Mercury in Biota and Sediment in the Walker River Basin, Nevada and California

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Common loons (*Gavia immer*) that stage during migration at Walker Lake, Nevada, were found to have elevated concentrations of mercury in their blood. The source of the mercury was unknown, although fish from Walker Lake were known to contain moderate concentrations. Therefore, an investigation was initiated to determine the sources of mercury in the Walker River basin and the concentrations of mercury in Walker Lake tui chub (*Gila bicolor*) of the size consumed by common loons to determine risk to this fish-eating species. A total of 12 fish and 29 aquatic invertebrate samples were collected in 1999-2001 at 19 sites in the Walker River basin. Mercury concentrations in aquatic invertebrate samples collected at sites downstream of historic mine sites, where mercury was used in precious metal recovery in the late 1800's, were often higher than at sites where no historic mining influences were present. Mercury concentrations in tui chub from Walker Lake increased with size of the fish, with a major increase for fish greater than 25 cm in length. Mercury concentrations in fish were below those associated with adverse effects to fish. Mercury concentrations in larger tui chubs may be a risk to fish-eating birds, including common loons. Data on mercury concentrations in stream sediment from the Walker River basin that were provided by the U.S. Geological Survey and the U.S. Environmental Protection Agency were examined in relation to the concentrations found in this study in aquatic invertebrates. These data sets suggested that mercury source areas included: an area of the Virginia Creek watershed, south of Bridgeport, California; several sites on the southeast side of the Sweetwater Range near the California-Nevada state line, which included areas along Sweetwater and Fryingpan Creeks; Bodie, California; and the nearby Aurora district in Nevada. Additional studies are needed to further define mercury source areas for possible stabilization or cleanup. Additional information is also needed on common loons which include the following: fall migration patterns and wintering areas to determine if the birds frequent known areas of mercury contamination; mercury exposure on the breeding grounds in Saskatchewan; and mercury in blood of loons using other Nevada lakes and reservoirs during migration to determine if Walker Lake is a significant source of mercury.

Background and Justification

More than 1,000 common loons (*Gavia immer*) stage during migration at Walker Lake, Nevada, each spring and fall to feed and rest. In April 1998, six loons were captured on Walker Lake as part of a cooperative study to determine the nesting and wintering locales of these birds. Blood and feather samples were collected and analyzed for mercury. High concentrations of mercury were found in the blood of three of the six birds sampled, placing them at high risk, according to Evers et al. (1998b). Additional common loons from Walker Lake were sampled in 1999, 2000 and 2001, with some having elevated concentrations of mercury in their blood (David Evers, personal communication; Yates et al. 2002). In contrast, two common loons captured on Topaz Lake in 2001 had background mercury concentrations in their blood (Yates et al. 2002). Walker Lake is also an important feeding area for other species of fish-eating birds, including American white pelicans (*Pelecanus erythrorhynchus*), double-crested cormorants (*Phalacrocorax auritus*), and various species of grebes, herons, and egrets.

The source of mercury contamination in the common loons sampled at Walker Lake is currently unknown. Blood mercury levels are thought to reflect uptake in the loon's diet during the two to three month period prior to sampling (David Evers, personal communication). Data on mercury concentrations found in a variety of sizes of two species of Walker Lake fish collected in 1994 to 1999 are presented in Table 1. Direct comparisons of mercury concentrations in tui chub (*Gila bicolor*) are not possible due to differences in size among samples. A direct comparison of the mercury concentrations in Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) between 1995 and 1999 is complicated by two factors. First, whole fish were analyzed in 1995, whereas fillets were analyzed in 1999. Mercury concentrations in whole bodies of brook trout (*Salvelinus fontinalis*) were slightly lower than in muscle (McKim et al. 1976). Second, the trout sampled in the 1999 were slightly larger than those sampled in 1995. Therefore, no definitive conclusion can be made in comparing these two samples. Mercury concentrations in fish from the Walker River were also slightly elevated at some locations in 1994 (Table 2), with greater concentrations in largemouth bass (*Micropterus salmoides*) near Schurz, Nevada, than that found at two sites upstream from this site; however, sizes of the bass samples are unknown. The concentration of mercury in hemipterans at the Schurz site was also elevated compared to concentrations in hemipterans at other sites for samples collected in 1994 (Table 2).

Locations of possible mercury sources in the Walker River basin are generally unknown. However, areas of historic precious metal mining are present in the Walker River basin. These include the Bodie and Aurora mining districts which were active during the late 1800's (Nevada Bureau of Mines 1964; State of California 1992; Dynamac Corporation 2002), as well as other potential locations. Mercury was used for the recovery of precious metals in other areas of Nevada during the late 1800's, most notably the Comstock Lode in the Carson River basin, resulting in severe contamination of the environment (Hoffman et al. 1990; Tuttle et al. 2000).

These data demonstrated the need for investigations of potential sources of mercury in the Walker River basin. Information was also needed on the concentrations of mercury in fish in Walker Lake that may be consumed by common loons and the relative risks at those levels of exposure.

Table 1. Mercury concentrations in fish from Walker Lake, 1994 to 1999.

Species and area	Tissue	Collection date	Size[a] (cm)	µg/g Mercury wet weight[b] [dry weight]	Source
Tui chub	Fillets?	Oct. 1994			Dept. of the Army (undated)
Background area (3 pools)			28	0.65 (0.59-0.74)	
Firing impact area (5 pools)			30	0.78 (0.57-1.00)	
Tui chub	Whole fish	July 1994			Thodal and Tuttle (1996)
Near Hawthorne (pool of 4 fish)			8 (5-12)[c]	0.15 [0.68]	
Tui chub	Whole fish	June 1996			Wiemeyer et al. (2001)
20-Mile Beach (pooled sample)			–	0.80 [2.54]	
Delta (pooled sample)			–	0.84 [3.27]	
Tui chub	Whole fish	April 1999			NDOW[d]
Sand Point (6 fish)			24 (13-28)[e]	0.59 (0.22-0.91)	
Lahontan cutthroat trout	Whole fish	May 1995			Dept. of the Army (undated)
Background area (2 fish)			42 (40-44)	0.38 (0.38)	
Firing impact area (5 fish)			36 (33-40)	0.29 (0.18-0.38)	
Lahontan cutthroat trout	Fillets	April 1999			NDOW[d]
Tufa Point (6 fish)			46 (35-55)[f]	0.68 (0.51-0.86)	

[a] Length. Means with extremes in parentheses.
[b] Means are given when more than one fish or pooled sample was analyzed; extremes in parentheses.
[c] Average weight 9.7 grams.

Table 1. (concluded)

[d] NDOW is the Nevada Division of Wildlife, Fallon, Nevada; data from Michael Sevon, personal communication, May 1999.
[e] Average weight 240 grams (range 28-340).
[f] Average weight 1160 grams (range 450-1840).

