USGS
science for a changing world

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, 2013–15

Open-File Report 2016–1098

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

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

By Marshall L. Williams and Dorene E. MacCoy

Prepared in cooperation with the City of Boise, Idaho

Open-File Report 2016–1098

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

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Director

U.S. Geological Survey, Reston, Virginia: 2016

Suggested citation:
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., http://dx.doi.org/10.3133/ofr20161098.

ISSN 2331–1258 (online)

Contents

Figures

Tables

Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
	Volume	
milliliter (mL)	0.03381	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).

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

By Marshall L. Williams and Dorene E. MacCoy

Abstract

Mercury (Hg) analyses were conducted on samples of sport fish and water collected from selected sampling sites in Brownlee Reservoir and the Boise and Snake Rivers to meet National Pollution Discharge and Elimination System (NPDES) permit requirements for the City of Boise, Idaho, between 2013 and 2015. City of Boise personnel collected water samples from six sites between October and November 2013 and 2015, with one site sampled in 2014. Total Hg concentrations in unfiltered water samples ranged from 0.48 to 8.8 nanograms per liter (ng/L), with the highest value in Brownlee Reservoir in 2013. All Hg concentrations in water samples were less than the U.S. Environmental Protection Agency (USEPA) Hg chronic aquatic life criterion of 12 ng/L.

The USEPA recommended a water-quality criterion of 0.30 milligrams per kilogram (mg/kg) methylmercury (MeHg) expressed as a fish-tissue residue value (wet-weight MeHg in fish tissue). The Idaho Department of Environmental Quality adopted the USEPA's fish-tissue criterion and established a reasonable potential to exceed (RPTE) threshold 20 percent lower than the criterion or greater than 0.24 mg/kg Hg based on an average concentration of 10 fish from a receiving waterbody. NPDES permitted discharge to waters with fish having Hg concentrations exceeding 0.24 mg/kg are said to have a reasonable potential to exceed the water-quality criterion and thus are subject to additional permit obligations, such as requirements for increased monitoring and the development of a Hg minimization plan. The Idaho Fish Consumption Advisory Program (IFCAP) issues fish advisories to protect general and sensitive populations of fish consumers and has developed an action level of 0.22 mg/kg Hg in fish tissue. Fish consumption advisories are water body- and species-specific and are used to advise allowable fish consumption from specific water bodies. 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 fish consumption advisory should be issued.

The U.S. Geological Survey collected and analyzed individual fillets of mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), smallmouth bass (*Micropterus dolomieu*), and channel catfish (*Ictalurus punctatus*) for Hg. The 2013 average Hg concentration for small mouth 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 Hg RPTE threshold (>0.24 mg/kg), and the IFCAP action level (>0.22 mg/kg). Average Hg concentrations in fish collected in 2014 or 2015 did not exceed evaluation criteria for any of the species assessed.

Selenium (Se) analysis was conducted on one composite fish tissue sample per site to assess general concentrations and to provide information for future risk assessments. Composite concentrations of Se in fish tissue collected between 2013 and 2015 ranged from 0.07 and 0.49 mg/kg wet weight with the highest concentration collected from smallmouth bass from the Snake River near Murphy, and the lowest from mountain whitefish from the Boise River at Eckert Road.

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 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) and other microbially mediated reactions. Methylmercury (MeHg) is by far the more bioavailable and toxic form of Hg; and, once Hg has moved through aquatic food chains into predatory fish, almost all Hg present in fish tissue is MeHg. In turn, sport fish that are most commonly caught and consumed by subsistence or recreational anglers tend to be predatory fish. As a result of these dynamics, risks of MeHg exposure to humans are largely through consumption of fish (U.S. Environmental Protection Agency, 2001).

The U.S. Environmental Protection Agency (USEPA) recommended water-quality criterion for MeHg is expressed as a concentration in fish-tissue (wet-weight MeHg in fish tissue). The MeHg criterion is based on wet weight, appropriately reflecting the nature of fish destined for human consumption. In 2005, Idaho Department of Environmental Quality (IDEQ) adopted USEPA's fish-tissue criterion of 0.3 mg based on a 17.5 g/d consumption rate and published implementation guidance for the Idaho Hg water-quality standard (Idaho Department of Environmental Quality, 2005). The USEPA recently updated the national fish consumption rate to 22 g/d for this criteria based on the results from the National Health and Nutrient Survey conducted between 2003 and 2010 (U.S. Environmental Protection Agency, 2014, 2015). Because the USEPA 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 water quality criteria to 66.5 g/d. All human health-based water quality were updated using the higher fish consumption rates, except MeHg, for which the value based on the 17.5 g/d fish consumption rate was retained (Idaho Department of Environmental Quality, 2016).

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). Interpretation of total Hg as MeHg probably introduces a small positive bias, between 1 and 5 percent, based on comparisons shown by Bloom (1992) and by Hammerschmidt and others (1999), 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). The facility/source monitoring is targeted at potential local sources. The USEPA 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 (RPTE) process (Idaho Department of Environmental Quality, 2005). The RPTE threshold is designed to protect people that 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 USEPA has included numerical Hg limitations, Hg minimization plan development, watershed-based fish tissue and water Hg sampling, and annual reporting requirements in the City of Boise's two effluent permits for the Lander Street and the West Boise Wastewater Treatment Facilities (U.S. Environmental Protection Agency, 2012b, 2012c).

