



Assessment of Mercury in Fish Tissue from Select Lakes of Northeastern Oregon

EPA Region 10 Report



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Abstract

A fish tissue study was conducted in five northeastern Oregon reservoirs to evaluate mercury concentrations in an area where elevated atmospheric mercury deposition had been predicted by a national EPA model, but where tissue data were sparse. The study targeted resident predator species that are known to be caught and consumed by humans. The study design was based on EPA guidance and intended to be adequate for use by state authorities who develop consumption advisories where needed.

A total of 19 composite samples of muscle tissue were collected and analyzed from Balm Creek, Bully Creek, Phillips, Thief Valley, and Powder River Arm of Brownlee reservoirs. An adequate number of samples useable for fish advisory evaluation was collected for at least one species at four of the five reservoirs. Mean total mercury concentration ranged from a low of 0.06 mg/kg in rainbow trout of Thief Valley Reservoir to a high of 0.58 mg/kg in yellow perch of Phillips Reservoir.

Data are compared to threshold values used by Oregon Department of Health for fish advisory screening. Based on these 2011 sample results, Phillips Reservoir is a candidate for development of a fish advisory for consumption of yellow perch. The mean of two samples was 0.58 mg/kg, substantially higher than the 0.23 mg/kg threshold used by Oregon Health Authority. These results confirm previous data collected from Phillips Reservoir. An advisory for sport fish has been in effect for

Brownlee Reservoir since 1997. The 2011 results from the Powder River Arm of Brownlee Reservoir are similar to what has been found in past data.

The Northeast Oregon results are compared to results from large scale studies conducted elsewhere in the Pacific Northwest. Data gaps that would be useful to fill if resources become available include sampling of the remaining game species in all five reservoirs, and sampling fish species for mercury concentrations in other nearby reservoirs.

Introduction

Exposures to mercury can affect the human nervous system and harm the brain, heart, kidneys, lungs, and immune system. The most common way people are exposed to mercury is by eating fish or shellfish that are contaminated with mercury. Results from a recent EPA national modeling effort, REMSAD (REgional Modeling System for Aerosols and Deposition), predicted a significant mercury deposition area in northeastern Oregon (ICF Consulting Inc. 2008). Currently, there is a general lack of fish tissue data from lakes and streams in this area. Given the potentially elevated level of mercury deposition and lack of fish tissue data, there is a need to measure mercury concentrations in fish to determine if there is a health risk.

To ensure the continued good health of its citizens, the State of Oregon issues fish consumption advisories for fish in waterbodies that exceed human health thresholds as identified by Oregon Health Authority (OHA 2010). Fish consumption advisories may be issued to protect the general public or sensitive populations such as women of childbearing age, nursing mothers, pregnant women, and children. When EPA initiated this project, both ODEQ and OHA requested that the sampling be designed to support establishment of an OHA fish consumption advisory, if warranted by the resulting data. EPA agreed to focus the sampling design toward OHA's needs for advisories, rather than sampling primarily for screening purposes.

EPA's study objective, therefore, was to collect mercury fish tissue concentration data to support an OHA determination as to whether people are at risk of health impacts due to elevated mercury from eating fish from this area and to assist OHA in communicating that information to state and local decision makers and the public. This project is not intended to investigate the sources of mercury in fish.

The main study questions are:

- What are mercury concentrations in the muscle tissue from commonly consumed fish species in five sample waterbodies of NE Oregon?
- How do fish tissue mercury concentrations compare to OHA's mercury health screening level?¹

Fish were collected from five reservoirs in northeastern Oregon in June, 2011, and the tissue was analyzed for mercury. The results from most of these measurements were determined to be of sufficient quality and quantity to suit OHA protocols for developing fish consumption advisories.

¹ OHA will use these data to draw conclusions about health issues associated with consumption of contaminated fish.

