WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Mercury Concentrations in Edible Muscle of Lake Whatcom Fish

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Mercury Concentrations in Edible Muscle of Lake Whatcom Fish

by
Dave Serdar, Washington State Department of Ecology
Jim Johnston, Washington Department of Fish and Wildlife
Karl Mueller, Washington Department of Fish and Wildlife
Glen Patrick, Washington State Department of Health

in cooperation with
Whatcom County Health and Human Services Department

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Abstract

Concentrations of total mercury were assessed in edible muscle (fillet) tissues of 273 fish collected from Lake Whatcom near Bellingham, Washington. Samples of six finfish species and signal crayfish were analyzed from each of the lake's three major basins.

Mercury concentrations were much higher in smallmouth bass (*Micropterus dolomieu*) compared to yellow perch (*Perca flavescens*), kokanee (*Oncorhynchus nerka*), pumpkinseed (*Lepomis gibbosus*), cutthroat trout (*Oncorhynchus clarki*), brown bullhead (*Ameiurus nebulosus*), and signal crayfish (*Pacifastacus leniusculus*). Concentrations were positively correlated with length and age in smallmouth bass, and to a lesser extent in yellow perch and Basin 2 signal crayfish, but no such relationship was seen in other species. The overall mercury concentration in smallmouth bass averaged 0.49 µg/g (wet weight), and the maximum concentration was 1.84 µg/g. Mean mercury concentrations in other species were generally 0.05 – 0.20 µg/g. All species from the southern Basin 3 had more mercury on average compared to their counterparts from the northern Basins 1 and 2, regardless of average size or age. However, there was no consistent direction in mercury concentrations between samples from Basin 1 and Basin 2.

The Washington State Department of Health will use these data to develop a health risk assessment for Lake Whatcom, as a separate document. The Washington Department of Fish and Wildlife will assess the potential impact of mercury on fish health, also as a separate document. Since 13 of the samples exceeded the EPA National Toxics Rule human health criterion of 0.825 µg/g, the Washington State Department of Ecology should add Lake Whatcom to the Section 303(d) list for mercury in tissue. Other recommendations are to investigate possible mercury sources to Lake Whatcom and determine if lake or watershed characteristics promote enhanced mercury uptake and accumulation by fish.

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Introduction

Mercury is a ubiquitous element that cycles through the environment in various forms, including long distance transport in its volatile state. Although it occurs naturally, human activity has been mobilizing increasing quantities of mercury into the biosphere since the beginning of the industrial age. Combustion of wastes and fossil fuels are currently the primary anthropogenic (man-made) source of environmental mercury in the U.S. (EPA, 1997).

Concerns about neurodevelopmental effects in humans from low-level mercury exposure have surfaced during the past decade, and safe levels are currently being evaluated (NRC, 2000). Mercury exposure through fish consumption is of special concern since it is the major route for human exposure to methylmercury, the organic form of mercury that is easily absorbed in living tissues (EPA, 2001).

Human health concerns about mercury contamination of Lake Whatcom fish were raised following a 1998 screening-level survey conducted by the Washington State Department of Ecology (Ecology) as a component of the Lake Whatcom Pledge Program (Serdar et al, 1999). In this study, one composite fillet sample of smallmouth bass (*Micropterus dolomieui*) was found to contain mercury at 0.5 µg/g (parts per million, wet weight). The representativeness of this sample result and the fish consumption habits of Lake Whatcom anglers were unknown at the time, and there were concerns that mercury levels in Lake Whatcom could affect human health. There were also concerns that exposure to elevated mercury concentrations could cause fish health problems, possibly affecting the ability of resident fish populations to thrive.

Worries about mercury contamination were amplified by the fact that Lake Whatcom is the sole drinking water source for the city of Bellingham. Approximately 65,000 people depend on the lake for domestic water supply. Although this raises public concern, there is no indication that mercury is a problem in drinking water (City of Bellingham, 1997). Lake Whatcom is also used extensively for sport fishing, swimming, and other forms of water recreation.

To address these concerns, Ecology, Washington Department of Fish and Wildlife (WDFW), Washington State Department of Health (DOH), and Whatcom County Health and Human Services Department conducted the present study – an intensive survey of mercury in fish from Lake Whatcom. The goal of the study is to help determine if consumers of Lake Whatcom fish are at risk from mercury exposure. DOH has conducted a companion survey to begin assessing human consumption of fish caught in Lake Whatcom, to be reported as a separate document. Together these surveys will provide DOH with data to develop a health risk assessment for Lake Whatcom. In addition, WDFW will use data from the present survey to assess the potential impact of mercury on fish health, to be reported separately later in 2001. WDFW is also planning an expanded angler survey for the 2001 fishing season (April to October, 2001).

Objectives

The primary objective of this study was to quantify mercury concentrations in fish and signal crayfish species likely to be caught by anglers in Lake Whatcom. These data will be used to assess human mercury exposure from consumption of Lake Whatcom fish and, hence, the need for actions to protect the public from the adverse effects of mercury. Data will also be used to assess potential threats to the survival of resident fish populations in Lake Whatcom. Archived tissue samples may be further analyzed for additional environmental contaminants, pending availability of supplemental funding

Methods

Sampling Strategy

Locations and Species

Lake Whatcom is a large natural lake located in the northwest corner of Washington State in Whatcom County near the western edge of the Cascade Range foothills (Figure 1). The lake has a surface area of 2,020 hectares (4,992 acres) and a watershed covering 13,052 hectares. With its many bays and inlets, Lake Whatcom's shoreline is approximately 45 km long.

The lake can be morphologically divided into three distinct basins formed by glacial sills. The northernmost Basins 1 and 2 are relatively small and shallow (<25 meters) whereas Basin 3, with a maximum depth of 100 m, contains 96 percent of the lake volume. Basin 1 is currently the most densely urbanized portion of the watershed, lying largely within Bellingham city limits. Basins 2 and 3 lie mainly within the jurisdiction of Whatcom County and comprise 94 percent of the watershed area. Due to the distinctiveness of each basin and the possibility that certain species of fish remain resident within a specific basin, fish from each basin were considered separate population units.

Six species of Lake Whatcom finfish as well as signal crayfish are potentially consumed by humans. These species, along with the number of individuals analyzed, are listed in Table 1.

Table 1. Samples analyzed for 2000 survey of mercury in edible muscle of Lake Whatcom fish.

Species	Individual Specimens per Basin[a] 1	2	3	Target Lengths (mm)	Range of Specimen Lengths (mm)
Yellow perch (*Perca flavescens*)	10	10	10	>152 (6")	154 – 333
Brown bullhead (*Ameiurus nebulosus*)	10	0	3	>152 (6")	186 – 356
Pumpkinseed (*Lepomis gibbosus*)	10	10	10	>76 (3")	96 – 195
Cutthroat trout (*Oncorhynchus clarki*)	10	10	10	>305 (12")	173 – 339[b]
Kokanee (*Oncorhynchus nerka*)	10	10	10	>178 (7")	189 – 240
Signal crayfish (*Pacifastacus leniusculus*)	15	15	15	>83 (3-1/4 ")	83 – 137
Smallmouth bass (*Micropterus dolomieu*)					
small (10"-12") size class	10	11	10	254 – 305 (10"-12")	249 – 325[c]
medium (12"-14") size class	10	10	10	305 – 356 (12"-14")	313 – 357[c]
large (>14") size class	14	10	10	>356 (14")	363 – 486

[a] Target sample size was 10 per basin except crayfish (15 per basin).
[b] Only 4 of 30 specimens met target length.
[c] Some specimens slightly outside target length range in order to meet target sample size (10 per basin).

During 1983 and 1984, smallmouth bass were introduced into Lake Whatcom to provide a warmwater sport fishery (Mueller et al, 1999). This species has thrived due to the favorable forage base and habitat, and Lake Whatcom has since become a trophy fishery for smallmouth bass. Three size classes of smallmouth bass were targeted for sampling due to the expectation that mercury concentrations would vary by length.

For other species, only those fish measuring greater than stock- or quality-length were targeted. Stock- and quality-lengths are nationally accepted standard length categories based on percentages of certified world-record lengths. Stock-length (20-26% of world-record length) refers to the minimum size fish with recreational value, whereas quality-length (36-41% of world-record length) refers to the minimum size fish most anglers like to catch (Gabelhouse, 1984; Anderson and Neumann, 1996). The selective criteria for the minimum lengths of fish sampled are also based on the population characteristics for each species from Lake Whatcom (Mueller et al, 1999).

Signal crayfish were retained according to Washington Administrative Code (WAC) 220-52-060, which states "the minimum commercial crayfish size is 3 ¼ inches [83 mm] in length from the tip of the rostrum (nose) to the tip of the tail and…all female crayfish with eggs or young attached to the abdomen must be immediately returned unharmed." Biological data for all specimens are in Appendix A.

Sample Size

Fish were analyzed individually to obtain estimates of mercury concentration variance for each species and size class from each location. Based on published mean and standard deviation values for mercury in fish tissue, it was determined that ten specimens from each sub-population of fish would be needed to provide 95% confidence intervals about the mean that were no more than ± 20-30% of the mean. The DOH Office of Environmental Health Assessments considered this sample size necessary to generate useful tissue concentration estimates which can be used with consumption data for a health risk assessment (White and Delahunt, written communication).

Aside from brown bullhead, the target sample sizes were met for each species in each of the three basins (Table 1). No brown bullhead were found at the target length (>152 mm) in Basin 2, and only three specimens were obtained in Basin 3. Large cutthroat trout were especially difficult to find, with only four of 30 specimens meeting the target length (>305 mm). Target lengths were met for other species. Target sample sizes for signal crayfish were increased to 15 per basin in order to analyze five individuals from three discrete locations within each basin. Relative to finfish species, signal crayfish are less motile and more closely associated with sediments, a potential sink for mercury in Lake Whatcom. Although not an explicit objective of this study, signal crayfish data could provide clues about the geographical distribution of mercury in Lake Whatcom.

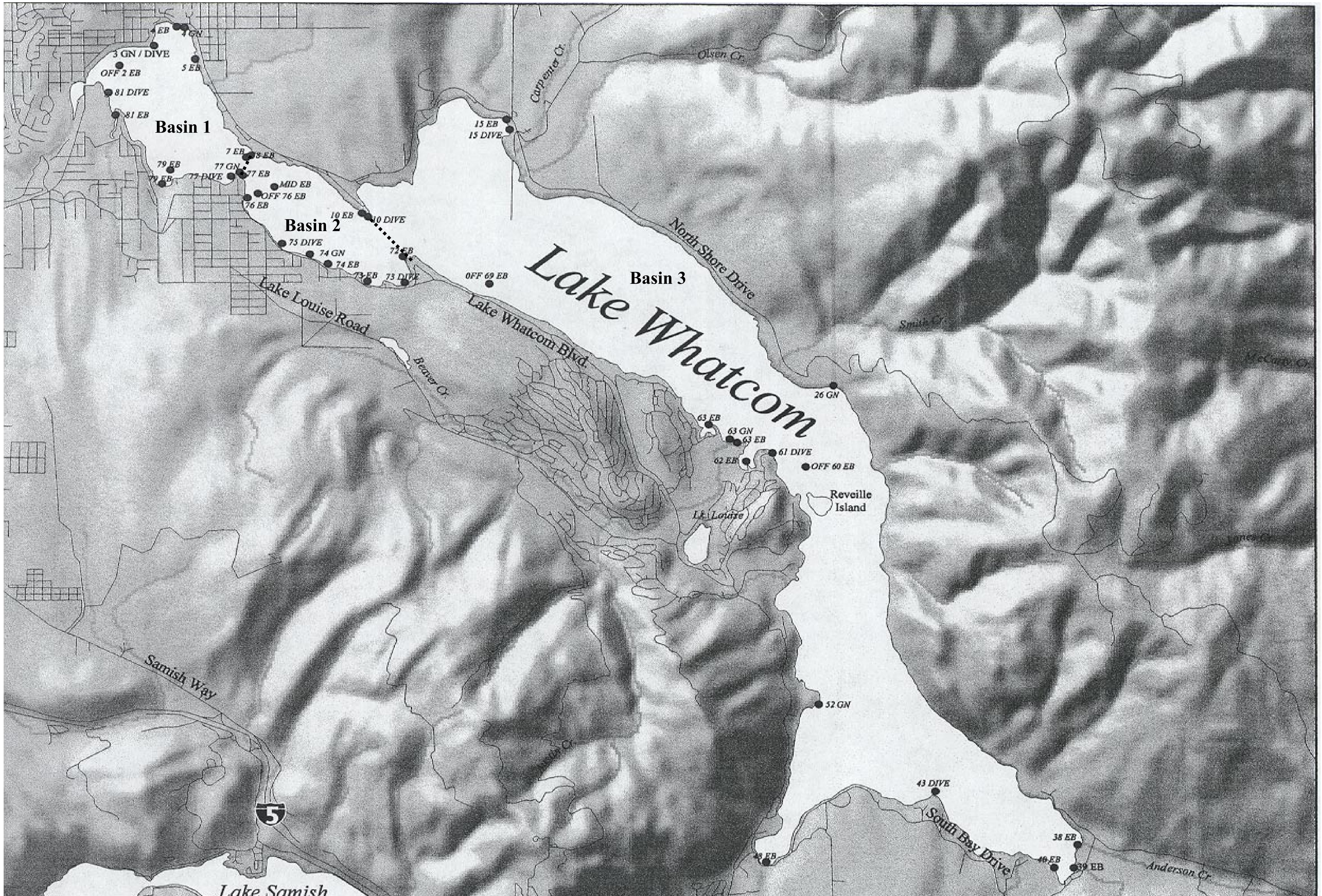

Figure 1.
Fish Sampling Locations for the 2000 Study of Mercury in Lake Whatcom Fish.

N

4000 ft

Legend:
EB=Electrofishing boat
GN=Gill net
DIVE=SCUBA diving
MID=Middle of basin
OFF=Offshore

Map provided
by
Whatcom County

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Sample Collection and Timing

Lake Whatcom fish were collected by two WDFW biologists and one scientific technician during May 15 – June 2, 2000. Fish collection data are in Appendix A. Fish and signal crayfish were captured using three sampling techniques: electrofishing, gill netting, and diving. The electrofishing unit consisted of a 4.9-m Smith-Root 5.0 GPP ‘shock boat’ set to 120 Hz and 6 amps pulsed DC. The experimental gill nets (45.7 m long × 2.4 m deep) are constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable-size (13, 19, 25, and 51 mm stretched) monofilament mesh. Divers used standard, open-circuit scuba and stayed within decompression limits derived from U.S. Navy dive tables.

Sample timing was selected to maximize the type and number of fish captured. Except for yellow perch and cutthroat trout, most fish were collected while electrofishing. Sampling occurred during evening hours to take advantage of the cover of darkness as well as the foraging habits of the target species. Gill nets were set overnight with the small-mesh end attached onshore while the large-mesh end was anchored offshore perpendicular to the shoreline. Signal crayfish were collected by daylight diving in known crayfish habitat previously verified by WDFW divers (Downen, 1999; unpublished WDFW data)

All fish captured were identified to the species level then measured and weighed to the nearest 1-mm and 1-g. Except for brown bullhead and signal crayfish, several scales were removed from each fish for aging purposes. Scale samples were mounted, pressed, and the fish aged by WDFW according to Jearld (1983) and Fletcher et al. (1993).

Samples were double-wrapped in aluminum foil (dull side in), labeled and placed in large plastic or zip-lock bags. Unique sample identification numbers were included with each sample and recorded in a field log. Wrapped samples were stored in ice-filled coolers until being transferred to a secure freezer for temporary storage or for direct transfer to Ecology headquarters for sample preparation. Chain-of-custody tags were affixed to sample coolers to ensure sample integrity.

Sample Preparation

Once at Ecology headquarters, fish were stored frozen at -20 °C. Fillet resection was performed by removing foil from the frozen specimen, scaling the fish using a stainless steel fillet knife, then removing the skin-on fillet with a stainless fillet knife or stainless scalpel. Only the fillet on the right side of the fish was used unless both sides were needed to provide adequate material for analysis. Care was taken to avoid carving into or otherwise puncturing internal organs. Skin was removed from bullhead specimens prior to fillet resection. Signal crayfish tail muscle was extracted for analysis.

