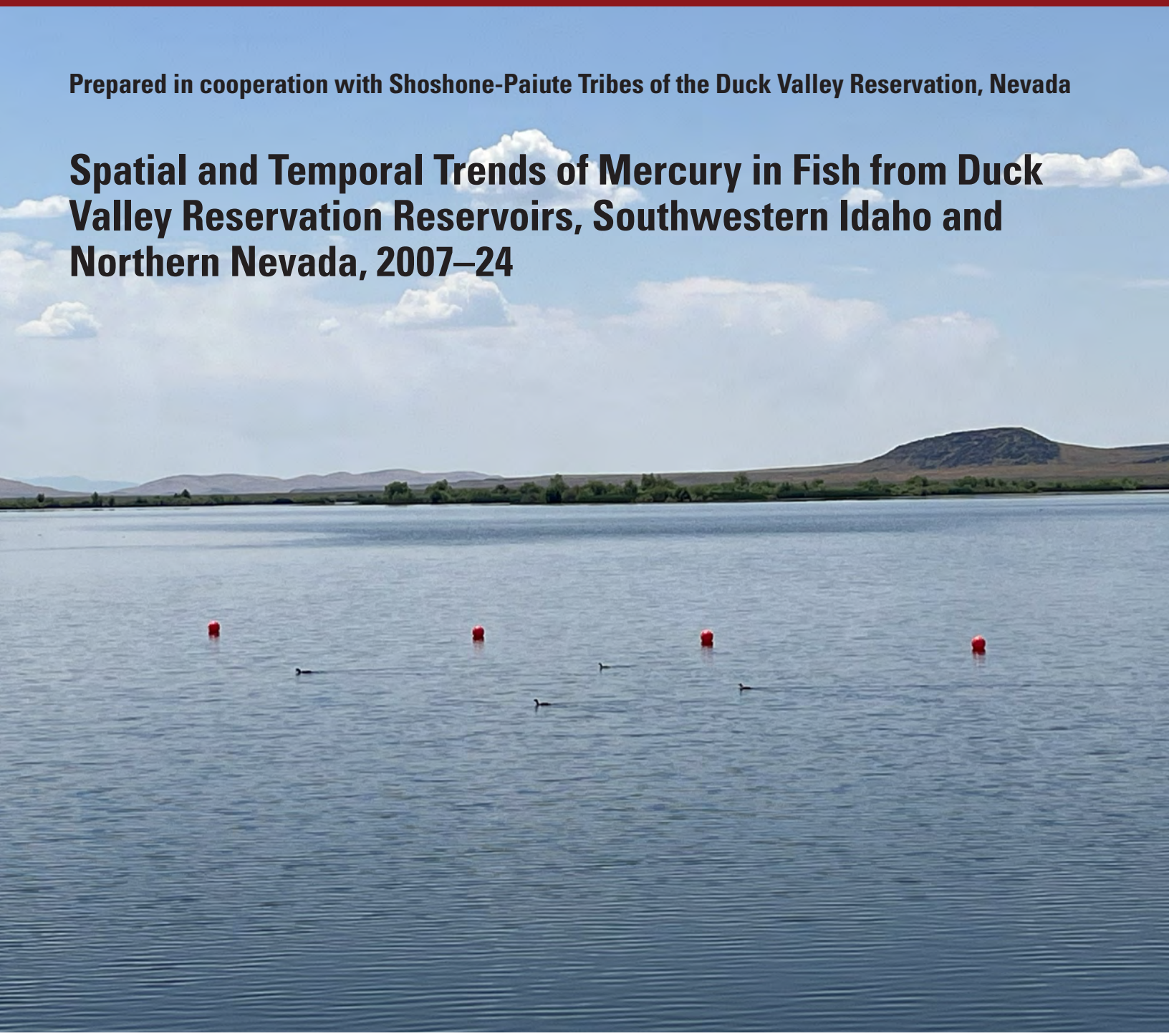
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Prepared in cooperation with Shoshone-Paiute Tribes of the Duck Valley Reservation, Nevada

Spatial and Temporal Trends of Mercury in Fish from Duck Valley Reservation Reservoirs, Southwestern Idaho and Northern Nevada, 2007–24



Scientific Investigations Report 2026–5019

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

Front Cover: A group of ducks swim past buoys in Lake Billy Shaw, Duck Valley Reservation, Nevada. The buoys mark the location of Fyke nets, that were set by U.S. Geological Survey (USGS) and Shoshone-Paiute Tribes staff to collect fish in July 2024. Photograph by Erin Murray, USGS.

Back Cover: Shoshone-Paiute Tribes staff set Fyke nets in Mountain View Reservoir, Duck Valley Reservation, Idaho, 2024. Fyke nets are designed for non-lethal fish sampling, where fish can swim into the nets but not out. Photograph by Erin Murray, USGS.

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By Erin M. Murray

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U.S. Geological Survey, Reston, Virginia: 2026

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
	Mass	
ounce, avoirdupois (oz)	28,349.52	milligram (mg)
ounce, avoirdupois (oz)	28.35	gram (g)
pound, avoirdupois (lb)	0.4536	kilogram (kg)

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.)
kilometer (km)	0.6214	mile (mi)
	Mass	
milligram (mg)	0.00003527	ounce, avoirdupois (oz)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

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

Supplemental Information

Concentrations of chemical constituents in fish tissue are given in milligrams per kilogram of wet weight (mg/kg ww), which is equivalent to parts per million (ppm).

Abbreviations

ANOVA	analysis of variance
BCTF	Black Canyon Trout Farm
DSTF	Desert Springs Trout Farm
EPA	U.S. Environmental Protection Agency
Hg	mercury
IDHW	Idaho Department of Health and Welfare
MDN	Mercury Deposition Network
MeHg	methylmercury
QAQC	quality assurance and quality control
Sho-Pai	Shoshone-Paiute
USGS	U.S. Geological Survey

Spatial and Temporal Trends of Mercury in Fish from Duck Valley Reservation Reservoirs, Southwestern Idaho and Northern Nevada, 2007–24

By Erin M. Murray

Abstract

The Shoshone-Paiute (Sho-Pai) Tribes of the Duck Valley Reservation, Nevada, manage reservoirs that support commercial and recreational activities, including robust *Oncorhynchus mykiss* (rainbow trout) fisheries that attract anglers year-round. Reservoirs are common environments for methylation and bioaccumulation of mercury, which is a potent neurotoxin when elevated levels are consumed. The U.S. Geological Survey, in cooperation with the Sho-Pai Tribes, measured total mercury concentrations in the muscle tissue of rainbow trout from three Reservation reservoirs in Idaho and Nevada in 2007, 2009, 2013, and 2024. This report highlights spatial and temporal trends of mercury concentrations in rainbow trout in the Duck Valley Reservation reservoirs from 2007 through 2024, and presents limited data on other commonly consumed species, specifically *Perca flavescens* (yellow perch), *Micropterus dolomieu* (smallmouth bass), and *Micropterus salmoides* (largemouth bass). Mercury data are also presented for nearby sites and lower trophic level species. In 2024, two fish sampling methods were used and compared: biopsy muscle plugs and muscle fillets. Results show good agreement between mercury concentrations of biopsy and fillet muscle samples taken from the same fish, with most sample pairs differing by less than 20 percent, though biopsied fish had an unexpectedly high mortality rate. Mercury concentrations increased in Sheep Creek Reservoir during the study period, but no significant trend was observed in Mountain View Reservoir or Lake Billy Shaw. Only 1 rainbow trout out of 160 sampled in the Reservation reservoirs during the study period exceeded the U.S. Environmental Protection Agency's recommended methylmercury criterion of 0.3 milligram per kilogram of wet weight (mg/kg ww). Largemouth bass, smallmouth bass, and yellow perch had higher mercury concentrations than rainbow trout and may pose a greater risk to consumers. Mercury concentrations in largemouth bass exceeded 0.3 mg/kg ww, although only two fish were sampled, both from Sheep Creek Reservoir. Fish consumption advisories on Tribal lands are determined by the Tribes, and these results may help Sho-Pai managers determine the mercury exposure risk to Tribal members and visiting anglers.

Introduction

The Shoshone-Paiute (Sho-Pai) Tribes of the Duck Valley Reservation, Nevada, manage reservoirs and rivers for commercial and recreational use. There are three prominent reservoirs on the Reservation (Mountain View Reservoir, Idaho; Lake Billy Shaw and Sheep Creek Reservoir, Nevada) that are known for their large *Oncorhynchus mykiss* (rainbow trout), making them popular angling destinations year-round. The Duck Valley Reservation spans a remote high desert landscape in southwest Idaho and northern Nevada (fig. 1*A*), with a small population center in Owyhee, Nevada, of 1,027 people according to the U.S. Census Bureau (2020). The Sho-Pai Tribes rely on their fisheries for food and generate tourism revenue through recreational angling on their lands. Rainbow trout are the main species sought by anglers on the Duck Valley Reservation and are stocked multiple times per year to support the sport fishery. Tribal members and the public also readily catch and consume resident, unstocked fish species, such as *Perca flavescens* (yellow perch), *Micropterus dolomieu* (smallmouth bass), and *Micropterus salmoides* (largemouth bass). In addition to the three reservoirs within the Duck Valley Reservation, the Owyhee River and Wild Horse Reservoir (fig. 1*A*) are common sites for Tribal members and the public to fish.