Study Area and Waterbody Selection

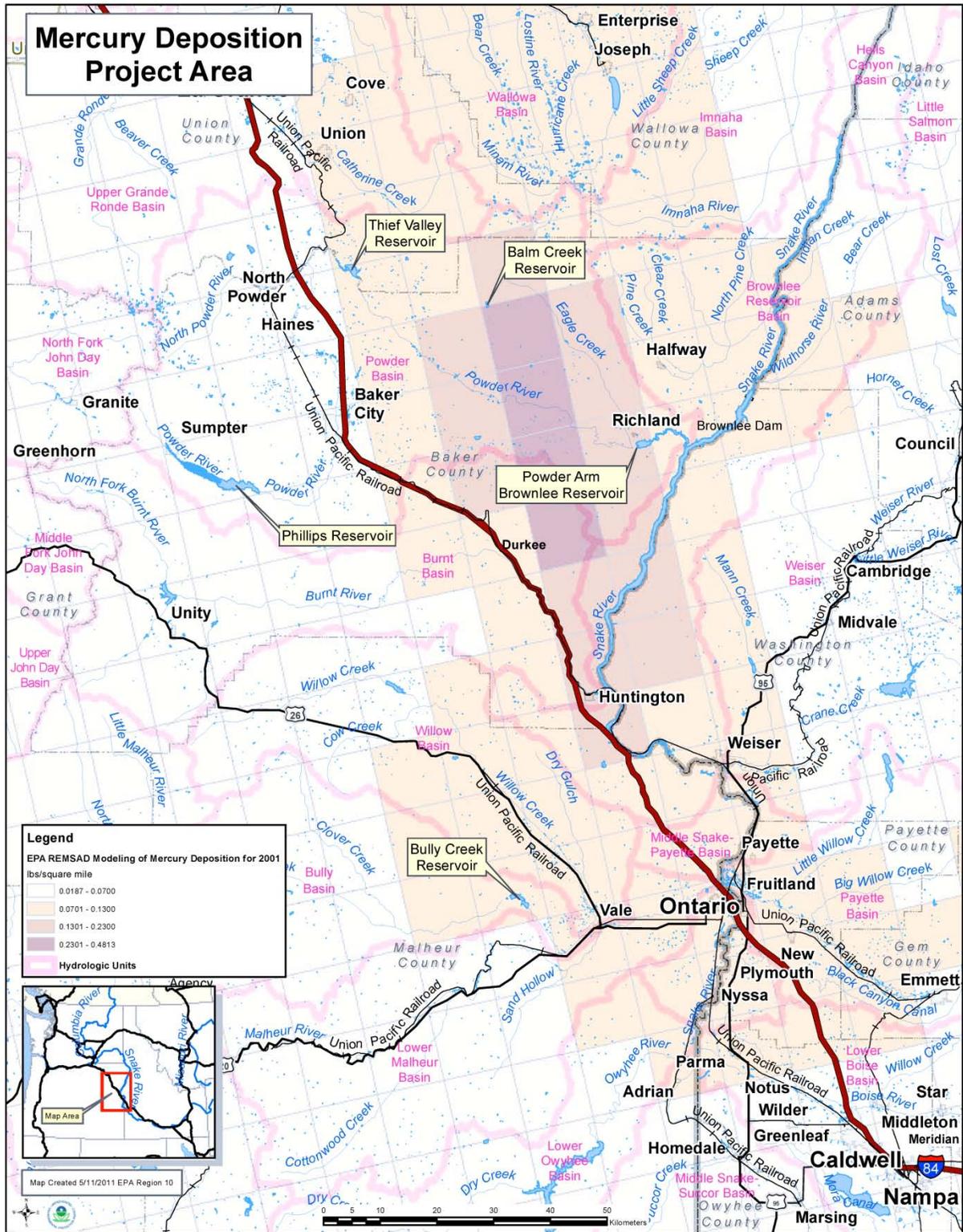
The general area of this study is the estimated area of elevated mercury deposition predicted by the REMSAD model (**Map 1**). The REMSAD model is a coarse scale model with a minimum cell size of 12 km². We used proximity to the area of predicted elevated mercury deposition as a starting place for selecting waterbodies to sample. Publicly-managed fisheries within that area were identified as candidates for sampling. Criteria used to identify the final list were: 1) proximity to the potential high deposition zone identified by the model, 2) high use by anglers, 3) high consumption of resident fish by anglers, and 4) availability and catchability of sport fish species. After evaluating numerous waterbodies based on these criteria (see **Appendix 1**), five were selected for sampling:

- Balm Creek Reservoir
- Bully Creek Reservoir
- Phillips Reservoir
- Powder River Arm of Brownlee Reservoir
- Thief Valley Reservoir

These reservoirs are described in **Table 1** and their locations are shown on Map 1.

Table 1. Location and description of sample reservoirs.

Site Identification	County	Basin	Area Sqkm	Elev (ft)	Lat_DD	Long_DD
Balm Creek Reservoir	Union	Powder River	0.295	4529	44.970928	-117.492410
Bully Creek Reservoir	Malheur	Bully Creek	2.474	2513	44.021791	-117.401284
Phillips Reservoir	Baker	Powder River	9.510	4075	44.677331	-118.007648
Powder Arm Brownlee	Baker	Powder River	5.202	2075	44.755474	-117.131696
Thief Valley Reservoir	Union/Baker	Powder River	3.039	3140	45.025920	-117.790134



Map 1. Northeastern Oregon Mercury Project Area showing model-predicted mercury deposition.

Target Species and Sample Hierarchy

In general, collecting fish for fish advisories involves targeting two fish species per waterbody (EPA 2000). The levels of mercury in fish depend on what they eat, how long they live and how high they are in the food chain (or their trophic level). Sampling two species that occupy different trophic levels (open-water predators or bottom-dwellers, for example) allows for a robust characterization of a chemical's presence in the fish population. Also, sampling species from multiple trophic levels allows for both human health and wildlife screening. This project is specifically focused on mercury presence in fish consumed by humans so only species that are known to be caught and consumed by anglers were targeted. Because mercury is known to bio-accumulate and reach higher concentrations in higher trophic level species, predatory species were preferred.