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.

USEPA considers a total recoverable mercury concentration of 12 ng/L in water to be the effective chronic aquatic life criterion in Idaho for the purposes of the Clear Water Act (Idaho Department of Environmental Quality, 2014, referred to as "USEPA aquatic life criteria" in this report). The City of Boise's NPDES permits require a minimum detection level for Hg of 0.5 ng/L, sufficiently low enough to compare to USEPA 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 are collected at the same time. Riva-Murray and others (2013) reported that, in Oregon and New York streams, the best BAF estimates came from sampling MeHg in water during the July– September growing season, regardless of when the fish were collected. In related analyses with fish, the optimal approach for estimating BAFs is to use Hg concentration data from at least 10 adult fish of a single species and similar length (Scudder Eikenberry and others, 2015). BAFs are currently not calculated using the data published in this report. It is the intent that this data will be combined with future data-collection efforts to calculate 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 USEPA further recommended that the permitting authority (which is the USEPA 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.

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 potential future risk assessments for a couple of reasons: (1) The relative risk of a given Hg concentration in fish tissue may increase when Se to Hg molar ratios in the tissue are less than 1, and (2) Se to Hg ratios are of interest in fish tissue monitoring studies and risk assessment (Khan and Wang, 2009; Essig, 2010). 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. Environmental Protection Agency, 2001; Idaho Department of Environmental Quality, 2005).

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). The 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 data for Hg and Se in fish tissue collected by the USGS as described in the Hg monitoring plan (Mebane and MacCoy, 2013). Data collected by both agencies are reported here to meet the City of Boise's NPDES permit requirements. Water samples and fish samples were collected at the same locations and near the same dates.

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 wastewater 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 wastewater 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 and 2015, water and fish were collected at all six sampling sites (table 1, fig. 1); in 2014, only the Middleton site was sampled (MacCoy, 2014). The sites were selected to meet specific NPDES requirements and to isolate the fish populations being sampled. There are no natural fish passage barriers between sampling sites to prevent fish migration although there are manmade diversions in the Boise River between Eckert and Middleton that act as fish passage barriers.

Targeted Fish Species

The targeted fish species 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 2014 at Middleton where 2 fish were less than 25 cm, and 2015 at the Boise mouth where only 6 fish were collected. Sampling at Murphy provided an opportunity to collect samples of two targeted fish species, smallmouth bass and channel catfish in 2013 and 2015. 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., March 12, 2014) following collection and quality-control procedures similar to those described in Lewis and Brigham (2004) and Essig (2010). Precleaned 200 mL glass bottles were used to collect dip water samples. Samples were placed on ice and delivered to the Boise City Public Works Water Quality Laboratory, within the same day. Field blanks were collected at some sites 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 and frozen to minimize possible loss of sample integrity. When 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 USEPA Method 1631 E (U.S. Environmental Protection Agency, Office of Water, 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 USEPA 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 can be found on their website **Error! Hyperlink reference not valid.**(U.S. Geological Survey, 2013)

Selenium in Fish Tissue

A sample size of less than 20 g is needed for Se analysis. 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 are listed here:

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, 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 quality-control samples are presented with the water sample results (table 4) and include field blanks and laboratory matrix spikes results. Hg concentrations in all but one field blank were near or less than the laboratory detection limit (0.2 ng/L). Matrix spike recovery of Hg in water samples ranged from 94.8 to 100.5 percent, well within the required recovery of 71–125 percent of the theoretical value. The relative percent difference of matrix spike duplicates required by USEPA is less than 24 percent (U.S. Environmental Protection Agency, Office of Water, 2002). The observed relative percent difference of the matrix spike recovery ranged from 0.41 to 8.1 percent, also within the USEPA's criteria.

Mercury in Water

Hg in water was collected at all six sampling sites on the Boise and Snake Rivers and Brownlee Reservoir. Hg concentrations, field blank concentrations, and laboratory matrix spike recovery data are shown in table 4. Concentrations of Hg in water were between 0.48 and 8.8 ng/L, with the highest concentration from Brownlee Reservoir. All samples were less than the USEPA aquatic life criteria (12 ng/L, U.S. Environmental Protection Agency, 1985; 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 (detection of 0.70 ng/L Hg). With that one exception, the blank values, as well as the laboratory spike recovery, were within data-quality objectives.

Fish Species, Size, and Tissue Mercury Concentrations

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 website**Error! Hyperlink reference not valid.** (U.S. Geological Survey, 2014). 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.

