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

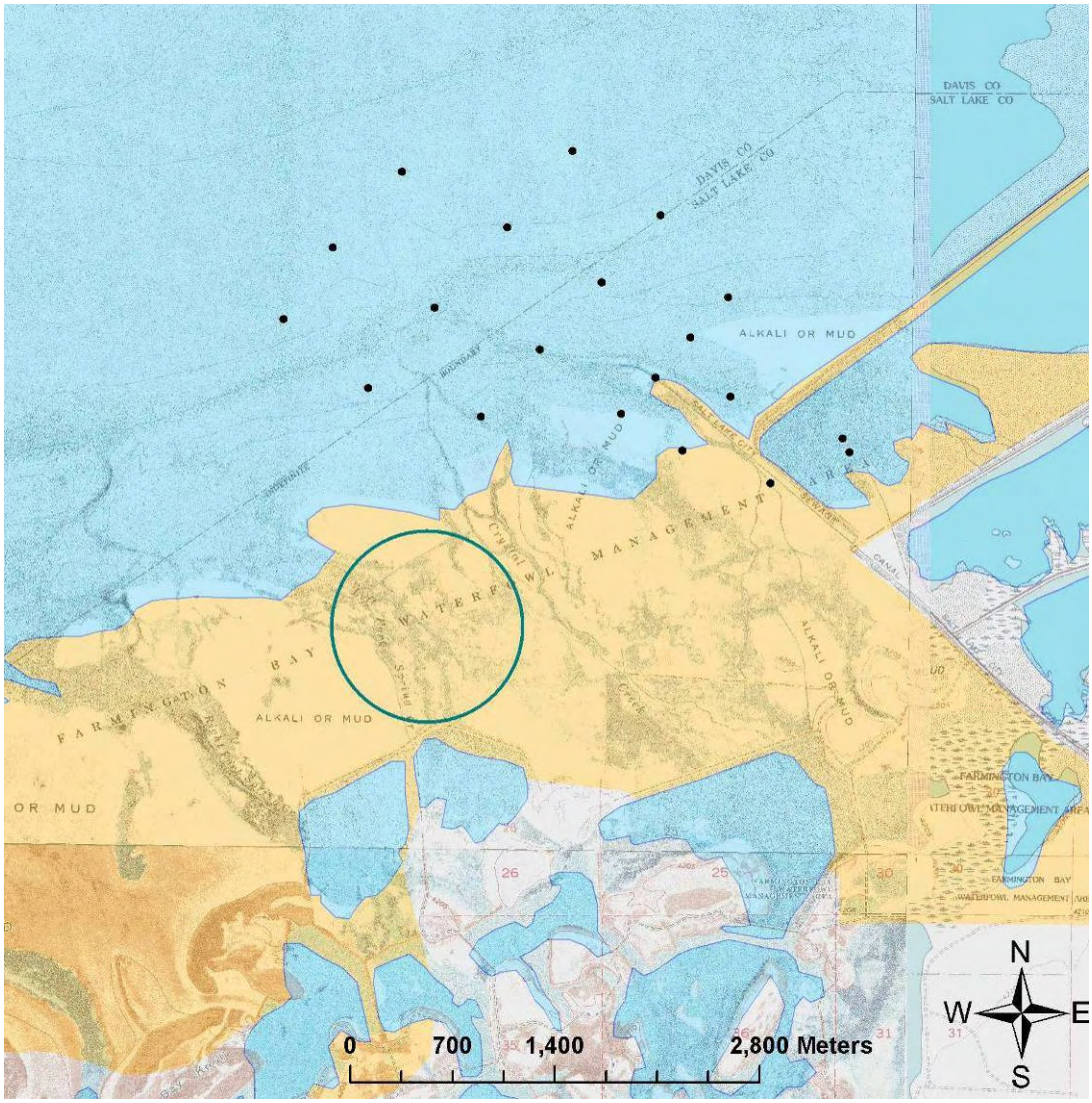

Figure 6-1. Approximate area (circled) of Forster's tern colony along Spring Creek near the Crystal Unit of Farmington Bay Waterfowl Management Area, sampled in 2000. Location of nearby sediment samples collected for the investigation of the Oil Drain Delta are also shown (black dots).

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.

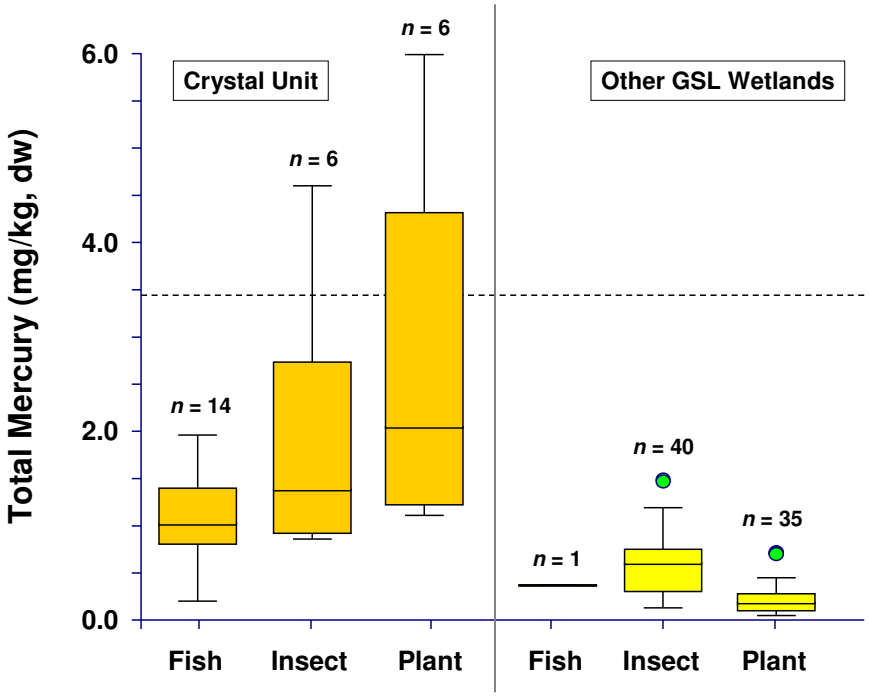

Figure 6-2. Total mercury in bird eggs from Great Salt Lake wetlands (1996 - 2000) by principal food preference and approximate trophic level (piscivore, insectivore, and herbivore).