.0*
C7CW3	5.34	< *0.1*	0.1	0.65	5.39	222.	0.34	1372	5.39	< *2.0*
97C7CW1	3.44	< *0.1*	0.15	4.26	9.2	114.	< *0.20*	1488	7.29	< *2.0*
97C7CW2	5.95	< *0.1*	0.23	3.05	9.08	126.	< *0.20*	1620	9.1	< *2.0*
97C7WB3	3.85	< *0.1*	< *0.1*	0.854	16.2	59.4	< *0.20*	1645	6.07	< *2.0*
GDCW1	5.44	0.3	< *0.1*	1.39	4.89	192.	0.13	1468	9.26	< *2.0*
GDCW2	2.94	< *0.1*	< *0.1*	< *0.5*	3.89	100.	0.12	1217	4.32	< *2.0*
GDCW3	3.91	0.22	< *0.1*	0.87	3.37	111.	0.18	1230	5.69	< *2.0*
97AMCW1	7.29	< *0.1*	< *0.1*	2.28	2.23	131.	< *0.20*	1377	5.79	< *2.0*
97AMCW2	3.45	< *0.1*	< *0.1*	2.89	2.27	136.	< *0.20*	1039	3.23	< *2.0*
97AMCW3	3.39	< *0.1*	< *0.1*	5.51	2.96	140.	0.26	1138	4.23	< *2.0*
ODCW1	3.75	< *0.1*	< *0.1*	0.53	3.79	138.	0.08	1324	4.38	< *2.0*
ODCW2	2.74	0.22	< *0.1*	0.74	4.27	120.	0.06	967	3.65	< *2.0*
ODGM2	3.87	< *0.1*	< *0.1*	1.49	5.51	141.	0.06	1470	12.	< *2.0*
SCCW1	7.64	0.18	< *0.1*	1.09	2.2	178.	0.1	1384	4.54	< *2.0*
SCCW2	4.65	< *0.1*	< *0.1*	0.73	2.65	127.	0.08	1223	3.21	< *2.0*
SCCW3	4.15	< *0.1*	< *0.1*	1.13	3.89	112.	0.1	1221	4.63	< *2.0*
97BPCW1	8.38	< *0.1*	< *0.1*	3.76	5.98	415.	< *0.20*	1439	8.59	< *2.0*
97BPCW2	3.96	< *0.1*	< *0.1*	3.63	1.98	157.	< *0.20*	1103	5.2	< *2.0*
97BPCW3	4.75	< *0.1*	< *0.1*	4.75	2.4	304.	< *0.20*	982	7.35	< *2.0*
97CUCW1	6.87	< *0.1*	< *0.1*	1.76	5.06	113.	0.259	1339	3.34	< *2.0*
97CUCW2	9.55	< *0.1*	< *0.1*	2.73	4.99	98.7	0.233	1622	5.62	< *2.0*
97CUCW3	7.38	< *0.1*	< *0.1*	1.21	4.56	109.	0.233	1468	4.49	< *2.0*
97F1CW1	4.64	< *0.1*	< *0.1*	2.94	2.07	147.	< *0.20*	1275	4.27	< *2.0*
97F1CW2	6.	< *0.1*	< *0.1*	2.82	2.18	160.	< *0.20*	1141	4.61	< *2.0*
97F1CW3	2.99	< *0.1*	< *0.1*	1.31	2.25	151.	< *0.20*	865	4.06	< *2.0*
KCFI1	21.3	0.2	0.1	7.08	4.83	823.	0.14	1831	33.4	< *2.0*
97HSCW1	8.14	< *0.1*	< *0.1*	2.65	2.39	127.	< *0.20*	972	4.36	< *2.0*
97HSCW2	6.97	< *0.1*	< *0.1*	3.61	1.86	139.	< *0.20*	955	3.88	< *2.0*
97HSCW3	15.1	< *0.1*	< *0.1*	2.91	3.67	288.	< *0.20*	1383	8.52	< *2.0*
OBCW1	6.71	< *0.1*	< *0.1*	0.8	3.79	185.	0.23	1163	9.04	< *2.0*
OBCW2	4.78	< *0.1*	< *0.1*	1.21	3.32	230.	0.21	1078	8.64	< *2.0*
OBCW3	9.05	< *0.1*	< *0.1*	1.27	2.79	175.	0.37	1291	10.3	< *2.0*
97OBCW1	7.21	< *0.1*	< *0.1*	2.87	2.8	162.	< *0.20*	1048	8.06	< *2.0*

Table A-6. Trace Elements in Fish from Freshwater Inflows, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. ***(Page 3 of 3)***

Sample Number	Sample Site Description	Species Code[(a)]	Ni	Pb	Se	Sr	V	Zn
	Area #3: GSL South Shore							
C7CW1	C7 Ditch (LC)	CC	< *0.5*	1.4	7.8	136.	< *0.5*	312.
C7CW2	C7 Ditch (LC)	CC	< *0.5*	1.5	9.1	331.	0.98	341.
C7CW3	C7 Ditch (LC)	CC	1.29	< *0.5*	3.5	210.	1.08	360.
97C7CW1	C7 Ditch (LC)	CC	0.899	0.98	5.93	199.	< *0.5*	299.
97C7CW2	C7 Ditch (LC)	CC	0.748	2.13	5.61	311.	< *0.5*	221.
97C7WB3	C7 Ditch (LC)	UC	< *0.5*	< *0.5*	8.03	211.	< *0.5*	72.9
	Area #4: South Shore Wetlands							
GDCW1	Goggin Drain (SD)	CC	< *0.5*	1.5	2.1	194.	0.76	262.
GDCW2	Goggin Drain (SD)	CC	2.1	0.6	2.	133.	0.81	250.
GDCW3	Goggin Drain (SD)	CC	1.61	0.9	1.7	157.	< *0.5*	221.
97AMCW1	Airport Mitigation Site (SA)	CC	0.634	< *0.5*	1.44	317.	< *0.5*	165.
97AMCW2	Airport Mitigation Site (SA)	CC	< *0.5*	< *0.5*	1.71	153.	< *0.5*	150.
97AMCW3	Airport Mitigation Site (SA)	CC	< *0.5*	< *0.5*	1.29	211.	< *0.5*	261.
	Area #5: South Shore Industrially Impacted Wetlands							
ODCW1	NW Oil Drain (IO)	CC	< *0.5*	< *0.5*	3.3	131.	< *0.5*	199.
ODCW2	NW Oil Drain (IO)	CC	< *0.5*	< *0.5*	3.	103.	< *0.5*	169.
ODGM2	NW Oil Drain (IO)	WM	< *0.5*	1.5	1.4	219.	< *0.5*	130.
	Area #6: Farmington Bay South							
SCCW1	State Canal (FS)	CC	< *0.5*	1	2.2	135.	< *0.5*	187.
SCCW2	State Canal (FS)	CC	< *0.5*	1.3	2.7	108.	< *0.5*	247.
SCCW3	State Canal (FS)	CC	< *0.5*	0.6	2.2	120.	< *0.5*	222.
97BPCW1	Bountiful Pond (FP)	CC	1.28	1.43	1.51	115.	< *0.5*	245.
97BPCW2	Bountiful Pond (FP)	CC	0.59	1.4	1.89	118.	< *0.5*	170.
97BPCW3	Bountiful Pond (FP)	CC	1.45	< *0.5*	1.41	36.7	< *0.5*	203.
97CUCW1	FBWMA- Crystal Unit (FC)	CC	< *0.5*	< *0.5*	1.65	144.	< *0.5*	209.
97CUCW2	FBWMA- Crystal Unit (FC)	CC	< *0.5*	< *0.5*	1.69	245.	0.569	208.
97CUCW3	FBWMA- Crystal Unit (FC)	CC	< *0.5*	< *0.5*	1.83	185.	< *0.5*	197.
97F1CW1	FBWMA- Unit 1 (FU)	CC	< *0.5*	0.51	2.04	106.	0.533	184.
97F1CW2	FBWMA- Unit 1 (FU)	CC	< *0.5*	0.8	1.14	121.	1.16	186.
97F1CW3	FBWMA- Unit 1 (FU)	CC	0.619	0.78	1.49	77.3	0.504	152.
	Area #7: Farmington BayNorth							
KCFI1	Kaysville Marsh (FK)	WM	3.08	1.5	1.7	62.2	1.79	151.
	Area #8: Ogden Bay							
97HSCW1	Howard Slough (OH)	CC	0.536	< *0.5*	0.94	79.5	1.05	172.
97HSCW2	Howard Slough (OH)	CC	0.531	< *0.5*	1.47	57.	< *0.5*	176.
97HSCW3	Howard Slough (OH)	CC	1.2	0.73	1.37	87.	1.61	179.
OBCW1	Ogden Bay WMA- South (OS)	CC	1.84	1.2	1.4	48.	< *0.5*	318.
OBCW2	Ogden Bay WMA- South (OS)	CC	1.39	1.2	1.5	24.8	< *0.5*	512.
OBCW3	Ogden Bay WMA- South (OS)	CC	1.56	3.2	1.2	75.6	< *0.5*	185.
97OBCW1	Ogden Bay WMA- North (ON)	CC	2.25	1.46	1.91	52.5	1.21	271.

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Table A-7. Organic Chemicals in Composite Fish Samples, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs) ***(Page 1 of 5)***

Sample Number	Sample Site Description [1]	Collection Date	Sample Weight	% Lipid	% Moisture		dieldrin		alpha BHC
	Area #3- GSL South Shore								
97C7CW2	C7 Ditch (LC)	7/23/1997	6771	3.46	71		**0.0013**	<	0.0010
C7CW1	C7 Ditch (LC)	7/30/1996	1103	3.18	76		**0.0043**	<	0.0002
C7CW2	C7 Ditch (LC)	7/30/1996	3900	4.38	73.9		**0.0054**		0.0005
C7CW3	C7 Ditch (LC)	7/30/1996	10762	1.35	29.7		**0.0026**		0.0003
	Area #4- S. Shore Conservation Wetlands								
97AMCW2	Airport Mitigation Site (SA)	7/16/1997	10322	7.14	70.4	<	0.0010	<	0.0010
97AMCW3	Airport Mitigation Site (SA)	7/16/1997	9295	7.96	67.9	<	0.0009	<	0.0009
GDCW1	Goggin Drain (SD)	8/15/1996	2359	5.27	74.1		**0.0059**		**0.0002**
GDCW2	Goggin Drain (SD)	8/16/1996	1657	5.13	75.8		**0.0064**		**0.0003**
GDCW3	Goggin Drain (SD)	8/16/1996	1288	4.55	75.6		**0.0063**		**0.0003**
	Area #5- SE Shore Industrially Impacted Wetlands								
ODCW3	Oil Drain Canal (IO)	8/13/1996	242	3.52	75.9		**0.0118**	<	0.0002
ODGM2	Oil Drain Canal (IO)- *Mosquito Fish*	7/11/1996	32	2.48	78.5		**0.0073**	<	0.0002
	Area #6- Farmington Bay South								
97BPCW2	Bountiful Pond (FP)	7/15/1997	5886	6.27	70.7		**0.0131**	<	0.0009
97BPCW3	Bountiful Pond (FP)	7/15/1997	6469	6.31	68.8		**0.0131**	<	0.0010
97CUCW1	FBWMA- Crystal Unit (FC)	8/19/1997	2074	2.95	76.3	<	0.000925	<	0.0009
97F1CW1	FBWMA- Unit 1 (FU)	7/31/1997	6994	6.23	70.9		**0.0039**	<	0.0009
SCCW1	State Canal (FS)	8/5/1996	1837	1.09	80.1		**0.0102**		**0.0002**
SCCW2	State Canal (FS)	8/6/1996	1831	2.74	75.4		**0.0227**		**0.0002**
SCCW3	State Canal (FS)	8/7/1996	1371	3.18	77.5		**0.0235**		**0.0002**
	Area #8- Ogden Bay								
97HSCW1	Howard Slough (OH)	8/22/1997	7278	7.91	69.6		**0.0022**	<	0.0010
97HSCW2	Howard Slough (OH)	8/22/1997	4983	5.84	71.6		**0.0013**	<	0.0009
97OBCW1	Ogden Bay WMA North (ON)	8/26/1997	8778	6.07	67.5		**0.0035**	<	0.0009
OBCW2	Ogden Bay WMA South Canal (OC)	8/27/1996	9811	3.73	76.1		**0.0053**		**0.0002**
OBCW3	Ogden Bay WMA South Canal (OC)	8/27/1996	13782	2.79	74.1		**0.0041**		**0.0002**

All values milligram per kilogram (parts per million) on a wet-weight basis
detected values are in presented in bold face type.
(1) All fish evaluated were Common Carp (*Cyprinio carpius)* unless noted

Analyzed but not detected (not shown on table): Aldrin, Endrin
Not analyzed: pentachloro-anisole, toxaphene

Table A-7. (continued) *(page 2 of 5)*

Sample Number	beta BHC	delta BHC	gamma BHC	alpha chlordane	gamma chlordane	oxy chlordane	Heptachlor
97C7CW2	< 0.0010	< 0.0010	**0.0014**	**0.0023**	**0.0019**	< 0.00097	< 0.0010
C7CW1	< 0.0002	< 0.0002	**0.0002**	**0.0052**	**0.0042**	**0.0019**	< 0.0002
C7CW2	< 0.0002	< 0.0002	**0.0003**	**0.0059**	**0.0054**	**0.002**	< 0.0002
C7CW3	< 0.0002	< 0.0002	**0.0002**	**0.0034**	**0.0021**	**0.0007**	< 0.0002
97AMCW2	< 0.0010	< 0.0010	< 0.000991	< 0.0010	< 0.000991	< 0.000991	< 0.0010
97AMCW3	< 0.0009	< 0.0009	< 0.000945	< 0.0009	< 0.000945	< 0.000945	< 0.0009
GDCW1	< 0.0002	< 0.0002	**0.0011**	**0.0043**	**0.0033**	**0.0021**	< 0.0002
GDCW2	< 0.0002	< 0.0002	**0.0012**	**0.004**	**0.0029**	**0.0023**	< 0.0002
GDCW3	< 0.0002	< 0.0002	**0.001**	**0.0038**	**0.0033**	**0.0021**	< 0.0002
ODCW3	**0.0002**	**0.0003**	**0.0022**	**0.0045**	**0.0038**	**0.0021**	< 0.0002
ODGM2	< 0.0002	< 0.0002	**0.0002**	**0.0023**	**0.0011**	**0.0017**	< 0.0002
		0.0002					
97BPCW2	< 0.0009	< 0.0009	**0.0015**	**0.0131**	**0.0123**	**0.0029**	< 0.0009
97BPCW3	< 0.0010	< 0.0010	**0.0012**	**0.0098**	**0.0096**	**0.0028**	< 0.0010
97CUCW1	< 0.0009	< 0.0009	< 0.000925	< 0.0009	< 0.000925	< 0.000925	< 0.0009
97F1CW1	< 0.0009	< 0.0009	< 0.000858	**0.0041**	**0.0059**	**0.0013**	< 0.0009
SCCW1	< 0.0002	< 0.0002	**0.0003**	**0.0073**	**0.0073**	**0.0013**	< 0.0002
SCCW2	< 0.0002	< 0.0002	**0.0006**	**0.0131**	**0.0137**	**0.0024**	**0.0006**
SCCW3	< 0.0002	< 0.0002	**0.0006**	**0.015**	**0.0142**	**0.0035**	**0.0004**
97HSCW1	< 0.0010	< 0.0010	< 0.000966	**0.0072**	**0.0104**	**0.002**	< 0.0010
97HSCW2	< 0.0009	< 0.0009	< 0.000874	**0.0079**	**0.0107**	**0.002**	< 0.0009
97OBCW1	< 0.0009	< 0.0009	< 0.00093	**0.012**	**0.0151**	**0.003**	< 0.0009
OBCW2	< 0.0002	< 0.0002	**0.0003**	**0.0087**	**0.008**	**0.0032**	**0.0002**
OBCW3	< 0.0002	< 0.000194	**0.0002**	**0.0082**	**0.008**	**0.0024**	**0.0003**

Table A-7. Organic Chemicals in Composite Fish Samples, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs) *(page 3 of 5)*

Sample Number	Sample Site Description (1)	heptachlor epoxide	cis-nonachlor	trans-nonachlor	endosulfan II	HCB
	Area #3- GSL South Shore					
97C7CW2	C7 Ditch (LC)	< 0.00097	**0.0014**	**0.0022**	< 0.00097	**0.001**
C7CW1	C7 Ditch (LC)	**0.0009**	**0.0026**	**0.0065**	**0.0005**	**0.002**
C7CW2	C7 Ditch (LC)	**0.0013**	**0.0027**	**0.0066**	**0.0005**	**0.002**
C7CW3	C7 Ditch (LC)	**0.0009**	**0.0034**	**0.0033**	< 0.000383	**0.001**
	Area #4- S. Shore Conservation Wetlands					
97AMCW2	Airport Mitigation Site (SA)	< 0.000991	< 0.0010	0.0011	< 0.000991	0.001
97AMCW3	Airport Mitigation Site (SA)	< 0.000945	< 0.0009	0.0011	< 0.000945	0.001
GDCW1	Goggin Drain (SD)	0.0006	0.0022	0.0046	0.0005	0.002
GDCW2	Goggin Drain (SD)	0.0006	0.0021	0.0044	< 0.000384	0.001
GDCW3	Goggin Drain (SD)	0.0006	0.002	0.0043	0.0004	0.001
	Area #5- SE Shore Industrially Impacted Wetlands					
ODCW3	Oil Drain Canal (IO)	**0.0017**	**0.0017**	**0.0044**	**0.0005**	**0.006**
ODGM2	Oil Drain Canal (IO)- *Mosquito Fish*	**0.0003**	**0.0012**	**0.0032**	< 0.000398	**0.001**
	Area #6- Farmington Bay South					
97BPCW2	Bountiful Pond (FP)	0.0029	0.0062	0.0162	< 0.00093	0.003
97BPCW3	Bountiful Pond (FP)	0.0026	0.0053	0.0135	< 0.000961	0.003
97CUCW1	FBWMA- Crystal Unit (FC)	< 0.000925	< 0.0009	**0.0012**	< 0.000925	< 0.001
97F1CW1	FBWMA- Unit 1 (FU)	< 0.000858	**0.0039**	**0.0055**	< 0.000858	< 0.001
SCCW1	State Canal (FS)	**0.0007**	**0.003**	**0.0072**	**0.0006**	**0.001**
SCCW2	State Canal (FS)	**0.0012**	**0.0047**	**0.0118**	**0.0006**	**0.002**
SCCW3	State Canal (FS)	**0.0015**	**0.0052**	**0.0133**	< 0.000398	**0.002**
	Area #8- Ogden Bay					
97HSCW1	Howard Slough (OH)	**0.0022**	**0.0035**	**0.009**	< 0.000966	**0.002**
97HSCW2	Howard Slough (OH)	**0.0022**	**0.0037**	**0.0086**	< 0.000874	**0.002**
97OBCW1	Ogden Bay WMA- North (ON)	**0.002**	**0.0078**	**0.013**	< 0.00093	**0.002**
OBCW2	Ogden Bay WMA South Canal (OC)	**0.002**	**0.0058**	**0.0118**	< 0.000394	**0.002**
OBCW3	Ogden Bay WMA South Canal (OC)	**0.0014**	**0.0053**	**0.0099**	**0.0004**	**0.001**

Sample Number		mirex		o,p'-DDD		o,p'-DDE		o,p'-DDT		p,p'-DDD		p,p'-DDE		p,p'-DDT
97C7CW2	<	0.00097		**0.001**	<	0.001	<	0.001		**0.007**		**0.028**	<	0.001
C7CW1		**0.0002**		**0.004**		**0.001**		**0.002**		**0.014**		**0.038**		**0.001**
C7CW2	<	0.000195		**0.005**		**0.001**		**0.003**		**0.018**		**0.036**		**0.001**
C7CW3		**0.0003**		**0.002**		**0.000**		**0.002**		**0.011**		**0.052**		**0.000**
97AMCW2	<	0.000991	<	0.001	<	0.001	<	0.001		**0.001**		**0.007**	<	0.001
97AMCW3	<	0.000945	<	0.001	<	0.001	<	0.001		**0.002**		**0.009**	<	0.001
GDCW1	<	0.00019		**0.003**		**0.001**		**0.002**		**0.011**		**0.036**		**0.001**
GDCW2	<	0.000192		**0.003**		**0.001**		**0.002**		**0.010**		**0.033**	<	0.000
GDCW3	<	0.000186		**0.003**		**0.001**		**0.002**		**0.011**		**0.036**		**0.001**
ODCW3	<	0.000197		**0.005**		**0.001**		**0.005**		**0.015**		**0.011**		**0.001**
ODGM2	<	0.000199		**0.001**		**0.000**		**0.001**		**0.008**		**0.005**		**0.000**
97BPCW2	<	0.00093		**0.019**		**0.005**		**0.006**		**0.054**	<	0.001		**0.015**
97BPCW3	<	0.000961		**0.021**		**0.004**		**0.006**		**0.059**	<	0.001		**0.012**
97CUCW1	<	0.000925	<	0.001	<	0.001	<	0.001		**0.002**		**0.004**	<	0.001
97F1CW1	<	0.000858		**0.007**		**0.002**		**0.001**		**0.029**		**0.058**	<	0.001
SCCW1	<	0.000188		**0.011**		**0.002**		**0.001**		**0.029**		**0.068**		**0.001**
SCCW2	<	0.000196		**0.016**		**0.002**		**0.003**		**0.043**		**0.077**		**0.001**
SCCW3	<	0.000199		**0.021**		**0.002**		**0.003**		**0.030**		**0.072**		**0.002**
97HSCW1	<	0.000966		**0.004**		**0.001**	<	0.001		**0.019**		**0.054**	<	0.001
97HSCW2	<	0.000874		**0.003**		**0.001**	<	0.001		**0.016**		**0.049**	<	0.001
97OBCW1	<	0.00093		**0.035**		**0.006**		**0.003**		**0.095**		**0.099**	<	0.001
OBCW2		**0.0004**		**0.010**		**0.001**		**0.005**		**0.029**		**0.045**		**0.000**
OBCW3		**0.0002**		**0.013**		**0.002**		**0.004**		**0.022**		**0.065**		**0.000**

Table A-7. Organic Chemicals in Composite Fish Samples, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs) ***(page 5 of 5)***

Sample Number	Sample Site Description [1]	Total DDTs [2]	Total PCBs
	Area #3- GSL South Shore		
97C7CW2	C7 Ditch (LC)	**0.038**	**0.070**
C7CW1	C7 Ditch (LC)	**0.061**	**0.188**
C7CW2	C7 Ditch (LC)	**0.063**	**0.192**
C7CW3	C7 Ditch (LC)	**0.068**	**0.202**
	Area #4- S. Shore Conservation Wetlands		
97AMCW2	Airport Mitigation Site (SA)	**0.010**	**0.033**
97AMCW3	Airport Mitigation Site (SA)	**0.013**	**0.033**
GDCW1	Goggin Drain (SD)	**0.053**	**0.173**
GDCW2	Goggin Drain (SD)	**0.048**	**0.183**
GDCW3	Goggin Drain (SD)	**0.052**	**0.189**
	Area #5- SE Shore Industrially Impacted Wetlands		
ODCW3	Oil Drain Canal (IO)	**0.038**	**0.281**
ODGM2	Oil Drain Canal (IO)- *Mosquito Fish*	**0.015**	**0.136**
	Area #6- Farmington Bay South		
97BPCW2	Bountiful Pond (FP)	**0.099**	**0.158**
97BPCW3	Bountiful Pond (FP)	**0.102**	**0.109**
97CUCW1	FBWMA- Crystal Unit (FC)	**0.008**	**0.051**
97F1CW1	FBWMA- Unit 1 (FU)	**0.097**	**0.253**
SCCW1	State Canal (FS)	**0.110**	**0.100**
SCCW2	State Canal (FS)	**0.141**	**0.177**
SCCW3	State Canal (FS)	**0.129**	**0.156**
	Area #8- Ogden Bay		
97HSCW1	Howard Slough (OH)	**0.079**	**0.090**
97HSCW2	Howard Slough (OH)	**0.070**	**0.076**
97OBCW1	Ogden Bay WMA- North (ON)	**0.238**	**0.640**
OBCW2	Ogden Bay WMA- South Canal (OC)	**0.089**	**0.550**
OBCW3	Ogden Bay WMA- South Canal (OC)	**0.105**	**0.409**

(1) All fish evaluated were Common Carp (*Cyprinio carpius)* unless noted
(2) Total DDTs: Summed DDT residues in samples where at least one isomer was detected; non-detected isomers included in sum as 0.5 x Detection limit

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Table A-8. Trace Elements in Avian Eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. ***(Page 1 of 9)***

Sample Number	Sample Site Description	Species Code[(a)]	Collection Date	Sample Weight (grams)	% moisture	Al	As	B
	Area #2: Antelope Island							
AICT1	Antelope Island South (AS)	AMCO	6/21/1996	23	74.8	< *5.0*	< *0.5*	3.4
AIST1	Antelope Island East (AE)	BNST	6/21/1996	19	83.1	< *5.0*	< *0.5*	2.77
AIST2	Antelope Island East (AE)	BNST	6/21/1996	18	77.3	< *5.0*	< *0.5*	8.84
AIST3	Antelope Island East (AE)	BNST	6/21/1996	19	73.6	< *5.0*	< *0.5*	4.34
	Area #3: GSL South Shore							
GSAST1	Saltair/GSL State Park (LS)	BNST	5/14/1996	19	75.7	< *5.0*	< *0.5*	< *2.0*
GSAST2	Saltair/GSL State Park (LS)	BNST	5/29/1996	20	81.4	< *5.0*	< *0.5*	< *2.0*
GSAST3	Saltair/GSL State Park (LS)	BNST	6/13/1996	19	73.6	< *5.0*	< *0.5*	< *2.0*
97GSST1	Saltair/GSL State Park (LS)	BNST	6/23/1997	20	74.6	< *5.0*	0.54	< *2.0*
97GSST2	Saltair/GSL State Park (LS)	BNST	6/23/1997	17	74.5	< *5.0*	< *0.5*	< *2.0*
97GSST3	Saltair/GSL State Park (LS)	BNST	6/25/1997	20	76.4	< *5.0*	1.1	< *2.0*
97SPAV1	Saltair/GSL State Park (LS)	AMAV	5/19/1997	24	76.0	< *5.0*	< *0.5*	< *2.0*
97SPST1	Saltair/GSL State Park (LS)	BNST	5/19/1997	19	72.0	< *5.0*	< *0.5*	< *2.0*
97SPST3	Saltair/GSL State Park (LS)	BNST	5/19/1997	17	76.2	< *5.0*	< *0.5*	< *2.0*
97SPCT1	Saltair/GSL State Park (LS)	AMCO	5/19/1997	20	80.3	5.4	< *0.5*	< *2.0*
97GSMA1	Saltair/GSL State Park (LS)	MALL	6/25/1997	41	64.3	< *5.0*	0.93	< *2.0*
97SPMA1	Saltair/GSL State Park (LS)	MALL	5/19/1997	49	66.2	< *5.0*	< *0.5*	< *2.0*
	Area #4: South Shore Wetlands							
97AMST1	Airport Mitigation Site (SA)	BNST	5/21/1997	16	67.9	< *5.0*	< *0.5*	< *2.0*
97AMST2	Airport Mitigation Site (SA)	BNST	5/21/1997	19	76.3	< *5.0*	< *0.5*	< *2.0*
97AMST3	Airport Mitigation Site (SA)	BNST	5/21/1997	18	74.0	< *5.0*	< *0.5*	< *2.0*
97AMDC1	Airport Mitigation Site (SA)	DCCO	5/21/1997	42	77.5	< *5.0*	< *0.5*	< *2.0*
97AMMA2	Airport Mitigation Site (SA)	MALL	5/21/1997	36	66.7	< *5.0*	< *0.5*	< *2.0*
97AMMA3	Airport Mitigation Site (SA)	MALL	6/3/1997	49	69.4	< *5.0*	< *0.5*	< *2.0*
NGAV1	Goggin Drain (SD)	AMAV	6/11/1996	26	72.0	< *5.0*	< *0.5*	< *2.0*
97LCSP2	Inland Sea Shorebird Reserve (SI)	SNPL	7/22/1997	7	69.6	5.78	< *0.5*	< *2.0*
	Area #5: South Shore Industrially Impacted Wetlands							
BHAV1	Beck Hot Springs (IB)	AMAV	6/11/1996	21	70.1	< *5.0*	< *0.5*	8.61
BHAV2	Beck Hot Springs (IB)	AMAV	6/11/1996	25	73.8	< *5.0*	< *0.5*	15.8
BHAV3	Beck Hot Springs (IB)	AMAV	6/11/1996	23	73.5	< *5.0*	< *0.5*	< *2.0*
WPCT1	SLC Sewage Treatment Plant (IS)	AMCO	6/13/1996	24	76.0	< *5.0*	0.7	< *2.0*
WPCT2	SLC Sewage Treatment Plant (IS)	AMCO	6/13/1996	24	74.3	< *5.0*	< *0.5*	< *2.0*
WPCT3	SLC Sewage Treatment Plant (IS)	AMCO	6/13/1996	25	74.8	< *5.0*	< *0.5*	< *2.0*
97WPCT1	SLC Sewage Treatment Plant (IS)	AMCO	6/17/1997	26	75.2	< *5.0*	< *0.5*	< *2.0*
97WPCT2	SLC Sewage Treatment Plant (IS)	AMCO	6/17/1997	28	78.6	< *5.0*	< *0.5*	< *2.0*
97WPMA1	SLC Sewage Treatment Plant (IS)	MALL	6/12/1997	55	69.3	< *5.0*	< *0.5*	< *2.0*
97PCCT1	Petrochem Ponds (IP)	AMCO	5/28/1997	24	75.2	< *5.0*	< *0.5*	< *2.0*
97PCMA1	Petrochem Ponds (IP)	MALL	6/10/1997	38	67.6	< *5.0*	< *0.5*	< *2.0*

(a) Avian Species Codes

AMAV = American avocet
AMCO= American Coot
BNST = Black necked stilt
CITE = Cinnamon teal
DCCO = Double-crested cormorant
MALL = Mallard
SNPL = Snowy plover

Sample Number	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
AICT1	< *1.*	< *0.1*	< *0.1*	< *0.5*	1.63	59.1	0.45	423	1.09	< *2.0*
AIST1	1.69	< *0.1*	< *0.1*	< *0.5*	2.99	93.4	1.11	402	1.33	< *2.0*
AIST2	1.65	< *0.1*	< *0.1*	< *0.5*	2.63	73.1	0.61	385	1.42	< *2.0*
AIST3	1.43	< *0.1*	< *0.1*	< *0.5*	2.36	85.2	0.7	376	< *1.0*	< *2.0*
GSAST1	1.58	< *0.1*	< *0.1*	< *0.5*	2.57	119.	1.05	403	1.05	< *2.0*
GSAST2	2.05	< *0.1*	< *0.1*	< *0.5*	3.22	108.	0.25	426	1.62	< *2.0*
GSAST3	1.76	< *0.1*	< *0.1*	0.64	3.24	116.	1.19	494	1.22	< *2.0*
97GSST1	2.44	< *0.1*	< *0.1*	< *0.5*	3.24	115.	0.48	400	1	< *2.0*
97GSST2	5.87	< *0.1*	< *0.1*	< *0.5*	3.57	108.	0.49	445	1.42	< *2.0*
97GSST3	2.65	< *0.1*	< *0.1*	< *0.5*	3.28	113.	0.29	367	< *1.0*	< *2.0*
97SPAV1	< *1.*	< *0.1*	< *0.1*	0.55	3.75	117.	0.23	457	2.53	< *2.0*
97SPST1	2.24	< *0.1*	< *0.1*	< *0.5*	7.15	95.7	0.35	359	< *1.0*	< *2.0*
97SPST3	1.96	< *0.1*	< *0.1*	0.62	4.95	102.	0.9	612	1.26	< *2.0*
97SPCT1	3.17	< *0.1*	< *0.1*	1.41	7.3	158.	0.23	789	3.69	< *2.0*
97GSMA1	3.42	< *0.1*	< *0.1*	< *0.5*	5.7	105.	0.33	324	< *1.0*	4.34
97SPMA1	4.2	< *0.1*	< *0.1*	< *0.5*	4.14	94.1	< *0.20*	432	1.01	< *2.0*
97AMST1	1.74	< *0.1*	< *0.1*	< *0.5*	3.16	85.6	1.13	332	1.62	< *2.0*
97AMST2	2.19	< *0.1*	< *0.1*	< *0.5*	2.88	79.5	0.4	386	1.54	< *2.0*
97AMST3	1.22	< *0.1*	< *0.1*	0.65	3.27	74.4	0.66	368	1.41	< *2.0*
97AMDC1	< *1.*	< *0.1*	< *0.1*	0.62	3.14	135.	0.38	525	2.02	< *2.0*
97AMMA2	12.9	< *0.1*	< *0.1*	< *0.5*	2.93	107.	< *0.20*	366	1.43	< *2.0*
97AMMA3	17.3	< *0.1*	< *0.1*	< *0.5*	4.16	116.	0.21	537	2.09	< *2.0*
NGAV1	4.3	< *0.1*	< *0.1*	< *0.5*	2.59	106.	0.15	434	2.41	< *2.0*
97LCSP2	2.7	< *0.1*	< *0.1*	1.3	3.55	104.	0.94	418	< *1.0*	< *2.0*
BHAV1	1.35	< *0.1*	< *0.1*	0.59	3.12	144.	0.13	410	2.02	< *2.0*
BHAV2	2.13	< *0.1*	< *0.1*	< *0.5*	2.86	124.	0.29	390	< *1.0*	< *2.0*
BHAV3	< *1.*	< *0.1*	< *0.1*	0.53	2.73	106.	0.24	358	1.73	< *2.0*
WPCT1	2.7	< *0.1*	< *0.1*	< *0.5*	2.82	113.	0.1	387	1.05	< *2.0*
WPCT2	1.37	< *0.1*	< *0.1*	< *0.5*	3.79	104.	0.1	421	< *1.0*	3.38
WPCT3	1.12	< *0.1*	< *0.1*	< *0.5*	2.89	98.4	0.24	480	< *1.0*	< *2.0*
97WPCT1	3.33	< *0.1*	< *0.1*	0.58	3.37	94.1	< *0.20*	379	1.71	< *2.0*
97WPCT2	2.	< *0.1*	0.23	< *0.5*	3.46	79.6	0.3	686	2.64	< *2.0*
97WPMA1	3.09	< *0.1*	< *0.1*	< *0.5*	2.93	114.	< *0.20*	299	1.74	< *2.0*
97PCCT1	1.62	< *0.1*	< *0.1*	0.57	3.04	90.7	< *0.20*	530	2.03	< *2.0*
97PCMA1	1.11	< *0.1*	< *0.1*	< 0.5	4.23	99.2	< *0.20*	355	3.09	< *2.0*