Rainbow trout were collected at the upstream site (Eckert) in 2015. Total fish lengths for rainbow trout were between 250 and 390 mm, and median Hg concentration was 0.02. 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 at the site downstream of the City of Boise wastewater facilities on the Boise River (Middleton, fig. 1) in 2013, 2014, and 2015. Total fish lengths for mountain whitefish were between 135 and 506 mm, with primarily larger fish sampled from Eckert (table 5, fig. 4*A*). Median Hg concentrations in mountain whitefish were 0.18 mg/kg at Eckert and ranged from 0.11 to 0.18 mg/kg at Middleton for the 3 sample years. Mean concentrations in mountain whitefish did not exceed the Idaho water-quality criterion, RPTE threshold level, or the IFCAP action level (table 5, fig. 3).

Smallmouth bass were collected from Murphy, the Snake River site upstream of the mouth of the Boise River in 2013 and 2015 and from Brownlee Reservoir in 2013. Total fish lengths were between 300 and 452 mm, with the largest fish sampled from Brownlee (table 5, fig. 4*B*). Median Hg concentrations in smallmouth bass were similar at Murphy between sample years (0.16 and 0.17 mg/kg). Only the 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).

Channel catfish were collected from the Boise mouth, Murphy, and Nyssa sites in 2013 and 2015; and from Brownlee in 2015. Individual fish lengths were between 483 and 720 mm with the largest individual fish sampled from Murphy (table 5). There was no discernible relation between fish length and Hg concentrations in channel catfish (fig. 4*C*). For the 2 years of sampling, the median Hg concentrations in channel catfish tissue were 0.24 and 0.28 mg/kg from Boise mouth, 0.11 and 0.18 mg/kg at Murphy, and 0.13 and 0.14 mg/kg from Nyssa; with a single median concentration of 0.16 mg/kg from Brownlee collected in 2015 (table 5, fig. 3). 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 median concentrations, although lower than in 2013, were higher in smallmouth bass (0.16 mg/kg) than channel catfish (0.11 mg/kg). Only the channel catfish collected in 2013 at Boise mouth site exceeded the Idaho water-quality criterion, RPTE threshold level, and the IFCAP action level (table 5, fig. 3). Although the average and geometric mean concentrations were calculated for the channel catfish collected in 2015 from the Boise mouth, 0.23 and 0.22 mg/kg, respectively (table 5), the values were not compared to RPTE threshold and IFCAP action level because fewer than 10 catfish were collected.

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, and wet weight concentrations are given to better compare the results to Hg wet-weight concentrations. Composite concentrations collected from 2013 to 2015 were between 0.07 and 0.49 mg/kg wet weight, with the lowest concentration in mountain whitefish from Eckert and the highest concentration in smallmouth bass collected from Murphy. Molar ratios of Se to Hg ranged from 0.99 to 25 (table 6).

Summary

Water samples and sport fish of edible size were collected for Hg analysis from six sites in the Boise and Snake Rivers and Brownlee Reservoir in 2013 and 2015, and from one site in 2014, to meet a portion of the City of Boise's 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 mg/kg in channel catfish) and Brownlee (0.32 and 0.32 mg/kg in small mouth bass) collected in 2013 exceeded Idaho's water quality criteria of 0.30 mg/kg, the IDEQs RPTE threshold of <0.24 mg/kg, and IFCAP action level of 0.22 mg/kg wet weight. There were no exceedances of these fish tissue criteria in 2015.

Total Hg concentrations in unfiltered water samples ranged from 0.48 to 8.8 ng/L total Hg, with the highest Brownlee Reservoir in 2013. All Hg concentrations in water samples were less than the U.S. Environmental Protection Agency (USEPA) Hg chronic aquatic life criterion of 12 ng/L.

Composite concentrations of Se in fish tissue collected between 2013 and 2015 were between 0.07 and 0.49 mg/kg wet weight with the highest concentration collected from smallmouth bass from the Snake River near Murphy and the lowest from mountain whitefish from the Boise River at Eckert Road. Se composite samples collected in this study provide information for comparing Se concentrations between species and for possible future use in fish consumption advisories.

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, accessed March 10, 2014, at http://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. [Also available at http://pubs.er.usgs.gov/publication/wri984103.]

Essig, D.A., 2010, Arsenic, mercury, and selenium in fish tissue and water from Idaho's major rivers—A statewide assessment: Idaho Department of Environmental Quality, accessed February 22, 2016, at http://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: Idaho Department of Environmental Quality, 80 p.

Fitzgerald, W.F., and Lamborg, C.H., 2007, Geochemistry of mercury in the environment: Elsevier, Treatise on Geochemistry, p. 1–47, http://www.sciencedirect.com/science/referenceworks/9780080437514.

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., http://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, accessed February 22, 2016, at http://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. 1,203, accessed February 22, 2016, at http://dx.doi.org/10.1126/science.1085941.

Idaho Department of Environmental Quality, 2005, Implementation guidance for the Idaho mercury water quality criteria: Boise, Idaho, Idaho Department of Environmental Quality, 212 p., accessed February 22, 2016, at http://www.deq.idaho.gov/water-quality/surface-water/mercury.aspx .

Idaho Department of Environmental Quality, 2014, EPA actions on proposed standards: Web page, accessed February 22, 2016, at http://www.deq.idaho.gov/epa-actions-on-proposed-standards.

