Prepared in cooperation with the City of Boise, Idaho

Mercury Concentrations in Water and Mercury and Selenium Concentrations in Fish from Brownlee Reservoir and Selected Sites in the Boise and Snake Rivers, Idaho and Oregon, 2013–17

Open-File Report 2018–1122

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph showing fish collection on the Boise River near Middleton, Idaho. Photograph by Marshall Williams, U.S. Geological Survey, October 5, 2016.

Mercury Concentrations in Water and Mercury and Selenium Concentrations in Fish from Brownlee Reservoir and Selected Sites in the Boise and Snake Rivers, Idaho and Oregon, 2013–17

By Dorene E. MacCoy and Christopher A. Mebane

Prepared in cooperation with the City of Boise, Idaho

Open-File Report 2018–1122

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2018

Suggested citation:
MacCoy, D.E., and Mebane, C.A., 2018, Mercury concentrations in water and mercury and selenium concentrations in fish from Brownlee Reservoir and selected sites in the Boise and Snake Rivers, Idaho and Oregon, 2013–17: U.S. Geological Survey Open-File Report 2018-1122, 37 p., https://doi.org/10.3133/ofr20181122.

ISSN 2331–1258 (online)

Contents

Figures

Tables

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
	Volume	
liter (L)	1.057	quart (qt)
milliliter (mL)	0.0381	ounce, fluid (fl. oz)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)
milligram (mg)	0.000035	ounce, avoirdupois (oz)
nanogram (ng)	3.5×10^{-11}	ounce, avoirdupois (oz)

Concentrations of chemical constituents in water are given in micrograms per liter (µg/L), equivalent to part per billion; nanograms per liter (ng/L), equivalent to part per trillion; nanograms per gram (ng/g), equivalent to part per billion; and milligrams per kilogram (mg/kg), equivalent to part per million.

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations

BAFs	bioaccumulation factors
EPA	U.S. Environmental Protection Agency
Hg	mercury
IDEQ	Idaho Department of Environmental Quality
IFCAP	Idaho Fish Consumption Advisory Program
MeHg	methylmercury
NPDES	National Pollutant Discharge and Elimination System
NWIS	National Water Information System
NWQL	USGS National Water Quality Laboratory
RPTE	reasonable potential to exceed
Se	selenium
USGS	U.S. Geological Survey
USGS MRL	USGS Mercury Research Laboratory

Mercury Concentrations in Water and Mercury and Selenium Concentrations in Fish from Brownlee Reservoir and Selected Sites in the Boise and Snake Rivers, Idaho and Oregon, 2013–17

By Dorene E. MacCoy and Christopher A. Mebane

Abstract

Mercury (Hg) analyses were conducted on samples of water and sport fish collected from selected sampling sites in the Boise and Snake Rivers and Brownlee Reservoir, in Idaho and Oregon, to meet National Pollution Discharge and Elimination System (NPDES) permit requirements for the City of Boise, Idaho, from 2013 to 2017. City of Boise personnel collected water samples from six sites in October and November of 2013, 2015 and 2017, and sampled one site in 2014 and 2016. Total Hg concentrations in unfiltered water samples ranged from 0.41 to 8.78 nanograms per liter (ng/L), with the highest value (8.78 ng/L) observed in Brownlee Reservoir in 2013. All samples were less than the U.S. Environmental Protection Agency aquatic life criterion of 12 ng/L.

Individual fillets of mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), smallmouth bass (*Micropterus dolomieu*), and channel catfish (*Ictalurus punctatus*) were collected and analyzed for Hg. The tissue Hg concentrations were compared with regulatory or advisory values for wet-weight methylmercury in fish tissue. In this report, methylmercury concentrations in fish tissue are considered similar to total Hg in fish muscle tissue and are simply referred to as Hg. The 2013 average Hg concentration for smallmouth bass (0.32 mg/kg) collected at Brownlee Reservoir and for channel catfish (0.33 mg/kg) collected at the Boise River mouth, exceeded the Idaho water quality criterion (>0.3 mg/kg). The 2017 Hg concentrations in smallmouth bass from Brownlee Reservoir (geometric mean of 0.22 mg/kg) was at the Idaho Fish Consumption Advisory Program (IFCAP) action level.

Selenium (Se) interacts with Hg to reduce the health risks of Hg, such that tissues with Se-to-Hg molar ratios greater than 1 are considered to present less potential health risks for a given Hg concentration than are tissues with lower Se-to-Hg ratios. One composite fish tissue sample per site was analyzed for Se. Selenium-to-Hg molar ratios in the fish tissue samples ranged from 0.99 to 24.7.

Introduction

Mercury (Hg) is a global pollutant that ultimately makes its way into every aquatic ecosystem through the hydrologic cycle. Atmospheric deposition of inorganic Hg contributes the vast majority of the Hg to aquatic systems, although geologic sources and point-source pollution also may contribute to Hg loading. Once it is in aquatic systems, inorganic Hg may become methylated through microbial sulfate reduction (Fitzgerald and Lamborg, 2007). Methylmercury (MeHg) is by far the more bioavailable and toxic form of Hg. Almost all Hg present in fish tissue is MeHg. Risks of MeHg exposure to humans are largely through consumption of fish (U.S. Environmental Protection Agency, 2001).

The U.S. Environmental Protection Agency (EPA) recommended water quality criterion for MeHg is expressed as a concentration in fish tissue (wet-weight MeHg in fish tissue; U.S. Environmental Protection Agency, 2001). The MeHg criterion is based on wet weight, appropriately representing the nature of fish destined for human consumption. In 2005, the Idaho Department of Environmental Quality (IDEQ) adopted the EPA fish-tissue criterion of 0.3 mg/kg based on a 17.5 g/d general population consumption rate and published implementation guidance for the Idaho Hg water quality standard (Idaho Department of Environmental Quality, 2005). The EPA recently updated the national fish consumption rate to 22 g/d for this criterion based on the results from the National Health and Nutrient Survey conducted from 2003 to 2010 (U.S. Environmental Protection Agency, 2014, 2015). However, the EPA prefers that States use local data to determine fish consumption rates for human health criteria. In 2016, the IDEQ updated its fish consumption rate used to set toxic substance water quality criteria to 66.5 g/d. All human health-based water quality criteria were updated using the higher fish consumption rates, except for the MeHg criterion, for which the value based on the 17.5 g/d fish consumption rate was retained (Idaho Department of Environmental Quality, 2016). As of this publication, Idaho has not increased the fish consumption rate used in the MeHg criterion, and the criterion remains at the 2005 level (0.3 mg/kg).

Although the fish-tissue criterion is based on methylmercury (MeHg), for the purposes of this study, total Hg is analyzed in place of MeHg for two reasons: (1) total Hg is easier and less costly for laboratories to determine than MeHg, and (2) nearly all Hg present in fish muscle tissue is MeHg (Bloom, 1992; Hammerschmidt and others, 1999; Harris and others, 2003; Scudder and others, 2009). Interpretation of total Hg as MeHg probably introduces a small positive bias of about 1–5 percent, based on comparisons shown by Bloom (1992) and by Hammerschmidt and others (1999). This magnitude of potential bias is well within the range of expected analytical variability. In comparing fish-tissue results with the criterion, the analytical results for total Hg in the fish tissue should be interpreted as 100 percent MeHg. For the remainder of this report, total Hg analyzed in both water and fish tissue will be referred to as Hg, with fish tissue values reported as wet weight concentration.

The Idaho implementation guidance describes two scales of monitoring for Hg in fish tissue: (1) statewide ambient monitoring, and (2) facility/source monitoring. The Idaho Statewide Ambient Monitoring Program was designed to monitor concentrations of Hg in fish tissue that represent an integrated exposure to Hg throughout a water body over time (Idaho Department of Environmental Quality, 2005). The Idaho Statewide Ambient Monitoring Program began collecting fish tissue in 2004 and was discontinued in 2009 because of funding constraints (Essig and Kosterman, 2008; Essig, 2010). Facility/source monitoring is targeted at potential local sources of mercury. The EPA Office of Wastewater Management, in partnership with the State of Idaho, manages the National Pollution Discharge and Elimination System (NPDES) to help track and manage permits for point-source dischargers (U.S. Environmental Protection Agency, 2012a). Certain NPDES permittees are required to analyze for Hg in effluent and in fish that inhabit the receiving waterbodies (Idaho Department of Environmental Quality, 2005).

The 2005 IDEQ implementation guidance document requires NPDES permittees to provide data for Hg in fish tissue under the reasonable potential to exceed criteria (RPTE) process (Idaho Department of Environmental Quality, 2005). The RPTE threshold is designed to protect people who consume fish and is based on an average Hg concentration from 10 fish not to exceed 80 percent of the 0.3 mg/kg Idaho criterion or greater than 0.24 mg/kg wet weight Hg in fish from the receiving water body. The IDEQ guidance recommends additional pollution prevention and sampling actions if the RPTE threshold is exceeded. The EPA has included numerical Hg limitations, Hg minimization plan development, watershed-based fish tissue and water Hg sampling, and annual reporting requirements for the two City of Boise, Idaho, effluent permits for the Lander Street and the West Boise water renewal facilities (U.S. Environmental Protection Agency, 2012b, 2012c). These requirements are what led to the present study.

The Idaho Fish Consumption Advisory Program (IFCAP) issues fish advisories to protect fish consumers and has developed an action level of 0.22 mg/kg wet weight Hg in fish tissue. Fish consumption advisories are water body- and species-specific and are used to advise general and sensitive populations of the allowable consumption of fish obtained from Idaho waters. The geometric mean Hg concentration of 10 fish of a single species collected from a single water body (lake or stream) in Idaho is compared to the action level to determine if a consumption advisory should be issued.

The EPA considers a total recoverable mercury concentration of 12 ng/L in water the effective chronic aquatic life criterion in Idaho for the purposes of the Clean Water Act (Idaho Department of Environmental Quality, 2014, referred to as "EPA aquatic life criteria" in this report). The City of Boise NPDES permits require a minimum detection level for Hg of 0.5 ng/L, sufficiently low to compare to EPA criteria.

The implicit purpose of collecting data on Hg in water and fish tissue at the same location is to facilitate developing fish bioaccumulation factors, which are ratios of Hg concentrations in tissue and water. Bioaccumulation factors (BAFs) can be useful for water quality management, such as site-specific implementation targets of the fish-tissue based MeHg water quality criteria and total maximum daily load target development (Idaho Department of Environmental Quality, 2005; U.S. Environmental Protection Agency, 2010). For developing BAFs, it is not essential that water and fish samples be collected at the same time. Riva-Murray and others (2013) reported that optimum BAF estimates came from sampling MeHg in water during the July–September growing season, regardless of when the fish were collected. A sample of at least 10 adult fish of a single species and similar length are collected to minimize variability in the concentration of Hg in tissue (Scudder Eikenberry and others, 2015). The EPA Hg implementation guidelines (U.S. Environmental Protection Agency, 2010) recommend measuring MeHg in water for calculation of BAFs to be used in Hg risk management. It is the intent that data from this study will be combined with future data-collection efforts for calculations of BAFs.

The City of Boise, in cooperation with U.S. Geological Survey (USGS), developed a multiyear water and fish tissue Hg monitoring plan (Mebane and MacCoy, 2013) in the Snake and Boise Rivers and Brownlee Reservoir to satisfy the watershed-based fish-tissue sampling requirements contained in the city permits. The IDEQ implementation guidance (Idaho Department of Environmental Quality, 2005) encourages municipal dischargers to establish monitoring cooperatives to help fund watershed-based statewide monitoring for Hg in fish tissue. The EPA further recommended that the permitting authority (which is the EPA in Idaho as of this report) require only one study per water body (U.S. Environmental Protection Agency, 2010). The multiyear water and fish tissue Hg monitoring plan (Mebane and MacCoy, 2013) was developed and intended to provide a framework for a cooperative Hg sampling program. Municipal NPDES permits issued to Lower Boise River dischargers since 2013 have included the requirement for the permitted facilities to either develop and submit an individual Methylmercury Monitoring Plan or join the cooperative effort initiated by the City of Boise. Several municipalities have joined the cooperative effort (Kate Harris, City of Boise, written commun., February 25, 2018).

Although selenium (Se) analysis is not required for NPDES permit compliance, analysis of composite samples of fish tissue for Se was done to provide information for future risk assessments. The potential for Hg toxicity reduction in the presence of certain concentrations of Se has not been considered in fish consumption advisories or in comparing to criteria for the protection of human health, but may be important in the future (U.S. Environment Protection Agency, 2001; Idaho Department of Environmental Quality, 2005; Cusack and others, 2017).