Table A-8. Trace Elements in Avian Eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. ***(Page 3 of 9)***

Sample Number	Sample Site Description	Species Code[a]	Ni	Pb	Se	Sr	V	Zn
	Area #2: Antelope Island							
AICT1	Antelope Island South (AS)	AMCO	< *0.5*	< *0.5*	1.5	5.8	< *0.5*	46.5
AIST1	Antelope Island East (AE)	BNST	< *0.5*	< *0.5*	2.8	19.3	< *0.5*	43.7
AIST2	Antelope Island East (AE)	BNST	< *0.5*	< *0.5*	3.2	18.5	< *0.5*	42.7
AIST3	Antelope Island East (AE)	BNST	< *0.5*	< *0.5*	3.6	23.8	< *0.5*	38.6
	Area #3: GSL South Shore							
GSAST1	Saltair/GSL State Park (LS)	BNST	< *0.5*	< *0.5*	5.3	11.6	< *0.5*	43.
GSAST2	Saltair/GSL State Park (LS)	BNST	0.89	< *0.5*	5.4	15.8	0.65	53.1
GSAST3	Saltair/GSL State Park (LS)	BNST	0.79	< *0.5*	7.5	27.	0.68	50.7
97GSST1	Saltair/GSL State Park (LS)	BNST	< *0.5*	< *0.5*	4.12	27.	< *0.5*	55.7
97GSST2	Saltair/GSL State Park (LS)	BNST	< *0.5*	< *0.5*	4.11	31.8	< *0.5*	48.2
97GSST3	Saltair/GSL State Park (LS)	BNST	< *0.5*	< *0.5*	3.67	20.	< *0.5*	46.5
97SPAV1	Saltair/GSL State Park (LS)	AMAV	< *0.5*	< *0.5*	5.9	23.3	< *0.5*	38.8
97SPST1	Saltair/GSL State Park (LS)	BNST	< *0.5*	< *0.5*	6.39	20.5	0.69	50.5
97SPST3	Saltair/GSL State Park (LS)	BNST	< *0.5*	< *0.5*	4.42	50.2	0.68	59.2
97SPCT1	Saltair/GSL State Park (LS)	AMCO	< *0.5*	< *0.5*	3.14	44.6	< *0.5*	82.1
97GSMA1	Saltair/GSL State Park (LS)	MALL	< *0.5*	< *0.5*	5.21	20.6	< *0.5*	72.
97SPMA1	Saltair/GSL State Park (LS)	MALL	< *0.5*	< *0.5*	4.44	45.	0.7	43.2
	Area #4: South Shore Wetlands							
97AMST1	Airport Mitigation Site (SA)	BNST	1.54	< *0.5*	4.12	14.6	< *0.5*	42.5
97AMST2	Airport Mitigation Site (SA)	BNST	< *0.5*	< *0.5*	3.5	10.4	< *0.5*	36.8
97AMST3	Airport Mitigation Site (SA)	BNST	0.95	< *0.5*	4.21	9.14	< *0.5*	37.9
97AMDC1	Airport Mitigation Site (SA)	DCCO	2.93	< *0.5*	3.18	10.8	< *0.5*	53.
97AMMA2	Airport Mitigation Site (SA)	MALL	0.95	< *0.5*	2.86	15.3	< *0.5*	52.9
97AMMA3	Airport Mitigation Site (SA)	MALL	< *0.5*	< *0.5*	2.86	19.8	< *0.5*	59.7
NGAV1	Goggin Drain (SD)	AMAV	< *0.5*	< *0.5*	3.2	11.1	< *0.5*	47.5
97LCSP2	Inland Sea Shorebird Reserve (SI)	SNPL	< *0.5*	< *0.5*	5.34	35.5	< *0.5*	46.1
	Area #5: South Shore Industrially Impacted Wetlands							
BHAV1	Beck Hot Springs (IB)	AMAV	< *0.5*	< *0.5*	4.4	22.7	0.51	48.7
BHAV2	Beck Hot Springs (IB)	AMAV	0.94	< *0.5*	2.5	9.25	0.64	45.6
BHAV3	Beck Hot Springs (IB)	AMAV	< *0.5*	< *0.5*	3.5	9.92	0.87	46.3
WPCT1	SLC Sewage Treatment Plant (IS)	AMCO	0.55	< *0.5*	4.8	12.1	< *0.5*	53.2
WPCT2	SLC Sewage Treatment Plant (IS)	AMCO	0.78	< *0.5*	3.8	10.8	< *0.5*	57.8
WPCT3	SLC Sewage Treatment Plant (IS)	AMCO	0.71	< *0.5*	4.1	6.29	< *0.5*	50.6
97WPCT1	SLC Sewage Treatment Plant (IS)	AMCO	< *0.5*	< *0.5*	3.69	12.5	1.03	49.5
97WPCT2	SLC Sewage Treatment Plant (IS)	AMCO	< *0.5*	< *0.5*	3.65	16.1	< *0.5*	42.9
97WPMA1	SLC Sewage Treatment Plant (IS)	MALL	< *0.5*	< *0.5*	2.38	22.6	< *0.5*	44.6
97PCCT1	Petrochem Ponds (IP)	AMCO	< *0.5*	< *0.5*	1.17	26.2	< *0.5*	57.5
97PCMA1	Petrochem Ponds (IP)	MALL	< *0.5*	0.55	3.37	19.3	< *0.5*	51.7

(a) Avian Species Codes

AMAV = American avocet
AMCO= American Coot
BNST = Black necked stilt
CITE = Cinnamon teal
DCCO = Double-crested cormorant
MALL = Mallard
SNPL = Snowy plover

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Table A-8. Trace Elements in Avian Eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. *(Page 4 of 9)*

Sample Number	Sample Site Description	Species Code[a]	Collection Date	Sample Weight (grams)	% moisture	Al	As	B
	Area #6: Farmington Bay South							
NSCT1	New State Duck Club (FN)	AMCO	5/30/1996	27	82.5	< *5.0*	< *0.5*	< *2.0*
NSCT2	New State Duck Club (FN)	AMCO	5/30/1996	24	81.8	< *5.0*	< *0.5*	< *2.0*
NSST1	New State Duck Club (FN)	BNST	5/30/1996	18	73.8	< *5.0*	< *0.5*	< *2.0*
NSST2	New State Duck Club (FN)	BNST	5/30/1996	21	74.1	< *5.0*	< *0.5*	< *2.0*
NSST3	New State Duck Club (FN)	BNST	5/30/1996	18	74.7	< *5.0*	< *0.5*	< *2.0*
97BPST2	Bountiful Pond (FP)	BNST	6/12/1997	21	75.6	6.36	< *0.5*	< *2.0*
97BPST3	Bountiful Pond (FP)	BNST	6/12/1997	16	75.2	< *5.0*	0.76	< *2.0*
97BPST4	Bountiful Pond (FP)	BNST	6/12/1997	22	74.1	< *5.0*	< *0.5*	< *2.0*
SCCT1	State Canal (FS)	AMCO	6/12/1996	26	76.1	< *5.0*	< *0.5*	< *2.0*
SCCT2	State Canal (FS)	AMCO	6/12/1996	23	75.4	< *5.0*	0.8	< *2.0*
SCCT3	State Canal (FS)	AMCO	6/12/1996	25	81.3	< *5.0*	0.7	< *2.0*
SCST1	State Canal (FS)	BNST	6/12/1996	19	74.6	< *5.0*	0.7	< *2.0*
SCST2	State Canal (FS)	BNST	6/17/1996	20	74.5	< *5.0*	0.6	< *2.0*
SCST3	State Canal (FS)	BNST	6/24/1996	20	74.6	< *5.0*	< *0.5*	< *2.0*
SCTE1	State Canal (FS)	CITE	6/12/1996	25	75.3	< *5.0*	< *0.5*	< *2.0*
CUCT1	FBWMA- Crystal Unit (FC)	AMCO	6/4/1996	26	78.4	< *5.0*	< *0.5*	< *2.0*
CUCT2	FBWMA- Crystal Unit (FC)	AMCO	6/4/1996	25	87.5	< *5.0*	< *0.5*	< *2.0*
CUCT3	FBWMA- Crystal Unit (FC)	AMCO	6/4/1996	22	73.0	< *5.0*	< *0.5*	< *2.0*
97CUCT3	FBWMA- Crystal Unit (FC)	AMCO	6/5/1997	28	73.7	< *5.0*	< *0.5*	< *2.0*
97CUCT4	FBWMA- Crystal Unit (FC)	AMCO	6/5/1997	22	74.3	< *5.0*	1.1	2.91
97CUCT6	FBWMA- Crystal Unit (FC)	AMCO	6/5/1997	25	77.3	< *5.0*	0.89	< *2.0*
CUST1	FBWMA- Crystal Unit (FC)	BNST	6/4/1996	18	78.2	< *5.0*	< *0.5*	< *2.0*
CUST2	FBWMA- Crystal Unit (FC)	BNST	6/4/1996	16	72.1	< *5.0*	< *0.5*	< *2.0*
CUST3	FBWMA- Crystal Unit (FC)	BNST	6/4/1996	17	73.0	< *5.0*	< *0.5*	< *2.0*
97CUST1	FBWMA- Crystal Unit (FC)	BNST	6/19/1997	19	84.8	< *5.0*	< *0.5*	< *2.0*
97CUST4	FBWMA- Crystal Unit (FC)	BNST	7/1/1997	16	76.6	< *5.0*	1.38	< *2.0*
97CUST5	FBWMA- Crystal Unit (FC)	BNST	7/1/1997	14	74.0	9.72	0.57	< *2.0*
97OMST1	NW Oil Drain Delta (FO)	BNST	6/19/1997	21	75.2	< *5.0*	< *0.5*	< *2.0*
97OMST4	NW Oil Drain Delta (FO)	BNST	6/19/1997	16	74.1	5.13	< *0.5*	< *2.0*
	Area #7: Farmington BayNorth							
KCCT1	Kaysville Marsh (FK)	AMCO	5/21/1996	28	83.2	< *5.0*	< *0.5*	< *2.0*
KCCT2	Kaysville Marsh (FK)	AMCO	5/21/1996	24	73.6	< *5.0*	< *0.5*	< *2.0*
KCCT3	Kaysville Marsh (FK)	AMCO	5/21/1996	25	84.2	< *5.0*	< *0.5*	< *2.0*
KCCT4	Kaysville Marsh (FK)	AMCO	5/21/1996	24	80.7	< *5.0*	< *0.5*	< *2.0*
KCST1	Kaysville Marsh (FK)	BNST	5/21/1996	17	74.8	< *5.0*	< *0.5*	< *2.0*
KCST2	Kaysville Marsh (FK)	BNST	5/21/1996	20	72.6	< *5.0*	< *0.5*	< *2.0*
KCST3	Kaysville Marsh (FK)	BNST	5/21/1996	19	74.4	< *5.0*	< *0.5*	< *2.0*

(a) Avian Species Codes

- AMAV = American avocet
- AMCO= American Coot
- BNST = Black necked stilt
- CITE = Cinnamon teal
- DCCO = Double-crested cormorant
- MALL = Mallard
- SNPL = Snowy plover

Table A-8. (Continued) *(Page 5of 9)*

Sample Number	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni
NSCT1	4.42	< *0.1*	< *0.1*	< *0.5*	2.85	118.	0.1	467	< *1.0*	< *2.0*	< *0.5*
NSCT2	3.85	< *0.1*	< *0.1*	< *0.5*	1.77	99.	0.11	461	1.23	< *2.0*	< *0.5*
NSST1	2.25	< *0.1*	< *0.1*	< *0.5*	2.68	89.4	0.68	448	1.33	< *2.0*	< *0.5*
NSST2	1.38	< *0.1*	< *0.1*	< *0.5*	2.88	119.	0.75	368	1	< *2.0*	< *0.5*
NSST3	1.86	< *0.1*	< *0.1*	< *0.5*	2.63	105.	0.19	432	1.46	< *2.0*	< *0.5*
97BPST2	6.97	< *0.1*	< *0.1*	< *0.5*	3.44	119.	0.628	362	1.66	< *2.0*	< *0.5*
97BPST3	1.32	< *0.1*	< *0.1*	0.56	3.48	83.4	0.377	326	1.7	< *2.0*	0.7
97BPST4	2.09	< *0.1*	< *0.1*	< *0.5*	2.49	91.	0.296	381	1.05	< *2.0*	< *0.5*
SCCT1	3.38	< *0.1*	< *0.1*	< *0.5*	2.98	103.	0.16	436	1.25	< *2.0*	< *0.5*
SCCT2	4.75	< *0.1*	< *0.1*	< *0.5*	2.83	104.	0.21	747	1.22	< *2.0*	< *0.5*
SCCT3	3.49	< *0.1*	< *0.1*	< *0.5*	2.55	113.	0.12	504	1.62	< *2.0*	< *0.5*
SCST1	2.36	< *0.1*	< *0.1*	< *0.5*	3.15	105.	0.58	390	1.43	< *2.0*	< *0.5*
SCST2	4.21	< *0.1*	< *0.1*	< *0.5*	2.61	124.	0.32	351	< *1.0*	< *2.0*	0.53
SCST3	4.23	< *0.1*	< *0.1*	< *0.5*	2.41	116.	0.62	422	1.01	< *2.0*	< *0.5*
SCTE1	11.5	< *0.1*	< *0.1*	< *0.5*	1.34	107.	0.31	288	1.97	< *2.0*	< *0.5*
CUCT1	3.27	< *0.1*	< *0.1*	< *0.5*	2.74	100.	5.99	495	1.11	< *2.0*	< *0.5*
CUCT2	3.85	< *0.1*	< *0.1*	< *0.5*	2.37	109.	3.76	401	< *1.0*	< *2.0*	< *0.5*
CUCT3	4.57	< *0.1*	< *0.1*	< *0.5*	2.11	105.	2.78	513	1.41	< *2.0*	< *0.5*
97CUCT3	4.17	< *0.1*	< *0.1*	< *0.5*	2.83	102.	1.11	415	1.36	< *2.0*	< *0.5*
97CUCT4	7.99	< *0.1*	0.48	0.66	3.83	89.7	1.26	563	2.23	< *2.0*	< *0.5*
97CUCT6	3.67	< *0.1*	< *0.1*	< *0.5*	2.82	60.1	1.32	521	< *1.0*	< *2.0*	< *0.5*
CUST1	2.18	< *0.1*	< *0.1*	< *0.5*	2.65	99.3	4.6	391	1.05	< *2.0*	< *0.5*
CUST2	1.57	< *0.1*	< *0.1*	< *0.5*	3.04	92.2	2.11	351	< *1.0*	< *2.0*	< *0.5*
CUST3	1.59	< *0.1*	< *0.1*	< *0.5*	2.62	67.7	0.86	298	1.02	< *2.0*	< *0.5*
97CUST1	3.05	< *0.1*	< *0.1*	< *0.5*	3.13	89.2	1.37	368	1.38	< *2.0*	< *0.5*
97CUST4	4.12	< *0.1*	0.43	< *0.5*	3.19	91.6	1.4	447	1.71	< *2.0*	< *0.5*
97CUST5	3.77	< *0.1*	< *0.1*	0.77	3.02	89.	0.94	415	1.45	< *2.0*	< *0.5*
97OMST1	2.45	< *0.1*	< *0.1*	< *0.5*	3.2	109.	0.739	365	1.14	< *2.0*	< *0.5*
97OMST4	4.39	< *0.1*	< *0.1*	0.79	2.92	104.	0.377	346	1.21	< *2.0*	< *0.5*
KCCT1	4.7	< *0.1*	< *0.1*	< *0.5*	2.18	85.6	0.19	476	1.14	< *2.0*	< *0.5*
KCCT2	2.29	< *0.1*	< *0.1*	< *0.5*	2.03	94.3	0.24	455	1.68	< *2.0*	< *0.5*
KCCT3	5.99	< *0.1*	< *0.1*	< *0.5*	2.11	105.	0.28	379	1.22	< *2.0*	< *0.5*
KCCT4	5.28	< *0.1*	< *0.1*	< *0.5*	1.77	92.9	0.27	428	1.63	< *2.0*	< *0.5*
KCST1	2.92	0.19	< *0.1*	< *0.5*	2.95	128.	1.47	377	1.11	< *2.0*	< *0.5*
KCST2	5.46	< *0.1*	< *0.1*	< *0.5*	2.5	99.6	0.37	385	< *1.0*	< *2.0*	< *0.5*
KCST3	5.69	< *0.1*	< *0.1*	< *0.5*	2.8	107.	0.25	334	< *1.0*	< *2.0*	< *0.5*

Table A-8. Trace Elements in Avian Eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. ***(Page 6 of 9)***

Sample Number	Sample Site Description	Species Code[(a)]		Pb	Se	Sr		V	Zn
	Area #6: Farmington Bay South								
NSCT1	New State Duck Club (FN)	AMCO	<	*0.5*	2.8	11.4	<	*0.5*	66.6
NSCT2	New State Duck Club (FN)	AMCO	<	*0.5*	2.1	11.5	<	*0.5*	47.9
NSST1	New State Duck Club (FN)	BNST	<	*0.5*	4.6	8.61	<	*0.5*	43.8
NSST2	New State Duck Club (FN)	BNST	<	*0.5*	4.7	7.	<	*0.5*	50.2
NSST3	New State Duck Club (FN)	BNST	<	*0.5*	3.9	8.13	<	*0.5*	46.3
97BPST2	Bountiful Pond (FP)	BNST	<	*0.5*	2.73	10.2	<	*0.5*	63.6
97BPST3	Bountiful Pond (FP)	BNST	<	*0.5*	3.1	6.33	<	*0.5*	38.9
97BPST4	Bountiful Pond (FP)	BNST	<	*0.5*	4.05	7.27	<	*0.5*	44.6
SCCT1	State Canal (FS)	AMCO	<	*0.5*	2.3	5.62	<	*0.5*	57.
SCCT2	State Canal (FS)	AMCO	<	*0.5*	4.	8.43	<	*0.5*	45.4
SCCT3	State Canal (FS)	AMCO		*0.6*	2.9	5.46	<	*0.5*	60.8
SCST1	State Canal (FS)	BNST	<	*0.5*	4.6	8.09	<	*0.5*	52.8
SCST2	State Canal (FS)	BNST	<	*0.5*	4.1	7.26	<	*0.5*	49.6
SCST3	State Canal (FS)	BNST	<	*0.5*	4.5	9.1	<	*0.5*	47.4
SCTE1	State Canal (FS)	CITE	<	*0.5*	2.9	6.55	<	*0.5*	48.5
CUCT1	FBWMA- Crystal Unit (FC)	AMCO	<	*0.5*	2.4	10.8		0.95	58.
CUCT2	FBWMA- Crystal Unit (FC)	AMCO	<	*0.5*	2.9	10.1	<	*0.5*	62.2
CUCT3	FBWMA- Crystal Unit (FC)	AMCO	<	*0.5*	2.3	12.2	<	*0.5*	52.3
97CUCT3	FBWMA- Crystal Unit (FC)	AMCO	<	*0.5*	1.9	14.2	<	*0.5*	78.4
97CUCT4	FBWMA- Crystal Unit (FC)	AMCO	<	*0.5*	2.55	29.3	<	*0.5*	76.
97CUCT6	FBWMA- Crystal Unit (FC)	AMCO	<	*0.5*	1.99	12.	<	*0.5*	52.3
CUST1	FBWMA- Crystal Unit (FC)	BNST	<	*0.5*	4.1	9.8	<	*0.5*	44.9
CUST2	FBWMA- Crystal Unit (FC)	BNST	<	*0.5*	3.8	7.81	<	*0.5*	44.
CUST3	FBWMA- Crystal Unit (FC)	BNST	<	*0.5*	2.9	8.92	<	*0.5*	36.2
97CUST1	FBWMA- Crystal Unit (FC)	BNST	<	*0.5*	3.42	16.4	<	*0.5*	43.7
97CUST4	FBWMA- Crystal Unit (FC)	BNST	<	*0.5*	3.36	18.1	<	*0.5*	50.7
97CUST5	FBWMA- Crystal Unit (FC)	BNST	<	*0.5*	2.13	18.6	<	*0.5*	57.
97OMST1	NW Oil Drain Delta (FO)	BNST	<	*0.5*	2.58	18.2	<	*0.5*	41.7
97OMST4	NW Oil Drain Delta (FO)	BNST	<	*0.5*	2.67	12.5	<	*0.5*	48.8
	Area #7: Farmington BayNorth								
KCCT1	Kaysville Marsh (FK)	AMCO	<	*0.5*	1.6	5.51	<	*0.5*	49.8
KCCT2	Kaysville Marsh (FK)	AMCO	<	*0.5*	1.7	4.21	<	*0.5*	48.2
KCCT3	Kaysville Marsh (FK)	AMCO	<	*0.5*	1.4	4.66	<	*0.5*	53.8
KCCT4	Kaysville Marsh (FK)	AMCO	<	*0.5*	1.5	5.52	<	*0.5*	48.2
KCST1	Kaysville Marsh (FK)	BNST	<	*0.5*	3.1	8.46	<	*0.5*	51.8
KCST2	Kaysville Marsh (FK)	BNST	<	*0.5*	2.4	6.69	<	*0.5*	45.5
KCST3	Kaysville Marsh (FK)	BNST	<	*0.5*	2.5	6.85	<	*0.5*	48.

(a) Avian Species Codes

AMAV = American avocet
AMCO= American Coot
BNST = Black necked stilt
CITE = Cinnamon teal
DCCO = Double-crested cormorant
MALL = Mallard
SNPL = Snowy plover

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Table A-8. Trace Elements in Avian Eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. *(Page 7 of 9)*

Sample Number	Sample Site Description	Species Code[a]	Collection Date	Sample Weight (grams)	% moisture	Al	As	B
	Area #8: Ogden Bay							
97HSCT1	Howard Slough (OH)	AMCO	6/2/1997	24	75.7	< *5.0*	0.5	< *2.0*
97HSCT2	Howard Slough (OH)	AMCO	6/2/1997	28	75.5	< *5.0*	< *0.5*	< *2.0*
97HSCT3	Howard Slough (OH)	AMCO	6/2/1997	23	75.2	894	< *0.5*	< *2.0*
97HSST1	Howard Slough (OH)	BNST	6/11/1997	19	74.8	< *5.0*	< *0.5*	< *2.0*
97HSST2	Howard Slough (OH)	BNST	6/30/1997	17	74.3	< *5.0*	0.84	< *2.0*
97HSST3	Howard Slough (OH)	BNST	6/30/1997	20	73.5	< *5.0*	< *0.5*	< *2.0*
OSCT1	Ogden Bay WMA- South (OS)	AMCO	6/25/1996	27	81.0	< *5.0*	< *0.5*	< *2.0*
OSCT2	Ogden Bay WMA- South (OS)	AMCO	6/25/1996	27	75.3	< *5.0*	0.6	< *2.0*
OSCT3	Ogden Bay WMA- South (OS)	AMCO	6/25/1996	22	74.6	< *5.0*	0.6	< *2.0*
OSST1	Ogden Bay WMA- South (OS)	BNST	6/25/1996	19	71.2	< *5.0*	< *0.5*	< *2.0*
OSST2	Ogden Bay WMA- South (OS)	BNST	6/25/1996	20	73.6	< *5.0*	< *0.5*	< *2.0*
OSST3	Ogden Bay WMA- South (OS)	BNST	6/25/1996	18	74.5	< *5.0*	< *0.5*	< *2.0*
OBCT1	Ogden Bay WMA- North (ON)	AMCO	6/6/1996	25	74.7	< *5.0*	0.7	< *2.0*
OBCT2	Ogden Bay WMA- North (ON)	AMCO	6/6/1996	25	74.6	< *5.0*	< *0.5*	< *2.0*
OBCT3	Ogden Bay WMA- North (ON)	AMCO	6/7/1996	26	75.7	< *5.0*	< *0.5*	< *2.0*
OBMA1	Ogden Bay WMA- North (ON)	MALL	6/6/1996	50	85.0	< *5.0*	< *0.5*	< *2.0*
OBMA2	Ogden Bay WMA- North (ON)	MALL	6/6/1996	44	75.7	< *5.0*	< *0.5*	< *2.0*

(a) Avian Species Codes

- AMAV = American avocet
- AMCO= American Coot
- BNST = Black necked stilt
- CITE = Cinnamon teal
- DCCO = Double-crested cormorant
- MALL = Mallard
- SNPL = Snowy plover

Table A-8. (Continued) *(Page 8 of 9)*

Sample Number	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni
97HSCT1	4.59	< *0.1*	< *0.1*	0.53	2.19	98.5	< *0.20*	616	1.25	< *2.0*	< *0.5*
97HSCT2	2.08	< *0.1*	< *0.1*	< *0.5*	2.17	68.1	0.25	360	1.46	< *2.0*	< *0.5*
97HSCT3	9.6	< *0.1*	< *0.1*	12.3	4.97	286.	0.268	401	2.48	< *2.0*	3.52
97HSST1	10.9	< *0.1*	< *0.1*	1.61	3.03	179.	0.712	425	1.88	< *2.0*	< *0.5*
97HSST2	2.95	< *0.1*	< *0.1*	< *0.5*	3.36	99.1	1.49	353	1.36	< *2.0*	< *0.5*
97HSST3	4.62	< *0.1*	< *0.1*	< *0.5*	3.67	97.8	0.601	437	1.63	< *2.0*	< *0.5*
OSCT1	8.44	< *0.1*	< *0.1*	< *0.5*	2.12	91.5	0.7	415	2.35	< *2.0*	< *0.5*
OSCT2	5.26	< *0.1*	< *0.1*	< *0.5*	2.42	82.5	0.71	411	1.18	< *2.0*	< *0.5*
OSCT3	9.43	< *0.1*	< *0.1*	0.75	2.22	107.	0.72	419	1.63	< *2.0*	< *0.5*
OSST1	3.14	0.21	< *0.1*	< *0.5*	3.73	112.	0.62	360	1.89	< *2.0*	< *0.5*
OSST2	5.43	< *0.1*	< *0.1*	< *0.5*	3.12	96.3	1.14	394	< *1.0*	< *2.0*	< *0.5*
OSST3	2.7	< *0.1*	< *0.1*	< *0.5*	2.81	119.	0.75	375	< *1.0*	< *2.0*	0.55
OBCT1	12.8	< *0.1*	< *0.1*	0.54	2.22	96.7	0.11	401	< *1.0*	< *2.0*	< *0.5*
OBCT2	4.79	< *0.1*	< *0.1*	< *0.5*	3.	79.3	0.1	437	< *1.0*	< *2.0*	< *0.5*
OBCT3	8.17	< *0.1*	< *0.1*	0.52	1.64	121.	0.05	476	< *1.0*	< *2.0*	< *0.5*
OBMA1	5.31	< *0.1*	< *0.1*	< *0.5*	3.13	101.	0.33	329	1.1	< *2.0*	< *0.5*
OBMA2	17.2	< *0.1*	< *0.1*	< *0.5*	3.13	106.	0.19	350	1.51	< *2.0*	< *0.5*

Table A-8. Trace Elements in Avian Eggs, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) dry weight; non-detected elements shown in italics. ***(Page 9 of 9)***

Sample Number	Sample Site Description	Species Code[a]		Ni		Pb	Se	Sr		V	Zn
	Area #8: Ogden Bay										
97HSCT1	Howard Slough (OH)	AMCO	<	*0.5*	<	*0.5*	1.37	7.16	<	*0.5*	52.9
97HSCT2	Howard Slough (OH)	AMCO	<	*0.5*	<	*0.5*	1.16	3.47		0.79	34.9
97HSCT3	Howard Slough (OH)	AMCO		3.52	<	*0.5*	1.49	7.26	<	*0.5*	59.
97HSST1	Howard Slough (OH)	BNST	<	*0.5*	<	*0.5*	1.65	20.3	<	*0.5*	43.8
97HSST2	Howard Slough (OH)	BNST	<	*0.5*	<	*0.5*	2.13	9.74	<	*0.5*	37.
97HSST3	Howard Slough (OH)	BNST	<	*0.5*	<	*0.5*	2.26	17.8	<	*0.5*	41.9
OSCT1	Ogden Bay WMA- South (OS)	AMCO	<	*0.5*	<	*0.5*	1.1	5.1	<	*0.5*	65.8
OSCT2	Ogden Bay WMA- South (OS)	AMCO	<	*0.5*	<	*0.5*	1.2	3.14	<	*0.5*	60.
OSCT3	Ogden Bay WMA- South (OS)	AMCO	<	*0.5*	<	*0.5*	0.9	3.12	<	*0.5*	62.3
OSST1	Ogden Bay WMA- South (OS)	BNST	<	*0.5*	<	*0.5*	2.8	8.55	<	*0.5*	55.4
OSST2	Ogden Bay WMA- South (OS)	BNST	<	*0.5*	<	*0.5*	2.6	7.84	<	*0.5*	49.3
OSST3	Ogden Bay WMA- South (OS)	BNST		0.55	<	*0.5*	3.2	7.81		0.55	54.8
OBCT1	Ogden Bay WMA- North (ON)	AMCO	<	*0.5*	<	*0.5*	1.6	4.05	<	*0.5*	50.
OBCT2	Ogden Bay WMA- North (ON)	AMCO	<	*0.5*	<	*0.5*	1.3	4.71	<	*0.5*	48.2
OBCT3	Ogden Bay WMA- North (ON)	AMCO	<	*0.5*	<	*0.5*	1.3	4.9	<	*0.5*	54.2
OBMA1	Ogden Bay WMA- North (ON)	MALL	<	*0.5*	<	*0.5*	1.7	3.84	<	*0.5*	52.
OBMA2	Ogden Bay WMA- North (ON)	MALL	<	*0.5*	<	*0.5*	1.4	5.34	<	*0.5*	64.9

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AMAV = American avocet
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Table A-9. Organic Chemicals in Avian Eggs: Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs), Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) wet weight; detected concentations shown in bold type. ***(Page 1 of 5)***

Sample Number	Location Description	Species Code[a]	Collection Date	Sample Weight (grams)	% Lipid	% Moisture		Aldrin
	Area #2- Antelope Island							
AIST3	Antelope Island East (AE)	BNST	6/21/1996	19	0.92	73	<	0.000928
AICT1	Antelope Island South (AS)	AMCO	6/21/1996	23	0.53	76.6	<	0.000942
	Area #3- GSL-South Shore							
GSAST1	Saltair/GSL State Park (LS)	BNST	5/14/1996	19	0.64	75.9		**0.0012**
	Area #4- South Shore Wetlands							
97AMDC1	Airport Mitigation Site (SA)	DCCO	5/21/1997	42	5.37	77.6	<	0.00185
97AMMA2	Airport Mitigation Site (SA)	MALL	5/21/1997	36	11.6	66.7	<	0.00166
97AMST1	Airport Mitigation Site (SA)	BNST	5/21/1997	16	8.5	70.7	<	0.0019
NGAV1	Gillmor Sanctuary (SG)	AMAV	6/11/1996	26	0.6	76.2	<	0.000989
97LCSP2	Inland Sea Shorebird Reserve (SI)	SNPL	7/22/1997	7	9.79	70	<	0.00181
	Area #5- SE Shore Industrially Impacted Wetlands							
BHAV2	Beck Hot Springs (IB)	AMAV	6/11/1996	25	0.73	75.2	<	0.000946
97PCCT1	Petrochem Ponds (IP)	AMCO	5/28/1997	24	7.18	75.7	<	0.00172
97PCMA1	Petrochem Ponds (IP)	MALL	6/10/1997	38	11	66.8	<	0.00193
97WPCT1	SLC Sewage Treatment Plant (IS)	AMCO	6/17/1997	26	7.08	75.4	<	0.00186
97WPCT2	SLC Sewage Treatment Plant (IS)	AMCO	6/17/1997	28	5.15	77.6	<	0.00185
97WPMA1	SLC Sewage Treatment Plant (IS)	AMCO	6/12/1997	55	10.6	69.4	<	0.00187
WPCT3	SLC Sewage Treatment Plant (IS)	AMCO	6/13/1996	25	0.56	76	<	0.00098
	Area #6- Farmington Bay South							
97BPST3	Bountiful Pond (FP)	BNST	6/12/1997	16	6.85	74.5	<	0.00198
97CUCT6	FBWMA- Crystal Unit (FC)	AMCO	6/5/1997	25	5.29	77.9	<	0.00191
97CUST5	FBWMA- Crystal Unit (FC)	BNST	7/1/1997	14	7.92	73.9	<	0.00183
CUCT3	FBWMA- Crystal Unit (FC)	AMCO	6/4/1996	22	0.63	76.2	<	0.000863
CUST2	FBWMA- Crystal Unit (FC)	BNST	6/4/1996	16	1.08	73.4	<	0.000748
CUST3	FBWMA- Crystal Unit (FC)	BNST	6/4/1996	17	0.99	72.6	<	0.000855
NSCT3	FBWMA- Crystal Unit (FC)	AMCO	5/30/1996	29	0.57	77.3	<	0.000892
NSST3	New State Duck Club (FN)	BNST	5/30/1996	18	0.94	74.1	<	0.000885
97OMST3	NW Oil Drain Delta (FO)	BNST	6/19/1997	18	7.83	73.4	<	0.00192
SCCT1	State Canal (FS)	AMCO	6/12/1996	26	0.65	75.3	<	0.000948
SCST3	State Canal (FS)	BNST	6/24/1996	20	0.6	75	<	0.000997
	Area #7- Farmington Bay North							
97KCCT1	Kaysville Marsh (FK)	AMCO	6/4/1997	29	7.92	73.4	<	0.0019
97KCST1	Kaysville Marsh (FK)	BNST	6/4/1997	23	7.87	75.4	<	0.00185
97KCST2	Kaysville Marsh (FK)	BNST	6/4/1997	22	7.36	73	<	0.00193
KCCT2	Kaysville Marsh (FK)	AMCO	5/21/1996	24	0.64	76.7	<	0.000939
KCST2	Kaysville Marsh (FK)	BNST	5/21/1996	20	0.66	76.7	<	0.000951
	Area #8- Ogden Bay							
97HSCT2	Howard Slough (OH)	AMCO	6/2/1997	28	6.83	74.7	<	0.00192
97HSST2	Howard Slough (OH)	BNST	6/30/1997	17	7.92	74.8	<	0.00186
OBCT1	Ogden Bay WMA- North (ON)	AMCO	6/6/1996	25	0.73	76.5	<	0.000794
OSCT3	Ogden Bay WMA- South (OS)	AMCO	6/25/1996	22	0.82	75	<	0.00088
OSST2	Ogden Bay WMA- South (OS)	BNST	6/25/1996	20	0.9	74.1	<	0.000915