Methods

Sample collection

More than 25 stream, river, and lake sites in the Walker River basin were selected for collection of aquatic invertebrates and fish in 1999, 2000, and 2001 (Tables 3 and 4). Samples were collected from many of the same sites as those selected for water and sediment sampling for mercury analysis by the U.S. Geological Survey (USGS; Michael Lico, personal communication). Biota samples from riverine sites were primarily collected during low flow periods in the Fall of 2000, with the exception of the Bodie, Aurora, and Rough Creek sites which were sampled in the Spring of 1999 to obtain preliminary data. Our original intent was to collect both aquatic invertebrates and fish from each riverine site and fish only from Walker Lake. However, fish were not available from most stream sites without the use of electro-fishing equipment, which we did not carry on our sampling trips. Therefore, our emphasis was on collection of aquatic invertebrates at these sites.

Invertebrates were collected with a kick net, by fine mesh screen, or by gloved hand in the case of some crayfish. Kick nets were cleaned with detergent and rinsed with site water between sampling sites. Invertebrates were removed from kick nets by gloved hand or stainless steel forceps and placed in glass jars or net contents were placed in stainless steel trays. Forceps and trays were cleaned with detergent and rinsed with dilute acid and de-ionized water between sampling sites. All glass jars used in the study were certified clean by the suppliers (VWR Scientific or I-Chem) and met U.S. Environmental Protection Agency designated priority pollutant analyte specifications. Small invertebrates were sorted by type and removed from trays with forceps and placed in tared glass jars. Crayfish were sorted by size when sufficient numbers were available and placed in tared glass jars. The number of individual crayfish in each sample was recorded. Invertebrate samples were weighed in the field to obtain approximate weights in an effort to ensure minimum sample weights of 10 grams (to the extent available) and re-weighed in the laboratory upon return from the field. Specimens in jars were placed on wet ice in the field and frozen upon return to the laboratory.

Fish were collected using several methods. Tui chub from Walker Lake were collected by hook and line in 2000, whereas all fish from the lake in 2001 were collected with gill nets that were set by Chris Drake of the Nevada Division of Wildlife (NDOW). All other fish were collected with use of a seine in 2000. Fish collected from the Walker River in 2000 were sorted by species with gloved hand, measured, individually weighed (to the nearest 0.1 gram), and placed in tared glass jars or clean zip-lock bags. Fish collected from Walker Lake in 2001 were sorted by size and placed in clean zip-lock bags. Tui chub collected from Walker Lake in 2000 were placed in clean zip-lock bags. Samples were usually weighed in the field and re-weighed

Table 2. Mercury concentrations in fish and aquatic invertebrates from primarily riverine sites in the Walker River basin, collected in 1994 (Thodal and Tuttle 1996).

Location	Species	µg/g Mercury (dry weight)
	Fish	
East Fork Stream Sites		
Bridgeport Reservoir	Tui chub	1.02
East Walker below Bridgeport Reservoir	Lahontan redside[a]	0.32
West Fork Stream Sites		
Topaz Lake	Lahontan redside	0.45
Main Stem Stream Sites		
Walker River near Wabuska	Black bullhead	0.87
Walker River above Weber Reservoir	Black bullhead	0.72
Walker River near Weber Reservoir	Largemouth bass	0.57
Weber Reservoir	Largemouth bass	0.41
Walker River below Weber Reservoir	Largemouth bass	1.31
	Aquatic Invertebrates	
East Fork Stream Sites		
Bridgeport Reservoir	Hemiptera (Corixidae)	<0.19
East Walker below Bridgeport Reservoir	Crayfish	<0.20
West Fork Stream Sites		
Topaz Lake	Hemiptera (Corixidae)	<0.19
Main Stem Stream Sites		
Walker River near Wabuska	Crayfish	0.51
Walker River at Schurz	Hemiptera (Notonectidae)	1.32
Walker Lake		
Walker Lake	Damselfly larvae	0.28

[a] *Richardsonius egregius.*

Note: Sizes of fish are not known with certainty; therefore, they are not reported here.

upon return to the laboratory. Specimens were placed on wet ice in the field and frozen upon return to the laboratory. All fish in zip-lock bags were double bagged in the laboratory.

Sediment samples collected in 1999 were from depositional areas. Samples were collected with a stainless steel spoon that was cleaned with detergent and rinsed with dilute acid and deionized water between sample locations. Samples were not sieved. Samples were placed in glass jars, placed on ice in the field, and frozen upon return to the laboratory.

Locations of sampling sites were obtained with a global positioning system unit.

Chemical analysis

All samples were analyzed for total mercury. Fish samples were composites of whole bodies. All samples collected in 1999 and 2001 were analyzed by the Patuxent Analytical Control Facility (U.S. Fish and Wildlife Service, Laurel, Maryland). Samples collected in 1999 were digested with sulfuric and nitric acids as described by Monk (1961). Mercury determination was performed by cold vapor atomic absorption spectrophotometry using a Spectro Products mercury analyzer equipped with a Varian VGA-76 vapor generation accessory. Analysis of duplicates, spike recoveries, procedural blanks, and reference materials was conducted for one sample each of tissue and sediment. The lower limit of detection for sediment and tissue samples was approximately 0.02 µg/g on a wet weight basis.

Fish samples collected in 2001 were freeze dried. One-half to one gram of freeze-dried tissue was digested in nitric acid and hydrogen peroxide. Mercury determination was by cold vapor atomic absorption spectroscopy as described by Hatch and Ott (1968) modified for use with a Perkin Elmer Atomic Absorption Spectrophotometer (AAS) 3100 equipped with a Perkin Elmer FIAS 200. Detection limits were approximately 0.03 µg/g on a wet weight basis. Analysis for duplicate, spike recovery, procedural blank, and reference material was conducted for one sample each.

~~Samples collected in 2000 were analyzed by the Environmental Trace Substances~~ Laboratory at the University of Missouri-Rolla. Samples were homogenized and approximately 0.5 gram sample digested with nitric acid and then diluted with 1% v/v hydrochloric acid. The samples were mixed with hydroxylamine for preliminary reduction and then stannous chloride for reduction to mercury vapor. Mercury determination was by cold vapor atomic absorption using a Perkin Elmer Model 403 AAS. Analysis for procedural blanks, duplicates, reference materials, and spike recoveries was conducted on each of three samples. Detection limits were 0.02 µg/g on a dry weight basis.

The Patuxent Analytical Control Facility certified laboratory quality control/quality assurance for all samples in all years of collection.

Results and Discussion

Sample locations and sample types

Information on sample locations and the general number and types of biota samples collected at each site is provided in Table 3. A total of 12 fish and 29 aquatic invertebrate samples were collected in 1999-2001 at 19 sites. In addition to these samples, a single sediment sample was collected at each of three sites in 1999. We were unable to obtain samples at eight

Table 3. General locations and coordinates of sites sampled for biota in the Walker River Basin, and number of samples collected in 1999-2001.