Purpose and Scope

This report contains water quality and fish-tissue data that meet the requirements of the Hg monitoring plan in the Boise and Snake Rivers and Brownlee Reservoir (Mebane and MacCoy, 2013). Some of the data contained in this report have been previously published in MacCoy (2014) and in Williams and MacCoy (2016). The cumulative data contained in this report will provide a reference to which future determinations of Hg in water and fish can be compared.

This report contains Hg in water data collected by City of Boise personnel and Hg and Se in fish tissue collected by the USGS as described in the Hg monitoring plan (Mebane and MacCoy, 2013) to meet the City of Boise NPDES permit requirements.

Site Locations

Six sampling sites (table 1) were selected to meet specific requirements for the City of Boise NPDES permits (U.S. Environmental Protection Agency, 2012b, 2012c). Site locations (fig. 1) were required to be upstream (Eckert) and downstream (Middleton) of the city's two water renewal facilities at Lander Street and West Boise on the Boise River, near the middle of the lower Boise River watershed (Middleton), at the mouth of the Boise River (Boise mouth), in the Snake River upstream (Murphy) and downstream (Nyssa) of the mouth of the Boise River, and in the impounded section of the Snake River downstream of the Boise River confluence (Brownlee). The site downstream of both water renewal facilities, Middleton, also was used to meet the middle of the lower Boise River watershed site requirement.

The basis for multiple years of sampling is provided in the Hg monitoring plan (Mebane and MacCoy, 2013). In 2013, 2015, and 2017, water and fish samples were collected at all six sampling sites (table 1, fig. 1); in 2014 and 2016, only the Middleton site was sampled. The sites were selected to meet specific NPDES requirements and to try to isolate the fish populations being sampled. No natural fish passage barriers between sampling sites exist to prevent fish migration, but manmade diversions in the Boise River between the Eckert and Middleton sites act as barriers to upstream fish passage (MacCoy, 2006).

Targeted Fish Species

The targeted fish species (table 2) were based on the Idaho Department of Environmental Quality (2005) recommendation that fish tissue samples should be representative of the Hg exposures likely encountered from recreational or subsistence fishing, and upon previous fish sampling at selected locations in the Boise and Snake Rivers and Brownlee Reservoir (table 2; Clark and Maret, 1998; Richter and Chandler, 2003; MacCoy, 2006).

Targeting specific fish species is inherently difficult because of fish movement and sample timing. Sampling crews were able to collect 10 individuals of a targeted fish species of edible size at each site in all years except 2015 at the Boise mouth, where only 6 fish were collected. The Idaho Department of Fish and Game has established the minimum length of some harvestable fish. As of 2016, the minimum harvestable size for smallmouth bass in southwestern Idaho is 30 cm (Idaho Department of Fish and Game, 2016). Thus, for smallmouth bass, the goal was to collect fish greater than 30 cm in length (Mebane and MacCoy, 2013). In 2017, nine smallmouth bass collected from Boise mouth were less than 30 cm long. All other fish were greater than 25 cm long except for three mountain whitefish collected from Middleton in 2014. Sampling at Murphy provided an opportunity to collect samples of two targeted fish species—smallmouth bass and channel catfish in 2013, 2015 and 2017. Smallmouth bass and channel catfish are important sport fish in the Snake River, and these samples will provide a much needed comparison of Hg in fish tissue between species and sites (fig. 2).

Field Sampling Procedures

Water samples were collected by City of Boise personnel using low-level Hg surface-water sampling protocols (City of Boise, Public Works field standard operating procedures, written commun., October 16, 2017) following collection and quality-control procedures similar to those described in Lewis and Brigham (2004) and in Essig (2010). Pre-cleaned 200-mL glass bottles were used to collect dip water samples. Samples were collected just below the water surface by wading into apparently well-mixed areas. Samples were placed on ice and delivered to the Boise City Public Works Water Quality Laboratory within 24 hours. Field blanks were collected at each site for quality control as described in Wilde (2006, section 4.3, "Quality-Control Samples").

Fish-tissue sampling was conducted during low-flow conditions to reduce hazards from maneuvering the boat or raft in high water velocities. Fish were captured by electrofishing; additional information on electrofishing sampling safety, sampling permit requirements, and justification for sampling outside the summer season is given in the Hg monitoring plan (Mebane and MacCoy, 2013).

Procedures for collecting and processing fish for analysis of Hg are similar to those outlined in Scudder and others (2008). Sampling procedures specific to this project are given here. Boat and raft electrofishing were used to collect targeted fish species at a site. Fish of edible size (typically greater than 25 cm in length, or, for smallmouth bass, greater than 30 cm in length) were placed in a live well. When at least 10 individuals of the same species were collected, the fish were weighed, measured, euthanized, and placed in separate clean, clear, zip-seal bags on wet ice. Fish were transported to the sample preparation area at the USGS Idaho Water Science Center in Boise for processing and frozen to minimize possible loss of sample integrity. When thawed and processed, two skinless fillets were obtained from each fish, one for the primary sample and the second retained frozen as a backup sample for Hg analysis. Approximately 5 g of tissue from each of the 10 fish collected from a site was composited for Se analysis. The backup samples were retained until data were received from the laboratory and reviewed. Fish-tissue samples for Hg analysis were shipped on dry ice to the USGS Mercury Research Laboratory (USGS MRL) in Middleton, Wisconsin. Fish-tissue samples for Se analysis were shipped on dry ice to the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado.

Laboratory Methods

Mercury in Water

Unfiltered water samples were analyzed for Hg using laboratory methods consistent with EPA Method 1631 E (U.S. Environmental Protection Agency, 2002) by the Boise City Public Works Water Quality Laboratory. This method provided a minimum detection level of 0.2 ng/L.

Mercury in Fish Tissue

The USGS MRL provided analysis of Hg in fish tissue consistent with EPA Method 7473 (U.S. Environmental Protection Agency, 2007). The USGS MRL has determined that this method has a minimum detection limit of 0.008 mg/kg dry weight, based on a 20–50 mg sample size for their laboratory equipment. The detection limit is sufficiently low to quantify Hg concentrations in fish tissue at less than 0.30 mg/kg wet weight. Additional USGS MRL quality-assurance procedures are available on their web page (U.S. Geological Survey, 2017a).

Selenium in Fish Tissue

A sample size of 20 g or more was needed by the NWQL for Se analyses. The composite of a portion of tissue from each of 10 fish from a site resulted in a sufficient sample size. NWQL analysis of Se in tissue used methods by Garbarino and others (2006). This method provided a minimum level of detection of 0.1 mg/kg dry weight. The Hg monitoring plan (Mebane and MacCoy, 2013) specified a composite of at least three fish per site. The composite of 10 fish provided a more than adequate sample for general Se screening.

Results

Data-Quality Objectives

All data-quality objectives were met for this study and provided reliable Hg concentrations in water and in fish-tissue data collected from the Snake and Boise Rivers and Brownlee Reservoir. The data-quality objectives of this monitoring study from Mebane and MacCoy (2013) were:

1. The fish collected represent the species and size ranges likely to be caught and consumed by recreational or subsistence anglers in the vicinity of the sampling sites.
2. Sample processing, handling, storing, and shipping to the laboratory used sufficient quality-assurance measures to avoid introducing sample contamination or bias to the data.
3. Laboratory analytical techniques had sufficiently low detection limits to quantify Hg concentrations in fish tissue at less than 0.24 mg/kg wet weight (Idaho RPTE threshold).
4. Quality-control samples were analyzed to provide accuracy and precision information for the fish-tissue samples collected (table 3). The accuracy of the data was within 20 percent of the most probable value for certified reference tissues for Hg (International Atomic Energy Agency, 2003), and the precision (repeatability) of the data was within 20 percent relative standard deviation in laboratory replicate analyses.
5. Following review, fish-tissue data were made available to the public and environmental management agencies through the online USGS National Water Information System (NWIS) and in this report.
6. Mercury concentrations in water should not exceed the laboratory detection limit (0.2 ng/L). Matrix spike recovery of Hg in water samples should be within 71–125 percent of the theoretical value. The relative percent difference of matrix spike duplicates should be less than 24 percent (U.S. Environmental Protection Agency, 2002).

Mercury in Water

Hg in water was collected at all six sampling sites on the Boise and Snake Rivers and Brownlee Reservoir. Concentrations, field blank concentrations, and laboratory matrix spike recovery data are shown in table 4. Because the 2016 Middleton water sample was not taken at the same location as the fish sampling, that result is not included in this summary. Total Hg concentrations in water ranged from 0.41 to 8.78 ng/L, with the highest concentration at Brownlee Reservoir in 2013. All samples were less than the EPA aquatic life criterion (12 ng/L; Idaho Department of Water Quality, 2014). All field blanks were near or less than the detection level except for the sample taken at Boise mouth in 2013 (detection of 0.70 ng/L Hg). With that one exception, the blank values were within data-quality objectives.

Quality-control samples for evaluating recoveries and repeatability were spiked with either 5 or 10 ng/L total Hg for matrix spikes and matrix spike duplicates. Laboratory spike recoveries ranged from 89 to 106 percent of the expected values. Relative percent differences between the duplicate matrix spikes ranged from 0.0 to 19.1 percent (table 4). All values were within data-quality objectives.

While compiling and reviewing the present report, an error was found in the previously reported 2013 quality-control samples for Hg in water. In table 4 of MacCoy (2014) and in table 4 of Williams and MacCoy (2016), matrix spike values given as 0.19 ng/L were incorrect. The 0.19 ng/L value was actually the method detection limit, not the matrix spike value. (Heather Rankin, City of Boise, oral commun., June 29, 2018).

Mercury in Fish Tissue

The concentration of Hg in fish tissue, as well as the length and weight of the fish collected from the Boise and Snake Rivers and Brownlee Reservoir, are shown in table 5. A graphical summary of Hg concentrations in all fish from all sites is shown in figure 3, and summaries of individual fish length and Hg concentrations are shown in figure 4. All fish-tissue data presented in this report can be accessed on the USGS NWIS web page (U.S. Geological Survey, 2017b). Although this study was not designed to compare fish size to Hg concentration, graphical summaries of fish size and Hg concentration are presented, as they may be useful for fish advisory development. Across all years and sites, the lowest Hg concentrations were found in rainbow trout. Mercury concentrations in all other fish species were variable both in time and location, with substantial overlap in concentration ranges.

Rainbow trout were collected at the upstream site (Eckert) in 2015. Total fish lengths for rainbow trout ranged from 250 to 390 mm, and median Hg concentration was 0.02, ranging only from 0.02to 0.03 mg/kg wet weight (fig. 4*A*). Mean concentrations did not exceed the Idaho water quality criterion, RPTE threshold level, or the IFCAP action level (table 5, fig. 3).

Mountain whitefish were collected at the upstream site (Eckert) in 2013 and 2017, and at the site downstream of the City of Boise water renewal facilities on the Boise River (Middleton, fig. 1) during 2013–17. Total fish lengths for mountain whitefish ranged from 135 to 460 mm, with primarily larger fish sampled at Eckert (fig. 4*B*). Median Hg concentrations in mountain whitefish were 0.18 mg/kg at Eckert in 2013 and 0.11 mg/kg in 2017. Median Hg concentrations in mountain whitefish at Middleton were between 0.11 and 0.25 mg/kg, with the highest concentration detected in 2017. The geometric mean concentration at Middleton in 2017 was higher than for previous years (0.20 mg/kg), but did not exceed the IFCAP action level. All other mean concentrations in mountain whitefish did not exceed criteria (table 5, fig. 3).

Smallmouth bass were collected from Boise Mouth in 2017; Murphy in 2013, 2015, and 2017; and Brownlee in 2013 and 2017. Total fish lengths ranged from 215 to 452 mm, with the largest fish sampled from Murphy and Brownlee (fig. 4*C*). Median Hg concentrations in smallmouth bass were similar at Murphy between sample years (0.16–0.17 mg/kg). Average Hg in Brownlee smallmouth bass (0.32 mg/kg) collected in 2013 exceeded the Idaho water quality criterion, RPTE threshold level, and the IFCAP action level (table 5, fig. 3). The geometric mean Hg concentrations were elevated at Boise mouth and Brownlee in 2017, with Brownlee concentrations at the 0.22 mg/kg IFCAP action level (table 5). Although the mean length of smallmouth bass collected in 2017 at Boise mouth (230 mm) was considerably less than the mean length of smallmouth bass collected at Murphy (348 mm), the average Hg concentration was higher in Boise mouth fish (0.22 mg/kg) than in Murphy fish (0.19 mg/kg) (fig 4C, table 5).

