



Measuring Mercury Trends in Freshwater Fish, 2011 Sampling Results

Abstract

This report summarizes results from the seventh year of a long-term monitoring program to evaluate temporal trends in mercury levels of Washington State freshwater fish. In 2011, Ecology analyzed total mercury in bass and other species from six waterbodies across the state: Mason, Meridian, Moses, Newman, Offutt, and Sammamish Lakes. Ecology had previously collected fish from these waterbodies in 2006.

Individual bass mercury concentrations ranged from not detected (16.5 U) – 607 ppb. Sammamish Lake bass contained the highest levels of mercury, and were also largest in size. The lowest mercury levels were measured in Moses Lake fish.

Statistical tests indicated no difference in fish mercury levels between 2006 and 2011 for Mason Lake, Meridian Lake, Moses Lake, and Offutt Lake.

Mercury levels were lower in Newman Lake largemouth bass in the 2006 and 2011 collection years compared to historical data from 2002. Levels were stable between 2006 and 2011. Lake Sammamish was the only waterbody with a significant difference in bass mercury levels between 2006 and 2011, with 5% higher levels in 2011. However, a difference in growth rates between years may be responsible for the trend detected in Lake Sammamish.

Publication Information

This report is available on the Department of Ecology's website at <https://fortress.wa.gov/ecy/publications/SummaryPages/1203051.html>

Data for this project are available at Ecology's Environmental Information Management (EIM) website www.ecy.wa.gov/eim/index.htm. Search User Study ID, HgFish11.

Ecology's Activity Tracker Code for this study is 06-501.

Water Resource Inventory Areas (WRIAs) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area:

- WRIAs: 08, 09, 13, 14, 41, 57.
- HUC numbers: 17110012, 17110013, 17110016, 17110019, 17020015, 17010305.

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Background

The Washington State Departments of Ecology (Ecology) and Health (DOH) developed a chemical action plan (CAP) for mercury in 2003 (Peele et al., 2003). The CAP addressed the threat of mercury in Washington State and made recommendations on mercury reduction actions.

To support the mercury CAP, Ecology began a monitoring program in 2005 to assess temporal trends in environmental mercury levels in freshwater fish. Ecology collects 10 individual largemouth or smallmouth bass from 6 waterbodies each year for analysis of mercury in muscle tissue. Trends are assessed by returning to each set of lakes every five years to determine if mercury levels are increasing or decreasing.

The seventh year of sampling as part of this monitoring program was completed in 2011. Ecology analyzed total mercury in fish from Mason, Meridian, Moses, Newman, Offutt, and Sammamish Lakes (Figure 1). Fish were previously collected from these lakes in 2006.