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Analyzed but not detected (not shown on table): Heptachlor, alpha BHC, delta BHC

Table A-9 (Continued) (*Page 2 of 5*)

Sample Number	dieldrin	endrin	beta BHC	gamma BHC	alpha chlordane	gamma chlordane	oxy chlordane
AIST3	**0.0024**	< 0.00093	< 0.000928	< 0.000928	< 0.000928	< 0.00093	**0.008**
AICT1	< 0.000942	< 0.00094	< 0.000942	< 0.000942	< 0.000942	< 0.00094	< 0.000942
GSAST1	**0.0256**	**0.0014**	< 0.000976	< 0.000976	**0.0017**	< 0.00098	**0.0121**
97AMDC1	< 0.00185	**0.0025**	**0.0031**	< 0.00185	< 0.00185	**0.002**	**0.0025**
97AMMA2	**0.0038**	**0.0041**	< 0.00166	< 0.00166	< 0.00166	**0.0022**	**0.0085**
97AMST1	**0.0088**	**0.0061**	**0.0299**	< 0.0019	< 0.0019	< 0.0019	**0.0115**
NGAV1	**0.0198**	< 0.00099	**0.0013**	< 0.000989	**0.0026**	< 0.00099	**0.0149**
97LCSP2	**0.0031**	**0.0021**	< **0.00181**	< 0.00181	**0.0025**	< 0.00181	**0.0055**
BHAV2	**0.106**	< 0.00095	**0.001**	< 0.000946	**0.0039**	**0.0033**	**0.0124**
97PCCT1	**0.0038**	**0.0025**	< 0.00172	< 0.00172	< 0.00172	< 0.00172	**0.0024**
97PCMA1	< 0.00193	< 0.00193	< 0.00193	< 0.00193	< 0.00193	< 0.00193	**0.0033**
97WPCT1	**0.0111**	**0.0172**	< 0.00186	< 0.00186	< 0.00186	< 0.00186	**0.0082**
97WPCT2	**0.0059**	**0.0036**	< 0.00185	< 0.00185	**0.0023**	< 0.00185	**0.006**
97WPMA1	< 0.00187	< 0.00187	< 0.00187	< 0.00187	< 0.00187	< 0.00187	< 0.00187
WPCT3	**0.0071**	< 0.00098	< 0.00098	< 0.00098	< 0.00098	< 0.00098	**0.013**
97BPST3	**0.0039**	**0.0033**	< 0.00198	< 0.00198	< 0.00198	< 0.00198	**0.0029**
97CUCT6	< 0.00191	**0.0037**	< 0.00191	< 0.00191	**0.0021**	< 0.00191	**0.002**
97CUST5	< 0.00183	**0.0023**	< 0.00183	< 0.00183	< 0.00183	< 0.00183	< 0.00183
CUCT3	**0.0201**	< 0.00086	< 0.000863	< 0.000863	**0.0018**	< 0.00086	**0.011**
CUST2	**0.0092**	**0.0009**	**0.0045**	< 0.000748	**0.0008**	< 0.00075	**0.0102**
CUST3	**0.0105**	< 0.00086	**0.0018**	< 0.000855	**0.0018**	< 0.00086	**0.0085**
NSCT3	**0.0124**	< 0.00089	< 0.000892	< 0.000892	< 0.000892	< 0.00089	**0.01**
NSST3	**0.0262**	< 0.00089	**0.0022**	< 0.000885	**0.0042**	< 0.00089	**0.0228**
97OMST3	< 0.00192	< 0.00192	< 0.00192	< 0.00192	< 0.00192	< 0.00192	< 0.00192
SCCT1	**0.013**	< 0.00095	< 0.000948	< 0.000948	< 0.000948	< 0.00095	**0.0121**
SCST3	< 0.000997	< 0.001	< 0.000997	< 0.000997	< 0.000997	< 0.001	**0.0031**
97KCCT1	< 0.0019	**0.0042**	< 0.0019	< 0.0019	< 0.0019	< 0.0019	**0.0041**
97KCST1	< 0.00185	**0.0029**	**0.0032**	< 0.00185	< 0.00185	< 0.00185	**0.0028**
97KCST2	**0.0064**	< 0.00193	< 0.00193	< 0.00193	< 0.00193	< 0.00193	**0.0054**
KCCT2	**0.0031**	< 0.00094	< 0.000939	< 0.000939	< 0.000939	< 0.00094	**0.007**
KCST2	**0.041**	< 0.00095	**0.0122**	**0.0014**	**0.005**	< 0.00095	**0.0119**
97HSCT2	< 0.00192	**0.0039**	< 0.00192	< 0.00192	< 0.00192	< 0.00192	**0.004**
97HSST2	**0.0022**	**0.0019**	< 0.00186	< 0.00186	< 0.00186	< 0.00186	**0.0024**
OBCT1	**0.0021**	< 0.00079	< 0.000794	< 0.000794	< 0.000794	< 0.00079	**0.0061**
OSCT3	< 0.00088	< 0.00088	< 0.00088	< 0.00088	< 0.00088	< 0.00088	**0.0036**
OSST2	**0.0077**	< 0.00092	**0.0027**	< 0.000915	< 0.000915	< 0.00092	**0.0051**

Table A-9. Organic Chemicals in Avian Eggs: Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs), Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) wet weight; detected concentations shown in bold type. ***(Page 3 of 5)***

Sample Number	Location Description	Species Code[a]	heptachlor epoxide	cis-nonachlor	trans-nonachlor	endosulfan II
	Area #2- Antelope Island					
AIST3	Antelope Island East (AE)	BNST	< **0.0015**	< 0.000928	**0.0017**	< 0.00186
AICT1	Antelope Island South (AS)	AMCO	< 0.000942	< 0.000942	< 0.00094	< 0.00188
	Area #3- GSL-South Shore					
GSAST1	Saltair/GSL State Park (LS)	BNST	< **0.0032**	**0.0022**	**0.0045**	< 0.00195
	Area #4- South Shore Wetlands					
97AMDC1	Airport Mitigation Site (SA)	DCCO	**0.0019**	**0.01**	**0.0169**	< 0.0037
97AMMA2	Airport Mitigation Site (SA)	MALL	0.00166	**0.0027**	**0.0072**	< 0.00332
97AMST1	Airport Mitigation Site (SA)	BNST	< **0.0043**	**0.0041**	**0.0032**	< 0.0038
NGAV1	Gillmor Sanctuary (SG)	AMAV	< **0.0024**	**0.0112**	**0.0049**	**0.0024**
97LCSP2	Inland Sea Shorebird Reserve (SI)	SNPL	< 0.00181	< 0.00181	**0.0028**	< 0.00363
	Area #5- SE Shore Industrially Impacted Wetlands					
BHAV2	Beck Hot Springs (IB)	AMAV	**0.0031**	**0.0069**	**0.0086**	**0.0029**
97PCCT1	Petrochem Ponds (IP)	AMCO	< 0.00172	< 0.00172	< 0.00172	< 0.00344
97PCMA1	Petrochem Ponds (IP)	MALL	< 0.00193	< 0.00193	**0.0021**	< 0.00385
97WPCT1	SLC Sewage Treatment Plant (IS)	AMCO	< **0.002**	< 0.00186	< 0.00186	< 0.00372
97WPCT2	SLC Sewage Treatment Plant (IS)	AMCO	< 0.00185	< 0.00185	< 0.00185	< 0.0037
97WPMA1	SLC Sewage Treatment Plant (IS)	MALL	< 0.00187	< 0.00187	**0.0021**	< 0.00374
WPCT3	SLC Sewage Treatment Plant (IS)	AMCO	< **0.0037**	< 0.00098	< 0.00098	< 0.00196
	Area #6- Farmington Bay South					
97BPST3	Bountiful Pond (FP)	BNST	< 0.00198	< 0.00198	< 0.00198	< 0.00397
97CUCT6	FBWMA- Crystal Unit (FC)	AMCO	< 0.00191	< 0.00191	< 0.00191	< 0.00382
97CUST5	FBWMA- Crystal Unit (FC)	BNST	< 0.00183	< 0.00183	< 0.00183	< 0.00366
CUCT3	FBWMA- Crystal Unit (FC)	AMCO	< **0.0048**	**0.0042**	**0.007**	**0.0018**
CUST2	FBWMA- Crystal Unit (FC)	BNST	< **0.0044**	**0.0025**	**0.0033**	**0.0023**
CUST3	FBWMA- Crystal Unit (FC)	BNST	< **0.0026**	**0.0042**	**0.0059**	**0.0025**
NSCT3	FBWMA- Crystal Unit (FC)	AMCO	< **0.0012**	< 0.000892	< 0.00089	< 0.00178
NSST3	New State Duck Club (FN)	BNST	< **0.0025**	**0.0073**	**0.0143**	**0.0044**
97OMST3	NW Oil Drain Delta (FO)	BNST	< 0.00192	< 0.00192	< 0.00192	< 0.00385
SCCT1	State Canal (FS)	AMCO	< **0.0015**	**0.0013**	< 0.00095	< 0.0019
SCST3	State Canal (FS)	BNST	< **0.0012**	< 0.000997	< 0.001	< 0.00199
	Area #7- Farmington Bay North					
97KCCT1	Kaysville Marsh (FK)	AMCO	< 0.0019	< 0.0019	< 0.0019	< 0.00381
97KCST1	Kaysville Marsh (FK)	BNST	< 0.00185	< 0.00185	< 0.00185	< 0.0037
97KCST2	Kaysville Marsh (FK)	BNST	< 0.00193	< 0.00193	< 0.00193	< 0.00387
KCCT2	Kaysville Marsh (FK)	AMCO	< **0.0021**	**0.001**	< 0.00094	< 0.00188
KCST2	Kaysville Marsh (FK)	BNST	< **0.0067**	**0.0298**	< 0.00095	0.0429
	Area #8- Ogden Bay					
97HSCT2	Howard Slough (OH)	AMCO	< 0.00192	< 0.00192	< 0.00192	< 0.00383
97HSST2	Howard Slough (OH)	BNST	< 0.00186	< 0.00186	< 0.00186	< 0.00372
OBCT1	Ogden Bay WMA- North (ON)	AMCO	< **0.0016**	**0.0008**	< 0.00079	< 0.00159
OSCT3	Ogden Bay WMA- South (OS)	AMCO	< **0.0018**	< 0.00088	< 0.00088	< 0.00176
OSST2	Ogden Bay WMA- South (OS)	BNST	< **0.0016**	**0.0013**	**0.0019**	< 0.00183

(a) Avian Species Codes

AMAV = American avocet
BNST = Black necked stilt
DCCO = Double-crested cormorant
AMCO= American Coot
CITE = Cinnamon teal
MALL = Mallard
SNPL = Snowy plover

Analyzed but not detected (not shown on table): Heptachlor, alpha BHC, delta BHC

Table A-9 (Continued) (*Page 4 of 5*)

Sample Number	HCB	mirex	o,p'-DDD	p,p'-DDD	o,p'-DDE	p,p'-DDE	o,p'-DDT	p,p'-DDT
AIST3	**0.0015**	< 0.000928	< 0.001	< 0.001	< 0.001	**0.068**	**0.005**	< 0.001
AICT1	< 0.000942	< 0.000942	< 0.001	< 0.001	< 0.001	**0.035**	< 0.001	< 0.001
GSAST1	**0.0049**	< 0.000976	< 0.001	**0.009**	**0.002**	**0.261**	**0.003**	**0.035**
97AMDC1	**0.005**	< 0.00185	**0.005**	**0.088**	< 0.002	**0.694**	**0.005**	**0.005**
97AMMA2	**0.0035**	< 0.00166	< 0.002	**0.010**	< 0.002	**0.194**	< 0.002	**0.003**
97AMST1	**0.0088**	< 0.0019	< 0.002	**0.007**	< 0.002	**1.870**	**0.002**	**0.006**
NGAV1	**0.0054**	**0.001**	**0.002**	**0.014**	< 0.001	**0.324**	**0.010**	**0.002**
97LCSP2	**0.0025**	< 0.00181	< 0.002	**0.008**	< 0.002	**0.039**	< 0.002	< 0.002
BHAV2	**0.004**	< 0.000946	**0.008**	**0.053**	**0.002**	**0.197**	**0.007**	< 0.001
97PCCT1	< 0.00172	< 0.00172	< 0.002	< 0.002	< 0.002	**0.008**	< 0.002	< 0.002
97PCMA1	< 0.00193	< 0.00193	< 0.002	< 0.002	< 0.002	**0.101**	< 0.002	< 0.002
97WPCT1	**0.0036**	< 0.00186	< 0.002	< 0.002	< 0.002	**0.021**	**0.002**	**0.007**
97WPCT2	**0.0033**	< 0.00185	< 0.002	< 0.002	< 0.002	**0.016**	< 0.002	< 0.002
97WPMA1	< 0.00187	< 0.00187	< 0.002	< 0.002	< 0.002	**0.009**	< 0.002	< 0.002
WPCT3	**0.0054**	< 0.00098	< 0.001	< 0.001	< 0.001	**0.043**	**0.001**	< 0.001
97BPST3	< 0.00198	< 0.00198	< 0.002	**0.004**	< 0.002	**0.147**	< 0.002	**0.003**
97CUCT6	< 0.00191	< 0.00191	< 0.002	< 0.002	< 0.002	**0.028**	< 0.002	< 0.002
97CUST5	**0.0027**	< 0.00183	< 0.002	< 0.002	< 0.002	**0.098**	< 0.002	< 0.002
CUCT3	**0.0074**	< 0.000863	< 0.001	**0.008**	**0.001**	**0.243**	**0.005**	**0.001**
CUST2	**0.0068**	< 0.000748	**0.001**	**0.003**	**0.001**	**0.213**	**0.004**	**0.003**
CUST3	**0.0034**	< 0.000855	< 0.001	**0.010**	**0.001**	**0.474**	**0.005**	**0.039**
NSCT3	**0.0022**	< 0.000892	**0.001**	< 0.001	< 0.001	**0.079**	< 0.001	< 0.001
NSST3	**0.007**	**0.0009**	**0.004**	**0.033**	**0.001**	**0.422**	**0.010**	**0.074**
97OMST3	< 0.00192	< 0.00192	< 0.002	< 0.002	< 0.002	**0.044**	< 0.002	< 0.002
SCCT1	**0.0016**	< 0.000948	**0.001**	**0.009**	< 0.001	**0.225**	**0.001**	< 0.001
SCST3	**0.0018**	< 0.000997	< 0.001	< 0.001	< 0.001	**0.077**	< 0.001	< 0.001
97KCCT1	**0.0059**	< 0.0019	< 0.002	< 0.002	< 0.002	**0.067**	< 0.002	< 0.002
97KCST1	< 0.00185	< 0.00185	< 0.002	< 0.002	< 0.002	**0.160**	< 0.002	**0.003**
97KCST2	**0.0047**	< 0.00193	< 0.002	< 0.002	< 0.002	**0.220**	< 0.002	< 0.002
KCCT2	**0.0024**	< 0.000939	< 0.001	**0.001**	< 0.001	**0.136**	< 0.001	**0.002**
KCST2	**0.0134**	< 0.000951	**0.025**	**0.042**	**0.022**	**1.190**	**0.167**	**0.011**
97HSCT2	**0.0022**	< 0.00192	< 0.002	< 0.002	< 0.002	**0.135**	< 0.002	**0.002**
97HSST2	**0.0029**	< 0.00186	< 0.002	**0.003**	< 0.002	**0.167**	< 0.002	< 0.002
OBCT1	**0.0018**	< 0.000794	**0.001**	**0.016**	< 0.001	**0.265**	**0.001**	**0.002**
OSCT3	**0.0017**	< 0.00088	< 0.001	< 0.001	**0.001**	**0.070**	< 0.001	< 0.001
OSST2	**0.0028**	< 0.000915	< 0.001	**0.002**	< 0.001	**0.172**	**0.003**	< 0.001

Table A-9. Organic Chemicals in Avian Eggs: Non-DDT and DDT Organochlorines and Polychlorinated Biphenyls (PCBs), Great Salt Lake Wetlands Synoptic Survey, 1996-1997. Concentrations reported in milligrams per kilogram (mg/kg, ppm) wet weight; detected concentations shown in bold type. ***(Page 5 of 5)***

Sample Number	Location Description	Species Code[a]	Total DDTs [b]	Total PCBs
	Area #2- Antelope Island			
AIST3	Antelope Island East (AE)	BNST	**0.075**	**0.172**
AICT1	Antelope Island South (AS)	AMCO	**0.037**	**0.040**
	Area #3- GSL-South Shore			
GSAST1	Saltair/GSL State Park (LS)	BNST	**0.311**	**0.132**
	Area #4- South Shore Wetlands			
97AMDC1	Airport Mitigation Site (SA)	DCCO	**0.798**	**0.699**
97AMMA2	Airport Mitigation Site (SA)	MALL	**0.209**	**0.282**
97AMST1	Airport Mitigation Site (SA)	BNST	**1.887**	**0.138**
NGAV1	Gillmor Sanctuary (SG)	AMAV	**0.352**	**0.480**
97LCSP2	Inland Sea Shorebird Reserve (SI)	SNPL	**0.050**	**0.205**
	Area #5- SE Shore Industrially Impacted Wetlands			
BHAV2	Beck Hot Springs (IB)	AMAV	**0.266**	**0.338**
97PCCT1	Petrochem Ponds (IP)	AMCO	**0.012**	**0.114**
97PCMA1	Petrochem Ponds (IP)	MALL	**0.106**	**0.294**
97WPCT1	SLC Sewage Treatment Plant (IS)	AMCO	**0.034**	**0.303**
97WPCT2	SLC Sewage Treatment Plant (IS)	AMCO	**0.020**	**0.264**
97WPMA1	SLC Sewage Treatment Plant (IS)	MALL	**0.014**	**0.112**
WPCT3	SLC Sewage Treatment Plant (IS)	AMCO	**0.045**	**0.325**
	Area #6- Farmington Bay South			
97BPST3	Bountiful Pond (FP)	BNST	**0.157**	**0.119**
97CUCT6	FBWMA- Crystal Unit (FC)	AMCO	**0.033**	**0.127**
97CUST5	FBWMA- Crystal Unit (FC)	BNST	**0.102**	**0.058**
CUCT3	FBWMA- Crystal Unit (FC)	AMCO	**0.259**	**0.246**
CUST2	FBWMA- Crystal Unit (FC)	BNST	**0.224**	**0.193**
CUST3	FBWMA- Crystal Unit (FC)	BNST	**0.529**	**0.305**
NSCT3	FBWMA- Crystal Unit (FC)	AMCO	**0.082**	**0.172**
NSST3	New State Duck Club (FN)	BNST	**0.543**	**0.484**
97OMST3	NW Oil Drain Delta (FO)	BNST	**0.049**	**0.056**
SCCT1	State Canal (FS)	AMCO	**0.238**	**0.182**
SCST3	State Canal (FS)	BNST	**0.080**	**0.142**
	Area #7- Farmington Bay North			
97KCCT1	Kaysville Marsh (FK)	AMCO	**0.071**	**0.093**
97KCST1	Kaysville Marsh (FK)	BNST	**0.166**	**0.081**
97KCST2	Kaysville Marsh (FK)	BNST	**0.225**	**0.109**
KCCT2	Kaysville Marsh (FK)	AMCO	**0.140**	**0.076**
KCST2	Kaysville Marsh (FK)	BNST	**1.457**	**1.390**
	Area #8- Ogden Bay			
97HSCT2	Howard Slough (OH)	AMCO	**0.141**	**0.093**
97HSST2	Howard Slough (OH)	BNST	**0.173**	**0.071**
OBCT1	Ogden Bay WMA- North (ON)	AMCO	**0.286**	**0.182**
OSCT3	Ogden Bay WMA- South (OS)	AMCO	**0.073**	**0.142**
OSST2	Ogden Bay WMA- South (OS)	BNST	**0.178**	**0.117**

(a) Avian Species Codes AMAV = American avocet; CITE = Cinnamon teal; SNPL = Snowy plover; AMCO= American Coot; DCCO = Double-crested cormorant; BNST = Black necked stilt; MALL = Mallard

(b) Total DDTs: *Summed DDT residues in samples where at least one isomer was detected non-detected isomers included in sum as 0.5 x Detection limit*

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Table A-10. Brain Acetylcholinesterase Activity in Common Carp (*Cyprinus carpio*) and Evaluation of Exposure to Carbamate ("Carb") and Organophosphate ("OP") Insecticides, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. *(Page 1 of 4)*

Sample Number	Sample Site Description	Collection Date	Sex	DIRECT (µg/mg/min)	CVD	REACT (µg/mg/min)	CVR	% C-DIFF	CARB
	Area #3- GSL South Shore								
C7CR1	C7 Ditch (LC)	7/31/1996	M	14.21	6.63	14.06	1.43	-1.06	--
C7CR5	C7 Ditch (LC)	8/1/1996	M	15.37	6.75	16.18	1.65	5.23	--
C7CR3	C7 Ditch (LC)	7/31/1996	F	12.00	9.24	12.14		1.14	--
C7CR4	C7 Ditch (LC)	7/31/1996	F	14.57	3.39	14.50	0.55	-0.47	--
C7CR6	C7 Ditch (LC)	8/1/1996	F	12.10	2.34	12.26	4.14	1.29	--
C7CR9	C7 Ditch (LC)	8/15/1996	F	10.15	0.31	10.27	1.94	1.21	--
97C7CR1	C7 Ditch (LC)	7/23/1997	M	14.19	3.01	13.13	6.70	-7.48	--
97C7CR4	C7 Ditch (LC)	7/23/1997	M	18.30	1.52	17.81	1.37	-2.70	--
97C7CR6	C7 Ditch (LC)	7/23/1997	M	16.53	2.99	16.14	1.67	-2.34	--
97C7CR5	C7 Ditch (LC)	7/23/1997	F	12.57	5.08	13.44	5.55	6.95	--
97C7CR7	C7 Ditch (LC)	7/23/1997	F	13.60	4.18	14.25	1.90	4.81	--
97C7CR8	C7 Ditch (LC)	7/23/1997	F	12.94	3.80	12.86	3.07	-0.58	--
	Area #4- S. Shore Conservation Wetlands								
97AMCR1	Airport Mitigation Site (SA)	7/29/1997	M	11.16	4.21	9.87	1.26	-11.58	--
97AMCR2	Airport Mitigation Site (SA)	7/29/1997	M	10.00	2.96	8.98	6.84	-10.20	--
97AMCR3	Airport Mitigation Site (SA)	7/29/1997	M	12.09	4.47	11.17	2.25	-7.64	--
97AMCR4	Airport Mitigation Site (SA)	7/29/1997	M	15.64	0.26	14.19	1.19	-9.31	--
97AMCR11	Airport Mitigation Site (SA)	7/29/1997	F	18.33	0.87	17.29	1.29	-5.67	--
97AMCR6	Airport Mitigation Site (SA)	7/29/1997	F	14.27	1.28	13.78	1.57	-3.44	--
GDCR1	Goggin Drain (SD)	8/16/1996	M	13.84	0.47	13.27	3.42	-4.11	--
GDCR5	Goggin Drain (SD)	8/16/1996	M	13.76	3.44	12.00	0.38	-12.77	--
GDCR2	Goggin Drain (SD)	8/16/1996	F	9.23	6.28	9.56	3.03	3.60	--
GDCR3	Goggin Drain (SD)	8/16/1996	F	14.96	1.89	14.29	2.03	-4.48	--
GDCR6	Goggin Drain (SD)	8/16/1996	F	13.96	3.37	13.91	2.09	-0.40	--
GDCR7	Goggin Drain (SD)	8/16/1996	F	15.00	3.02	13.50	5.38	-10.00	--
	Area #6- Farmington Bay South								
97BPCR1	Bountiful Pond (FP)	7/25/1997	M	10.51	4.43	9.96	5.30	-5.24	--
97BPCR3	Bountiful Pond (FP)	7/25/1997	M	8.60	2.81	8.12	1.65	-5.51	--
97BPCR4	Bountiful Pond (FP)	7/25/1997	M	15.33	1.59	14.30	2.91	-6.75	--
97BPCR6	Bountiful Pond (FP)	7/25/1997	M	12.67	3.24	11.99	0.83	-5.34	--
97BPCR10	Bountiful Pond (FP)	7/25/1997	F	12.38	5.01	12.08	2.86	-2.43	--
97BPCR8	Bountiful Pond (FP)	7/25/1997	F	8.32	0.14	8.07	5.29	-2.99	--
97CUCR4	FBWMA- Crystal Unit (FC)	8/27/1997	M	10.59	2.82	10.83	2.63	2.25	--
97CUCR1	FBWMA- Crystal Unit (FC)	8/20/1997	F	9.70	1.75	9.73	3.71	0.33	--
97CUCR2	FBWMA- Crystal Unit (FC)	8/20/1997	F	14.37	1.60	14.59	1.32	1.56	--
97CUCR3	FBWMA- Crystal Unit (FC)	8/20/1997	F	10.39	4.37	10.63	3.29	2.35	--
97F1CR1	FBWMA- Unit 1 (FU)	7/30/1997	M	10.37	1.00	11.02	1.75	6.26	--
97F1CR7	FBWMA- Unit 1 (FU)	7/30/1997	M	11.05	0.79	11.14	1.80	0.75	--
97F1CR3	FBWMA- Unit 1 (FU)	7/30/1997	F	8.35	4.25	8.21	0.95	-1.59	--
97F1CR4	FBWMA- Unit 1 (FU)	7/30/1997	F	7.98	3.31	7.36	4.95	-7.82	--
97F1CR5	FBWMA- Unit 1 (FU)	7/30/1997	F	8.03	0.77	7.97	1.09	-0.66	--
97F1CR6	FBWMA- Unit 1 (FU)	7/30/1997	F	8.78	2.78	8.25	1.85	-6.03	--

µg/mg/min: µmol assay substrate (Acetylthiocholine) hydrolyzed per milligram brain tissue per minute

KEY:

CARB: A %C-DIFF value ≥ 10% is diagnostic of AChE inhibition by carbamate compounds

DIRECT: Basic (untreated) rate of AChE activity

% C-DIFF: Percent difference in rates with or without reactivation

REACT: AChE activity after heat incubation (to induce spontaneous reactivation of inhibited enzyme

CVD, CVR: Coefficient of variation for assay run in triplicate

Sample Number	Sample Site Description	Collection Date	Sex	PLUS (µg/mg/min)	MINUS (µg/mg/min)	% OPDIFF	OP
	Area #3- GSL South Shore						
C7CR1	C7 Ditch (LC)	7/31/1996	M	13.31	14.69	-9.39	--
C7CR5	C7 Ditch (LC)	8/1/1996	M	14.64	15.17	-3.53	--
C7CR3	C7 Ditch (LC)	7/31/1996	F	11.96	11.02	8.53	--
C7CR4	C7 Ditch (LC)	7/31/1996	F	13.83	13.88	-0.40	--
C7CR6	C7 Ditch (LC)	8/1/1996	F	13.06	11.63	12.30	**Y**
C7CR9	C7 Ditch (LC)	8/15/1996	F	9.30	10.04	-7.32	--
97C7CR1	C7 Ditch (LC)	7/23/1997	M	14.42	13.05	10.51	**Y**
97C7CR4	C7 Ditch (LC)	7/23/1997	M	18.77	19.15	-1.96	--
97C7CR6	C7 Ditch (LC)	7/23/1997	M	13.64	15.19	-10.22	--
97C7CR5	C7 Ditch (LC)	7/23/1997	F	11.87	11.95	-0.62	--
97C7CR7	C7 Ditch (LC)	7/23/1997	F	12.35	13.85	-10.85	--
97C7CR8	C7 Ditch (LC)	7/23/1997	F	13.15	12.75	3.12	--
	Area #4- S. Shore Conservation Wetlands						--
97AMCR1	Airport Mitigation Site (SA)	7/29/1997	M	10.10	10.60	-4.69	--
97AMCR2	Airport Mitigation Site (SA)	7/29/1997	M	9.27	8.76	5.81	--
97AMCR3	Airport Mitigation Site (SA)	7/29/1997	M	10.15	10.76	-5.63	--
97AMCR4	Airport Mitigation Site (SA)	7/29/1997	M	14.22	13.53	5.10	--
97AMCR11	Airport Mitigation Site (SA)	7/29/1997	F	15.56	15.62	-0.43	--
97AMCR6	Airport Mitigation Site (SA)	7/29/1997	F	13.18	14.66	-10.09	--
GDCR1	Goggin Drain (SD)	8/16/1996	M	13.40	12.88	4.02	--
GDCR5	Goggin Drain (SD)	8/16/1996	M	10.34	12.01	-13.93	--
GDCR2	Goggin Drain (SD)	8/16/1996	F	8.95	9.37	-4.43	--
GDCR3	Goggin Drain (SD)	8/16/1996	F	12.79	13.97	-8.49	--
GDCR6	Goggin Drain (SD)	8/16/1996	F	12.95	13.42	-3.50	--
GDCR7	Goggin Drain (SD)	8/16/1996	F	12.20	12.40	-1.63	--
	Area #6- Farmington Bay South						
97BPCR1	Bountiful Pond (FP)	7/25/1997	M	10.22	10.30	-0.80	--
97BPCR3	Bountiful Pond (FP)	7/25/1997	M	7.56	7.90	-4.27	--
97BPCR4	Bountiful Pond (FP)	7/25/1997	M	13.74	13.77	-0.22	--
97BPCR6	Bountiful Pond (FP)	7/25/1997	M	11.53	11.20	2.98	--
97BPCR10	Bountiful Pond (FP)	7/25/1997	F	12.06	11.35	6.22	--
97BPCR8	Bountiful Pond (FP)	7/25/1997	F	7.73	8.25	-6.35	--
97CUCR4	FBWMA- Crystal Unit (FC)	8/27/1997	M	10.03	10.61	-5.41	--
97CUCR1	FBWMA- Crystal Unit (FC)	8/20/1997	F	9.43	9.39	0.45	--
97CUCR2	FBWMA- Crystal Unit (FC)	8/20/1997	F	13.05	13.89	-6.08	--
97CUCR3	FBWMA- Crystal Unit (FC)	8/20/1997	F	9.90	10.12	-2.22	--
97F1CR1	FBWMA- Unit 1 (FU)	7/30/1997	M	9.85	10.24	-3.75	--
97F1CR7	FBWMA- Unit 1 (FU)	7/30/1997	M	10.16	10.39	-2.15	--
97F1CR3	FBWMA- Unit 1 (FU)	7/30/1997	F	7.53	7.69	-2.09	--
97F1CR4	FBWMA- Unit 1 (FU)	7/30/1997	F	6.76	7.81	-13.44	--
97F1CR5	FBWMA- Unit 1 (FU)	7/30/1997	F	6.91	7.42	-6.83	--
97F1CR6	FBWMA- Unit 1 (FU)	7/30/1997	F	7.74	7.80	-0.68	--

Table A-10. Brain Acetylcholinesterase Activity in Common Carp (*Cyprinus carpio*) and Evaluation of Exposure to Carbamate ("Carb") and Organophosphate ("OP") Insecticides, Great Salt Lake Wetlands Synoptic Survey, 1996-1997. ***(Page 3 of 4)***