Site No.	Coordinates (latitude; longitude)		Location description	Number of samples		
				Fish	Crayfish	Invertebrates[a]
West Fork Stream Sites						
1.	38°21'58"	119°28'47"	W. Walker above Little Walker, near Sonora Junction, CA	0	0	1
2.	38°22'01"	119°26'34"	Little Walker above West Walker, 1 mile north of Sonora Junction, CA	0	0	2
3.	38°30'50"	119°26'58"	West Walker at Walker, CA	0	0	1
4.	38°45'36"	119°22'50"	West Walker at Wellington, NV	0	1	0
5.	38°53'22"	119°10'42"	West Walker just above confluence with East Walker, NV	2	3	0
East Fork Stream Sites						
6.	38°11'28"	119°12'24"	Virginia Creek, south of Bridgeport, CA	0	1	1
7.	38°10'24"	119°13'57"	Green Creek, south of Bridgeport, CA	0	0	1
8.	38°10'19"	119°19'26"	Robinson Creek, south of Bridgeport, CA	0	3	2
9.	38°14'18"	119°19'51"	Buckeye Creek, west of Bridgeport, CA	0	0	2
10.	38°27'05"	119°11'40"	Green Creek above Sweetwater Creek, NV	0	0	1
11.	38°26'28"	119°06'21"	E. Walker 1.25 miles below Sweetwater Creek (at bridge), NV	0	1	2
12.	38°26'03"	119°00'38"	Rough Creek just above confluence East Walker, NV[b]	0	0	1
13.	38°20'04"	118°54'38"	Bodie Creek at bridge, below confluence with Aurora Creek, NV[b]	0	0	3
14.	38°17'43"	118°55'38"	Aurora Creek above confluence With Bodie Creek, NV[b]	0	0	1

Table 3. General locations and coordinates of sites sampled for biota in the Walker River Basin, and number of samples collected in 1999-2001 (concluded).

Site No.	Coordinates (latitude; longitude)		Location description	Number of samples		
				Fish	Crayfish	Invertebrates[a]
Main Stem Stream Sites						
15.	39°09'10"	119°05'53"	Walker River just below confluence with Wabuska Drain, NV	3	2	0
Walker Lake						
16.	38°46'23"	118°44'46"	North shore near Reservation, NV	1	0	0
17.	38°39'36"	118°45'45"	South shore, NV	1	0	0
18.	38°39'00"	118°45'00"	West shore, NV[c]	4	0	0
19.	38°42'23"	118°45'45"	Tufa Point, west shore, NV	1	0	0

[a] Other than crayfish.

[b] Also sampled sediment at this site.

[c] Fish were collected at three points on the west shore; coordinates averaged. Sampling points were near Tufa Point, near Cliff House, and near Rose Creek confluence. Coordinates were roughly averaged for this site.

additional sites due to access problems or finding that the sites were unsuitable for the presence of the desired types of biota (Table 4). Stonefly (Plecoptera) larvae were most commonly collected at stream sites (total of 13 samples at 10 sites), followed by crayfish (Cambaridae; total of 11 samples at six sites), caddisfly (Trichoptera) and crane fly (Tipulidae) larvae (one sample of each at each of two sites), and one sample of dragonfly (Anisoptera) larvae (Table 5). Collection dates, sample weights for all samples, and the average weight per individual for crayfish samples are also given in Table 5. Fish were collected at only two stream sites and at Walker Lake (Table 6). Fish collected at Walker Lake in 2001 were selected to represent the size range of fish believed to be food items for common loons based on information from David Evers (personal communication). These fish were pooled based on four size categories for separate analyses to determine if fish size was related to mercury concentration. Date of collection and average weight and length per individual for all fish samples are provided in Table 6.

Mercury concentrations in aquatic invertebrates and potential sources

Data on mercury concentrations in all samples are provided in Table 7, and those for invertebrate samples are plotted in Figure 1. Mercury concentrations on a dry weight basis in aquatic invertebrates at sites 1, 3, 8, 9, and 10 were all below 0.1 µg/g and were usually < 0.07 µg/g. These sites are therefore considered background or reference sites. Based on examination of topographic maps, no evidence of mining was noted upstream of sites 1, 3, 8, and 9, whereas a few prospects were noted near Green Creek, Nevada, upstream of site 10. Mercury concentrations were only slightly higher at sites 2, 4, and 11, where concentrations were still < 0.15 µg/g. No evidence of mining was noted on topographic maps upstream of site 2. Evidence of mercury exposure was present at all other sites where aquatic invertebrates were sampled. Gold and silver mining in the 1860's to 1880's occurred upstream from sites 12, 13, and 14 in the Bodie-Aurora-Rough Creek watershed (Nevada Bureau of Mines 1964; State of California 1992). Mercury concentrations in samples from Virginia Creek and Green Creek, California, (sites 6 and 7) south of Bridgeport were also somewhat elevated. Little evidence of mining was seen on examination of topographic maps for areas upstream of the Green Creek, California, (site 7) sampling site. However, extensive evidence of mining was noted in the Virginia Creek watershed, which included many areas of tailings along Dog Creek which flows to Virginia Creek. A mill site is present on upper Dunderberg Creek (Michael Lico, personal communication), which flows to Dog Creek. Potential sources of mercury at site 11 include inputs from Sweetwater Creek (e.g., Angelo Mission Mine near headwaters of the creek and tailings in Silverado Canyon which flows to Sweetwater Creek), Fryingpan Creek (e.g., evidence of mines, mine dumps, adits, and Star City and Monte Cristo sites), the Masonic Gulch area to the south of the East Walker River and to the northeast of Bridgeport, and Aurora Canyon Creek (inactive gold milling site [CCJM 1991] or mercury retort [Brown & Root Environmental 1996] active in the 1960's) approximately 1.5 miles east of Bridgeport. A stamp mill associated with the Golden Gate Mine is present on an unnamed tributary to the West Walker River (just north of Mill Creek, west of Walker, California), which flows to the West Walker River, just downstream from our sampling site 3 at Walker, California (Michael Lico, personal communication).

Table 4. Locations of proposed sampling sites where no samples were collected.

Site	Location description	Conditions
East Fork Stream Sites		
A	East Walker, above confluence with West Walker, CA	Unsuitable for collections
B	Sweetwater Creek above confluence with East Walker, at highway bridge, NV	Unsuitable for collections
C	Fryingpan Creek, above confluence with East Walker, CA	Access problems
D	East Walker below confluence with Masonic Gulch, NV	Access problems
E	East Walker at Hoye Bridge, upstream of Wellington, NV	Access problems
Main Stem Stream Sites		
F	Walker River near upstream end of Weber Reservoir, NV	Access problems
G	Walker River just downstream of Weber Reservoir, NV	Access problems
H	Walker River near Schurz, NV	Access problems

The Pine Grove/Rockland area, also known as the Wilson District, between the East and West Walker Rivers about 20 miles south of Yerington, was also an active gold and silver mining area in the late 1860's and early 1870's (Nevada Bureau of Mines 1964; State of California 1992). However, upon examination of topographic maps we found no continuous flow path from this area linking it to the East Walker River, thereby precluding possible mercury contamination of the river from this source. No mercury mines were noted in the Walker River basin within Nevada (Nevada Bureau of Mines 1964).

More than one type of aquatic invertebrate was collected at several sites allowing for comparisons of mercury uptake among invertebrate types (Table 7). At Virginia Creek (site 6) stonefly larvae and very small crayfish had similar concentrations of mercury. Similar results were found at the Robinson Creek site where both stonefly larvae and small to medium sized crayfish had nearly identical mercury concentrations, with the largest crayfish having a slightly higher concentration. Caddisfly and stonefly larvae from Buckeye Creek (site 9) had nearly identical mercury concentrations. At the East Walker River site downstream of Sweetwater Creek (site 11), dragonfly larvae had slightly lower concentrations of mercury than either crayfish and stonefly larvae. The mercury concentration in a sample of crane fly larvae from Bodie Creek (site 13) was approximately three times higher than concentrations found in two stonefly larvae samples.