Elevated mercury (Hg) concentrations have previously been found in fish, invertebrates, and bed sediment of southern Idaho rivers near the Duck Valley Reservation (Maret, 1995). Potential sources of Hg in these systems likely include atmospheric deposition, historical gold and silver mining operations, and natural weathering of rocks and soil. In some gold and silver deposits, Hg can be naturally present in the ore and be released into the air when the ore is heated during the extraction process. Although mining has been historically prevalent in Idaho and Nevada, only one mine has operated within the Upper Owyhee River watershed upstream of the

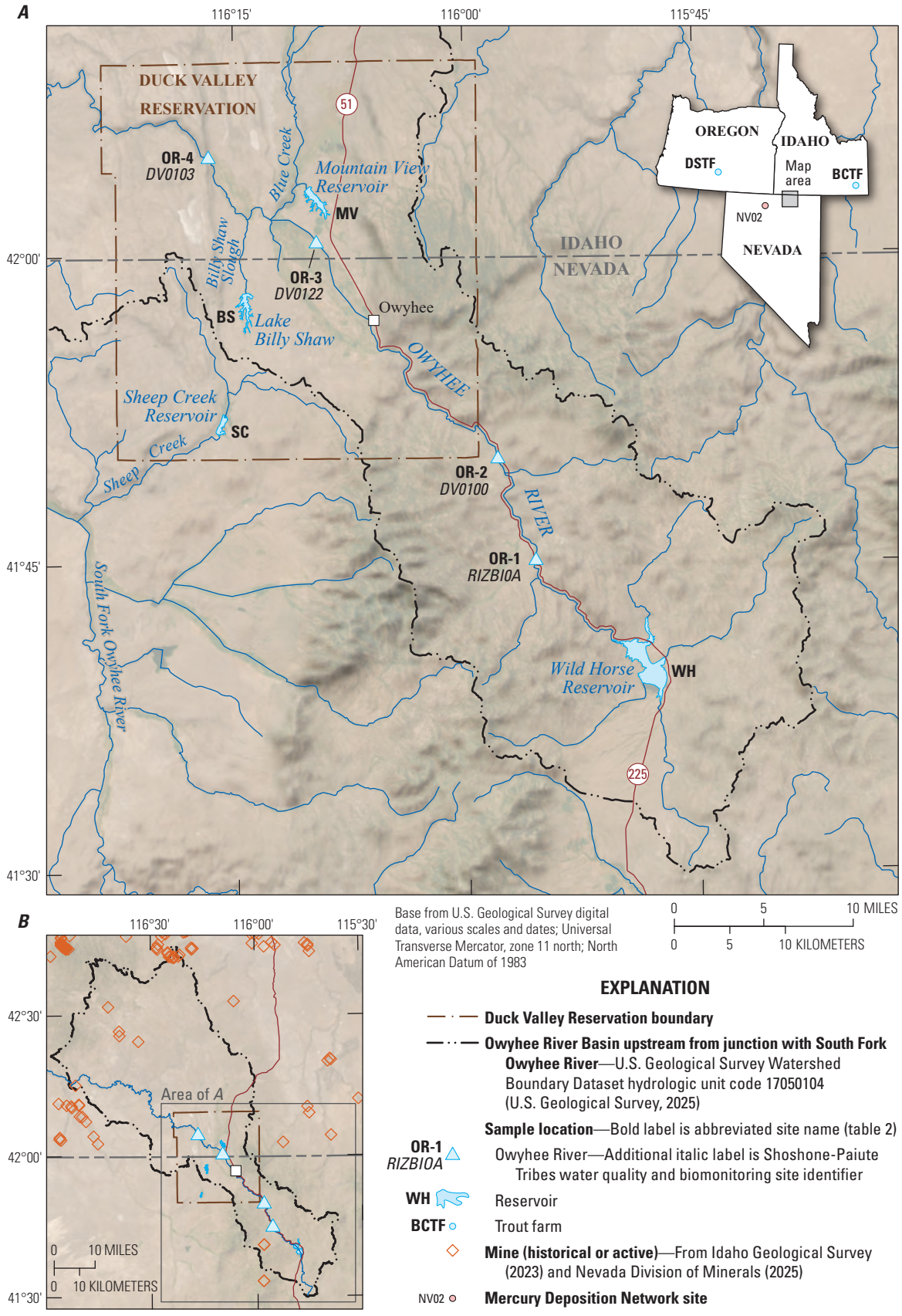


Figure 1. Maps of study area: *A*, location of Duck Valley Reservation reservoirs and Owyhee River sampling locations, and *B*, approximate historical and active mine locations in Idaho and Nevada.

Duck Valley Reservation and no activity has been reported at this site since 1990 (fig. 1*B*; Idaho Geological Survey, 2023; Nevada Division of Minerals, 2025). The U.S. Environmental Protection Agency (EPA) Toxic Release Inventory shows a 96-percent reduction in stack emissions of Hg in Nevada since monitoring began in 2001 to the most recent report in 2023, from 12,817 to 501 pounds, respectively (table 1; fig. 2; EPA, 2024). Stack emissions of Hg in Nevada predominantly come from gold and silver ore mining and processing facilities (table 1; fig. 2). Although the Toxic Release Inventory quantifies the amount of Hg released into the atmosphere by industry, the subsequent deposition of atmospheric Hg onto the land surface is dependent on facility locations, wind, and weather patterns. Despite the reduction in stack emissions of Hg, Williams and others (2015) saw no significant temporal linear trend from 2003 to 2013 in the rate of wet Hg deposition at Mercury Deposition Network (MDN) site NV02, which is approximately 68 miles upwind of the Duck Valley Reservation (fig. 1*A*). MDN site NV02 was discontinued in 2015. No other MDN sites were operating near the Duck Valley Reservation (or in Nevada at all) at the time of writing. Therefore, Hg contributions from atmospheric deposition to the study area in recent years are not known.

Reservoir environments can promote both methylation (microbial conversion of inorganic Hg to methylmercury [MeHg]) and bioaccumulation (uptake and retention of contaminants through the food web) (Willacker and others, 2016). Methylation predominantly occurs during bacterial respiration, especially in organic-rich, anoxic sediments via sulfate-reduction, iron-reduction, and methanogenesis (Compeau and Bartha, 1985; Bravo and others, 2018). Reservoirs are particularly prone to methylation of Hg because water level fluctuations can promote increased microbial activity relative to natural lakes (St. Louis and others, 2004; Eckley and others, 2017). MeHg is the most toxic form of Hg and can have detrimental human health impacts, such as neurotoxicity, when elevated levels are consumed (Wu and others, 2024). MeHg is also more bioavailable than inorganic Hg, and because it is readily absorbed and accumulated by organisms, nearly all of the Hg present in fish tissues is in the methyl form (Bloom, 1992). Bioaccumulation of MeHg in the aquatic food chain can yield concentrations in fish that are more than a million times greater than concentrations in water (Fitzgerald and others, 2007).

Safe human consumption levels for MeHg in fish tissue depend on the quantity of fish an individual consumes and become more stringent for women who are pregnant or breastfeeding and for children. The EPA established a MeHg criterion of 0.3 milligram per kilogram of wet weight (mg/kg ww) fish tissue in 2001 under Clean Water Act § 304(a) (EPA, 2001). The criterion is designed to be protective of human health and limit MeHg exposure via fish consumption (EPA, 2010). In 2005, Idaho adopted the same fish tissue MeHg criterion to protect individuals who may eat fish from Idaho surface waters (Idaho Department of Environmental Quality, 2005). The MeHg criterion of 0.3 mg/kg ww is based on protecting an adult consumer who eats an average of 17.5 grams of fish per day, or about one 8-ounce fish meal every other week (Idaho Department of Environmental Quality, 2005; EPA, 2010). Although this criterion is based on MeHg, total Hg is commonly analyzed as a proxy because most Hg in fish muscle tissue is present as MeHg (Bloom, 1992). The Idaho Department of Health and Welfare (IDHW) also issues State fish consumption advisories by waterbody and fish species on the basis of these criteria. At the time of writing, the IDHW recommends eating no more than 8 meals per month of bass (smallmouth or largemouth) caught anywhere in Idaho (IDHW, variously dated). For women who are pregnant, planning to become pregnant, or

Table 1. Stack emissions of mercury (Hg) in Nevada by year, 2001–23.

[Data are from U.S. Environmental Protection Agency (2024). lb, pound]

Year	Total Hg emissions[1] (lb)	Gold ore and silver mining Hg emissions[2] (lb)	Percent of total Hg emissions from gold ore and silver mining
2001	12,817	12,233	95
2002	9,051	8,647	96
2003	5,318	4,947	93
2004	5,105	4,839	95
2005	4,866	4,636	95
2006	4,323	4,191	97
2007	4,932	4,802	97
2008	3,254	3,099	95
2009	1,305	1,166	89
2010	1,292	1,054	82
2011	1,888	1,647	87
2012	1,422	1,266	89
2013	1,200	933	78
2014	795	593	75
2015	631	538	85
2016	628	536	85
2017	593	519	88
2018	945	883	93
2019	1,098	1,002	91
2020	1,380	1,296	94
2021	1,556	1,273	82
2022	876	802	92
2023	501	435	87

[1]Total emissions are the sum of all reported stack emissions in Nevada by year.

[2]Gold ore and silver mining emissions are the sum of stack emissions reported by the North American Industry Classification System code 21222, as defined by the U.S. Census Bureau (2022).

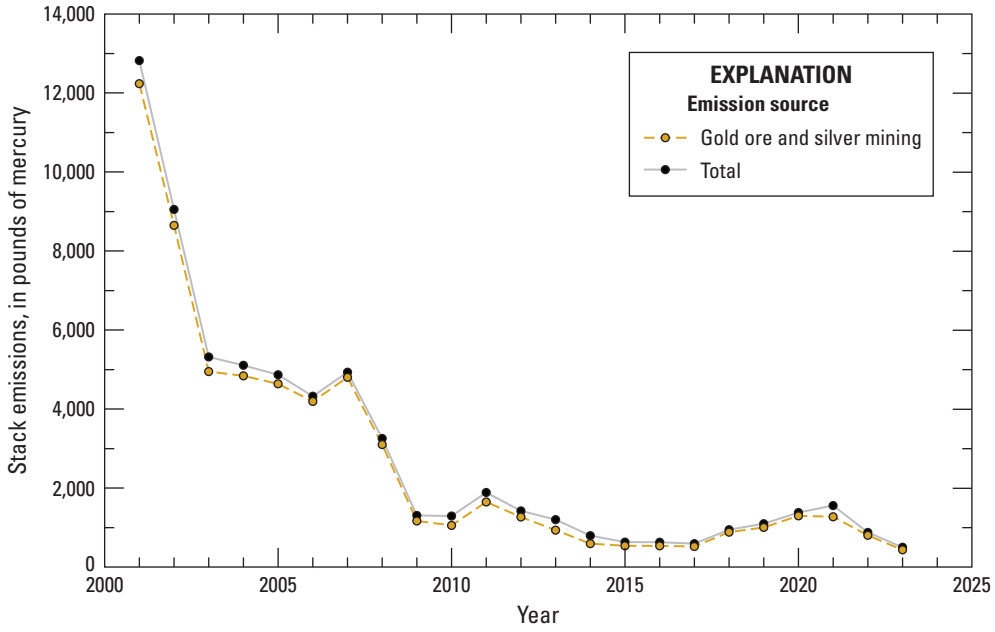


Figure 2. Line graph showing annual Nevada stack emissions of mercury reported in the U.S. Environmental Protection Agency Toxic Release Inventory, 2001–23. Data are from U.S. Environmental Protection Agency (2024).

nursing and children under age 15, the IDHW recommends eating no more than 2 meals per month of bass (IDHW, variously dated). The Nevada Department of Wildlife similarly issues fish consumption rate recommendations for the State of Nevada (Nevada Department of Wildlife, variously dated). Fish consumption advisories on Tribal lands are determined by the Tribes, and State and Federal guidelines serve as potential reference resources for evaluation of advisory needs on the Duck Valley Reservation.