Channel catfish were collected from the Boise mouth in 2013 and 2015; at Murphy and Nyssa in 2013, 2015 and 2017; and from Brownlee in 2015. Individual fish lengths ranged from 483 to 720 mm, with the largest individual fish sampled from Murphy (table 5). Channel catfish showed no discernible relation between fish length and Hg concentrations (fig. 4*D*). Median Hg concentrations in channel catfish tissue were between 0.10 and 0.28 mg/kg, with the highest concentration from Boise mouth in 2013. The mean of this sample exceeded the Idaho water quality criterion, RPTE threshold level, and the IFCAP action level (table 5, fig. 3). The geometric mean of the 2015 Boise mouth sample was at the IFCAP action level. Median Hg concentrations were similar between the channel catfish (0.18 mg/kg) and smallmouth bass from Murphy (0.17 mg/kg) in 2013, but in 2015 and 2017 median concentrations were higher in smallmouth bass (0.16 and 0.17 mg/kg) than in channel catfish (0.11 and 0.10 mg/kg). Although the 2015 Boise mouth channel catfish average and geometric mean concentrations were calculated (0.23 and 0.22 mg/kg, respectively; table 5), these values were not compared to the RPTE threshold and the IFCAP action level because fewer than 10 catfish were collected at that site.

One of the purposes of collecting the data reported here was to evaluate MeHg in fish tissue relative to discharges upstream and downstream of the City of Boise water renewal facilities (U.S. Environmental Protection Agency, 2012a, 2012b; Mebane and MacCoy, 2013). Mercury in the same species of fish tissue could be statistically compared only for the 2013 and 2017 collections between the upstream reference site (Eckert) and the closest site downstream of all City of Boise discharges (Middleton). For this comparison, two simple techniques were used—(1) the t-test for comparing the distribution of two groups, and (2) a determination of whether the 95th percentile confidence intervals of the one mean overlaps the other mean. If the probability from the t-test that the means were drawn from the same distribution was less than 5 percent ($p<0.05$) using a two-tailed test, the mercury concentrations in the fish from the two sites were considered to be different. The "two-tailed" t-test is used when no prior assumption is made about one site being higher than the other. Similarly, if the mean mercury concentration at Middleton was greater than the 95th percentile confidence interval of the Eckert mean, the concentrations were considered to be statistically different. Otherwise, the concentrations were considered to be statistically indistinguishable between the two sites.

Mean (± 95th percentile confidence interval) mercury concentrations in mountain whitefish in 2013 were statistically indistinguishable between Eckert and Middleton, with 0.19 (±0.45) mg/kg Hg wet weight at Eckert and 0.18 (±0.48) mg/kg Hg wet weight at Middleton. The p-value of 0.59 in a two-tailed t-test can be interpreted as there being a 59-percent probability that the samples were from the same distribution; thus, the samples are statistically indistinguishable.

However, by the same criteria, 2017 concentrations of mercury in mountain whitefish were statistically different between Eckert and Middleton, with 0.120 (± 0.027) mg/kg Hg wet weight at Eckert and 0.220 (± 0.058) mg/kg Hg wet weight at Middleton. The p-value of 0.009 in a two-tailed t-test can be interpreted as there being a less than 1-percent probability that the samples were from the same distribution; thus, the samples are considered to be statistically different.

Selenium in Fish Tissue

The concentration of Se in composite fish-tissue samples collected from the Boise and Snake Rivers and Brownlee Reservoir are given in table 6. Percent water, percent solids, wet weight concentrations, and Se to Hg molar ratios are also given to better compare the results to the Hg results. The lowest result of less than (<) 0.1 mg/kg dry weight Se was reported for the 2016 mountain whitefish sample, and was anomalous for the species and location. Exclusive of that value, measured selenium in composite samples ranged from 0.20 to 2.13 mg/kg dry weight with the lowest concentrations occurring in mountain whitefish and the highest concentrations occurring in smallmouth bass.

All results are well below the U.S. Environmental Protection Agency (2016) updated aquatic life criteria for Se, which established an 11.3 mg/kg dry weight criterion for Se concentrations in the muscle tissue of fish, among other measurement endpoints. However, the purpose for measuring Se in fish tissue was not to evaluate concentrations, but to help evaluate the Hg results. Selenium has a protective effect against Hg toxicity, and when Hg is elevated and Se is concurrently low, Hg may be of greater risk to fish and their consumers than if Se were higher. If selenium is relatively low (that is, the Se to Hg molar ratio is lower than 1 to 1) and if Hg is concurrently elevated above the 0.3 mg/kg wet weight guideline, this could be considered of even greater concern than if Hg were elevated while selenium was deficient (Yang and others, 2008; Peterson and others, 2009; Cusack and others, 2017). Almost all (22 of 23) samples had Se to Hg ratios of about 1 or greater. The Se to Hg ratios calculated from average concentrations per species per site ranged from 0.99 to 24.7 (table 6), exclusive of a ratio of <0.59 calculated from the anomalously low 2016 Middleton mountain whitefish sample. With one exception, all samples that had relatively low Se to Hg ratios also had absolute Hg concentrations of less than 0.3 mg/kg wet weight. The one exception was channel catfish collected from the mouth of the Boise River in 2013, with a Se to Hg ratio of 1.08 and an average Hg concentration of 0.33 mg/kg wet weight.

Summary

Water samples and sport fish of edible size were collected for mercury (Hg) analysis from six sites in the Boise and Snake Rivers and Brownlee Reservoir, in Idaho and Oregon, in 2013, 2015 and 2017, and from one site in 2014 and 2016, to assist the City of Boise, Idaho, in meeting their National Pollution Discharge and Elimination System Hg monitoring requirements. Water samples were collected at each site to closely coincide with fish sampling efforts. Fish collected at each of the sites represent typical sport fish likely to be taken by recreational and subsistence anglers for consumption. Average and geometric mean Hg concentrations in fish from the Boise mouth (0.33 and 0.28 milligrams per kilogram [mg/kg] in channel catfish) and Brownlee (0.32 and 0.32 mg/kg in smallmouth bass) collected in 2013 exceeded the Idaho water quality criterion of 0.30 mg/kg, the Idaho Department of Environmental Quality reasonable potential to exceed criteria (RPTE) threshold of 0.24 mg/kg, and Idaho Fish Consumption Advisory Program (IFCAP) action level of 0.22 mg/kg. Geometric mean Hg concentrations from Brownlee smallmouth bass in 2017 were at the 0.22 mg/kg IFCAP action level. Although the mean length of smallmouth bass collected in 2017 at Boise mouth (230 millimeters [mm]) was considerably less than the mean length of smallmouth bass collected at Murphy (348 mm), the mean Hg concentration was higher in Boise mouth fish (0.22 mg/kg) than in Murphy fish (0.19 mg/kg). Statistical comparisons of Hg in the same species of fish upstream and downstream of the City of Boise discharges could only be made in 2013 and 2017, when mountain whitefish were collected at both the upstream reference site (Eckert) and the closest site downstream of all City of Boise discharges (Middleton). The 2013 samples were statistically indistinguishable, but, in 2017, methylmercury was higher in the Middleton samples than in the Eckert samples. Total Hg concentrations in unfiltered water samples ranged from 0.41 to 8.78 ng/L total Hg, with the highest concentrations from Brownlee Reservoir in 2013.

Composite concentrations of Se in fish tissue collected between 2013 and 2015 ranged from less than 0.10 to 2.13 mg/kg dry weight, with the highest concentration collected from smallmouth bass from the Snake River at Murphy. At high selenium (Se) to Hg molar ratios of greater than 1.0, Hg may be considered of lesser toxicological concern for organisms and their consumers than are the same Hg concentrations at lower Se to Hg molar ratios (<1). Almost all (22 of 23) samples had Se to Hg molar ratios of about 1 or greater, ranging from 0.99 to 24.7.

References Cited

Bloom, N.S., 1992, On the chemical form of mercury in edible fish and marine invertebrate tissue: Canadian Journal of Fisheries and Aquatic Sciences, v. 49, no. 5, p. 1010–1017, https://dx.doi.org/10.1139/f92-113.

Clark, G.M., and Maret, T.R., 1998, Organochlorine compounds and trace elements in fish tissue and bed sediments in the Lower Snake River Basin, Idaho and Oregon: U.S. Geological Survey Water-Resources Investigations Report 98-4103, 35 p., https://pubs.er.usgs.gov/publication/wri984103.

Cusack, L.K., Eagles-Smith, C., Harding, A.K., Kile, Molly, and Stone, D., 2017, Selenium-mercury molar ratios in freshwater fish in the Columbia River Basin—Potential applications for specific fish consumption advisories: Biological Trace Element Research, v. 178, no. 1, p. 136–146, https://doi.org/10.1007/s12011-016-0907-9.

Essig, D.A., 2010, Arsenic, mercury, and selenium in fish tissue and water from Idaho's major rivers—A statewide assessment: Boise, Idaho Department of Environmental Quality, 64 p. plus appendixes, accessed January 11, 2018, at https://www.deq.idaho.gov/water-quality/surface-water/mercury.aspx.

Essig, D.A., and Kosterman, M.A., 2008, Arsenic, mercury, and selenium in fish tissue from Idaho lakes and reservoirs—A statewide assessment: Boise, Idaho, Idaho Department of Environmental Quality, 46 p. plus appendixes, accessed January 11, 2018, at https://www.deq.idaho.gov/water-quality/surface-water/mercury.aspx.

Fitzgerald, W.F., and Lamborg, C.H., 2007, Geochemistry of mercury in the environment—Treatise on geochemistry: Elsevier, v. 9, p. 1–47, http://dx.doi.org/10.1016/B0-08-043751-6/09048-4.

Garbarino, J.R., Kanagy, L.K., and Cree, M.E., 2006, Determination of elements in natural-water, biota, sediment, and soil samples using collision/reaction cell inductively coupled plasma—Mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. B1, 88 p., https://pubs.usgs.gov/tm/2006/tm5b1/.

Hammerschmidt, C.R., Wiener, J.G., Frazier, B.E., and Rada, R.G., 1999, Methylmercury content of eggs in yellow perch related to maternal exposure in four Wisconsin lakes: Environmental Science and Technology, v. 33, no. 7, p. 999–1,003, https://dx.doi.org/10.1021/es980948h.

Harris, H.H., Pickering, I.J., and George, G.N., 2003, The chemical form of mercury in fish: Science, v. 301, no. 5637, p. 1203, https://dx.doi.org/10.1126/science.1085941.

Idaho Department of Environmental Quality, 2005, Implementation guidance for the Idaho mercury water quality criteria: Boise, Idaho Department of Environmental Quality, 212 p., accessed January 16, 2018, at https://www.deq.idaho.gov/water-quality/surface-water/mercury.aspx.

Idaho Department of Environmental Quality, 2014, Idaho EPA actions on proposed standards: Boise, Idaho Department of Environmental Quality, accessed January 16, 2018, at https://www.deq.idaho.gov/epa-actions-on-proposed-standards.

Idaho Department of Environmental Quality, 2016, Water quality—Docket no. 58-0102-1201—Final rule: Boise, Idaho Department of Environmental Quality web page, accessed January 23, 2018, at https://www.deq.idaho.gov/58-0102-1201.

Idaho Department of Environmental Quality [various dates], Rules of the Department of Environmental Quality, IDAPA 58.01.02—Water quality standards": Idaho Department of Environmental Quality web page, accessed June 28, 2018 at http://adminrules.idaho.gov/rules/current/58/index.html.

Idaho Department of Environmental Quality, 2017, Idaho pollutant discharge elimination system—Effluent limit development guidance: Boise, Idaho Department of Environmental Quality, 136 p., accessed May 10, 2018, at https://www.deq.idaho.gov/media/60179928/ipdes-effluent-limit-development-guidance-0417.pdf.

Idaho Department of Fish and Game, 2016, 2016–2018 fishing seasons and rules: Idaho Department of Fish and Game web page, accessed December 20, 2017, at https://fishandgame.idaho.gov/public/fish/rules/.

International Atomic Energy Agency, 2003, Trace elements and methylmercury in fish tissue—Reference sheet IAEA-407: International Atomic Energy Agency web page, accessed January 16, 2018, at https://www.iaea.org/nael/refmaterial/iaea407.pdf.