Mercury concentrations in aquatic invertebrates may be influenced by feeding habits of the various taxa that were collected. Stonefly larvae feeding habits vary among families (e.g.,

Table 5. Collection data for aquatic invertebrate composite samples from the Walker River basin, collected in 1999-2001[a].

Location[b]	Collection Date	Biota type[c]	Total sample weight (g)	Average weight per individual (g)
West Fork Stream Sites				
1. West Walker above Little Walker CA	9/28/00	Stonefly larvae	10.8	- -
2. Little Walker above West Walker, CA	9/28/00	Stonefly larvae	12.0	- -
2. Little Walker above West Walker, CA	9/28/00	Stonefly larvae	11.9	- -
3. West Walker at Walker, CA	9/28/00	Stonefly larvae	13.1	- -
4. West Walker at Wellington, NV	9/26/00	Crayfish (adult)	84.4	21.1
5. West Walker above East Walker, NV	9/25/00	Crayfish (adult)	124.7	31.2
5. West Walker above East Walker, NV	9/25/00	Crayfish (adult)	87.5	17.5
5. West Walker above East Walker, NV	9/25/00	Crayfish (mixed)	55.3	11.1
East Fork Stream Sites				
6. Virginia Creek, south of Bridgeport, CA	9/27/00	Stonefly larvae	15.7	- -
6. Virginia Creek, south of Bridgeport, CA	9/27/00	Crayfish (juvenile)	3.1	1.0
7. Green Creek, south of Bridgeport, CA	9/27/00	Stonefly larvae	10.0	- -
8. Robinson Creek, south of Bridgeport, CA	9/27/00	Crayfish (adult)	151.7	30.3
8. Robinson Creek, south of Bridgeport, CA	9/27/00	Crayfish (adult)	83.4	16.7
8. Robinson Creek, south of Bridgeport, CA	9/27/00	Crayfish (juvenile)	19.7	3.9
8. Robinson Creek, south of Bridgeport, CA	9/27/00	Stonefly larvae	11.5	- -
8. Robinson Creek, south of Bridgeport, CA	9/27/00	Stonefly larvae	18.2	- -
9. Buckeye Creek, west of Bridgeport, CA	9/27/00	Caddisfly larvae	11.8	- -
9. Buckeye Creek, west of Bridgeport, CA	9/27/00	Stonefly larvae	11.1	- -
10. Green Creek above Sweetwater Cr., NV	9/26/00	Stonefly larvae	6.8	- -
11. East Walker below Sweetwater Cr., NV	9/26/00	Dragonfly larvae	12.3	- -
11. East Walker below Sweetwater Cr., NV	9/26/00	Crayfish (mixed)	118.6	23.7
11. East Walker below Sweetwater Cr., NV	9/26/00	Stonefly larvae	4.1	- -
12. Rough Creek above East Walker, NV	4/02/99	Crane fly larvae	23.6	- -

Table 5. Collection data for aquatic invertebrate composite samples from the Walker River basin, collected in 1999-2001[a] (concluded).

Location[b]	Collection Date	Biota type[c]	Total sample weight (g)	Average weight per individual (g)
13. Bodie Creek below Aurora Creek, NV	4/02/99	Stonefly larvae	4.5	- -
13. Bodie Creek below Aurora Creek, NV	4/14/99	Stonefly larvae	6.2	- -
13. Bodie Creek below Aurora Creek, NV	4/14/99	Crane fly larvae	8.7	- -
14. Aurora Creek above Bodie Creek, NV	4/14/99	Caddisfly larvae	8.2	- -
Main Stem Stream Sites				
15. Walker River below Wabuska Drain, NV	9/25/00	Crayfish (juvenile)	26.3	3.3
15. Walker River below Wabuska Drain, NV	9/25/00	Crayfish (adult)	87.9	29.3

[a] See Table 3 for latitude and longitude coordinates of sampling sites. Location numbers are consistent with site numbers in Table 3.
[b] See Figure 1 for locations of sampling sites with corresponding site numbers.
[c] Age of crayfish in parentheses.

Table 6. Collection data for fish samples from the Walker River basin, collected in 2000-2001[a].

Location	Collection date	Fish type (age)	Total sample weight (g)	Avg. per individual Weight (g)	Avg. per individual Length (cm)
West Fork Stream Sites					
5. West Walker above East Walker, NV	9/25/00	Tahoe sucker (juvenile)[b]	28.2	1.57	5.3
5. West Walker above East Walker, NV	9/25/00	Tahoe sucker (juvenile)[c]	27.9	1.55	5.3
Main Stem Stream Sites					
15. Walker River below Wabuska Drain, NV	9/25/00	Black bullhead (sub-adult)[d]	465.0	66.4	17.5
15. Walker River below Wabuska Drain, NV	9/25/00	Largemouth bass (juvenile)[e]	142.0	14.2	9.9
15. Walker River below Wabuska Drain, NV	9/25/00	Carp (juvenile)[f]	50.0	16.7	10.1
Walker Lake					
16. North shore near Reservation, NV	6/02/00	Tui chub (adult)[g]	1535.	307.0	29.0
17. South shore, NV	6/02/00	Tui chub (adult)[h]	1559.	311.8	28.8
18. West shore, NV[i]	5/17/01	Tui chub (juvenile)[j]	190.4	17.3	10.7
18. West shore, NV[i]	5/17/01	Tui chub (juvenile)[k]	551.2	39.4	13.9
18. West shore, NV[i]	5/17/01	Tui chub (juvenile)[l]	280.6	93.5	18.2
18. West shore, NV[i]	5/17/01	Tui chub (juvenile)[m]	448.0	112.0	19.7
19. Tufa Point, west shore, NV	5/17/01	Lahontan cutthroat trout (juvenile)[n]	127.1	63.6	19.5

[a] See Table 3 for latitude and longitude coordinates of sampling sites. Location numbers are consistent with site numbers in Table 3.
[b] 18 fish; 4.5 - 7.1 cm total length; *Catostomus tahoensis*.
[c] 18 fish; 3.9 - 7.4 cm total length.
[d] 7 fish; 15.0 - 19.1 cm total length.
[e] 10 fish; 8.4 - 11.0 cm total length.
[f] *Cyprinus carpio*; 3 fish; 8.8 - 11.7 cm total length.
[g] 5 fish; 26.9 - 30.8 cm total length.
[h] 5 fish; 26.6 - 30.9 cm total length.

Table 6. Collection data for fish samples from the Walker River basin, collected in 2000-2001[a] (concluded).