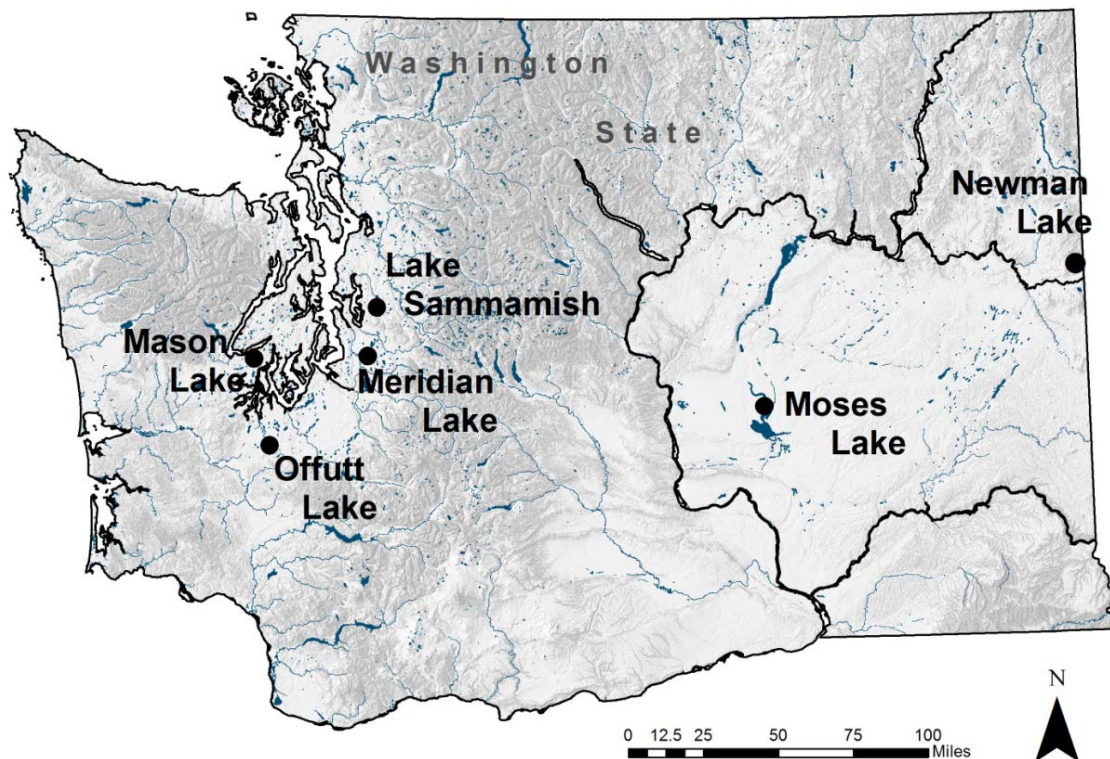


Figure 1. Locations of 2011 Sampling Sites.

Methods

Ecology collected 50 individual bass, 10 individual walleye, 10 individual yellow perch and 83 additional fish for 19 composite samples in fall 2011. Yellow perch were collected from Mason Lake to match the previous effort in 2006. Walleye were collected in addition to bass from Moses Lake, also to match 2006 collections. Fish were collected and processed following Ecology standard operating procedures (Sandvik, 2010a and 2010b). A summary of sampling conducted in 2011 is provided below in Table 1.

Table 1. Summary of Sampling Conducted in 2011 for the Mercury in Fish Project.

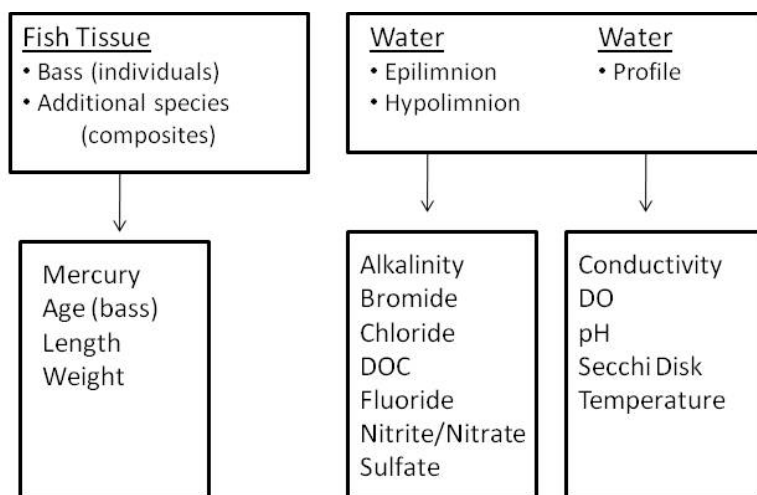
Collection Goal	Mason	Meridian	Moses	Offutt	Newman	Sammamish
Species collected for individuals	YP	LMB	SMB, WAL	LMB	LMB	LMB
Species collected for composites	LMB, LSS, PEA	KOK	BG, YP	LSS	BG, YP	BBH, YP
2 water samples	NA	+	+	+	+	+
Multi-parameter profile	NA	+	+	+	+	+

NA: Goal not attained. "+": Goal achieved.

YP: yellow perch; LMB: largemouth bass; SMB: smallmouth bass; WAL: walleye;

LSS: largescale sucker; PEA: peamouth; KOK: kokanee; BG: bluegill; BBH: brown bullhead.

Edible muscle tissue from fish were analyzed individually or as 3-5 fish composites for total mercury using cold vapor atomic absorption (EPA Method 245.6). Data generally met measurement quality objectives outlined in the Quality Assurance Project Plan (QAPP) (Seiders, 2006) and were deemed usable without qualification. Detailed quality assurance data are available upon request.