Lewis, M.E., and Brigham, M.E., 2004, Low-level mercury, book 9, chap. A5, section 5.6.4.B, *of* Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., eds., National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, accessed January 16, 2018, at https://pubs.water.usgs.gov/twri9A5/.

MacCoy, D.E., 2006, Fish communities and related environmental conditions of the lower Boise River, southwestern Idaho, 1974–2004: U.S. Geological Survey Scientific Investigations Report 2006-5111, 36 p., https://pubs.usgs.gov/sir/2006/5111/.

MacCoy, D.E., 2014, Mercury concentrations in water, and mercury and selenium concentrations in fish from Brownlee Reservoir and selected sites in Boise and Snake Rivers, Idaho and Oregon, 2013: U.S. Geological Survey Open-File Report 2014-1099, 26 p., https://dx.doi.org/10.3133/ofr20141099.

Mebane, C.A., and MacCoy, D.E., 2013, Monitoring plan for mercury in fish tissue and water from the Boise River, Snake River, and Brownlee Reservoir, Idaho and Oregon: U.S. Geological Survey Open-File Report 2013-1068, 24 p., https://pubs.usgs.gov/of/2013/1068/.

Peterson, S.A., Ralston, N.V.C., Peck, D.V., Van Sickle, J., Robertson, J.D., Spate, V.L., and Morris, J.S., 2009, How might selenium moderate the toxic effects of mercury in stream fish of the western U.S.?: Environmental Science and Technology, v. 43, no. 10, p. 3919–3925, https://dx.doi.org/10.1021/es803203g.

Richter, T.J., and Chandler, J.A., 2003, Water-level impacts to spawning smallmouth bass, crappie spp., and channel catfish, *in* Richter, T.J., ed., Hells Canyon complex resident fish study (revised 2003): Boise, Idaho, Idaho Power Company, 76 p., accessed January 16, 2018, at https://docs.idahopower.com/pdfs/relicensing/hellscanyon/hellspdfs/techappendices/Aquatic/e31_05_ch05.pdf.

Riva-Murray, K., Bradley, P.M., Scudder Eikenberry, B.C., Knightes, C.D., Journey, C.A., Brigham, M.E., and Button, D.T., 2013, Optimizing stream water mercury sampling for calculation of fish bioaccumulation factors: Environmental Science and Technology, https://dx.doi.org/10.1021/es303758e.

Scudder, B.C., Chasar, L.C., DeWeese, L.R., Brigham, M.E., Wentz, D.A., and Brumbaugh, W.G., 2008, Procedures for collecting and processing aquatic invertebrates and fish for analysis of mercury as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 2008-1208, 34 p., https://pubs.usgs.gov/of/2008/1208/.

Scudder, B.C., Chasar, L.C., Wentz, D.A., Bauch, N.J., Brigham, M.E., Moran, P.W., and Krabbenhoft, D.P., 2009, Mercury in fish, bed sediment, and water from streams across the United States, 1998–2005: U.S. Geological Survey Scientific Investigations Report 2009–5109, 74 p., https://pubs.usgs.gov/sir/2009/5109/.

Scudder Eikenberry, B.C. Riva-Murray, K., Knightes, C.D., Journey, C.A., Chasar, L.C., Brigham, M.E., and Bradley, P.M., 2015, Optimizing fish sampling for fish–mercury bioaccumulation factors: Chemosphere, v. 135, p. 467-473, https://doi.org/10.1016/j.chemosphere.2014.12.068.
U.S. Environmental Protection Agency, 2001, Water quality criterion for the protection of human health—Methylmercury: U.S. Environmental Protection Agency, EPA-823-R-01-001, 303 p., accessed January 16, 2018, at https://www.epa.gov/wqc/human-health-criteria-methylmercury.
U.S. Environmental Protection Agency, 2002, Method 1631, Revision E—Mercury in water by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry: U.S. Environmental Protection Agency, EPA-821-R-02-019, 38 p., accessed January 9, 2018, at https://www.nemi.gov/methods/method_summary/9628/.
U.S. Environmental Protection Agency, 2007, Mercury in solids and solutions by thermal decomposition, amalgamation, and atomic absorption spectrophotometry: U.S. Environmental Protection Agency, EPA Method 7473 (SW-846), accessed January 16, 2018, at https://www.epa.gov/sites/production/files/2015-12/documents/7473.pdf.
U.S. Environmental Protection Agency, 2010, Guidance for implementing the January 2001 methylmercury water quality criteria: U.S. Environmental Protection Agency, EPA-823-R-10-001, 221 p., accessed January 16, 2018, at https://www.epa.gov/wqc/guidance-implementing-january-2001-methylmercury-water-quality-criterion.
U.S. Environmental Protection Agency, 2012b, Authorization to discharge under the National Pollutant Discharge Elimination System—Lander Street Wastewater Treatment Facility, City of Boise: U.S. Environmental Protection Agency, Permit No.: ID-002044-3, 53 p., accessed January 16, 2018, at https://www.epa.gov/npdes-permits/idaho-npdes-permits.
U.S. Environmental Protection Agency, 2012c, Authorization to discharge under the National Pollutant Discharge Elimination System—West Boise wastewater treatment facility, city of Boise: U.S. Environmental Protection Agency, Permit No. ID-002044-3, 52 p., accessed January 16, 2018, at https://www.epa.gov/npdes-permits/idaho-npdes-permits.
U.S. Environmental Protection Agency, 2012a, National Pollutant Discharge Elimination System (NPDES): U.S. Environmental Protection Agency web page, accessed January 16, 2018, at https://www.epa.gov/npdes.
U.S. Environmental Protection Agency, 2014, Estimated fish consumption rates for the U.S. population and selected subpopulations (NHANES 2003-2010): U.S. Environmental Protection Agency, EPA -820-R-14-002, 110 p., accessed January 16, 2018, at https://www.epa.gov/sites/production/files/2015-01/documents/fish-consumption-rates-2014.pdf.
U.S. Environmental Protection Agency, 2015, Human health ambient water quality criteria—2015 update: U.S. Environmental Protection Agency, Office of Water, EPA 820-F-15-001, 3 p., accessed January 11, 2018, at https://www.epa.gov/wqc/2015-epa-updated-ambient-water-quality-criteria-protection-human-health.
U.S. Environmental Protection Agency, 2016, Aquatic life ambient water quality criterion for selenium—Freshwater 2016: U.S. Environmental Protection Agency, 822-R-16-006, accessed February 21, 2018, at https://www.epa.gov/wqc/aquatic-life-criterion-selenium.
U.S. Geological Survey, 2017a, USGS Mercury Research Laboratory: U.S. Geological Survey Mercury Research Laboratory web page, accessed December 20, 2017, at https://wi.water.usgs.gov/mercury-lab/index.html.

U.S. Geological Survey, 2017b, USGS Water-quality for Idaho: U.S. Geological Survey National Water Information System web page, accessed December 20, 2017, at https://waterdata.usgs.gov/id/nwis/qw.

Wilde, F.D., ed., 2006, Collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap A4 (v. 2.0), 231 p., accessed January 16, 2018, at https://water.usgs.gov/owq/FieldManual/chapter4/html/Ch4_contents.html.

Williams, M.L., and MacCoy, D.E., 2016, Mercury concentrations in water and mercury and selenium concentrations in fish from Brownlee Reservoir and selected sites in the Boise and Snake Rivers, Idaho and Oregon, 2013–15: U.S. Geological Survey Open-File Report 2016–1098, 29 p., https://dx.doi.org/10.3133/ofr20161098.

Yang, D.-Y., Chen, Y.-W., Gunn, J.M., and Belzile, N., 2008, Selenium and mercury in organisms—Interactions and mechanisms: Environmental Reviews, v. 16, p. 71–92, https://dx.doi.org/10.1139/A08-001.

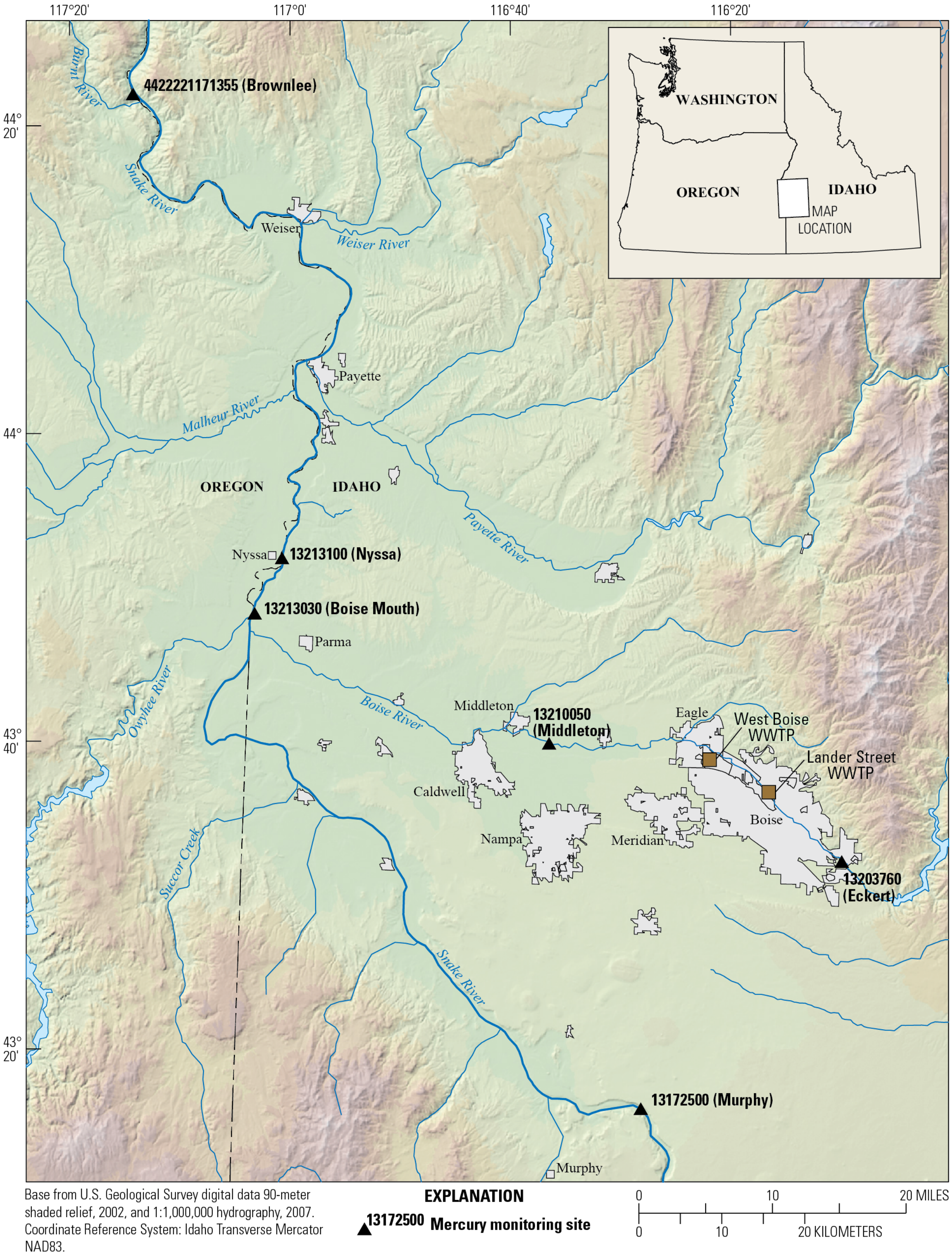


Figure 1. Location of sites where water and fish tissue samples were collected for analysis of total mercury and selenium, Idaho and Oregon, 2013–17. Gray shading indicates urban areas.

Figure 2. Channel catfish (*A*) and smallmouth bass (*B*) at the Snake River near Murphy sampling site, Idaho, October 2013. (Photographs by Dorene MacCoy, U.S. Geological Survey).