[i] Fish were collected at three points on the west shore; Tufa Point, near Cliff House, and near Rose Creek Confluence. Fish were pooled into discrete size ranges as provided in the following footnotes.
[j] 11 fish; 9 - < 13 cm fork length.
[k] 14 fish; 13 - < 16 cm fork length.
[l] 3 fish; 16 - < 19 cm fork length.
[m] 4 fish; 19 - < 21 cm fork length.
[n] 2 fish; 19 - 20 cm fork length.

some being predators and others herbivores/detritivores), developmental stage, and food availability (Thorp and Covich 1991). The feeding habits of crane fly larvae are also variable and include detritivores and predators (Merritt and Cummins 1984; Thorp and Covich 1991). Caddisfly larvae that were collected from the Aurora Creek site were extracted from cases. Case-building caddisfly larvae are mostly herbivores, but include some omnivores (Thorp and Covich 1991). Caddisfly larvae from Buckeye Creek were not found in cases and were considered to be more free-living. Dragonfly larvae are predaceous (Usinger 1956; Thorp and Covich 1991). Crayfish tend to be generalists with regard to their food habits (Thorp and Covich 1991). We did not identify the aquatic invertebrates generally beyond Order; therefore, we are unable to determine the feeding habits of the types we collected. Predaceous types would be expected to have higher concentrations of mercury due to their being higher on the food chain.

Crayfish were collected in both 1994 (Table 2) and 2000 (Table 5) at two similar sites. On the East Walker River, crayfish from a site about 2 miles downstream of Bridgeport Reservoir contained < 0.20 µg/g mercury (dry weight) in 1994, whereas at a site somewhat further downstream, crayfish contained 0.149 µg/g (dry weight) in 2000. The detection limit used for the 1994 samples would not have been low enough to detect the concentration found in the sample collected in 2000. At the site near Wabuska, the mercury concentration in the sample collected in 1994 (see Table 2) and the mean of the concentrations in two samples collected in 2000 were identical. Mercury concentrations increased with crayfish size for the three samples collected at site 5 in 2000.

Mercury in fish

Fish were collected at only two riverine sites in addition to Walker Lake (Table 7). The same species were never collected at more than one site, precluding comparisons among sites. The mercury concentration (i.e., 0.131 µg/g dry weight) in the black bullhead (*Ictalurus melas*) sample collected in 2000 near Wabuska (site 15) was much lower than that found near this location in 1994 (0.87 µg/g dry weight; see Table 2); however, the size of the fish collected in 1994 is unknown, precluding a direct comparison. The mercury concentration (i.e., 1.57 µg/g dry weight) in largemouth bass collected near Wabuska in 2000 was much higher than that found in this species near and in Weber Reservoir (0.57 and 0.41 µg/g dry weight; see Table 2), but similar to that found in this species near Schurz, all in 1994 (see Table 2). However, the size of

Table 7. Mercury concentrations in sediment and biota samples from the Walker River basin, collected in 1999-2001.

Location[a]	Biota type (age)[b]	Mercury concentration µg/g wet wt.	Mercury concentration µg/g dry wt.
West Fork Stream Sites			
1. W. Walker above Little Walker	Stonefly larvae	0.0090	0.0613
2. Little Walker above West Walker	Stonefly larvae	0.0204	0.123
2. Little Walker above West Walker	Stonefly larvae	0.0162	0.122
3. West Walker at Walker, CA	Stonefly larvae	0.0135	0.0773
4. West Walker at Wellington	Crayfish (a)	0.0227	0.106
5. West Walker above East Walker	Tahoe sucker (j)	0.0916	0.423
5. West Walker above East Walker	Tahoe sucker (j)	0.0685	0.309
5. West Walker above East Walker	Crayfish (a)	0.0829	0.326
5. West Walker above East Walker	Crayfish (a)	0.0363	0.159
5. West Walker above East Walker	Crayfish (m)	0.0292	0.133
East Fork Stream Sites			
6. Virginia Creek, South of Bridgeport	Stonefly larvae	0.0215	0.197
6. Virginia Creek, South of Bridgeport	Crayfish (j)	0.0387	0.182
7. Green Creek, South of Bridgeport, CA	Stonefly larvae	0.0441	0.324
8. Robinson Creek, South of Bridgeport	Crayfish (a)	0.0226	0.0943
8. Robinson Creek, South of Bridgeport	Crayfish (a)	0.0172	0.0669
8. Robinson Creek, South of Bridgeport	Crayfish (j)	0.0142	0.0641
8. Robinson Creek, South of Bridgeport	Stonefly larvae	0.0141	0.0659
8. Robinson Creek, South of Bridgeport	Stonefly larvae	0.0101	0.0717
9. Buckeye Creek, West of Bridgeport	Caddisfly larvae	0.0058	0.0666
9. Buckeye Creek, West of Bridgeport	Stonefly larvae	0.0111	0.0641
10. Green Creek above Sweetwater Cr., NV	Stonefly larvae	0.00585	0.0249
11. E. Walker below Sweetwater Cr.	Dragonfly larvae	0.0124	0.102
11. E. Walker below Sweetwater Cr.	Crayfish (m)	0.0379	0.149
11. E. Walker below Sweetwater Cr.	Stonefly larvae	0.0357	0.135
12. Rough Creek above East Walker	Sediment[c]	–	0.262
12. Rough Creek above East Walker	Crane fly larvae	0.0455	0.415
13. Bodie Creek below Aurora Creek	Sediment[c]	–	0.150
13. Bodie Creek below Aurora Creek	Stonefly larvae	0.0583	0.263
13. Bodie Creek below Aurora Creek	Stonefly larvae	0.0571	0.302
13. Bodie Creek below Aurora Creek	Crane fly larvae	0.125	0.863
14. Aurora Creek above Bodie Creek	Sediment[d]	–	0.249
14. Aurora Creek above Bodie Creek	Caddisfly larvae	0.0667	0.498

Table 7. Mercury concentrations in sediment and biota samples from the Walker River basin, collected in 1999-2001 (concluded).

Location[a]	Biota type (age)[b]	Mercury concentration µg/g wet wt.	Mercury concentration µg/g dry wt.
Main Stem Stream Sites			
15. Walker River below Wabuska Drain	Black bullhead (sa)	0.0296	0.131
15. Walker River below Wabuska Drain	Largemouth bass (j)	0.363	1.57
15. Walker River below Wabuska Drain	Carp (j)	0.286	1.40
15. Walker River below Wabuska Drain	Crayfish (j)	0.104	0.472
15. Walker River below Wabuska Drain	Crayfish (a)	0.134	0.552
Walker Lake			
16. North shore near Reservation	Tui chub (a)	0.898	3.17
17. South shore	Tui chub (a)	0.835	2.98
18. West shore[e]	Tui chub (j)	0.0883	0.380
18. West shore[e]	Tui chub (j)	0.0938	0.385
18. West shore[e]	Tui chub (j)	0.130	0.525
18. West shore[e]	Tui chub (j)	0.116	0.463
19. Tufa Point, west shore	LCT[f] (j)	<0.0304	<0.132

[a] See Figure 1 for locations of most sampling sites with corresponding site numbers and Table 3 for coordinates of sampling sites. Samples, within sites, are listed in the same order as those listed in Tables 5 and 6. Location numbers are consistent with site numbers in Table 3.
[b] Ages in parentheses; a = adult; j = juvenile; m = mixed ages; sa = sub-adult.
[c] Collected 4/2/99.
[d] ~~Collected 4/14/99.~~
[e] Fish were collected from three points on the west shore: Tufa Point, near Cliff House, and near Rose Creek confluence.
[f] Lahontan cutthroat trout.

fish collected in 1994 is unknown, again precluding a direct comparison.