Only predator species that are resident (non-migratory) and are known to be caught and consumed by humans were targeted for sampling. Collection of fish of a single species was considered the minimum sample with the option of sampling more than one predator species as available. The predator species that were considered the best targets were identified for each reservoir (See Appendix 1). Because these systems are dynamic, the relative abundance of the species that are caught and consumed by anglers can vary depending on the year/water conditions. Most sites have more than one predator species that could be captured and still meet the sampling goal. A single predator species was selected for sampling from each waterbody. Samples were composites of 3 to 5 fish of a similar size. The sampling goal at each lake was two composite samples from two size classes of the available predator species (plus a replicate from each size class). Where the numbers and sizes of fish caught were inadequate, the hierarchy shown in (**Figure 1**) was used to determine the species and quantities that would make up the composite samples.

Adult fish that were within the length ranges typically consumed by anglers for each species and within the legal limits as defined by the State of Oregon fishing regulations (ODFW 2011) were eligible for inclusion in the sample. Inclusion of trout in the sampling was carefully considered by reservoir. Small lakes in Oregon are commonly stocked with fingerlings and sub-catchable sized trout. The study targeted only rainbow trout that had over-wintered at least once and were of catchable/consumable size. Practical considerations such as gear type, lake conditions, timing, and fish abundance dictated the species actually captured.

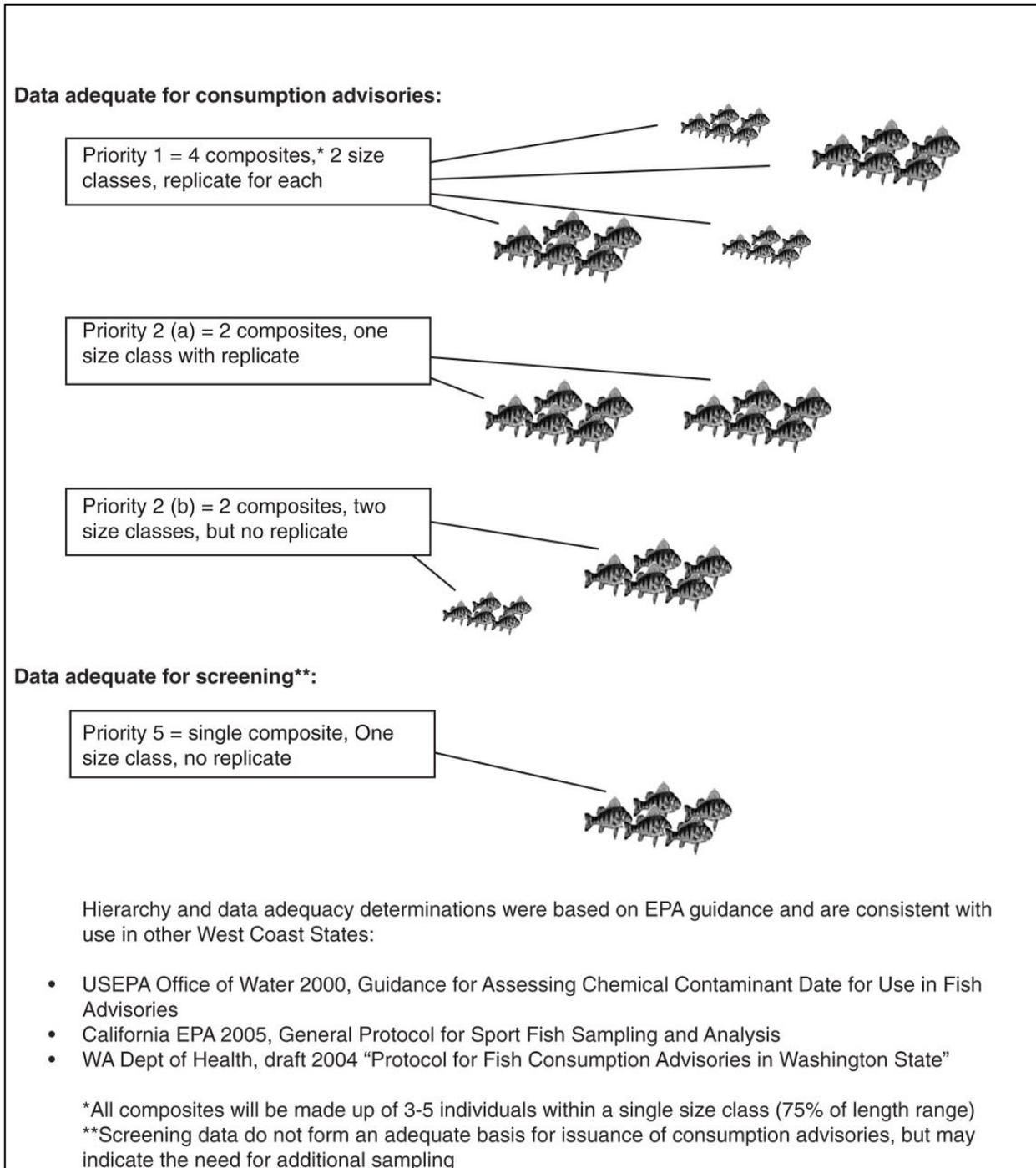


Figure 1. Hierarchy for fish advisory for NE Oregon lake fish tissue study used to guide fish collection.

