

HEALTH CONSULTATION

**An Evaluation of Mercury Concentrations in Ducks from
The Great Salt Lake, Utah for 2005 and 2006**

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Prepared by

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Background and Statement of Issues

In 2005, duck consumption advisories were issued for Common Goldeneye and Northern Shoveler ducks from the Great Salt Lake due to mercury contamination [UDOH 2005]. Based on high mercury levels in Common Goldeneye and Northern Shoveler ducks, a consumption advisory was issued by the Utah Department of Health and the Utah Division of Wildlife Resources (UDWR) stating that Common Goldeneye and Northern Shoveler from the Great Salt Lake should not be consumed. The source of this mercury contamination is currently unknown. In conjunction with research carried out by the UDWR Great Salt Lake Ecosystem Project and Utah State University's College of Natural Resources, UDWR is analyzing contaminant concentrations in migratory ducks from the Great Salt Lake. Ten species of ducks were collected from Great Salt Lake marshlands between October 2005 and February 2006. UDWR requested that the Environmental Epidemiology Program (EEP) review the duck sampling data from ducks collected in 2005-2006. This health consultation is an evaluation of mercury in ducks from areas near the Great Salt Lake covering the period October 2005 through February 2006.

Results

Duck Analysis

Ten different duck species were collected from three drainage systems of the Great Salt Lake. These drainage systems include the Bear River, Ogden Bay, and Farmington Bay (Figure 1). All mercury concentrations are reported as a wet weight concentration in milligrams of contaminant per kilogram duck muscle tissue (mg/kg). Muscle tissue samples were analyzed from each individual duck from each species collected. Individual muscle samples were digested in nitric acid under heat, diluted to a final nitric acid content of 5%, and analyzed by inductively coupled plasma mass spectroscopy (ICP-MS).

Mallard

Breast muscle tissue was analyzed for mercury from twenty Mallards collected from the Bear River Drainage area of the Great Salt Lake. Mercury levels ranged from 0.001 mg mercury/kg muscle tissue to 0.377 mg/kg (Table 2). The average mercury level was 0.057 mg/kg. Only one of the twenty samples exceeded the 0.3 mg/kg screening value for mercury.

Breast muscle tissue was analyzed for mercury from twenty-one Mallards collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.007 mg mercury/kg muscle tissue to 0.412 mg/kg (Table 3). The average mercury level was 0.055 mg/kg. Only one of the twenty-one samples exceeded the 0.3 mg/kg screening value for mercury.

Breast muscle tissue was analyzed for mercury from twenty-two Mallards collected from the Ogden Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.006 mg mercury/kg muscle tissue to 0.113 mg/kg (Table 4). The average mercury level was 0.056 mg/kg.

Northern Pintail

Breast muscle tissue was analyzed for mercury from twenty Northern Pintails collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.005 mg mercury/kg muscle tissue to 0.171 mg/kg (Table 5). The average mercury level was 0.050 mg/kg.

Breast muscle tissue was analyzed for mercury from six Northern Pintails collected from the Ogden Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.008 mg mercury/kg muscle tissue to 0.066 mg/kg (Table 6). The average mercury level was 0.032 mg/kg.

American Green-Winged Teal

Breast muscle tissue was analyzed for mercury from twenty-seven American Green-Winged Teal collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.010 mg mercury/kg muscle tissue to 0.233 mg/kg (Table 7). The average mercury level was 0.083 mg/kg.

Breast muscle tissue was analyzed for mercury from ten American Green-Winged Teal collected from the Ogden Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.015 mg mercury/kg muscle tissue to 0.241 mg/kg (Table 8). The average mercury level was 0.112 mg/kg.

Cinnamon Teal

Breast muscle tissue was analyzed for mercury from twenty Cinnamon Teal collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.080 mg mercury/kg muscle tissue to 1.667 mg/kg (Table 9). The average mercury level was 0.394 mg/kg which exceeds the EPA screening value of 0.3 mg/kg. Ten of the twenty samples exceeded 0.3 mg/kg.

Breast muscle tissue was analyzed for mercury from thirteen Cinnamon Teal collected from the Ogden Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.113 mg mercury/kg muscle tissue to 0.532 mg/kg (Table 10). The average mercury level was 0.335 mg/kg which exceeds the EPA screening value of 0.3 mg/kg. Seven of the thirteen samples exceeded 0.3 mg/kg.