Sample Number	Sample Site Description	Collection Date	Sex	DIRECT	CVD	REACT	CVR	% CADIFF	CARB
	Area #6- Farmington Bay South								
SCCR3	State Canal (FS)	8/5/1996	M	14.30	4.84	13.48	4.11	-5.68	--
SCCR8	State Canal (FS)	8/6/1996	F	19.95	4.94	19.28	1.53	-3.37	--
SCCCR17	State Canal (FS)	8/7/1996	M	13.08	5.47	13.88	5.26	6.19	--
SCCCR18	State Canal (FS)	8/7/1996	M	13.79	3.04	13.37	3.40	-3.05	--
SCCCR14	State Canal (FS)	8/7/1996	F	9.16	0.18	8.14	4.88	-11.09	--
SCCCR19	State Canal (FS)	8/7/1996	F	12.92	0.96	11.22	2.51	-13.12	--
97SCCR2	State Canal (FS)	8/13/1997	F	8.43	2.43	8.12	1.07	-3.75	--
97SCCR5	State Canal (FS)	8/13/1997	F	9.78	0.31	8.50	1.34	-13.09	--
97SCCR6	State Canal (FS)	8/13/1997	F	10.16	3.58	9.77	0.31	-3.77	--
	Area #8- Ogden Bay								
97HSCR10	Howard Slough (OH)	8/25/1997	M	10.64	3.52	10.71	3.16	0.62	--
97HSCR11	Howard Slough (OH)	8/25/1997	M	11.56	1.20	11.69	1.94	1.06	--
97HSCR15	Howard Slough (OH)	8/25/1997	M	10.30	4.13	9.82	2.80	-4.68	--
97HSCR4	Howard Slough (OH)	8/25/1997	M	9.97	3.07	9.82	1.37	-1.57	--
97HSCR9	Howard Slough (OH)	8/25/1997	M	10.04	0.50	9.01	1.66	-10.20	--
97HSCR8	Howard Slough (OH)	8/25/1997	F	9.89	2.44	9.27	1.67	-6.26	--
OBCR6	Ogden Bay WMA- South Canal (OC)	8/27/1997	M	9.39	2.60	9.38	5.86	-0.06	--
OBCR1	Ogden Bay WMA- South Canal (OC)	8/26/1997	F	4.68	5.12	4.60	8.06	-1.70	--
OBCR3	Ogden Bay WMA- South Canal (OC)	8/26/1997	F	7.95	9.41	7.14	5.51	-10.26	--
OBCR4	Ogden Bay WMA- South Canal (OC)	8/26/1997	F	10.65	5.65	10.39	1.02	-2.42	--
OBCR5	Ogden Bay WMA- South Canal (OC)	8/27/1997	F	6.74	1.90	6.14	4.97	-8.95	--
97OBCR12	Ogden Bay WMA- North (ON)	8/28/1997	M	13.00	5.81	13.47	8.23	3.62	--
97OBCR4	Ogden Bay WMA- North (ON)	8/21/1997	M	13.50	4.96	13.96	1.73	3.42	--
97OBCR9	Ogden Bay WMA- North (ON)	8/28/1997	M	15.56	2.84	16.60	0.93	6.70	--
97OBCR2	Ogden Bay WMA- North (ON)	8/21/1997	F	15.60	3.53	14.35	1.25	-8.01	--
97OBCR3	Ogden Bay WMA- North (ON)	8/21/1997	F	11.88	3.51	12.45	1.98	4.76	--
97OBCR6	Ogden Bay WMA- North (ON)	8/21/1997	F	13.71	2.56	13.45	2.65	-1.89	--

µg/mg/min: µmol assay substrate (Acetylthiocholine) hydrolyzed per milligram brain tissue per minute

KEY:

DIRECT: Basic (untreated) rate of AChE activity

REACT: AChE activity after heat incubation (to induce spontaneous reactivation of inhibited enzyme

CVD, CVR: Coefficient of variation for assay run in triplicate

% C-DIFF: Percent difference in rates with or without reactivation

CARB: A %C-DIFF value > 10% is diagnostic of AChE inhibition by carbamate compounds

Sample Number	Sample Site Description	Collection Date	Sex	PLUS	MINUS	% OPDIFF	OP
	Area #6- Farmington Bay South						
SCCR3	State Canal (FS)	8/5/1996	M	13.11	14.25	-7.97	--
SCCR8	State Canal (FS)	8/6/1996	F	19.32	19.82	-2.53	--
SCCCR17	State Canal (FS)	8/7/1996	M	13.75	14.49	-5.12	--
SCCCR18	State Canal (FS)	8/7/1996	M	13.65	14.86	-8.11	--
SCCCR14	State Canal (FS)	8/7/1996	F	8.49	9.15	-7.19	--
SCCCR19	State Canal (FS)	8/7/1996	F	11.02	11.67	-5.58	--
97SCCR2	State Canal (FS)	8/13/1997	F	8.00	8.46	-5.40	--
97SCCR5	State Canal (FS)	8/13/1997	F	8.08	8.42	-4.01	--
97SCCR6	State Canal (FS)	8/13/1997	F	8.94	8.98	-0.45	--
	Area #8- Ogden Bay						
97HSCR10	Howard Slough (OH)	8/25/1997	M	9.67	9.74	-0.68	--
97HSCR11	Howard Slough (OH)	8/25/1997	M	11.33	11.22	0.97	--
97HSCR15	Howard Slough (OH)	8/25/1997	M	8.86	9.52	-6.92	--
97HSCR4	Howard Slough (OH)	8/25/1997	M	9.40	9.89	-4.97	--
97HSCR9	Howard Slough (OH)	8/25/1997	M	9.09	8.65	5.09	--
97HSCR8	Howard Slough (OH)	8/25/1997	F	9.10	8.81	3.29	--
OBCR6	Ogden Bay WMA- South Canal (OC)	8/27/1997	M	9.10	9.00	1.22	--
OBCR1	Ogden Bay WMA- South Canal (OC)	8/26/1997	F	3.97	3.83	3.52	--
OBCR3	Ogden Bay WMA- South Canal (OC)	8/26/1997	F	6.95	7.35	-5.40	--
OBCR4	Ogden Bay WMA- South Canal (OC)	8/26/1997	F	10.09	10.57	-4.55	--
OBCR5	Ogden Bay WMA- South Canal (OC)	8/27/1997	F	5.87	6.56	-10.50	--
97OBCR12	Ogden Bay WMA- North (ON)	8/28/1997	M	12.13	12.40	-2.23	--
97OBCR4	Ogden Bay WMA- North (ON)	8/21/1997	M	13.65	13.72	-0.48	--
97OBCR9	Ogden Bay WMA- North (ON)	8/28/1997	M	14.70	14.44	1.77	--
97OBCR2	Ogden Bay WMA- North (ON)	8/21/1997	F	14.53	17.53	-17.11	--
97OBCR3	Ogden Bay WMA- North (ON)	8/21/1997	F	10.93	11.84	-7.72	--
97OBCR6	Ogden Bay WMA- North (ON)	8/21/1997	F	13.92	13.82	0.69	--

Table A-11. Brain Ethoxyresorufin-O-deethylase (EROD) Activity in Common Carp (*Cyprinus carpio*), Great Salt Lake Wetlands Synoptic Survey, 1996-1997. ***(Page 1 of 2)***

Sample Number	Sample Site Description	Collection Date	Sex	Average fluorescence units	pmol product• mg protein^{-1}• min^{-1} (a)	mg microsomal protein• g liver tissue^{-1}	pmol product• min^{-1}• g liver tissue^{-1}
	Area #3- GSL South Shore						
C7CL1	C7 Ditch (LC)	07/31/96	M	8.0	2.1	21.3	44
C7CL3	C7 Ditch (LC)	07/31/96	F	310.0	61.2	22.1	1355
C7CL4	C7 Ditch (LC)	07/31/96	F	4.0	1.7	11.4	20
C7CL5	C7 Ditch (LC)	08/01/96	M	84.0	18.8	19.3	362
C7CL6	C7 Ditch (LC)	08/01/96	F	145.0	22.2	28.3	630
C7CL9	C7 Ditch (LC)	08/15/96	F	16.0	6.4	10.3	65
	Area #4- S. Shore Conservation Wetlands						
GDCL1	Goggin Drain (SD)	08/16/96	M	72.0	20.5	15.1	309
GDCL2	Goggin Drain (SD)	08/16/96	F	33.0	7.7	17.6	136
GDCL3	Goggin Drain (SD)	08/16/96	F	46.0	12.3	14.8	182
GDCL5	Goggin Drain (SD)	08/16/96	M	204.0	43.2	20.6	887
GDCL6	Goggin Drain (SD)	08/16/96	F	90.0	17.5	20.3	357
GDCL7	Goggin Drain (SD)	08/16/96	F	15.0	4.3	13.4	58
97AMCL1	Airport Mitigation Site (SA)	07/29/97	M	31.0	29.70	2.97	176.48
97AMCL2	Airport Mitigation Site (SA)	07/29/97	M	9.0	8.55	2.96	50.55
97AMCL3	Airport Mitigation Site (SA)	07/29/97	M	10.7	13.65	2.20	60.08
97AMCL4	Airport Mitigation Site (SA)	07/29/97	F	24.3	20.03	3.45	138.38
97AMCL5	Airport Mitigation Site (SA)	07/29/97	M	20.3	23.55	2.45	115.43
97AMCL6	Airport Mitigation Site (SA)	07/29/97	F	13.7	10.05	3.86	77.25
	Area #6- Farmington Bay South						
97BPCL1	Bountiful Pond (FP)	07/25/97	M	84.7	58.35	4.15	483.75
97BPCL2	Bountiful Pond (FP)	07/25/97	F	5.3	6.83	2.16	29.55
97BPCL3	Bountiful Pond (FP)	07/25/97	M	3.7	3.08	3.23	20.03
97BPCL4	Bountiful Pond (FP)	07/25/97	M	120.0	83.93	3.32	556.95
97BPCL5	Bountiful Pond (FP)	07/25/97	M	5.0	6.15	2.25	27.68
97BPCL6	Bountiful Pond (FP)	07/25/97	M	206.0	139.13	3.38	939.98
SCCL14	State Canal (FS)	08/07/96	F	33.0	13.2	9.9	131
SCCL17	State Canal (FS)	08/07/96	M	52.0	11.9	18.4	219
SCCL18	State Canal (FS)	08/07/96	M	290.0	47.4	24.0	1139
SCCL19	State Canal (FS)	08/07/96	F	15.0	3.5	26.4	91
SCCL3	State Canal (FS)	08/05/96	M	310.0	109.6	11.1	1217
SCCL8	State Canal (FS)	08/06/96	F	258.0	72.5	15.5	1126
97SCCL1	State Canal (FS)	08/13/97	M	60.3	1.13	3.99	5.40
97SCCL2	State Canal (FS)	08/13/97	F	7.0	2.18	4.69	14.85
97SCCL3	State Canal (FS)	08/13/97	M	261.0	47.78	2.81	314.85
97SCCL4	State Canal (FS)	08/13/97	F	100.3	2.93	2.82	16.43
97SCCL5	State Canal (FS)	08/13/97	F	323.0	4.58	3.71	29.03
97SCCL6	State Canal (FS)	08/13/97	F	58.7	2.70	2.90	18.00

(a) picomoles of enzymatic reaction product per milligram of liver protein per minute: This is the measure of EROD enzyme activity per minute, standardized to microsomal protein mass in the liver, which can vary and can be induced by the presence of compounds that are metabolized by these enzymes.

Table A-11. (continued) *(page 2 of 2)*

Sample Number	Sample Site Description	Collection Date	Sex	Average fluorescence units	pmol product• mg protein^{-1}• min^{-1} (a)	mg microsomal protein• g liver tissue^{-1}	pmol product• min^{-1}• g liver tissue^{-1}
	Area #6- Farmington Bay South						
97CUCL1	FBWMA- Crystal Unit (FC)	08/20/97	F	10.0	10.13	2.78	56.25
97CUCL2	FBWMA- Crystal Unit (FC)	08/20/97	F	15.7	14.63	3.03	88.73
97CUCL3	FBWMA- Crystal Unit (FC)	08/20/97	M	59.3	43.35	3.91	338.70
97CUCL4	FBWMA- Crystal Unit (FC)	08/27/97	M	103.3	73.80	3.27	482.70
97F1CL1	FBWMA- Unit 1 (FU)	07/30/97	M	101.0	87.30	2.70	472.28
97F1CL2	FBWMA- Unit 1 (FU)	07/30/97	M	37.5	37.80	2.82	213.75
97F1CL3	FBWMA- Unit 1 (FU)	07/30/97	F	74.0	89.25	2.37	422.70
97F1CL4	FBWMA- Unit 1 (FU)	07/30/97	F	57.3	58.20	2.81	327.30
97F1CL5	FBWMA- Unit 1 (FU)	07/30/97	F	102.3	93.68	2.33	436.73
97F1CL6	FBWMA- Unit 1 (FU)	07/30/97	F	58.7	70.58	2.00	281.70
	Area #8- Ogden Bay						
97HSCL1	Howard Slough (OH)	08/20/97	F	8.7	7.58	2.97	44.85
97HSCL2	Howard Slough (OH)	08/22/97	F	4.3	5.78	2.10	24.30
97HSCL3	Howard Slough (OH)	08/22/97	F	1.7	2.33	2.50	11.70
97HSCL4	Howard Slough (OH)	08/25/97	M	137.0	102.15	2.84	579.38
97HSCL5	Howard Slough (OH)	08/25/97	F	1.7	2.25	2.61	11.70
97HSCL6	Howard Slough (OH)	08/25/97	F	17.3	20.40	2.10	85.88
OBCL1	Ogden Bay WMA- South Canal (OC)	08/26/96	F	86.0	23.3	14.6	341
OBCL2	Ogden Bay WMA- South Canal (OC)	08/26/96	F	100.0	17.9	22.1	396
OBCL3	Ogden Bay WMA- South Canal (OC)	08/26/96	F	173.0	46.0	16.3	751
OBCL4	Ogden Bay WMA- South Canal (OC)	08/26/96	F	10.0	4.3	9.7	42
OBCL5	Ogden Bay WMA- South Canal (OC)	08/27/96	F	51.0	16.7	12.2	204
OBCL6	Ogden Bay WMA- South Canal (OC)	08/27/96	M	254.0	67.4	16.4	1106
97OBCL1	Ogden Bay WMA- Weber River (OW)	08/21/97	F	0.3	1.13	2.36	5.40
97OBCL3	Ogden Bay WMA- Weber River (OW)	08/21/97	F	2.3	2.18	3.46	14.85
97OBCL4	Ogden Bay WMA- Weber River (OW)	08/21/97	M	65.6	47.78	3.29	314.85
97OBCL5	Ogden Bay WMA- Weber River (OW)	08/21/97	F	2.7	2.93	2.78	16.43
97OBCL7	Ogden Bay WMA- Weber River (OW)	08/28/97	F	5.3	4.58	3.20	29.03
97OBCL8	Ogden Bay WMA- Weber River (OW)	08/28/97	F	3.0	2.70	3.37	18.00

(a) picomoles of enzymatic reaction product per milligram of liver protein per minute: This is the measure of EROD enzyme activity per minute, standardized to microsomal protein mass in the liver, which can vary and can be induced by the presence of compounds that are metabolized by these enzymes.

Table A-12. Concentrations (pg/ml) of 17β-estradiol (E), 11-keto-testosterone (T), and vitellogenin (V) (mg/ml) in common carp (Cyprinus carpio) and reproductive status based on gonad histology. (*page 1 of 4*)

Sample	Weight (g)	Sex	E	T	E/T Ratio	V	Gonad (g)	GSI[1]	Reproductive Status
GSL-South Shore: C7 Ditch									
C7CB7	568	F	626	1740	0.36	0.915	13	2.3	early vitellogenic
C7CB9	2807	F	1911	486	3.93	1.63	205	7.3	early vitellogenic
C7CB2	3379	F	677	1311	0.52	3.26	204	6.0	late vitellogenic
C7CB4	2356	F	604	2026	0.30	2.38	367	15.6	late vitellogenic
C7CB6	2051	F	418	1431	0.29	0.31	154	7.5	late vitellogenic
C7CB8	969	F	998	1092	0.91	1.67	65	6.7	late vitellogenic
C7CB10	1378	F	512	733	0.70	4.35	121	8.8	late vitellogenic
97C7CB5	684	F	1079	723	1.49	3.07	97	14.2	late vitellogenic
97C7CB3	1738	F	545	470	1.16	0.928	275	15.8	late vitellogenic
97C7CB1	802	F	464	371	1.25	3.82	39	4.9	mid vitellogenic
97C7CB2	1854	F	441	347	1.27	3.35	112	6.0	mid vitellogenic
C7CB3	2700	F	827	1002	0.83	0.153	36	1.3	pre vitellogenic
97C7CB7	524	F	567	605	0.94	0.	13	2.5	pre vitellogenic
C7CB1	1907	M	656	1993	0.33	0.	126	6.6	high spermatogenic
C7CB5	1920	M	406	2133	0.19	0.	116	6.0	high spermatogenic
C7CB11	1555	M	407	543	0.75	0.	74	4.8	high spermatogenic
C7CB12	529	M	549	2046	0.27	0.	9	1.7	high spermatogenic
C7CB13	737	M	518	2409	0.22	0.	57	7.7	high spermatogenic
97C7CB6	620	M	354	167	2.12	0.004	33	5.3	high spermatogenic
97C7CB4	1330	M	497	615	0.81	0.	67	5.0	high spermatogenic
97AMCB12	2174	F	552	314	1.76	2.82	94	4.3	early vitellogenic
97AMCB19	3810	F	388	257	1.51	0.834	272	7.1	late vitellogenic
97AMCB4	1041	F	730	320	2.28	16.1	53	5.1	mid vitellogenic
97AMCB15	2158	F	552	134	4.12	1.27	76	3.5	mid vitellogenic
97AMCB16	3001	F	643	124	5.19	1.5	131	4.4	mid vitellogenic
97AMCB6	2614	F	1248	552	2.26	1.67	78	3.0	mid vitellogenic
97AMCB17	2217	F	570	141	4.04	6.17	300	13.5	mid vitellogenic
97AMCB18	2290	F	219	177	1.24	4.62	132	5.8	mid vitellogenic
97AMCB11	1314	F	478	265	1.80	7.86	53	4.0	mid vitellogenic
97AMCB7	2082	M	431	828	0.52	0.	99	4.8	high spermatogenic
97AMCB1	2179	M	508	2138	0.24	0.	129	5.9	high spermatogenic
97AMCB2	3400	M	593	942	0.63	0.	137	4.0	high spermatogenic
97AMCB13	1617	M	455	783	0.58	0.	86	5.3	high spermatogenic
97AMCB10	2626	M	531	1215	0.44	0.	132	5.0	high spermatogenic
97AMCB5	2689	M	320	405	0.79	0.	150	5.6	high spermatogenic
97AMCB3	831	M	419	591	0.71	0.	27	3.2	high spermatogenic
97AMCB9	2175	M	400	451	0.89	0.	110	5.1	high spermatogenic
97AMCB14	1561	M	315	942	0.33	0.	99	6.3	high spermatogenic
97AMCB8	1943	M	459	933	0.49	0.	80	4.1	high spermatogenic

Sample	Weight (g)	Sex	E	T	E/T	V	Gonad (g)	GSI[1]	Reproductive Status
South Shore Wetlands: Goggin Drain									
GDCB8	1734	F	1543	745	2.07	2.36	62	3.6	early vitellogenic
GDCB2	4164	F	631	673	0.94	2.76	760	18.3	late vitellogenic
GDCB3	5688	F	1046	477	2.19	2.53	791	13.9	late vitellogenic
GDCB6	1567	F	3125	603	5.18	3.84	171	10.9	late vitellogenic
GDCB7	3522	F	419	1135	0.37	2.1	382	10.8	late vitellogenic
GDCB11	1700	F	2335	525	4.45	1.74	177	10.4	late vitellogenic
GDCB1	1310	M	442	3087	0.14	0.	52	4.0	high spermatogenic
GDCB4	739	M	1002	1587	0.63	0.	46	6.2	high spermatogenic
GDCB5	2315	M	1904	1728	1.10	0.	150	6.5	high spermatogenic
GDCB9	2100	M	437	1245	0.35	0.	171	8.1	high spermatogenic
GDCB10	2222	M	1979	4076	0.49	0.	161	7.2	high spermatogenic
Farmington Bay South: Bountiful Pond									
97BPCB9	851	F	488	281	1.74	0.141	4	0.5	early pre-vitellogenic
97BPCB8	884	F	325	131	2.48	0.	20	2.3	gonad not present
97BPCB2	2997	F	392	61	6.43	5.51	190	6.3	late vitellogenic
97BPCB14	772	M	1293	720	1.80	0.	2	0.3	high spermatogenic
97BPCB11	860	M	396	281	1.41	0.	4	0.5	high spermatogenic
97BPCB1	1995	M	445	1170	0.38	0.016	99	5.0	high spermatogenic
97BPCB7	2405	M	231	1303	0.18	0.	145	6.0	high spermatogenic
97BPCB10	1309	M	422	1180	0.36	0.	27	2.1	high spermatogenic
97BPCB4	1605	M	323	1253	0.26	0.	58	3.6	high spermatogenic
97BPCB13	2247	M	381	1143	0.33	0.	151	6.7	high spermatogenic
97BPCB5	1052	M	402	854	0.47	0.	29	2.8	high spermatogenic
97BPCB12	3442	M	292	1597	0.18	0.	88	2.6	high spermatogenic
97BPCB3	1607	M	246	1148	0.21	0.	62	3.9	high spermatogenic
Farmington Bay South: Crystal Unit									
97CUCB2	830	F	244	843	0.29	0.27	5	0.6	early pre-vitellogenic
97CUCB1	4074	F	869	661	1.31	7.75	331	8.1	late vitellogenic
97CUCB3	1156	M	72	1978	0.04	0.	95	8.2	high spermatogenic
97CUCB4	1151	M	227	1596	0.14	0.	61	5.3	high spermatogenic
Farmington Bay South: Unit 1									
97F1CB5	1126	F	128	492	0.26	0.468	8	0.7	early pre-vitellogenic
97F1CB4	1336	F	186	679	0.27	0.232	13	1.0	early pre-vitellogenic
97F1CB9	1723	F	831	576	1.44	1.47	15	0.9	early pre-vitellogenic
97F1CB6	1682	F	143	370	0.39	0.164	7	0.4	early pre-vitellogenic
97F1CB12	1538	F	162	363	0.45	0.355	3	0.2	undeveloped oocytes
97F1CB3	1539	F	231	484	0.48	0.748	7	0.5	undeveloped oocytes
97F1CB11	1337	M	144	684	0.21	0.007	65	4.9	high spermatogenic
97F1CB7	1353	M	96	520	0.18	0.	35	2.6	high spermatogenic
97F1CB2	2078	M	143	1409	0.10	0.	134	6.4	high spermatogenic
97F1CB8	1797	M	90	607	0.15	0.	102	5.7	high spermatogenic
97F1CB1	1608	M	92	648	0.14	0.	88	5.5	high spermatogenic
97F1CB10	1489	M	40	1064	0.04	0.	103	6.9	high spermatogenic
97F1CB13	990	M	341	2204	0.15	0.	22	2.2	high spermatogenic
97F1CB14	2393	M	137	1624	0.08	0.	139	5.8	high spermatogenic

Table A-12. Concentrations (pg/ml) of 17β-estradiol (E), 11-keto-testosterone (T), and vitellogenin (V) (mg/ml) in common carp (Cyprinus carpio) and reproductive status based on gonad histology. (*page 3 of 4*)

Sample	Weight (g)	Sex	E	T	E/T Ratio	V	Gonad (g)	GSI[1]	Reproductive Status
Farmington Bay South: State Canal									
SCCB8	1486	F	876	1084	0.81	3.65	51	3.4	early vitellogenic
SCCB14	2846	F	606	398	1.52	4.57	86	3.0	early vitellogenic
SCCB2	4101	F	534	244	2.19	1.63	560	13.7	late vitellogenic
SCCB5	3056	F	542	953	0.57	4.78	204	6.7	late vitellogenic
SCCB6	5363	F	384	1123	0.34	4.11	532	9.9	late vitellogenic
SCCB7	4725	F	619	555	1.12	4.25	607	12.8	late vitellogenic
SCCB9	3213	F	648	472	1.37	0.839	265	8.2	late vitellogenic
SCCB19	2091	F	486	2036	0.24	2.29	237	11.3	late vitellogenic
97SCCB7	2295	F	264	178	1.48	2.57	116	5.1	late vitellogenic
97SCCB4	3260	F	511	115	4.44	3.28	138	4.2	mid vitellogenic
97SCCB2	2280	F	218	274	0.80	1.63	237	10.4	mid vitellogenic
97SCCB12	1095	F	428	301	1.42	2.02	14	1.3	mid vitellogenic
97SCCB17	2532	F	552	431	1.28	4.87	98	3.9	mid vitellogenic
97SCCB9	2348	F	1243	912	1.36	1.42	108	4.6	mid vitellogenic
97SCCB6	3035	F	1090	582	1.87	1.7	253	8.3	mid vitellogenic
97SCCB11	4390	F	248	136	1.82	3.51	298	6.8	mid vitellogenic
97SCCB5	1676	F	282	108	2.61	6.4	64	3.8	mid vitellogenic
SCCB10	1074	F	755	994	0.76	0.427	20	1.9	pre vitellogenic
SCCB13	1397	F	539	914	0.59	0.72	23	1.6	pre vitellogenic
97SCCB14	1130	F	372	174	2.14	0.1	3	0.3	pre vitellogenic
SCCB1	2920	M	382	1898	0.20	0.	103	3.5	high spermatogenic
SCCB3	2546	M	475	936	0.51	0.	72	2.8	high spermatogenic
SCCB4	3362	M	419	2461	0.17	0.	226	6.7	high spermatogenic
SCCB11	1207	M	824	731	1.13	0.	32	2.7	high spermatogenic
SCCB12	956	M	545	886	0.62	0.	34	3.6	high spermatogenic
SCCB15	4168	M	707	1596	0.44	0.	225	5.4	high spermatogenic
SCCB16	4194	M	954	495	1.93	0.01	222	5.3	high spermatogenic
SCCB17	1782	M	1504	627	2.40	0.	73	4.1	high spermatogenic
SCCB18	2326	M	2010	2594	0.77	0.	169	7.3	high spermatogenic
SCCB20	1094	M	445	849	0.52	0.	28	2.6	high spermatogenic
97SCCB15	1599	M	316	196	1.61	0.	44	2.8	high spermatogenic
97SCCB18	2357	M	486	434	1.12	0.	192	8.1	high spermatogenic
97SCCB16	2029	M	500	588	0.85	0.	66	3.3	high spermatogenic
97SCCB8	2127	M	224	628	0.36	0.	120	5.6	high spermatogenic
97SCCB19	2325	M	513	1028	0.50	0.	124	5.3	high spermatogenic
97SCCB13	3520	M	266	739	0.36	0.	270	7.7	high spermatogenic
97SCCB3	3052	M	297	967	0.31	0.	129	4.2	high spermatogenic
97SCCB1	3895	M	477	1110	0.43	0.	248	6.4	high spermatogenic
97SCCB10	3402	M	523	1196	0.44	0.	106	3.1	high spermatogenic
97SCCB20	1511	M	500	1285	0.39	0.	125	8.3	high spermatogenic

Sample	Weight (g)	Sex	E	T	E/T Ratio	V	Gonad (g)	GSI[1]	Reproductive Status
Ogden Bay: Howard Slough									
97HSCB5	4504	F	1435	985	1.46	7.12	612	13.6	late vitellogenic
97HSCB2	5941	F	721	826	0.87	9.26	873	14.7	late vitellogenic
97HSCB3	4271	F	478	145	3.30	9.37	636	14.9	late vitellogenic
97HSCB8	2462	F	892	160	5.58	1.36	236	9.6	late vitellogenic
97HSCB14	4554	F	273	172	1.59	2.44	635	13.9	late vitellogenic
97HSCB12	6147	F	1631	336	4.85	10.2	1091	17.7	late vitellogenic
97HSCB13	3436	F	1257	396	3.17	6.91	420	12.2	late vitellogenic
97HSCB6	3803	F	1292	551	2.34	1.87	550	14.5	late vitellogenic
97HSCB11	1716	F	411	179	2.30	2.88	106	6.2	late vitellogenic
97HSCB10	2297	M	70	81	0.86	0.	199	8.7	high spermatogenic
97HSCB16	1735	M	209	700	0.30	0.	177	10.2	high spermatogenic
97HSCB15	1590	M	153	177	0.86	0.	145	9.1	high spermatogenic
97HSCB9	2208	M	87	184	0.47	0.	206	9.3	high spermatogenic
97HSCB18	2092	M	100	132	0.76	0.	163	7.8	high spermatogenic
97HSCB17	590	M	185	333	0.56	0.	21	3.6	high spermatogenic
97HSCB4	3349	M	107	1373	0.08	0.	265	7.9	high spermatogenic
97HSCB7	3667	M	108	310	0.35	0.	285	7.8	high spermatogenic
Ogden Bay: Ogden Bay WMA- S Canal									
OBCB5	2623	F	2842	1501	1.89	0.832	74	2.8	early vitellogenic
OBCB1	4623	F	1932	723	2.67	1.35	332	7.2	late vitellogenic
OBCB3	5275	F	2512	379	6.63	1.16	449	8.5	late vitellogenic
OBCB4	5916	F	2247	276	8.14	3.59	389	6.6	late vitellogenic
OBCB2	4924	F	2787	579	4.81	0.046	112	2.3	pre vitellogenic
OBCB6	2430	M	1559	2851	0.55	0.	89	3.7	high spermatogenic
OBCB7	3058	M	3996	923	4.33	0.	190	6.2	high spermatogenic
OBCB8	1380	M	2954	1270	2.33	0.	17	1.2	high spermatogenic
OBCB9	2345	M	2138	1706	1.25	0.	159	6.8	high spermatogenic
Ogden Bay: Ogden Bay WMA- Weber River									
97OBCB2	1677	F	775	1560	0.50	9.	99	5.9	late vitellogenic
97OBCB6	873	F	166	1013	0.16	0.	3	0.3	late vitellogenic
97OBCB3	3373	F	597	1028	0.58	1.27	276	8.2	late vitellogenic
97OBCB5	5413	F	602	1099	0.55	3.9	470	8.7	late vitellogenic
97OBCB1	5602	F	837	998	0.84	5.17	553	9.9	mid vitellogenic
97OBCB8	5246	F	344	1771	0.19	0.932	617	11.8	mid vitellogenic
97OBCB7	4156	F	831	1034	0.80	3.99	316	7.6	mid vitellogenic
97OBCB4	2844	M	205	1098	0.19	0.	212	7.5	high spermatogenic
97OBCB11	2531	M	281	1376	0.20	0.	198	7.8	high spermatogenic
97OBCB12	1939	M	272	1205	0.23	0.	124	6.4	high spermatogenic
97OBCB10	3588	M	203	2191	0.09	0.	326	9.1	high spermatogenic
97OBCB9	2426	M	72	1068	0.07	0.	219	9.0	high spermatogenic

Table A-13. Polynuclear Aromatic Hydrocarbon (PAH) Metabolites (milligrams/Liter, wet weight) in Bile from Common Carp (*Cyprinus carpio*), Great Salt Lake Wetlands Synoptic Survey, 1996-1997.

Sample Number	Sample Site Description	Collection Date	Sex	Benzo(a) pyrene	Naph- thalene	Phenan- threne
	Area #3- GSL South Shore					
97C7C5	C7 Ditch (LC)	07/23/97	F	1.7	850	190
97C7C6	C7 Ditch (LC)	07/23/97	M	1.4	750	160
97C7C8	C7 Ditch (LC)	07/23/97	F	0.5	260	62
	Area #4- South Shore Conservation Wetlands					
97AMC1	Airport Mitigation Site (SA)	07/29/97	M	0.2	110	70
97AMC12	Airport Mitigation Site (SA)	07/29/97	F	0.1	60	34
97AMC9	Airport Mitigation Site (SA)	07/29/97	M	0.1	48	36
	Area #6- Farmington Bay South					
97BPC1	Bountiful Ponds (FP)	07/25/97	M	0.2	71	24
97BPC4	Bountiful Ponds (FP)	07/25/97	M	0.3	150	46
97BPC7	Bountiful Ponds (FP)	07/25/97	M	0.4	230	73
97CUC1	FBWMA- Crystal Unit (FC)	08/20/97	F	0.2	82	16
97CUC2	FBWMA- Crystal Unit (FC)	08/20/97	F	0.1	52	10
97CUC4	FBWMA- Crystal Unit (FC)	08/27/97	M	0.2	94	20
97SCC3	State Canal (FS)	08/13/97	M	0.7	370	94
97SCC4	State Canal (FS)	08/13/97	F	1.3	570	210
97SCC6	State Canal (FS)	08/13/97	F	2.8	1300	340
97F1C6	FBWMA- Unit 1 (FU)	07/30/97	F	0.3	150	140
97F1C8	FBWMA- Unit 1 (FU)	07/30/97	M	0.2	130	140
97F1C9	FBWMA- Unit 1 (FU)	07/30/97	F	0.3	110	100
	Area #8- Ogden Bay					
97HSC3	Howard Slough (OH)	08/22/97	F	0.2	67	31
97HSC5	Howard Slough (OH)	08/25/97	F	0.3	100	40
97HSC6	Howard Slough (OH)	08/25/97	F	0.4	150	45
97OBC1	Ogden Bay North (ON)	08/21/97	F	1.0	210	61
97OBC5	Ogden Bay North (ON)	08/21/97	F	1.4	420	100
97OBC7	Ogden Bay North (ON)	08/21/97	F	1.1	300	73

NOTES:

Detection Limits (mg/L, wet weight)

Benzo(a)pyrene: 0.1

Naphthalene: 0.6

Phenanthrene: 0.1

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APPENDIX B

Great Salt Lake Open Waters and South Shore Deltas, 1997-2000

Table B-1. Concentrations of Trace Elements (parts per million, dry weight) in Sediments, Gilbert Bay (Great Salt Lake Open Waters) 1996-1999. ***(Page 1 of 2)***

Sample ID	Weight (grams)	Collection Date	%M	Al	As	B	Ba	Be	Cd	Cr	Cu
Gilbert Bay- USGS Sites, 1996											
GSLS1	272	9/23/1996	34.3	4228	11.9	128.	393	0.363	< 0.2	6.36	37.8
GSLS2	362	9/23/1996	43.1	8962	20.4	95.8	223	1.01	< 0.2	17.1	123.
GSLS4	357	9/23/1996	40.6	6023	13.	127.	327	0.458	< 0.2	7.42	16.2
2433S1	594	10/23/1996	46.2	978	26.7	208.	154	< 0.2	< 0.2	1.85	6.39
2565S1	674	10/23/1996	47.1	5558	6.	130.	303	0.356	< 0.2	7.14	41.5
2820S1	648	10/23/1996	44.3	3563	14.9	146.	571	< 0.2	< 0.2	5.19	20.3
2935S1	588	10/23/1996	58.0	5576	9.07	145.	268	0.329	< 0.2	8.38	51.2
2583S1	456	10/24/1996	34.9	6057	29.6	155.	459	0.377	< 0.2	8.12	26.9
2267S1	589	10/28/1996	50.5	7529	26.	125.	269	0.585	< 0.2	10.2	29.8
3510S1	588	2/10/1997	63.4	8646	18.9	124.	219	0.711	0.27	12.3	233.
Gilbert Bay; 1999											
99SASE01	317	9/23/1999	56.6	5982	28.3	129.	229	0.49	0.884	7.98	140.
99SASE02	310	9/28/1999	55.9	7015	21.6	116.	244	0.55	0.689	8.78	146.
99SASE03	286	10/1/1999	63.4	9921	25.6	106.	175	0.89	0.51	24.	620.
99SASE04	318	9/23/1999	45.0	4743	17.8	101.	256	0.37	0.23	4.72	20.
99SASE05	324	9/23/1999	56.1	7490	19.	111.	210	0.6	0.91	8.93	169.
99SASE06	304	9/28/1999	57.6	7528	21.4	115.	183	0.59	1.71	10.1	240.
99SASE07	305	10/1/1999	52.0	8502	20.2	112.	211	0.74	0.544	12.4	242.
99SASE08	445	10/1/1999	20.4	1413	14.9	82.3	302	< 0.2	< 0.2	2.67	15.4
99SASE09	335	9/23/1999	47.6	6643	19.	112.	266	0.57	0.353	7.42	53.1
99SASE10	334	9/28/1999	54.3	8102	15.6	111.	234	0.66	0.556	8.85	112.
99SASE11	336	10/4/1999	54.1	9236	16.5	117.	224	0.74	0.446	9.84	130.
99SASE12	316	10/4/1999	55.4	7640	19.7	110.	195	0.62	0.476	10.9	216.
99SASE13	343	9/29/1999	37.8	4645	16.9	101.	263	0.35	< 0.2	4.87	22.9
99SASE14	338	9/29/1999	53.2	9385	15.9	117.	238	0.76	0.505	10.3	137.
99SASE15	302	9/28/1999	56.0	8831	18.7	108.	181	0.67	0.34	12.	235.
99SASE16	363	9/29/1999	41.6	5453	21.4	111.	523	0.42	< 0.2	5.95	19.8
99SASE17	332	9/29/1999	54.3	9825	17.9	123.	245	0.77	0.236	10.6	75.
99SASE18	307	9/30/1999	59.5	10445	23.6	134.	205	0.78	0.32	12.5	140.
99SASE19	331	9/30/1999	55.2	11330	26.5	139.	220	0.81	0.583	15.5	231.
99SASE20	349	9/30/1999	44.3	4318	29.	138.	781	0.36	< 0.2	5.3	23.9
99SASE21	310	10/4/1999	57.2	9108	21.5	120.	188	0.74	0.331	15.8	267.
99SASE22	336	10/4/1999	55.7	9651	19.9	127.	237	0.75	0.26	11.5	151.
99SASE23	324	10/5/1999	55.7	5955	26.8	94.1	189	0.54	< 0.2	11.	91.
99SASE24	376	10/5/1999	38.8	13643	45.6	41.6	187	1.47	< 0.2	58.9	1083.
99SASE25	311	10/5/1999	57.0	8083	23.2	113.	192	0.73	0.343	17.4	316.
99SASE26	337	10/5/1999	53.7	6379	28.5	116.	280	0.53	0.321	8.58	132.
99SASE27	290	10/12/1999	57.9	8587	20.5	130.	234	0.69	0.267	11.	95.2
99SASE28	305	10/12/1999	56.2	11233	18.7	131.	227	0.85	0.251	12.4	207.