Methods

The methods were designed to efficiently sample for total mercury to generate data useful for fish consumption advisories, or screening level analysis (if inadequate numbers of fish are collected for advisories). Screening-level data, although not adequate for advisories, may indicate the need for additional sampling in the future.

Field Methods

All field sampling activities followed procedures in the project's QAPP (US EPA 2011) with the objective of maintaining sample integrity from the time of fish collection through sample shipment to arrival at the laboratory. Fish were collected using gillnets at all waterbodies except the Powder River Arm of Brownlee Reservoir where boat electrofishing was used. Fishing was a collaborative effort, with ODFW participating at four of the five waterbodies and Idaho Power Company (IPC) participating with fish collection on the Powder River Arm of Brownlee Reservoir. All sites were sampled between June 14th and 17th, 2011.

Captured fish were identified to species and measured for length. Individuals meeting the species and size criteria were retained. Each composite sample consisted of similar sized fish (each fish within 75% of the length of the other individuals in the 3-5 fish sample). Whole fish were weighed, packaged, preserved on dry ice, and delivered to the EPA Region 10 Laboratory in Manchester Washington where they were stored at -20°C.

Laboratory Fish Processing Methods

Initial processing was conducted in September 2011. Equal portions of muscle tissue (skinless) were removed from each fish so that individuals were equally represented in the composite sample. Tissues were then combined and homogenized in a mini-blender (**Figure 2**). A total of approximately 40 grams of tissue per fish was used for each composite sample. The homogenized samples were stored at -20°C until final processing.



Figure 2. Fish tissue processing: tissue excision and blending composited tissue.

The chemical analysis was performed by EPA chemists following standard operating procedures for digestion and analysis in order to achieve the required measurement quality objectives. These are described in detail in the QAPP for this project (See Attachment 1). The wet tissue was digested and analyzed using EPA method 245.6 (USEPA 1991). The reporting limits for mercury were 0.0125 mg/kg.

Data Summary Methods

All results are reported separately for each species on a site by site basis. Since samples were analyzed as composites, only one value is reported per sample. In cases where there are replicate samples, data are reported as means of the two composites. To aid the reader in interpreting the concentrations, the data are compared to 1) threshold values used by Oregon Health Authority for fish advisory screening (OHA 2010), 2) other fish tissue mercury data collected from these reservoirs, and 3) data from large scale studies conducted in the Pacific Northwest region.

Results

Sampling Results

Of the fish captured and retained as samples, all were considered target species as they met the study criteria of resident predators within appropriate size specifications that represent fish commonly captured and consumed by anglers (see QAPP). A total of 19 samples were collected from the five waterbodies. No single species was captured consistently across all the sampled reservoirs.

Sample results are shown in **Table 2**. The Powder River Arm of Brownlee Reservoir had the most species sampled with composites from four different target species. Three waterbodies-- Balm Creek Reservoir, Bully Creek Reservoir, and Phillips Reservoir, had only one species sampled. An adequate number of individuals, useable for fish advisory level evaluation, was collected for a minimum of one species at each of

four reservoirs. At Bully Creek Reservoir, however, only two channel catfish were captured. These two fish were analyzed as individuals (not composited) because only two fish would be an inadequate composite and they would be more valuable for screening level analysis for this reservoir as individual samples.

Analysis Results

Mercury analysis results were generated for all 19 samples. Replicate samples were collected for eight of the species/size/reservoir combinations. These are presented as mean values in Table 2. Quality assurance review was conducted on all samples plus two duplicates and one rinsate. All measures of quality control met the laboratory and QAPP criteria (US EPA Region 10 Memo 2011).

Table 2. Northeast Oregon fish sampling results.