Idaho Department of Environmental Quality, 2016, Water quality—Docket no. 58-0102-1201—Final rule: Web page, accessed April 12, 2016, at http://www.deq.idaho.gov/58-0102-1201.

International Atomic Energy Agency, 2003, Trace elements and methylmercury in fish tissue: Reference sheet IAEA-407, accessed May 2, 2014, at http://www.iaea.org/nael/refmaterial/iaea407.pdf.

Khan, M.A.K., and Wang, F., 2009, Mercury–selenium compounds and their toxicological significance—Toward a molecular understanding of the mercury–selenium antagonism: Environmental Toxicology and Chemistry, v. 28, no. 8, p. 1567–1577, http://dx.doi.org/10.1897/08-375.1.

Lewis, M.E., and Brigham, M.E., 2004, Low-level mercury, *in* Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., eds., Chapter A5 processing of water samples—National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, accessed March 10, 2014, at http://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. [Also available at http://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.. [Also available at http://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. [Also available at http://pubs.usgs.gov/of/2013/1068/.]

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 March 10, 2014, at http://www.idahopower.com/pdfs/Relicensing/hellscanyon/hellspdfs/techappendices/Aquatic/e31_05_ch01.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, v. 47, no. 11, p. 5,904–5,912, http://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. [Also available at http://pubs.usgs.gov/of/2008/1208/.]

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, http://dx.doi.org/10.1016/j.chemosphere.2014.12.068.

U.S. Environmental Protection Agency, 1985, Ambient water quality criteria for mercury—1984: U.S. Environmental Protection Agency, EPA 440/5-84-026, 144 p., accessed April 20, 2016, at https://www.epa.gov/nscep.

U.S. Environmental Protection Agency, 2001, Water quality criterion for the protection of human health—Methylmercury: U.S Evironmental Protection Agency, EPA-823-R-01-001, 303 p., accessed March 10, 2014, at http://www.epa.gov/waterscience/criteria/methylmercury/.

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 March 10, 2014, at www.epa.gov/osw/hazard/testmethods/sw846/pdfs/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 March 10, 2014, at http://www.epa.gov/wqc/guidance-implementing-january-2001-methylmercury-water-quality-criterion .

U.S. Environmental Protection Agency, 2012a, National Pollutant Discharge Elimination System (NPDES): Websites, accessed March 19, 2014, at http://cfpub.epa.gov/npdes/about.cfm?program_id=0.
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 March 10, 2014, at http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/Current+ID1319.
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 March 10, 2014, at http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/Current+ID1319.
U.S. Environmental Protection Agency, 2014, Estimated fish consumption rates for the U.S. population and selected subpopulations (NHANES 2003–2010): Washington, D.C. EPA -820-R-14-002, 110 p., accessed February 23, 2016, at http://www.epa.gov/sites/production/files/2015-01/documents/fish-consumption-rates-2014.pdf.
U.S. Environmental Protection Agency, 2015, Final updated ambient water quality criteria for the protection of human health: Federal Register, v. 80, no. 124, p. 36986–36989, accessed February 23, 2016, at http://www.epa.gov/wqc/human-health-water-quality-criteria.
U.S. Environmental Protection Agency, Office of Water, 2002, Method 1631, Revision E—Mercury in water by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry: Washington, D.C., EPA-821-R-02-019, 46 p., accessed March 10, 2014, at http://water.epa.gov/scitech/methods/cwa/metals/mercury/index.cfm.
U.S. Geological Survey, 2013, USGS Mercury Research Laboratory: Website, accessed April 25, 2014, at http://wi.water.usgs.gov/mercury-lab/index.html.
U.S. Geological Survey, 2014, USGS Water-quality for Idaho: Website, accessed April 25, 2014, at http://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 March 10, 2014, at *http://water.usgs.gov/owq/FieldManual/chapter4/html/Ch4_contents.html*.