Tissue was homogenized with three passes through a Kitchen-Aid® food processor or non-contaminating hand-held grinder. Ground tissue was thoroughly mixed following each pass through the grinder. All equipment used for tissue preparation was vigorously washed with

Liquinox® detergent, rinsed in hot tap water, 10% Baker Instra-Analyzed® nitric acid/deionized water solution, deionized water, and acetone. This decontamination procedure was repeated between the processing of each sample. When adequate quantities were available, fully homogenized tissue from each specimen was split between two 4-oz. glass jars; one cleaned for metals per USEPA Office of Solid Waste and Emergency Response Directive #9240.0-05, the other with a Teflon lid liner and certificate for trace organics analysis (I-CHEM® series 300 or equivalent). Samples were stored at -20 °C until analysis. Samples for future organics analysis are being archived at Ecology headquarters for at least one year.

Analytical Methods and Data Quality

Tissues were analyzed for mercury at Manchester Environmental Laboratory using cold vapor atomic absorption EPA Method 245.5 (EPA, 1986). Method detection limits were 0.005 – 0.01 µg/g (wet weight).

Precision and bias were assessed through analysis of matrix spikes, matrix spike duplicates, and replicate analyses of 5% of samples (Appendix B). On average, 84% of spiked mercury was recovered from samples. Laboratory precision was very high, with a 9% average relative percent difference (RPD, a measure of the range about the mean) between matrix spike duplicates. Laboratory triplicate analyses also showed a high level of precision (average relative standard deviation of 8%) suggesting that sample preparation methods yielded homogenous samples. Sample condition, instrument calibration, procedural blanks, and analysis of laboratory control samples were reviewed and deemed acceptable by chemists at the Manchester Laboratory.

Only 23% of samples were analyzed within the 28-day holding time recommended by EPA (1995) and the Puget Sound Estuary Program (PSEP, 1996). Holding times ranged from 14 to 82 days, with a median period from collection to analysis of 41 days. However, the EPA and PSEP holding times are based on the potentially volatile nature of mercury in (unfrozen) water samples and do not pertain to frozen tissue. In their discussion of holding times for mercury in fish tissue, PSEP cites an unpublished WDFW study in which frozen tissue was analyzed six times ranging from four to 86 days without a significant change in mercury concentrations (PSEP, 1996).

To assess any possible differences between skin-on and skin-off fillets, eight specimens (5 bass, 2 cutthroat, and 1 kokanee) were prepared with the skin remaining on the right side fillet while the left side had the skin removed. Analysis of these pairs showed higher mercury concentrations in six of the eight skin-off samples. On average, skin-off samples were 5% higher than skin-on samples, although concentrations in paired samples of cutthroat trout and kokanee were identical or near so. Results suggest that skin probably contains little mercury and dilutes the samples when homogenized with muscle, resulting in slightly reduced mercury concentrations.

Results

Table 2 summarizes mercury concentrations in fish from Lake Whatcom. Smallmouth bass had the highest mean concentrations, ranging from 0.20 µg/g in the Basin 1 small size class (10"- 12") group to 0.86 µg/g in the large size class (>14") from Basin 3. Concentrations were higher in tissues from the larger size class regardless of the basin.

Yellow perch had mean concentrations of 0.12 – 0.29 µg/g, the second highest mercury concentrations among the six finfish species. Kokanee and pumpkinseed had similar concentrations on average, slightly above 0.1 µg/g except for the pumpkinseed samples from Basin 2 (0.07 µg/g). Cutthroat trout appear to have the least tendency to accumulate mercury in muscle tissue, with mean concentrations of 0.06 – 0.08 µg/g.

Brown bullhead from Basin 1 also had a low mean mercury concentration (0.07 µg/g) with concentrations of the ten samples not exceeding 0.12 µg/g. Bullhead could not be obtained from Basin 2 and only three samples were available from Basin 3. Initial inspection of the results suggests that specimens from Basin 3 accumulate much more mercury than those from Basin 1 (0.44 vs. 0.07 µg/g). However, Basin 3 brown bullhead were approximately 30% larger than Basin 1 specimens which may account for the higher concentrations in the Basin 3 samples.

Signal crayfish generally had mercury concentrations between 0.05 µg/g and 0.2 µg/g, although two specimens from Basin 2 and Basin 3 had concentrations of 0.54 µg/g and 0.46 µg/g, respectively. These extreme values resulted in elevated means and standard deviations compared to Basin 1, where mercury concentrations were consistently low.

Results appear to confirm data from the 1998 Lake Whatcom screening survey (Serdar et al, 1999) which found 0.14 µg/g in one composite sample of "small" smallmouth bass from Basin 1 compared to a mean of 0.20 µg/g for the present survey. Kokanee concentrations were even closer between the two surveys: 0.11 µg/g vs. 0.13 µg/g in Basin 3 kokanee from the 1998 and 2000 surveys, respectively. However, Basin 3 smallmouth bass were much higher in the 2000 survey (mean of 0.86 µg/g) compared to the composite sample analyzed in 1998 (0.50 µg/g), even though collection sites and average lengths of the fish were similar. These differences are not necessarily indicative of an increasing trend in fish tissue mercury concentrations. They are more likely an expression of variability in tissue concentrations, as demonstrated by the fact that the 1998 results fall well within the ranges of the present survey. Another possible explanation is that seasonal differences account for at least some of the variation. Fish muscle may contain higher mercury concentrations in spring than fall due to increased microbial production of methylmercury, higher protein content of muscle tissues, increased springtime feeding rates, or increased spring runoff (Ward and Neumann, 1999).

In Washington State, freshwater fish typically have mercury concentrations low by nearly any standard. The statewide median concentration in edible muscle tissue is approximately 0.07 µg/g (Figures 2-4). This value is based on results from Ecology screening surveys (Hopkins et al, 1985; Hopkins, 1991; Johnson and Norton, 1990; Serdar et al, 1994) and estimates a

Table 2. Mercury concentrations in edible muscle of Lake Whatcom fish collected and analyzed during 2000 (mean ± s.d., min.-max. values in parentheses).

Basin	Species	n	Total Length (mm)		Age (yrs)		Hg Conc. (μg/g, ww)	
1	Smallmouth bass[a]	10	281 ± 25	(249-325)	4 ± 1	(3-6)	0.20 ± 0.07	(0.10-0.29)
2	"	11	274 ± 20	(249-305)	3 ± 1	(3-5)	0.23 ± 0.12	(0.11-0.46)
3	"	10	276 ± 15	(255-300)	3 ± 1	(3-5)	0.32 ± 0.09	(0.22-0.45)
1	Smallmouth bass[b]	10	351 ± 6	(337-357)	5 ± 1	(5-6)	0.45 ± 0.18	(0.24-0.88)
2	"	10	338 ± 15	(318-353)	5 ± 0	(5)	0.36 ± 0.14	(0.25-0.69)
3	"	10	338 ± 14	(313-354)	5 ± 1	(5-6)	0.55 ± 0.20	(0.25-0.92)
1	Smallmouth bass[c]	14	412 ± 38	(370-486)	7 ± 2	(5-10)	0.72 ± 0.40	(0.26-1.84)
2	"	10	390 ± 26	(363-440)	7 ± 1	(5-8)	0.61 ± 0.23	(0.28-1.05)
3	"	10	408 ± 37	(365-468)	7 ± 2	(5-9)	0.86 ± 0.31	(0.29-1.30)
1	Yellow perch	10	191 ± 32	(154-257)	3 ± 1	(2-6)	0.12 ± 0.07	(0.05-0.31)
2	"	10	227 ± 60	(165-333)	4 ± 2	(2-8)	0.17 ± 0.11	(0.07-0.37)
3	"	10	220 ± 56	(157-320)	4 ± 2	(2-7)	0.29 ± 0.26	(0.08-0.87)
1	Kokanee	10	220 ± 14	(195-240)	3 ± 1	(2-4)	0.12 ± 0.05	(0.09-0.25)
2	"	10	201 ± 9	(189-215)	3 ± 1	(2-4)	0.10 ± 0.02	(0.07-0.12)
3	"	10	206 ± 9	(194-222)	3 ± 1	(2-4)	0.13 ± 0.04	(0.07-0.18)
1	Pumpkinseed	10	145 ± 11	(132-166)	4 ± 1	(3-6)	0.11 ± 0.06	(0.05-0.23)
2	"	10	131 ± 20	(96-152)	4 ± 1	(2-6)	0.07 ± 0.02	(0.04-0.09)
3	"	10	141 ± 25	(99-185)	3 ± 1	(2-6)	0.12 ± 0.08	(0.03-0.28)
1	Cutthroat trout	10	190 ± 30	(173-274)	1 ± 1	(1-2)	0.06 ± 0.01	(0.03-0.07)
2	"	10	255 ± 52	(191-339)	2 ± 1	(2-3)	0.07 ± 0.03	(0.03-0.12)
3	"	10	240 ± 54	(184-326)	2 ± 0	(2)	0.08 ± 0.05	(0.03-0.20)
1	Brown bullhead	10	251 ± 27	(186-288)	na		0.07 ± 0.03	(0.03-0.12)
3	"	3	322 ± 42	(275-356)	na		0.44 ± 0.32	(0.14-0.78)
1	Signal crayfish	15	96 ± 11	(83-114)	na		0.06 ± 0.04	(0.03-0.18)
2	"	15	99 ± 17	(85-137)	na		0.12 ± 0.13	(0.04-0.54)
3	"	15	102 ± 12	(83-125)	na		0.13 ± 0.10	(0.04-0.46)

[a] 10"-12" size class
[b] 12"-14" size class
[c] >14" size class
na= not analyzed

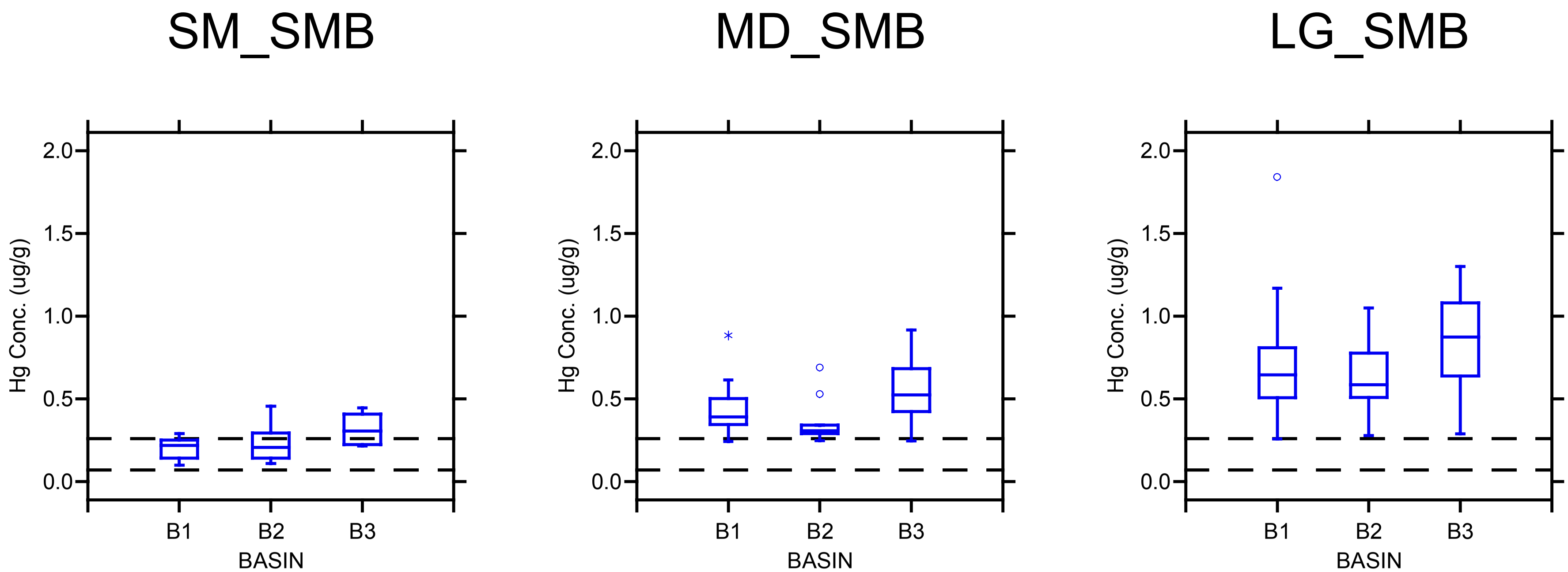

Figure 2. Box and whisker plots of mercury concentrations in three size classes of smallmouth bass from Lake Whatcom (n=10 per basin except small size class from Basin 2 [n=11] and the large size class from Basin 1 [n=14]). Upper dashed line represents median from EPA national study (n=219) and lower dashed line represents median from Ecology statewide data (n=23).

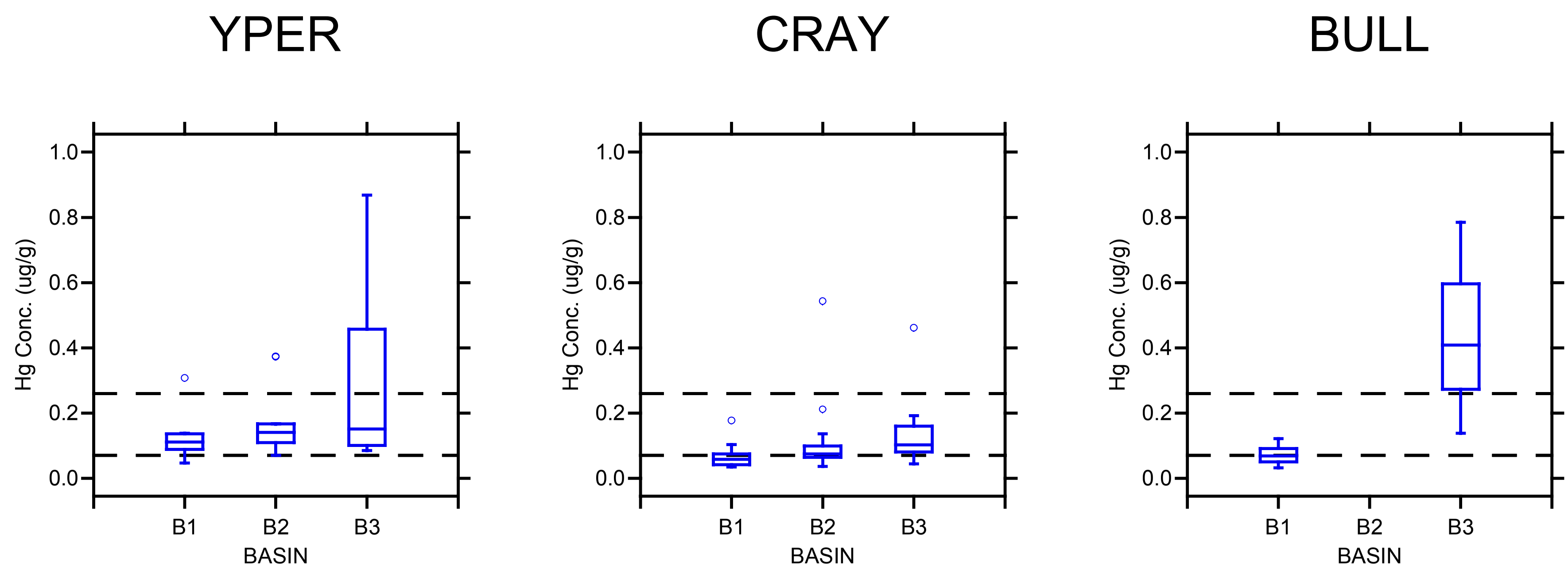

Figure 3. Box and whisker plots of mercury concentrations in yellow perch (n=10 per basin), signal crayfish (n=15 per basin), and brown bullhead (n=10 in Basin 1, n=3 in Basin 3) from Lake Whatcom. Upper dashed line represents median from EPA national study (n=219) and lower dashed line represents median from Ecology statewide data (n=23).