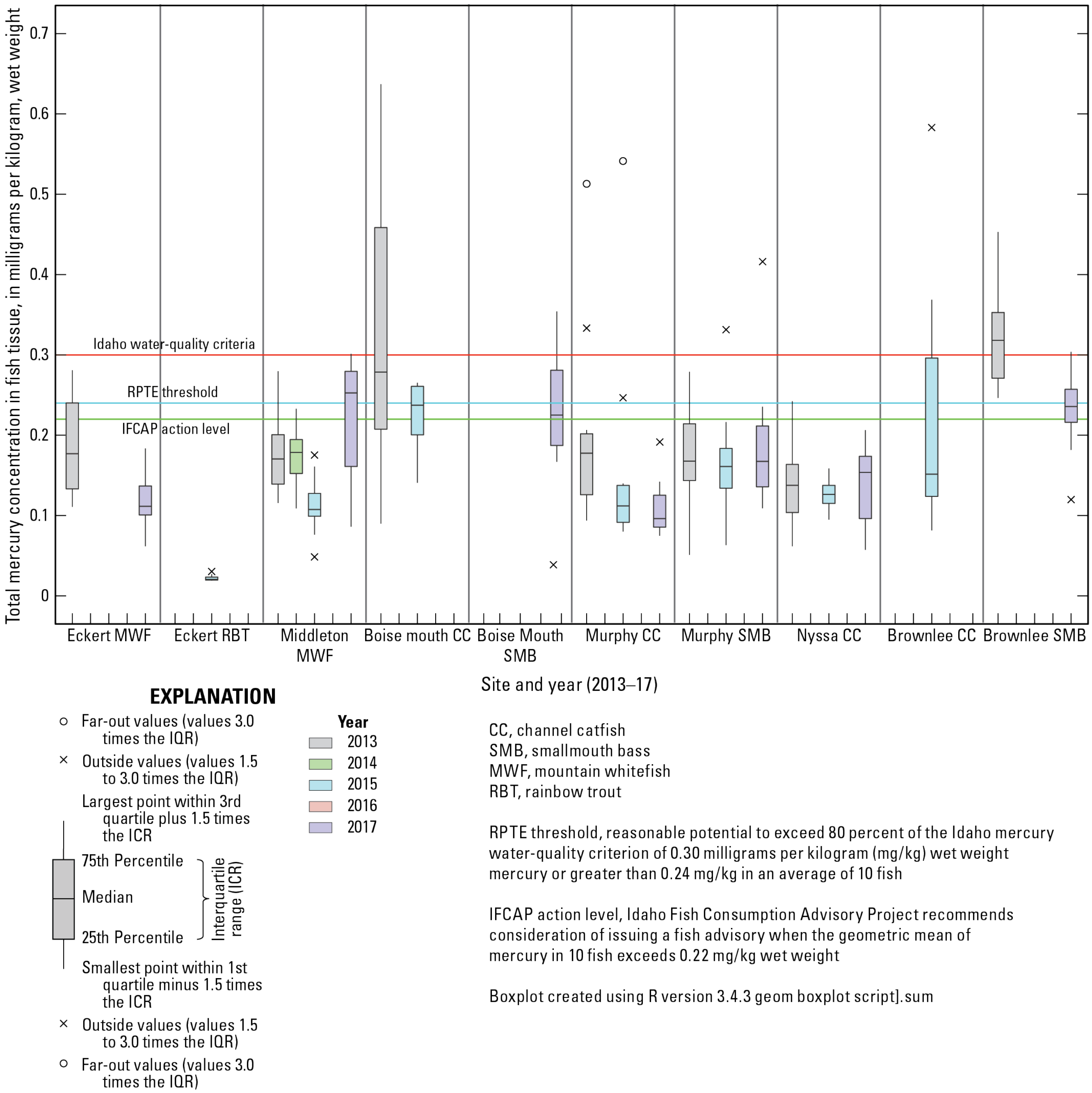


Figure 3. Total mercury concentrations in fish tissue collected from sites in the Boise and Snake Rivers and Brownlee Reservoir, Idaho and Oregon, October 2013–17. Site names are shown in table 1.

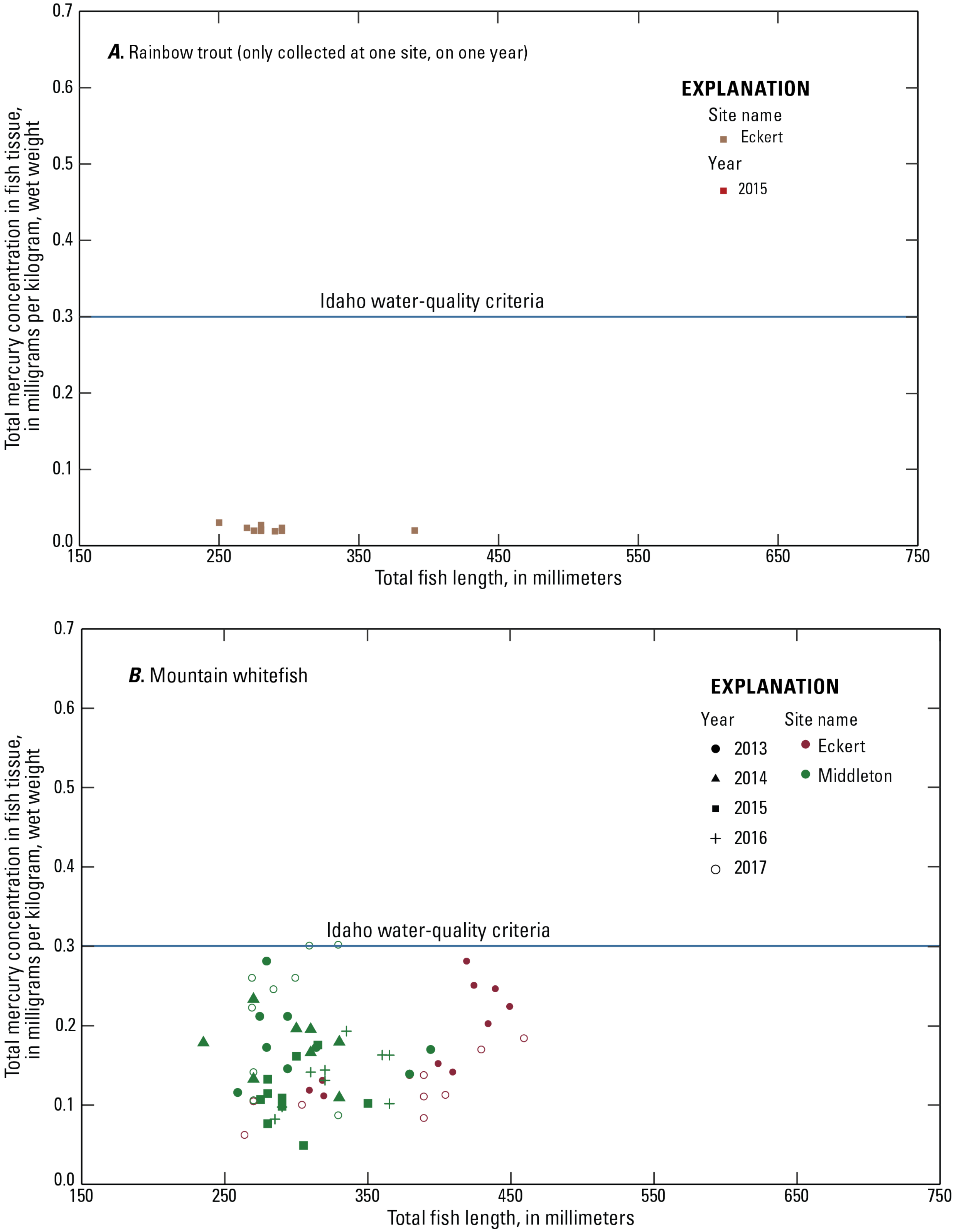
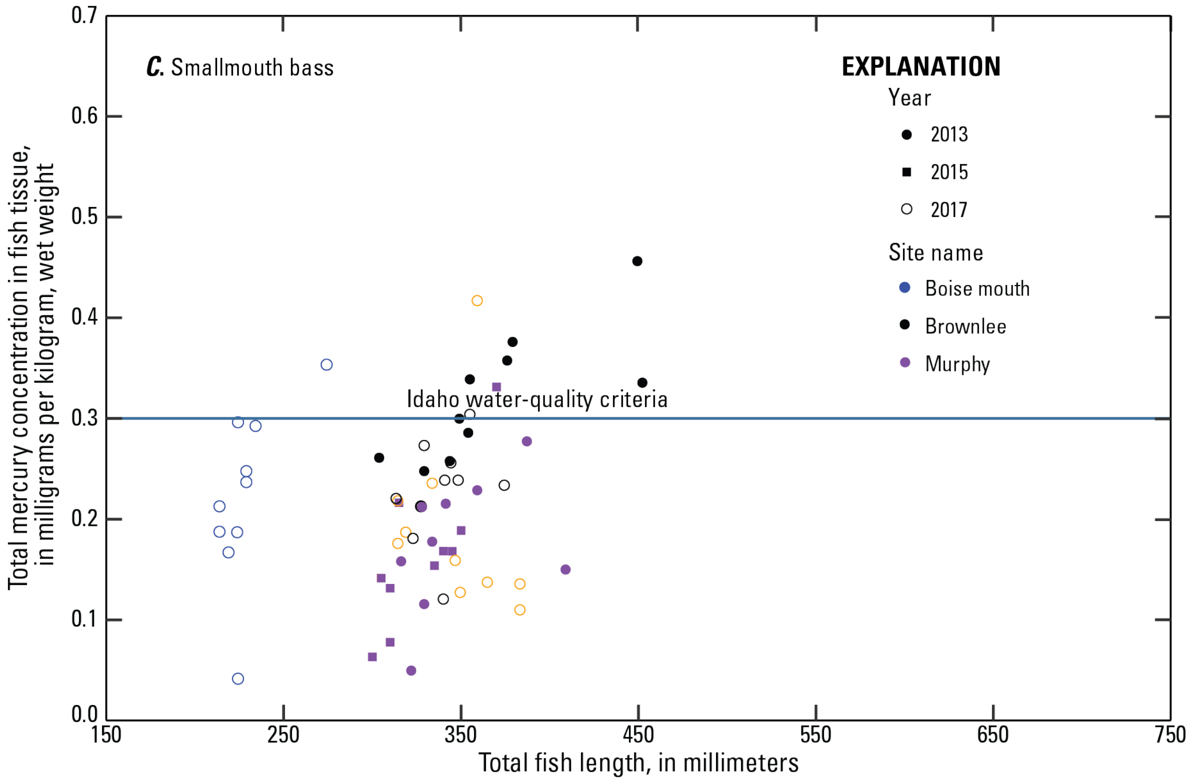


Figure 4. Total mercury tissue concentrations and total length of rainbow trout (*A*), mountain whitefish (*B*), smallmouth bass (*C*), and channel catfish (*D*) in samples from the Boise and Snake Rivers and Brownlee Reservoir, Idaho and Oregon, 2013–17.



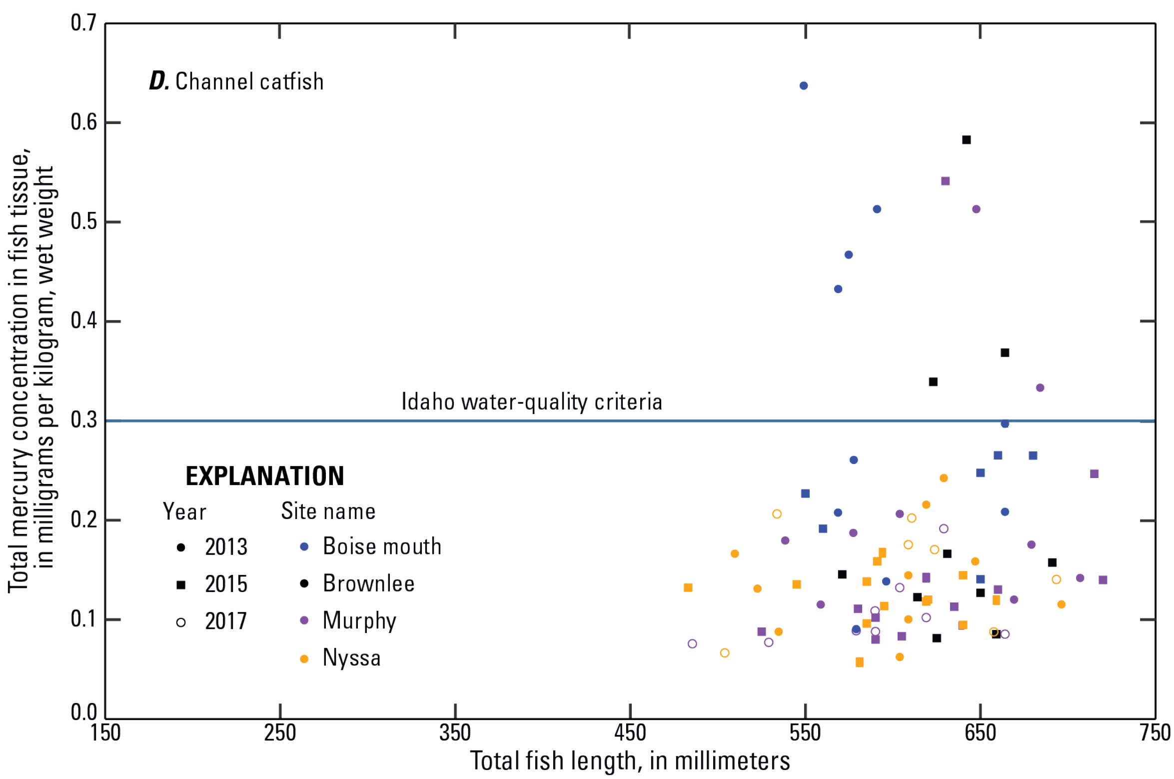


Figure 4.—Continued.