Gadwall

Breast muscle tissue was analyzed for mercury from one Gadwall collected from the Farmington Bay Drainage area of the Great Salt Lake. The mercury level in the one Gadwall sample was 0.017 mg/kg (Table 11).

Northern Shoveler

Breast muscle tissue was analyzed for mercury from nineteen Northern Shoveler collected from the Bear River Drainage area of the Great Salt Lake. Mercury levels ranged from 0.019 mg mercury/kg muscle tissue to 0.485 mg/kg (Table 12). The average mercury level was 0.219 mg/kg. Four of the nineteen samples exceeded the 0.3 mg/kg screening value for mercury.

Breast muscle tissue was analyzed for mercury from thirty Northern Shoveler collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.036 mg mercury/kg muscle tissue to 1.794 mg/kg (Table 13). The average mercury level was 0.383 mg/kg which exceeds the EPA screening value of 0.3 mg/kg. Fourteen of the thirty samples exceeded 0.3 mg/kg.

Breast muscle tissue was analyzed for mercury from twenty-nine Northern Shoveler collected from the Ogden Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.069 mg mercury/kg muscle tissue to 1.139 mg/kg (Table 14). The average mercury level was 0.308 mg/kg which exceeds the EPA screening value of 0.3 mg/kg. Ten of the twenty-nine samples exceeded 0.3 mg/kg.

Common Goldeneye

Breast muscle tissue was analyzed for mercury from twenty-three Common Goldeneye collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.139 mg mercury/kg muscle tissue to 3.110 mg/kg (Table 15). The average mercury level was 0.678 mg/kg which exceeds the EPA screening value of 0.3 mg/kg. Fourteen of the twenty-three samples exceeded 0.3 mg/kg.

Breast muscle tissue was analyzed for mercury from three Common Goldeneye collected from the Bear River Drainage area of the Great Salt Lake. Mercury levels ranged from 0.267 mg mercury/kg muscle tissue to 1.120 mg/kg (Table 16). The average mercury level was 0.562 mg/kg which exceeds the EPA screening value of 0.3 mg/kg. Two of the three samples exceeded 0.3 mg/kg.

Breast muscle tissue was analyzed for mercury from three Common Goldeneye collected from the Ogden Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.256 mg mercury/kg muscle tissue to 1.398 mg/kg (Table 17). The average mercury level was 0.706 mg/kg which exceeds the EPA screening value of 0.3 mg/kg. Two of the three samples exceeded 0.3 mg/kg.

Lesser Scaup

Breast muscle tissue was analyzed for mercury from eleven Lesser Scaup collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.040 mg mercury/kg muscle tissue to 0.253 mg/kg (Table 18). The average mercury level was 0.174 mg/kg.

Redhead

Breast muscle tissue was analyzed for mercury from nine Redhead collected from the Ogden Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.004 mg mercury/kg muscle tissue to 0.053 mg/kg (Table 19). The average mercury level was 0.017 mg/kg.

Ruddy Duck

Breast muscle tissue was analyzed for mercury from five Ruddy Duck collected from the Farmington Bay Drainage area of the Great Salt Lake. Mercury levels ranged from 0.044 mg mercury/kg muscle tissue to 0.166 mg/kg (Table 20). The average mercury level was 0.098 mg/kg.

Table 1: Summary of Mercury Concentrations (mg/kg wet weight) in Ducks by Species and Sample Location.

SPECIES	Bear River	Ogden Bay	Farmington Bay
Mallard	0.057 (20)	0.056 (22)	0.055 (21)
Northern Pintail	-	0.032 (6)	0.050 (20)
American Green-Winged Teal	-	0.112 (10)	0.083 (27)
Cinnamon Teal	-	0.335 (13)	0.394 (20)
Gadwall	-	-	0.017 (1)
Northern Shoveler	0.219 (20)	0.308 (29)	0.383 (30)
Common Goldeneye	0.562 (3)	0.706 (3)	0.678 (23)
Lesser Scaup	-	-	0.174 (11)
Redhead	-	0.017 (9)	-
Ruddy Duck	-	-	0.098 (5)
- no samples analyzed. Bold values exceed EPAs screening value of 0.3 mg/kg. Number in parentheses () is the total number of ducks sampled.			

Discussion

Screening values (SVs) were developed by the U.S. Environmental Protection Agency (EPA) and are used as standards by which levels of contamination can be compared. Screening values are defined as the concentrations of target analytes that can trigger further investigation and/or consideration of consumption advisories for the species where such concentrations occur [EPA 2000b].