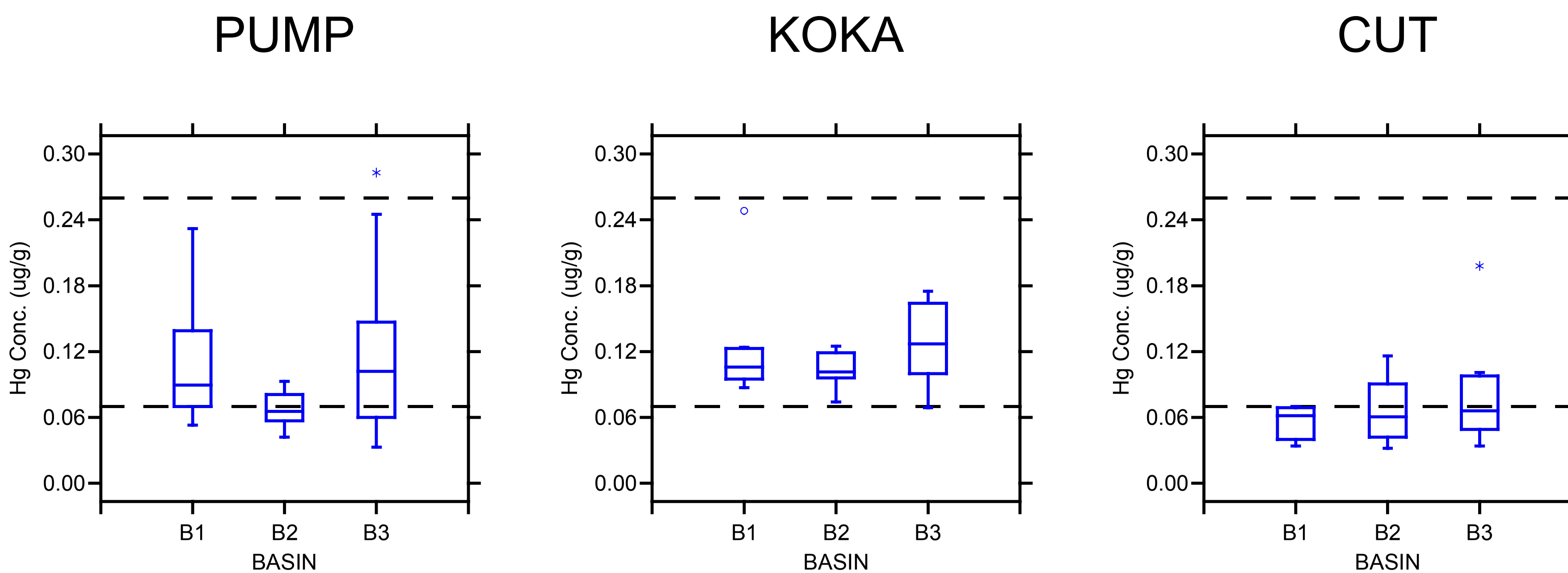

Figure 4. Box and whisker plots of mercury concentrations in kokanee, pumpkinseed, and cutthroat trout from Lake Whatcom (n=10 per basin). Upper dashed line represents median from EPA national study (n=219) and lower dashed line represents median from Ecology statewide data (n=23).

representative cross-section of lakes and rivers in the state, although the number of samples is low (n=23). Concentrations ranged from 0.02 – 0.54 µg/g, with almost half the samples composed of largemouth bass (*Micropterus salmoides*).

Elsewhere in Washington, Lake Roosevelt is the only fresh waterbody where a meaningful data set on mercury in fish tissue was previously available. Lake Roosevelt has mercury contamination associated primarily with a large lead-zinc smelter located upstream on the Columbia River in British Columbia. Forty-five walleye (*Stizostedion vitreum*) fillets analyzed over a nine-year period had a mean concentration of 0.28 µg/g with a range of 0.11 – 0.44 µg/g (Johnson et al, 1988; Munn and Short, 1997). Other species from Lake Roosevelt (lake whitefish, white sturgeon, yellow perch, rainbow trout) generally had lower concentrations.

Nationally, the median mercury concentration in fish fillets is 0.26 µg/g, nearly four times the typical concentration in Washington State. The national median value is derived from an EPA survey conducted during the late-1980s in which fish were analyzed from a variety of freshwater areas including sites influenced by industrial discharges, urban point and non-point pollution, agricultural run-off, and background sites (EPA, 1992). Mercury concentrations in smallmouth bass of the small size class from Lake Whatcom Basins 1 and 2 fell within Washington State and U.S. national medians, while those from Basin 3 along with all of the medium and large size class smallmouth had mercury levels at or above the national median (Figure 2). Aside from smallmouth bass, most Lake Whatcom fish had mercury levels between state and national medians while some species – cutthroat trout and signal crayfish – had median concentrations closer to statewide concentrations (Figures 3 and 4).

Length and age have been shown to be important factors determining mercury concentrations in fish (Lathrop et al, 1991; Stafford and Haines, 1997). In Lake Whatcom, a strong positive relationship exists between both age and length of smallmouth bass and concentrations of mercury in muscle (Table 3). This relationship also holds true for yellow perch from Basins 2 and 3, but not for age-dependency in Basin 1 samples. For other species, neither length or age appears tied to mercury levels, except for Basin 2 signal crayfish which showed mercury concentrations dependent on length.

The largest and oldest bass specimens generally had high mercury concentrations. Mercury levels in these fish were in the top quartile of all smallmouth bass samples (Figure 5), yet high mercury concentrations are not necessarily certain in fish that are both large (>430 mm) and old (>8 yrs). The largest bass, a 486-mm specimen from Basin 1, had a concentration of 0.68 µg/g; less than the mean concentration in the Basin 1 large size class. Inversely, two samples of moderate age and size (both 5 yrs, 352 mm; one each from Basins 1 and 3) had concentrations in the top 10% of samples, or about 0.9 µg/g.

Mean mercury concentrations were higher in samples from Basin 3 compared to Basins 1 and 2. This finding was consistent for all species analyzed and the three size classes examined for smallmouth bass. Median concentrations were also highest from Basin 3 (Figures 2-4), indicating that outlier values alone are not responsible for influencing average concentrations since medians are unaffected by outlier data. For instance, maximum individual concentrations in "large" smallmouth bass and kokanee were from Basin 1. "Small" smallmouth bass and signal crayfish maximums were from Basin 2.

Table 3. Regression equations for the relationships between total length (TL, mm), age (yr), and $\log_{10}$ mercury concentration (µg/g, ww) in Lake Whatcom fish analyzed during 2000.

Basin	Species	n	Regression Equation	r^2	p
1	Smallmouth bass	34	$\log_{10}Hg = 0.004(TL) – 1.829$	0.744	0.000
"	"	33	$\log_{10}Hg = 0.123(Age) – 1.097$	0.637	0.000
2	"	31	$\log_{10}Hg = 0.004(TL) – 1.731$	0.628	0.000
"	"	29	$\log_{10}Hg = 0.150(Age) – 1.233$	0.699	0.000
3	"	30	$\log_{10}Hg = 0.003(TL) – 1.425$	0.702	0.000
"	"	30	$\log_{10}Hg = 0.109(Age) – 0.882$	0.637	0.000
1	Yellow perch	10	$\log_{10}Hg = 0.004(TL) – 1.775$	0.435	0.038
"	"	10	$\log_{10}Hg = –0.059(Age) – 0.766$	0.140	0.288
2	"	10	$\log_{10}Hg = 0.004(TL) – 1.683$	0.935	0.000
"	"	10	$\log_{10}Hg = 0.097(Age) – 1.200$	0.840	0.000
3	"	10	$\log_{10}Hg = 0.006(TL) – 1.978$	0.784	0.001
"	"	10	$\log_{10}Hg = 0.157(Age) – 1.312$	0.873	0.000
1	Kokanee	10	$\log_{10}Hg = –0.001(TL) – 0.727$	0.012	0.760
"	"	10	$\log_{10}Hg = –0.007(Age) – 0.923$	0.002	0.899
2	"	10	$\log_{10}Hg = –0.002 (TL) – 0.505$	0.091	0.397
"	"	10	$\log_{10}Hg = 0.044(Age) – 1.099$	0.184	0.216
3	"	10	$\log_{10}Hg = 0.005(TL) – 1.865$	0.088	0.406
"	"	10	$\log_{10}Hg = 0.095(Age) – 1.194$	0.305	0.098
1	Pumpkinseed	10	$\log_{10}Hg = 0.001(TL) – 1.217$	0.005	0.840
"	"	10	$\log_{10}Hg = 0.025(Age) – 1.106$	0.018	0.709
2	"	10	$\log_{10}Hg = 0.002(TL) – 1.441$	0.155	0.260
"	"	10	$\log_{10}Hg = 0.034(Age) – 1.298$	0.163	0.274
3	"	10	$\log_{10}Hg = 0.006(TL) – 1.789$	0.208	0.185
"	"	10	$\log_{10}Hg = 0.075(Age) – 1.253$	0.105	0.361
1	Cutthroat trout	10	$\log_{10}Hg = 0.001(TL) – 1.540$	0.133	0.300
"	"	7	$\log_{10}Hg = 0.167(Age) – 1.506$	0.498	0.076
2	"	10	$\log_{10}Hg = 0.001(TL) – 1.520$	0.102	0.369
"	"	7	$\log_{10}Hg = 0.033(Age) – 1.312$	0.006	0.870
3	"	10	$\log_{10}Hg = 0.002(TL) – 1.646$	0.221	0.170
"	"	6	nr	nr	nr
1	Signal crayfish	15	$\log_{10}Hg = 0.008(TL) – 2.022$	0.186	0.109
2	"	15	$\log_{10}Hg = 0.010(TL) – 2.045$	0.322	0.028
3	"	15	$\log_{10}Hg = 0.010(TL) – 2.002$	0.209	0.087
1	Brown bullhead	10	$\log_{10}Hg = 0.002(TL) – 1.700$	0.120	0.327
3		3	nr	nr	nr

nr= not reported due to insufficient data. No age data available for signal crayfish or brown bullhead.

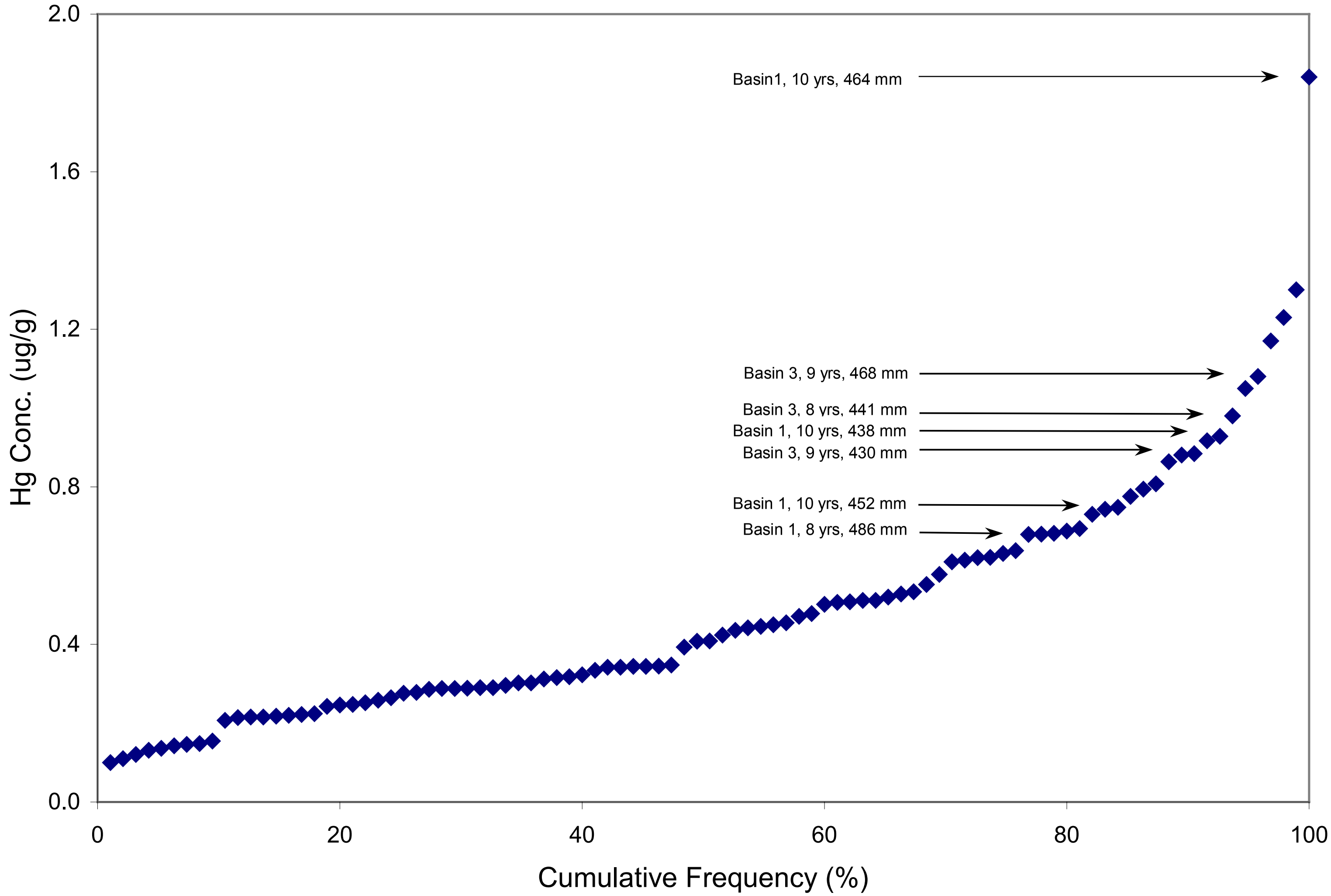

Figure 5. Cumulative frequency distribution of mercury concentrations in Lake Whatcom smallmouth bass with oldest and largest specimens identified.

Although Basin 3 fish had higher average mercury concentrations for all species and size classes tested, average lengths or weights (Appendix A) in Basin 3 were seldom greatest among species/size classes sampled for each basin. Nor did age appear to account for the differences in mercury concentrations among basins. All three bass groups had similar mean ages; Basin 3 yellow perch and kokanee were approximately the same average age as Basins 2 and 1 samples, respectively, and Basin 3 fish had intermediate mean ages compared to other pumpkinseed and cutthroat trout.

Signal crayfish were collected by divers from three discrete locations in each basin (n=5 per station). Figure 6 shows mercury concentrations from individual samples plotted by station along with the median concentration (0.075 µg/g) for all 45 samples. Basin 1 samples (Stations 3, 81, and 77) exceed the median in only three samples. In contrast, only three Basin 3 samples are below the median (Stations 15, 61, and 43), while Basin 2 samples (Stations 75, 10, and 72) are intermediate (seven below and eight above the median).

The stations in Figure 6 are plotted along Lake Whatcom's approximate longitudinal axis; the left side of the axis corresponds to the northwest end, and the right side corresponds to the southeast end of the lake. The pattern of mercury concentrations in signal crayfish reveals an increasing trend from northwest to southeast. Mercury concentrations in smallmouth bass, yellow perch, and kokanee plotted in this manner appear to show an increasing northwest to southeast trend much like the trends in signal crayfish concentrations (Appendix C).