Hg concentrations in fish have been monitored periodically on the Duck Valley Reservation to support evaluation of potential human health exposure from locally caught fish. The U.S. Geological Survey (USGS), in cooperation with the Sho-Pai Tribes, measured Hg concentrations in rainbow trout fish muscle tissue in 2007, 2009, and 2013 on three reservoirs in the Duck Valley Reservation: Mountain View Reservoir, Lake Billy Shaw, and Sheep Creek Reservoir (fig. 1*A*). IDHW toxicologists determined that concentrations found did not warrant a fish consumption advisory for rainbow trout in any sampling year because no sampled trout had a Hg concentration greater than 0.3 mg/kg ww (Williams and others, 2015). The USGS again sampled rainbow trout in these three reservoirs in 2024 to assess (1) human health exposure risk to Hg in rainbow trout and (2) trends in Hg concentrations as compared to prior sampling in 2007, 2009, and 2013.

Reservoir rainbow trout populations are maintained through stocking from two hatcheries: small trout are stocked from Black Canyon Trout Farm (BCTF) near Grace, Idaho, and large, catch-ready trout are stocked from Desert Springs Trout Farm (DSTF) near Summer Lake, Oregon. Stocking practices influence Hg concentrations, because newly stocked fish likely contain lower Hg owing to lower exposure during hatchery rearing. The mixture of stocked and resident species shapes the fish community available to Tribal members and visitors and influences how Hg can accumulate differently among species. Although rainbow trout has been the focus of monitoring in all sampling years, Hg data also exist for several resident species, such as yellow perch, smallmouth bass, and largemouth bass. Because Hg bioaccumulates and biomagnifies, characterizing Hg concentrations in prey species is important for understanding exposure in larger predatory fish such as rainbow trout and bass. In 2008, *Cottus beldingii* (Paiute sculpin) and several macroinvertebrate species were collected at four locations in the Owyhee River (fig. 1*A*), and these data can help to characterize Hg availability within the aquatic food web, particularly at the lowest trophic levels.

Purpose and Scope

This report evaluates temporal changes of Hg concentrations in rainbow trout in three Duck Valley Reservation reservoirs from 2007 through 2024: Mountain View Reservoir, Lake Billy Shaw, and Sheep Creek Reservoir. In addition to rainbow trout, which are stocked to support the Reservation's fisheries, this report presents a limited dataset of Hg concentrations in other resident, unstocked fish species that may be consumed by people, specifically yellow perch, smallmouth bass, and largemouth bass. Hg concentrations from hatchery rainbow trout obtained from the BCTF and DSTF are also presented to document Hg levels prior to stocking. All fish tissue Hg concentrations are compared to the EPA MeHg criterion of 0.3 mg/kg ww to provide context for potential human health exposure risk.

This report further compiles existing data from other sites within and adjacent to the Reservation that may be of interest to fishery managers and anglers, namely the Owyhee River and Wild Horse Reservoir. Although these sites were not sampled in 2024, Hg concentrations in rainbow trout and smallmouth bass were quantified in previous sampling years (2008 in the Owyhee River and 2007 in Wild Horse Reservoir). Finally, data are presented for a small-bodied fish (Paiute sculpin) and macroinvertebrates collected from the Owyhee River in 2008. This report and accompanying data release (Chasmar and Murray, 2026) provide the Sho-Pai Tribes with information on Hg consumption risk to their local people and visiting anglers.

Methods

This section describes the field and laboratory procedures used to collect and analyze fish and macroinvertebrate samples throughout the study period. Field sampling methods are summarized first, followed by laboratory analytical procedures and statistical approaches used to evaluate Hg concentrations.

Field Methods

Rainbow trout was the target species for monitoring, and individuals were primarily collected from three reservoirs (Mountain View Reservoir, Lake Billy Shaw, and Sheep Creek Reservoir) in May 2007, June 2009 and 2013, and July 2024. Fishing methods varied by year and site, and included the use of gill nets, fyke nets, hook and line, and electrofishing (Chasmar and Murray, 2026). Upon capture, fish were weighed and measured from the anterior-most part of the fish (head) to the tip of the longest caudal fin ray (tail). During measurement, the lobes of the caudal fin were depressed dorsoventrally to determine the longest portion of the tail for a measurement of total length. Rainbow trout were additionally collected directly from the trout farms that supply fish for stocking, to measure the background concentration of fish being introduced into the system. In 2007, 2009, and 2013, hatchery-raised rainbow trout were collected from the BCTF, and in 2024, from the DSTF.

In 2007, 2009, and 2013, fish were euthanized and frozen within 24 hours of capture. A 1-inch skinless fillet was taken from each fish just below the dorsal fin (Williams and others, 2015) and evaluated using the methods described in the "Laboratory Evaluation" section. In 2024, an attempt was made to sample muscle tissue using non-lethal techniques. After fish were collected on site, two muscle biopsy plugs were collected from each fish (one plug from each side), according to the methodology outlined in EPA (2023a). After clearing a small area of scales, biopsy muscle plugs were collected with a sterile, 8-millimeter-diameter biopsy punch to an approximate equal depth of 8 millimeters, placed in a glass vial, and immediately placed in a freezer. Biopsy methods have been approved in an independent quality assurance project plan (EPA, 2023b). Fish were then placed in a live well to recover from the biopsy and released when possible. If a fish did not survive the biopsy plug sampling, a 1-inch piece of muscle fillet was collected and frozen so the results of the fillet and plug method could be compared. Though rainbow trout were the focus of this study, muscle samples were collected from other species using these methods (fillets in 2007, 2009, and 2013; plugs in 2024) if they were encountered as bycatch. These included three fish species that are readily caught and consumed: yellow perch, smallmouth bass, and largemouth bass.

To assess Hg concentrations in rainbow trout prey species, macroinvertebrate samples were collected in 2008 using a D-frame kick-net, identified and sorted to the lowest practical taxonomic level in the field, and composited into a sample where adequate mass was present for metals analyses. Taxa collected were *Pteronarcys californica* (giant stoneflies), *Hydropsychidae* sp. (net-spinning caddisflies), and *Limnephilidae* sp. (northern caddisflies). Sample preparation and handling followed the methods outlined in Crawford and Luoma (1993). The number of macroinvertebrate individuals composited into a sample can be found in Chasmar and Murray (2026). In 2008, whole-body samples were also collected for Paiute sculpin, with each sample composited from 10 individual fish.

Although the three Duck Valley Reservation reservoirs were the focus sites in this study, some samples were previously collected at additional sites: Wild Horse Reservoir in 2007 and four sites on the Owyhee River in 2008 (fig. 1*A*). The four Owyhee River sites are abbreviated as OR-1 (farthest upstream), OR-2, OR-3, and OR-4 (farthest downstream) within this report for the reader's convenience. For readers intimately familiar with the study area, a longer site code is also denoted in figure 1*A* as follows: OR-1 is equivalent to site RIZBI0A, OR-2 to DV0100, OR-3 to DV0122, and OR-4 to DV0103. A complete list of sampling location metadata is compiled in table 2.

Table 2. Sampling sites within and near the Duck Valley Reservation, Idaho and Nevada.

[Data are from Chasmar and Murray (2026) and U.S. Geological Survey (2025). Short and abbreviated (abbr.) site names are used for brevity throughout this report. Latitude and longitude are referenced to the North American Datum of 1983. ID, Idaho; NV, Nevada; Mi, Miles; Res., Reservoir Nr, Near; OR, Oregon]

Site number	Site name			Latitude	Longitude
	Long	Short	Abbr.		
420317116095800	Mountain View Reservoir, ID	Mountain View	MV	41.9653	−116.2386
415755116141900	Billy Shaw Reservoir, NV	Billy Shaw	BS	41.8628	−116.2625
415146116154500	Sheep Creek Reservoir, NV	Sheep Creek	SC	42.0547	−116.1661
414127115481200	Wild Horse Reservoir, NV	Wild Horse	WH	41.6908	−115.8033
414512115533000	Owyhee River 6 Mi South of Mountain City, NV	Owyhee River 1 (RIZBI0A)	OR-1	41.7533	−115.9258
415010115575700	Owyhee River at Res. Boundary at Mountain City NV	Owyhee River 2 (DV0100)	OR-2	41.8361	−115.9658
420043116093800	Owyhee River near Riddle ID	Owyhee River 3 (DV0122)	OR-3	42.0119	−116.1606
420452116163800	Owyhee River below Ross Slough Nr Riddle ID	Owyhee River 4 (DV0103)	OR-4	42.0811	−116.2772
10080050	Black Canyon Trout Farm near Grace, ID	Black Canyon Trout Farm	BCTF	42.5600	−111.8014
425921120435800	Desert Springs Trout Farm Nr Summer Lake, OR	Desert Springs Trout Farm	DSTF	42.9890	−120.7325

Laboratory Evaluation

Total Hg is analyzed in fish tissue rather than MeHg because total Hg concentrations serve as a reliable proxy for MeHg, which constitutes most Hg in fish tissue, and because total Hg laboratory analyses are less expensive (Bloom, 1992). For the purposes of comparison with the EPA MeHg criterion, total Hg in fish tissue was subsequently assumed to be equivalent to MeHg. Fish tissue samples from 2007, 2009, and 2013 were sent to the USGS M3 Research Laboratory (MRL) in Middleton, Wisconsin. Samples were analyzed according to EPA method 7473 (EPA, 2007), with Hg reported on a dry weight basis, with a minimum detection limit of 0.008 milligram per kilogram of dry weight. The USGS MRL obtained percent moisture values from the sample mass before and after freeze-drying. Hg concentration reported on a wet weight basis is calculated as:

$$Hg_{ww} = Hg_{dw} \times \frac{(100 - \%_{moisture})}{100}, \quad (1)$$

where

Hg_{ww} is Hg concentration expressed on a wet weight (ww) basis, in milligrams per kilogram;

Hg_{dw} is Hg concentration expressed on a dry weight (dw) basis, in milligrams per kilogram; and

$\%_{moisture}$ is percent moisture, in percent.