Waterbody	Fish Species	Fish per sample	Length Range (mm)	Hg conc. Wet wt. (mg/kg)	Species Mean	Size Class Mean	Size	Sample (n)
Balm Cr.	rainbow trout (sm)	4	270-306	0.099	0.123	0.099	small	1
Balm Cr.	rainbow trout (lg)	3	345-392	0.131		0.135	large	2
Balm Cr.	rainbow trout (lg)	4	335-398	0.139				
Bully Cr.	channel catfish	1	470	0.207	0.248	0.248	all	2
Bully Cr.	channel catfish	1	356	0.288				
Phillips R.	yellow perch	5	195-208	0.558	0.581	0.581	all	2
Phillips R.	yellow perch	5	193-230	0.604				
Powder Arm	black crappie	5	242-263	0.380	0.395	0.395	all	2
Powder Arm	black crappie	5	240-265	0.410				
Powder Arm	bluegill (sm)	5	173-184	0.122	0.196	0.130	small	2
Powder Arm	bluegill (sm)	5	171-183	0.137				
Powder Arm	bluegill (lg)	3	220-233	0.329		0.329	large	1
Powder Arm	smallmouth bass	4	305-355	0.287	0.316	0.316	all	2
Powder Arm	smallmouth bass	4	306-344	0.344				
Powder Arm	white crappie	4	266-282	0.325	0.339	0.339	all	2
Powder Arm	white crappie	4	282-316	0.353				
Thief Valley	bluegill	5	140-170	0.247	0.247	0.247	all	1
Thief Valley	rainbow trout	3	283-295	0.053	0.061	0.061	all	2
Thief Valley	rainbow trout	4	300-325	0.069				

Mean total mercury concentrations (expressed as wet weight) ranged from a low of 0.061 mg/kg in rainbow trout of Thief Valley Reservoir to a high of 0.58 mg/kg in yellow perch of Phillips Reservoir (Table 2). Rainbow trout collected in both Balm Creek Reservoir and Thief Valley Reservoir had relatively low total mercury concentrations compared with other species (**Figure 3**). The small-sized bluegill collected in the Powder

River Arm of Brownlee Reservoir also had low total mercury concentration (mean 0.13 mg/kg).

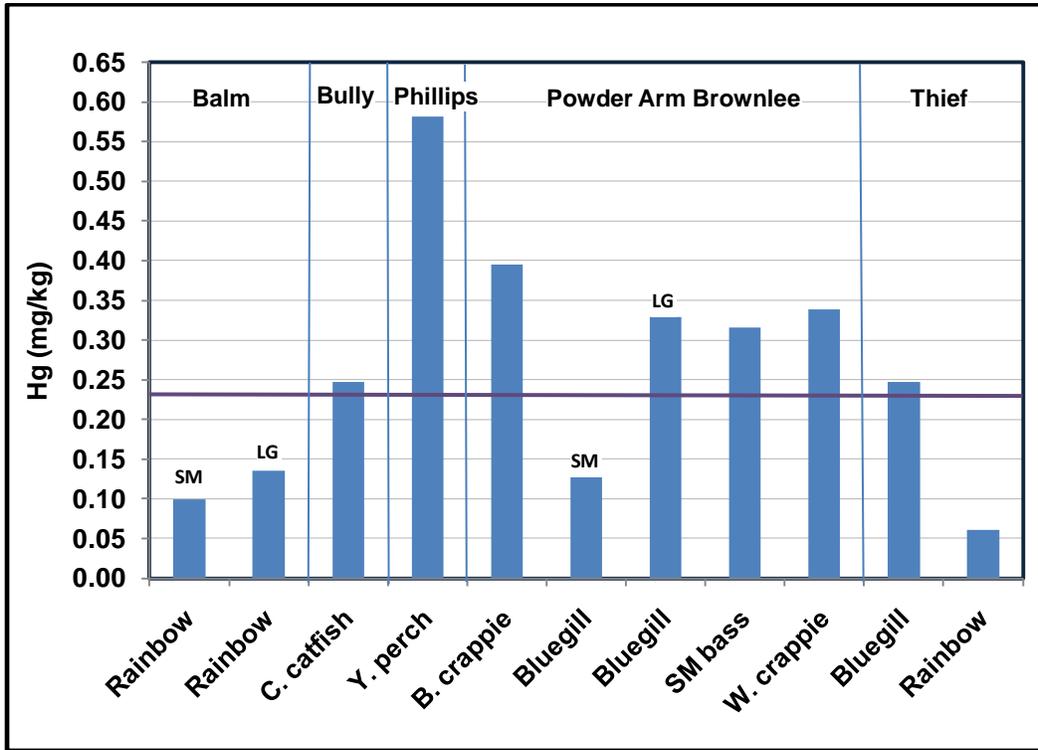


Figure 3. Graph of mercury concentration in fish species by water body. Where replicate samples were collected, data are presented as mean values as shown on Table 1. Purple line indicates current advisory threshold of 0.23 mg/kg used by OHA.

Discussion

A. Thresholds for evaluating need for fish advisories

The screening level thresholds for mercury depend on the fish consumption rate used. The more fish consumed, the lower the screening level. Oregon Health Authority currently uses a level of 0.23 mg/kg of Hg, which assumes up to 4 meals per month of fish for an adult. This calculation is based on the method in EPA’s Fish Advisory Guidance (USEPA 2000). There may be local anglers who consume more than one meal of fish per week, and therefore a fish advisory calculated for only four meals per month may not be protective of those individuals. However, health agencies also consider the benefits of fish consumption, so they do not want to express advisories in a way that is overly cautious and may discourage people from consuming fish at all.