Brown trout (*Salmo trutta*; n = 8), mountain whitefish (*Prosopium williamsoni*; n = 1), and sucker (species not indicated; n =1) were collected from the East Walker River at Bridgeport in the 1980's (California Regional Water Quality Control Board 2001). Mercury concentrations ranged from 0.05 to 0.32 µg/g (presumed wet weight).

Mercury concentrations in tui chub from Walker Lake increased with size of the fish (Figure 2). Mercury concentrations were consistently low (i.e., < 0.25 µg/g, wet weight) in fish up to 20 cm in length (mixed total and fork lengths and both whole fish and possible fillets). These sizes of fish are most likely those consumed by common loons; however, male loons may consume slightly larger fish than females (Evers et al. 1998a). Mercury concentrations were elevated in most tui chub samples greater than 25 cm in length. Sigler and Sigler (1987) indicated that "Large tui chub feed to some extent on fish." Koch et al. (1979) indicated that tui chub in Walker Lake are omnivorous and opportunistic in their food habits; a large female (32.4 cm long; 636.8 g) had the remains of a young of the year tui chub in its stomach. Wiener et al. (in press) reported that mercury accumulation in fish can increase with age, with an abrupt increase when fish switch from an invertebrate diet to a fish diet.

Larger tui chubs collected in more recent years also may have been exposed to higher mercury concentrations that might have been associated with rising lake levels, including the flood of January 1997. However, this does not explain the elevated concentration found in the sample collected by the Army in 1994. Rising lake levels in the mid- to late-1990's would have re-flooded sediments along shorelines. Some of these sediments would have likely contained elevated mercury concentrations deposited during the late 1800's in relation to the use of mercury in precious metal mining in the Walker River basin during that era. Mercury concentrations (both methyl and total) near the surface (i.e., up to 4 cm in depth) of Walker Lake sediment were much higher than that found in somewhat deeper portions of a core sample taken in 2001 (Michael Lico, personal communication). Far deeper portions of the core sample had much higher mercury concentrations, which may have been laid down during the late 1800's, during the period of active mining in the basin. When wetlands in Lahontan Valley were re-flooded after a period of drought, mercury concentrations in biota were much higher in the first year after re-flooding, and then gradually declined (Tuttle et al. 2000). Mercury was not detected in juvenile Lahontan cutthroat trout from Walker Lake in 2001 (Table 7). These fish had been recently stocked in the lake and did not have ample time to accumulate mercury unlike larger fish of this species collected in earlier years (Table 1).

Mercury effects concentrations

Mercury concentrations in fish from our study appear to be below those associated with adverse effects to fish. McKim et al. (1976) indicated a whole body mercury concentration of 2.7 µg/g (wet weight) in brook trout was associated with mercury intoxication. In rainbow trout (*Onchorynchus mykiss*), 1 to 5 µg/g mercury (wet weight) in whole body is the chronic effects estimate (Niimi and Kisson 1994).

Mercury in food items may also have adverse effects on fish-eating birds. Barr (1986) reported that reductions in egg laying and nest site fidelity of common loons were associated with mean mercury concentrations ranging from 0.3 to 0.4 µg/g (wet weight) in prey. No successful reproduction occurred where the mercury concentration in small prey species exceeded 0.4 µg/g. Mercury concentrations in prey fish from common loon breeding areas have been correlated with mercury concentrations in blood of adult loons (Scheuhammer et al. 1998a; Evers et al. 2002). Fish in the size range of 10- 70 g are reported to predominate in the diet of common loons; however, fish up to 300 g are occasionally eaten (McIntyre and Barr 1997). Mercury concentrations in Walker Lake tui chubs of the size thought to be consumed by common loons were below the threshold for adverse reproductive effects in this species presented by Barr (1986). However, common loons from Walker Lake had higher mercury concentrations in their blood than expected, based on mercury concentrations in Walker Lake fish. We are uncertain as to the cause of the elevated mercury concentrations in blood of common loons using Walker Lake. One possibility is that the feeding rate of the common loons during their migratory stop overs may be higher than that during the breeding season, resulting in a greater uptake of mercury than expected. A second possibility is that the loons are being exposed to mercury in another area before migrating to Walker Lake. In assessing the mercury risk to reproductive success of the common loons using Walker Lake, one must also consider its depuration rate (i.e., methyl mercury has a half-life of about 2 to 3 months in avian tissues; Scheuhammer 1987) during the period prior to breeding. Common loons are capable of demethylating mercury and storing non-toxic mercury in their liver and kidney (Scheuhammer et al. 1998b).

Larger tui chubs (e.g., those greater than 25 cm in length) from Walker Lake had mercury concentrations that may be a risk to American white pelicans that feed on these larger fish while they are spawning. However, white pelicans may be able to demethylate methyl mercury, the predominate form found in fish, thereby protecting themselves from adverse effects of this more toxic form of mercury (Wiemeyer et al. 2001). However, their young may be at greater risk than their parents.

Adverse reproductive effects in mallards (*Anas platyrhynchos*) were associated with a methyl mercury dietary concentration of 0.5 µg/g dry weight or about 0.1 µg/g wet weight (Heinz 1979). Nearly all mercury found in fish is in the methyl form (Wiener and Spry 1996). Mercury concentrations in fish from our study often exceeded the threshold concentration for adverse reproductive effects in mallards. However, mercury concentrations in aquatic invertebrates from our study rarely exceeded the threshold concentration for mallards. American dipper (*Cinclus mexicanus*) in the Walker River Basin may be the only avian species that would be likely to consume aquatic invertebrates in their larval stages, thereby being exposed to any mercury contamination that may be present. Major food items of American dippers include larval life stages of caddisflies, mayflies, stoneflies, and Diptera, including midges, crane flies, mosquitoes, etc. (Kingery 1996). The sensitivity of American dippers to mercury is unknown.

Mercury in sediment - U.S. Geological Survey and U.S. Environmental Protection Agency data

The U.S. Geological Survey (Ralph Seiler and Michael Lico, personal communications) collected water and sediment samples in the Walker River basin in 2000 in conjunction with our study in an effort to locate mercury source areas in the basin. EPA conducted a Regional Environmental Monitoring and Assessment Program (REMAP) study (Robert Hall, personal communication) in the Walker River basin in 2000, which included analyses of water and sediment samples for mercury analyses. The results of the sediment sampling from these studies is provided in Table 8 and the data are plotted in Figure 3 in relation to sampling sites, as they aid in the location of mercury source areas.

The established Effects Range-Low (ERL) for mercury in sediment (i.e., the lower 10 percentile toxicity value) is 0.15 µg/g (dry weight), whereas the Effects Range-Median (ERM; i.e., the median toxicity value) for sediment is 1.3 µg/g (dry weight) (Long and Morgan 1991). Concentrations of mercury in stream sediment from the USGS and EPA data bases were usually lower than the ERL, with none exceeding the ERM. The sediment effects threshold for mercury for freshwater invertebrates is 0.2 µg/g (Persaud et al. 1993). MacDonald et al. (2000) identified a consensus-based probable effect concentration of 1.06 µg/g mercury in sediment of freshwater ecosystems. Based on these data, aquatic invertebrate communities might be adversely affected

Table 8. Mercury concentrations in sediment from the Walker River Basin collected by USGS or EPA in 2000; results of split samples in parentheses.