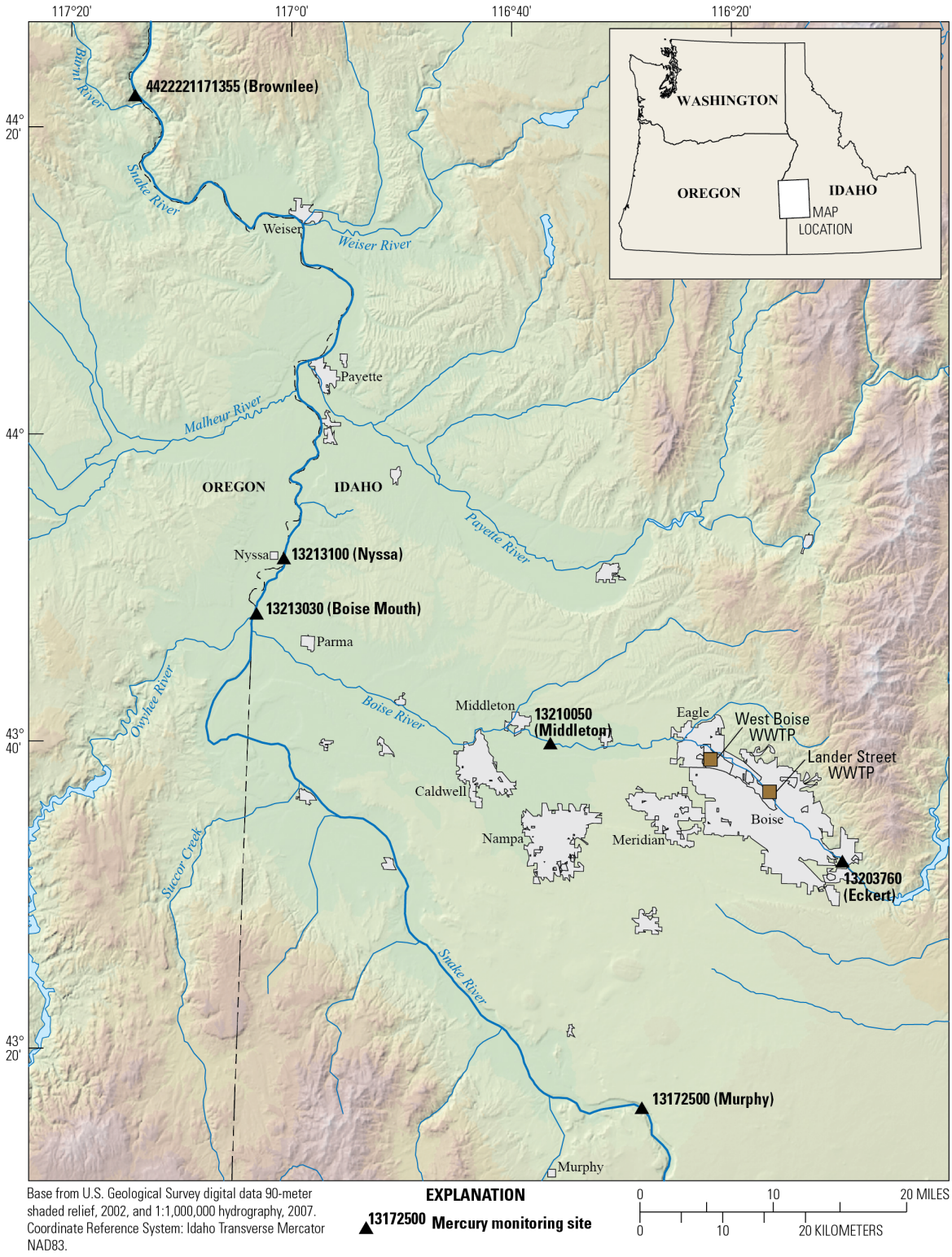

Figure 1. Map showing location of sites where water and fish tissue samples were collected for analysis of total mercury and selenium, Idaho and Oregon, 2013–15.

Figure 2. Photographs of channel catfish (a) and smallmouth bass (b) at the Snake River near Murphy sampling site, October 2013. (Photographs by Dorene MacCoy, U.S. Geological Survey.)