In duck tissue, the majority of mercury is methylmercury. Methylmercury is rapidly absorbed from the gastrointestinal tract. The human body absorbs about 90 to 100 percent of ingested

methylmercury. Methylmercury can be changed by your body to inorganic mercury. When this happens in the brain, the mercury can remain there for a long time. When methylmercury does leave your body after you have been exposed, it leaves slowly over a period of several months, mostly as inorganic mercury in the feces. The biological half-life of methylmercury in humans is roughly 50 to 65 days. The half-life is a measure of rate for the time required to eliminate one half of a quantity of a chemical from the body. As with inorganic mercury, some of the methylmercury in a nursing woman's body will pass into her breast milk [ATSDR 1999].

Results of the 2005-2006 mercury concentrations in ducks were compared to the SV. The SV for mercury is 0.3 milligrams mercury per kilogram fresh muscle tissue weight (mg/kg) [EPA 2000a].

The average concentration of mercury exceeded the SV for mercury of 0.3 mg/kg for Cinnamon Teal, Northern Shoveler, and Common Goldeneye from 2005-2006 collections. Cinnamon Teal breast muscle samples from the Farmington Bay Drainage area of the Great Salt Lake averaged 0.394 mg/kg mercury with 10 of 20 samples above the 0.3 mg/kg screening value for mercury. Cinnamon Teal breast muscle samples from the Ogden Bay Drainage area of the Great Salt Lake averaged 0.335 mg/kg mercury with 7 of 13 samples above the 0.3 mg/kg screening value for mercury.

Northern Shoveler breast muscle samples from the Bear River Drainage area of the Great Salt Lake averaged 0.219 mg/kg mercury with 3 of 19 samples above the 0.3 mg/kg screening value. Northern Shoveler breast muscle samples from the Farmington Bay Drainage area of the Great Salt Lake averaged 0.383 mg/kg mercury with 14 of 30 samples above the 0.3 mg/kg screening value. Northern Shoveler breast muscle samples from the Ogden Bay Drainage area of the Great Salt Lake averaged 0.308 mg/kg mercury with 10 of 29 samples above the 0.3 mg/kg screening value.

Common Goldeneye breast muscle samples from the Farmington Bay Drainage area of the Great Salt Lake averaged 0.678 mg/kg mercury with 14 of 23 samples above the 0.3 mg/kg screening value. Common Goldeneye breast muscle samples from the Bear River Drainage area of the Great Salt Lake averaged 0.562 mg/kg mercury with 2 of 3 samples above the 0.3 mg/kg screening value. Common Goldeneye breast muscle samples from the Ogden Bay Drainage area of the Great Salt Lake averaged 0.706 mg/kg mercury with 2 of 3 samples above the 0.3 mg/kg screening value.

The Great Salt Lake has high concentrations of mercury and there is evidence that brine shrimp that live in the lake accumulate increasing levels of methyl-mercury throughout the summer and fall months (Naftz, et al., 2004). The source of this mercury contamination is currently unknown. The differences in mercury concentrations found in the ten species sampled from the Great Salt Lake may be explained by differences in migratory behaviors and diet preferences. The Cinnamon Teal which was found to have high mercury levels lives in Utah throughout the summer as opposed to some of the species that only use the Great Salt Lake as part of a brief migration stop. The Northern Shoveler, which was also high in mercury, is a year-round resident in Utah. The Common Goldeneye, which have high mercury levels, arrive in Utah mid-fall,

spends the winter and then departs early spring for their breeding grounds. However, this species is thought to frequently forage on brine fly larvae from the Great Salt Lake (Vest, unpublished data).

Some Mallards and Northern Pintail are residents in Utah throughout the year, others migrate through, and some spend only the winter in Utah. Sampled Mallards and Northern Pintail were low in mercury concentrations. They may be protected through their diet as both species have a high variety of food sources. Of the other species sampled, some only stop at the Great Salt Lake as part of a migration route and/or have varied diets.

Toxicological Evaluation

The nervous system is very sensitive to all forms of mercury. In poisoning incidents that occurred in other countries, some people who ate fish contaminated with large amounts of methylmercury or seed grains treated with methylmercury or other organic mercury compounds developed permanent damage to the brain and kidneys. Animals exposed orally to long-term, high levels of methylmercury or phenylmercury in laboratory studies experienced damage to the kidneys, stomach, and large intestine; changes in blood pressure and heart rate; adverse effects on the developing fetus, sperm, and male reproductive organs; and increases in abortions and stillbirths [ATSDR 1999].