Samples from 2024 were analyzed in-kind by the EPA Region 9 laboratory in Corvallis, Oregon, with Hg reported on a wet weight basis. The laboratory uses EPA Method 7473 (SW-846) as the reference method for determining Hg concentration (EPA, 2007). Detailed analytical procedures, including deviations from the reference method, are documented in a laboratory standard operating procedure (SOP 535; EPA, 2023c). Analytical results are reported in milligram total Hg per kilogram of wet weight, with a method detection level of approximately 0.0125 mg/kg ww, with suitable sample mass provided. Analytical methods by the EPA Region 9 laboratory have been approved in EPA (2023b), a quality assurance project plan. Because biopsy plugs were submitted to the laboratory in 2024, the sample mass did not allow for laboratory analysis of percent moisture. The 2024 Hg results can thus not be converted to a dry weight basis.

Macroinvertebrate samples were analyzed for total Hg and other trace metals by the USGS Georgia Water Science Center Sediment-Partitioning Research Laboratory in 2008. The laboratory used acid digestion with quantification by hydride generation atomic absorption (Elrick and Horowitz, 1985). In addition to Hg, the full suite of analytes reported for macroinvertebrate samples comprises the following: copper, lead, zinc, cadmium, chromium, cobalt, nickel, phosphorus, arsenic, selenium, iron, manganese, aluminum, titanium, and percent moisture. At the time of writing, this laboratory is no longer in operation and the USGS Georgia Water Science Center is part of the South Atlantic Water Science Center.

All of the laboratories practice standard quality assurance and quality control (QAQC) procedures. Laboratory QAQC protocols include the use of certified reference materials, blanks, matrix spikes, calibration standards, and duplicates. Field replicates have also been submitted in various sampling years. Data quality objectives have been reviewed in each sampling year, and the laboratory QAQC metrics of 2007, 2009, and 2013 are discussed in detail in Williams and others (2015). The QAQC data for all sampling years are compiled in the accompanying data release to this report (Chasmar and Murray, 2026). In 2024, the EPA Region 9 laboratory used two certified reference materials in analytical runs, Lake Superior Fish Tissue (SRM-1946, certified Hg concentration of 0.433 mg/kg ww) and oyster tissue (SRM-1566b, certified Hg concentration of 0.0371 mg/kg ww), and reported recoveries of 93−98 percent (Chasmar and Murray, 2026). Laboratory duplicates in 2024 had a relative difference of 2−11 percent (Chasmar and Murray, 2026). Three field duplicates (a second sample taken from the same individual fish in the field) submitted in 2024 were within a 12 percent relative difference (Chasmar and Murray, 2026). All 2024 blanks and calibration standards passed internal laboratory QAQC checks. Method comparison results of 2024 biopsy and fillet samples are discussed in the "Results and Discussion" section.

Statistics

For assessment of interannual trends in rainbow trout Hg concentrations at each Duck Valley Reservation reservoir, Hg concentrations were first normalized by fish length (by taking the ratio of Hg concentration divided by fish length) and log-10 transformed, to account for correlations between length and Hg and heteroscedasticity of the sample data. A Mann-Kendall test was performed on the normalized, transformed data to determine monotonic changes in Hg concentrations over time (Mann, 1945). The Mann-Kendall test was performed on each reservoir using the yearly average of the normalized and log-transformed data using the R function "MannKendall" (McLeod, 2022) in R version 4.5.2 (R Core Team, 2025), and a p-value was calculated from the resulting S statistic (S). The null hypothesis of "no change" is rejected if S is significantly different from zero ($p<0.05$).

Comparisons between species were made using measured concentrations without normalizing by length or log-10 transforming, because the actual Hg concentration is relevant to what people would be consuming from fish, and different fish species have different length distributions. Results of the measured Hg concentrations without data transformation are presented in report figures and tables to clearly compare concentrations to the EPA MeHg criterion of 0.3 mg/kg ww. Although measured concentrations are reported, the statistical analysis of site differences in rainbow trout Hg concentrations was done on length-normalized and log-10 transformed data. To test statistical differences between species and sites, an analysis of variance was performed, followed by a Tukey's Honest Significant Difference test (Tukey, 1949). Significance was assessed at a 95-percent confidence interval ($p<0.05$). In the "Results and Discussion" section, "measured Hg" refers to the lab-reported measured Hg concentrations in mg/kg ww, and "normalized Hg" refers to Hg concentrations after they have been length-normalized and log-10 transformed. References to Hg concentrations hereafter refer to total Hg.

Results and Discussion

This section summarizes observed Hg concentrations in fish and macroinvertebrate samples collected from the Duck Valley Reservation reservoirs, Wild Horse Reservoir, and four sites on the Owyhee River. Patterns in measured and normalized Hg are compared across years, species, and locations. Discussion following the results interprets these patterns in terms of ecological processes that influence Hg accumulation and the potential human health implications of consuming fish from the study area.

Rainbow Trout in Duck Valley Reservoirs

Measured Hg concentrations of rainbow trout muscle tissue by reservoir and year are summarized in table 3 and plotted in figure 3 so that Hg concentrations can be easily compared to the EPA MeHg criterion of 0.3 mg/kg ww. In 2024, one sampled rainbow trout from Sheep Creek Reservoir exceeded the EPA MeHg criterion, measuring 0.32 mg/kg ww. All other sampled rainbow trout in the three Duck Valley reservoirs (Mountain View Reservoir, Lake Billy Shaw, and Sheep Creek Reservoir) were below the EPA criterion in 2007, 2009, 2013, and 2024 (n=159).

Measured Hg was positively correlated with fish length (coefficient of determination [R^2]=0.42, $p<0.001$; fig. 4), and fish sampled in 2024 were longer on average than those sampled in earlier years (2007, 2009, and 2013). The average concentration of measured Hg in the sampled 2024 fish is thus expected to be higher than in other years prior to normalizing the data by length. Results of the Mann-Kendall trend test on normalized (length-normalized, log-10 transformed) Hg concentrations showed a significant increasing trend in Hg concentration in Sheep Creek Reservoir rainbow trout from 2007 to 2024 (Kendall's tau=1, S=6, $p<0.05$). The mean measured Hg concentration of sampled fish in Sheep Creek Reservoir increased from 0.059 mg/kg ww in 2007 to 0.177 mg/kg ww in 2024, which is still below the EPA criterion of 0.3 mg/kg ww (table 3). No significant trends were observed in the normalized Hg concentration of rainbow trout in Mountain View Reservoir or Lake Billy Shaw ($p>0.49$ for each reservoir).

Rainbow trout are stocked by the Sho-Pai Tribes and sourced from two fish hatcheries. The BCTF provides small fish, and was sampled in 2007, 2009, and 2013. All sampled fish from the BCTF had measured Hg concentrations below

Table 3. Summary of measured mercury by site, species, and year.

[Data are from Chasmar and Murray (2026). Additional site information is in table 2. *n*, number; mg/kg ww, milligrams per kilogram of wet weight; —, no data]

Site	Species	Year	*n*	Measured mercury (mg/kg ww)		
				Mean	Minimum	Maximum
MV	Rainbow trout	2007	15	0.125	0.024	0.257
		2009	15	0.067	0.019	0.139
		2013	15	0.055	0.013	0.105
		2024	8	0.098	0.064	0.150
	Yellow perch	2024	1	0.140	—	—
	Smallmouth bass	2024	1	0.130	—	—
BS	Rainbow trout	2007	15	0.119	0.029	0.260
		2009	15	0.073	0.033	0.114
		2013	14	0.089	0.047	0.158
		2024	7	0.183	0.140	0.240
	Yellow perch	2013	1	0.177	—	—
		2024	1	0.290	—	—
	Smallmouth bass	2013	1	0.069	—	—
SC	Rainbow trout	2007	15	0.059	0.024	0.292
		2009	15	0.054	0.017	0.103
		2013	15	0.102	0.037	0.227
		2024	10	0.177	0.110	0.320
	Yellow perch	2013	10	0.150	0.086	0.222
		2024	2	0.185	0.180	0.190
	Largemouth bass	2013	2	0.715	0.396	1.033
	Smallmouth bass	2013	3	0.157	0.130	0.173
WH	Rainbow trout	2007	15	0.113	0.021	0.321
OR-1	Rainbow trout	2008	5	0.165	0.080	0.254
	Paiute sculpin	2008	1	0.128	—	—
	Giant stoneflies	2008	1	0.012	—	—
OR-2	Rainbow trout	2008	12	0.152	0.079	0.274
	Paiute sculpin	2008	1	0.044	—	—
	Giant stoneflies	2008	1	0.024	—	—
	Net-spinning caddisflies	2008	1	0.019	—	—
OR-3	Rainbow trout	2008	3	0.430	0.283	0.584
	Net-spinning caddisflies	2008	1	0.004	—	—
	Northern caddisflies	2008	1	0.018	—	—
OR-4	Smallmouth bass	2008	1	0.667	—	—
	Northern caddisflies	2008	1	0.044	—	—
BCTF	Rainbow trout	2007	5	0.037	0.029	0.046
		2009	5	0.017	0.011	0.028
		2013	7	0.013	0.011	0.022
DSTF	Rainbow trout	2024	5	0.089	0.080	0.099