B. Relevance to Fish Advisories

Phillips Reservoir

Based on these 2011 sample results, Phillips Reservoir is a candidate for development of a fish advisory for consumption of yellow perch. The mean of two samples was 0.581 mg/kg, substantially higher than the 0.23 mg/kg threshold value. These results confirm previous data collected from Phillips in 1994, which showed that mercury concentrations were slightly elevated above threshold levels² in both smallmouth bass and black crappie (**Table 3**). Like yellow perch, both of these species are consumed by anglers. Although this is a limited dataset, it does show that elevated concentrations of mercury have been found in fish tissue from Phillips Reservoir for almost two decades.

Table 3. Data collected from Phillips Reservoir on September 27, 1994 from the deepest part of the lake (unpublished data provided by OHA).

Species	Hg (mg/kg)	Age	Length	Weight (grams)	Species mean
smallmouth bass	0.27	3	250	185	
smallmouth bass	0.39	4	250	185	
smallmouth bass	0.39	3	220	120	
smallmouth bass	0.40	3	235	155	
smallmouth bass	0.41	3	265	235	
					0.37
black crappie	0.35	3	205	125	
black crappie	0.39	5	250	205	
					0.37
rainbow trout	0.14	1	230	95	
rainbow trout	0.15	1	225	95	
rainbow trout	0.16	1	220	95	
					0.15

Powder Arm of Brownlee Reservoir

A sport fish consumption advisory has been in effect for Brownlee Reservoir since 1997 (OHR 1997). This advisory states that fish mercury concentrations of 0.41 mg/kg prompted the advisory, as this level exceeds the threshold of 0.35 mg/kg used at the time. Species-specific data were not presented in the Advisory. Past fish tissue analyses in Brownlee Reservoir yielded results similar to our 2011 study. A 1997 study of trace elements in fish tissue from the lower Snake River Basin found mercury levels of 0.30, 0.27, and 0.33 mg/kg wet weight in smallmouth bass, white crappie, and channel catfish fillets, respectively in Brownlee Reservoir (USGS 1998). A 2006 TMDL study of Brownlee Reservoir mercury found levels ranged from 0.48 to 0.78 mg/kg wet weight in smallmouth bass fillet composite samples from various locations (IDEQ 2006).

² Oregon used a higher threshold concentration (0.35 mg/kg) for setting advisories in 1994

The 2011 results from the Powder River Arm of Brownlee Reservoir (Table 2) are similar to what has been found in past data. White crappie, smallmouth bass, and large-sized bluegill samples exceeded 0.30 mg/kg and black crappie exceeded 0.40 mg/kg.

C. Comparison with regional studies

Fish tissue mercury concentrations from the five Northeast Oregon reservoirs were compared to three large-scale studies in the area to provide context for these results. The three studies are briefly described below. All studies used composite samples and methods protocols similar to those used in this Northeast Oregon study. Summarized results are in **Table 4**.

Idaho Statewide study: Fifty lakes were assessed using a random design that was stratified by lake size. The study analyzed 89 composite samples (fillets) from 20 different species (Essig and Kosterman 2008). Samples were classified as salmonids (37 samples) or spiny ray species (52 samples).

National Lake Fish Tissue Study (Pacific Northwest Region): A nationwide study of contaminants in fish tissue collected samples from 500 lakes between 2000 and 2003 (Stahl et al. 2009). Lakes were selected using a random design that was stratified by lake size. Thirty of the lakes sampled were in the Pacific Northwest region (PNW from here on), which includes Idaho, Oregon, and Washington. Samples were collected from 16 different species in the PNW region. The analysis grouped fish species into either predators (trout, bass) or bottom-dwellers (suckers, carp, and catfish). Twenty eight predator samples and 19 bottom-dweller samples were analyzed (Herger et al. 2011). Table 4 includes only the predator species data from that study.

Northeast Washington background study: This study focused on sampling lakes considered to have background condition for contaminants. Lakes in northeastern Washington were selected based on having relatively low impact from human activities and low likelihood of local contamination sources. Mercury was analyzed from fish fillets from 31 composite samples collected from 13 lakes and three rivers, in 2010-2011. Fourteen species were sampled (8 salmonids and 6 spiny ray samples). This study also included the upper Priest Lake and Upper Joe River, both located in Idaho.

Table 4. Summary of fish tissue mercury concentrations from other studies in the area compared to the NE Oregon results (units in mg/kg wet weight).