Consumption Limits

When SVs are exceeded, consumption limits can be estimated to determine how many meals of duck can be safely consumed each month [EPA 2000b]. Calculations are based on an adult body weight of 70 kg with a meal size of 227 g duck and a child body weight of 16 kg with a meal size of 113 g of duck (Appendix B).

Although several species of duck were sampled from different areas along the Great Salt Lake, only one consumption limit advisory per species for all of the Great Salt Lake area is recommended. The consumption advisory for each species is based on the most protective consumption value within a species. The basis of an advisory for all of the Great Salt Lake area, rather than issuing advisories for small geographic areas, is because of the ability of ducks to fly to different locations along the Great Salt Lake and hunters to harvest ducks near the edges of geographical areas sampled.

Cinnamon Teal

Based on an average mercury concentration of 0.394 mg/kg in Cinnamon Teal collected from the Farmington Bay Drainage area of the Great Salt Lake in 2005-2006, adults should eat no more than two 8-ounce meals per month. Children, pregnant women, and women that can become pregnant should eat no more than one 4-ounce meal per month of Cinnamon Teal from the Great Salt Lake marshes.

Northern Shoveler

Based on an average mercury concentration of 0.383 mg/kg in Northern Shoveler collected from the Farmington Bay Drainage area of the Great Salt Lake in 2005-2006, adults should eat no more than two 8-ounce meals per month of Northern Shoveler from the Great Salt Lake marshes. Children, pregnant women, and women that can become pregnant should eat no more than one 4-ounce meal per month of Northern Shoveler from the Great Salt Lake marshes.

Common Goldeneye

Based on an average mercury concentration of 0.706 mg/kg in Common Goldeneye collected from Ogden Bay in 2005-2006, adults should eat no more than one 8-ounce meal per month of Common Goldeneye from Great Salt Lake marshes. Children, pregnant women, and women that can become pregnant should not eat Common Goldeneye from the Great Salt Lake.

Other Duck Species Tested

Of the sixty-four samples of Mallard collected from the Great Salt Lake in 2005-2006, only two samples exceeded the 0.3 mg/kg screening value for mercury (one from Bear River and one from Farmington Bay). None of the samples collected for Northern Pintail, American Green-Winged Teal, Lesser Scaup, Redhead, and Ruddy Duck exceeded the 0.3 mg/kg screening value. Only one sample of Gadwall was collected for mercury analysis and its mercury level was well below the 0.3 mg/kg screening value. Consumption limits for Mallard, Northern Pintail, American Green-Winged Teal, Lesser Scaup, Redhead, Gadwall, and Ruddy Duck were therefore not calculated.

Children's Health Considerations

Infants and children have unique vulnerabilities to environmental contaminants. Children are less developed and may have developmental harm from exposure that would not be experienced by a completely developed adult. The developing body systems of children may sustain permanent damage if toxic exposures occur during critical growth stages. Children's health was considered as a part of this health consultation.

Very young children may be more sensitive to mercury than adults. Mercury in the mother's body passes to the fetus and may accumulate there. It can also pass to a nursing infant through breast milk. However, the benefits of breast-feeding may be greater than the possible adverse effects of mercury in breast milk. Mercury's harmful effects that may be passed from the mother to the fetus include brain damage, mental retardation, incoordination, blindness, seizures, and inability to speak. Children poisoned by mercury may develop problems of their nervous and digestive systems, and kidney damage [ATSDR 1999]. Due to the possible health effects from chemical contaminants on the fetus, pregnant women should follow the consumption limits assigned to children.

Conclusions

Cinnamon Teal, *Northern Shoveler*, and *Common Goldeneye* from the Great Salt Lake have levels of mercury that may result in adverse health effects when large amounts are eaten.

Adults should eat no more than two 8-ounce meals per month and children, pregnant women, and women that can become pregnant should eat no more than one 4-ounce meal per month of *Cinnamon Teal* from Great Salt Lake marshes.

Adults should eat no more than two 8-ounce meals per month of *Northern Shoveler* from Great Salt Lake marshes. Children, pregnant women, and women that can become pregnant should eat no more than one 4-ounce meal per month of *Northern Shoveler* from Great Salt Lake marshes.

Adults should eat no more than one 8-ounce meal per month and children, pregnant women, and women that can become pregnant should not eat *Common Goldeneye* from Great Salt Lake marshes.