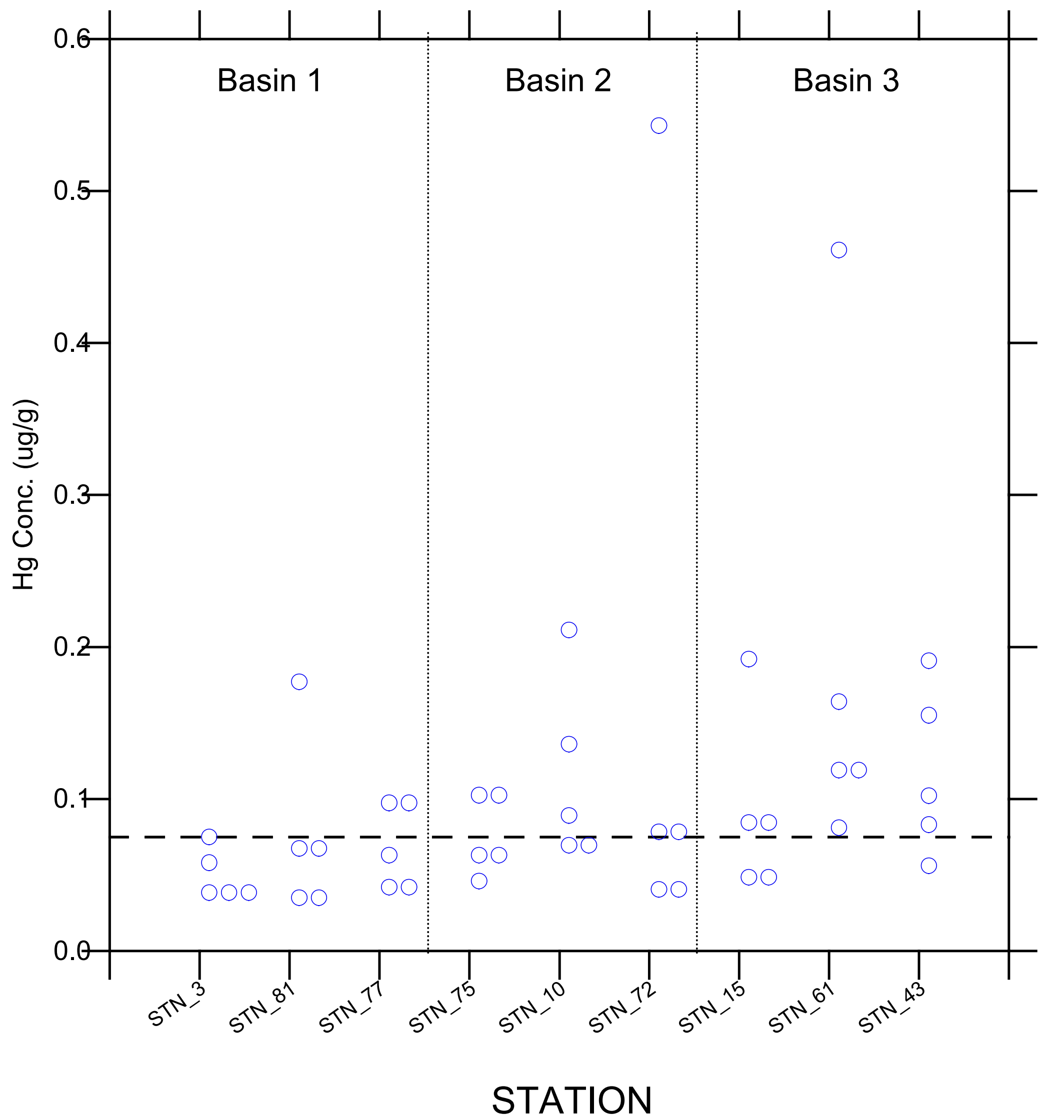

Figure 6. Mercury concentrations in Lake Whatcom signal crayfish plotted by stations (n=5 per station). Dashed line represents median concentration of all (45) samples.

Discussion

Differences Among Species

Results of this survey show high concentrations of mercury in smallmouth bass and in some yellow perch, especially those from Basin 3 of Lake Whatcom. Elevated mercury concentrations in smallmouth bass are primarily due to: 1) their trophic status, i.e. they are top predators among fish species in Lake Whatcom; and 2) their being a long-lived species which increases the duration of their exposure to mercury. Yellow perch had the second highest concentrations among Lake Whatcom species, which is a reflection of their diet. Young perch (1-3 yrs) tend to feed on immature insects (Wydoski and Whitney, 1979) whereas older specimens prey on other fish and small crayfish, and as a result their diet is higher in mercury. Since they grow slower than younger fish, mercury accumulation in older fish may outpace the concentration dilution that occurs as a result of body growth. The result of a diet richer in mercury and a lower growth rate is that older fish like yellow perch from Basins 2 and 3 tend to have stronger relationships between length, age, and mercury concentrations than younger fish such as the Basin 1 yellow perch.

The pattern of relative concentrations is consistent with empirical data demonstrating mercury biomagnification in higher trophic (i.e. predatory) species. EPA (1999) reported that mercury in fillets of U.S. freshwater fish is generally 0.1 – 0.3 µg/g in bottom feeders and 0.2 – 0.7 µg/g in predators. In their investigation of Massachusetts' 24 least-impacted lakes, Rose et al. (1999) found mercury concentrations consistently followed a pattern of largemouth bass > yellow perch > brown bullhead. Size was not found to correlate with mercury concentrations in yellow perch and brown bullhead from the Massachusetts lakes, but was highly correlated with concentrations in the largemouth bass.

In their national study of chemicals in fish, EPA (1992) reported a mean concentration of 0.35 µg/g in 219 composite fillet samples, most of which were top predators (e.g., largemouth bass, smallmouth bass, and walleye). Mean concentrations among the aforementioned top predators and Lake Whatcom smallmouth bass were similar (0.44 µg/g vs. 0.49 µg/g, respectively), as was the frequency of samples having > 1 µg/g (6% of samples). However, smallmouth bass from the EPA survey had a lower mean concentration (0.35 µg/g, n=19), possibly reflecting differences between [unreported] sizes and ages of the EPA specimens and those reported for the present survey. The maximum concentration reported by EPA among all fillet samples was nearly identical to Lake Whatcom (1.77 µg/g vs. 1.84 µg/g, respectively). It is notable that the maximum concentration found in the EPA national survey – a walleye from the Wisconsin River in Rhinelander, Wisconsin – was from a designated background area, even though most survey samples were collected from industrial and urban areas.

The small size and relative immaturity of specimens used for this study (except smallmouth bass) make it difficult to estimate average mercury concentrations in larger, more sought-after specimens. Many of the samples were below desirable size even as they met minimum target lengths based on the stock and quality lengths of species (Mueller et al, 1999). Only 53% of yellow perch, 27% of pumpkinseed, and 0% of the cutthroat trout were ≥ quality length, i.e. minimum lengths preferred by anglers, although there is no minimum size restriction for these species in lakes under the statewide general rules (WDFW, 2000). None of the kokanee analyzed were particularly large, with a maximum specimen length of 240 mm. Kokanee kept by anglers in Lake Whatcom are generally 7 – 9" (178 – 229 mm) similar to the size analyzed here (189 – 240 mm), although size of the fish may vary considerably year-to-year (WDFW, unpublished data). In contrast, Lake Whatcom has developed into a trophy smallmouth bass fishery since their introduction to the lake in 1983.

Differences Among Basins

The scope of the present study does not include investigation of mercury sources or factors responsible for accumulation of mercury in fish. However, the data reveal a distinct geographical pattern; mercury concentrations are highest in all species from Basin 3. This pattern holds true for the high concentrations in smallmouth bass as well as the species that comprise their forage base. Size and age of fish do not appear to account for the differences in mercury among basins.

Numerous factors could account for differences in mercury among Lake Whatcom basins. One possibility is greater exogenous sources of mercury to Basin 3 through tributaries, storm runoff, or aerial deposition. However, few data are available on the many small, generally seasonal streams flowing into Lake Whatcom, and no data have been found on aerial deposition to the lake. Water samples from Austin Creek and stormwater drains from Park Place (Basin 1) and Cable Street (Basin 2) collected during rain events had only moderate mercury concentrations (0.004 – 0.01 µg/L), although mercury loading from Austin Creek was two orders above the other tributaries (Serdar et al, 1999). Tissue mercury concentrations lower than medians for each species/size classes were consistently seen at Station 3 in the vicinity of the Park Place drain (Station 72 was the only other station with consistently low mercury in fish). In contrast, samples from Stations 61, 62, and 63 near the mouth of Austin Creek had mercury concentrations above median concentrations, possibly due to the delivery of higher mercury loads from this tributary.

Station-by-station comparisons indicate that fish in the vicinity of the Anderson Creek mouth – Stations 38, 39, and 40 at the southeastern lobe of Lake Whatcom – also accumulate more mercury than fish in most other areas. Anderson Creek annually receives diversion water from the middle fork of the Nooksack River to help maintain summertime lake levels, but no data are available on mercury in Anderson Creek or in the middle fork of the Nooksack River.

The possibility that aerial deposition is a major route of mercury contamination in Lake Whatcom has not been thoroughly investigated. Mercury deposited on a local scale would be expected to result in similar levels of contamination of the area's lakes. Limited sampling conducted in Samish Lake – located a few miles southwest of Lake Whatcom – found no evidence of mercury contamination in two bottom sediment samples (< 0.20 and <0.16 µg/g, dry) (Johnson and Norton, 1990). However, one composite sample of five Samish Lake largemouth bass ranging in length from 210 – 300 mm had mercury at 0.27 µg/g in edible muscle, comparable to average concentrations in "small" smallmouth bass from Lake Whatcom.

Mercury concentrations in bed sediment are not necessarily correlated with concentrations in fish tissues (Munn et al, 1995; Rose et al, 1999). Data on mercury in Lake Whatcom bed sediments do little to explain differences in fish among the three basins. Western Washington University found low-to-moderate concentrations in sediments throughout the lake (n=10, range 0.08 – 0.21 µg/g, dry) with no clear differences among basins (Matthews, 1999). Serdar et al. (1999) analyzed a single sediment sample from each basin and found elevated concentrations in Basin 1 compared to Basin 2 and Basin 3. The Basin 1 sediment sample had a dry weight mercury concentration of 0.5 µg/g and, other than fish, is the only evidence of significant mercury contamination in the aquatic environment of Lake Whatcom.

Water chemistry may amplify mercury accumulation through increased mercury methylation and increased permeability of biological membranes to mercury. Literature on the subject is teeming with examples of elevated mercury in fish tissues from lakes with no known or indirect anthropogenic source of contamination yet have lake or watershed characteristics that promote accumulation of mercury in fish. For instance, Horwitz et al. (1995) reported that water pH explained much of the geographical variation in fish mercury concentrations from New Jersey lakes. Hakanson et al. (1988) found that lake water pH, conductivity, and alkalinity all had significant negative correlation with mercury accumulation in northern pike (*Esox lucius*). They developed a model that predicts mercury content in 1-kg pike, based on these water characteristics as well as lake area and mercury concentrations in sediments. Richardson et al. (1995) reviewed data to examine the common view that acid deposition increases uptake of mercury in fish from Ontario lakes and found that increased fish mercury levels could be attributed to lower pH in seepage lakes but not drainage lakes.

Lake morphology, certain watershed characteristics, and biological communities may also influence mercury levels in fish. For instance, dissolved organic carbon is thought to increase terrestrial transport of mercury to lakes (Richardson et al, 1995). The amount of wetlands in a watershed and recent disturbance of terrestrial soils may have an indirect effect on fish mercury through enhanced methylation and transport (Rudd, 1995). Stemberger and Chen (1998) reported that, among other variables, mercury in fish from northeastern U.S. lakes was positively correlated with increased food chain length, presence of trout, and lakes that had large-bodied zooplankton such as *Leptodora*, *Epischura*, and *Skistodiaptomus* species.

In one of the most unusual cases reported in the literature, Gauthier et al. (1997) analyzed fish from twin seepage lakes situated in a caldera of an ancient volcano in central Oregon, far from anthropogenic sources of mercury. Although the lakes appeared to be identical in many respects, total mercury concentrations in water and fish were an order of magnitude higher in one of the lakes. Differences in methylmercury in the water column were two orders of magnitude. The authors suggested that differences may be due to higher sulfate and a larger shoal area (< 10 m deep) in the lake with higher mercury.

Water chemistry in Lake Whatcom has been routinely monitored by Western Washington University and the city of Bellingham (e.g., Rector and Matthews, 1987; Matthews et al, 1997;

ENTRANCO, 1999). Cursory examination of the data does not point towards an obvious reason for elevated mercury concentrations in fish or explain why Basin 3 fish have higher levels. Nor does limited watershed information suggest a high level of mercury input to Lake Whatcom (Serdar et al, 1999). In some respects the available lake chemistry data alone would indicate a slightly greater potential for mercury uptake by fish in Basin 1 due to the higher mercury concentration in sediment detected by Serdar et al. (1999) and depletion of hypolimnetic oxygen reported by Pelletier (1998). However, mercury cycling in the environment is a complex process and additional study will be required to fully understand the reasons for high concentrations in some Lake Whatcom fish, especially those from Basin 3.

Regulatory and Advisory Values to Protect Human Health

Recommendations about human consumption of Lake Whatcom fish are beyond the scope of this report and are generally the purview of the Washington State Department of Health (DOH), currently preparing a companion report to address this issue. The following discussion serves to provide the reader with regulatory and advisory levels used by government agencies to protect human health. It should be noted that these values tend to vary, as a reflection of the different agency mandates and their approaches to deriving these numbers.

There is currently not a statewide mercury level in edible fish tissue used to trigger consumption advisories in Washington State. Instead, DOH makes the decision about the need for an advisory on a case-by-case basis. Information used to develop health risk assessments typically include contaminant levels in fish tissue, identification of the population(s) at risk, fish consumption rates, and a TDI (tolerable daily intake) or RfD (reference dose) that is unlikely to result in adverse health effects. Their case-by-case approach to health assessment has precluded DOH from declaring a specific tissue concentration that would trigger an advisory. Historically, DOH has used EPA's mercury RfD of 0.1 µg/kg body weight/day as a basis for assessing the need for an advisory due to mercury in fish (e.g., USGS, 1997). On the federal level, the Food and Drug Administration uses a fish tissue concentration action level of 1 µg/g for removing fish from the marketplace due to mercury contamination (FDA, 1985).

Recent concerns about environmental mercury and renewed concerns about the health risks associated with mercury have led government agencies to re-examine TDIs or RfDs used to calculate regulatory or advisory levels (NRC, 2000). DOH has recently derived a TDI they will use to evaluate fish tissue mercury concentrations and determine the need for consumption advisories.

EPA has recently derived an updated water quality criterion for mercury to protect human health (EPA, 2001). The new criterion is a fish tissue residue concentration of 0.3 µg [methylmercury]/g, and since nearly 100% of the mercury in fish tissue is methylated (EPA, 2001), the new criterion is essentially 0.3 µg [total mercury]/g. However, EPA has not revised the mercury criterion in the National Toxics Rule (NTR; 40 CFR 131.36) which is used as the default standard for states – including Washington – that have not developed their own human health-based water quality standards for toxics. Ecology therefore uses the existing NTR criterion for mercury in fish tissue (0.825 µg/g) as a human health regulatory standard. In Lake Whatcom, 12 smallmouth bass samples and one yellow perch exceeded the NTR criterion.

Summary and Conclusions

This study analyzed total mercury concentrations in fillet tissue from 273 Lake Whatcom finfish and signal crayfish. Finfish species included yellow perch, kokanee, pumpkinseed, cutthroat trout, brown bullhead, and three size classes of smallmouth bass. The sampling was designed to identify concentration differences among the three major basins of the lake.

Results showed that smallmouth bass had the highest mercury concentrations among species analyzed. The overall mean concentration in smallmouth bass was 0.49 µg/g, with a significant dependence on length and age. There was generally no such relationship between mercury concentration and length or age in other species except larger yellow perch from Basins 2 and 3 and signal crayfish from Basin 2. These findings are consistent with other studies showing a high degree of magnification in the uppermost trophic level of the aquatic food chain. Mean mercury concentrations in other species were as follows: yellow perch – 0.20 µg/g; brown bullhead – 0.16 µg/g; kokanee – 0.12 µg/g; pumpkinseed – 0.10 µg/g; signal crayfish – 0.10 µg/g; and cutthroat trout – 0.07 µg/g.

Fish from Basin 3, the largest yet least developed of the three basins, consistently had the highest mercury concentrations regardless of species, length, or age. However, there is no known apparent reason to expect elevated mercury concentrations in Basin 3 compared to Basin 1 or Basin 2. Nor are there apparent reasons for elevated mercury concentrations in Lake Whatcom as a whole, such as a defined mercury source to the lake. It is possible that certain characteristics of Lake Whatcom or its watershed amplify the uptake and accumulation of mercury by fish. Literature on the subject suggests it may not be unusual to find high concentrations in fish from lakes with limited exogenous mercury sources.

Median mercury concentrations for most species fell between medians for Washington State (0.07 µg/g) and the U.S. (0.26 µg/g). Average mercury concentrations for smallmouth bass were similar to those reported for top predators in a national survey. However, one perch and 12 bass samples had mercury concentrations above the National Toxics Rule human health criterion of 0.825 µg/g, and six of the bass exceeded the FDA Action Level of 1.0 µg/g.

Recommendations

Results of this study clearly indicate at least one species of Lake Whatcom fish contains high mercury concentrations. However, little is understood about the source of mercury or why smallmouth bass are accumulating high levels. It is therefore recommended that reasons for high mercury levels in fish be investigated. Source investigations should be conducted initially since any significant inputs to Lake Whatcom should be controlled immediately. If no significant sources of mercury can be found, then investigators should focus on the possibility that internal factors are promoting enhanced mercury uptake by fish. A review of existing data on water chemistry and limnological conditions (e.g., stratification, trophic status) may be a good place to begin.