Table B-1. (continued) ***(page 2 of 2)***

Sample ID	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
Gilbert Bay- USGS Sites, 1996											
GSLS1	3703	< 0.2	25971	134.	8.97	5.75	41.6	1.64	3108	16.	47.1
GSLS2	10955	< 0.2	27729	359.	< 5.	12.	83.9	2.02	1020	22.	145.
GSLS4	5546	< 0.2	31248	179.	11.5	6.61	19.5	2.52	2372	17.2	44.2
2433S1	809	< 0.2	20364	42.3	< 5.	< 5.	21.4	1.95	3183	9.51	19.8
2565S1	5082	< 0.2	27790	136.	< 5.	9.85	53.7	1.72	2413	16.4	51.5
2820S1	3446	< 0.2	31955	122.	9.76	5.21	29.8	1.49	2998	16.3	42.9
2935S1	4909	< 0.2	33343	164.	7.05	8.5	45.5	1.5	1688	18.3	49.6
2583S1	5558	0.373	32520	332.	15.2	7.78	42.3	1.56	2768	19.2	74.4
2267S1	7144	< 0.2	30465	334.	10.3	8.99	46.8	1.48	2127	18.1	69.1
3510S1	8078	0.372	25131	179.	13.7	11.1	129.	1.19	1228	20.4	132.
Gilbert Bay; 1999											
99SASE01	6177	0.243	28204	171.	13.6	9.38	70.1	2.22	1648	17.2	83.4
99SASE02	7182	0.226	29678	187.	13.3	9.61	62.9	2.08	1618	14.3	72.9
99SASE03	12469	0.249	27836	310.	32.5	18.	76.7	2.2	460	27.5	130.
99SASE04	4613	< 0.2	25846	136.	9.54	7.01	27.8	2.49	2506	12.6	36.3
99SASE05	7723	0.36	25672	166.	10.6	10.6	110.	2.1	1312	16.2	92.8
99SASE06	7939	0.374	25997	168.	18.4	10.1	109.	2.53	1077	14.9	98.2
99SASE07	9462	0.266	29610	230.	14.2	11.	54.	2.58	1036	19.4	75.5
99SASE08	2305	< 0.2	16575	123.	< 5.	< 5.	14.3	2.2	2855	6.67	18.6
99SASE09	6526	< 0.2	27646	175.	7.56	8.1	33.9	3.34	1862	15.3	54.7
99SASE10	8915	0.306	30618	200.	7.82	11.	88.9	1.85	1192	16.	86.5
99SASE11	9429	0.285	31382	209.	7.01	11.	77.6	2.11	1095	15.1	76.
99SASE12	8937	0.32	27930	216.	15.6	10.9	86.4	1.97	1135	17.5	96.9
99SASE13	4615	< 0.2	24104	140.	5.51	6.35	37.	3.08	2548	11.9	36.
99SASE14	9324	0.407	27712	207.	6.23	12.1	115.	2.45	1271	18.4	101.
99SASE15	8742	0.376	22654	186.	8.67	11.6	142.	1.14	839	19.8	119.
99SASE16	4936	< 0.2	27858	146.	14.	9.39	20.	2.29	2411	18.3	42.5
99SASE17	9458	0.356	31769	215.	6.55	12.7	96.9	1.76	1210	18.5	97.
99SASE18	9692	0.252	32144	276.	11.1	13.3	62.9	1.66	987	19.7	101.
99SASE19	10463	0.414	29595	226.	22.1	14.1	145.	1.75	1006	22.4	152.
99SASE20	4392	0.294	34850	412.	5.46	6.69	28.4	2.4	2417	13.9	43.8
99SASE21	9134	0.323	29371	227.	20.8	12.5	91.8	1.66	810	21.6	105.
99SASE22	8575	0.318	30841	213.	7.87	13.4	95.9	1.69	1107	19.3	92.4
99SASE23	6640	< 0.2	25957	258.	10.6	10.7	43.7	1.56	1310	13.3	76.7
99SASE24	17826	< 0.2	20385	137.	54.1	31.6	73.9	1.97	932	51.3	101.
99SASE25	9155	0.22	27153	232.	24.6	13.5	83.5	1.83	973	21.1	105.
99SASE26	5443	< 0.2	27321	151.	22.9	9.48	62.1	2.27	2211	18.2	68.8
99SASE27	8217	0.297	28064	195.	13.5	11.8	80.2	1.69	1272	20.4	87.6
99SASE28	10867	0.385	29462	240.	9.47	14.7	123.	1.41	1032	20.5	154.

Table B-2. Concentrations of Trace Elements (parts per million, dry weight) in Sediments, Great Salt Lake South Shore Deltas, 2000. ***(page 1 of 2)***

Sample ID	Weight (grams)	Collection Date	%M	Al	As	B	Ba	Be	Cd	Cr	Cu
C7 Ditch Delta; 2000											
00C7SE01	358	4/25/2000	46.5	18427	33.7	64.8	176	1.19	0.252	78.4	1308.
00C7SE02	469	4/25/2000	20.5	1097	7.44	74.	179	< 0.2	< 0.2	2.36	22.
00C7SE03	466	5/4/2000	18.4	1376	10.7	69.2	216	< 0.2	< 0.2	6.1	47.8
00C7SE04	464	5/4/2000	17.7	1074	7.4	71.2	199	< 0.2	< 0.2	2.55	16.8
00C7SE05	481	4/25/2000	19.4	1491	8.15	71.	215	< 0.2	< 0.2	3.82	58.3
00C7SE06	472	4/25/2000	20.8	955	10.5	64.7	186	< 0.2	< 0.2	2.42	152.
00C7SE07	469	5/4/2000	17.2	1377	10.5	81.7	203	< 0.2	< 0.2	3.02	30.2
00C7SE08	495	4/25/2000	17.1	942	12.	63.7	214	< 0.2	< 0.2	2.46	160.
00C7SE09	442	5/4/2000	22.3	4886	22.5	66.	201	0.41	0.203	12.6	278.
Goggin Drain Delta; 2000											
00GDSE01	376	5/3/2000	40.4	5662	14.5	58.1	144	0.43	< 0.2	8.93	51.3
00GDSE02	345	5/3/2000	46.3	9888	22.4	54.8	142	0.75	0.851	21.9	228.
00GDSE03	371	5/3/2000	41.6	10954	15.3	57.1	159	0.89	0.355	21.7	110.
00GDSE04	377	5/3/2000	42.6	7833	15.3	42.4	95.5	0.53	< 0.2	13.2	62.8
Lee's Creek Delta; 2000											
00LCSE01	489	5/4/2000	16.9	1128	9.12	75.4	180	< 0.2	< 0.2	2.37	15.6
00LCSE02	462	5/4/2000	20.7	1276	8.51	79.2	162	< 0.2	< 0.2	2.32	26.4
00LCSE03	437	5/3/2000	22.8	1454	8.35	74.6	157	< 0.2	< 0.2	2.67	31.9
00LCSE04	456	5/4/2000	19.6	1795	10.5	85.2	175	< 0.2	< 0.2	3.14	146.
00LCSE05	404	5/3/2000	34.8	3505	9.93	67.2	136	0.27	< 0.2	6.06	63.7

Table B-2. (continued) ***(page 2 of 2)***

Sample ID	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	Sr	V	Zn
00C7SE01	19955	< 0.2	23430	216.	57.	33.6	54.4	2.01	240	449	51.2	112.
00C7SE02	1364	< 0.2	10220	45.4	< 5.	< 5.	10.8	1.09	2476	3115	9.56	18.9
00C7SE03	2066	< 0.2	11426	54.2	< 5.	< 5.	14.7	< 1	2424	2970	9.9	35.4
00C7SE04	1508	< 0.2	10877	48.5	< 5.	< 5.	15.2	1.52	2489	3024	8.52	27.1
00C7SE05	2063	< 0.2	12109	56.1	< 5.	5.09	9.3	< 1	2313	2870	10.3	22.7
00C7SE06	1547	< 0.2	10003	63.9	< 5.	5.03	22.1	< 1	2368	2991	8.03	75.4
00C7SE07	1884	< 0.2	13606	82.	< 5.	< 5.	14.8	< 1	2396	2894	9.78	40.9
00C7SE08	1493	< 0.2	8594	75.6	< 5.	5.85	24.8	< 1	2604	3141	8.79	67.
00C7SE09	4328	< 0.2	13564	117.	11.3	12.3	30.6	< 1	1837	2364	17.	124.
00GDSE01	7708	< 0.2	15601	205.	< 5.	6.88	53.6	< 1	773	1298	14.3	91.4
00GDSE02	14364	< 0.2	20753	286.	9.28	15.	170.	1.04	203	378	23.9	242.
00GDSE03	15178	< 0.2	20152	289.	< 5.	17.6	129.	< 1	368	630	25.1	179.
00GDSE04	10414	< 0.2	14210	224.	< 5.	10.2	71.	< 1	159	277	17.1	163.
00LCSE01	1339	< 0.2	11921	58.2	< 5.	< 5.	15.2	1.2	2531	3046	8.9	19.6
00LCSE02	1510	< 0.2	12445	59.	< 5.	< 5.	24.7	< 1	2407	3036	8.34	22.5
00LCSE03	1844	< 0.2	13300	82.9	< 5.	< 5.	26.6	< 1	2167	2807	8.81	24.1
00LCSE04	2298	< 0.2	16062	123.	< 5.	< 5.	28.9	< 1	2289	2847	10.	30.4
00LCSE05	3772	< 0.2	13435	141.	< 5.	5.85	22.	< 1	1441	2210	11.3	51.8

Table B-3. Concentrations of elements (parts per million, dry weight) in brine shrimp and brine shrimp cysts from Great Salt Lake, 1996-2000. (*Page 1 of 4*)

Sample ID	Weight (grams)	Collection Date	% M	Al	As	B	Ba	Be	Cd	Cr	Cu
Gilbert Bay- USGS Sites; 1996											
GSLBS1B	84.	09/23/96	87.1	473.	10.6	49.9	6.44	< 0.1	0.17	1.64	11.4
GSLBS2	105.	09/23/96	86.0	741.	8.64	56.5	7.65	0.108	0.13	2.81	13.4
GSLBS3A	62.	09/23/96	87.2	718.	8.19	66.7	7.28	0.106	0.13	2.44	11.2
GSLBS3B	76.	09/23/96	87.5	757.	8.69	54.7	7.61	< 0.1	0.13	3.13	13.2
GSLBS4A	86.	09/23/96	86.7	409.	11.5	58.2	5.91	< 0.1	0.14	1.23	10.9
2433BS1	101.	10/23/96	86.5	126.	13.	63.6	4.83	< 0.1	< 0.1	1.71	8.67
2565BS1	96.	10/23/96	88.9	107.	8.51	33.8	2.02	< 0.1	0.23	0.693	9.04
2820BS2	77.	10/23/96	90.3	195.	8.56	33.	3.28	< 0.1	0.18	1.2	10.1
2935BS3	113.	10/23/96	88.1	95.3	8.41	28.9	1.88	< 0.1	0.19	1.35	8.85
2583BS2	29.	10/24/96	91.3	228.	8.87	35.8	3.02	< 0.1	0.24	3.1	17.8
2200BS3	51.	10/28/96	91.2	236.	7.92	27.9	3.73	< 0.1	0.28	1.72	12.
2267BS1	54.	10/28/96	87.6	402.	9.47	54.8	4.84	< 0.1	0.2	1.56	10.2
Gilbert Bay- USGS Sites; 1996; Brine Shrimp Cysts											
2200BSE3	112.	10/28/96	66.7	42.5	10.6	30.6	< 1	< 0.1	< 0.1	0.58	7.11
2820BSE1	117.	10/23/96	67.3	45.9	10.4	19.3	< 1	< 0.1	< 0.1	0.716	5.18
2935BSE1	106.	10/23/96	77.8	17.8	8.63	56.3	< 1	< 0.1	< 0.1	< 0.5	2.94
BSE35102	78.	02/10/97	61.9	28.7	9.98	69.1	< 1	< 0.1	< 0.1	0.519	8.94
Gilbert Bay; 1999											
99SABS01	45.	09/23/99	91.3	47.	16.	35.4	1.19	< 0.1	0.226	< 0.5	7.85
99SABS04	47.	09/23/99	90.8	20.5	18.3	39.1	< 1	< 0.1	0.225	< 0.5	8.15
99SABS05	31.	09/23/99	91.2	15.7	16.4	40.5	< 1	< 0.1	0.207	< 0.5	6.71
99SABS09	49.	09/23/99	91.1	22.2	17.1	38.6	< 1	< 0.1	0.248	< 0.5	6.79
99SABS02	22.6	09/28/99	90.3	116.	16.3	69.5	2.46	< 0.1	0.216	< 0.5	9.18
99SABS06	14.3	09/28/99	90.6	122.	17.1	38.6	16.6	< 0.1	0.28	1.06	9.62
99SABS10	31.8	09/28/99	90.8	46.9	17.	39.8	1.29	< 0.1	0.27	1.04	8.64
99SABS15	62.	09/28/99	91.0	120.	18.2	39.6	1.74	< 0.1	0.276	< 0.5	10.3
99SABS13	20.4	09/29/99	90.9	145.	18.7	50.	4.3	< 0.1	0.278	1.36	9.38
99SABS14	20.5	09/29/99	91.3	28.8	16.8	49.2	1.6	< 0.1	0.266	1.09	8.02
99SABS16	34.3	09/29/99	91.2	38.5	16.3	37.7	1.13	< 0.1	0.275	< 0.5	8.09
99SABS17	58.2	09/29/99	91.2	49.1	18.5	41.4	1.22	< 0.1	0.315	0.53	9.58
99SABS18	29.2	09/30/99	91.4	72.8	13.7	42.4	1.5	< 0.1	0.31	< 0.5	7.12
99SABS19	25.	09/30/99	91.3	81.7	14.6	42.9	3.84	< 0.1	0.294	< 0.5	7.76
99SABS20	31.8	09/30/99	91.4	89.3	13.8	44.6	1.58	< 0.1	0.295	0.51	7.27
99SABS03	25.2	10/01/99	90.9	79.8	15.3	40.	1.58	< 0.1	0.237	< 0.5	9.12
99SABS07	19.7	10/01/99	90.4	199.	15.6	50.1	3.64	< 0.1	0.247	< 0.5	13.9
99SABS08	18.9	10/01/99	90.7	156.	15.2	49.4	2.2	< 0.1	0.259	1.45	9.47
99SABS11	63.	10/04/99	90.2	41.2	18.6	39.8	1.11	< 0.1	0.361	< 0.5	8.19
99SABS12	16.7	10/04/99	90.8	82.7	14.2	40.9	1.4	< 0.1	0.327	0.6	8.01
99SABS21	33.	10/04/99	90.5	35.1	15.7	38.4	1.07	< 0.1	0.341	< 0.5	8.12

Sample ID	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
Gilbert Bay- USGS Sites; 1996											
GSLBS1B	455	0.419	12639	28.2	< 2.	1.36	1.2	2.47	34.8	< 0.5	63.1
GSLBS2	757	0.332	14253	52.7	< 2.	1.54	2.75	1.72	34.6	< 0.5	62.1
GSLBS3A	669	0.253	14978	29.	< 2.	1.33	2.22	1.25	32.1	< 0.5	78.3
GSLBS3B	684	0.298	13837	29.8	< 2.	0.52	1.99	1.63	31.2	< 0.5	62.8
GSLBS4A	443	0.486	14024	18.	< 2.	1.38	< 0.5	2.2	28.2	1.79	62.8
2433BS1	192	0.395	13779	10.2	< 2.	1.31	1.	2.54	58.7	< 0.5	62.6
2565BS1	248	0.478	5111	7.48	< 2.	< 0.5	1.02	2.96	14.	< 0.5	88.5
2820BS2	284	0.541	6301	30.4	< 2.	1.47	< 0.5	2.84	19.	0.979	106.
2935BS3	284	0.362	4559	8.9	< 2.	0.669	< 0.5	2.98	11.7	< 0.5	83.4
2583BS2	324	0.601	6609	24.3	< 2.	1.14	0.74	2.79	24.	< 0.5	98.3
2200BS3	337	0.576	5033	14.9	< 2.	1.25	2.51	3.81	18.8	1.27	93.5
2267BS1	363	< 0.2	12701	19.4	< 2.	0.916	1.41	3.11	26.3	< 0.5	67.
Gilbert Bay- USGS Sites; 1996; Brine Shrimp Cysts											
2200BSE3	495	< 0.2	2557	9.19	< 2.	< 0.5	1.5	2.15	2.51	< 0.5	76.
2820BSE1	381	< 0.2	2039	8.35	< 2.	0.743	< 0.5	1.91	1.92	< 0.5	64.8
2935BSE1	255	< 0.2	10892	5.73	< 2.	< 0.5	< 0.5	1.12	9.89	< 0.5	38.5
BSE35102	522	< 0.2	6541	5.99	< 2.	< 0.5	1.43	1.98	6.41	< 0.5	56.7
Gilbert Bay; 1999											
99SABS01	144	0.346	9887	11.8	< 2.	1.04	< 0.5	2.39	8.48	< 0.5	55.3
99SABS04	127	0.366	9983	16.3	< 2.	0.95	< 0.5	3.	8.67	< 0.5	50.7
99SABS05	121	0.351	10373	9.22	< 2.	0.92	< 0.5	2.55	9.16	< 0.5	50.1
99SABS09	123	0.305	9632	11.5	< 2.	< 0.5	< 0.5	2.9	9.19	< 0.5	47.9
99SABS02	184	0.293	12883	123.	< 2.	1.43	1.52	2.46	13.8	1.52	45.9
99SABS06	176	0.369	9672	17.4	< 2.	0.75	0.587	2.63	10.7	< 0.5	52.3
99SABS10	145	0.382	9970	14.4	< 2.	< 0.5	< 0.5	2.63	10.2	< 0.5	55.
99SABS15	196	0.363	10257	19.8	< 2.	< 0.5	0.501	3.	10.5	2.1	60.1
99SABS13	201	0.284	12140	60.	< 2.	< 0.5	0.966	2.73	13.3	< 0.5	48.5
99SABS14	124	0.335	12095	13.	< 2.	< 0.5	< 0.5	3.04	11.2	< 0.5	47.4
99SABS16	129	0.312	10498	15.3	< 2.	0.98	< 0.5	3.19	8.88	1.33	48.8
99SABS17	138	0.338	10311	15.5	< 2.	1.18	0.54	3.29	9.17	0.59	62.
99SABS18	147	0.292	11085	34.2	< 2.	0.65	0.597	2.78	11.1	< 0.5	49.7
99SABS19	166	0.36	10464	31.5	< 2.	< 0.5	0.653	2.84	12.	< 0.5	55.
99SABS20	155	0.289	10047	30.	< 2.	0.5	0.651	2.84	12.4	< 0.5	49.8
99SABS03	165	0.354	10239	25.6	< 2.	< 0.5	< 0.5	2.58	11.	< 0.5	53.
99SABS07	292	0.295	10978	40.7	< 2.	1.33	1.66	2.41	27.6	< 0.5	53.
99SABS08	220	0.317	11555	33.	< 2.	< 0.5	0.718	2.52	13.	< 0.5	52.
99SABS11	128	0.282	9430	14.1	< 2.	0.87	< 0.5	3.59	8.76	< 0.5	62.3
99SABS12	156	0.268	10424	20.2	< 2.	0.92	< 0.5	2.66	10.1	< 0.5	59.4
99SABS21	126	0.293	9559	13.	< 2.	0.61	< 0.5	3.26	8.62	0.54	57.3

Table B-3. Concentrations of elements (parts per million, dry weight) in brine shrimp and brine shrimp cysts from Great Salt Lake, 1996-2000. (*Page 3 of 4*)

Sample ID	Weight (grams)	Collection Date	% M	Al	As	B	Ba	Be	Cd	Cr	Cu
Gilbert Bay 199 (cont.)											
99SABS22	64.	10/04/99	90.6	44.3	16.6	36.6	1.03	< 0.1	0.364	< 0.5	7.53
99SABS23	26.3	10/05/99	90.0	46.4	16.3	38.6	1.28	< 0.1	0.353	< 0.5	8.25
99SABS24	34.	10/05/99	90.9	82.5	13.3	45.6	1.49	< 0.1	0.323	< 0.5	9.06
99SABS25	36.	10/05/99	91.2	38.6	14.9	41.4	1.26	< 0.1	0.336	0.61	9.81
99SABS26	30.1	10/05/99	90.6	45.4	15.5	37.3	1.38	< 0.1	0.348	< 0.5	8.78
99SABS27	59.	10/12/99	91.4	42.4	16.2	45.4	1.1	< 0.1	0.401	< 0.5	9.25
99SABS28	64.	10/12/99	91.4	62.9	14.8	44.2	1.22	< 0.1	0.369	< 0.5	8.83
Gilbert Bay- USGS Sites; 1999; Brine Shrimp Cysts											
9SABSC04	16.	09/23/99	85.6	95.7	12.7	65.2	2.64	< 0.1	< 0.1	0.92	10.5
9SABSC17	8.9	09/29/99	82.2	146.	11.6	65.1	2.97	< 0.1	< 0.1	0.98	8.63
9SABSC11	29.	10/04/99	82.9	196.	9.07	87.2	4.42	< 0.1	< 0.1	< 0.5	10.8
9SABSC12	22.3	10/04/99	85.2	182.	8.3	86.4	3.19	< 0.1	< 0.1	0.92	7.22
Gilbert Bay; 2000											
00SABS06	15.	05/09/00	88.8	49.8	11.3	36.6	1.52	< 0.1	0.186	0.5	13.7
00SABS04	32.	05/18/00	88.8	26.7	9.49	27.7	< 1	< 0.1	0.203	< 0.5	12.1
00SABS09	23.	05/18/00	89.9	17.3	10.6	36.6	1	< 0.1	0.286	< 0.5	11.2
00SABS10	64.	05/18/00	90.5	31.7	11.	24.8	1.04	< 0.1	0.203	< 0.5	11.5
00SABS13	62.	05/18/00	90.0	26.8	10.1	32.1	1.09	< 0.1	0.199	< 0.5	11.2
00SABS14	63.	05/18/00	90.0	18.	9.45	27.6	< 1	< 0.1	0.18	< 0.5	11.5
00SABS16	62.	05/18/00	90.2	34.2	9.33	31.8	1.19	< 0.1	0.186	< 0.5	12.9
00SABS02	64.	05/19/00	89.7	49.8	9.46	28.3	1.06	< 0.1	0.193	0.87	12.
00SABS05	64.	05/19/00	89.9	30.2	8.96	27.4	3.69	< 0.1	0.202	< 0.5	11.9
00SABS07	61.	05/19/00	89.2	36.3	8.66	27.	1.13	< 0.1	0.21	< 0.5	12.2
00SABS11	63.	05/19/00	89.5	75.4	9.49	30.9	1.38	< 0.1	0.174	< 0.5	11.3
00SABS12	61.	05/19/00	89.3	120.	9.12	22.5	1.9	< 0.1	0.205	< 0.5	13.5
00SABS15	64.	05/19/00	89.8	60.7	9.57	30.9	1.43	< 0.1	0.203	< 0.5	12.
00SABS21	62.	05/19/00	89.2	83.	10.7	26.3	1.5	< 0.1	0.184	1.96	13.5
00SABS01	64.	05/22/00	89.8	13.1	8.55	26.9	1.01	< 0.1	0.192	< 0.5	12.2
00SABS03	48.	05/22/00	89.8	78.6	10.3	27.1	1.63	< 0.1	0.188	< 0.5	13.3
00SABS08	44.	05/22/00	89.1	110.	9.35	28.	1.75	< 0.1	0.191	< 0.5	15.2
00SABS22	60.	05/22/00	90.0	39.8	10.7	28.8	1.16	< 0.1	0.188	2.38	14.2
00SABS23	63.	05/22/00	89.3	59.4	11.	23.6	1.17	< 0.1	0.174	2.31	12.2
00SABS24	64.	05/22/00	89.2	77.1	10.4	22.4	1.42	< 0.1	0.181	0.83	13.7
00SABS25	64.	05/22/00	89.7	49.2	11.3	26.8	1.23	< 0.1	0.177	2.08	13.4
00SABS26	63.	05/22/00	89.9	45.5	14.8	23.7	1.02	< 0.1	0.185	2.36	13.5
00SABS17	63.	05/24/00	91.1	12.1	11.2	39.1	1.09	0.38	0.25	< 0.5	14.4
00SABS18	65.	05/24/00	91.4	12.1	11.9	41.5	1	< 0.1	0.231	< 0.5	13.1
00SABS19	65.	05/24/00	91.0	28.9	10.5	32.5	1.16	< 0.1	0.231	< 0.5	12.8
00SABS20	68.	05/24/00	90.7	58.	11.3	34.6	1.42	0.24	0.193	< 0.5	11.7
00SABS27	63.	05/24/00	90.8	29.1	15.3	33.3	1.02	< 0.1	0.224	2.75	14.2
00SABS28	65.	05/24/00	90.8	34.4	14.5	34.2	1.12	< 0.1	0.201	3.77	12.8

Sample ID	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
Gilbert Bay 1999 (cont.)											
99SABS22	137	0.315	8722	13.6	< 2.	1.28	< 0.5	3.26	8.14	< 0.5	63.8
99SABS23	139	0.276	8826	20.8	< 2.	1.29	< 0.5	3.41	9.46	< 0.5	66.1
99SABS24	172	0.319	10401	19.7	< 2.	0.87	< 0.5	2.82	10.7	1.01	69.2
99SABS25	143	0.268	10049	18.8	< 2.	1.01	< 0.5	2.75	10.	< 0.5	65.5
99SABS26	138	0.283	9198	21.3	< 2.	1.2	< 0.5	3.08	9.37	< 0.5	64.5
99SABS27	142	0.354	10472	18.2	< 2.	< 0.5	< 0.5	2.92	10.	< 0.5	65.4
99SABS28	152	0.324	10423	21.6	< 2.	1.07	< 0.5	2.84	9.85	1.12	64.1
Gilbert Bay- USGS Sites; 1999; Brine Shrimp Cysts											
9SABSC04	515	< 0.2	8959	70.	< 2.	1.56	2.03	1.63	9.53	1.62	46.7
9SABSC17	517	< 0.2	10656	67.6	2.58	1.26	2.12	1.46	10.	2.32	44.5
9SABSC11	891	< 0.2	10869	31.5	2.32	0.59	1.77	1.47	10.9	1.04	27.4
9SABSC12	810	< 0.2	12751	35.4	< 2.	0.69	1.47	1.15	15.6	< 0.5	29.6
Gilbert Bay; 2000											
00SABS06	162	< 0.2	9173	22.	< 2.	1.74	< 0.5	2.65	11.3	0.86	117.
00SABS04	151	< 0.2	7971	9.54	< 2.	2.13	< 0.5	3.01	8.08	0.53	112.
00SABS09	130	< 0.2	9780	7.87	< 2.	1.84	< 0.5	2.97	9.47	0.89	105.
00SABS10	169	< 0.2	7145	10.1	< 2.	1.7	< 0.5	2.55	7.33	1.44	125.
00SABS13	153	< 0.2	8686	11.	< 2.	1.45	< 0.5	2.95	9.04	1.54	103.
00SABS14	159	< 0.2	7649	8.4	< 2.	1.93	< 0.5	3.05	7.78	1.4	124.
00SABS16	162	< 0.2	8428	10.9	< 2.	1.98	< 0.5	2.53	8.88	1.19	113.
00SABS02	191	< 0.2	7813	14.5	< 2.	2.57	< 0.5	2.64	8.32	< 0.5	109.
00SABS05	156	< 0.2	7564	10.8	< 2.	2.17	< 0.5	2.78	7.87	0.69	106.
00SABS07	179	< 0.2	7616	14.3	< 2.	2.04	< 0.5	2.63	8.38	0.79	118.
00SABS11	191	< 0.2	8309	16.2	< 2.	1.74	< 0.5	2.2	9.67	1.81	113.
00SABS12	272	< 0.2	6510	19.4	< 2.	2.68	< 0.5	2.63	9.88	1.66	140.
00SABS15	208	< 0.2	8521	17.	< 2.	2.02	< 0.5	2.48	9.57	1.53	131.
00SABS21	214	< 0.2	7478	17.2	< 2.	1.13	< 0.5	2.44	8.88	< 0.5	114.
00SABS01	158	< 0.2	7936	8.61	< 2.	1.53	< 0.5	2.55	7.9	0.59	115.
00SABS03	232	< 0.2	7954	12.	< 2.	1.33	< 0.5	2.87	10.5	0.55	118.
00SABS08	247	< 0.2	7803	18.6	< 2.	< 0.5	< 0.5	2.8	10.8	0.53	124.
00SABS22	182	< 0.2	7879	10.8	< 2.	1.1	< 0.5	2.86	8.41	0.79	111.
00SABS23	238	< 0.2	7076	14.4	< 2.	1.08	< 0.5	2.63	8.75	< 0.5	124.
00SABS24	251	< 0.2	6822	15.5	< 2.	0.72	< 0.5	2.48	8.2	< 0.5	132.
00SABS25	186	< 0.2	8068	11.3	< 2.	1.28	< 0.5	2.37	8.3	< 0.5	108.
00SABS26	223	< 0.2	7030	10.4	< 2.	0.82	< 0.5	2.24	7.4	< 0.5	125.
00SABS17	152	< 0.2	9690	9.97	< 2.	3.03	< 0.5	2.67	9.56	3.65	104.
00SABS18	153	< 0.2	9976	6.64	< 2.	2.48	< 0.5	2.61	9.78	1.66	106.
00SABS19	180	< 0.2	8357	12.2	< 2.	2.74	< 0.5	2.51	8.76	1.95	116.
00SABS20	208	< 0.2	9392	27.7	< 2.	3.01	< 0.5	2.75	10.2	0.82	95.8
00SABS27	193	< 0.2	8654	9.27	< 2.	2.28	< 0.5	2.68	8.22	< 0.5	113.
00SABS28	182	< 0.2	9666	12.2	< 2.	1.38	< 0.5	2.33	9.01	0.66	105.