Recommendations

The Environmental Epidemiology Program recommends consumption advisories for ducks harvested from the Great Salt Lake region because of elevated levels of mercury detected in *Cinnamon Teal*, *Northern Shoveler*, and *Common Goldeneye*. Consumption advisories from 2005 exist for *Northern Shoveler* and *Common Goldeneye*. Consumption advisories for these two species should be modified based on the new data.

Common Goldeneye

The *Common Goldeneye* advisory from 2005 is based on sampling from an area on the Great Salt Lake between Farmington and Ogden bays. Mercury levels in *Common Goldeneye* sampled in 2005-2006 are lower than concentrations found in sampling conducted in 2004-2005. The consumption advisory for this species should reflect this change. Adults should eat no more than one 8-ounce meal per month and children, pregnant women, and women that can become pregnant should not eat *Common Goldeneye* from Great Salt Lake marshes.

Northern Shoveler

The consumption advisory from 2005 for the *Northern Shoveler* is based on samples from the southern end of the Great Salt Lake (Goggin/Lee Creek). This area was not sampled again during the 2005-2006 sampling period. Mercury levels in *Northern Shoveler* sampled in Bear River, Ogden Bay and Farmington Bay drainages in 2005-2006 are lower than concentrations found in sampling conducted in 2004-2005. The consumption advisory for this species should reflect this change. Adults should eat no more than two 8-ounce meals per month of *Northern Shoveler* from Great Salt Lake marshes. Children, pregnant women, and women that can become pregnant should eat no more than one 4-ounce meal per month of *Northern Shoveler* from Great Salt Lake marshes.

Cinnamon Teal

A new consumption advisory for Cinnamon Teal should also be issued. Adults should eat no more than two 8-ounce meals per month and children, pregnant women, and women that can become pregnant should eat no more than one 4-ounce meal per month of Cinnamon Teal from Great Salt Lake marshes.

The EEP recommends that concentrations of mercury continue to be monitored in ducks from different areas of the Great Salt Lake region. Since the 2005 consumption advisory for the Northern Shoveler is based on samples from the southern end of the Great Salt Lake (Lee's Creek/Goggin drainage area), which was not re-sampled during the 2005-2006 sampling period, additional sampling should be conducted in the southern end of the Great Salt Lake.

Public Health Action Plan

This section describes the public health action plan to be taken by EEP and other government agencies at and near the Great Salt Lake watershed site. The purpose of the public health action plan is to ensure actions designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment from the Great Salt Lake watershed site are implemented.

- The EEP, in coordination with the Utah Division of Wildlife Resources, will generate duck consumption advisories for Cinnamon Teal, Northern Shoveler, and Common Goldeneye. A coordinated press release will also be issued detailing the consumption advisories and the adverse health effects that can be caused by ingestion of mercury contaminated duck meat.
- The EEP will work with the Department of Environmental Quality and Division of Wildlife Resources to investigate the source of the mercury contamination in the environment.
- The EEP will generate pamphlets and material to be posted on EEP's website describing the consumption advisories and the adverse health effects of mercury.

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Appendices

Appendix A – Figures and Tables

Figure 1. Approximate sampling locations of ducks from the Great Salt Lake, Utah (2005-2006).



Table 2. Mercury results for individual Mallard breast muscle samples from the Bear River Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
MALL6	0.001
MALL7	0.001
MALL11	0.006
MALL12	0.013
MALL14	0.009
MALL16	0.006
MALL19	0.003
MALL20	0.017
MALL21	0.010
MALL3	0.032
MALL4	0.063
MALL17	0.145
MALL18	0.058
MALL23	0.054
MALL24	0.037
MALL48	0.076
MALL49	0.377
MALL50	0.059
MALL51	0.105
MALL52	0.066
Average =	0.057

Duck samples collected by Utah Division of Wildlife Resources.

Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 3. Mercury results for individual Mallard breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
MALL10	0.010
MALL13	0.026
MALL15	0.036
MALL25	0.026
MALL26	0.010
MALL27	0.011
MALL28	0.007
MALL29	0.035
MALL30	0.024
MALL31	0.022
MALL32	0.030
MALL33	0.057
MALL34	0.018
MALL35	0.103
MALL5	0.062
MALL53	0.038
MALL54	0.056
MALL57	0.412
MALL58	0.123
MALL8	0.024
MALL9	0.028
Average =	0.055

Duck samples collected by Utah Division of Wildlife Resources.

Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 4. Mercury results for individual Mallard breast muscle samples from the Ogden Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
MALL1	0.006
MALL2	0.025
MALL36	0.100
MALL37	0.105
MALL38	0.113
MALL39	0.027
MALL40	0.006
MALL41	0.061
MALL42	0.074
MALL43	0.033
MALL44	0.027
MALL45	0.060
MALL46	0.056
MALL47	0.025
MALL55	0.059
MALL56	0.041
MALL59	0.056
MALL60	0.071
MALL61	0.058
MALL62	0.109
MALL63	0.052
MALL64	0.064
Average =	0.056

Duck samples collected by Utah Division of Wildlife Resources.

* Wet weight concentration.

Table 5. Mercury results for individual Northern Pintail breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
NOPI3	0.015
NOPI4	0.024
NOPI5	0.032
NOPI6	0.041
NOPI7	0.085
NOPI8	0.043
NOPI9	0.016
NOPI10	0.005
NOPI11	0.088
NOPI12	0.011
NOPI13	0.008
NOPI14	0.086
NOPI15	0.040
NOPI16	0.016
NOPI17	0.064
NOPI18	0.100
NOPI19	0.063
NOPI20	0.016
NOPI21	0.171
NOPI26	0.068
Average =	0.050

Duck samples collected by Utah Division of Wildlife Resources.

* Wet weight concentration.

Mercury in Ducks from the Great Salt Lake

Table 6. Mercury results for individual Northern Pintail breast muscle samples from the Ogden Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
NOPI1	0.008
NOPI2	0.048
NOPI22	0.027
NOPI23	0.022
NOPI24	0.066
NOPI25	0.023
Average =	0.032

Duck samples collected by Utah Division of Wildlife Resources.

* Wet weight concentration.

Table 7. Mercury results for individual American Green-Winged Teal breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
AGWT9	0.233
AGWT10	0.064
AGWT11	0.090
AGWT12	0.160
AGWT13	0.050
AGWT14	0.137
AGWT25	0.042
AGWT26	0.051
AGWT36	0.015
AGWT1	0.161
AGWT2	0.123
AGWT3	0.110
AGWT4	0.050
AGWT5	0.063
AGWT6	0.010
AGWT7	0.021
AGWT8	0.061
AGWT37	0.012
AGWT27	0.177
AGWT28	0.090
AGWT29	0.041
AGWT30	0.050
AGWT31	0.210
AGWT32	0.055
AGWT33	0.067
AGWT34	0.044
AGWT35	0.049
Average =	0.083

Duck samples collected by Utah Division of Wildlife Resources.

* Wet weight concentration.

Table 8. Mercury results for individual American Green-Winged Teal breast muscle samples from the Ogden Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
AGWT15	0.100
AGWT16	0.127
AGWT17	0.022
AGWT18	0.219
AGWT19	0.026
AGWT20	0.023
AGWT21	0.136
AGWT22	0.213
AGWT23	0.015
AGWT24	0.241
Average =	0.112

Duck samples collected by Utah Division of Wildlife Resources.

* Wet weight concentration.

Table 9. Mercury results for individual Cinnamon Teal breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
CITE32	0.080
CITE1	0.128
CITE2	0.450
CITE3	0.458
CITE4	0.198
CITE5	0.201
CITE6	0.308
CITE7	0.409
CITE8	0.500
CITE9	0.416
CITE10	1.667
CITE11	0.923
CITE12	0.563
CITE13	0.369
CITE14	0.172
CITE15	0.185
CITE16	0.139
CITE17	0.221
CITE33	0.215
CITE18	0.272
Average =	0.394

Duck samples collected by Utah Division of Wildlife Resources.

Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 10. Mercury results for individual Cinnamon Teal breast muscle samples from the Ogden Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
CITE29	0.113
CITE30	0.295
CITE31	0.308
CITE19	0.187
CITE20	0.425
CITE21	0.271
CITE22	0.509
CITE23	0.532
CITE24	0.459
CITE25	0.270
CITE26	0.287
CITE27	0.367
CITE28	0.328
Average =	0.335

Duck samples collected by Utah Division of Wildlife Resources.

Values that exceed the SV are shown in bold.

* Wet weight concentration.

Mercury in Ducks from the Great Salt Lake

Table 11. Mercury results for individual Gadwall breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
GADW1	0.017

Duck samples collected by Utah Division of Wildlife Resources.

* Wet weight concentration.