Some samples were found to exceed the National Toxics Rule human health criterion for mercury in edible fish tissue (0.825 µg/g). Lake Whatcom should therefore be included on the Section 303(d) list for mercury. The listing will require Ecology to examine the reasons for the high rate of mercury accumulation by fish and may require a Total Maximum Daily Load (TMDL) assessment if deemed necessary.

There is currently no program to routinely monitor mercury in fish from Washington lakes. Mercury was detected in Lake Whatcom fish by chance during a screening investigation. This raises questions about the possibility that fish from other un-monitored lakes could contain significant mercury levels, even in cases where exogenous mercury sources are minimal or not evident. It is therefore recommended that a statewide monitoring program be implemented to monitor mercury in fish from Washington lakes. Lakes could be categorized and prioritized for monitoring based on their proximity to potential mercury sources and lake/watershed characteristics (e.g., water pH, trophic status, presence of piscivorous species), or by fishing pressure and trophic level of the dominantly caught fish species.

No recommendations are made regarding potential health risks to consumers of Lake Whatcom fish. The Washington State Department of Health is currently using the data from this study for a human health assessment.

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Appendices

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Appendix A

Station Locations, Biological Data, and Mercury Concentrations in Fish

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Table A-1. Station Locations for 2000 Study of Mercury in Lake Whatcom Fish.

GPS File No.	Basin	Station No.	Fish Collection Method	Latitude (48 deg -)	Longitude (122 deg -)
R061316B	1	81	DIVE	45'37.70711"N	25'01.72267"W
R061316C	1	81	EB	45'28.57025"N	24'57.95780"W
R061316D	1	OFF 2	EB	45'48.60400"N	24'55.48290"W
R061316E	1	3	GN	45'56.64109"N	24'36.44970"W
R061316E	1	3	DIVE	45'56.64109"N	24'36.44970"W
R061316F	1	4	GN	46'04.17035"N	24'19.57742"W
R061316G	1	4	EB	46'04.51481"N	24'23.86873"W
R061317A	1	5	EB	45'51.09808"N	24'13.90429"W
R061317B	1	77	DIVE	45'03.42288"N	23'54.42288"W
R061317C	1	79	EB	45'06.07334"N	24'28.19845"W
R061317D	1	79	EB	45'00.32470"N	24'32.87194"W
R061317E	2	77	GN	45'05.12692"N	23'50.09792"W
R061317F	2	77	EB	45'03.79953"N	23'48.32331"W
R061317G	2	OFF 76	EB	44'56.24019"N	23'40.20510"W
R061317H	2	MID	EB	44'58.99280"N	23'31.02266"W
R061317I	2	7	EB	45'11.23809"N	23'46.34771"W
R061317J	2	8	EB	45'12.03272"N	23'43.80422"W
R061317K	2	76	EB	44'54.41716"N	23'45.98030"W
R061318A	2	75	DIVE	44'35.67666"N	23'26.98674"W
R061318B	2	74	GN	44'31.24823"N	23'11.92909"W
R061318C	2	74	EB	44'27.33449"N	23'01.94590"W
R061318D	2	73	EB	44'20.21222"N	22'40.29146"W
R061318E	2	73	DIVE	44'19.57729"N	22'19.76061"W
R061318F	2	72	EB	44'30.31486"N	22'20.48447"W
R061318G	2	10	DIVE	44'46.66303"N	22'39.48498"W
R061318H	2	10	EB	44'48.11450"N	22'42.85529"W
R061318I	3	OFF 69	EB	44'18.92789"N	21'33.35926"W
R061318J	3	63	EB	43'21.26387"N	19'32.35742"W
R061318K	3	63	GN	43'15.32527"N	19'20.66560"W
R061318L	3	63	EB	43'13.89075"N	19'16.65465"W
R061318M	3	62	EB	43'06.23684"N	19'11.69153"W
R061318Q	3	61	DIVE	43'09.64887"N	18'56.94633"W
R061319A	3	OFF 60	EB	43'03.95781"N	18'38.55438"W
R061319B	3	52	GN	41'26.08860"N	18'32.90201"W
R061319C	3	48	EB	40'22.08103"N	19'03.09871"W
R061319D	3	43	DIVE	40'50.56752"N	17'27.89240"W
R061319E	3	40	EB	40'19.27884"N	16'22.51727"W
R061319F	3	39	EB	40'19.08127"N	16'11.76152"W
R061319G	3	38	EB	40'28.49029"N	16'09.45702"W
R061319H	3	26	GN	43'36.95561"N	18'22.52337"W
R061320A	3	15	DIVE	45'22.22506"N	21'21.15489"W
R061320B	3	15	EB	45'26.37915"N	21'22.76856"W

EB = Electrofishing boat
GN = Gill net
DIVE = SCUBA diving
MID = Middle of basin
OFF = Offshore of

Table A-2. Size, Age, and Mercury Concentrations in Lake Whatcom Small Size-Class Smallmouth Bass.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/15/00	4	EB	248697	249	187	60	3	0.143	--
5/17/00	81	EB	248706	254	222	53	3	0.155	--
5/16/00	5	EB	248724	255	218	71	4	0.100	--
5/16/00	81	EB	248718	272	268	85	3	0.121	--
5/17/00	81	EB	238692	275	281	84	3	0.252	--
5/25/00	81	EB	258748	287	343	102	4	0.290	--
5/15/00	5	EB	238657	295	338	100	5	0.216	--
5/22/00	79	EB	258753	298	295	74	4	0.220	--
5/15/00	4	EB	248711	302	377	114	5	0.222	--
5/16/00	4	GN	218633	325	492	146	6	0.288	--
			mean=	**281**	**302**	**89**	**4**	**0.201**	
			median=	**281**	**288**	**85**	**4**	**0.218**	
BASIN 2									
5/16/00	77	EB	268781	249	205	68	3	0.148	--
5/18/00	74	EB	268788	251	224	79	3	0.136	--
5/19/00	7	EB	258774	254	238	69	3	0.110	--
5/23/00	72	EB	238665	262	234	61	na	0.286	--
5/24/00	72	EB	268786	262	227	75	3	0.207	--
5/24/00	73	EB	268783	273	290	85	5	0.455	--
5/16/00	10	EB	258751	286	283	89	4	0.409	--
5/16/00	7	EB	238691	288	283	86	4	0.131	--
5/24/00	77	EB	248733	290	336	108	4	0.146	--
5/23/00	74	EB	268792	296	342	118	4	0.302	--
5/22/00	77	EB	238645	305	460	158	4	0.214	--
			mean=	**274**	**284**	**91**	**4**	**0.231**	
			median=	**273**	**283**	**85**	**4**	**0.207**	
BASIN 3									
5/15/00	38	EB	268785	255	248	80	3	0.289	--
5/15/00	62	EB	258746	255	206	59	3	0.265	--
5/17/00	62	EB	258745	265	231	68	3	0.216	--
5/15/00	15	EB	268787	267	235	67	4	0.218	--
5/23/00	62	EB	268782	280	291	98	3	0.224	--
5/24/00	62	EB	258776	282	297	92	4	0.393	--
5/16/00	62	EB	258747	285	316	93	4	0.446	--
5/15/00	62	EB	268780	287	334	105	5	0.323	--
5/18/00	62	EB	268789	289	319	104	4	0.442	--
5/25/00	38	EB	258777	300	334	114	5	0.408	--
			mean=	**276**	**281**	**88**	**4**	**0.322**	
			median=	**281**	**294**	**92**	**4**	**0.306**	

na=not analyzed

Table A-3. Size, Age, and Mercury Concentrations in Lake Whatcom Medium Size-Class Smallmouth Bass.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN1									
5/16/00	4	GN	218628	337	624	216	5	0.450	--
5/15/00	5	EB	218632	347	593	188	5	0.344	--
5/24/00	4	GN	238675	348	610	200	5	0.243	--
5/18/00	3	GN	218621	350	630	146	6	0.348	--
5/15/00	4	GN	208610	352	592	160	5	0.884	--
5/22/00	4	GN	238656	353	606	170	na	0.344	--
5/18/00	4	GN	218624	355	590	160	6	0.436	--
5/16/00	4	GN	218631	355	590	186	5	0.614	--
5/22/00	3	GN	208600	356	714	184	6	0.342	--
5/15/00	4	GN	218629	357	666	196	5	0.502	--
			mean=	**351**	**622**	**181**	**5**	**0.451**	
			median=	**353**	**608**	**185**	**5**	**0.392**	
BASIN 2									
5/18/00	75	EB	218615	318	373	124	5	0.276	--
5/23/00	77	EB	258749	320	438	128	5	0.248	--
5/17/00	74	EB	218623	321	386	134	5	0.312	--
5/23/00	77	GN	218611	325	534	124	5	0.302	--
5/15/00	73	EB	218622	340	546	156	5	0.688	--
5/16/00	74	EB	238646	346	527	130	5	0.528	--
5/19/00	7	EB	218640	351	540	192	5	0.342	--
5/25/00	73	EB	218614	351	616	166	na	0.290	--
5/16/00	77	GN	218612	352	670	184	5	0.316	--
5/16/00	73	EB	258756	353	642	210	5	0.296	--
			mean=	**338**	**527**	**155**	**5**	**0.360**	
			median=	**343**	**537**	**145**	**5**	**0.307**	
BASIN 3									
5/16/00	15	EB	238667	313	429	134	5	0.246	--
5/24/00	39	EB	238654	325	418	142	5	0.318	--
5/15/00	62	EB	248717	327	469	154	5	0.631	--
5/23/00	63	EB	238659	329	478	164	5	0.471	--
5/18/00	62	EB	238668	330	487	134	5	0.730	--
5/17/00	62	EB	238672	343	535	192	6	0.682	--
5/17/00	63	GN	218620	349	650	192	5	0.534	--
5/23/00	39	EB	238652	352	611	196	5	0.917	--
5/22/00	62	EB	238666	353	596	180	5	0.424	--
5/15/00	38	EB	238670	354	684	210	5	0.512	--
			mean=	**338**	**536**	**170**	**5**	**0.546**	
			median=	**336**	**511**	**172**	**5**	**0.523**	

na=not analyzed

Table A-4. Size, Age, and Mercury Concentrations in Lake Whatcom Large Size-Class Smallmouth Bass.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/23/00	4	GN	218630	370	670	200	5	0.258	--
5/19/00	4	GN	208607	371	750	178	6	0.520	--
5/22/00	4	GN	238677	372	722	214	5	0.507	--
5/15/00	4	GN	218625	380	780	260	6	0.610	--
5/16/00	3	GN	208601	386	831	226	6	0.478	--
5/16/00	4	GN	238649	389	827	264	5	0.345	--
5/23/00	5	EB	238651	405	1110	390	7	1.170	--
5/18/00	4	GN	238693	407	1007	230	7	0.679	--
5/25/00	4	GN	208609	420	1118	310	6	0.578	--
5/16/00	4	GN	238662	434	1265	474	8	0.808	--
5/15/00	5	EB	208605	438	1392	414	10	0.928	--
5/16/00	81	EB	208602	452	1380	326	10	0.748	--
5/25/00	81	EB	218635	464	1488	434	10	1.840	--
5/16/00	5	EB	208608	486	1593	510	8	0.680	--
			mean=	**412**	**1067**	**316**	**7**	**0.725**	
			median=	**406**	**1058**	**287**	**7**	**0.644**	
BASIN 2									
5/17/00	77	GN	208604	363	752	262	5	0.508	--
5/16/00	77	GN	218618	364	704	218	5	0.278	--
5/23/00	77	GN	218626	368	726	226	7	0.552	--
5/23/00	77	GN	218616	370	733	230	6	0.334	--
5/23/00	77	GN	208606	380	755	252	6	0.512	--
5/23/00	77	GN	218613	395	957	264	8	0.794	--
5/25/00	10	EB	238647	405	915	262	7	1.050	--
5/17/00	72	EB	248732	410	924	268	6	0.620	--
5/23/00	77	GN	218627	410	1046	310	8	0.776	--
5/15/00	7	EB	218637	440	1076	306	8	0.694	--
			mean=	**390**	**859**	**260**	**7**	**0.612**	
			median=	**388**	**835**	**262**	**7**	**0.586**	
BASIN 3									
5/15/00	38	EB	238661	365	737	274	5	0.621	--
5/22/00	63	GN	218639	366	765	230	7	0.638	--
5/15/00	63	GN	218636	369	691	190	5	0.288	--
5/16/00	62	EB	238679	374	766	260	5	0.743	--
5/16/00	63	GN	218619	417	1098	378	7	1.300	--
5/15/00	62	EB	238669	422	1058	260	8	1.230	--
5/23/00	63	GN	218638	424	1160	340	8	0.864	--
5/22/00	63	EB	238655	430	1163	372	9	0.881	--
5/15/00	38	EB	238680	441	1110	466	8	0.980	--
5/23/00	63	EB	238696	468	1706	522	9	1.080	--
			mean=	**408**	**1025**	**329**	**7**	**0.862**	
			median=	**420**	**1078**	**307**	**8**	**0.872**	

Table A-5. Size, Age, and Mercury Concentrations in Lake Whatcom Yellow Perch.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/16/00	4	EB	248725	177	52	14	6	0.047	--
5/16/00	4	EB	248728	185	65	18	3	0.100	--
5/16/00	4	EB	248730	200	87	23	2	0.082	--
5/15/00	79	EB	238660	257	210	124	3	0.307	--
5/15/00	79	EB	238690	183	58	13	5	0.120	--
5/15/00	79	EB	248708	154	40	10	2	0.088	--
5/15/00	79	EB	248709	206	82	15	2	0.138	--
5/15/00	79	EB	248712	221	117	34	3	0.122	--
5/15/00	79	EB	248716	167	46	14	3	0.136	--
5/15/00	79	EB	248721	156	35	9	3	0.101	--
			mean=	**191**	**79**	**27**	**3**	**0.124**	
			median=	**184**	**62**	**14**	**3**	**0.110**	
BASIN 2									
5/16/00	74	GN	208603	332	680	166	8	0.374	Gravid female
5/16/00	74	GN	218617	333	548	166	8	0.372	Gravid female
5/16/00	74	GN	258771	230	148	48	3	0.143	--
5/16/00	77	GN	248698	208	108	35	3	0.155	--
5/16/00	77	GN	248699	195	79	21	3	0.124	--
5/16/00	77	GN	248700	192	84	27	3	0.138	--
5/16/00	77	GN	248715	169	49	13	2	0.090	--
5/16/00	77	GN	248738	241	177	44	3	0.167	--
5/16/00	77	GN	288812	165	44	14	2	0.070	--
5/16/00	77	GN	288817	207	87	22	4	0.109	--
			mean=	**227**	**200**	**56**	**4**	**0.174**	
			median=	**208**	**98**	**31**	**3**	**0.140**	
BASIN 3									
5/19/00	26	GN	288819	200	86	25	2	0.145	--
5/19/00	26	GN	288822	162	44	14	2	0.087	--
5/22/00	40	EB	258744	255	169	53	5	0.385	--
5/22/00	40	EB	258754	249	178	48	7	0.506	--
5/22/00	40	EB	268784	245	164	57	6	0.457	--
5/19/00	BTWN 43&48	GN	248726	165	44	13	2	0.109	--
5/19/00	BTWN 43&49	GN	248729	157	40	9	2	0.085	--
5/19/00	BTWN 43&50	GN	278802	174	47	11	2	0.100	--
5/22/00	48	EB	238653	320	440	136	7	0.869	--
5/22/00	48	EB	258770	269	217	66	5	0.156	--
			mean=	**220**	**143**	**43**	**4**	**0.290**	
			median=	**222**	**125**	**36**	**4**	**0.150**	