Table B-4. Concentrations of elements (parts per million, dry weight) in Eared Grebe livers from Great Salt Lake, 1997-2000. (*Page 1 of 2*)

Sample ID	Weight (grams)	Collection Date	% M	Al	As	B	Ba	Be	Cd	Cr	Cu
1997 Samples (Composites)											
97SAEG1	56.	11/13/97	68.9	< 5	5.96	2.21	< 1	< 0.1	2.09	0.561	15.
97SAEG2	72.	11/18/97	68.9	< 5	5.06	2.43	< 1	< 0.1	1.78	0.512	14.
97SAEG3	100.	11/18/97	70.5	< 5	6.83	2.83	< 1	< 0.1	1.61	< 0.5	16.3
1998 Samples (Individually analyzed)											
98SAEG1	23.32	09/23/98	68.9	< 5	0.79	< 2	< 1	< 0.1	2.03	0.5	9.6
98SAEG10	30.01	09/24/98	76.4	< 5	1.63	< 2	< 1	< 0.1	1.57	< 0.5	9.86
98SAEG11	25.66	09/24/98	70.7	< 5	1.46	< 2	< 1	< 0.1	1.43	< 0.5	11.3
98SAEG12	19.62	09/24/98	67.0	< 5	1.17	< 2	< 1	< 0.1	3.17	< 0.5	10.6
98SAEG13	19.97	12/07/98	69.0	< 5	3.19	< 2	< 1	< 0.1	3.06	0.5	10.9
98SAEG14	13.92	12/07/98	67.1	< 5	2.34	< 2	< 1	< 0.1	1.31	< 0.5	8.42
98SAEG15	20.7	12/07/98	74.4	< 5	3.3	2.2	< 1	< 0.1	0.34	0.57	10.5
98SAEG16	13.01	12/07/98	60.5	< 5	1.03	< 2	< 1	< 0.1	1.06	< 0.5	11.7
98SAEG2	23.27	09/23/98	69.9	< 5	1.37	< 2	< 1	< 0.1	1.77	< 0.5	10.4
98SAEG3	24.19	09/23/98	68.8	< 5	2.2	< 2	< 1	< 0.1	0.781	< 0.5	10.3
98SAEG4	23.97	09/23/98	68.6	< 5	1.71	< 2	< 1	< 0.1	2.43	< 0.5	10.1
98SAEG5	18.38	09/23/98	71.4	< 5	1.43	< 2	< 1	< 0.1	0.814	0.72	11.9
98SAEG6	21.42	09/23/98	69.1	< 5	1.58	< 2	< 1	< 0.1	0.26	0.61	11.3
98SAEG7	13.02	09/24/98	69.9	< 5	1.42	< 2	< 1	< 0.1	6.54	< 0.5	11.6
98SAEG8	17.38	09/24/98	66.8	< 5	0.88	< 2	< 1	< 0.1	0.938	< 0.5	12.2
98SAEG9	27.95	09/24/98	70.8	< 5	0.77	< 2	< 1	< 0.1	1.11	< 0.5	7.94
2000 Samples (Individually analyzed)											
0SAEGL01	25.	04/25/00	76.9	< 5	2.12	< 2	< 1	< 0.1	2.89	0.7	11.3
0SAEGL02	19.	04/25/00	69.4	< 5	2.79	< 2	< 1	< 0.1	1.26	< 0.5	10.2
0SAEGL03	8.	04/25/00	68.1	< 5	1.01	< 2	< 1	< 0.1	12.7	< 0.5	19.2
0SAEGL04	17.	05/18/00	72.0	< 5	1.96	< 2	< 1	< 0.1	4.	< 0.5	11.
0SAEGL05	12.	05/18/00	69.4	< 5	0.918	< 2	< 1	< 0.1	4.18	0.55	20.
0SAEGL06	19.	05/18/00	73.3	< 5	1.88	< 2	< 1	< 0.1	3.24	0.74	12.7
0SAEGL07	14.	05/18/00	71.7	< 5	1.76	< 2	< 1	< 0.1	3.49	0.95	15.9
0SAEGL08	11.	05/19/00	68.6	< 5	1.69	< 2	< 1	< 0.1	10.8	0.63	13.9
0SAEGL09	24.	05/19/00	66.5	< 5	2.32	< 2	< 1	< 0.1	3.06	< 0.5	7.77
0SAEGL10	16.	05/19/00	74.6	< 5	1.39	< 2	< 1	< 0.1	1.75	1.2	10.6
0SAEGL11	19.	05/19/00	72.6	< 5	2.23	< 2	< 1	< 0.1	1.67	< 0.5	10.5
0SAEGL12	13.	05/19/00	67.9	< 5	2.33	< 2	< 1	< 0.1	4.72	< 0.5	10.4
0SAEGL13	16.	05/19/00	70.1	< 5	1.67	< 2	< 1	< 0.1	7.88	0.52	12.7
0SAEGL14	18.	05/22/00	72.3	< 5	2.29	< 2	< 1	< 0.1	6.47	< 0.5	12.8
0SAEGL15	28.	05/22/00	75.4	< 5	1.39	< 2	< 1	< 0.1	2.27	< 0.5	9.51
0SAEGL16	23.	05/22/00	72.5	< 5	1.98	< 2	< 1	< 0.1	2.03	< 0.5	11.6
0SAEGL17	8.	05/22/00	68.1	< 5	< 0.5	< 2	< 1	< 0.1	13.1	0.96	30.2
0SAEGL18	10.	05/22/00	67.4	< 5	0.764	< 2	< 1	< 0.1	4.4	0.68	24.5
0SAEGL19	20.	05/24/00	72.6	< 5	2.9	< 2	< 1	< 0.1	4.65	0.75	10.6
0SAEGL20	17.	05/24/00	72.9	< 5	1.97	< 2	< 1	< 0.1	2.56	< 0.5	10.2
0SAEGL21	19.	05/24/00	70.0	< 5	2.26	< 2	< 1	< 0.1	2.63	< 0.5	12.6
0SAEGL22	15.	05/24/00	71.3	< 5	1.68	< 2	< 1	< 0.1	2.71	0.72	11.7
0SAEGL23	19.	05/24/00	72.0	< 5	2.61	< 2	< 1	< 0.1	3.52	< 0.5	13.
0SAEGL24	14.	05/24/00	72.9	< 5	1.33	< 2	< 1	< 0.1	17.9	0.53	11.8

Sample ID	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
1997 Samples (Composites)											
97SAEG1	1697	11.7	649	13.5	< 2	0.67	< 0.5	9.69	< 0.5	2.43	119.
97SAEG2	1126	10.5	634	13.	2.03	< 0.5	< 0.5	9.35	< 0.5	0.65	111.
97SAEG3	1118	12.6	733	14.3	< 2	1.15	< 0.5	11.3	< 0.5	1.53	122.
1998 Samples (Individually analyzed)											
98SAEG1	362	5.88	541	7.63	< 2	< 0.5	< 0.5	5.36	< 0.5	< 0.5	73.1
98SAEG10	832	7.13	703	8.91	< 2	0.92	< 0.5	5.	< 0.5	< 0.5	71.4
98SAEG11	594	4.31	588	9.97	2.03	< 0.5	< 0.5	4.33	< 0.5	< 0.5	81.1
98SAEG12	766	5.49	506	11.3	< 2	< 0.5	< 0.5	5.55	< 0.5	< 0.5	72.6
98SAEG13	926	19.1	535	9.6	< 2	< 0.5	< 0.5	13.7	< 0.5	< 0.5	99.1
98SAEG14	1687	19.3	562	8.27	< 2	< 0.5	< 0.5	14.	< 0.5	< 0.5	83.9
98SAEG15	1311	15.5	642	9.25	2.48	< 0.5	< 0.5	15.5	< 0.5	< 0.5	82.1
98SAEG16	1275	5.83	417	9.18	< 2	< 0.5	< 0.5	4.04	< 0.5	< 0.5	66.
98SAEG2	584	8.17	517	8.57	< 2	< 0.5	< 0.5	6.57	< 0.5	< 0.5	65.8
98SAEG3	601	9.51	521	9.48	< 2	< 0.5	< 0.5	7.24	< 0.5	0.65	74.5
98SAEG4	546	9.15	548	10.1	< 2	< 0.5	< 0.5	5.76	< 0.5	0.94	81.3
98SAEG5	629	8.73	661	13.3	< 2	< 0.5	< 0.5	5.08	< 0.5	0.87	78.4
98SAEG6	568	6.	560	9.51	< 2	< 0.5	< 0.5	7.87	< 0.5	0.69	72.8
98SAEG7	744	6.86	691	9.85	< 2	< 0.5	< 0.5	8.16	1.02	< 0.5	116.
98SAEG8	809	5.48	563	10.3	2.23	< 0.5	< 0.5	7.59	< 0.5	< 0.5	69.
98SAEG9	944	5.75	490	6.83	< 2	< 0.5	< 0.5	7.83	< 0.5	0.52	57.9
2000 Samples (Individually analyzed)											
0SAEGL01	1697	2.3	661	9.82	< 2	< 0.5	< 0.5	6.47	< 0.5	< 0.5	105.
0SAEGL02	2558	4.23	628	11.2	< 2	< 0.5	< 0.5	18.9	< 0.5	< 0.5	118.
0SAEGL03	2741	8.72	606	13.1	< 2	< 0.5	< 0.5	9.34	< 0.5	< 0.5	169.
0SAEGL04	1347	0.462	537	8.6	< 2	< 0.5	< 0.5	5.12	< 0.5	< 0.5	93.5
0SAEGL05	2984	2.42	563	10.7	< 2	0.6	< 0.5	6.17	< 0.5	0.57	176.
0SAEGL06	1969	0.838	561	11.2	< 2	< 0.5	< 0.5	6.54	< 0.5	< 0.5	114.
0SAEGL07	1787	1.29	621	11.2	< 2	< 0.5	< 0.5	4.94	< 0.5	< 0.5	181.
0SAEGL08	3299	0.969	630	13.4	< 2	< 0.5	< 0.5	4.89	< 0.5	0.63	166.
0SAEGL09	1137	0.425	467	8.92	< 2	< 0.5	< 0.5	6.82	< 0.5	0.97	61.8
0SAEGL10	2350	2.61	671	10.3	< 2	< 0.5	< 0.5	6.94	< 0.5	< 0.5	82.7
0SAEGL11	2576	8.93	573	9.49	< 2	1.55	< 0.5	7.16	< 0.5	0.69	67.2
0SAEGL12	3098	20.5	562	13.4	< 2	1.01	< 0.5	14.7	< 0.5	< 0.5	126.
0SAEGL13	2090	3.74	573	11.5	< 2	0.61	< 0.5	6.98	< 0.5	< 0.5	111.
0SAEGL14	1340	3.98	628	11.6	< 2	< 0.5	< 0.5	7.03	< 0.5	< 0.5	111.
0SAEGL15	1231	1.17	521	8.43	< 2	< 0.5	< 0.5	7.19	< 0.5	0.7	69.6
0SAEGL16	1084	0.793	550	9.57	< 2	< 0.5	< 0.5	6.54	< 0.5	< 0.5	73.7
0SAEGL17	4637	6.5	615	14.4	< 2	0.53	< 0.5	7.69	< 0.5	< 0.5	190.
0SAEGL18	3183	3.55	497	10.8	< 2	0.62	< 0.5	17.	< 0.5	< 0.5	114.
0SAEGL19	3087	3.86	634	10.1	< 2	1.11	< 0.5	7.04	< 0.5	0.84	87.
0SAEGL20	1919	0.814	569	10.3	< 2	< 0.5	< 0.5	8.81	< 0.5	< 0.5	126.
0SAEGL21	1453	0.778	543	10.3	< 2	< 0.5	< 0.5	7.	< 0.5	< 0.5	98.9
0SAEGL22	2019	6.79	584	14.9	< 2	< 0.5	< 0.5	11.	< 0.5	< 0.5	155.
0SAEGL23	974	0.978	627	9.92	< 2	< 0.5	< 0.5	4.79	< 0.5	< 0.5	91.8
0SAEGL24	3772	1.06	640	9.45	< 2	< 0.5	< 0.5	3.78	< 0.5	< 0.5	140.

Table B-5. Chlorinated Organic Compounds (Organochlorine pesticides and herbicides including DDT isomers, and total PCBs) and Dioxins & Furans, in Eared Grebe Livers (Composite Samples) Gilbert Bay (Open Water) Great Salt Lake, 1997. (*Page 1 of 2*)

Chlorinated Organics- Herbicides, Pesticides, PCBs

Sample IDr	Collection Date	% Lipid	% Moisture	Aldrin	dieldrin	endrin	alpha BHC
97SAEG1	11/13/1997	7.89	68.4	< 0.00859	< 0.00859	< 0.00859	< 0.00859
97SAEG2	11/18/1997	6.83	69.1	< 0.00921	< 0.00921	< 0.00921	< 0.00921
97SAEG3	11/18/1997	15.8	70.5	< 0.00812	< 0.00812	< 0.00812	< 0.00812

Sample IDr	heptachlor epoxide	cis-nonachlor	trans-nonachlor	endosulfan II	HCB	mirex	toxaphene
97SAEG1	< 0.00859	< 0.00859	< 0.00859	< 0.00859	< 0.00859	< 0.00859	< 0.043
97SAEG2	< 0.00921	< 0.00921	< 0.00921	< 0.00921	< 0.00921	< 0.00921	< 0.046
97SAEG3	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.0406

Sample IDr	beta BHC	delta BHC	gamma BHC	alpha chlordane	gamma chlordane	oxy-chlordane	Heptachlor
97SAEG1	< 0.00859	< 0.00859	< 0.00859	< 0.00859	< 0.00859	< 0.00859	< 0.00859
97SAEG2	< 0.00921	< 0.00921	< 0.00921	< 0.00921	< 0.00921	< 0.00921	< 0.00921
97SAEG3	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.00812

Sample IDr	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	o,p'-DDD	o,p'-DDE	Total PCBs
97SAEG1	< 0.00859	< 0.00859	**0.0387**	< 0.00859	< 0.00859	< 0.00859	**0.0787**
97SAEG2	< 0.00921	< 0.00921	**0.00953**	< 0.00921	< 0.00921	< 0.00921	**0.116**
97SAEG3	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.00812	< 0.0406

NOTES:

all results reported in milligrams per kilogram (mg/kg) wet weight basis

detected residues shown in **Bold type**

Table B-5. (continued) *(page 2 of 2)*

Dioxins and Furans

Sample IDr	2,3,7,8-TCDD	2,3,7,8-TCDF	OCDD	OCDF	1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF
97SAEG1	< 3.7E-06	< 3.7E-06	< 3.7E-05	< 3.7E-05	< 1.9E-05	< 1.9E-05	< 1.85E-05
97SAEG2	< 4.2E-06	< 4.2E-06	< 4.2E-05	< 4.2E-05	< 2.1E-05	< 2.1E-05	< 2.12E-05
97SAEG3	< 4.1E-06	< 4.1E-06	< 4.1E-05	< 4.1E-05	< 2.1E-05	< 2.1E-05	< 2.06E-05

Sample IDr	1,2,3,4,7,8-HxCDD	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDD	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-HxCDF	1,2,3,7,8-PeCDD
97SAEG1	< 1.9E-05	< 1.9E-05	< 1.9E-05	< 1.9E-05	< 1.9E-05	< 1.9E-05	< 1.85E-05
97SAEG2	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.12E-05
97SAEG3	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.1E-05	< 2.06E-05

Sample IDr	1,2,3,7,8-PeCDF	2,3,4,6,7,8-HxCDF	2,3,4,7,8-PeCDF
97SAEG1	< 1.9E-05	< 1.9E-05	< 1.9E-05
97SAEG2	< 2.1E-05	< 2.1E-05	< 2.1E-05
97SAEG3	< 2.1E-05	< 2.1E-05	< 2.1E-05

NOTES:

all results reported in milligrams per kilogram (mg/kg) wet weight basis

detected residues shown in **Bold type**

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APPENDIX C

Mercury in Terns at Farmington Bay Waterfowl Management Area, 2000

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Table C-1. Total mercury and methyl mercury (mg/kg) in eggs and chick carcasses of Forster's terns (FOTE) and great blue herons (GBHE) from the Crystal Unit, Farmington Bay Waterfowl Management Area, Great Salt Lake, Utah, 2000.

						Total Mercury (T-Hg)		Methyl Mercury (Me-Hg)		
Sample ID	Collection Date	Sample Matrix	Species Code [a]	Weight (grams)	% Moisture	wet weight (ww)	dry weight (dw)	wet weight (ww)	dry weight (dw)	% Me-Hg[b] (dry weight)
Whole Eggs										
00CUFT02	06/26/00	Egg	FOTE	18	78.4	0.325	1.51	0.358	1.66	109.9%
00CUFT03	06/26/00	Egg	FOTE	18	78.2	0.177	0.812	0.176	0.81	99.8%
00CUFT04	06/26/00	Egg	FOTE	19	76.5	0.183	0.777	0.172	0.73	94.0%
00CUFT05	06/26/00	Egg	FOTE	19	78.2	0.214	0.98	0.157	0.72	73.5%
00CUFT06	06/26/00	Egg	FOTE	16	71.8	0.058	0.204	0.085	0.3	147.1%
00CUFT07	06/26/00	Egg	FOTE	19	76.4	0.235	0.999	0.158	0.67	67.1%
00CUFT08	06/26/00	Egg	FOTE	18	78.0	0.299	1.36	0.176	0.8	58.8%
00CUFT09	06/26/00	Egg	FOTE	19	77.6	0.236	1.05	0.24	1.07	101.9%
00CUFT10	06/26/00	Egg	FOTE	20	78.0	0.253	1.15	0.207	0.94	81.7%
00CUFT11	06/26/00	Egg	FOTE	20	78.5	0.368	1.71	0.278	1.29	75.4%
00CUFT12	06/26/00	Egg	FOTE	16	76.3	0.126	0.531	0.057	0.24	45.2%
00CUFT20	06/26/00	Egg	FOTE	14	77.8	0.277	1.25	0.2	0.9	72.0%
00CUFT21	06/26/00	Egg	FOTE	17	78.1	0.429	1.96	0.421	1.92	98.0%
00CUGB01	05/25/00	Egg	GBHE	58	79.5	0.169	0.824	0.096	0.47	57.0%
Whole Body Chick Carcasses										
00CUFT14	06/26/00	Carcass	FOTE	10	74.5	0.81	3.18	0.359	1.41	44.3%
0CUGBC01	06/06/00	Carcass	GBHE	797	77.7	0.069	0.31	0.092	0.41	132.3%

NOTES

(a) Species Codes: FOTE: Forsters' Tern (*Sterna forsteri*)

GBHE: Great Blue Heron (*Ardea herodias*)

(B) % Methyl mercury calculated as [(Me-$Hg_{Reported}$)/(T-$Hg_{Reported}$)] x 100

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APPENDIX D

Contaminants in Sediments, Northwest Oil Drain Delta, 2000

Table D-1. Concentrations of trace elements (parts per million, dry weight) in sediments from the Northwest Oil Drain, 2000. (*Page 1 of 2*)

Sample ID	Transect No. [(a)]	Weight (grams)	Collection Date	% M	Al	As	B	Ba	Be	Cd	Cr
00ODSE01	T-6	487	4/12/00	57.5	13432	32.8	110.	239.	0.79	1.38	30.
00ODSE02	T-6	598	4/17/00	64.9	16266	29.5	72.5	274.	1.96	10.9	136.
00ODSE03	T-6	621	4/19/00	63.6	12914	29.2	104.	168.	0.82	3.17	45.
00ODSE04	T-5	630	4/17/00	52.4	14625	36.4	110.	219.	0.86	2.08	42.1
00ODSE05	T-5	610	4/12/00	49.7	11122	40.8	107.	276.	0.8	5.03	32.2
00ODSE06	T-5	861	4/19/00	31.2	3347	20.1	101.	248.	0.22	0.859	7.43
00ODSE07	T-5	899	4/19/00	26.5	3797	20.7	123.	305.	0.25	0.301	5.6
00ODSE08	T-4	640	4/17/00	50.2	13367	43.	137.	259.	0.92	2.74	73.8
00ODSE09	T-4	611	4/12/00	55.4	12214	35.8	112.	265.	0.8	1.44	67.
00ODSE10	T-4	659	4/20/00	57.5	10337	23.4	52.2	256.	0.9	7.08	310.
00ODSE11	T-4	744	4/19/00	38.8	8825	36.5	123.	224.	0.48	1.82	20.3
00ODSE12	T-3	840	4/12/00	26.3	6121	22.	132.	289.	0.36	0.29	11.4
00ODSE13	T-3	803	4/12/00	30.4	6376	18.5	109.	198.	0.42	0.297	10.1
00ODSE14	T-3	628	4/20/00	58.2	16702	26.	95.4	226.	1.11	2.81	120.
00ODSE15	T-3	629	4/20/00	62.1	13790	26.3	129.	163.	0.82	1.07	39.
00ODSE16	T-2	608	4/20/00	65.7	16989	20.4	112.	181.	0.97	0.949	56.5
00ODSE17	T-2	602	4/20/00	62.1	14665	23.3	141.	166.	0.9	0.973	41.1
00ODSE19	T-1	612	4/27/00	61.5	14677	22.3	67.2	164.	0.8	3.31	28.7
00ODSE20	T-1	641	4/27/00	59.9	11790	21.	54.2	170.	0.76	3.72	26.
00ODSE21	T-1	521	4/27/00	80.5	16132	11.7	83.2	197.	1.06	0.368	52.3

NOTES:

(a) Transect 6: Furthest Off-shore (approx 2.2 km from Turpin Dike); Transect 1furthest on-shore (within Turpin Unit of Farmington Bay Waterfowl Management Area). See Section 7, Figure 7-1

Sample ID	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
00ODSE01	113.	12121	1.01	31640	438	17.4	16.4	122.	< 1	992.	34.3	209.
00ODSE02	282.	18703	6.17	19007	238	11.6	36.5	409.	1.34	358.	112.	660.
00ODSE03	145.	12095	1.05	32049	443	5.06	18.9	181.	< 1	664.	49.3	272.
00ODSE04	204.	14940	2.25	33153	393	10	18.7	239.	1.18	642.	45.9	385.
00ODSE05	268.	13464	4.69	30381	329	9.8	19.	453.	1.96	646.	30.1	611.
00ODSE06	55.7	5010	0.765	26603	334	< 5	9.57	149.	< 1	2523.	16.5	135.
00ODSE07	43.3	4367	0.202	28179	186	< 5	8.33	70.3	1.04	2710.	14.5	71.3
00ODSE08	244.	15268	3.52	38311	390	8.94	23.9	308.	2.13	462.	38.2	512.
00ODSE09	236.	14967	5.15	32828	344	9.32	22.6	407.	1.57	623.	33.1	522.
00ODSE10	286.	15556	1.98	18207	249	< 5	26.3	374.	1.65	287.	28.5	932.
00ODSE11	123.	9496	0.846	35554	305	< 5	12.8	195.	< 1	1434.	27.6	231.
00ODSE12	35.4	6964	0.216	38284	334	< 5	8.65	61.1	< 1	1914.	18.	82.7
00ODSE13	19.	7126	< 0.2	30894	246	< 5	8.58	53.4	< 1	1957.	17.7	57.9
00ODSE14	277.	17906	0.987	26118	302	< 5	27.3	222.	2.48	347.	31.	359.
00ODSE15	146.	13317	0.427	36768	413	< 5	19.3	138.	1.84	726.	31.	237.
00ODSE16	189.	16117	0.58	29291	364	< 5	20.4	173.	2.3	489.	32.8	314.
00ODSE17	153.	14411	0.458	35393	394	< 5	17.	143.	2.08	629.	30.	248.
00ODSE19	183.	15191	1.05	25870	352	< 5	16.3	408.	2.19	595.	34.2	389.
00ODSE20	193.	13797	1.75	23360	315	< 5	14.4	433.	2	594.	30.2	420.
00ODSE21	165.	16988	0.345	20726	233	6.11	20.7	132.	1.91	342.	28.	250.

Table D-2. Total PCBs, DDT isomers, and Organochlorine (OC) Pesticide Residues in Sediments from the Oil Drain Delta in Farmington Bay, Great Salt Lake, Utah , 2000. *(Page 1 of 4)*

Sample ID	Collection Date	Total PCBs	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE
Transect 6[(a)]							
00ODSE01	4/12/2000	**0.445**	**0.0071**	< 0.00116	**0.00132**	**0.0109**	**0.0107**
00ODSE02	4/17/2000	**5.55**	**0.0519**	**0.0124**	**0.0159**	**0.116**	**0.0787**
00ODSE03	4/19/2000	**0.807**	**0.0052**	**0.00223**	**0.004**	**0.0111**	**0.0233**
Transect 5							
00ODSE04	4/17/2000	**0.879**	**0.0189**	**0.00179**	**0.00271**	**0.0462**	**0.0179**
00ODSE05	4/12/2000	**0.429**	**0.0295**	**0.00564**	**0.157**	**0.0479**	< 0.00096
00ODSE06	4/19/2000	**0.179**	< 0.000727	< 0.000727	**0.024**	**0.0098**	**0.0047**
00ODSE07	4/19/2000	**0.0895**	< 0.000667	< 0.000667	< 0.000667	< 0.000667	< 0.000667
Transect 4							
00ODSE08	4/17/2000	**0.527**	**0.0376**	**0.0109**	**0.197**	**0.0778**	**0.00696**
00ODSE09	4/12/2000	**0.85**	**0.101**	**0.059**	< 0.00108	< 0.00108	< 0.00108
00ODSE10	4/20/2000	**1.08**	**0.00248**	< 0.00116	**0.00183**	**0.00277**	**0.0345**
00ODSE11	4/19/2000	**0.173**	**0.0242**	< 0.000807	< 0.000807	**0.0497**	**0.00913**
Transect 3							
00ODSE12	4/12/2000	**0.145**	**0.00496**	< 0.00066	< 0.00066	**0.0086**	**0.00191**
00ODSE13	4/12/2000	**0.0427**	**0.000978**	< 0.000717	< 0.000717	**0.00147**	< 0.000717
00ODSE14	4/20/2000	**0.562**	**0.00697**	< 0.00117	**0.00591**	**0.012**	**0.0142**
00ODSE15	4/20/2000	**0.0668**	**0.00153**	< 0.00131	< 0.00131	**0.00206**	**0.00142**
Transect 2							
00ODSE16	4/20/2000	**0.1**	**0.002**	< 0.00143	**0.00283**	**0.00203**	**0.00192**
00ODSE17	4/20/2000	**0.158**	**0.00295**	< 0.0013	**0.00347**	**0.004**	**0.00306**
Transect 1							
00ODSE19	4/27/2000	**0.0997**	**0.00564**	< 0.00129	< 0.00129	**0.00597**	**0.00272**
00ODSE20	4/27/2000	**0.15**	**0.00855**	< 0.00124	< 0.00124	**0.0128**	**0.00306**
00ODSE21	4/27/2000	**0.395**	**0.00363**	**0.00367**	**0.00678**	**0.0043**	**0.00626**

NOTES

BOLD: Detected concentrations

a Transect 6: Furthest Off-shore (approx 2.2 km from Turpin Dike); Transect 1furthest on-shore (within Turpin Unit of Farmington Bay Waterfowl Management Area). See Section 7, Figure 7-1

Table D-2. (continued) *(page 2 of 4)*

Sample ID	p,p'-DDT	total DDT(b)	Aldrin	dieldrin	endrin	alpha BHC	beta BHC
00ODSE01	**0.0029**	0.03289	< 0.00116	**0.0137**	< 0.00116	< 0.00116	< 0.00116
00ODSE02	< 0.00139	**0.2749**	< 0.00139	**0.251**	0.00229	**0.0017**	< 0.00139
00ODSE03	< 0.00137	0.04583	< 0.00137	**0.0135**	< 0.00137	< 0.00137	< 0.00137
00ODSE04	< 0.00104	0.0875	< 0.00104	**0.012**	< 0.00104	< 0.00104	< 0.00104
00ODSE05	**0.0123**	**0.2523**	**0.01**	< 0.00096	< 0.00096	< 0.00096	< 0.00096
00ODSE06	**0.0044**	0.04292	< 0.000727	**0.0052**	**0.0008**	< 0.000727	< 0.000727
00ODSE07	< 0.000667	ND	< 0.000667	< 0.000667	< 0.000667	< 0.000667	< 0.000667
00ODSE08	**0.0299**	**0.3602**	**0.0058**	< 0.00097	< 0.00097	< 0.00097	< 0.00097
00ODSE09	**0.101**	0.261	< 0.00108	< 0.00108	< 0.00108	**0.0013**	< 0.00108
00ODSE10	< 0.00116	0.04158	< 0.00116	**0.0186**	< 0.00116	< 0.00116	< 0.00116
00ODSE11	< 0.000807	0.08303	< 0.000807	**0.0013**	< 0.000807	< 0.000807	< 0.000807
00ODSE12	< 0.00066	0.01547	< 0.00066	< 0.00066	< 0.00066	< 0.00066	< 0.00066
00ODSE13	< 0.000717	0.002448	< 0.000717	< 0.000717	< 0.000717	< 0.000717	< 0.000717
00ODSE14	< 0.00117	0.03908	< 0.00117	**0.017**	< 0.00117	< 0.00117	< 0.00117
00ODSE15	< 0.00131	0.00501	< 0.00131	< 0.00131	< 0.00131	< 0.00131	< 0.00131
00ODSE16	< 0.00143	0.00878	< 0.00143	< 0.00143	< 0.00143	< 0.00143	< 0.00143
00ODSE17	< 0.0013	0.01348	< 0.0013	< 0.0013	< 0.0013	< 0.0013	< 0.0013
00ODSE19	< 0.00129	0.01433	< 0.00129	< 0.00129	< 0.00129	< 0.00129	< 0.00129
00ODSE20	< 0.00124	0.02441	< 0.00124	< 0.00124	< 0.00124	< 0.00124	< 0.00124
00ODSE21	< 0.00252	0.02464	< 0.00252	< 0.00252	< 0.00252	< 0.00252	< 0.00252

b) Calculated value. Summed concentration of ortho- and para- isomers of DDD, DDE and DDT. Concentration of non-detected samples treated as 0.5 * DL for purposes of calculation

Table D-2. Total PCBs, DDT isomers, and Organochlorine (OC) Pesticide Residues in Sediments from the Oil Drain Delta in Farmington Bay, Great Salt Lake, Utah , 2000. ***(Page 3 of 4)***

Sample ID	gamma BHC	delta BHC	alpha chlordane	gamma chlordane	oxy-chlordane	Heptachlor	heptachlor epoxide
Transect 6[(a)]							
00ODSE01	< 0.00116	< 0.00116	**0.00382**	**0.00688**	< 0.00116	< 0.00116	< 0.00116
00ODSE02	< 0.00139	< 0.00139	**0.067**	**0.128**	< 0.00139	**0.0264**	**0.00219**
00ODSE03	< 0.00137	< 0.00137	**0.00477**	**0.0113**	< 0.00137	< 0.00137	< 0.00137
Transect 5							
00ODSE04	< 0.00104	< 0.00104	**0.0117**	**0.0197**	< 0.00104	**0.00257**	< 0.00104
00ODSE05	**0.00175**	< 0.00096	**0.0149**	< 0.00096	< 0.00096	**0.00271**	< 0.00096
00ODSE06	< 0.000727	< 0.000727	**0.00589**	**0.00304**	< 0.000727	< 0.000727	< 0.000727
00ODSE07	< 0.000667	< 0.000667	**0.00279**	< 0.000667	< 0.000667	< 0.000667	< 0.000667
Transect 4							
00ODSE08	< 0.00097	< 0.00097	**0.021**	< 0.00097	< 0.00097	**0.00961**	< 0.00097
00ODSE09	**0.00499**	< 0.00108	< 0.00108	< 0.00108	< 0.00108	**0.00457**	**0.0147**
00ODSE10	< 0.00116	< 0.00116	**0.00256**	**0.00236**	< 0.00116	**0.00835**	**0.00689**
00ODSE11	< 0.000807	< 0.000807	**0.00578**	**0.00752**	< 0.000807	< 0.000807	< 0.000807
Transect 3							
00ODSE12	< 0.00066	< 0.00066	**0.00329**	**0.00218**	< 0.00066	< 0.00066	< 0.00066
00ODSE13	< 0.000717	< 0.000717	< 0.000717	< 0.000717	< 0.000717	< 0.000717	< 0.000717
00ODSE14	**0.00125**	< 0.00117	**0.0154**	**0.0185**	< 0.00117	< 0.00117	< 0.00117
00ODSE15	< 0.00131	< 0.00131	< 0.00131	< 0.00131	< 0.00131	< 0.00131	< 0.00131
Transect 2							
00ODSE16	< 0.00143	< 0.00143	< 0.00143	**0.00166**	< 0.00143	< 0.00143	< 0.00143
00ODSE17	< 0.0013	< 0.0013	**0.00168**	0.00225	< 0.0013	< 0.0013	< 0.0013
Transect 1							
00ODSE19	< 0.00129	< 0.00129	< 0.00129	< 0.00129	< 0.00129	< 0.00129	< 0.00129
00ODSE20	< 0.00124	< 0.00124	**0.0016**	< 0.00124	< 0.00124	< 0.00124	< 0.00124
00ODSE21	< 0.00252	< 0.00252	**0.00349**	**0.00377**	< 0.00252	< 0.00252	< 0.00252

NOTES

BOLD: Detected concentrations

(a) Transect 6: Furthest Off-shore (approx 2.2 km from Turpin Dike); Transect 1furthest on-shore (within Turpin Unit of Farmington Bay Waterfowl Management Area). See Section 7, Figure 7-1

Table D-2. (continued) *(page 4 of 4)*

Samle ID	cis-nonachlor	trans-nonachlor	endosulfan II	HCB	mirex	pentachloro-anisole
00ODSE01	**0.00185**	**0.00177**	**0.00405**	< 0.00116	< 0.00116	< 0.00116
00ODSE02	**0.0261**	**0.0307**	**0.0158**	< 0.00139	**0.00565**	**0.00143**
00ODSE03	**0.00366**	**0.00318**	**0.00226**	< 0.00137	< 0.00137	< 0.00137
00ODSE04	**0.00508**	**0.00511**	**0.00315**	< 0.00104	< 0.00104	< 0.00104
00ODSE05	**0.00298**	< 0.00096	< 0.00096	< 0.00096	< 0.00096	< 0.00096
00ODSE06	< 0.000727	< 0.000727	**0.0025**	< 0.000727	< 0.000727	< 0.000727
00ODSE07	**0.00232**	< 0.000667	**0.000702**	< 0.000667	< 0.000667	< 0.000667
00ODSE08	**0.00101**	**0.00639**	< 0.00097	< 0.00097	**0.00526**	< 0.00097
00ODSE09	< 0.00108	< 0.00108	< 0.00108	**0.0012**	< 0.00108	< 0.00108
00ODSE10	**0.00944**	**0.0128**	**0.00363**	**0.00607**	< 0.00116	< 0.00116
00ODSE11	**0.00337**	**0.00262**	**0.00165**	< 0.000807	< 0.000807	< 0.000807
00ODSE12	**0.00124**	**0.00111**	**0.00319**	< 0.00066	< 0.00066	< 0.00066
00ODSE13	< 0.000717	< 0.000717	< 0.000717	< 0.000717	< 0.000717	< 0.000717
00ODSE14	**0.00698**	**0.0122**	**0.00356**	< 0.00117	**0.00227**	< 0.00117
00ODSE15	< 0.00131	< 0.00131	< 0.00131	< 0.00131	< 0.00131	< 0.00131
00ODSE16	< 0.00143	< 0.00143	< 0.00143	< 0.00143	< 0.00143	< 0.00143
00ODSE17	**0.00135**	**0.00172**	< 0.0013	< 0.0013	< 0.0013	< 0.0013
00ODSE19	< 0.00129	< 0.00129	**0.00398**	< 0.00129	< 0.00129	< 0.00129
00ODSE20	< 0.00124	< 0.00124	< 0.00124	< 0.00124	< 0.00124	< 0.00124
00ODSE21	< 0.00252	< 0.00252	**0.00295**	< 0.00252	< 0.00252	< 0.00252