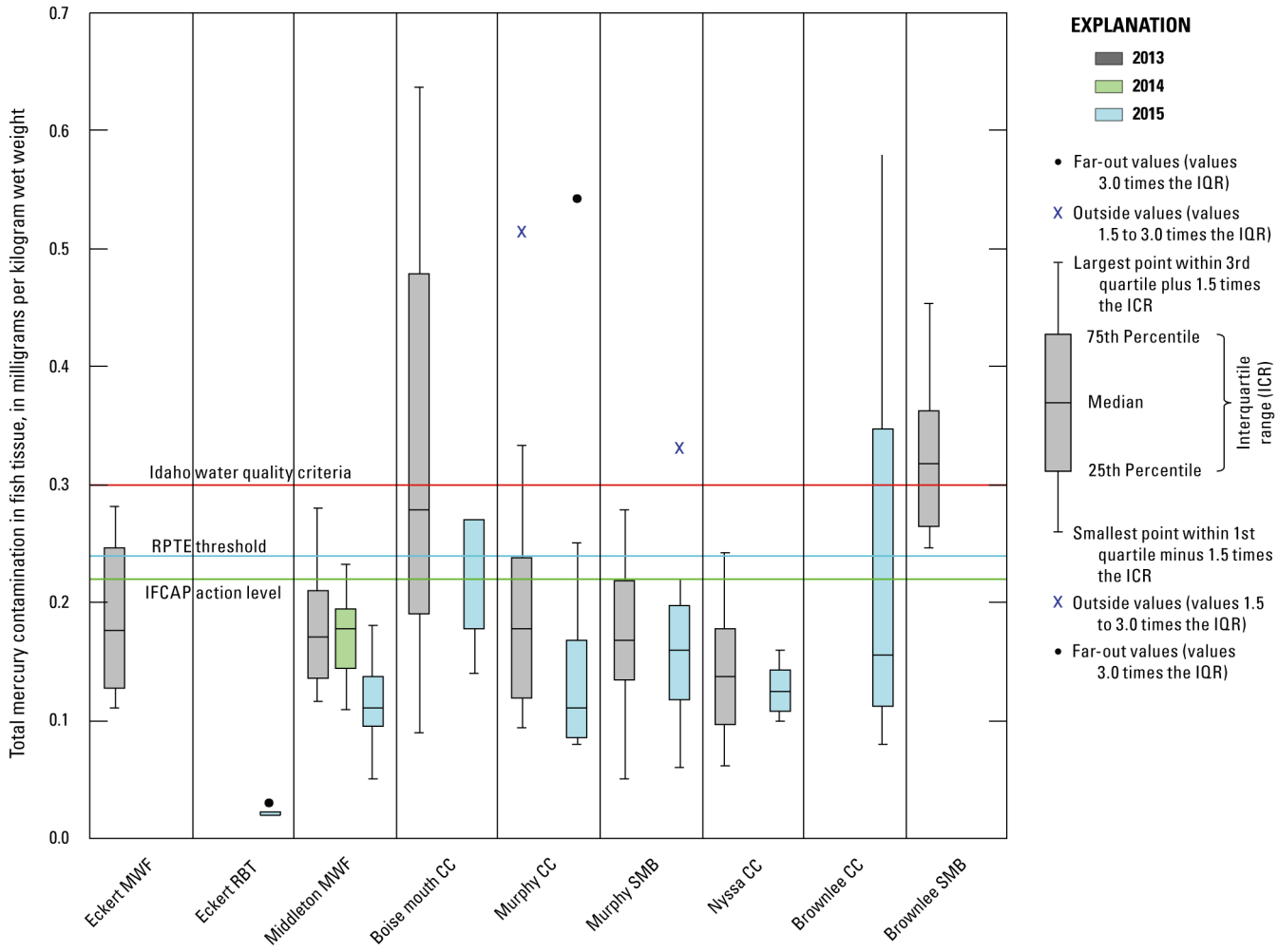

Figure 3. Boxplot showing total mercury concentrations in fish tissue collected from sites in the Boise and Snake Rivers and Brownlee Reservoir, October 2013–15, Idaho and Oregon. (CC, channel catfish; MWF, mountain whitefish; RBT, rainbow trout; SMB, smallmouth bass.) (IFCAP action level, Idaho Fish Consumption Advisory Project recommends consideration of issuing a fish advisory when the geometric mean of mercury in 10 fish exceeds 0.22 mg/kg wet weight; RPTE threshold, reasonable potential to exceed 80 percent of the Idaho mercury water-quality criterion of 0.30 milligrams per kilogram [mg/kg] wet weight mercury or greater than 0.24 mg/kg in an average of 10 fish). Site names are shown in table 1.