Study group	Mean	Median	Min.	Max.	Sample N
Predator Species					
NE Oregon	.267	.287	.053	.604	19
PNW regionwide ¹	.198	.133	.023	.601	28
Salmonid Species					
NE Oregon	.098	.099	.053	.139	5
Idaho statewide ²	.151	.103	.026	.723	37
NE WA background ³	.069	.047	.018	.214	17
Spiny Ray Species					
NE Oregon	.327	.327	.122	.604	14
Idaho statewide	.319	.243	.020	1.380	52
NE WA background	.169	.186	.029	.492	14

1. Herger et al. 2011 2. Essig and Kosterman 2008 3. Johnson et al. 2011

None of the three comparison studies provides a perfect comparison with the Northeast Oregon study because they were undertaken for different purposes, have different sample designs, and used different classifications of the fish. They do provide a useful context for the Northeast Oregon data if these differences are taken into account.

Comparing the predator species samples between Northeast Oregon study and the PNW region-wide study shows the mercury concentration is higher in the Oregon study (**Figure 4**). One factor that affects these results is that the random lake selection for the region-wide study includes a broader diversity of ecological conditions. For example, the PNW lake survey includes pristine high elevation lakes within National Parks as well as reservoirs of the Columbia River. Also, the PNW sample includes one sample each from 28 lakes. In contrast, the 19 samples for the NE Oregon lakes are all from the five targeted Oregon reservoirs.

The comparison of salmonid species and spiny ray species results among the studies shows the Northeast Oregon results are similar to the Idaho statewide results (Figure 4). The background study of Northeast Washington has results lower than the other studies for both the salmonid species and the spiny ray species. This is an expected result as these lakes were selected for their lack of human disturbance and contamination sources.

Results from the studies described here consistently show lower mean mercury concentrations in salmonids versus spiny ray species. This is an expected result as salmonid species often feed at a lower trophic level compared to spiny ray species, which tend to be piscivorous. For example, rainbow trout and whitefish are

insectivorous. The exceptions would be char species such as lake and bull trout and brown trout, which are more piscivorous in their feeding habits.