Table 1. Sites in the Boise and Snake Rivers and Brownlee Reservoir where water and fish samples were collected for mercury analysis, Idaho and Oregon, 2013–17.

[Site locations are shown in figure 1. NAD83, North American Datum of 1983]

USGS site identification	Site name	Site short name	Decimal latitude (NAD83)	Decimal longitude (NAD83)
13203760	Boise River at Eckert Road, near Boise, Idaho	Eckert	43.56572	-116.13205
13210050	Boise River near Middleton, Idaho	Middleton	43.68488	-116.57374
13213030	Boise River at mouth, near Parma, Idaho	Boise mouth	43.81516	-117.02043
13172500	Snake River near Murphy, Idaho	Murphy	43.29183	-116.42094
13213100	Snake River at Nyssa, Oregon	Nyssa	43.87611	-116.9825
4422221171355	Brownlee Reservoir at Burnt River, Oregon	Brownlee	44.37266	-117.23295

Table 2. Targeted fish species in the Boise and Snake Rivers and Brownlee Reservoir, Idaho and Oregon.

[Site locations are shown in figure 1. Full site names are listed in table 1. Species in bold were collected at sites for tissue analysis]

USGS site identification	Site short name	Expected species
13203760	Eckert	**Mountain whitefish** (*Prosopium williamsoni*), brown trout (*Salmo trutta*), **rainbow trout** (*Oncorhynchus mykiss*)
13210050	Middleton	**Mountain whitefish**, brown trout, largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*)
13213030	Boise mouth	Mountain whitefish, largemouth bass, smallmouth bass, **channel catfish** (*Ictalurus punctatus*)
13172500	Murphy	**Smallmouth bass**, largemouth bass, **channel catfish**
13213100	Nyssa	Smallmouth bass, mountain whitefish, largemouth bass, **channel catfish**
4422221171355	Brownlee	**Smallmouth bass**, crappie spp. (*Pomoxis* sp.), largemouth bass, **channel catfish**

Table 3. Quality-control sample results for analysis of total mercury in fish from the Boise and Snake Rivers and Brownlee Reservoir, Idaho and Oregon, October 2013–17.

[Certified reference material from the International Atomic Energy Agency, laboratory identification number beginning with IAEA (2003); a description of IAEA-407 is available at http://www.iaea.org/nael/refmaterial/iaea407.pdf. Triplicate samples from a single fish at a sampling site (laboratory identification samples beginning with MSC) were analyzed separate from the original sample for laboratory method repeatability (precision) and reported as relative standard deviation (RSD), RSD = Standard deviation of the three replicate concentrations divided by the average of those replicates. **Abbreviation**: ng/g, nanogram per gram]

Laboratory identification	Date of analysis	Mercury, ng/g dry weight	Laboratory detection limit, ng/g dry weight	Certified reference material percent recovery
IAEA-407	2/18/2014	213	2.99	96
IAEA-407	2/18/2014	221	3.4	99.6
IAEA-407	2/18/2014	224	3.56	101
IAEA-407	2/18/2014	240	4.22	108
IAEA-407	2/18/2014	246	3.48	111
IAEA-407	2/18/2014	238	2.46	107
IAEA-407	2/19/2014	236	5.31	106
IAEA-407	2/19/2014	248	6.1	112
IAEA-407	2/19/2014	248	4.63	112
IAEA-407	2/19/2014	247	6.02	111
IAEA-407	2/19/2014	249	6.45	112
IAEA-407	2/19/2014	248	7.3	112
IAEA-407	2/19/2014	244	6.57	110
IAEA-407	2/19/2014	250	6.39	113
IAEA-407	2/19/2014	248	5.95	112
IAEA-407	2/20/2014	237	10.5	107
IAEA-407	2/20/2014	247	7.72	111
IAEA-407	2/20/2014	247	10.5	111
IAEA-407	2/20/2014	254	7.02	114
IAEA-407	2/20/2014	255	11.3	115
IAEA-407	2/21/2014	249	5.68	112
IAEA-407	2/21/2014	242	3.91	109
IAEA-407	2/21/2014	240	4.51	108
IAEA-407	2/21/2014	245	4.29	110
IAEA-407	2/24/2014	238	4.73	107
IAEA-407	2/24/2014	242	4.59	109
IAEA-407	2/24/2014	251	4.99	113
IAEA-407	1/26/2015	231	4.21	104
IAEA-407	1/26/2015	242	4.4	109

Laboratory identification	Date of analysis	Mercury, ng/g dry weight	Laboratory detection limit, ng/g dry weight	Certified reference material percent recovery
IAEA-407	1/26/2015	236	4.18	106
IAEA-407	1/26/2015	246	5.61	111
IAEA-407	11/9/2015	214	14.3	96.5
IAEA-407	11/9/2015	216	15.9	97.4
IAEA-407	11/9/2015	219	17.3	98.5
IAEA-407	11/9/2015	223	13.1	100
IAEA-407	11/9/2015	221	14.5	99.6
IAEA-407	11/10/2015	218	3.83	98.4
IAEA-407	11/10/2015	235	4.03	106
IAEA-407	11/10/2015	230	2.89	104
IAEA-407	11/10/2015	229	3.2	103
IAEA-407	11/10/2015	225	3.01	102
IAEA-407	11/11/2015	213	3.61	95.8
IAEA-407	11/11/2015	238	5.93	107
IAEA-407	11/11/2015	229	5.11	103
IAEA-407	11/11/2015	228	4.52	103
IAEA-407	11/11/2015	225	5.06	101
IAEA-407	11/13/2015	215	1.33	96.9
IAEA-407	11/13/2015	229	0.88	103
IAEA-407	11/13/2015	232	1.1	104
IAEA-407	11/13/2015	219	1.11	98.5
IAEA-407	2/21/2017	218	2.47	98
IAEA-407	2/21/2017	222	2.31	100
IAEA-407	2/21/2017	223	1.94	101
IAEA-407	2/21/2017	226	2.12	102
IAEA-407	12/14/2017	201	17.51	91
IAEA-407	12/14/2017	203	14.79	91
IAEA-407	12/14/2017	212	17.51	95
IAEA-407	12/14/2017	215	16.40	97
IAEA-407	12/14/2017	218	15.55	98
IAEA-407	12/14/2017	221	21.22	100
IAEA-407	12/15/2017	202	12.78	91
IAEA-407	12/15/2017	209	16.73	94
IAEA-407	12/15/2017	216	15.65	97
IAEA-407	12/15/2017	199	13.91	90
IAEA-407	12/18/2017	220	16.28	99
IAEA-407	12/18/2017	207	15.72	93

Laboratory identification	Date of analysis	Mercury, ng/g dry weight	Laboratory detection limit, ng/g dry weight	Certified reference material percent recovery
IAEA-407	12/18/2017	206	14.46	93
IAEA-407	12/18/2017	217	15.00	98
IAEA-407	12/18/2017	219	16.89	99
IAEA-407	12/18/2017	216	14.70	97

Laboratory identification	Date of analysis	Mercury, ng/g dry weight	Laboratory detection limit, ng/g dry weight	Triplicate relative standard deviation (percent)
MSC568T	2/18/2014	957	4.1	1.1
MSC568T	2/18/2014	975	3.88	
MSC568T	2/18/2014	976	4.1	
MSC718T	2/18/2014	929	4.42	1.43
MSC718T	2/18/2014	956	4.04	
MSC718T	2/18/2014	948	3.83	
MSC299T	2/19/2014	714	10.1	1.2
MSC299T	2/19/2014	697	8.92	
MSC299T	2/19/2014	704	6.69	
MSC565T	2/19/2014	1,215	12.14	0.91
MSC565T	2/19/2014	1,227	12.9	
MSC565T	2/19/2014	1,237	11.38	
MSC887T	2/19/2014	328	8.35	4.39
MSC887T	2/19/2014	351	7.34	
MSC887T	2/19/2014	357	13.38	
MSC891T	2/20/2014	3,035	13.03	3.27
MSC891T	2/20/2014	3,173	15.12	
MSC891T	2/20/2014	3,237	15.57	
MSC726T	2/21/2014	626	5.71	2.4
MSC726T	2/21/2014	656	5.15	
MSC726T	2/21/2014	648	5.78	
MSC730T	2/21/2014	982	7.45	2.08
MSC730T	2/21/2014	1,020	7.73	
MSC730T	2/21/2014	988	6.37	
MSC675X	1/26/2015	433	7.36	0.46
MSC675X	1/26/2015	435	7.5	
MSC675X	1/26/2015	431	7.5	
MSC147AA	11/9/2015	352	19.98	1.32

Laboratory identification	Date of analysis	Mercury, ng/g dry weight	Laboratory detection limit, ng/g dry weight	Triplicate relative standard deviation (percent)
MSC147AA	11/9/2015	361	17.96	
MSC147AA	11/9/2015	361	20.19	
MSC188AA	11/9/2015	462	17.79	0.88
MSC188AA	11/9/2015	460	19.36	
MSC188AA	11/9/2015	454	18.31	
MSC167AA	11/10/2015	3,078	14.00	1.17
MSC167AA	11/10/2015	3,010	11.09	
MSC167AA	11/10/2015	3,024	16.11	
MSC196AA	11/10/2015	90.3	3.71	1.89
MSC196AA	11/10/2015	86.9	3.62	
MSC196AA	11/10/2015	88.6	4.59	
MSC137AA	11/11/2015	1,131	18.95	4.38
MSC137AA	11/11/2015	1,234	8.28	
MSC137AA	11/11/2015	1,176	12.14	
MSC160AA	11/11/2015	444	5.13	1.52
MSC160AA	11/11/2015	457	6.41	
MSC160AA	11/11/2015	447	4.74	
MSC186AA	11/13/2015	354	2.42	2.51
MSC186AA	11/13/2015	339	2.22	
MSC186AA	11/13/2015	354	2.61	
MSC794AC	2/21/2017	483	2.35	0.46
MSC794AC	2/21/2017	480	2.37	
MSC794AC	2/21/2017	479	2.14	
MSC231AG	12/14/2017	810	17.69	0.16
MSC231AG	12/14/2017	811	17.18	
MSC231AG	12/14/2017	808	15.10	
MSC232AG	12/14/2017	585	16.86	1.00
MSC232AG	12/14/2017	576	15.55	
MSC232AG	12/14/2017	574	14.20	
MSC271AG	12/14/2017	265	22.98	1.51
MSC271AG	12/14/2017	257	15.82	
MSC271AG	12/14/2017	262	22.69	
MSC269AG	12/15/2017	317	17.45	0.79
MSC269AG	12/15/2017	321	17.20	
MSC269AG	12/15/2017	317	15.58	
MSC284AG	12/15/2017	1,359	15.32	1.15
MSC284AG	12/15/2017	1,330	16.35	

Laboratory identification	Date of analysis	Mercury, ng/g dry weight	Laboratory detection limit, ng/g dry weight	Triplicate relative standard deviation (percent)
MSC284AG	12/15/2017	1,335	16.28	
MSC229AG	12/18/2017	467	17.30	0.63
MSC229AG	12/18/2017	472	19.33	
MSC229AG	12/18/2017	467	16.82	
MSC248AG	12/18/2017	1,254	17.99	0.69
MSC248AG	12/18/2017	1,258	18.73	
MSC248AG	12/18/2017	1,270	16.43	
MSC260AG	12/18/2017	536	17.64	0.60
MSC260AG	12/18/2017	532	16.97	
MSC260AG	12/18/2017	530	16.07	

Table 4. Total mercury concentrations in water from the Boise and Snake Rivers and Brownlee Reservoir and associated field blanks and laboratory matrix spike recovery for samples collected in October and November, 2013–17.