Table A-6. Size, Age, and Mercury Concentrations in Lake Whatcom Kokanee.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/15/00	OFF 79	EB	228642	195	93	29	2	0.104	Fork length = 179
5/15/00	OFF 79	EB	238689	206	90	32	2	0.123	Fork length = 190
5/15/00	OFF 79	EB	248703	237	131	42	2	0.095	Fork length = 217
5/15/00	OFF 79	EB	248713	212	86	25	3	0.124	Fork length = 192
5/23/00	OFF 2	EB	288824	240	122	33	4	0.110	Fork length = 219; Offshore of station 2; anchor worms
5/23/00	OFF 2	EB	288828	225	98	36	4	0.106	Fork length = 204; Offshore of station 2; anchor worms
5/23/00	OFF 2	EB	288829	228	105	29	4	0.087	Fork length = 204; Offshore of station 2;anchor worms
5/23/00	OFF 2	EB	288831	222	99	28	3	0.248	Fork length = 199; Offshore of station 2; anchor worms
5/23/00	OFF 2	EB	288839	225	104	30	3	0.092	Fork length = 202; Offshore of station 2; anchor worms
5/23/00	OFF 2	EB	288844	206	85	30	2	0.106	Fork length = 187; Offshore of station 2; anchor worms
			mean=	**220**	**99**	**31**	**3**	**0.120**	
			median=	**224**	**98**	**30**	**3**	**0.106**	
BASIN 2									
5/23/00	MID	EB	278797	215	85	27	2	0.098	Fork length = 194; Captured down middle of basin
5/23/00	MID	EB	278807	214	83	28	3	0.099	Fork length = 195; Captured down middle of basin
5/23/00	MID	EB	288811	197	62	18	2	0.119	Fork length = 179; Captured down middle of basin
5/23/00	MID	EB	288815	189	55	14	3	0.125	Fork length = 170; Captured down middle of basin
5/23/00	MID	EB	288845	191	64	18	2	0.096	Fork length = 174; Captured down middle of basin
5/24/00	OFF 76	EB	248737	201	66	11	3	0.125	Fork length = 182; Offshore of station 76; anchor worms
5/24/00	OFF 76	EB	278795	192	59	20	2	0.104	Fork length = 174; Offshore of station 76; anchor worms
5/24/00	OFF 76	EB	278801	206	85	30	3	0.091	Fork length = 187; Offshore of station 76; anchor worms
5/24/00	OFF 76	EB	288816	204	75	18	4	0.117	Fork length = 184; Offshore of station 76; anchor worms
5/24/00	OFF 76	EB	288832	202	68	24	2	0.074	Fork length = 179; Offshore of station 76; anchor worms
			mean=	**201**	**70**	**21**	**3**	**0.105**	
			median=	**202**	**67**	**19**	**3**	**0.102**	
BASIN 3									
5/22/00	62	EB	288842	222	87	31	4	0.140	Fork length = 201
5/25/00	OFF 60	EB	278794	207	75	24	3	0.107	Fork length = 187; Offshore of sta. 60, north of Reveille Is; anchor worms
5/25/00	OFF 60	EB	278799	194	66	18	2	0.175	Fork length = 175; Offshore of sta. 60, north of Reveille Is; anchor worms
5/25/00	OFF 60	EB	288814	210	70	24	3	0.114	Fork length = 189; Offshore of sta. 60, north of Reveille Is; anchor worms
5/25/00	OFF 60	EB	288823	199	60	20	2	0.085	Fork length = 180; Offshore of sta. 60, north of Reveille Is; anchor worms
5/25/00	OFF 60	EB	288825	196	65	20	3	0.100	Fork length = 178; Offshore of sta. 60, north of Reveille Is; anchor worms
5/25/00	OFF 60	EB	288836	217	83	30	4	0.162	Fork length = 195; Offshore of sta. 60, north of Reveille Is; anchor worms
5/25/00	OFF 60	EB	288837	207	82	25	3	0.164	Fork length = 187; Offshore of sta. 60, north of Reveille Is; anchor worms
5/25/00	OFF 60	EB	288843	204	68	18	4	0.167	Fork length = 183; Offshore of sta. 60, north of Reveille Is; anchor worms
5/24/00	OFF 69	EB	278808	201	70	25	2	0.069	Fork length = 182; Offshore of sta. 69; anchor worms
			mean=	**206**	**73**	**24**	**3**	**0.128**	
			median=	**206**	**70**	**24**	**3**	**0.127**	

Table A-7. Size, Age, and Mercury Concentrations in Lake Whatcom Pumpkinseed.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/16/00	4	EB	248731	138	57	17	3	0.053	--
5/16/00	5	EB	278796	143	65	19	3	0.232	--
5/16/00	81	EB	228641	166	111	30	5	0.106	--
5/16/00	81	EB	228644	162	91	23	5	0.070	--
5/16/00	81	EB	238685	142	73	22	3	0.058	--
5/16/00	81	EB	238686	145	68	15	6	0.129	--
5/16/00	81	EB	238688	142	61	15	3	0.162	--
5/16/00	81	EB	248701	132	56	13	3	0.073	--
5/16/00	81	EB	248702	136	60	12	3	0.071	--
5/16/00	81	EB	248723	140	67	15	4	0.139	--
			mean=	**145**	**71**	**18**	**4**	**0.109**	
			median=	**142**	**66**	**16**	**3**	**0.090**	
BASIN 2									
5/17/00	10	EB	278805	126	40	10	3	0.065	--
5/17/00	10	EB	278810	145	61	15	4	0.093	--
5/17/00	72	EB	278800	121	36	8	2	0.057	--
5/17/00	72	EB	288848	140	57	16	4	0.069	--
5/24/00	74	EB	288847	96	17	4	2	0.057	--
5/25/00	77	EB	248735	140	67	12	4	0.042	--
5/25/00	77	EB	278798	150	79	21	4	0.066	--
5/25/00	77	EB	278803	101	19	4	3	0.064	--
5/24/00	77	EB	278804	152	76	21	6	0.086	--
5/24/00	77	EB	288835	140	68	17	3	0.081	--
			mean=	**131**	**52**	**13**	**4**	**0.068**	
			median=	**140**	**59**	**14**	**4**	**0.066**	
BASIN 3									
5/22/00	48	EB	278809	99	18	4	2	0.033	--
5/22/00	48	EB	288827	122	33	8	3	0.062	--
5/22/00	48	EB	288830	137	54	11	3	0.060	--
5/22/00	48	EB	288840	140	53	13	3	0.067	--
5/23/00	62	EB	268790	185	161	49	5	0.147	--
5/23/00	62	EB	278806	163	95	24	6	0.140	--
5/23/00	62	EB	288833	121	36	9	2	0.245	--
5/23/00	62	EB	288838	154	84	20	3	0.053	--
5/23/00	62	EB	288846	162	91	21	4	0.283	--
5/23/00	62	EB	288851	127	42	9	2	0.137	--
			mean=	**141**	**67**	**17**	**3**	**0.123**	
			median=	**138**	**54**	**12**	**3**	**0.102**	

Table A-8. Size and Mercury Concentrations in Lake Whatcom Brown Bullhead.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/16/00	81	EB	238650	288	320	90	na	0.091	--
5/15/00	79	EB	238663	242	195	48	na	0.069	--
5/16/00	81	EB	238674	274	305	74	na	0.121	--
5/15/00	79	EB	248705	186	87	18	na	0.049	--
5/15/00	79	EB	248707	234	173	30	na	0.094	--
5/16/00	81	EB	248722	260	260	48	na	0.032	--
5/16/00	81	EB	248740	256	257	51	na	0.063	--
5/16/00	81	EB	258752	253	219	40	na	0.068	--
5/16/00	81	EB	258772	255	247	51	na	0.050	--
5/16/00	81	EB	268791	262	258	53	na	0.076	--
			mean=	**251**	**232**	**50**	--	**0.071**	
			median=	**256**	**252**	**50**	--	**0.068**	
BASIN 3									
5/25/00	62	EB	238648	356	790	190	na	0.785	--
5/25/00	62	EB	238658	275	269	64	na	0.138	--
5/22/00	62	EB	258755	335	659	126	na	0.408	--
			mean=	**322**	**573**	**127**	--	**0.444**	
			median=	**335**	**659**	**126**	--	**0.408**	

na=not analyzed

Table A-9. Size and Mercury Concentrations in Lake Whatcom Signal Crayfish.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Muscle Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/31/00	77	DIVE	258762	111	48	6	na	0.103	16' deep at end of log
5/31/00	81	DIVE	258764	114	28	3	na	0.063	8' deep under woody debris
5/31/00	3	DIVE	258768	110	37	4	na	0.058	11' deep under woody debris
5/31/00	3	DIVE	258769	111	31	5	na	0.047	11' deep under woody debris
5/31/00	81	DIVE	288853	102	28	5	na	0.177	8' deep under woody debris
5/31/00	3	DIVE	288855	88	19	3	na	0.075	11' deep under woody debris
5/31/00	77	DIVE	288861	83	15	3	na	0.042	8' deep under log
5/31/00	77	DIVE	288862	89	15	3	na	0.042	5' deep near wood
5/31/00	3	DIVE	288863	87	14	2	na	0.034	11' deep under woody debris
5/31/00	77	DIVE	288864	98	26	3	na	0.093	8' deep under log
5/31/00	81	DIVE	288866	93	20	4	na	0.040	8' deep under woody debris
5/31/00	81	DIVE	288870	89	19	2	na	0.035	8' deep under woody debris
5/31/00	3	DIVE	288872	86	14	3	na	0.034	11' deep under woody debris
5/31/00	81	DIVE	288873	85	17	2	na	0.074	8' deep under woody debris
5/31/00	77	DIVE	288878	96	23	3	na	0.063	8' deep near wood
			mean=	**96**	**24**	**3**	--	**0.065**	
			median=	**93**	**20**	**3**	--	**0.058**	
BASIN 2									
6/2/00	72	DIVE	258757	111	39	5	na	0.084	5' deep
6/2/00	75	DIVE	258758	135	47	5	na	0.100	11' deep
6/2/00	72	DIVE	258760	137	69	6	na	0.543	10' deep
6/2/00	10	DIVE	258761	107	44	5	na	0.072	13' deep
6/2/00	75	DIVE	288854	90	21	4	na	0.046	14' deep
6/2/00	10	DIVE	288856	85	19	3	na	0.136	14' deep
6/2/00	75	DIVE	288857	90	18	3	na	0.098	7' deep
6/2/00	10	DIVE	288858	96	23	3	na	0.211	15' deep
6/2/00	10	DIVE	288860	89	17	3	na	0.065	13' deep
6/2/00	72	DIVE	288867	92	19	3	na	0.047	7' deep
6/2/00	72	DIVE	288869	91	20	3	na	0.036	14' deep
6/2/00	72	DIVE	288874	88	21	3	na	0.074	15' deep
6/2/00	75	DIVE	288875	96	22	3	na	0.063	14' deep
6/2/00	75	DIVE	288877	89	18	3	na	0.069	8' deep
6/2/00	10	DIVE	288879	91	18	2	na	0.089	13' deep
			mean=	**99**	**28**	**4**	--	**0.116**	
			median=	**91**	**21**	**3**	--	**0.074**	
BASIN 3									
6/1/00	61	DIVE	248727	125	53	7	na	0.461	17' deep
6/1/00	15	DIVE	258759	114	47	4	na	0.192	15' deep
6/1/00	61	DIVE	258763	112	40	5	na	0.119	20' deep
6/1/00	61	DIVE	258765	104	33	4	na	0.081	20' deep
6/1/00	15	DIVE	258766	120	48	8	na	0.057	20' deep
6/1/00	43	DIVE	258767	103	31	5	na	0.083	14' deep
6/1/00	15	DIVE	288849	90	22	4	na	0.093	15' deep
6/1/00	43	DIVE	288850	94	22	3	na	0.102	19' deep
6/1/00	15	DIVE	288852	97	25	5	na	0.080	17' deep
6/1/00	15	DIVE	288859	98	30	4	na	0.044	16' deep
6/1/00	43	DIVE	288865	102	22	2	na	0.191	15' deep
6/1/00	61	DIVE	288868	92	23	3	na	0.164	20' deep
6/1/00	61	DIVE	288871	94	19	2	na	0.125	14' deep
6/1/00	43	DIVE	288876	83	13	2	na	0.056	21' deep
6/1/00	43	DIVE	288880	105	27	4	na	0.155	20' deep
			mean=	**102**	**30**	**4**	--	**0.134**	
			median=	**102**	**27**	**4**	--	**0.102**	

na=not analyzed

Table A-10. Size, Age, and Mercury Concentrations in Lake Whatcom Cutthroat Trout.

Date	Location	Gear type	Ecology No.	Length (mm)	Weight (g)	Total Fillet Weight (g)	Age (yr)	Hg Conc. (ug/g ww)	Comments
BASIN 1									
5/16/00	4	EB	228643	178	44	12	1	0.039	Fork length = 171
5/15/00	4	GN	238664	274	195	79	2	0.069	Fork length = 268
5/16/00	4	EB	238683	173	51	15	1	0.034	Fork length = 165
5/16/00	4	EB	238684	186	52	14	1	0.051	Fork length = 178
5/16/00	4	EB	238687	180	46	13	2	0.07	Fork length = 170
5/16/00	5	EB	248710	178	53	14	1	0.065	Fork length = 169
5/24/00	3	EB	278793	183	56	16	na	0.04	Fork length = 176
5/24/00	4	EB	288818	175	38	7	2	0.063	Fork length = 166
5/24/00	4	EB	288820	185	52	11	na	0.06	Fork length = 176
5/24/00	4	EB	288821	189	59	16	na	0.069	Fork length = 179
			mean=	**190**	**65**	**20**	**1**	**0.056**	
			median=	**182**	**52**	**14**	**1**	**0.062**	
BASIN 2									
5/18/00	8	EB	218634	339	320	138	na	0.082	Fork length = 319
5/16/00	74	GN	238682	215	92	23	2	0.116	Fork length = 207
5/16/00	77	GN	248714	191	58	15	2	0.032	Fork length = 182
5/16/00	77	GN	248719	273	194	80	3	0.039	Fork length = 258
5/16/00	74	GN	248734	205	75	19	2	0.048	Fork length = 197
5/16/00	77	GN	258750	312	260	80	2	0.0732	Fork length = 304
5/16/00	74	GN	258775	260	145	51	2	0.045	Fork length = 249
5/17/00	74	EB	268778	310	260	94	na	0.0904	Fork length = 292
5/17/00	74	EB	268779	227	104	35	na	0.042	Fork length = 217
5/17/00	76	EB	288813	214	79	20	3	0.096	Fork length = 200
			mean=	**255**	**159**	**56**	**2**	**0.066**	
			median=	**244**	**125**	**43**	**2**	**0.061**	
BASIN 3									
5/19/00	52	GN	238694	326	257	72	na	0.198	Fork length = 312
5/19/00	52	GN	248736	265	150	44	2	0.049	Fork length = 249
5/19/00	26	GN	248739	268	160	39	2	0.034	Fork length = 252
5/19/00	52	GN	248741	184	52	10	2	0.076	Fork length = 174
5/19/00	52	GN	248742	289	216	53	na	0.101	Fork length = 275
5/19/00	63	GN	248743	194	58	12	na	0.054	Fork length = 184
5/22/00	63	EB	258773	298	238	66	na	0.0954	Fork length = 285
5/22/00	62	EB	288826	198	60	15	2	0.056	Fork length = 187
5/22/00	48	EB	288834	196	63	19	2	0.037	Fork length = 184
5/22/00	39	EB	288841	187	47	12	2	0.098	Fork length = 172
			mean=	**241**	**130**	**34**	**2**	**0.080**	
			median=	**232**	**107**	**29**	**2**	**0.066**	

na=not analyzed

Appendix B

Quality Assurance Data

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Table B-1. Results of Matrix Spike and Laboratory Replicate Analyses.