Table 12. Mercury results for individual Northern Shoveler breast muscle samples from the Bear River Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
NSHO1	0.438
NSHO2	0.216
NSHO3	0.032
NSHO4	0.019
NSHO5	0.354
NSHO6	0.299
NSHO14	0.179
NSHO15	0.170
NSHO18	0.152
NSHO19	0.052
NSHO7	0.060
NSHO8	0.210
NSHO9	0.290
NSHO10	0.215
NSHO11	0.252
NSHO12	0.221
NSHO13	0.485
NSHO43	0.177
NSHO44	0.337
Average =	0.219

Duck samples collected by Utah Division of Wildlife Resources.

Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 13. Mercury results for individual Northern Shoveler breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
NSHO61	0.630
NSHO62	1.066
NSHO63	0.460
NSHO64	0.695
NSHO74	0.224
NSHO75	0.142
NSHO76	0.245
NSHO16	0.221
NSHO17	0.229
NSHO20	0.354
NSHO21	0.184
NSHO22	0.223
NSHO23	0.232
NSHO24	0.317
NSHO25	0.160
NSHO73	0.397
NSHO26	0.215
NSHO27	0.384
NSHO28	0.304
NSHO29	0.211
NSHO30	0.206
NSHO31	0.336
NSHO32	0.151
NSHO65	0.071
NSHO66	0.255
NSHO67	0.974
NSHO68	0.036
NSHO69	1.794
NSHO61	0.630
NSHO62	1.066
Average =	0.383

Duck samples collected by Utah Division of Wildlife Resources.
 Values that exceed the SV are shown in bold. * Wet weight concentration.

Table 14. Mercury results for individual Northern Shoveler breast muscle samples from the Ogden Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
NSHO33	1.139
NSHO34	0.127
NSHO71	0.235
NSHO35	0.239
NSHO36	0.305
NSHO37	0.132
NSHO38	0.279
NSHO39	0.315
NSHO40	0.233
NSHO41	0.198
NSHO42	0.707
NSHO45	0.255
NSHO46	0.130
NSHO47	0.552
NSHO48	0.268
NSHO49	0.161
NSHO50	0.475
NSHO51	0.097
NSHO52	0.089
NSHO53	0.118
NSHO54	0.164
NSHO55	0.324
NSHO56	0.190
NSHO57	0.458
NSHO58	0.930
NSHO59	0.069
NSHO60	0.234
NSHO70	0.301
NSHO72	0.215
Average =	0.308

Duck samples collected by Utah Division of Wildlife Resources. Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 15. Mercury results for individual Common Goldeneye breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
COGO1	0.198
COGO3	0.183
COGO26	1.548
COGO27	0.618
COGO28	0.819
COGO29	0.204
COGO2	0.286
COGO4	0.254
COGO5	0.239
COGO6	0.152
COGO7	0.447
COGO8	0.187
COGO9	3.110
COGO10	0.743
COGO13	0.482
COGO19	0.312
COGO23	1.468
COGO24	0.400
COGO25	0.318
COGO11	1.095
COGO12	1.287
COGO14	0.139
COGO15	1.093
Average =	0.678

Duck samples collected by Utah Division of Wildlife Resources.
 Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 16. Mercury results for individual Common Goldeneye breast muscle samples from the Bear River Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
COGO16	0.300
COGO17	1.120
COGO18	0.267
Average =	0.562

Duck samples collected by Utah Division of Wildlife Resources. Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 17. Mercury results for individual Common Goldeneye breast muscle samples from the Ogden Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
COGO21	0.256
COGO22	0.464
COGO20	1.398
Average =	0.706

Duck samples collected by Utah Division of Wildlife Resources. Values that exceed the SV are shown in bold.

* Wet weight concentration.

Table 18. Mercury results for individual Lesser Scaup breast muscle samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
LESC1	0.253
LESC2	0.187
LESC3	0.217
LESC4	0.169
LESC5	0.066
LESC6	0.040
LESC7	0.232
LESC8	0.223
LESC9	0.149
LESC10	0.164
LESC11	0.214
Average =	0.174

Duck samples collected by Utah Division of Wildlife Resources.
* Wet weight concentration.

Table 19. Mercury results for individual Redhead breast muscle samples from the Ogden Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
REDH1	0.013
REDH2	0.005
REDH3	0.005
REDH4	0.004
REDH5	0.004
REDH6	0.053
REDH7	0.028
REDH8	0.037
REDH9	0.006
Average =	0.017

Duck samples collected by Utah Division of Wildlife Resources.
* Wet weight concentration.