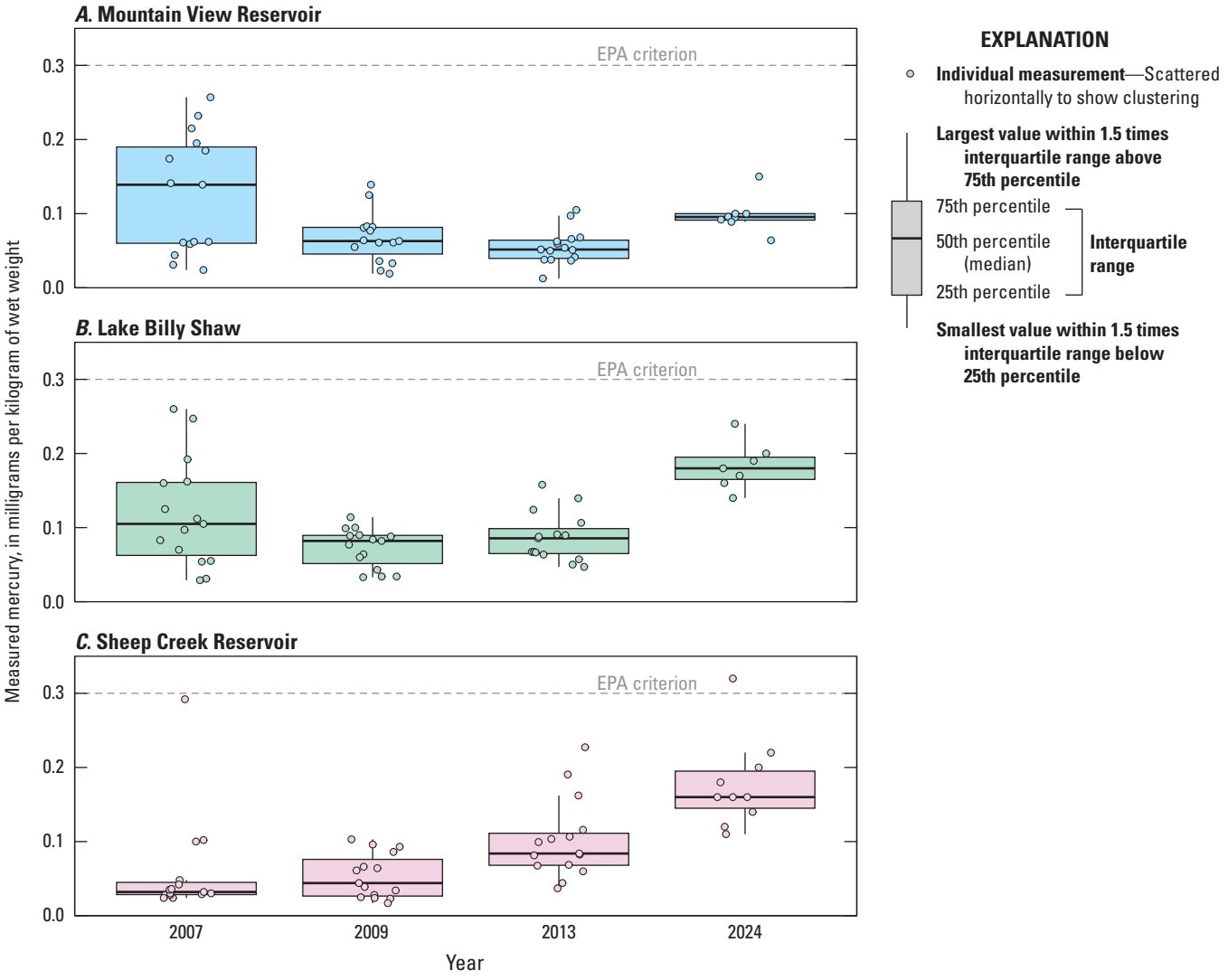


Figure 3. Boxplots showing measured mercury in rainbow trout muscle tissue collected from *A*, Mountain View Reservoir, *B*, Lake Billy Shaw, and *C*, Sheep Creek Reservoir in 2007, 2009, 2013, and 2024. Mercury concentration criterion is from U.S. Environmental Protection Agency (2001). Additional site information is in table 2.

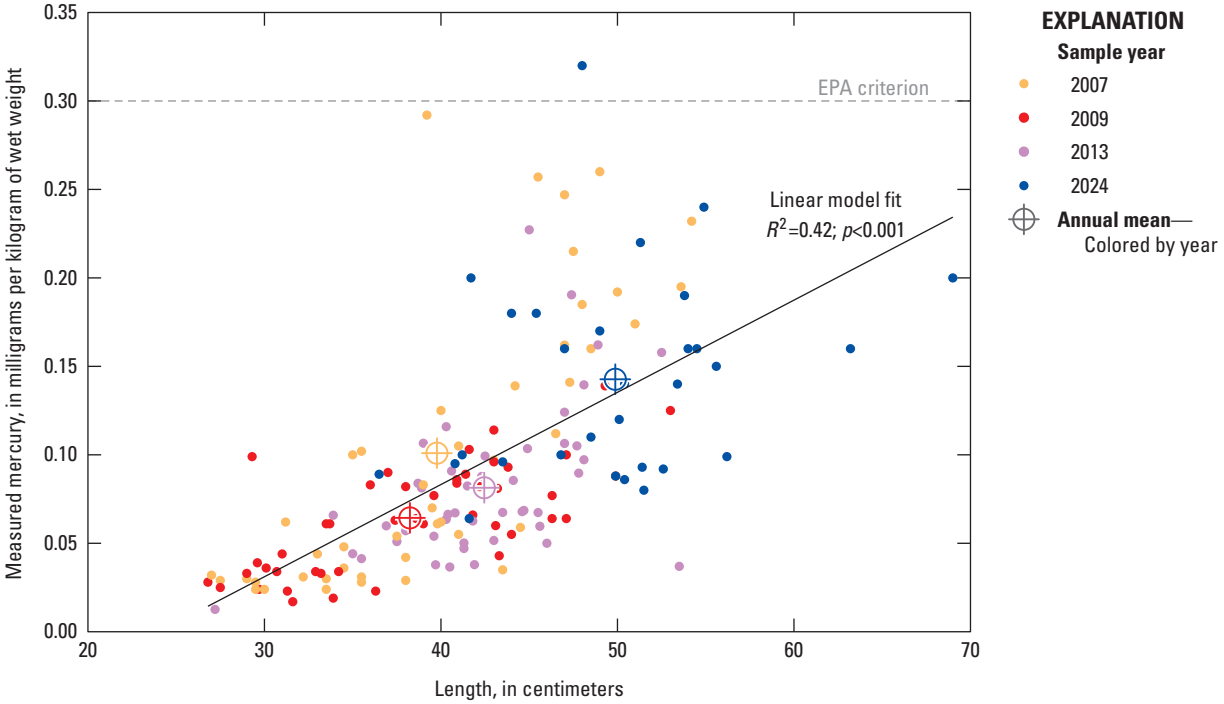


Figure 4. Plot showing measured mercury in rainbow trout muscle tissue by length of specimens collected from three Duck Valley Reservation reservoirs in 2007, 2009, 2013, and 2024. Mercury concentration criterion is from U.S. Environmental Protection Agency (2001). A linear model is fitted to the individual fish data, whereas annual means are shown for reference. Additional site information is in table 2. [R^2, coefficient of determination]

0.05 mg/kg ww (Williams and others, 2015). The Sho-Pai Tribes began stocking the reservoirs with large, catch-ready rainbow trout from the DSTF at some point between 2013 and 2024, in addition to the smaller fish from the BCTF. The large hatchery fish from the DSTF had higher average measured Hg concentrations (0.089 mg/kg ww) than the smaller fish from the BCTF (0.011–0.029 mg/kg ww, depending on the sample year; table 3; fig. 5). We would expect larger fish to have a higher Hg burden on the basis of size correlation. However, the normalized Hg concentration of DSTF fish tissue was still statistically higher than that of BCTF fish (p<0.001; table 4). All hatchery fish, regardless of source, had Hg concentrations well below EPA's recommended criterion of 0.3 mg/kg ww (fig. 5).

In 2024, Mountain View Reservoir rainbow trout had statistically lower normalized Hg concentrations than Lake Billy Shaw or Sheep Creek Reservoir (p<0.01; table 4), although it is possible this was a sampling artifact. In 2024, Lake Billy Shaw and Sheep Creek Reservoir had statistically higher normalized Hg concentrations than hatchery fish from the DSTF (p<0.001; table 4), but the same was not true for Mountain View Reservoir (table 4). Exact fish stocking schedules could not be confirmed at the time of sampling, but normalized Hg concentrations in rainbow trout from the DSTF and Mountain View Reservoir were statistically similar (p=0.412; table 4), indicating that recently stocked fish may have been sampled at Mountain View Reservoir in 2024. Lake Billy Shaw and Sheep Creek Reservoir normalized Hg concentrations were statistically similar to each other in 2024 (p=0.927; table 4) and higher than stocked fish from the hatchery (p<0.001; table 4).