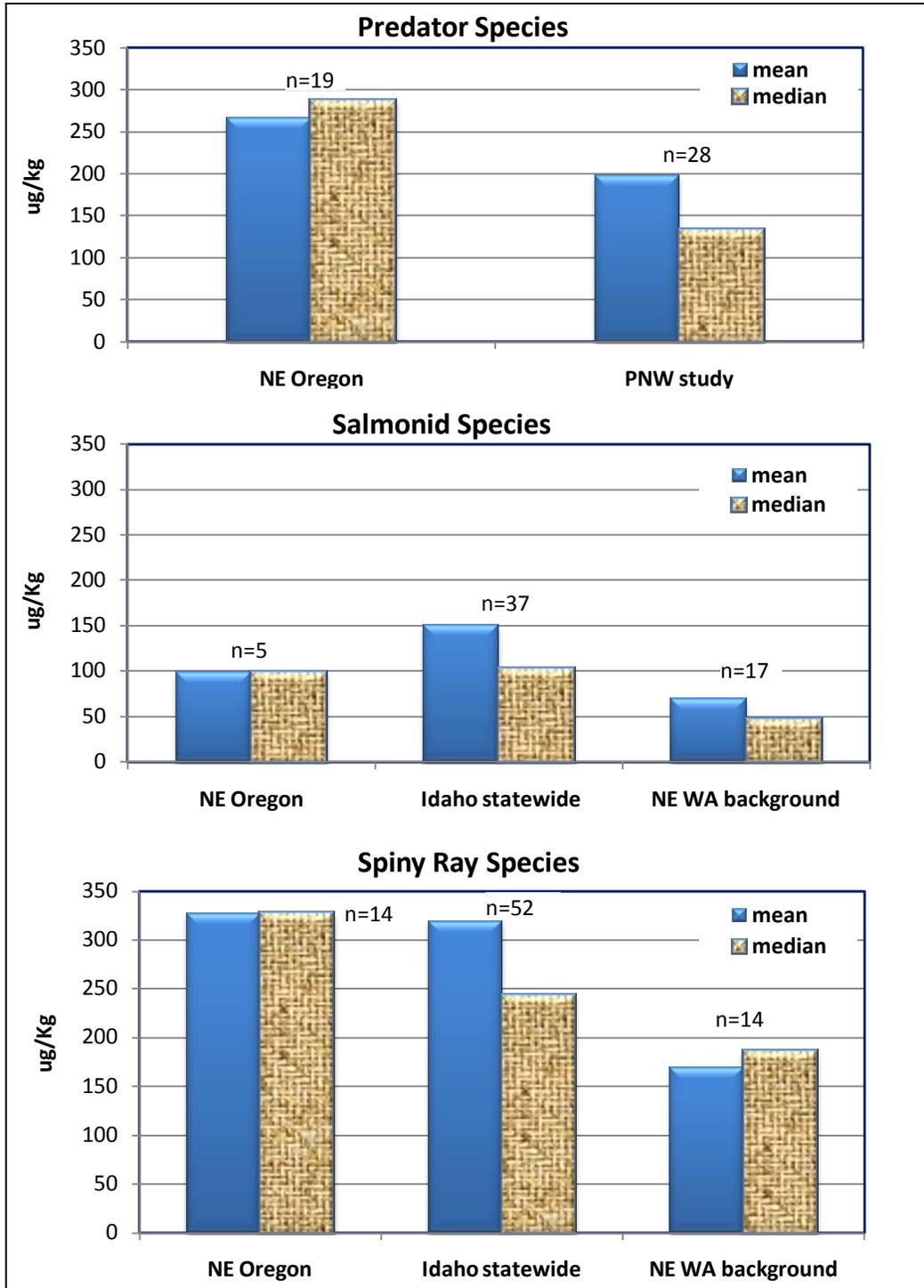


Figure 4. Comparison of NE Oregon fish tissue mercury concentration means and medians to results from other studies (sources: Essig and Kosterman 2008, Herger et al. 2011, Johnson et al. 2011).

Conclusions

The data collected during this study provide insight into the general mercury content in fish of Northeast Oregon reservoirs. These data were intended to be useful to OHA to support development of fish advisories, as appropriate. The data do support a new fish advisory on Phillips Reservoir for yellow perch and show the continued need for an advisory on Brownlee Reservoir for select species. In addition, new information was acquired on mercury levels in three other reservoirs that have not been assessed to date. This work, of course, leads to more questions. The following are data gaps that would be useful to fill as resources become available:

- Screening level sampling at Bully Creek Reservoir and sampling of only one centrarchid species in Thief Valley Reservoir yielded results just above the threshold value of 0.23 mg/kg, suggesting that more sampling would be warranted. Data gaps include bass and crappie species in Bully Creek, Phillips, and Balm Creek Reservoirs, and yellow perch in Thief Valley Reservoir.
- Additional evaluation of the REMSAD model's 'significant deposition area' could be done to identify other waterbodies that have substantial use by anglers yet lack data on mercury concentrations. If candidate waterbodies meet criteria, consider a second phase of sampling.

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North east Oregon Lake Hg

Appendix 1. List of lakes considered for sampling in northeastern Oregon.

Waterbody	Deposition Zone Prox.	Possible target species	Other species	Fish consumption	Methylation potential	Condition Comments	Draft Recommendation for Inclusion in Sampling
Powder Arm, Brownlee Resr.	high	Sm. Lm. bass, bl. Wh. crappie, y. perch, catfish sp.		high	high	eutrophic	Y -- Both ODEQ and ODFW have highlighted this area
Highway 203 Pond	high	bass (small), bluegill (small)	trout (catchable-size stocked)	high trout; low bass	unk.		Probably N -- stocked trout not likely to substantially accumulate Hg; bass & bluegill very small
Burnt River	high	bass, trout (natural)	trout (catchable-size stocked)	low	unk.	low gradient	Y-- bass available
Catherine Cr.	high	carp, trout		low (some trout)	unk.		Maybe -- may be info on GR Basin
Powder River	high	adult trout below Thief Valley Resr.	trout (catchable-size stocked)	medium	unk.		Probably N-- Thief Valley and Brownlee Arm part of Powder R.
Bully Cr Resr.	med	bass, crappie	Channel catfish	high	high	Elev fluctuates; eutrophic	Y
Phillips Resr.	med	y.perch, sm lm bass, black crappie,	trout (fingerlings and sub-catchables stocked), suckers, walleye	high	unk.	Elev.fluctuates	Y
Thief Valley Resr.	med	trout (fingerlings stocked), y. perch	Bluegill, b. crappie	high (mostly trout)	high	Elev. fluctuates; eutrophic	Y
Pilcher Resr.	med	crappie	trout (fingerlings stocked)	high trout; med. crappie	unk.		Maybe
Malheur Resr.	med	trout (fingerlings stocked)		medium	med	Elev. fluctuates	Maybe -- Only trout caught (But premier trout fishing spot)
Balm Cr Resr.	med	Sm bass, black crappie	trout (fingerlings stocked)	medium with high potential	unk.	Elev. fluctuates	Maybe -- Close proximity to yellow zone.
Unity Resr.	low	bass, crappie	trout (fingerlings stocked),	high	unk.	Elev. fluctuates	Maybe, but more distant
Grande Ronde	low	Bass,, trout		low	high /unk	low gradient	Fairly Distant --
Beulah Resr	low	trout		unk.	unk.		N due to distance and species
Warm Springs Resr.	low	bass, perch, trout crappie, catfish		unk.	unk.		Fairly Distant --> Maybe Later if Subsequent Sampling
Pole Cr Resr	low	trout		unk.	unk.		Need to verify exact location
Wolf Cr. Resr.	med	crappie	trout (fingerlings stocked)	sometimes high	unk.		Maybe

Proximity to REMSAD zones (map 1): H=in red or yellow; M=within 24km of red/yellow; L > 24 km from red/yellow.