[Site locations are shown in figure 1. Full site names are listed in table 1. Samples collected by City of Boise personnel and analyzed by Boise City Public Works Water Quality Laboratory, Boise, Idaho. Results of matrix spike duplicates are reported as relative percent difference (RPD), where {(x1 – x2)/[x1 + x2)/2]100, and x = sample concentration. **Total mercury concentration:** Environmental Protection Agency total mercury chronic aquatic life criteria for Idaho is 12 ng/L (Idaho Department of Environmental Quality, various dates). **Abbreviations:** ng/L, nanogram per liter; µg/L, microgram per liter; <, less than; –, no data]

Field blanks					
USGS site identification	Site name	Sample date	Sample time	Total mercury concentration (ng/L)	Trip blank concentration (ng/L)
13203760	Eckert	11/1/2013	0937	0.73	0.22
13210050	Middleton	11/1/2013	1057	0.89	<0.20
13213030	Boise mouth	11/1/2013	1221	1.2	0.70
13172500	Murphy	10/28/2013	1515	0.93	<0.20
13213100	Nyssa	10/28/2013	1323	1.2	<0.20
4422221171355	Brownlee	10/28/2013	1138	8.8	<0.20
13210050	Middleton	10/23/2014	1055	1.2	<0.20
13203760	Eckert	10/7/2015	0945	0.77	–
13210050	Middleton	10/7/2015	1047	1.1	–
13213030	Boise mouth	10/7/2015	1131	1.6	<0.20
13172500	Murphy	10/12/2015	1455	0.48	<0.20
13213100	Nyssa	10/12/2015	1329	0.61	–
4422221171355	Brownlee	10/12/2015	1155	0.71	–
13203760	Eckert	10/12/2017	0914	1.13	<0.20
13210050	Middleton	10/12/2017	1549	1.35	<0.20
13213030	Boise mouth	10/12/2017	1045	1.48	<0.20
13172500	Murphy	10/12/2017	1703	0.41	<0.20
13213100	Nyssa	10/12/2017	1120	1.04	<0.20
4422221171355	Brownlee	10/12/2017	1330	1.86	<0.20

Table 4. Total mercury concentrations in water from the Boise and Snake Rivers and Brownlee Reservoir and associated field blanks and laboratory matrix spike recovery for samples collected in October and November, 2013–17.—Continued

Matrix spike recoveries						
Lab sample ID	**Date of analysis**	**Sample type**	**Total mercury spike concentration (ng/L)**	**Matrix spike, percent recovery**	**Recovery concentration**	**Relative percent difference**
AP07402-F3HG3 LFB	11/12/2013	Blank spike	5	106	5.28	3.7
AP07402-R3HG3 MS	11/12/2013	Matrix spike	5	101	5.81	10.3
MSD	11/12/2013	Matrix spike duplicate	5	99	5.69	8.8
AP07406-F3HG3 LFB	11/12/2013	Blank spike	5	106	5.28	3.7
AP07406-R3HG3 MS	11/12/2013	Matrix spike	5	93	5.86	10.8
MSD	11/12/2013	Matrix spike duplicate	5	100	6.21	14.9
AQ07919-F3HG3 LFB	10/30/2014	Blank spike	5	99	4.97	0.4
AQ07919-R3HG3 MS	10/30/2014	Matrix spike	5	98	6.18	14.6
MSD	10/30/2014	Matrix spike duplicate	5	89	5.70	8.9
B5J0813-BS1	10/8/2015	Blank spike	10	100	10.00	0.0
B5J0813-MS1	10/8/2015	Matrix spike	10	94	12.10	13.1
B5J0813-MSD1	10/8/2015	Matrix spike duplicate	10	99	12.50	15.4
B5J1214-BS1	10/12/2015	Blank spike	10	98	9.80	1.3
B5J1214-MS1	10/12/2015	Matrix spike	10	95	10.20	1.3
B5J1214-MSD1	10/12/2015	Matrix spike duplicate	10	95	10.20	1.3
B7J606-BS1	10/16/2017	Blank spike	5	99	4.95	0.7
B7J1606-MS1	10/16/2017	Matrix spike	5	95	6.58	19.1
B7J1606-MSD1	10/16/2017	Matrix spike duplicate	5	94	6.55	18.7
B7J1606-MS2	10/16/2017	Matrix spike	5	98	6.04	13.0
B7J1606-MSD2	10/16/2017	Matrix spike duplicate	5	96	5.94	11.8

Table 5. Individual sport fish tissue total mercury concentrations, fish size data, and statistical site summaries in samples collected from the Boise and Snake Rivers and Brownlee Reservoir, Idaho and Oregon, October 2013–17.

[Site locations are shown in figure 1. **Abbreviations:** g, gram; mm, millimeter; mg/kg, milligram per kilogram]

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
					Mountain whitefish						
Boise River at Eckert Road, near Boise, Idaho	10/29/2013	1001	440	959	0.975	74.8	25.2	0.25	0.18	0.18	0.19
		1002	420	626	1.19	76.4	23.6	0.28			
		1003	450	850	0.94	76.2	23.8	0.22			
		1004	400	702	0.507	70.1	29.9	0.15			
		1005	425	699	0.851	70.6	29.4	0.25			
		1006	435	866	0.626	67.7	32.3	0.20			
		1007	410	636	0.58	75.7	24.3	0.14			
		1008	320	360	0.436	74.6	25.4	0.11			
		1009	310	330	0.418	71.6	28.4	0.12			
		1010	320	315	0.498	73.8	26.2	0.13			
	10/12/2017	1145	405	636	0.529	78.8	21.2	0.11	0.11	0.11	0.12
		1146	390	604	0.467	76.3	23.7	0.11			
		1147	380	501	0.577	76.4	23.6	0.14			
		1148	430	697	0.746	77.3	22.7	0.17			
		1149	305	279	0.419	76.2	23.8	0.10			
		1150	390	637	0.352	76.5	23.5	0.08			
		1151	460	803	0.904	79.7	20.3	0.18			
		1152	390	484	0.612	77.6	22.4	0.14			
		1153	270	169	0.414	75.0	25.0	0.10			
		1154	265	150	0.266	76.8	23.2	0.06			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
Rainbow trout											
Boise River at Eckert Road, near Boise, Idaho	10/5/2015	931	390	238	0.088	77.3	22.7	0.02	0.02	0.02	0.02
		932	280	261	0.124	78.1	21.9	0.03			
		933	250	147	0.15	79.8	20.2	0.03			
		934	270	184	0.113	79.3	20.7	0.02			
		935	295	255	0.112	79.1	20.9	0.02			
		936	290	234	0.089	78.6	21.4	0.02			
		937	280	236	0.089	78.0	22.0	0.02			
		938	275	190	0.1	80.2	19.8	0.02			
		939	295	235	0.094	79.1	20.9	0.02			
		940	280	225	0.1	78.8	21.2	0.02			
Mountain whitefish											
Boise River near Middleton, Idaho	10/21/2013	1201	380	491	0.527	74.0	26.0	0.14	0.17	0.17	0.17
		1202	280	182	1.08	74.1	25.9	0.28			
		1203	395	506	0.652	74.0	26.0	0.17			
		1204	295	217	0.948	77.8	22.2	0.21			
		1205	315	321	0.708	75.8	24.2	0.17			
		1206	280	207	0.783	78.1	21.9	0.17			
		1207	280	186	0.534	74.9	25.1	0.13			
		1208	295	211	0.625	76.8	23.2	0.15			
		1209	275	190	0.906	76.7	23.3	0.21			
		1210	260	149	0.433	73.3	26.7	0.12			
	10/23/2014	1131	330	340	0.432	74.8	25.2	0.11	0.17	0.18	0.17
		1132	135	250	0.76	74.5	25.5	0.19			
		1133	310	279	0.684	71.5	28.5	0.19			
		1134	300	257	0.768	74.5	25.5	0.20			
		1135	270	180	0.49	73.0	27.0	0.13			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
		1136	270	179	0.943	75.3	24.7	0.23			
		1137	330	382	0.694	74.2	25.8	0.18			
		1138	135	259	0.589	74.9	25.1	0.15			
		1139	235	300	0.659	73.0	27.0	0.18			
		1140	310	259	0.6	72.4	27.6	0.17			
	10/5/2015	1301	300	296	0.691	76.7	23.3	0.16	0.11	0.11	0.11
		1302	315	308	0.709	75.3	24.7	0.18			
		1303	280	205	0.318	76.1	23.9	0.08			
		1304	275	215	0.456	76.6	23.4	0.11			
		1305	290	247	0.45	75.9	24.1	0.11			
		1306	290	221	0.438	77.6	22.4	0.10			
		1307	305	286	0.219	77.8	22.2	0.05			
		1308	280	231	0.572	76.9	23.1	0.13			
		1309	350	405	0.41	75.2	24.8	0.10			
		1310	280	215	0.447	74.5	25.5	0.11			
	10/5/2016	1005	365	494	0.578	71.9	28.1	0.16	0.13	0.14	0.13
		1010	360	430	0.600	72.9	27.1	0.16			
		1015	335	350	0.884	78.2	21.8	0.19			
		1020	320	298	0.606	76.3	23.7	0.14			
		1025	340	376	0.538	74.0	26.0	0.14			
		1030	365	460	0.480	78.9	21.1	0.10			
		1035	320	350	0.549	76.2	23.8	0.13			
		1040	310	300	0.613	77.0	23.0	0.14			
		1045	285	222	0.312	73.8	26.2	0.08			
		1050	290	250	0.382	76.1	23.9	0.09			
	10/19/2017	930	270	181	0.937	76.3	23.7	0.22	0.20	0.25	0.22