In comparing the full data distribution of Hg in rainbow trout among reservoirs across all sample years, there is not a statistically significant difference in normalized Hg concentrations between the three Duck Valley Reservation reservoirs (table 4). The reservoirs may have similar Hg methylation rates to produce similar bioaccumulation values in rainbow trout, but additional water sampling would be necessary to characterize the Hg cycling within each reservoir. Interannual variability is also probable owing to variability in the population and fish stocking schedules across the sampling years. It is also worth noting that rainbow trout were sampled in slightly different seasons in each sample year: late spring (May 2007), early summer (June 2009 and 2013), and midsummer (July 2024). Interannual variability could be introduced by seasonal shifts in diet between the sampling months, or seasonality of MeHg production (Mills and others, 2018; Willacker and others, 2025). Thus, the

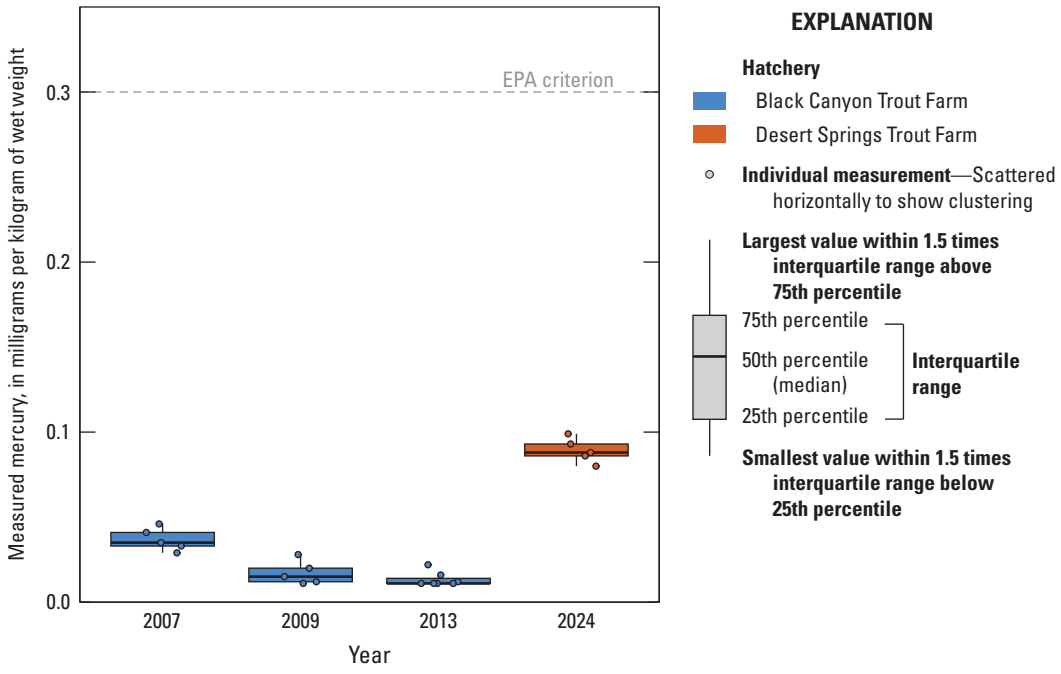


Figure 5. Boxplots showing measured mercury in rainbow trout muscle tissue collected from two hatcheries, Black Canyon Trout Farm near Grace, Idaho (2007, 2009, and 2013), and Desert Springs Trout Farm near Summer Lake, Oregon (2024). Mercury concentration criterion is from U.S. Environmental Protection Agency (2001).

within-site variability between sample years may make it difficult to discern statistically significant differences between the reservoirs when averaging the full dataset.

Method Comparison

Measured Hg concentrations of biopsy and fillet muscle samples from the same individual fish were generally comparable (fig. 6). Eight method comparison samples collected in 2024 (biopsy versus fillet) were within a 20 percent relative difference. One sample had a relative percentage difference between 20 and 25, but the absolute difference in measured Hg was small (less than 0.02 mg/kg ww absolute difference). One sample had fillet results that differed from the biopsy result by 38 percent (Hg concentrations of 0.22 mg/kg ww versus 0.15 mg/kg ww, respectively), and it is possible that sample handling influenced the difference rather than true concentration differences (for example, if sample drying impacted percent moisture). We did not observe any directional bias in one method result always being lower or higher than the other (fig. 6). Other studies have also shown that biopsy results are representative of whole muscle fillet results (Stahl and others, 2021). Thus, results between methods can be considered equivalent, and either method can be confidently used to determine the Hg concentration of muscle tissue within a fish.

We chose to utilize the biopsy plug method in 2024 because it offers several advantages compared to the fillet method for sampling muscle tissue in fish. First, it is a non-lethal technique, theoretically allowing fish to be released unharmed after sampling. Additionally, the biopsy plug method streamlines the logistics of sample preparation, as taking biopsy plugs directly in the field eliminates the need to transport, store, and thaw large fish. However, we experienced some notable drawbacks to the biopsy plug method. The small size of the biopsy sample mass relative to a 1-inch muscle fillet limits the scope of analysis, restricting analysis to a single analyte (in this case, total Hg) and excluding analyses of percent moisture or additional metals. Non-lethal fishing methods can present sampling challenges, requiring more time in the field and incurring higher costs for specialized supplies. Taking the biopsy plug can be particularly stressful for certain species, and we experienced a high mortality rate of rainbow trout when taking biopsy plugs in 2024. Sampling took place in late July, and it is conceivable that the high air and water temperatures inhibited the fish's ability to recover from a biopsy plug. Although the biopsy plug method has benefits, careful consideration of its drawbacks is essential for effective implementation in fish tissue sampling.

Table 4. Results of statistical tests comparing fish muscle tissue mercury (Hg) concentrations across sites, years, and species, using an analysis of variance (ANOVA) formula followed by Tukey's Honest Significant Difference test.

[Data are from Chasmar and Murray (2026). The ANOVA formula specifies the Hg dataset used in statistical tests, with "measured Hg" referring to lab-reported measured concentrations and "normalized Hg" referring to the fully transformed Hg concentrations (after normalizing by length and log-10 transformation). A determination is only given for statistically significant (p<0.05) test results and indicates the direction of the difference. For example, the determination "DSTF<BS" means that the concentration of Hg in Desert Springs Trout Farm fish was statistically lower than the concentration of Hg in Lake Billy Shaw fish, using the specified ANOVA formula and datasets. The difference and lower and upper confidence intervals are output by the ANOVA test as the difference between comparison group means relative to the variability within comparison groups and provide the direction of difference (in the previous example of DSTF<BS, the difference is negative). Additional site information is in table 2. 95% CI, 95-percent confidence interval; Adj., adjusted; Hg, total mercury; RBT, rainbow trout; <, less than; >, greater than; NA, not applicable; LMB, largemouth bass; SMB, smallmouth bass; YP, yellow perch]

ANOVA formula (response ~ predictor)	Datasets included in ANOVA formula			Comparison groups	Difference	Lower (95% CI)	Upper (95% CI)	Adj. *p*-value	Determination
	Year(s)	Sites	Species						
normalized Hg ~ site	2007, 2009, 2013, 2024	BCTF, DSTF	RBT	DSTF:BCTF	0.8115	0.4991	1.1238	<0.001	DSTF>BCTF
normalized Hg ~ site	2024	MV, BS, SC, DSTF	RBT	DSTF:BS	−0.6378	−0.9907	−0.2849	<0.001	DSTF<BS
				MV:BS	−0.4410	−0.7529	−0.1291	0.003	MV<BS
				SC:BS	−0.0664	−0.3634	0.2306	0.927	NA
				MV:DSTF	0.1968	−0.1468	0.5404	0.412	NA
				SC:DSTF	0.5714	0.2413	0.9015	<0.001	SC>DSTF
				SC:MV	0.3745	0.0887	0.6604	0.007	SC>MV
normalized Hg ~ site	2007, 2009, 2013, 2024	MV, BS, SC, WH	RBT	MV:BS	−0.1670	−0.4147	0.0807	0.344	NA
				SC:BS	−0.1336	−0.3791	0.1119	0.564	NA
				WH:BS	0.0120	−0.3589	0.3829	1.000	NA
				SC:MV	0.0334	−0.2097	0.2764	0.996	NA
				WH:MV	0.1790	−0.1903	0.5482	0.670	NA
				WH:SC	0.1456	−0.2222	0.5134	0.811	NA
measured Hg ~ species	2007, 2009, 2013, 2024	MV, BS, SC, WH, OR- 1, OR- 2, OR- 3, OR- 4	RBT, LMB, SMB, YP	SMB:RBT	0.1202	0.0231	0.2173	0.007	SMB>RBT
				LMB:RBT	0.6115	0.4451	0.7780	<0.001	LMB>RBT
				YP:RBT	0.0620	−0.0010	0.1245	0.056	NA
				LMB:SMB	0.4913	0.3001	0.6826	<0.001	LMB>SMB
				YP:SMB	−0.0585	−0.1716	0.0547	0.614	NA
				YP:LMB	−0.5498	−0.7261	−0.3735	<0.001	YP<LMB

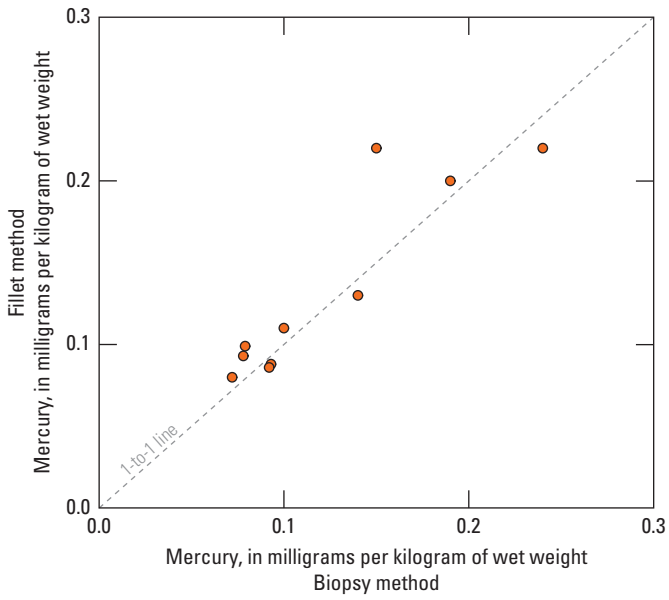


Figure 6. Plot comparing mercury concentrations of fish from three Duck Valley Reservation reservoirs that were sampled using the biopsy and fillet methods in 2024.