Table D-3. Non-alkylated Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments from the Oil Drain Delta in Farmington Bay, Great Salt Lake, Utah , 2000. ***(Page 1 of 4)***

Sample ID	Collection Date	% M		acenaph thalene		acenaph thene	anthracene	Benzo (*a*) anthracene		Dibenz (*a,h*) anthracene
Transect 6[(a)]										
00ODSE01	4/12/2000	57.5		0.009		0.0097	0.0465	0.0632		0.0236
00ODSE02	4/17/2000	64.9		0.109		0.165	0.898	0.368		0.0821
00ODSE03	4/19/2000	63.6		0.0095	<	*0.0031*	0.045	0.14	<	*0.0031*
Transect 5										
00ODSE04	4/17/2000	52.4		0.0137	<	*0.0025*	0.0643	0.0553		0.0416
00ODSE05	4/12/2000	49.7		0.0928		0.0172	0.619	0.445		0.826
00ODSE06	4/19/2000	31.2		0.0136	<	*0.002*	0.224	0.0412		0.253
00ODSE07	4/19/2000	26.5		0.0036		0.0042	0.051	0.0131		0.042
Transect 4										
00ODSE08	4/17/2000	50.2		0.0282	<	*0.0025*	0.152	0.105		0.135
00ODSE09	4/12/2000	55.4		0.0466		0.0076	0.292	0.151		0.155
00ODSE10	4/20/2000	57.5		0.0366		0.0514	0.157	0.118		0.0302
00ODSE11	4/19/2000	38.8		0.006	<	*0.002*	0.051	0.0195		0.0465
Transect 3										
00ODSE12	4/12/2000	26.3	<	*0.0015*		0.005	0.0141	0.008		0.012
00ODSE13	4/12/2000	30.4	<	*0.002*	<	*0.002*	0.0076	0.0057		0.0047
00ODSE14	4/20/2000	58.2		0.0198	<	*0.003*	0.0477	0.0418		0.0309
00ODSE15	4/20/2000	62.1	<	*0.0035*	<	*0.0035*	0.0189	0.0146		0.0133
Transect 2										
00ODSE16	4/20/2000	65.7		0.012		0.0132	0.025	0.0258		0.0145
00ODSE17	4/20/2000	62.1		0.0093		0.016	0.0391	0.0281		0.0179
Transect 1										
00ODSE19	4/27/2000	61.5		0.0515	<	*0.003*	0.242	0.114		0.229
00ODSE20	4/27/2000	59.9		0.0999	<	*0.003*	0.285	0.099		0.328
00ODSE21	4/27/2000	80.5		0.0176		0.0287	0.0452	0.0505		0.0285

NOTES

Italics: Non-Detected concentrations (shown as < Detection Limit)

(a) Transect 6: Furthest Off-shore (approx 2.2 km from Turpin Dike); Transect 1furthest on-shore (within Turpin Unit of Farmington Bay Waterfowl Management Area). See Section 7, Figure 7-1

Sample ID	benzo (*b*) fluoranthene	benzo (*e*) pyrene	benzo (*g,h,i*) perylene	benzo (*k*) fluoranthene	biphenyl	chrysene	dibenzo thiophene
00ODSE01	0.0457	0.0702	0.0438	0.0125	*< 0.0029*	0.102	0.008
00ODSE02	0.228	0.397	0.247	0.0731	0.0356	0.631	0.46
00ODSE03	0.0526	0.0305	0.0653	0.01	*< 0.0031*	0.129	0.00962
00ODSE04	0.0767	0.167	0.11	0.0145	*< 0.0025*	0.232	0.00992
00ODSE05	1.08	2.31	1.64	0.178	0.0282	1.61	0.0462
00ODSE06	0.114	0.64	0.629	0.0143	0.0037	0.158	*< 0.002*
00ODSE07	0.061	0.202	0.103	0.0072	*< 0.0015*	0.152	*< 0.0015*
00ODSE08	0.215	0.428	0.363	0.05	0.0068	0.855	0.0199
00ODSE09	0.28	0.72	0.433	0.0643	0.0083	1.07	0.0333
00ODSE10	0.105	0.122	0.094	0.0284	0.0232	0.224	0.0539
00ODSE11	0.0883	0.294	0.156	0.0203	*< 0.002*	0.201	0.00531
00ODSE12	0.0249	0.0456	0.0279	0.0045	*< 0.0015*	0.0733	0.0143
00ODSE13	0.0108	0.0167	0.0116	*< 0.002*	*< 0.002*	0.0168	*< 0.0036*
00ODSE14	0.0852	0.107	0.0902	0.0242	*< 0.003*	0.136	0.00785
00ODSE15	0.0267	0.0375	0.0382	0.0079	*< 0.0035*	0.0393	*< 0.0066*
00ODSE16	0.0471	0.0536	0.0514	0.011	*< 0.0035*	0.0728	*< 0.0035*
00ODSE17	0.0455	0.0626	0.0639	0.0154	*< 0.003*	0.0777	0.00728
00ODSE19	0.0096	0.205	0.524	*< 0.003*	0.0206	0.188	0.0153
00ODSE20	0.193	0.529	0.722	0.0539	0.0147	0.165	0.0091
00ODSE21	0.0774	0.0989	0.101	0.0159	*< 0.0065*	0.131	0.016

NOTES

Italics: Non-Detected concentrations (shown as < Detection Limit)

Table D-3. Non-alkylated Polycyclic Aromatic Hydrocarbons (PAHs) in Sediments from the Oil Drain Delta in Farmington Bay, Great Salt Lake, Utah , 2000. ***(Page 3 of 4)***

Sample ID	Collection Date	% M	fluor-anthene	fluorene	naphthal-ene	1-methyl naphthalene	2-methyl naphthalene	1,6,7-Trimethyl-naphthalene
Transect 6[(a)]								
00ODSE01	4/12/2000	57.5	0.0675	0.0084	0.0089	0.0116	0.0183	0.312
00ODSE02	4/17/2000	64.9	0.348	0.186	0.0664	0.716	0.141	2.97
00ODSE03	4/19/2000	63.6	0.0494	0.0081	0.0119	0.0113	0.0205	0.0535
Transect 5								
00ODSE04	4/17/2000	52.4	0.0474	0.0138	0.0129	0.0118	0.0279	0.0439
00ODSE05	4/12/2000	49.7	0.419	0.0623	0.0622	0.0796	0.208	0.282
00ODSE06	4/19/2000	31.2	0.0098	0.0069	0.0146	0.0169	0.0429	0.0197
00ODSE07	4/19/2000	26.5	0.0109	0.004	0.0077	0.0073	0.0145	0.0124
Transect 4								
00ODSE08	4/17/2000	50.2	0.173	0.0178	0.0183	0.0172	0.0439	0.0495
00ODSE09	4/12/2000	55.4	0.123	0.0224	0.0197	0.0225	0.0543	0.0575
00ODSE10	4/20/2000	57.5	0.172	0.147	0.0558	0.103	0.207	0.759
00ODSE11	4/19/2000	38.8	0.015	*< 0.002*	0.0089	0.0062	0.0139	0.0119
Transect 3								
00ODSE12	4/12/2000	26.3	0.0144	*< 0.0015*	0.0052	0.0049	0.008	0.0308
00ODSE13	4/12/2000	30.4	0.0052	*< 0.002*	0.0057	0.0056	0.0063	0.0076
00ODSE14	4/20/2000	58.2	0.0388	0.0096	0.0112	0.0092	0.0237	0.0179
00ODSE15	4/20/2000	62.1	0.0272	0.0074	0.0116	*< 0.0035*	0.0147	0.0127
Transect 2								
00ODSE16	4/20/2000	65.7	0.0431	0.0165	0.0126	0.0102	0.0192	0.0308
00ODSE17	4/20/2000	62.1	0.0607	0.0111	0.0162	0.014	0.0246	0.0258
Transect 1								
00ODSE19	4/27/2000	61.5	0.0937	0.0265	0.0563	0.0722	0.198	0.0633
00ODSE20	4/27/2000	59.9	0.072	0.024	0.0434	0.0376	0.097	0.0614
00ODSE21	4/27/2000	80.5	0.0961	0.0227	0.0136	0.0158	0.0203	0.0672

NOTES

Italics: Non-Detected concentrations (shown as < Detection Limit)

(a) Transect 6: Furthest Off-shore (approx 2.2 km from Turpin Dike); Transect 1furthest on-shore (within Turpin Unit of Farmington Bay Waterfowl Management Area). See Section 7, Figure 7-1

Sample ID	2,6-dimethyl naphthalene	perylene	phenanthrene	1-methyl phenanthrene	pyrene	indeno(1,2,3-cd)pyrene	Total PAH (summed)[(b)]
00ODSE01	0.058	0.0272	0.0875	0.123	0.25	0.0268	1.48
00ODSE02	1.47	0.136	3.19	2.04	1.29	0.11	16.75
00ODSE03	0.0344	0.153	0.0563	0.0635	0.14	0.0357	1.18
00ODSE04	0.035	0.0174	0.0584	0.088	0.314	0.0563	1.56
00ODSE05	0.158	0.125	0.382	0.46	2.87	0.89	16.01
00ODSE06	0.0172	0.0184	0.0276	0.0855	0.0874	0.251	2.75
00ODSE07	0.0106	*0.0015*	0.0167	0.0212	0.0658	0.0531	0.89
00ODSE08	0.0445	0.0117	0.105	0.269	1.27	0.178	4.61
00ODSE09	0.0406	0.0639	0.108	0.115	1.06	0.216	5.29
00ODSE10	0.481	0.0369	0.512	0.445	0.426	0.0602	4.56
00ODSE11	0.0119	0.0046	0.022	0.0102	0.0734	0.0673	1.18
00ODSE12	0.0214	< *0.0015*	0.0257	0.0586	0.0499	0.014	0.48
00ODSE13	0.0078	< *0.002*	0.007	0.0067	0.0104	0.0082	0.17
00ODSE14	0.0194	0.028	0.0312	0.0183	0.175	0.0592	1.16
00ODSE15	0.0136	0.0083	0.0248	0.0135	0.0458	0.0203	0.44
00ODSE16	0.0308	0.0097	0.037	0.0257	0.0883	0.0298	0.73
00ODSE17	0.0263	0.0098	0.0493	0.03	0.104	0.037	0.83
00ODSE19	0.11	0.0273	0.146	0.0303	0.196	0.0776	2.91
00ODSE20	0.0593	0.0504	0.0891	0.0264	0.149	0.386	3.85
00ODSE21	0.0777	0.0145	0.083	0.0605	0.232	0.0535	1.45

NOTES

Italics: Non-Detected concentrations (shown as < Detection Limit)

(b) Sum of detected PAH's

Table D-4. Alkylated Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments from the Oil Drain Delta in Farmington Bay, Great Salt Lake, Utah , 2000. *(Page 1 of 3)*

Sample ID	Collection Date	% M	C1-Fluor-anthenes & Pyrenes	C1-Phen-anthrenes & Anthracenes	C1-chrysenes	C1-dibenzo thiophenes	C1-fluorenes	C1-naphth-alenes
Transect 6[(a)]								
00ODSE01	4/12/2000	57.5	0.705	0.431	0.239	0.235	0.32	0.0299
00ODSE02	4/17/2000	64.9	3.32	8.35	2.77	3.79	2.72	0.857
00ODSE03	4/19/2000	63.6	0.137	0.086	0.0278	0.065	0.0841	0.0319
Transect 5								
00ODSE04	4/17/2000	52.4	0.985	0.301	0.725	0.111	0.0591	0.0397
00ODSE05	4/12/2000	49.7	8.39	1.83	3.12	0.373	0.344	0.288
00ODSE06	4/19/2000	31.2	0.532	0.214	0.388	0.016	0.0281	0.0598
00ODSE07	4/19/2000	26.5	0.3	0.0707	0.28	0.0206	0.014	0.0218
Transect 4								
00ODSE08	4/17/2000	50.2	2.63	0.742	1.64	0.257	0.113	0.0611
00ODSE09	4/12/2000	55.4	3.41	0.574	2.58	0.18	0.147	0.0767
00ODSE10	4/20/2000	57.5	0.896	1.52	0.652	0.946	0.86	0.31
00ODSE11	4/19/2000	38.8	0.257	0.0694	0.411	0.0171	0.0099	0.0202
Transect 3								
00ODSE12	4/12/2000	26.3	0.106	0.137	0.133	0.115	0.0233	0.0129
00ODSE13	4/12/2000	30.4	0.0242	0.0216	0.0273	0.012	0.0068	0.0119
00ODSE14	4/20/2000	58.2	0.395	0.0874	0.368	0.0284	0.0365	0.0329
00ODSE15	4/20/2000	62.1	0.0779	0.0607	0.0645	0.023	0.0186	0.0212
Transect 2								
00ODSE16	4/20/2000	65.7	0.172	0.122	0.157	0.0401	0.0571	0.0293
00ODSE17	4/20/2000	62.1	0.192	0.121	0.168	0.0444	0.0359	0.0386
Transect 1								
00ODSE19	4/27/2000	61.5	0.437	0.283	0.429	0.0339	0.0451	0.27
00ODSE20	4/27/2000	59.9	0.357	0.237	0.502	0.0202	0.0444	0.135
00ODSE21	4/27/2000	80.5	0.331	0.282	0.318	0.0811	0.128	0.0361

NOTES

Italics: Non-Detected concentrations (shown as < Detection Limit

(a) Transect 6: Furthest Off-shore (approx 2.2 km from Turpin Dike); Transect 1furthest on-shore (within Turpin Unit of Farmington Bay Waterfowl Management Area). See Section 7, Figure 7-1

Sample ID	C2-Phen-anthrenes & Anthracenes	C2-chrysenes	C2-dibenzo thiophenes	C2-fluorenes	C2-naphtha-lenes	C3-Phenanth-renes & Anthracenes	C3-chrysenes	C3-dibenzo thiophenes
00ODSE01	0.924	0.285	0.573	1.04	0.248	0.934	0.0177	0.459
00ODSE02	10.7	2.91	5.8	5	8.45	6.98	0.236	4.11
00ODSE03	0.42	0.0818	0.258	0.253	0.108	0.48	0.0068	0.336
00ODSE04	1.25	0.711	0.759	0.406	0.0846	1.81	0.0515	1.18
00ODSE05	3.8	4.68	1.41	1.7	0.455	4	0.389	1.86
00ODSE06	0.19	0.573	0.048	0.138	0.0575	0.162	0.0934	0.0771
00ODSE07	0.127	0.24	0.0867	0.0505	0.0368	0.148	0.0265	0.15
00ODSE08	3.03	1.35	1.56	1.1	0.0987	3.06	0.0949	2.11
00ODSE09	2.46	2.27	1.57	0.516	0.115	4.27	0.154	3.13
00ODSE10	2.84	0.622	1.63	2.15	1.35	2.21	0.0549	1.28
00ODSE11	0.118	0.419	0.0702	0.0227	0.0307	0.141	0.0309	0.124
00ODSE12	0.327	0.115	0.282	0.106	0.0563	0.208	0.0089	0.225
00ODSE13	0.0469	0.0387	0.0382	0.0246	0.0324	0.0452	*0.0036*	0.0393
00ODSE14	0.27	0.461	0.137	0.122	0.0589	0.537	0.0386	0.334
00ODSE15	0.114	0.0734	0.064	0.071	0.0425	0.133	0.0084	0.0723
00ODSE16	0.27	0.147	0.155	0.218	0.065	0.279	0.0139	0.173
00ODSE17	0.292	0.185	0.15	0.122	0.0773	0.337	0.0156	0.218
00ODSE19	0.298	0.522	0.0588	0.126	0.316	0.177	0.0623	0.0723
00ODSE20	0.206	0.651	0.0399	0.0875	0.133	0.158	0.103	0.0432
00ODSE21	0.505	0.348	0.233	0.276	0.144	0.667	0.0526	0.318

Table D-4. Alkylated Polycyclic Aromatic Hydrocarbons (PAHs) in Sediments from the Oil Drain Delta in Farmington Bay, Great Salt Lake, Utah , 2000. ***(Page 1 of 3)***

Sample ID	Collection Date	C3-fluorenes	C3-naphthalenes	C4-Phen-anthrenes & Anthracenes	C4-chrysenes	C4-naphthalenes
Transect 6[(a)]						
00ODSE01	4/12/2000	0.97	1.29	0.39	0.0166	0.898
00ODSE02	4/17/2000	4.15	17.8	3.4	0.12	13.1
00ODSE03	4/19/2000	0.344	0.273	0.316	*< 0.0068*	0.328
Transect 5						
00ODSE04	4/17/2000	0.863	0.207	1.29	0.0629	0.416
00ODSE05	4/12/2000	2.94	1.28	3.2	0.977	1.9
00ODSE06	4/19/2000	0.233	0.0932	0.132	0.058	0.132
00ODSE07	4/19/2000	0.17	0.0607	0.138	0.0877	0.0585
Transect 4						
00ODSE08	4/17/2000	1.63	0.176	1.43	0.162	0.341
00ODSE09	4/12/2000	1.12	0.235	2.95	0.227	0.574
00ODSE10	4/20/2000	1.79	3.28	0.849	0.0332	3.41
00ODSE11	4/19/2000	0.102	0.044	0.244	0.1	0.0321
Transect 3						
00ODSE12	4/12/2000	0.522	0.12	0.112	0.0188	0.105
00ODSE13	4/12/2000	0.0568	0.0481	0.0381	0.0068	0.0343
00ODSE14	4/20/2000	0.292	0.062	0.383	0.0381	0.123
00ODSE15	4/20/2000	0.0905	0.0675	0.0448	0.0147	0.0822
Transect 2						
00ODSE16	4/20/2000	0.364	0.124	0.178	0.0154	0.264
00ODSE17	4/20/2000	0.248	0.0948	0.262	0.0288	0.131
Transect 1						
00ODSE19	4/27/2000	0.19	0.234	0.306	0.184	0.152
00ODSE20	4/27/2000	0.116	0.123	0.128	0.301	0.0693
00ODSE21	4/27/2000	0.424	0.301	0.396	0.0414	0.444

NOTES

Italics: Non-Detected concentrations (shown as < Detection Limit

(a) Transect 6: Furthest Off-shore (approx 2.2 km from Turpin Dike); Transect 1furthest on-shore (within Turpin Unit of Farmington Bay Waterfowl Management Area). See Section 7, Figure 7-1

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APPENDIX E

Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments, Macroinvertebrates, Barn Swallow (*Hirundo* rustica) Eggs and Chicks, Ogden Bay Waterfowl Management Area compared to Bear River Migratory Bird Refuge (Reference Area), 1999

Table E-1. Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 1 of 10)*

Loc'n Code	Sample Number	Sample Weight	Collection Date	Common Name	%M		1,6,7-Trimethyl-naphthalene		1-methyl-naphthalene
Sediments (Composite)									
ON	9OBSE03	1069	7/20/1999		40.9		**0.012**		**0.006**
ON	9OBSE01	343	6/25/1999		38.2		**0.016**		**0.006**
ON	9OBSE02	1172	7/20/1999		25		**0.007**		**0.002**
BR	9BRSE01	221	6/23/1999		37.6		**0.002**		**0.001**
BR	9BRSE02	395	7/22/1999		28.6		**0.032**		**0.007**
BR	9BRSE03	377	7/22/1999		35.1		**0.001**		**0.001**
Benthic Macroinvertebrates (Composite)									
ON	9OBCH01	4.51	7/18/1999	Chironomids	86.7	<	0.070	<	0.070
ON	99OBFI02	2.85	9/2/1999	Mixed Invert's	58.7	<	0.023	<	0.023
BR	9BRCH01	4.22	7/23/1999	Chironomids	91.3	<	0.218	<	0.218
BR	9BRMI01	9	7/22/1999	Mixed Invert's	65.7	<	0.013	<	0.013
BR	9BRMI02	30	7/22/1999	Mixed Invert's	69.6	<	0.015	<	0.015
BR	9BRMI04	10	7/23/1999	Mixed Invert's	70.9	<	0.016	<	0.016
Avian Eggs (Barn Swallow; Individual)									
ON	9OBBS07E	2.98	6/9/1999	Barn Swallow	82.1	<	0.153	<	0.153
ON	9OBBS11E	3.18	6/9/1999	Barn Swallow	81.9	<	0.153	<	0.153
ON	9OBBS01E	2.77	6/6/1999	Barn Swallow	78.3	<	0.136	<	0.136
ON	9OBBS05E	3.65	6/9/1999	Barn Swallow	82	<	0.106	<	0.106
ON	9OBBS06E	2.85	6/9/1999	Barn Swallow	79.9	<	0.083	<	0.083
ON	9OBBS15E	3.37	6/9/1999	Barn Swallow	81.6	<	0.093	<	0.093
ON	9OBBS24E	2.81	6/18/1999	Barn Swallow	81.5	<	0.096	<	0.096
ON	9OBBS28E	2.86	6/18/1999	Barn Swallow	76.7	<	0.071	<	0.071
ON	9OBBS41E	3.32	6/25/1999	Barn Swallow	81.3	<	0.094		**0.171**
ON	9OBBS43E	3.23	6/25/1999	Barn Swallow	82	<	0.089	<	0.089
ON	9OBBS49E	3.03	6/30/1999	Barn Swallow	80.8	<	0.095	<	0.095
ON	9OBBS52E	3.03	7/1/1999	Barn Swallow	81	<	0.104	<	0.104
ON	9OBBS55E	2.67	6/30/1999	Barn Swallow	78.8	<	0.094	<	0.094
ON	9OBBS56E	3.02	6/30/1999	Barn Swallow	78.2	<	0.084	<	0.084
ON	9OBBS67E	3.31	7/9/1999	Barn Swallow	77.5	<	0.088	<	0.088
BR	9BRBS03E	2.94	7/9/1999	Barn Swallow	80.3	<	0.145	<	0.145
BR	9BRBS20E	2.81	6/9/1999	Barn Swallow	83.1	<	0.168	<	0.168
BR	9BRBS22E	2.5	6/14/1999	Barn Swallow	79.5	<	0.137	<	0.137
BR	9BRBS26E	2.62	6/9/1999	Barn Swallow	69.2	<	0.083	<	0.083
BR	9BRBS29E	3.66	7/14/1999	Barn Swallow	83.6	<	0.158	<	0.158
BR	9BRBS36E	2.67	6/9/1999	Barn Swallow	80.7	<	0.141	<	0.141
BR	9BRBS37E	3.08	7/12/1999	Barn Swallow	80.5	<	0.127	<	0.127
BR	9BRBS38E	2.32	6/16/1999	Barn Swallow	80.1	<	0.137	<	0.137
BR	9BRBS39E	2.29	7/9/1999	Barn Swallow	75.9	<	0.138	<	0.138
BR	9BRBS79E	3.18	7/9/1999	Barn Swallow	78.9	<	0.137	<	0.137
BR	9BRBS81E	2.78	7/12/1999	Barn Swallow	82.2	<	0.134	<	0.134
BR	9BRBS83E	3.46	7/9/1999	Barn Swallow	81	<	0.149	<	0.149
BR	9BRBS90E	2.78	7/12/1999	Barn Swallow	81.2	<	0.144	<	0.144
BR	9BRBS91E	2.62	7/7/1999	Barn Swallow	79.4	<	0.143	<	0.143
BR	9BRBS92E	3.04	7/9/1999	Barn Swallow	79.6	<	0.140	<	0.140

Table E-1 (continued) *(Page 2 of 10)*

Sample Number	1-methyl-phenanthrene	2,6-dimethyl-naphthalene	2-methyl-naphthalene	Benzo (a) anthracene	Dibenz (a,h) anthracene	ace-naphthalene
9OBSE03	**0.008**	**0.012**	**0.013**	**0.030**	**0.004**	**0.003**
9OBSE01	**0.011**	**0.010**	**0.011**	**0.049**	**0.008**	**0.004**
9OBSE02	**0.006**	**0.003**	**0.004**	**0.025**	**0.003**	**0.001**
9BRSE01	< 0.001	**0.002**	**0.002**	**0.001**	< 0.001	< 0.001
9BRSE02	**0.002**	**0.005**	**0.008**	< 0.001	< 0.001	< 0.001
9BRSE03	**0.001**	**0.001**	**0.002**	**0.003**	< 0.001	< 0.001
9OBCH01	**0.151**	< 0.070	**0.070**	**1.880**	**0.089**	**0.224**
99OBFI02	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
9BRCH01	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218
9BRMI01	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013
9BRMI02	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRMI04	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
9OBBS07E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS11E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS01E	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136
9OBBS05E	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106
9OBBS06E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
9OBBS15E	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093
9OBBS24E	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096
9OBBS28E	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071
9OBBS41E	< 0.094	< 0.094	**0.190**	< 0.094	< 0.094	< 0.094
9OBBS43E	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089
9OBBS49E	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095
9OBBS52E	< 0.104	< 0.104	< 0.104	< 0.104	< 0.104	< 0.104
9OBBS55E	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094
9OBBS56E	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084
9OBBS67E	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088
9BRBS03E	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145
9BRBS20E	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168
9BRBS22E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS26E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
9BRBS29E	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158
9BRBS36E	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141
9BRBS37E	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127
9BRBS38E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS39E	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138
9BRBS79E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS81E	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134
9BRBS83E	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149
9BRBS90E	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144
9BRBS91E	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143
9BRBS92E	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140

Table E-1. Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 3 of 10)*

Loc'n Code	Sample Number	ace-naphthene	anthracene	benzo(a) pyrene	benzo(b) fluoranthene	benzo(e) pyrene	benzo(g,h,i) perylene
Sediments (Composite)							
ON	9OBSE03	**0.003**	**0.009**	**0.026**	**0.039**	**0.024**	**0.015**
ON	9OBSE01	**0.005**	**0.016**	**0.046**	**0.062**	**0.037**	**0.027**
ON	9OBSE02	**0.004**	**0.007**	**0.022**	**0.024**	**0.014**	**0.009**
BR	9BRSE01	< 0.001	< 0.001	**0.004**	**0.003**	**0.002**	**0.002**
BR	9BRSE02	< 0.001	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
BR	9BRSE03	**0.001**	**0.001**	**0.004**	**0.005**	**0.003**	**0.002**
Benthic Macroinvertebrates (Composite)							
ON	9OBCH01	< 0.070	**0.337**	**1.030**	**1.100**	**0.583**	**0.432**
ON	99OBFI02	**0.064**	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
BR	9BRCH01	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218
BR	9BRMI01	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013
BR	9BRMI02	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
BR	9BRMI04	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Avian Eggs (Barn Swallow; Individual)							
ON	9OBBS07E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
ON	9OBBS11E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
ON	9OBBS01E	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136
ON	9OBBS05E	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106
ON	9OBBS06E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
ON	9OBBS15E	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093
ON	9OBBS24E	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096
ON	9OBBS28E	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071
ON	9OBBS41E	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094
ON	9OBBS43E	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089
ON	9OBBS49E	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095
ON	9OBBS52E	< 0.104	< 0.104	< 0.104	< 0.104	< 0.104	< 0.104
ON	9OBBS55E	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094
ON	9OBBS56E	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084
ON	9OBBS67E	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088
BR	9BRBS03E	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145
BR	9BRBS20E	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168
BR	9BRBS22E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
BR	9BRBS26E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
BR	9BRBS29E	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158
BR	9BRBS36E	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141
BR	9BRBS37E	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127
BR	9BRBS38E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
BR	9BRBS39E	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138
BR	9BRBS79E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
BR	9BRBS81E	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134
BR	9BRBS83E	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149
BR	9BRBS90E	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144
BR	9BRBS91E	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143
BR	9BRBS92E	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140

Table E-1 (continued) *(Page 4 of 10)*

Sample Number	benzo(k) fluoranthene	biphenyl	chrysene	dibenzo-thiophene	fluoranthene	fluorene	indeno (1,2,3-cd) pyrene
9OBSE03	**0.018**	**0.002**	**0.037**	**0.004**	**0.065**	**0.006**	**0.025**
9OBSE01	**0.027**	**0.003**	**0.054**	**0.005**	**0.097**	**0.008**	**0.048**
9OBSE02	**0.012**	**0.001**	**0.028**	**0.002**	**0.056**	**0.004**	**0.014**
9BRSE01	**0.001**	**0.001**	**0.003**	< 0.001	**0.004**	**0.001**	**0.003**
9BRSE02	< 0.001	**0.001**	**0.001**	< 0.001	**0.002**	< 0.001	**0.001**
9BRSE03	**0.002**	**0.001**	**0.004**	< 0.001	**0.009**	**0.001**	**0.003**
9OBCH01	**0.808**	< 0.070	**1.330**	< 0.070	**3.200**	**0.106**	**0.504**
99OBFI02	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
9BRCH01	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218
9BRMI01	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013
9BRMI02	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRMI04	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
9OBBS07E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS11E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS01E	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136
9OBBS05E	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106
9OBBS06E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
9OBBS15E	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093
9OBBS24E	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096
9OBBS28E	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071
9OBBS41E	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094
9OBBS43E	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089
9OBBS49E	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095
9OBBS52E	< 0.104	< 0.104	< 0.104	< 0.104	< 0.104	< 0.104	< 0.104
9OBBS55E	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094
9OBBS56E	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084
9OBBS67E	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088
9BRBS03E	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145
9BRBS20E	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168
9BRBS22E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS26E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
9BRBS29E	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158
9BRBS36E	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141
9BRBS37E	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127
9BRBS38E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS39E	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138
9BRBS79E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS81E	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134
9BRBS83E	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149
9BRBS90E	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144
9BRBS91E	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143
9BRBS92E	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140

Table E-1. Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 5 of 10)*

Loc'n Code	Sample Number		naphthalene		perylene		phenanthrene		pyrene
Sediments (Composite)									
ON	9OBSE03		**0.010**		**0.027**		**0.027**		**0.071**
ON	9OBSE01		**0.012**		**0.033**		**0.047**		**0.107**
ON	9OBSE02		**0.005**		**0.010**		**0.025**		**0.061**
BR	9BRSE01		**0.001**		**0.016**		**0.003**		**0.004**
BR	9BRSE02		**0.007**		**0.004**		**0.004**		**0.002**
BR	9BRSE03		**0.002**		**0.014**		**0.006**		**0.008**
Benthic Macroinvertebrates (Composite)									
ON	9OBCH01		**0.144**		**0.252**		**1.280**		**2.290**
ON	99OBFI02		**0.023**	<	0.023	<	0.023	<	0.023
BR	9BRCH01		**0.372**	<	0.218	<	0.218	<	0.218
BR	9BRMI01		**0.018**	<	0.013	<	0.013	<	0.013
BR	9BRMI02		**0.021**	<	0.015	<	0.015	<	0.015
BR	9BRMI04		**0.020**	<	0.016	<	0.016	<	0.016
Avian Eggs (Barn Swallow; Individual)									
ON	9OBBS07E	<	0.153	<	0.153	<	0.153	<	0.153
ON	9OBBS11E	<	0.153	<	0.153	<	0.153	<	0.153
ON	9OBBS01E	<	0.136	<	0.136	<	0.136	<	0.136
ON	9OBBS05E	<	0.106	<	0.106	<	0.106	<	0.106
ON	9OBBS06E	<	0.083	<	0.083	<	0.083	<	0.083
ON	9OBBS15E	<	0.093	<	0.093	<	0.093	<	0.093
ON	9OBBS24E	<	0.096	<	0.096	<	0.096	<	0.096
ON	9OBBS28E	<	0.071	<	0.071	<	0.071	<	0.071
ON	9OBBS41E		**0.283**	<	0.094	<	0.094	<	0.094
ON	9OBBS43E	<	0.089	<	0.089	<	0.089	<	0.089
ON	9OBBS49E	<	0.095	<	0.095	<	0.095	<	0.095
ON	9OBBS52E	<	0.104	<	0.104	<	0.104	<	0.104
ON	9OBBS55E	<	0.094	<	0.094	<	0.094	<	0.094
ON	9OBBS56E	<	0.084	<	0.084	<	0.084	<	0.084
ON	9OBBS67E	<	0.088	<	0.088	<	0.088	<	0.088
BR	9BRBS03E	<	0.145	<	0.145	<	0.145	<	0.145
BR	9BRBS20E	<	0.168	<	0.168	<	0.168	<	0.168
BR	9BRBS22E	<	0.137	<	0.137	<	0.137	<	0.137
BR	9BRBS26E	<	0.083	<	0.083	<	0.083	<	0.083
BR	9BRBS29E	<	0.158	<	0.158	<	0.158	<	0.158
BR	9BRBS36E	<	0.141	<	0.141	<	0.141	<	0.141
BR	9BRBS37E	<	0.127	<	0.127	<	0.127	<	0.127
BR	9BRBS38E	<	0.137	<	0.137	<	0.137	<	0.137
BR	9BRBS39E	<	0.138	<	0.138	<	0.138	<	0.138
BR	9BRBS79E		**0.275**	<	0.137	<	0.137	<	0.137
BR	9BRBS81E	<	0.134	<	0.134	<	0.134	<	0.134
BR	9BRBS83E	<	0.149	<	0.149	<	0.149	<	0.149
BR	9BRBS90E	<	0.144	<	0.144	<	0.144	<	0.144
BR	9BRBS91E	<	0.143	<	0.143	<	0.143	<	0.143
BR	9BRBS92E	<	0.140	<	0.140	<	0.140	<	0.140