Mercury in Ducks from the Great Salt Lake

Table 20. Mercury results for individual Ruddy Duck breast samples from the Farmington Bay Drainage Area, Great Salt Lake, Utah (2005-2006).

Sample	Mercury concentration (mg/kg)*
RUDU1	0.044
RUDU2	0.114
RUDU3	0.056
RUDU4	0.166
RUDU5	0.111
Average =	0.098

Duck samples collected by Utah Division of Wildlife Resources.
* Wet weight concentration.

Appendix B – Screening Value and Consumption Limit Calculations

Screening Value and Consumption Limit Calculations

For Noncarcinogenic Health Effects

$$SV = [(MRL)(BW)]/CR$$

- SV = Screening value for a contaminant (in mg/kg or ppm)
- MRL = Minimal risk level (in mg/kg/day)
- BW = Mean body weight of the general population or subpopulation of concern (kg)
- CR = Mean daily consumption rate of the species of interest by the general population or by the subpopulation of concern averaged over a 70-yr lifetime (in kg/day)

Consumption Rate Calculations for Non-Carcinogenic Health Effects

To calculate the maximum allowable duck consumption rate for a non-carcinogen:

$$CR_{lim} = [(RfD)(BW)]/C_m$$

Cinnamon Teal Farmington Bay	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.394	0.0178
Child	0.0001	16	0.394	0.0041
Cinnamon Teal Ogden Bay	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.335	0.0209
Child	0.0001	16	0.335	0.0048

Mercury in Ducks from the Great Salt Lake

Northern Shoveler Bear River	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.219	0.0320
Child	0.0001	16	0.219	0.0073
Northern Shoveler Farmington Bay	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.383	0.0183
Child	0.0001	16	0.383	0.0042
Northern Shoveler Ogden Bay	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.308	0.0227
Child	0.0001	16	0.308	0.0052

Common Goldeneye Farmington Bay	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.678	0.0103
Child	0.0001	16	0.678	0.0024
Common Goldeneye Bear River Bay	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.562	0.0125
Child	0.0001	16	0.562	0.0028
Common Goldeneye Ogden Bay	RfD	BW	C _m	CR _{lim}
Adult	0.0001	70	0.706	0.0099
Child	0.0001	16	0.706	0.0023

Where:

CR_{lim} = maximum allowable duck consumption rate (kg/day)

RfD = reference dose (EPA) or minimal risk level (ATSDR)

BW = mean body weight of the general population or sub-population of concern (kg)

C_m = measured concentration of chemical contaminant in a given species of ducks
(mg/kg)

$$CR_{mm} = [(CR_{lim})(T_{ap})]/MS$$

Mercury in Ducks from the Great Salt Lake

Cinnamon Teal Farmington Bay	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0178	30.44	0.227	2.4
Child	0.0041	30.44	0.113	1.1
Cinnamon Teal Ogden Bay	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0209	30.44	0.227	2.8
Child	0.0048	30.44	0.113	1.3

Northern Shoveler Bear River	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0320	30.44	0.227	4.3
Child	0.0073	30.44	0.113	2.0
Northern Shoveler Farmington Bay	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0183	30.44	0.227	2.5
Child	0.0042	30.44	0.113	1.1
Northern Shoveler Ogden Bay	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0227	30.44	0.227	3.0
Child	0.0052	30.44	0.113	1.4

Common Goldeneye Farmington Bay	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0103	30.44	0.227	1.4
Child	0.0024	30.44	0.113	0.6
Common Goldeneye Bear River	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0125	30.44	0.227	1.7
Child	0.0028	30.44	0.113	0.8
Common Goldeneye Ogden Bay	CR _{lim}	T _{ap}	MS	CR _{mm}
Adult	0.0099	30.44	0.227	1.3
Child	0.0023	30.44	0.113	0.6

Mercury in Ducks from the Great Salt Lake

Where:

CR_{mm} = maximum allowable duck consumption rate (meals/month)

CR_{lim} = as calculated above

T_{ap} = time averaging period (365.25 days/12 months = 30.44 days per month)

MS = meal size (0.227 kg duck/meal for adults, 0.113 kg duck/meal for children)

Assumptions for Consumption Rate Calculations are as follows:

An average adult weighs 70 kg and eats 227 g of duck per meal.

An average child weighs 16 kg and eats 113 g of duck per meal.