Other Species and Sites

Comparisons between species were made on measured Hg concentrations without length normalization or log-10 transformation, because the measured Hg best represents what people would consume, and the species differ in their length distributions. All sampled fish were of reasonable consumption size, and the length distribution of sampled fish by species, in centimeters, was as follows: yellow perch, 24.5–28.3; smallmouth bass, 23.7–48.6; largemouth bass, 26.2–47.3; and rainbow trout, 19.0–69.0 (Chasmar and Murray, 2026). The small number of total fish caught for many sites and species limits statistical interpretation. One rainbow trout from OR-3 had a high measured Hg concentration of 0.58 mg/kg ww (table 3; fig. 7). Upon further investigation, this sample had an abnormally low water content of 43 percent moisture compared to a median of 78 percent observed in the full dataset of rainbow trout samples (Chasmar and Murray, 2026), and it is possible that the sample was allowed to dry at some point in the sample collection or lab analysis process. Because wet weight Hg calculations depend on the percent moisture of the tissue (eq. 1), the sample result from this single fish may be biased high. This measured Hg concentration (0.58 mg/kg ww) is reported and plotted in this report (table 3; fig. 7) but is flagged in the data release (Chasmar and Murray, 2026) and omitted from statistical tests.

Largemouth bass and smallmouth bass had higher measured Hg concentrations than rainbow trout (p<0.001 and p=0.007, respectively; table 4). Although only two largemouth bass were sampled, both had higher measured Hg than any other species (p<0.001; table 4) and exceeded the EPA MeHg criterion of 0.3 mg/kg ww (fig. 7). Despite being smaller than rainbow trout, smallmouth bass had higher measured concentrations of Hg, on average. Measured Hg concentrations in yellow perch were higher than in rainbow trout, although the difference was not quite significant at the 95-percent confidence interval (p=0.056; table 4). Given that sampled yellow perch were much smaller on average than sampled rainbow trout, the near-significant value indicates that Hg concentrations in yellow perch likely pose a higher risk to consumers than similarly sized rainbow trout. Yellow perch Hg concentrations were statistically similar to smallmouth bass (p=0.614; table 4). Data distributions of measured Hg in all fish species at all sampled sites are presented in figure 7.

Rainbow trout concentrations in the Duck Valley reservoirs may be lower than those of other species, owing in part to the high stocking frequency of the reservoirs. The unstocked species (yellow perch, smallmouth bass, and largemouth bass) may better represent the full bioaccumulation potential of these reservoirs. The unstocked species may also pose a greater risk for human consumption, especially for the highest trophic levels with a higher bioaccumulation potential, such as largemouth bass. Although stocking practices play a role, Trout (Salmonidae) family fish commonly have a lower Hg muscle concentration than fish in the Sunfish (Centrarchidae) and Perch (Percidae) families when looking at data across the United States from 1985 through 2005, and diet is an important factor to species-level bioaccumulation (Scudder and others, 2009). The high Hg concentrations measured in largemouth bass are not surprising, as they are a large predatory fish species that are expected to bioaccumulate a higher level of Hg, and the IDHW has an active statewide fish advisory in effect for bass caught in Idaho at the time of writing this report. Rainbow trout were also classified in a slightly lower trophic level (primarily insectivore) than yellow perch, smallmouth bass, and largemouth bass (insectivore-piscivore) within the Hells Canyon Complex in Idaho and Oregon (Richter, 2001), although many factors (such as food availability, fish size, habitat characteristics, and species populations) could affect the relative trophic position of these species in Duck Valley Reservation reservoirs.

One rainbow trout out of 15 sampled in Wild Horse Reservoir in 2007 exceeded the EPA MeHg criterion, measuring 0.321 mg/kg ww, and 2 other fish were close to this value (fig. 7). The normalized Hg concentrations of rainbow trout in Wild Horse Reservoir were not statistically different from any Duck Valley Reservation reservoir (table 4). Rainbow trout were sampled at three Owyhee River sites in 2008, but we did not statistically compare these concentrations to the reservoir sites because sample sizes were small. Additionally, the rainbow trout sampled from the river were smaller than those in the reservoirs on average, and a comparison of normalized Hg concentrations could be biased.

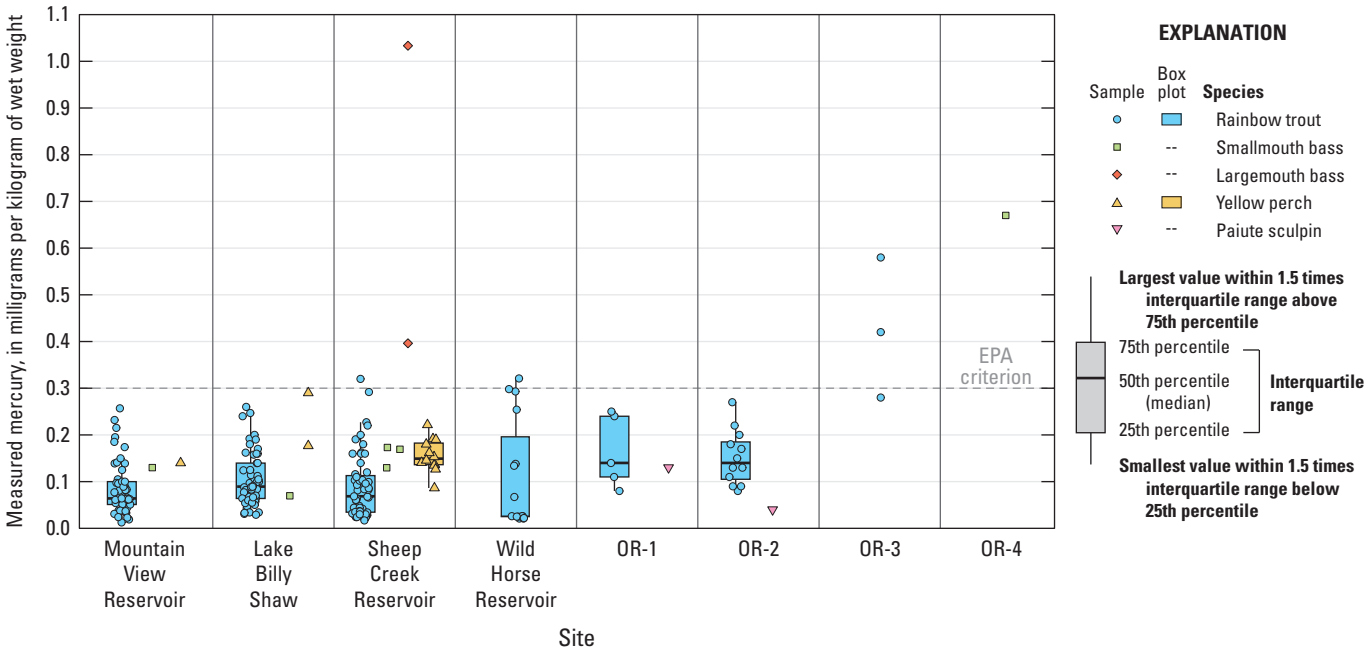


Figure 7. Boxplots showing measured mercury concentrations of all fish species collected across all reservoirs and Owyhee River sites and years (2007, 2008, 2009, 2013, and 2024). Boxes are only drawn when the sample size for a given site and species is greater than or equal to five. Mercury concentration criterion is from U.S. Environmental Protection Agency (2001). Additional site information is in table 2.

One sampled rainbow trout at OR-3 had a measured Hg concentration of 0.58 mg/kg ww that we flagged as potentially erroneous but left in table 3 and figure 7. However, a second rainbow trout sampled at OR-3 measured 0.42 mg/kg ww, which was the highest measured Hg concentration observed in rainbow trout muscle tissue at any site. The measured Hg concentrations at OR-1 and OR-2 were low in comparison to OR-3. Only one fish sample, smallmouth bass, was taken at the farthest downstream Owyhee River site (OR-4). Although statistical determinations cannot be made from a sample size of one fish, this sample had a higher measured Hg concentration than any other smallmouth bass sampled at other sites (fig. 7). The extent of Hg exposure for anglers fishing the Owyhee River within the Duck Valley Reservation is less well characterized, as sampling in this area has been limited. It is feasible that the Owyhee River has different Hg cycling dynamics because the river has different hydrologic controls (depth, flow, and so on) and presumably different water chemistry than the reservoirs. The trophic position of rainbow trout in the Owyhee River is likely to differ from that in the reservoirs, because variations in macroinvertebrate communities will subsequently change the food web structure. Wild Horse Reservoir upstream of the Owyhee River sites is stocked with rainbow trout, and some of those fish may pass downstream over the spillway into the river, which could partially explain the lower measured Hg concentrations at OR-1 and OR-2 relative to downstream sites. Trout (Salmonidae) family species from streams in the United States sampled between 1985 and 2005 had a mean Hg concentration of 0.109 mg/kg ww, ranging from 0.014 to 0.588 mg/kg ww across 53 averaged sites (Scudder and others, 2009). The distribution of Hg in rainbow trout sampled from river or reservoir sites in this study was comparable, with a mean Hg concentration of 0.106 mg/kg ww, and a range of 0.013–0.42 mg/kg ww (excluding the flagged 0.58 mg/kg ww concentration at OR-3; Chasmar and Murray, 2026)

Measured Hg concentrations of all lower trophic level species are compiled in table 3 and figure 8. The Hg concentration in Paiute sculpin collected in 2008 ranged from 0.04 mg/kg ww in Owyhee River site OR-2 to 0.13 mg/kg ww in OR-1 (table 3; fig. 8), both below the EPA MeHg criterion of 0.3 mg/kg ww. In the Western United States and Canada, Eagles-Smith and others (2016) found that the median Paiute sculpin Hg concentration from 7 distinct sites between 1969 and 2014 was 0.092 mg/kg ww (maximum 0.236 mg/kg ww) and determined that sculpin as a generalized group had a geometric mean of 0.06 mg/kg ww. Thus, the two Paiute sculpin samples collected in the Owyhee River seem to be in a low to normal range. Sculpin are also considered to be primarily insectivorous and would be expected to have lower Hg concentrations than piscivorous fish owing to their lower trophic position.