Location	Coordinates		Mercury
	Latitude	Longitude	µg/g dry weight
USGS data - stream sites			
W. Walker above Little Walker	38°22'24"	119°27'12"	0.025
Little Walker R. above W. Walker R.	38°21'39"	119°26'38"	0.044
W. Walker R. near Coleville	38°30'37"	119°26'55"	0.017
W. Walker R. at Wellington	38°43'40"	119°25'34"	0.023
W. Walker R. above E. Walker	38°53'25"	119°10'45"	0.095
Virginia Creek near Bridgeport	38°11'30"	119°12'30"	0.148
Green Creek near Bridgeport	38°10'25"	119°14'00"	0.024
Robinson Creek near Bridgeport	38°10'20"	119°19'25"	0.001
Buckeye Creek near Bridgeport	38°14'20"	119°19'30"	0.011
Frying Pan Cr. at E. Walker	38°24'31"	119°10'25"	0.330
Silverado Canyon Creek near Sweetwater Creek	38°27'39"	119°11'19"	0.021
Sweetwater Creek below Silverado Ranch	38°28'08"	119°10'51"	0.067
Silverado Canyon below tailings	38°27'16"	119°13'22"	0.132 (0.127)
Green Creek above Ferris Ditch	38°26'02"	119°13'17"	0.060
Ferris ditch above Green Creek	38°26'06"	119°13'22"	0.047
Green Creek above Sweetwater Creek	38°27'26"	119°10'01"	0.036
Sweetwater Creek at E. Walker	38°26'20"	119°07'45"	0.535
E. Walker R. below Masonic Gulch	38°26'28"	119°06'23"	0.046
Sonoma Creek above E. Walker	38°26'14"	119°06'08"	0.047
Rough Creek above E. Walker	38°26'01"	119°00'36"	0.083
E. Walker R. above W. Walker	38°53'22"	119°10'02"	0.100 (0.104)
Walker River at Wabuska	39°09'10"	119°05'50"	0.057
Walker River above Weber Reservoir near Schurz	39°06'04"	118°55'37"	0.168
USGS data - reservoir sites			
Topaz Lake (4.5" core)	38°40'32"	119°32'24"	0.053
Bridgeport Reservoir (1-5" core)	38°18'38"	119°13'05"	0.006
EPA data			
Buckeye Creek	38°13'35"	119°23'49"	<0.03
Bodie-Upper Rensit	38°17'08"	118°55'39"	0.21
Mainstem Walker (nr. Wabuska)	39°09'09"	119°05'30"	0.18
West Walker-Leavitt	38°19'30"	119°32'56"	<0.03

Table 8. Mercury concentrations in sediment from the Walker River Basin collected by USGS or EPA in 2000. (concluded)

Location	Coordinates		Mercury
	Latitude	Longitude	µg/g dry weight
W. Walker	38°21'58"	119°27'50"	<0.04
Bodie-Upper	38°17'08"	118°55'39"	0.6
Rough Creek	38°22'12"	118°56'42"	0.03
Sonora Bridge	38°21'50"	119°29'13"	<0.03
Robinson Creek	38°11'47"	119°19'08"	<0.03
Lost Cannon	38°29'16"	119°29'34"	<0.07
W. Walker Fall Creek	38°16'11"	119°33'02"	<0.02
Sweetwater	38°28'15"	119°17'03"	<0.04
Eagle Creek	38°11'44"	119°22'03"	<0.05
Green-Dyanmo	38°09'09"	119°13'17"	<0.03
Walker Bridge	38°58'46"	119°10'55"	0.11
Chris Flat	38°25'05"	119°26'48"	0.03
E. Walker USFS	38°28'59"	118°59'37"	0.78
Deep Creek	38°27'17"	119°27'13"	<0.05
Pickle	38°20'51"	119°31'22"	<0.05
MWMU (masonwma)	39°06'24"	119°07'23"	0.05
Poison Creek	38°18'44"	119°27'47"	<0.04
Upper W. Walker River	38°20'32"	119°32'29"	0.02
Swauger	38°16'46"	119°17'26"	<0.03
Upper Desert	38°34'00"	119°18'15"	<0.03
Upper Dalzell	38°35'56"	119°13'28"	<0.07
Lapham	38°10'31"	119°11'23"	0.03
East Green	38°05'12"	119°17'21"	<0.02
Lobdell Desert Creek	38°29'18"	119°20'50"	0.08
Middle Green Cr.	38°07'51"	119°14'04"	<0.04
By Day Cr.	38°16'13"	119°18'54"	<0.1
Bodie-Lower	38°19'47"	118°54'54"	0.67
Fales Cr.	38°21'11"	119°25'24"	<0.04
Slinkard	38°38'32"	119°33'51"	<0.04
Desert Creek Peak	38°37'09"	119°20'15"	<0.06
W. Walker Logjam	38°16'56"	119°32'19"	<0.03

Note: Multiple sediment samples were also taken by USGS from Weber Reservoir and especially Walker Lake. These results are not reported here. USGS data reported above were provided by Ralph Seiler, whereas EPA data were provided by Robert Hall.

by mercury contamination at some stream sites that were sampled.

Management Recommendations

The following steps should be taken to insure that data from this study and that from USGS are put to use to benefit the environment:

1. A full evaluation of the data collected to date should be made to determine data gaps and to prioritize additional studies.
2. Data from this study, that of USGS, and data on mercury in common loons at Walker Lake should be integrated into one report and should be published in a peer reviewed USGS publication series.
3. Searches should be made for additional data on historic mines in the Walker River basin that could be sources of mercury contamination.
4. A joint presentation should be made by both the Fish and Wildlife Service and USGS to the Nevada Abandoned Mine Lands Environmental Task Force, with emphasis on potential mercury source areas.
5. Funding should be sought from various sources, including agencies participating in the Nevada Abandoned Mine Lands Environmental Task Force and similar agencies in California, to sample and further examine potential source areas with the ultimate goal of preventing further mercury inputs from such areas and thus protecting downstream aquatic environments from additional mercury contamination.
6. Mercury source areas that can be effectively remediated should be cleaned up or controlled.

Additional data should be collected by those conducting studies on common loons in order to determine if Walker Lake is a significant mercury source. The following research should be considered:

1. Satellite transmitters should be placed on common loons that use Walker Lake on Fall migration to determine movement patterns toward the birds' wintering grounds, as well as their northward return in the Spring, and to determine if they frequent areas of known mercury contamination.
2. Information should be sought or collected on mercury concentrations in fish on the loon's breeding grounds in Saskatchewan and on mercury concentrations in the loons.
3. Common loons should be captured and blood samples taken for analysis from birds using other Nevada lakes or reservoirs during migration to aid in determining if Walker Lake is the source of the elevated mercury concentrations in blood for loons captured at Walker Lake.

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Figure 1. Mercury concentrations (ppm or µg/g dry weight) in aquatic invertebrate samples collected in the Walker River system, California and Nevada, 1999 and 2000. See Table 3 for a description of sample locations, including coordinates, and Table 7 for mercury concentrations and the type of invertebrate sampled. Numbers in parentheses indicate the number of samples collected per site where more than one sample was collected.