Matrix Spikes

Sample No.	Recovery	RPD
208609	66%	17%
"	78%	
218629	84%	21%
"	104%	
228641	100%	5%
"	95%	
228642	78%	6%
"	83%	
238675	89%	24%
"	70%	
238675	86%	14%
"	75%	
248699	93%	4%
"	97%	
248723	83%	2%
"	81%	
248725	81%	6%
"	76%	
248737	77%	6%
"	82%	
258752	80%	28%
"	106%	
258770	75%	3%
"	77%	
268780	75%	4%
"	72%	
268792	77%	14%
"	89%	
278810	83%	1%
"	84%	
288811	82%	2%
"	84%	
288841	93%	4%
"	89%	
288842	92%	2%
"	90%	
288843	89%	5%
"	94%	

Laboratory Replicates

Sample No.	Result (ug/kg)	RSD
228641	106	
"	101	5%
"	111	
228642	108	
"	107	6%
"	96	
238675	262	
"	240	7%
"	227	
238675	265	
"	267	3%
"	278	
248699	119	
"	122	5%
"	132	
248723	138	
"	133	5%
"	147	
248725	47	
"	49	5%
"	44	
248737	138	
"	109	12%
"	127	
258752	69	4%*
"	66	
258770	154	
"	163	4%
"	151	
278810	93	
"	94	2%
"	91	
288811	98	
"	159	29%
"	99	
288841	98	
"	94	4%
"	101	
288842	142	
"	138	1%
"	141	
288843	131	
"	185	19%
"	186	

RPD=Relative Percent Difference
RSD=Relative Standard Deviation
*RPD

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Appendix C

Mercury Concentrations in Lake Whatcom Fish Plotted by Station

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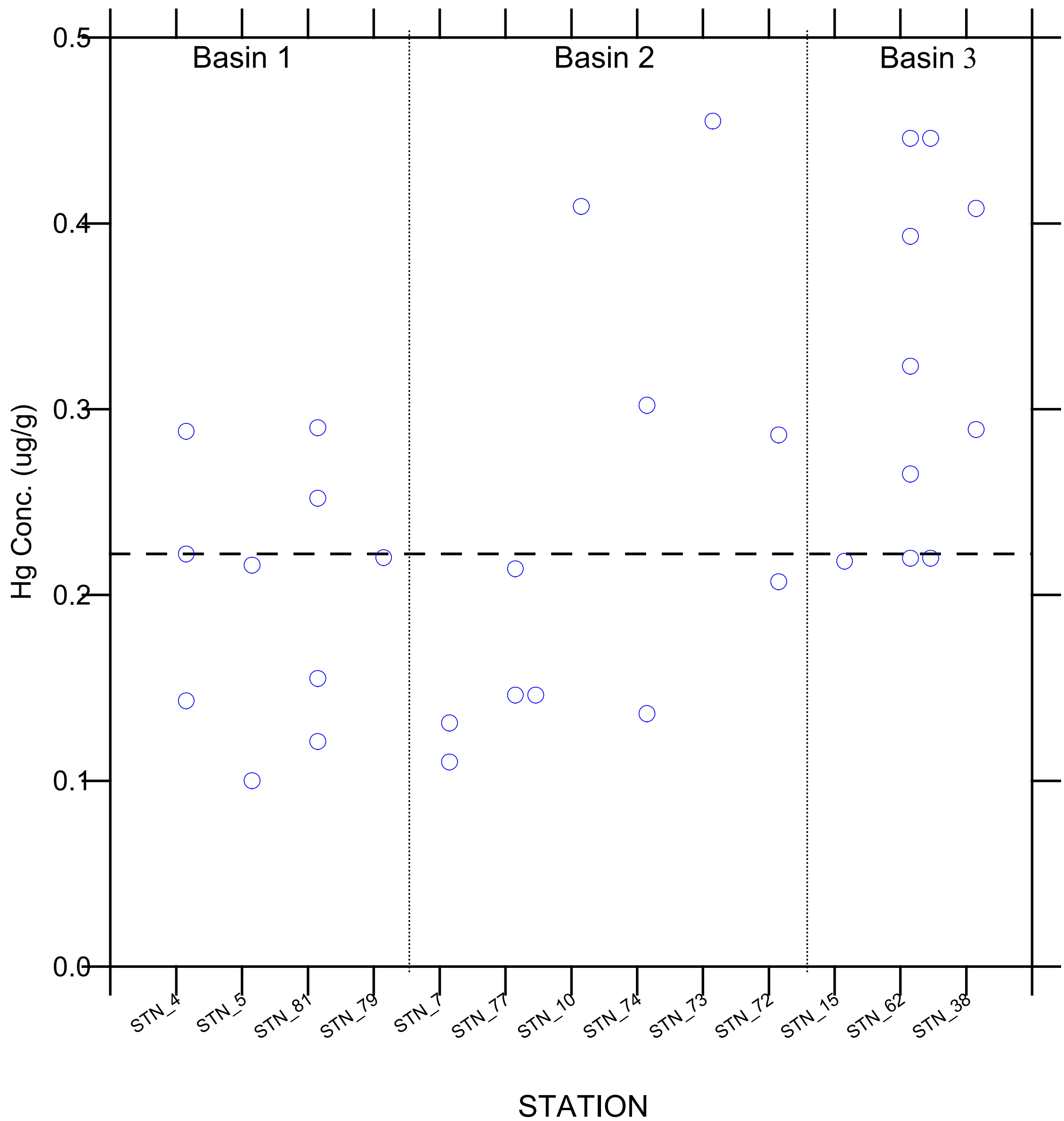

Figure C-1. Mercury Concentrations in Lake Whatcom Small Size-Class Smallmouth Bass (10"-12") Plotted by Station. Dashed Line Represents Median Concentration of All (31) Samples.

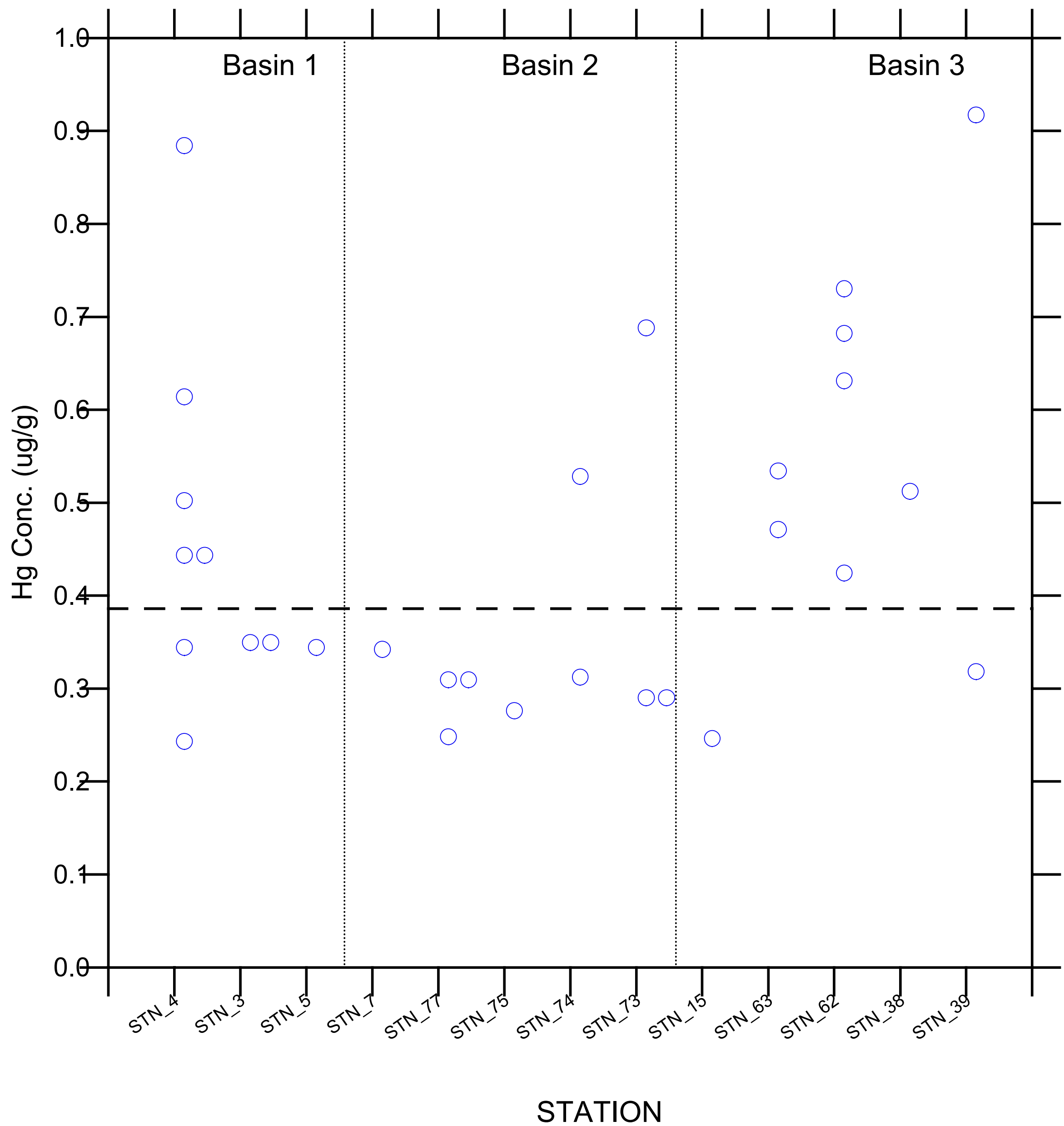

Figure C-2. Mercury Concentrations in Lake Whatcom Medium Size-Class Smallmouth Bass (12”-14”) Plotted by Station. Dashed Line Represents Median Concentration of All (30) Samples.

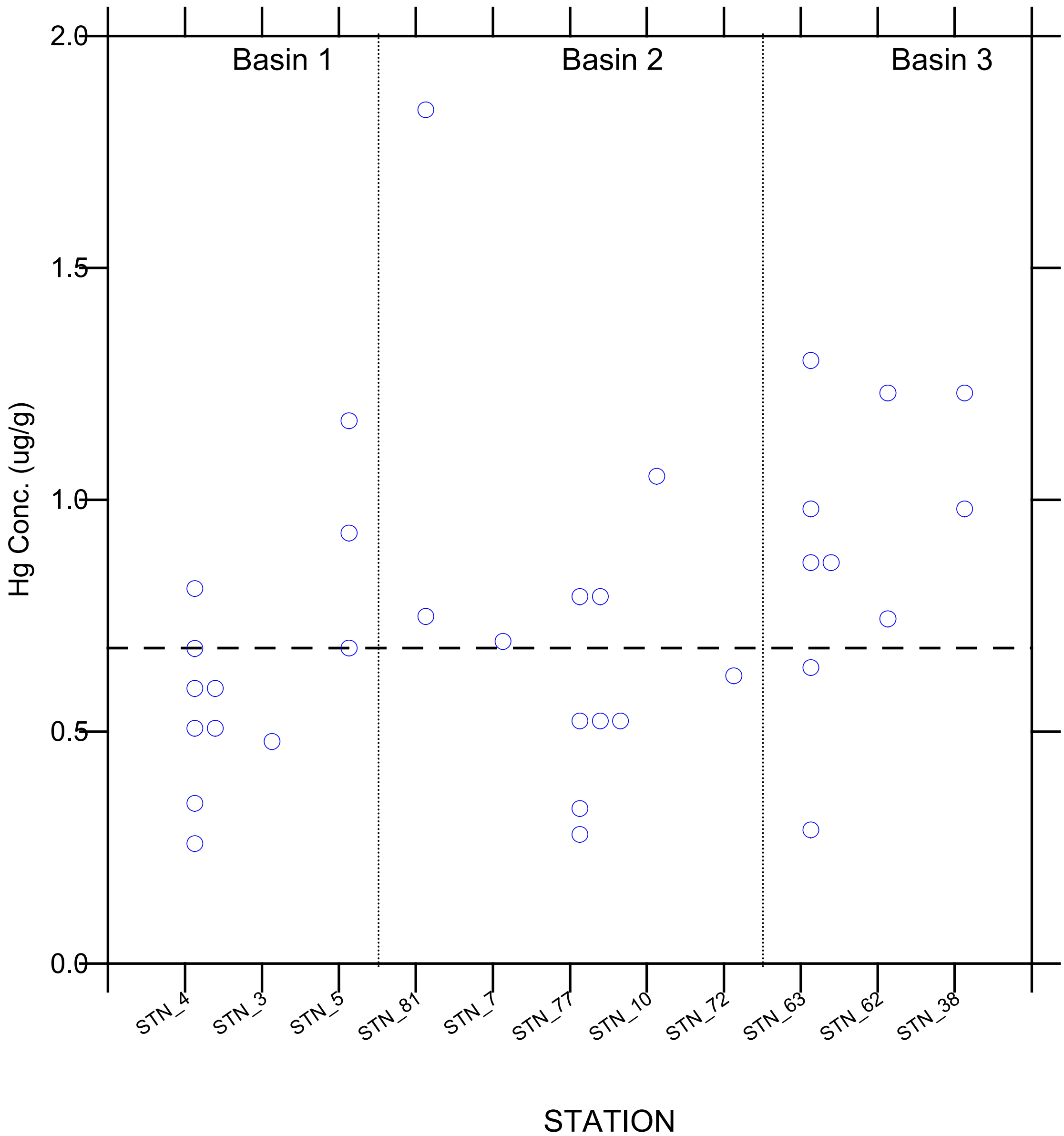

Figure C-3. Mercury Concentrations in Lake Whatcom Large Size-Class Smallmouth Bass (> 14”) Plotted by Station. Dashed Line Represents Median Concentration of All (34) Samples.

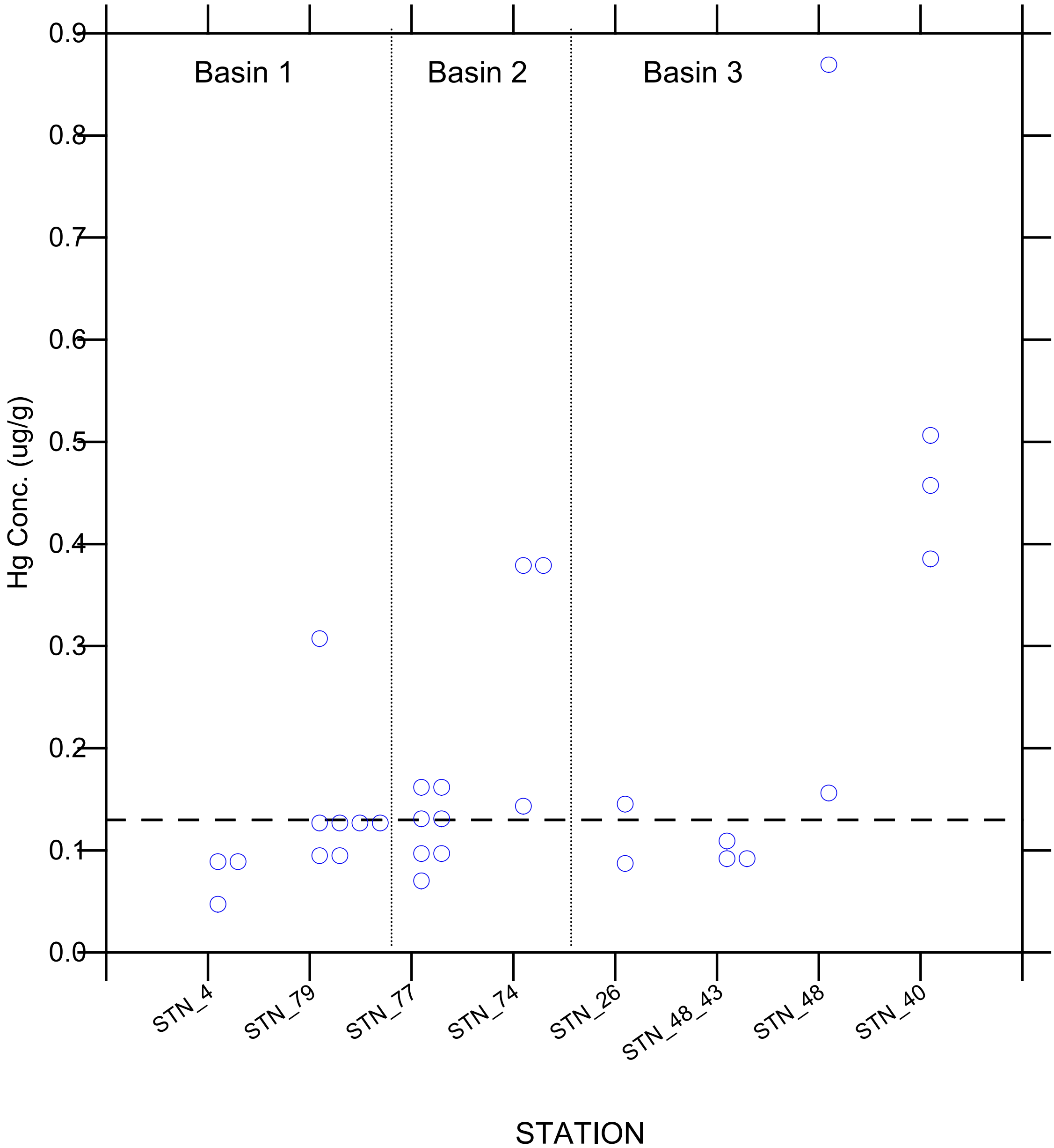

Figure C-4. Mercury Concentrations in Lake Whatcom Yellow Perch Plotted by Station. Dashed Line Represents Median Concentration of All (30) Samples.