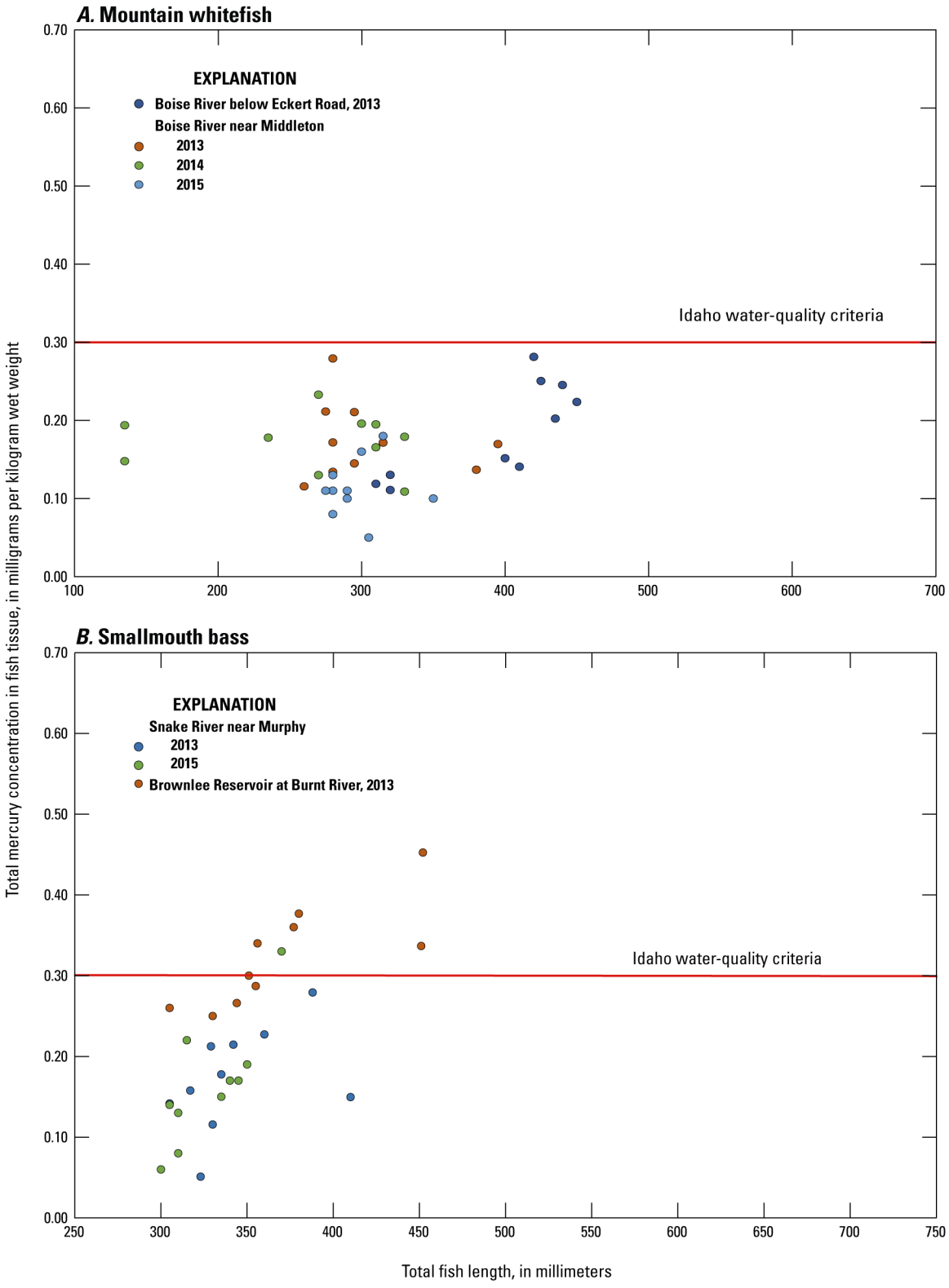

Figure 4. Graphs showing total mercury tissue concentrations and total length of mountain whitefish (*A*), smallmouth bass (*B*) channel catfish (*C*) and rainbow trout (*D*) in samples from the Boise and Snake Rivers and Brownlee Reservoir, Idaho and Oregon, 2013–15.

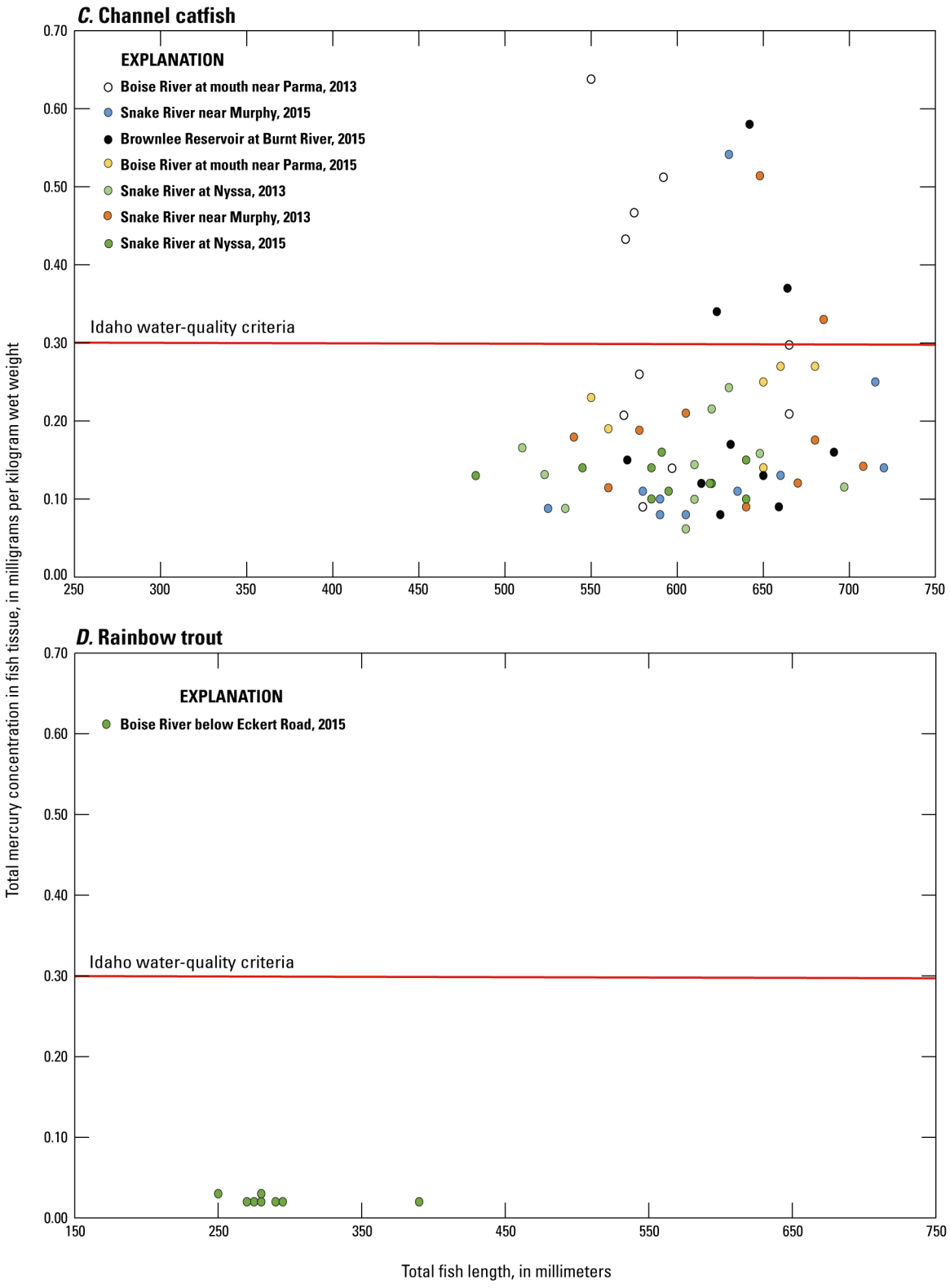

Figure 4.—Continued

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, 2013–15.