Mercury in Aquatic Invertebrate Samples Collected in the Walker River System, California & Nevada, 1999-2000

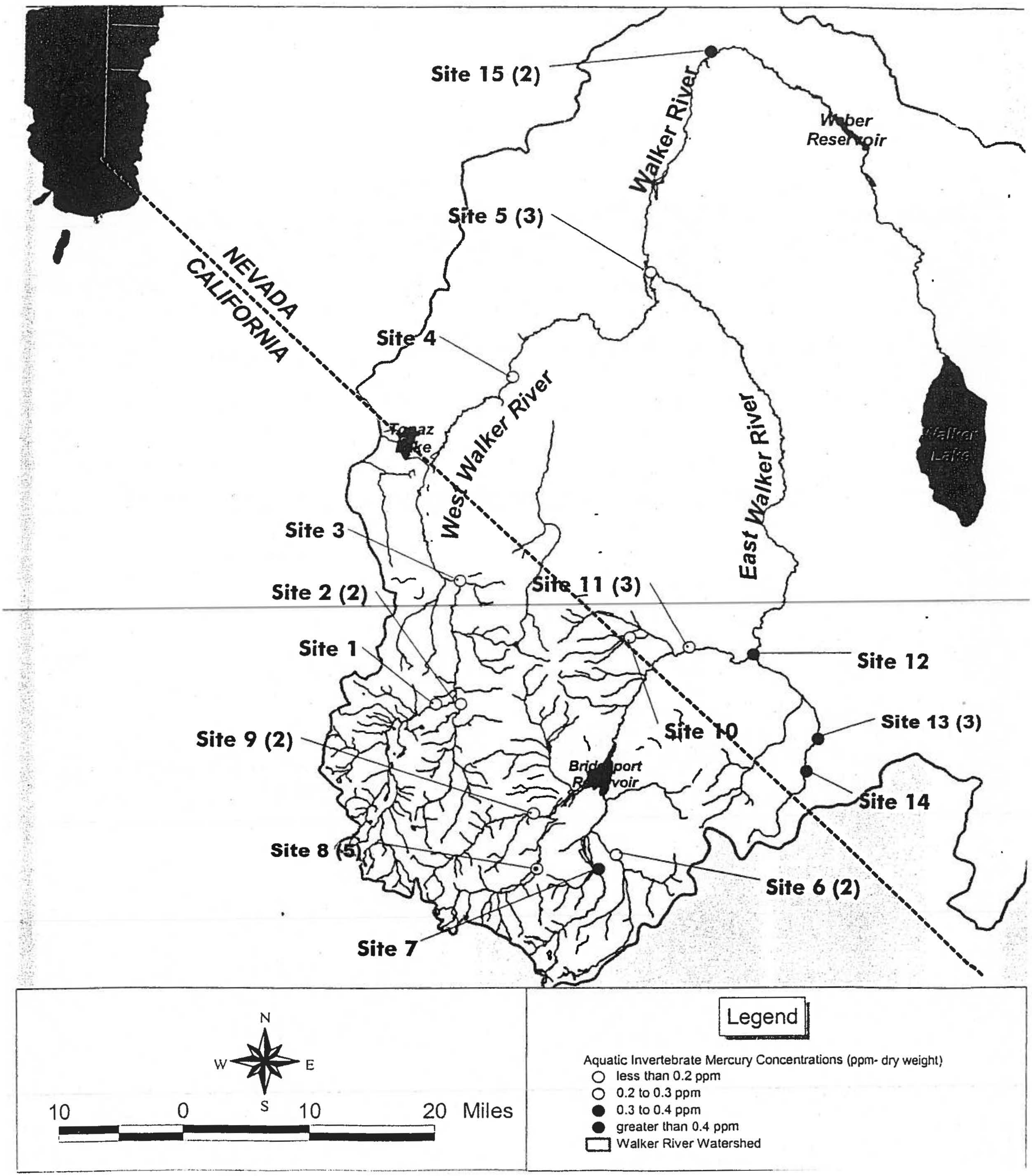

Figure 2. Mercury concentrations (ppm or µg/g wet weight) in tui chub from Walker Lake in relation to size (mixed total and fork lengths). U.S. Fish and Wildlife Service (FWS) data are for whole fish; samples are composites, with several fish in each sample; lengths are means for the pooled samples. Nevada Division of Wildlife (NDOW) data are for whole fish; data are for individual fish. Army data may be for fillets, but that is uncertain; samples are composites; lengths are means for the pooled samples. See text for information on data sources.

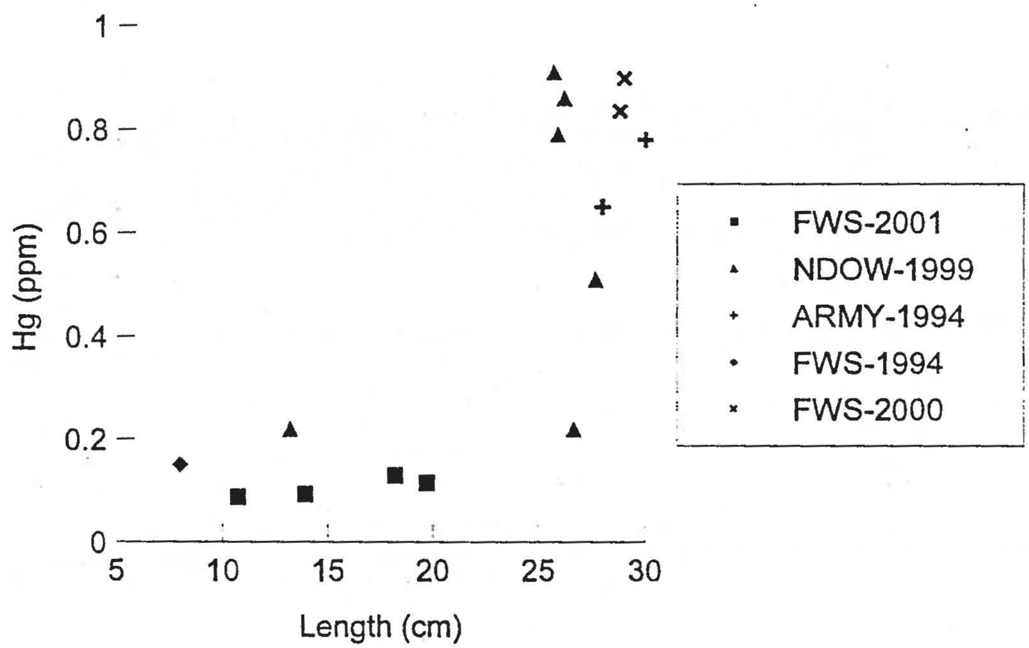

Figure 3. Mercury (ppm or µg/g dry weight) in sediment samples collected by the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (EPA) in the Walker River system, California and Nevada, 1999-2000. See Table 8 for sample locations, coordinates, and concentrations. EPA samples with concentrations below detection limits were not plotted.

Mercury in Sediment Samples
Collected by USGS and U.S. EPA in the Walker River System, California & Nevada, 2000