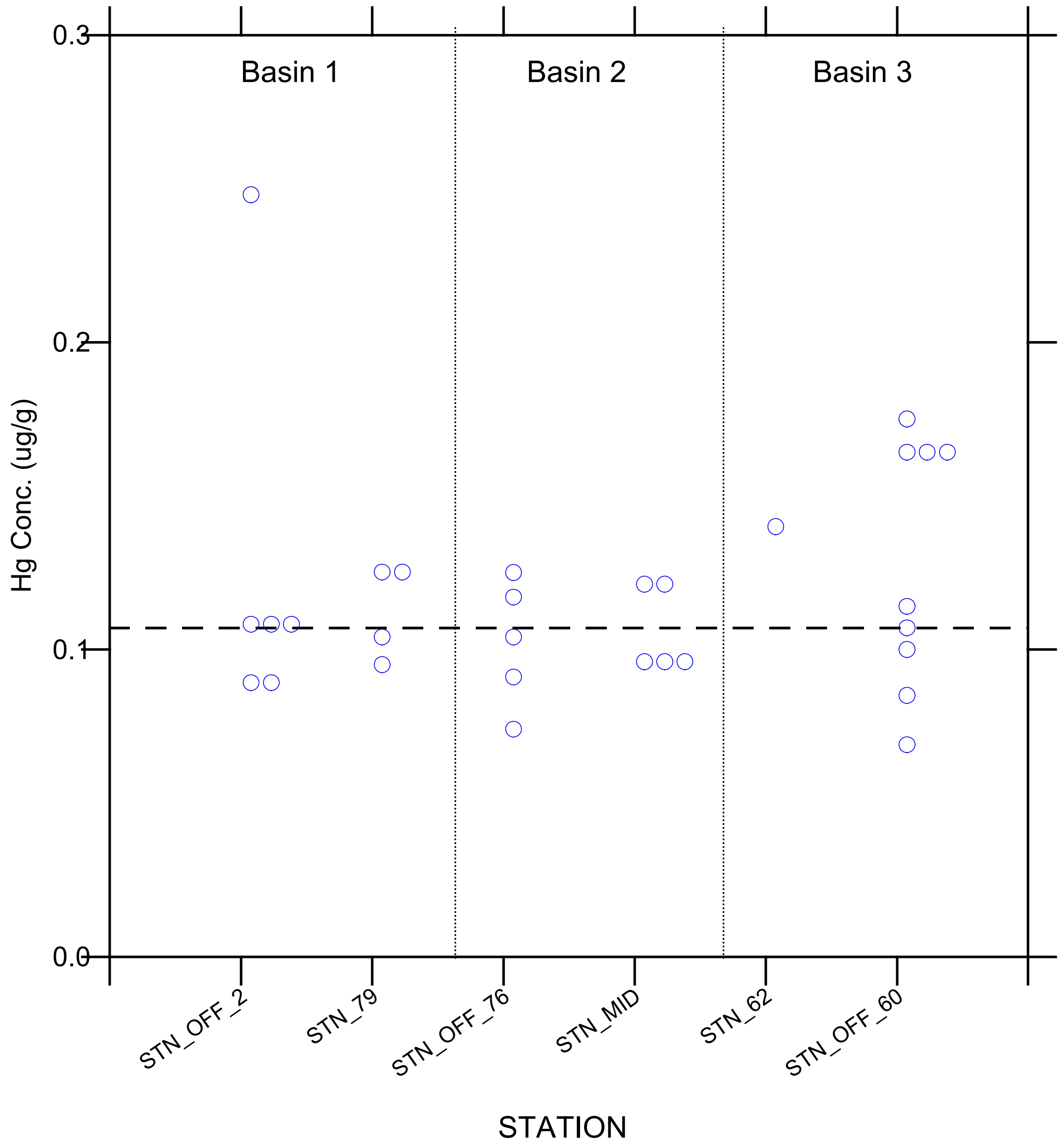

Figure C-5. Mercury Concentrations in Lake Whatcom Kokanee Plotted by Station.
Dashed Line Represents Median Concentration of All (30) Samples.

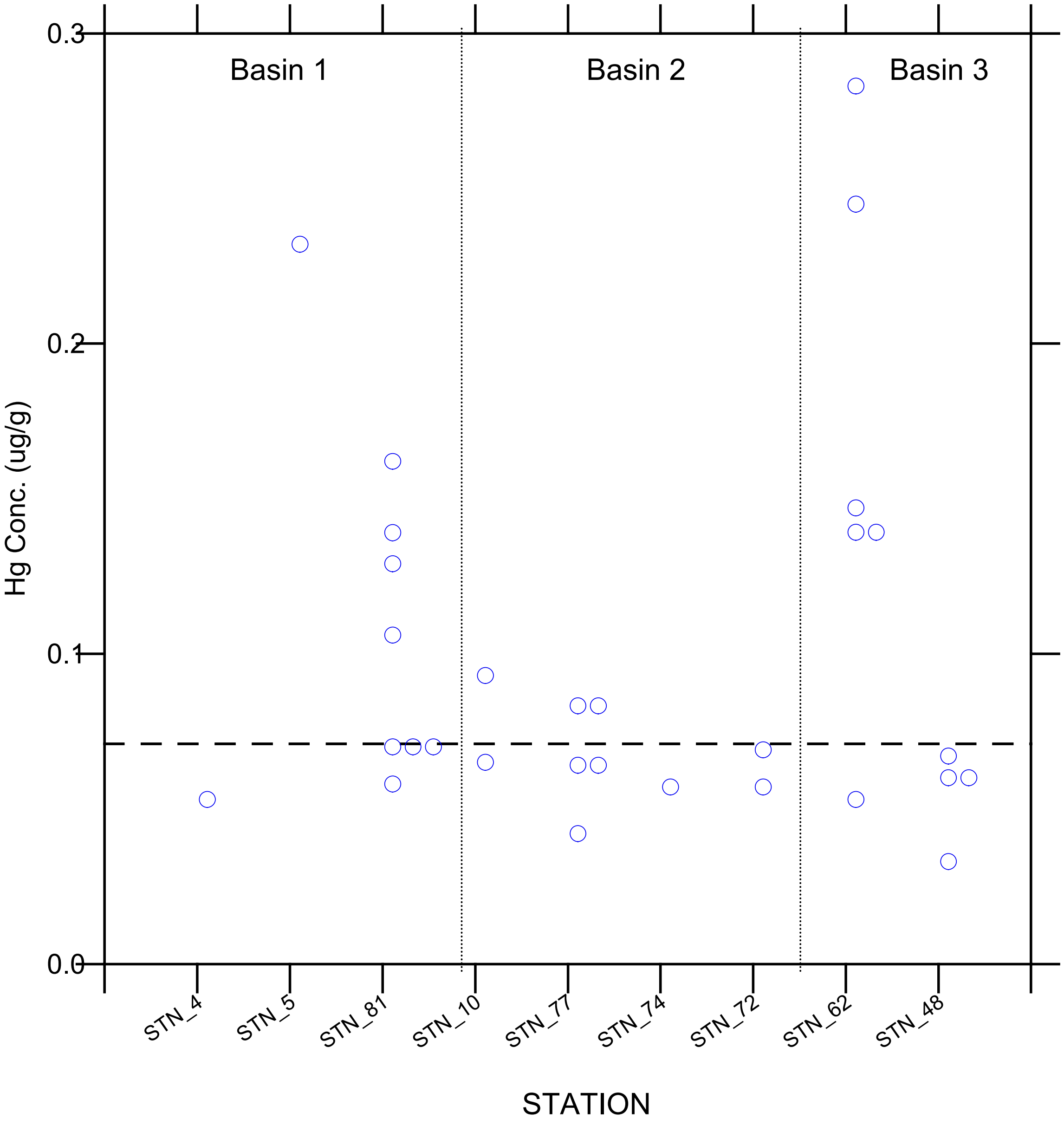

Figure C-6. Mercury Concentrations in Lake Whatcom Pumpkinseed Plotted by Station. Dashed Line Represents Median Concentration of All (30) Samples.

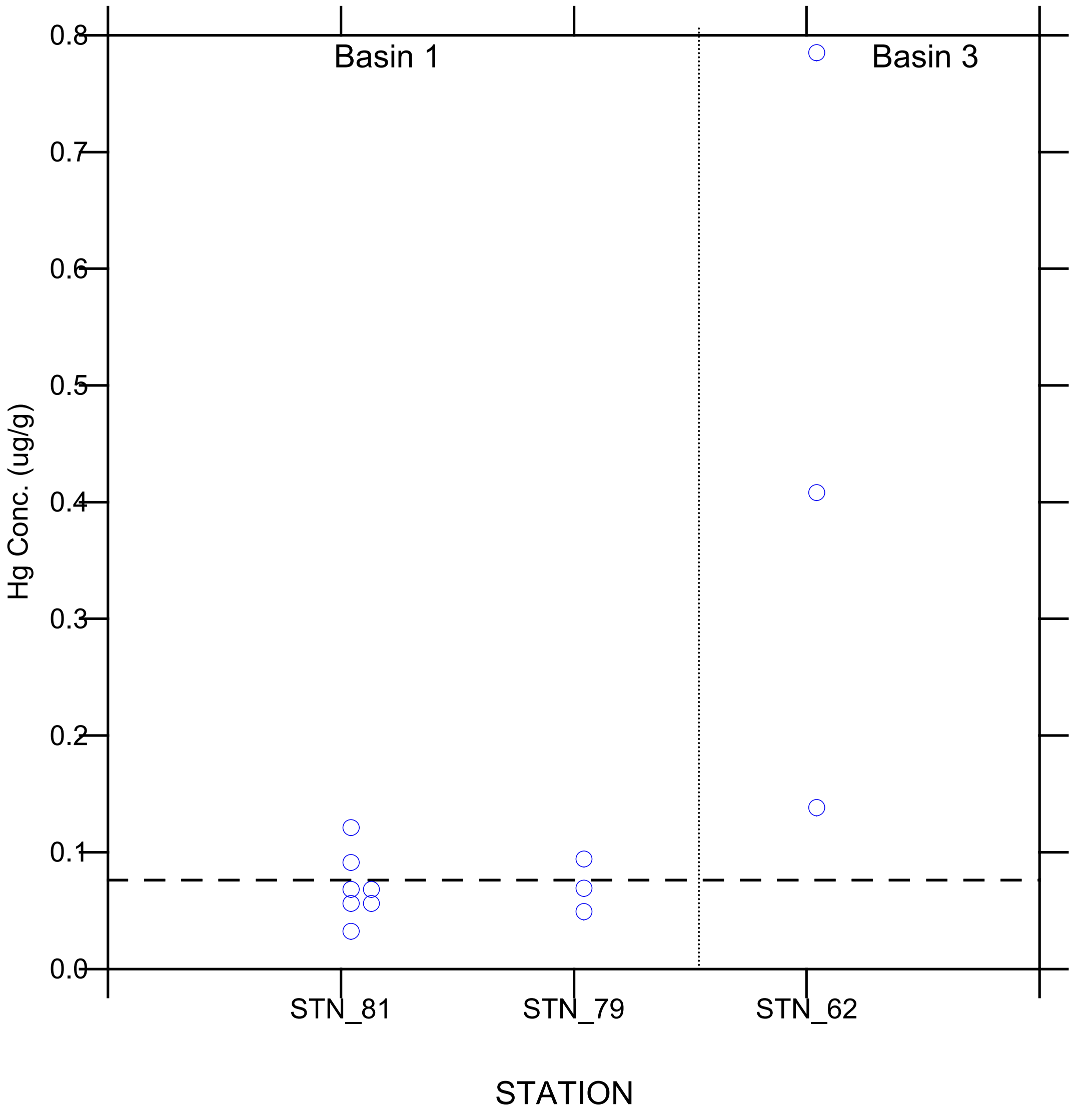

Figure C-7. Mercury Concentrations in Lake Whatcom Brown Bullhead Plotted by Station. Dashed Line Represents Median Concentration of All (23) Samples.

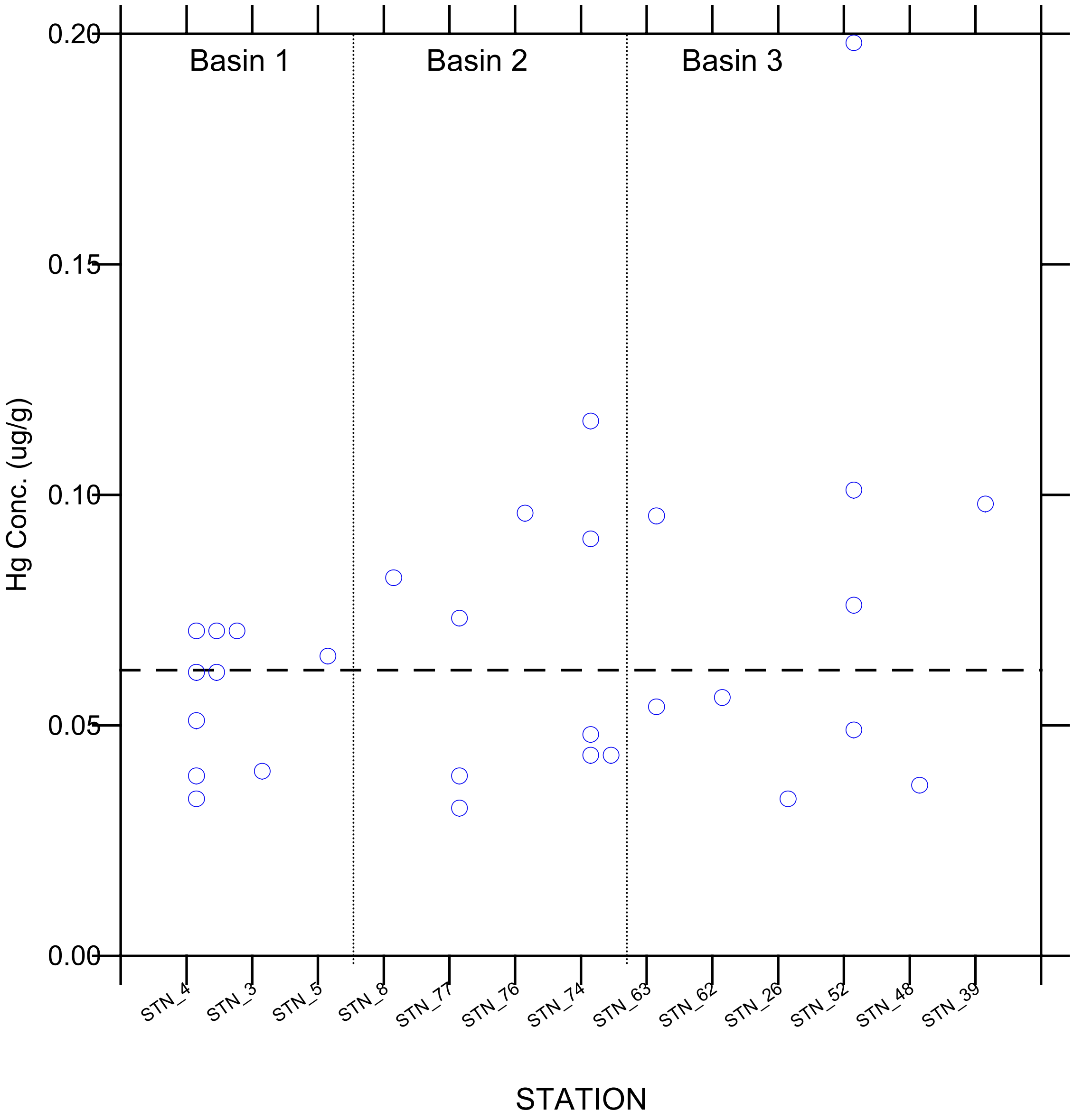

Figure C-8. Mercury Concentrations in Lake Whatcom Cutthroat Trout Plotted by Station. Dashed Line Represents Median Concentration of All (30) Samples.