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
		931	330	310	1.310	77.0	23.0	0.30			
		932	300	226	1.150	77.4	22.6	0.26			
		933	310	248	1.340	77.6	22.4	0.30			
		934	270	167	0.642	78.1	21.9	0.14			
		935	330	298	1.260	77.3	22.7	0.29			
		936	330	333	0.384	77.6	22.4	0.09			
		937	285	201	1.120	78.1	21.9	0.25			
		938	270	158	0.461	77.5	22.5	0.10			
		939	270	163	1.160	77.6	22.4	0.26			
Channel catfish											
Boise River at mouth, near Parma, Idaho	10/21/2013	1501	665	3,485	1.58	81.2	18.8	0.30	0.28	0.28	0.33
		1502	580	2,086	0.35	74.3	25.7	0.09			
		1503	570	1,595	2.23	80.6	19.4	0.43			
		1504	550	1,211	3.17	79.9	20.1	0.64			
		1505	665	3,080	1.08	80.7	19.3	0.21			
		1506	592	2,245	2.33	78.0	22.0	0.51			
		1507	578	2,017	1.25	79.2	20.8	0.26			
		1508	569	2,007	1.02	79.7	20.3	0.21			
		1509	575	1,785	2.29	79.6	20.4	0.47			
		1510	597	2,326	0.644	78.4	21.6	0.14			
	10/7/2015	1101	650	3,000	1.18	79.0	21.0	0.25	0.22	0.24	0.23
		1102	680	4,100	1.36	80.5	19.5	0.27			
		1103	550	2,800	1.22	81.4	18.6	0.23			
		1104	650	3,800	0.729	80.7	19.3	0.14			
		1105	660	2,500	1.32	79.9	20.1	0.27			
		1106	560	2,000	0.939	79.6	20.4	0.19			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
					Smallmouth bass						
Boise River at mouth, near Parma, Idaho	10/18/2017	1001	225	159	0.185	77.6	22.4	0.04	0.20	0.23	0.22
		1002	225	150	1.44	79.4	20.6	0.30			
		1003	235	175	1.34	78.2	21.8	0.29			
		1004	275	284	1.64	78.4	21.6	0.35			
		1005	230	144	1.09	77.3	22.7	0.25			
		1006	215	118	0.876	78.6	21.4	0.19			
		1007	215	121	0.989	78.5	21.5	0.21			
		1008	230	154	1.11	78.6	21.4	0.24			
		1009	220	141	0.783	78.7	21.3	0.17			
		1010	225	136	0.886	78.9	21.1	0.19			
					Smallmouth bass						
Snake River near Murphy, Idaho	10/22/2013	1001	330	557	0.517	77.6	22.4	0.12	0.16	0.17	0.17
		1002	388	906	1.28	78.2	21.8	0.28			
		1003	305	442	0.64	77.9	22.1	0.14			
		1004	410	1,108	0.659	77.3	22.7	0.15			
		1005	342	661	0.918	76.6	23.4	0.21			
		1006	323	441	0.219	76.7	23.3	0.05			
		1007	360	689	1.03	77.9	22.1	0.23			
		1008	329	596	0.953	77.7	22.3	0.21			
		1009	335	535	0.788	77.5	22.5	0.18			
		1010	317	457	0.696	77.3	22.7	0.16			
	10/8/2015	1201	370	682	1.57	78.9	21.1	0.33	0.15	0.16	0.16
		1202	345	693	0.775	78.3	21.7	0.17			
		1203	340	581	0.772	78.2	21.8	0.17			
		1204	335	504	0.758	79.7	20.3	0.15			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
		1205	310	475	0.36	78.4	21.6	0.08			
		1206	350	612	0.925	79.6	20.4	0.19			
		1207	305	339	0.664	78.7	21.3	0.14			
		1208	310	412	0.623	78.9	21.1	0.13			
		1209	315	381	1.04	79.2	20.8	0.22			
		1210	300	334	0.302	79.1	20.9	0.06			
	10/11/2017	1056	360	625	2.03	79.5	20.5	0.42	0.18	0.17	0.19
		1057	320	487	0.84	77.9	22.1	0.19			
		1058	348	675	0.75	78.7	21.3	0.16			
		1059	384	967	0.478	77.2	22.8	0.11			
		1100	384	844	0.625	78.4	21.6	0.14			
		1101	366	709	0.66	79.1	20.9	0.14			
		1102	316	408	1.01	78.2	21.8	0.22			
		1103	335	543	1.08	78.2	21.8	0.24			
		1104	350	670	0.576	78.0	22.0	0.13			
		1105	315	550	0.81	78.4	21.6	0.17			
Channel catfish											
Snake River near Murphy, Idaho	10/22/2013	1201	540	1,747	0.889	79.8	20.2	0.18	0.18	0.18	0.21
		1202	578	1,841	0.898	79.1	20.9	0.19			
		1203	670	2,663	0.568	78.8	21.2	0.12			
		1204	648	2,526	2.7	81.0	19.0	0.51			
		1205	708	3,880	0.648	78.1	21.9	0.14			
		1206	560	1,717	0.536	78.6	21.4	0.11			
		1207	685	3,526	1.65	79.8	20.2	0.33			
		1208	640	2,715	0.446	79.0	21.0	0.09			
		1209	605	2,496	0.988	79.1	20.9	0.21			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
		1210	680	3,017	0.853	79.4	20.6	0.18			
	10/8/2015	1101	630	2,802	2.68	79.8	20.2	0.54	0.13	0.11	0.16
		1102	590	2,410	0.46	77.8	22.2	0.10			
		1103	605	2,715	0.391	78.7	21.3	0.08			
		1104	590	2,614	0.354	77.4	22.6	0.08			
		1105	580	1,932	0.516	78.5	21.5	0.11			
		1106	635	2,996	0.505	77.6	22.4	0.11			
		1107	720	4,902	0.651	78.5	21.5	0.14			
		1108	715	4,341	1.24	80.1	19.9	0.25			
		1109	660	3,367	0.606	78.5	21.5	0.13			
		1110	525	1,624	0.409	78.5	21.5	0.09			
	10/11/2017	1030	530	1,420	0.306	74.7	25.3	0.08	0.10	0.10	0.11
		1031	487	1,120	0.317	76.4	23.6	0.07			
		1032	590	2,184	0.383	72.5	27.5	0.11			
		1033	605	2,089	0.452	70.8	29.2	0.13			
		1034	620	2,755	0.384	63.0	37.0	0.14			
		1035	590	2,051	0.297	70.0	30.0	0.09			
		1036	580	2,385	0.333	73.8	26.2	0.09			
		1037	630	2,725	1.03	81.4	18.6	0.19			
		1038	665	3,367	0.288	70.5	29.5	0.08			
		1039	620	2,561	0.378	72.7	27.3	0.10			
Channel catfish											
Snake River at Nyssa, Oregon	10/22/2013	1331	535	1,409	0.33	73.4	26.6	0.09	0.13	0.14	0.14
		1332	523	1,299	0.528	75.1	24.9	0.13			
		1333	510	1,202	0.704	76.5	23.5	0.17			
		1334	610	2,187	0.822	82.5	17.5	0.14			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
		1335	697	2,122	0.524	78.0	22.0	0.12			
		1336	605	2,228	0.247	75.0	25.0	0.06			
		1337	620	2,159	1.27	83.0	17.0	0.22			
		1338	610	2,368	0.368	72.9	27.1	0.10			
		1339	648	2,399	0.821	80.7	19.3	0.16			
		1340	630	2,404	1.23	80.3	19.7	0.24			
	10/1/2015	901	545	1,780	0.525	74.2	25.8	0.14	0.13	0.13	0.13
		902	619	3,201	0.592	80.0	20.0	0.12			
		903	591	2,115	0.822	80.7	19.3	0.16			
		904	483	1,427	0.618	78.6	21.4	0.13			
		905	585	2,308	0.443	78.3	21.7	0.10			
		906	595	2,493	0.555	79.5	20.5	0.11			
		907	585	2,367	0.632	78.1	21.9	0.14			
		908	640	2,808	0.46	79.4	20.6	0.10			
		909	640	3,097	0.67	78.4	21.6	0.15			
		910	620	1,437	0.623	80.7	19.3	0.12			
	10/10/2017	1701	505	1,443	0.262	74.6	25.4	0.07	0.13	0.15	0.14
		1702	610	2,223	0.99	82.3	17.7	0.18			
		1703	582	2,085	0.146	60.8	39.2	0.06			
		1704	595	2,087	0.989	83.1	16.9	0.17			
		1705	660	2,725	0.724	83.5	16.5	0.12			
		1706	535	1,733	1.14	81.9	18.1	0.21			
		1707	612	2,469	1.14	82.4	17.6	0.20			
		1708	658	3,460	0.347	74.5	25.5	0.09			
		1709	694	3,406	0.655	78.6	21.4	0.14			
		1710	625	2,561	0.831	79.6	20.4	0.17			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
Smallmouth bass											
Brownlee Reservoir	10/23/2013	1401	452	1,306	2.05	77.9	22.1	0.45	0.32	0.32	0.32
At Burnt River, Oregon		1402	355	647	1.28	77.6	22.4	0.29			
		1403	451	1,378	1.52	77.9	22.1	0.34			
		1404	344	620	1.17	77.3	22.7	0.27			
		1405	380	888	1.75	78.5	21.5	0.38			
		1406	330	456	1.13	78.2	21.8	0.25			
		1407	305	424	1.18	77.8	22.2	0.26			
		1408	377	789	1.64	78.2	21.8	0.36			
		1409	351	737	1.3	76.9	23.1	0.30			
		1410	356	673	1.52	77.7	22.3	0.34			
	10/10/2017	1301	341	645	0.532	77.5	22.5	0.12	0.22	0.24	0.23
		1302	345	692	1.14	76.9	23.1	0.26			
		1303	328	650	0.978	78.2	21.8	0.21			
		1304	355	733	1.42	78.6	21.4	0.30			
		1305	375	854	1.03	77.4	22.6	0.23			
		1306	342	693	1.08	77.9	22.1	0.24			
		1307	350	764	1.02	76.6	23.4	0.24			
		1308	330	608	1.22	77.7	22.3	0.27			
		1309	324	550	0.79	77.0	23.0	0.18			
		1310	315	490	0.947	76.3	23.7	0.22			
Channel catfish											
Brownlee Reservoir	10/7/2015	1201	623	2,102	1.68	79.8	20.2	0.34	0.18	0.16	0.22
At Burnt River, Oregon		1202	631	3,418	0.844	80.3	19.7	0.17			
		1203	650	3,750	0.599	78.8	21.2	0.13			
		1204	664	3,675	1.92	80.8	19.2	0.37			

Site name	Sample date	Time	Total length (mm)	Weight (g)	Mercury, dry weight (mg/kg)	Percent water	Percent solids	Mercury wet weight, (mg/kg)	Mercury wet weight geometric mean per site (mg/kg)	Mercury, wet weight median per site (mg/kg)	Mercury wet weight average per site (mg/kg)
		1205	614	2,896	0.56	78.1	21.9	0.12			
		1206	642	2,950	3.02	80.7	19.3	0.58			
		1207	625	2,850	0.384	78.8	21.2	0.08			
		1208	659	3,648	0.378	77.4	22.6	0.09			
		1209	691	3,941	0.736	78.6	21.4	0.16			
		1210	571	2,171	0.724	79.9	20.1	0.15			

Table 6. Selenium concentrations in individual sport fish tissue collected from the Boise and Snake Rivers and Brownlee Reservoir, Idaho and Oregon, October 2013–17.

[Site locations are shown in figure 1. Full site names are listed in table 1. **Abbreviations:** dry wt., dry weight; Se/Hg, selenium to mercury; wet wt., wet weight; µmol/kg, micromole per kilogram; mg/kg, milligram per kilogram]

Site	USGS site identification	Sample date	Species	Number in composite	Selenium (mg/kg, dry wt.)	Percent water	Selenium (mg/kg, wet wt.)*	Selenium (µmol/kg, wet wt.)	Mercury (µmol/kg, wet wt., average)	Molar ratio, Se/Hg
Eckert	13203760	10/29/2013	Mountain whitefish	10	0.30	75.4	0.07	0.93	0.95	0.99
Middleton	13210050	10/21/2013	Mountain whitefish	10	0.77	78.8	0.16	2.07	0.85	2.44
Boise mouth	13213030	10/30/2013	Channel catfish	10	0.72	80.6	0.14	1.77	1.65	1.08
Murphy	13172500	10/22/2013	Channel catfish	10	0.67	78.4	0.14	1.84	1.05	1.75
Murphy	13172500	10/22/2013	Smallmouth bass	10	2.13	77.1	0.49	6.19	0.85	7.30
Nyssa	13213100	10/22/2013	Channel catfish	10	0.88	79.8	0.18	2.25	0.70	3.23
Brownlee	4422221171355	10/23/2013	Smallmouth bass	10	1.48	78.4	0.32	4.05	1.60	2.54
Middleton	13210050	10/23/2014	Mountain whitefish	10	1.07	76.4	0.25	3.17	0.85	3.74
Eckert	13203760	10/5/2015	Rainbow trout	10	0.84	76.9	0.19	2.46	0.10	24.7
Middleton	13210050	10/5/2015	Mountain whitefish	10	0.52	71.6	0.15	1.87	0.55	3.41
Boise mouth	13213030	10/7/2015	Channel catfish	6	0.93	76.3	0.22	2.79	1.15	2.43
Murphy	13172500	10/8/2015	Channel catfish	10	0.87	75.3	0.21	2.72	0.80	3.41
Murphy	13172500	10/8/2015	Smallmouth bass	10	1.74	76.8	0.40	5.11	0.80	6.41
Nyssa	13213100	10/1/2015	Channel catfish	10	0.83	77.6	0.19	2.35	0.65	3.63
Brownlee	4422221171355	10/7/2015	Channel catfish	10	0.57	78.7	0.12	1.54	1.10	1.40
Middleton	13210050	10/5/2016	Mountain whitefish	10	<0.1	74.5	<0.03	<0.38	0.65	<0.59
Eckert	13203760	10/12/2017	Mountain whitefish	10	0.20	75.2	0.05	0.63	0.60	1.05
Middleton	13210050	10/19/2017	Mountain whitefish	10	0.36	74.9	0.09	1.14	1.10	1.04
Boise mouth	13213030	10/18/2017	Smallmouth bass	10	1.60	74.9	0.40	5.09	1.10	4.64
Murphy	13172500	10/11/2017	Smallmouth bass	10	2.11	73.3	0.56	7.13	0.95	7.53
Murphy	13172500	10/11/2017	Channel catfish	10	0.73	74.2	0.19	2.39	0.55	4.35
Nyssa	13213100	10/10/2017	Channel catfish	10	0.77	77.5	0.17	2.19	0.70	3.14
Brownlee	4422221171355	10/10/2017	Smallmouth bass	10	1.23	74.0	0.32	4.05	1.10	3.69

Publishing support provided by the U.S. Geological Survey
Science Publishing Network, Tacoma Publishing Service Center

For more information concerning the research in this report, contact the
Director, Idaho Water Science Center
U.S. Geological Survey
230 Collins Road
Boise, Idaho 83702
https://id.water.usgs.gov

MacCoy and Mebane—**Mercury and Selenium Concentrations, Brownlee Reservoir and Selected Sites, Boise and Snake Rivers, Idaho and Oregon, 2013–17**—Open-File Report 2018-1122

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20181122