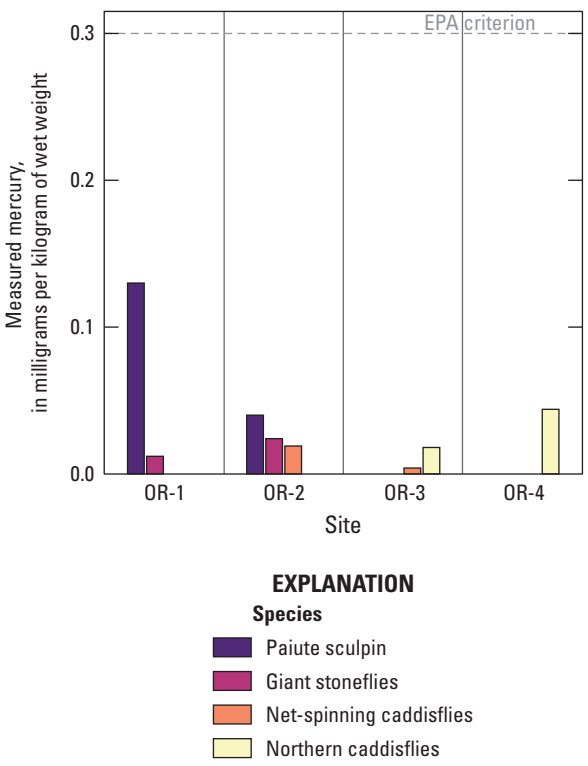


Figure 8. Bar graph showing measured mercury concentrations of lower trophic level species collected from the four Owyhee River sites in 2008. Each bar represents a single sample result, and each sample was a composite of whole-body individuals. Mercury concentration criterion is from U.S. Environmental Protection Agency (2001). Additional site information is in table 2.

Measured Hg in macroinvertebrates ranged from 0.004 to 0.044 mg/kg ww, depending on the site and taxa (table 3; fig. 8). Because we only have one result per site and species for the year sampled, we did not do any interspecies statistical comparisons. Individual taxa are plotted in figure 8 in reference to the EPA criterion, although this criterion does not apply to macroinvertebrates, and we would expect macroinvertebrate Hg concentrations to be much lower than those of predatory fish. We can assume most of the total Hg is in the methyl form in fish (Bloom, 1992), but the same assumption does not hold for macroinvertebrates, and the functional feeding group of the invertebrate species impacts the ratio of MeHg to total Hg (Clayden and others, 2014). Studies from other regions illustrate this variability: in streams of the Adirondack Mountains in New York, the ratio of MeHg to total Hg was only 52 percent in shredders (for example, northern caddisflies), and this value varied significantly between taxa, among sites, and seasonally (Marziali and others, 2021). Therefore, we cannot infer the MeHg available to fish without directly measuring MeHg in macroinvertebrates (as opposed to total Hg), and the measured Hg in macroinvertebrates should be considered the maximum possible concentration of MeHg (if all Hg is in the form MeHg). The measurements we have of Hg concentration in macroinvertebrates may help us to compare sites and track temporal trends in the base of the food web. The farthest downstream Owyhee River site (OR-4) had the highest concentration of total Hg in any macroinvertebrate: 0.044 mg/kg ww in northern caddisflies, which was 2.3 times the concentration of total Hg in northern caddisflies at OR-3 (0.018 mg/kg ww; table 3; fig. 8). Consistent sampling of the same taxa at multiple sites could help to explain the higher Hg concentrations seen downstream at Owyhee River sites OR-3 and OR-4 as compared to the upstream Owyhee River sites OR-1 and OR-2; present data do not allow for this analysis owing to limited sample size. If more sampling confirmed a higher Hg concentration in biota in the downstream river sites, the mechanisms for increased MeHg availability or uptake could be further explored. For example, land-use changes from upstream to downstream in the Owyhee River, such as increased agriculture and wetland flow returns, could affect MeHg production.

Dry weight concentrations of the following analytes in 2008 macroinvertebrate samples are provided in the associated data release to this report: copper, lead, zinc, cadmium, chromium, cobalt, nickel, phosphorus, arsenic, selenium, mercury, iron, manganese, aluminum, and titanium (Chasmar and Murray, 2026). The additional metals analyzed in these samples are not discussed in detail in this report, but aquatic insects are useful bioindicators of trace element contamination in streams (Cain and others, 1992). The 2008 data could provide a baseline level for the Owyhee River sites if any contamination occurs, such as new mining activity or other disturbances proximal to the Duck Valley Reservation.

Considerations for Future Monitoring

Measuring Hg in fish tissue is ideal for assessing exposure risk to human populations because doing so directly measures the amount of Hg people consume via those fish. Because rainbow trout are widely harvested and consumed on the Duck Valley Reservation, they remain a priority species for evaluating human exposure to Hg. A robust dataset spanning sampling in 2007, 2009, 2013, and 2024 supports future assessment of temporal trends in Hg concentrations in rainbow trout muscle tissue in Mountain View Reservoir, Lake Billy Shaw, and Sheep Creek Reservoir. This study also collected limited samples of other commonly consumed fish species, such as yellow perch, smallmouth bass, and largemouth bass. This study's small sample sizes for non-rainbow trout species limited statistical characterization of the Hg in these species as it relates to human health risk. However, concentrations above the EPA MeHg criterion were observed during this study (0.396 mg/kg ww and 1.033 mg/kg ww in largemouth bass),

indicating that additional data could improve understanding of Hg exposure across the fishery. Fish collected from the Owyhee River (sites OR-3 and OR-4) also showed elevated Hg concentrations, with three of four individuals exceeding the EPA MeHg criterion. Increased sample sizes of fish harvested from the Owyhee River, including within the Duck Valley Reservation, would allow for more robust evaluation of Hg concentrations in riverine rainbow trout, particularly in the absence of stocking management practices.

Biopsy plugs, tested in 2024, were not a viable sampling method because they resulted in longer sampling times, higher costs, and a high rate of fish mortality. The fishing methods available to the Sho-Pai Tribes in 2024 consisted of gill nets, fyke nets, and hook and line, with gill nets being the most efficient method (albeit the most lethal). Biopsy plugs may be worth trying in future monitoring under two conditions. First, better ambient conditions (cooler air and water temperatures), which may improve the fish's ability to recover. Ambient weather was very hot during the July 2024 sampling, which likely exacerbated the stress to fish upon receiving a biopsy punch. Second, a citizen fishing derby is a scenario in which anglers could bring fish they intended to catch-and-keep to a sampling station. In this setting, a biopsy plug may be the preferred sampling method because it leaves most of the muscle fillet tissue intact for the angler to take home and eat. Otherwise, it may be more feasible to sample with a traditional fillet method in future studies, so humane practices of fish euthanasia could be employed and small sample masses would not limit analytical capabilities.

Fish sampling can be difficult and expensive, and Hg concentrations can vary with natural population differences, stocking schedules, and the size distribution of sampled fish. Hg concentrations in fish also represent a composite of long-term exposure to Hg, and a large or rapid change in Hg sources or availability within the system may not be immediately reflected in fish tissue. Complementary data types, such as water-column Hg and MeHg, can more directly characterize the Hg and MeHg occurrence and dynamics (for example, methylation and demethylation), which influence fish tissue concentrations. Water sampling for Hg isotopes can help identify the relative percentages of Hg originating from legacy mining activity versus more regional atmospheric deposition (Baldwin and others, 2024; Lopez and others, 2024). Sampling of sediment, periphyton, and lower trophic level biota can characterize the movement of MeHg from the water into and through the food web, thus informing the MeHg available for fish, and subsequently humans. Food web information can also improve understanding of the diet and trophic position of sport fish (such as trout, bass, and perch) in these reservoirs and inform which species or size classes pose the greatest risk. Hg isotopes within biological samples can further clarify the sources of Hg entering the system (Lopez and others, 2025). Any data collected on Hg or other metals within the Reservation can also serve as baseline information if future changes occur in the system, such as new mining activity, land-use changes, or shifts in management practices.

Summary

The U.S. Geological Survey, in cooperation with the Shoshone-Paiute (Sho-Pai) Tribes of the Duck Valley Reservation, Nevada, measured total mercury (Hg) concentrations in *Oncorhynchus mykiss* (rainbow trout) muscle tissue from three Reservation reservoirs (Mountain View Reservoir, Idaho; Lake Billy Shaw and Sheep Creek Reservoir, Nevada) in 2007, 2009, 2013, and 2024. In all sampling years, only 1 sampled trout out of 160 exceeded the U.S. Environmental Protection Agency's recommended MeHg criterion of 0.3 milligram per kilogram of wet weight (mg/kg ww), which is intended to protect adults who incorporate an average of one 8-ounce fish meal into their diet every other week. There was a statistically significant trend of increasing Hg in Sheep Creek Reservoir rainbow trout, but no significant trend was observed in the other two reservoirs (Mountain View Reservoir and Lake Billy Shaw).

Although monitoring focused on rainbow trout in Duck Valley Reservation reservoirs, limited results are available for three other fish species readily consumed by people. Resident *Perca flavescens* (yellow perch), *Micropterus dolomieu* (smallmouth bass), and *Micropterus salmoides* (largemouth bass) had higher Hg concentrations than rainbow trout and may pose a greater risk to consumers. All sampled largemouth bass exceeded Hg concentrations of 0.3 mg/kg ww, although only two fish, both from Sheep Creek Reservoir, were sampled. Data on Hg in rainbow trout collected in 2007 were compiled from Wild Horse Reservoir. In addition, four sites on the Owyhee River were sampled in 2008 for Hg in rainbow trout, smallmouth bass, and several lower trophic level species (macroinvertebrates and Paiute sculpin). In 2008, higher concentrations of Hg were observed in rainbow trout in an Owyhee River site within the Reservation (OR-3), relative to all other sample sites across all sampling years, although too few fish were sampled for statistical comparison. Should additional sampling, if conducted, indicate higher Hg levels at this site, it may be prudent to investigate the Hg sources and cycling dynamics that make this site different from the reservoirs or upstream river sites, such as Hg depositional quantities, food web structure, land-use practices, and geochemical conditions. The three Duck Valley Reservation reservoirs (Mountain View Reservoir, Lake Billy Shaw, and Sheep Creek Reservoir) were not statistically different from each other or from Wild Horse Reservoir when comparing the full data distribution of Hg concentrations in rainbow trout sampled in all years.

Fish consumption advisories on Tribal lands are determined by the Tribes, so these results could help Sho-Pai managers determine the Hg exposure risk to Tribal members and visiting anglers. Sources of Hg and methylation processes are dynamic and can change over time, so continued monitoring of all fish species that are caught for consumption is essential to assessing human exposure risk.

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