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Table E-1. Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 6 of 10)*

Loc'n Code	Sample Number	Sample Weight	Collection Date	Common Name	%M		1,6,7-Trimethyl-naphthalene		1-methyl-naphthalene
Nestlings (Barn Swallow; Individual)									
ON	9OBBS24N	20.08	7/1/1999	Barn Swallow	71.8	<	0.018	<	0.018
ON	9OBBS05N	20.25	6/28/1999	Barn Swallow	67.2	<	0.015	<	0.015
ON	9OBBS06N	21.09	6/21/1999	Barn Swallow	68.1	<	0.016	<	0.016
ON	9OBBS07N	16.96	6/21/1999	Barn Swallow	74	<	0.019	<	0.019
ON	9OBBS11N	11.89	6/18/1999	Barn Swallow	74.8	<	0.020	<	0.020
ON	9OBBS15N	13.97	6/18/1999	Barn Swallow	75.6	<	0.019	<	0.019
ON	9OBBS28N	17.18	7/1/1999	Barn Swallow	75.2	<	0.019	<	0.019
ON	9OBBS41N	10.99	7/1/1999	Barn Swallow	80.4	<	0.025	<	0.025
ON	9OBBS43N	16.35	7/6/1999	Barn Swallow	73.9	<	0.018	<	0.018
ON	9OBBS49N	21.07	7/12/1999	Barn Swallow	68.7	<	0.014	<	0.014
ON	9OBBS52N	17.16	7/12/1999	Barn Swallow	74.5	<	0.019	<	0.019
ON	9OBBS55N	11.17	7/12/1999	Barn Swallow	77.9	<	0.022	<	0.022
ON	9OBBS56N	19.64	7/16/1999	Barn Swallow	70.4	<	0.016	<	0.016
ON	9OBBS67N	18.42	7/20/1999	Barn Swallow	75	<	0.020	<	0.020
BR	9OBBS01N	15.49	6/21/1999	Barn Swallow	76.2	<	0.019	<	0.019
BR	9BRBS03N	14.94	7/19/1999	Barn Swallow	74.2	<	0.017	<	0.017
BR	9BRBS20N	16.29	6/21/1999	Barn Swallow	66.7	<	0.014	<	0.014
BR	9BRBS22N	20.33	6/25/1999	Barn Swallow	67	<	0.015	<	0.015
BR	9BRBS26N	15.44	6/25/1999	Barn Swallow	73.1	<	0.018	<	0.018
BR	9BRBS29N	15.1	7/21/1999	Barn Swallow	76.7	<	0.017	<	0.017
BR	9BRBS36N	18.2	6/23/1999	Barn Swallow	69.5	<	0.015	<	0.015
BR	9BRBS37N	10.87	7/21/1999	Barn Swallow	74.1	<	0.019	<	0.019
BR	9BRBS38N	21	6/28/1999	Barn Swallow	73.9	<	0.018	<	0.018
BR	9BRBS39N	17.88	7/23/1999	Barn Swallow	72.9	<	0.017	<	0.017
BR	9BRBS79J	13.64	7/23/1999	Barn Swallow	71.7	<	0.017	<	0.017
BR	9BRBS81N	16.54	7/21/1999	Barn Swallow	74.6		**0.025**		**0.059**
BR	9BRBS83N	9.29	7/16/1999	Barn Swallow	81.3	<	0.024	<	0.024
BR	9BRBS90N	10.14	7/19/1999	Barn Swallow	79.5	<	0.023	<	0.023
BR	9BRBS91N	10.15	7/14/1999	Barn Swallow	79.7	<	0.022	<	0.022
BR	9BRBS92C	15.91	7/19/1999	Barn Swallow	76.1	<	0.020	<	0.020
Gastrointestinal Tract Contents (Composite)									
ON	9OBII01	6.62	7/23/1999	Barn Swallow	68.2	<	0.015	<	0.015
BR	9BRII01	4.54	7/23/1999	Barn Swallow	57.5	<	0.011	<	0.011

Sample Number		1-methyl-phenanthrene		2,6-dimethyl-naphthalene		2-methyl-naphthalene		Benzo (a) anthracene		Dibenz (a,h) anthracene		ace-naphthalene
9OBBS24N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
9OBBS05N	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
9OBBS06N	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016
9OBBS07N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9OBBS11N	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
9OBBS15N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9OBBS28N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9OBBS41N	<	0.025	<	0.025	<	0.025	<	0.025	<	0.025	<	0.025
9OBBS43N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
9OBBS49N	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014
9OBBS52N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9OBBS55N	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022
9OBBS56N	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016
9OBBS67N	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
9OBBS01N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9BRBS03N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
9BRBS20N	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014
9BRBS22N	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
9BRBS26N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
9BRBS29N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
9BRBS36N	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
9BRBS37N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9BRBS38N		**0.034**	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
9BRBS39N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
9BRBS79J	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
9BRBS81N	<	0.017		**0.023**		**0.084**	<	0.017	<	0.017	<	0.017
9BRBS83N	<	0.024	<	0.024	<	0.024	<	0.024	<	0.024	<	0.024
9BRBS90N	<	0.023	<	0.023	<	0.023	<	0.023	<	0.023	<	0.023
9BRBS91N	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022
9BRBS92C	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
9OBII01	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
9BRII01	<	0.011	<	0.011	<	0.011	<	0.011	<	0.011	<	0.011

Table E-1. Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 8 of 10*)

Loc'n Code	Sample Number	ace-naphthene	anthracene	benzo(a) pyrene	benzo(b) fluoranthene	benzo(e) pyrene	benzo(g,h,i) perylene
Nestlings (Barn Swallow; Individual)							
ON	9OBBS24N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
ON	9OBBS05N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
ON	9OBBS06N	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
ON	9OBBS07N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS11N	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
ON	9OBBS15N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS28N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS41N	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
ON	9OBBS43N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
ON	9OBBS49N	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014
ON	9OBBS52N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS55N	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022
ON	9OBBS56N	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
ON	9OBBS67N	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
BR	9OBBS01N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
BR	9BRBS03N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
BR	9BRBS20N	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014
BR	9BRBS22N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
BR	9BRBS26N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
BR	9BRBS29N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
BR	9BRBS36N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
BR	9BRBS37N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
BR	9BRBS38N	< 0.018	0.065	< 0.018	< 0.018	< 0.018	< 0.018
BR	9BRBS39N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
BR	9BRBS79J	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
BR	9BRBS81N	**0.041**	**0.100**	**0.024**	< 0.017	< 0.017	< 0.017
BR	9BRBS83N	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
BR	9BRBS90N	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
BR	9BRBS91N	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022
BR	9BRBS92C	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Gastrointestinal Tract Contents (Composite)							
ON	9OBII01	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
BR	9BRII01	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011

Table E-1 (continued) *(Page 9 of 10)*

Sample Number	benzo(k) fluoranthene	biphenyl	chrysene	dibenzo-thiophene	fluoranthene	fluorene	indeno (1,2,3-cd) pyrene
9OBBS24N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9OBBS05N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9OBBS06N	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
9OBBS07N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS11N	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
9OBBS15N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS28N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS41N	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
9OBBS43N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9OBBS49N	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014
9OBBS52N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS55N	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022
9OBBS56N	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
9OBBS67N	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
9OBBS01N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9BRBS03N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS20N	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014
9BRBS22N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRBS26N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9BRBS29N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS36N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRBS37N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9BRBS38N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9BRBS39N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS79J	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS81N	< 0.017	**0.021**	< 0.017	< 0.017	**0.018**	**0.019**	< 0.017
9BRBS83N	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
9BRBS90N	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
9BRBS91N	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022
9BRBS92C	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
9OBII01	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRII01	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011

Table E-1. Polynuclear Aromatic Hydrocarbons (PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 10 of 10)*

Loc'n Code	Sample Number	naphthalene	perylene	phenanthrene	pyrene
Nestlings (Barn Swallow; Individual)					
ON	9OBBS24N	< 0.018	< 0.018	< 0.018	< 0.018
ON	9OBBS05N	< 0.015	< 0.015	< 0.015	< 0.015
ON	9OBBS06N	< 0.016	< 0.016	< 0.016	< 0.016
ON	9OBBS07N	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS11N	< 0.020	< 0.020	< 0.020	< 0.020
ON	9OBBS15N	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS28N	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS41N	< 0.025	< 0.025	< 0.025	< 0.025
ON	9OBBS43N	**0.021**	< 0.018	< 0.018	< 0.018
ON	9OBBS49N	**0.016**	< 0.014	< 0.014	< 0.014
ON	9OBBS52N	< 0.019	< 0.019	< 0.019	< 0.019
ON	9OBBS55N	**0.025**	< 0.022	< 0.022	< 0.022
ON	9OBBS56N	< 0.016	< 0.016	< 0.016	< 0.016
ON	9OBBS67N	**0.024**	< 0.020	< 0.020	< 0.020
BR	9OBBS01N	< 0.019	< 0.019	< 0.019	< 0.019
BR	9BRBS03N	< 0.017	< 0.017	< 0.017	< 0.017
BR	9BRBS20N	< 0.014	< 0.014	< 0.014	< 0.014
BR	9BRBS22N	< 0.015	< 0.015	< 0.015	< 0.015
BR	9BRBS26N	< 0.018	< 0.018	< 0.018	< 0.018
BR	9BRBS29N	**0.021**	< 0.017	< 0.017	< 0.017
BR	9BRBS36N	< 0.015	< 0.015	< 0.015	< 0.015
BR	9BRBS37N	< 0.019	< 0.019	< 0.019	< 0.019
BR	9BRBS38N	< 0.018	< 0.018	**0.026**	< 0.018
BR	9BRBS39N	< 0.017	< 0.017	< 0.017	< 0.017
BR	9BRBS79J	< 0.017	< 0.017	< 0.017	< 0.017
BR	9BRBS81N	**0.093**	**0.030**	**0.075**	< 0.017
BR	9BRBS83N	< 0.024	< 0.024	< 0.024	< 0.024
BR	9BRBS90N	< 0.023	< 0.023	< 0.023	< 0.023
BR	9BRBS91N	< 0.022	< 0.022	< 0.022	< 0.022
BR	9BRBS92C	< 0.020	< 0.020	< 0.020	< 0.020
Gastrointestinal Tract Contents (Composite)					
ON	9OBII01	**0.017**	< 0.015	< 0.015	< 0.015
BR	9BRII01	**0.013**	< 0.011	< 0.011	< 0.011

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Table E-2. Alkylated Polynuclear Aromatic Hydrocarbons (A-PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 1 of 8*)

Loc'n Code	Sample Number	Sample Weight (grams)	Collection Date	Common Name	%M		C1-Fluoranthenes & Pyrenes		C1-Phen-anthrenes & Anthracenes
Sediments (Composite)									
ON	9OBSE03	1069	7/20/1999	Sediment	40.9		**0.044**		**0.030**
ON	9OBSE01	343	6/25/1999	Sediment	38.2		**0.064**		**0.040**
ON	9OBSE02	1172	7/20/1999	Sediment	25		**0.032**		**0.021**
BR	9BRSE01	221	6/23/1999	Sediment	37.6		**0.002**		**0.003**
BR	9BRSE02	395	7/22/1999	Sediment	28.6		**0.002**		**0.005**
BR	9BRSE03	377	7/22/1999	Sediment	35.1		**0.003**		**0.003**
Benthic Macroinvertebrates (Composite)									
ON	9OBCH01	4.51	7/18/1999	Chironomids	86.7		**0.822**		**0.523**
ON	99OBFI02	2.85	9/2/1999	Mixed Invert's	58.7	<	0.023	<	0.023
BR	9BRCH01	4.22	7/23/1999	Chironomids	91.3	<	0.218	<	0.218
BR	9BRMI01	9	7/22/1999	Mixed Invert's	65.7	<	0.013	<	0.013
BR	9BRMI02	30	7/22/1999	Mixed Invert's	69.6	<	0.015	<	0.015
BR	9BRMI04	10	7/23/1999	Mixed Invert's	70.9	<	0.016	<	0.016
Avian Eggs (Barn Swallow; Individual)									
ON	9OBBS07E	2.98	6/9/1999	Barn Swallow	82.1	<	0.153	<	0.153
ON	9OBBS11E	3.18	6/9/1999	Barn Swallow	81.9	<	0.153	<	0.153
ON	9OBBS01E	2.77	6/6/1999	Barn Swallow	78.3	<	0.136	<	0.136
ON	9OBBS05E	3.65	6/9/1999	Barn Swallow	82	<	0.106	<	0.106
ON	9OBBS06E	2.85	6/9/1999	Barn Swallow	79.9	<	0.083	<	0.083
ON	9OBBS15E	3.37	6/9/1999	Barn Swallow	81.6	<	0.093	<	0.093
ON	9OBBS24E	2.81	6/18/1999	Barn Swallow	81.5	<	0.096	<	0.096
ON	9OBBS28E	2.86	6/18/1999	Barn Swallow	76.7	<	0.071	<	0.071
ON	9OBBS41E	3.32	6/25/1999	Barn Swallow	81.3	<	0.094	<	0.094
ON	9OBBS43E	3.23	6/25/1999	Barn Swallow	82	<	0.089	<	0.089
ON	9OBBS49E	3.03	6/30/1999	Barn Swallow	80.8	<	0.095	<	0.095
ON	9OBBS52E	3.03	7/1/1999	Barn Swallow	81	<	0.104	<	0.104
ON	9OBBS55E	2.67	6/30/1999	Barn Swallow	78.8	<	0.094	<	0.094
ON	9OBBS56E	3.02	6/30/1999	Barn Swallow	78.2	<	0.084	<	0.084
ON	9OBBS67E	3.31	7/9/1999	Barn Swallow	77.5	<	0.088	<	0.088
BR	9BRBS03E	2.94	7/9/1999	Barn Swallow	80.3	<	0.145	<	0.145
BR	9BRBS20E	2.81	6/9/1999	Barn Swallow	83.1	<	0.168	<	0.168
BR	9BRBS22E	2.5	6/14/1999	Barn Swallow	79.5	<	0.137	<	0.137
BR	9BRBS26E	2.62	6/9/1999	Barn Swallow	69.2	<	0.083	<	0.083
BR	9BRBS29E	3.66	7/14/1999	Barn Swallow	83.6	<	0.158	<	0.158
BR	9BRBS36E	2.67	6/9/1999	Barn Swallow	80.7	<	0.141	<	0.141
BR	9BRBS37E	3.08	7/12/1999	Barn Swallow	80.5	<	0.127	<	0.127
BR	9BRBS38E	2.32	6/16/1999	Barn Swallow	80.1	<	0.137	<	0.137
BR	9BRBS39E	2.29	7/9/1999	Barn Swallow	75.9	<	0.138	<	0.138
BR	9BRBS79E	3.18	7/9/1999	Barn Swallow	78.9	<	0.137	<	0.137
BR	9BRBS81E	2.78	7/12/1999	Barn Swallow	82.2	<	0.134	<	0.134
BR	9BRBS83E	3.46	7/9/1999	Barn Swallow	81	<	0.149	<	0.149
BR	9BRBS90E	2.78	7/12/1999	Barn Swallow	81.2	<	0.144	<	0.144
BR	9BRBS91E	2.62	7/7/1999	Barn Swallow	79.4	<	0.143	<	0.143
BR	9BRBS92E	3.04	7/9/1999	Barn Swallow	79.6	<	0.140	<	0.140

Table E-2 (continued) *(Page 2 of 8)*

Sample Number	C1-chrysenes	C1-dibenzo-thiophenes	C1-fluorenes	C1-naphthalenes	C2-Phen-anthrenes & Anthracenes	C2-chrysenes
9OBSE03	**0.031**	**0.011**	**0.009**	**0.019**	**0.035**	**0.030**
9OBSE01	**0.056**	**0.013**	**0.014**	**0.017**	**0.048**	**0.043**
9OBSE02	**0.019**	**0.004**	**0.006**	**0.007**	**0.017**	**0.013**
9BRSE01	**0.003**	**0.001**	**0.002**	**0.003**	**0.003**	**0.003**
9BRSE02	**0.002**	**0.002**	**0.002**	**0.015**	**0.005**	**0.002**
9BRSE03	**0.002**	**0.001**	**0.002**	**0.003**	**0.003**	**0.002**
9OBCH01	**0.442**	**0.075**	**0.114**	**0.120**	**0.341**	**0.106**
99OBFI02	< 0.023	< 0.023	< 0.023	**0.027**	< 0.023	< 0.023
9BRCH01	< 0.218	< 0.218	< 0.218	**0.276**	< 0.218	< 0.218
9BRMI01	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013
9BRMI02	< 0.015	< 0.015	< 0.015	**0.018**	< 0.015	< 0.015
9BRMI04	< 0.016	< 0.016	< 0.016	**0.021**	< 0.016	< 0.016
9OBBS07E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS11E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS01E	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136
9OBBS05E	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106
9OBBS06E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
9OBBS15E	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093
9OBBS24E	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096
9OBBS28E	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071
9OBBS41E	< 0.094	< 0.094	< 0.094	**0.361**	< 0.094	< 0.094
9OBBS43E	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089	< 0.089
9OBBS49E	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095
9OBBS52E	< 0.104	< 0.104	< 0.104	**0.109**	< 0.104	< 0.104
9OBBS55E	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094
9OBBS56E	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084
9OBBS67E	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088
9BRBS03E	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145
9BRBS20E	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168	< 0.168
9BRBS22E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS26E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
9BRBS29E	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158
9BRBS36E	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141
9BRBS37E	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127
9BRBS38E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS39E	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138
9BRBS79E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS81E	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134
9BRBS83E	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149
9BRBS90E	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144
9BRBS91E	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143
9BRBS92E	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140

Table E-2. Alkylated Polynuclear Aromatic Hydrocarbons (A-PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 3 of 8)*

Loc'n Code	Sample Number		C2-dibenzo-thiophenes		C2-fluorenes		C2-naphthalenes		C3-Phen-anthrenes & Anthracenes		C3-chrysenes
Sediments (Composite)											
ON	9OBSE03		**0.020**		**0.021**		**0.026**		**0.026**		**0.003**
ON	9OBSE01		**0.024**		**0.019**		**0.021**		**0.035**		**0.004**
ON	9OBSE02		**0.007**		**0.011**		**0.008**		**0.012**		**0.001**
BR	9BRSE01		**0.001**		**0.006**		**0.003**		**0.002**	<	0.001
BR	9BRSE02		**0.002**		**0.003**		**0.016**		**0.003**	<	0.001
BR	9BRSE03		**0.001**		**0.003**		**0.002**		**0.001**	<	0.001
Benthic Macroinvertebrates (Composite)											
ON	9OBCH01		**0.091**	<	0.070		**0.073**		**0.135**	<	0.070
ON	99OBFI02	<	0.023	<	0.023	<	0.023	<	0.023	<	0.023
BR	9BRCH01	<	0.218	<	0.218	<	0.218	<	0.218	<	0.218
BR	9BRMI01	<	0.013	<	0.013	<	0.013	<	0.013	<	0.013
BR	9BRMI02	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
BR	9BRMI04	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016
Avian Eggs (Barn Swallow; Individual)											
ON	9OBBS07E	<	0.153	<	0.153	<	0.153	<	0.153	<	0.153
ON	9OBBS11E	<	0.153	<	0.153	<	0.153	<	0.153	<	0.153
ON	9OBBS01E	<	0.136	<	0.136	<	0.136	<	0.136	<	0.136
ON	9OBBS05E	<	0.106	<	0.106	<	0.106	<	0.106	<	0.106
ON	9OBBS06E	<	0.083	<	0.083		**0.085**	<	0.083	<	0.083
ON	9OBBS15E	<	0.093	<	0.093	<	0.093	<	0.093	<	0.093
ON	9OBBS24E	<	0.096	<	0.096	<	0.096	<	0.096	<	0.096
ON	9OBBS28E	<	0.071	<	0.071	<	0.071	<	0.071	<	0.071
ON	9OBBS41E	<	0.094	<	0.094		**0.172**	<	0.094	<	0.094
ON	9OBBS43E	<	0.089	<	0.089	<	0.089	<	0.089	<	0.089
ON	9OBBS49E	<	0.095	<	0.095	<	0.095	<	0.095	<	0.095
ON	9OBBS52E	<	0.104	<	0.104	<	0.104	<	0.104	<	0.104
ON	9OBBS55E	<	0.094	<	0.094	<	0.094	<	0.094	<	0.094
ON	9OBBS56E	<	0.084	<	0.084	<	0.084	<	0.084	<	0.084
ON	9OBBS67E	<	0.088	<	0.088	<	0.088	<	0.088	<	0.088
BR	9BRBS03E	<	0.145	<	0.145	<	0.145	<	0.145	<	0.145
BR	9BRBS20E	<	0.168	<	0.168		**0.231**	<	0.168	<	0.168
BR	9BRBS22E	<	0.137	<	0.137	<	0.137	<	0.137	<	0.137
BR	9BRBS26E	<	0.083	<	0.083	<	0.083	<	0.083	<	0.083
BR	9BRBS29E	<	0.158	<	0.158	<	0.158	<	0.158	<	0.158
BR	9BRBS36E	<	0.141	<	0.141	<	0.141	<	0.141	<	0.141
BR	9BRBS37E	<	0.127	<	0.127	<	0.127	<	0.127	<	0.127
BR	9BRBS38E	<	0.137	<	0.137	<	0.137	<	0.137	<	0.137
BR	9BRBS39E	<	0.138	<	0.138	<	0.138	<	0.138	<	0.138
BR	9BRBS79E	<	0.137	<	0.137	<	0.137	<	0.137	<	0.137
BR	9BRBS81E	<	0.134	<	0.134	<	0.134	<	0.134	<	0.134
BR	9BRBS83E	<	0.149	<	0.149	<	0.149	<	0.149	<	0.149
BR	9BRBS90E	<	0.144	<	0.144	<	0.144	<	0.144	<	0.144
BR	9BRBS91E	<	0.143	<	0.143	<	0.143	<	0.143	<	0.143
BR	9BRBS92E	<	0.140	<	0.140	<	0.140	<	0.140	<	0.140

Sample Number	C3-dibenzo-thiophenes	C3-fluorenes	C3-naphthalenes	C4-Phen-anthrenes & Anthracenes	C4-chrysenes	C4-naphthalenes
9OBSE03	**0.022**	**0.023**	**0.031**	**0.014**	**0.003**	**0.026**
9OBSE01	**0.029**	**0.038**	**0.031**	**0.019**	**0.004**	**0.027**
9OBSE02	**0.008**	**0.010**	**0.014**	**0.005**	**0.001**	**0.010**
9BRSE01	**0.001**	**0.001**	**0.005**	**0.001**	< 0.001	**0.003**
9BRSE02	**0.002**	**0.003**	**0.005**	**0.001**	< 0.001	**0.015**
9BRSE03	**0.001**	**0.004**	**0.002**	< 0.001	< 0.001	**0.002**
9OBCH01	< 0.070	< 0.070	**0.081**	< 0.070	< 0.070	< 0.070
99OBFI02	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
9BRCH01	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218	< 0.218
9BRMI01	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013
9BRMI02	< 0.015	**0.016**	< 0.015	< 0.015	< 0.015	< 0.015
9BRMI04	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
9OBBS07E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS11E	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153	< 0.153
9OBBS01E	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136	< 0.136
9OBBS05E	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106	< 0.106
9OBBS06E	< 0.083	< 0.083	**0.103**	< 0.083	< 0.083	< 0.083
9OBBS15E	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093	< 0.093
9OBBS24E	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096	< 0.096
9OBBS28E	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071	< 0.071
9OBBS41E	< 0.094	< 0.094	**0.152**	< 0.094	< 0.094	< 0.094
9OBBS43E	< 0.089	< 0.089	**0.131**	< 0.089	< 0.089	< 0.089
9OBBS49E	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095	< 0.095
9OBBS52E	< 0.104	< 0.104	**0.119**	< 0.104	< 0.104	< 0.104
9OBBS55E	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094	< 0.094
9OBBS56E	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084	< 0.084
9OBBS67E	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088	< 0.088
9BRBS03E	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145	< 0.145
9BRBS20E	< 0.168	< 0.168	**0.173**	< 0.168	< 0.168	< 0.168
9BRBS22E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS26E	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083	< 0.083
9BRBS29E	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158	< 0.158
9BRBS36E	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141	< 0.141
9BRBS37E	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127	< 0.127
9BRBS38E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS39E	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138	< 0.138
9BRBS79E	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137	< 0.137
9BRBS81E	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134	< 0.134
9BRBS83E	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149	< 0.149
9BRBS90E	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144	< 0.144
9BRBS91E	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143	< 0.143
9BRBS92E	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140

Table E-2. Alkylated Polynuclear Aromatic Hydrocarbons (A-PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 5 of 8*)

Loc'n Code	Sample Number	Sample Weight	Collection Date	Common Name	%M		C1-Fluoranthenes & Pyrenes		C1-Phen-anthrenes & Anthracenes
Nestlings (Barn Swallow; Individual)									
ON	9OBBS24N	20.08	7/1/1999	Barn Swallow	71.8	<	0.018	<	0.018
ON	9OBBS05N	20.25	6/28/1999	Barn Swallow	67.2	<	0.015	<	0.015
ON	9OBBS06N	21.09	6/21/1999	Barn Swallow	68.1	<	0.016	<	0.016
ON	9OBBS07N	16.96	6/21/1999	Barn Swallow	74	<	0.019	<	0.019
ON	9OBBS11N	11.89	6/18/1999	Barn Swallow	74.8	<	0.020	<	0.020
ON	9OBBS15N	13.97	6/18/1999	Barn Swallow	75.6	<	0.019	<	0.019
ON	9OBBS28N	17.18	7/1/1999	Barn Swallow	75.2	<	0.019	<	0.019
ON	9OBBS41N	10.99	7/1/1999	Barn Swallow	80.4	<	0.025	<	0.025
ON	9OBBS43N	16.35	7/6/1999	Barn Swallow	73.9	<	0.018	<	0.018
ON	9OBBS49N	21.07	7/12/1999	Barn Swallow	68.7	<	0.014	<	0.014
ON	9OBBS52N	17.16	7/12/1999	Barn Swallow	74.5	<	0.019	<	0.019
ON	9OBBS55N	11.17	7/12/1999	Barn Swallow	77.9	<	0.022	<	0.022
ON	9OBBS56N	19.64	7/16/1999	Barn Swallow	70.4	<	0.016	<	0.016
ON	9OBBS67N	18.42	7/20/1999	Barn Swallow	75	<	0.020	<	0.020
BR	9OBBS01N	15.49	6/21/1999	Barn Swallow	76.2	<	0.019	<	0.019
BR	9BRBS03N	14.94	7/19/1999	Barn Swallow	74.2	<	0.017	<	0.017
BR	9BRBS20N	16.29	6/21/1999	Barn Swallow	66.7	<	0.014	<	0.014
BR	9BRBS22N	20.33	6/25/1999	Barn Swallow	67	<	0.015	<	0.015
BR	9BRBS26N	15.44	6/25/1999	Barn Swallow	73.1	<	0.018	<	0.018
BR	9BRBS29N	15.1	7/21/1999	Barn Swallow	76.7	<	0.017	<	0.017
BR	9BRBS36N	18.2	6/23/1999	Barn Swallow	69.5	<	0.015	<	0.015
BR	9BRBS37N	10.87	7/21/1999	Barn Swallow	74.1	<	0.019	<	0.019
BR	9BRBS38N	21	6/28/1999	Barn Swallow	73.9	<	0.018	<	0.018
BR	9BRBS39N	17.88	7/23/1999	Barn Swallow	72.9	<	0.017	<	0.017
BR	9BRBS79J	13.64	7/23/1999	Barn Swallow	71.7	<	0.017	<	0.017
BR	9BRBS81N	16.54	7/21/1999	Barn Swallow	74.6	<	0.017	<	0.017
BR	9BRBS83N	9.29	7/16/1999	Barn Swallow	81.3	<	0.024	<	0.024
BR	9BRBS90N	10.14	7/19/1999	Barn Swallow	79.5	<	0.023	<	0.023
BR	9BRBS91N	10.15	7/14/1999	Barn Swallow	79.7	<	0.022	<	0.022
BR	9BRBS92C	15.91	7/19/1999	Barn Swallow	76.1	<	0.020	<	0.020
Gastrointestinal Tract Contents (Composite)									
ON	9OBII01	6.62	7/23/1999	Barn Swallow	68.2	<	0.015	<	0.015
BR	9BRII01	4.54	7/23/1999	Barn Swallow	57.5	<	0.011	<	0.011

Sample Number		C1-chrysenes		C1-dibenzo-thiophenes		C1-fluorenes		C1-naphthalenes		C2-Phen-anthrenes & Anthracenes		C2-chrysenes
9OBBS24N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
9OBBS05N	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
9OBBS06N	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016
9OBBS07N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9OBBS11N	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
9OBBS15N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9OBBS28N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9OBBS41N	<	0.025	<	0.025	<	0.025	<	0.025	<	0.025	<	0.025
9OBBS43N	<	0.018	<	0.018	<	0.018		**0.020**	<	0.018	<	0.018
9OBBS49N	<	0.014	<	0.014	<	0.014		**0.019**	<	0.014	<	0.014
9OBBS52N	<	0.019	<	0.019	<	0.019		**0.024**	<	0.019	<	0.019
9OBBS55N	<	0.022	<	0.022	<	0.022		**0.027**		**0.048**	<	0.022
9OBBS56N	<	0.016	<	0.016	<	0.016		**0.018**	<	0.016	<	0.016
9OBBS67N	<	0.020	<	0.020	<	0.020		**0.023**	<	0.020	<	0.020
9OBBS01N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9BRBS03N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
9BRBS20N	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014
9BRBS22N	<	0.015	<	0.015		**0.017**	<	0.015	<	0.015	<	0.015
9BRBS26N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
9BRBS29N	<	0.017	<	0.017		**0.017**	<	0.017	<	0.017	<	0.017
9BRBS36N	<	0.015	<	0.015	<	0.015		**0.016**	<	0.015	<	0.015
9BRBS37N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
9BRBS38N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
9BRBS39N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
9BRBS79J	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
9BRBS81N	<	0.017	<	0.017	<	0.017		**0.143**	<	0.017	<	0.017
9BRBS83N	<	0.024	<	0.024	<	0.024	<	0.024	<	0.024	<	0.024
9BRBS90N	<	0.023	<	0.023	<	0.023	<	0.023	<	0.023	<	0.023
9BRBS91N	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022
9BRBS92C	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
9OBII01	<	0.015	<	0.015	<	0.015		**0.022**	<	0.015	<	0.015
9BRII01	<	0.011	<	0.011	<	0.011		**0.017**	<	0.011	<	0.011

Table E-2. Alkylated Polynuclear Aromatic Hydrocarbons (A-PAHs) in Sediments, Macroinvertebrates and Barn Swallow (*Hirundo rustica*) tissues, Ogden Bay Waterfowl Management Area (ON) compared to Bear River Migratory Bird Refuge (BR), 1999. (*Page 7of 8)*

Loc'n Code	Sample Number	C2-dibenzo-thiophenes		C2-fluorenes		C2-naphthalenes		C3-Phen-anthrenes & Anthracenes		C3-chrysenes	
Nestlings (Barn Swallow; Individual)											
ON	9OBBS24N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
ON	9OBBS05N	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
ON	9OBBS06N	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016
ON	9OBBS07N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
ON	9OBBS11N	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
ON	9OBBS15N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
ON	9OBBS28N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
ON	9OBBS41N	<	0.025	<	0.025	<	0.025	<	0.025	<	0.025
ON	9OBBS43N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
ON	9OBBS49N	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014
ON	9OBBS52N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
ON	9OBBS55N	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022
ON	9OBBS56N	<	0.016	<	0.016	<	0.016	<	0.016	<	0.016
ON	9OBBS67N	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
BR	9OBBS01N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
BR	9BRBS03N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
BR	9BRBS20N	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014
BR	9BRBS22N	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
BR	9BRBS26N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
BR	9BRBS29N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
BR	9BRBS36N	<	0.015	<	0.015	<	0.015	<	0.015	<	0.015
BR	9BRBS37N	<	0.019	<	0.019	<	0.019	<	0.019	<	0.019
BR	9BRBS38N	<	0.018	<	0.018	<	0.018	<	0.018	<	0.018
BR	9BRBS39N	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
BR	9BRBS79J	<	0.017	<	0.017	<	0.017	<	0.017	<	0.017
BR	9BRBS81N	<	0.017	<	0.017		**0.064**	<	0.017	<	0.017
BR	9BRBS83N	<	0.024	<	0.024	<	0.024	<	0.024	<	0.024
BR	9BRBS90N	<	0.023	<	0.023	<	0.023	<	0.023	<	0.023
BR	9BRBS91N	<	0.022	<	0.022	<	0.022	<	0.022	<	0.022
BR	9BRBS92C	<	0.020	<	0.020	<	0.020	<	0.020	<	0.020
Gastrointestinal Tract Contents (Composite)											
ON	9OBII01	<	0.015		**0.032**	<	0.015	<	0.015	<	0.015
BR	9BRII01	<	0.011	<	0.011	<	0.011	<	0.011	<	0.011

Table E-2 (continued) *(Page 8 of 8)*

Sample Number	C3-dibenzo-thiophenes	C3-fluorenes	C3-naphthalenes	C4-Phen-anthrenes & Anthracenes	C4-chrysenes	C4-naphthalenes
9OBBS24N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9OBBS05N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9OBBS06N	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
9OBBS07N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS11N	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
9OBBS15N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS28N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS41N	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
9OBBS43N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9OBBS49N	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014
9OBBS52N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9OBBS55N	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022
9OBBS56N	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
9OBBS67N	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
9OBBS01N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9BRBS03N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS20N	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014	< 0.014
9BRBS22N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRBS26N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9BRBS29N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS36N	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRBS37N	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
9BRBS38N	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018
9BRBS39N	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS79J	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
9BRBS81N	< 0.017	< 0.017	**0.085**	< 0.017	< 0.017	**0.024**
9BRBS83N	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
9BRBS90N	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
9BRBS91N	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022
9BRBS92C	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
9OBII01	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
9BRII01	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011

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