[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 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 2013–15.

[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, nanograms 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

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	

Laboratory identification	Date of analysis	Mercury, ng/g dry weight	Laboratory detection limit, ng/g dry weight	Triplicate relative standard deviation (percent)
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
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	

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, 2013–15.

[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. Abbreviations: <, less than; ng/L, nanograms per liter; µg/L, micrograms per liter]

USGS site identification	Site name	Sample date	Sample time	Total mercury concentration (ng/L)[a]	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	--

Boise City Public Works Water Quality Laboratory matrix spike recovery

Lab sample ID	Date of analysis	Total mercury spike concentration (µg/L)	Laboratory matrix spike, percent recovery	Matrix spike duplicates, RPD
AP07402	11/12/2013	0.00019	100	2.0
AP07406	11/12/2013	0.00019	96.5	5.9
AQ07919	10/30/2014	0.00022	94.8	8.1
B5J0813	10/8/2015	0.005	96.5	3.5
B5J1214	10/12/2015	0.005	94.9	0.41

[a]Environmental Protection Agency total mercury chronic aquatic life criteria for Idaho is 12 ng/L (Idaho Department of Environmental Quality, variously dated).

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 2013–15.

[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			
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			

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 near	10/21/2013	1201	380	491	0.527	74.0	26.0	0.14	0.17	0.17	0.17
Middleton, Idaho		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			
		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			

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)
		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			
					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			
					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			

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)
		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			
		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			
Channel Catfish											
Snake River near	10/22/2013	1201	540	1,747	0.889	79.8	20.2	0.18	0.18	0.18	0.21
Murphy, Idaho		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			
		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			

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)
		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			
Channel Catfish											
Snake River at	10/22/2013	1331	535	1,409	0.33	73.4	26.6	0.09	0.13	0.14	0.14
Nyssa, Oregon		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			
		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			

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 Reservior	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			
					Channel Catfish						
Brownlee Reservior	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			
		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 2013–15.

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

Site	USGS site identification	Sample date	Species	Number in composite	Selenium (mg/kg, dry wt)	Percent water	Percent solids	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	24.6	0.07	0.89	0.95	0.94
Middleton	13210050	10/21/2013	mountain whitefish	10	0.77	78.8	21.2	0.16	2.03	0.85	2.4
Boise mouth	13213030	10/30/2013	channel catfish	10	0.72	80.6	19.4	0.14	1.77	1.65	1.1
Murphy	13172500	10/22/2013	channel catfish	10	0.67	78.4	21.6	0.14	1.77	1.05	1.7
Murphy	13172500	10/22/2013	smallmouth bass	10	2.13	77.1	22.9	0.49	6.20	0.85	7.3
Nyssa	13213100	10/22/2013	channel catfish	10	0.88	79.8	20.2	0.18	2.28	0.70	3.3
Brownlee	4422221171355	10/23/2013	smallmouth bass	10	1.48	78.4	21.6	0.32	4.05	1.60	2.5
Middleton	13210050	10/23/2014	mountain whitefish	10	1.07	76.4	23.6	0.25	3.17	0.85	3.7
Eckert	13203760	10/5/2015	rainbow trout	10	0.84	76.9	23.1	0.19	2.41	0.10	24.1
Middleton	13210050	10/5/2015	mountain whitefish	10	0.52	71.6	28.4	0.15	1.90	0.55	3.5
Boise mouth	13213030	10/7/2015	channel catfish	6	0.93	76.3	23.7	0.22	2.79	1.65	1.7
Murphy	13172500	10/8/2015	channel catfish	10	0.87	75.3	24.7	0.21	2.66	0.80	3.3
Murphy	13172500	10/8/2015	smallmouth bass	10	1.74	76.8	23.2	0.40	5.06	0.80	6.3
Nyssa	13213100	10/1/2015	channel catfish	10	0.83	77.6	22.4	0.19	2.41	0.65	3.7
Brownlee	4422221171355	10/7/2015	channel catfish	10	0.57	78.7	21.3	0.12	1.52	1.10	1.4

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
http://id.water.usgs.gov

Williams and MacCoy—Mercury and Selenium Concentrations from Selected Sites, Boise and Snake Rivers, Idaho and Oregon, 2013–15—Open-File Report 2016–1098

Printed on recycled paper

ISSN 2331-1258 (online)
http://dx.doi.org/10.3133/ofr20161098