To better understand patterns, dynamics, and changes in fish mercury accumulation, Ecology also collects water chemistry and in-situ measurements from each site. Figure 2 displays all parameters collected or measured at each site in 2011.

More detailed information on the study design of this project can be found in the QAPP (Seiders, 2006) and QAPP Addendum (Meredith and Furl, 2010).

Figure 2. Analytes and Measurements Recorded for each Waterbody as Part of the Mercury Trends Sampling Design. DOC: dissolved organic carbon; DO: dissolved oxygen.

Fish Tissue Criteria

The National Toxics Rule (NTR) and the EPA Recommended Criterion provide numerical thresholds useful in assessing mercury levels of waterbodies. However, Ecology has adopted the NTR Rule as the state’s regulatory criterion to determine whether a waterbody meets water quality standards for the protection of human health in Washington State.

Ecology’s role is to determine whether water quality standards are met and to begin the process to correct problems where standards are not met. DOH and local health departments are responsible for developing fish consumption advisories in Washington. DOH uses the mercury data generated from this monitoring program, and others at Ecology, to establish and update fish consumption advisories. For more information on DOH’s fish consumption advisories, visit www.doh.wa.gov/CommunityandEnvironment/Food/Fish.aspx.

2011 Fish Results

Complete results of 2011 fish tissue mercury and water chemistry data are available for download at www.ecy.wa.gov/eim by searching User Study ID: HgFish11.

Mercury concentrations in largemouth and smallmouth bass ranged from not detected (16.5 U) – 607 ppb. Sammamish Lake bass had the highest levels, with an average of 371 ppb. These fish were also the largest. The lowest mercury levels were measured in Moses Lake bass. Figure 3 displays mercury concentrations measured in individual fish.

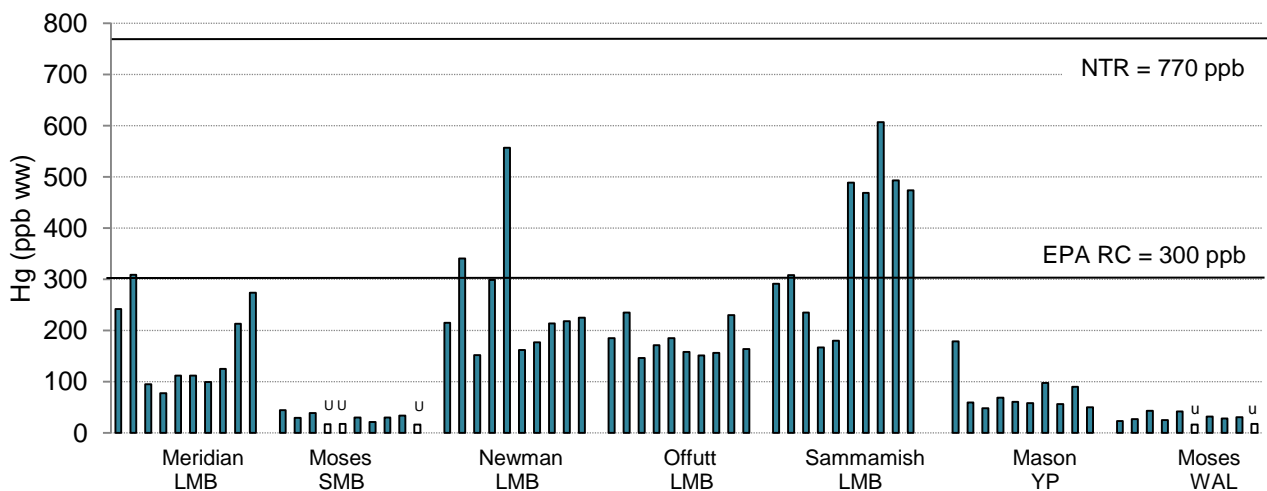


Figure 3. Mercury Concentrations of Individual Fish Collected in 2011.

NTR: National Toxics Rule; EPA RC: EPA Recommended Criterion; U: not detected at the level shown; LMB: largemouth bass; SMB: smallmouth bass; YP: yellow perch; WAL: walleye.

Eighteen percent of individual bass samples were above (did not meet) the EPA Recommended Criterion of 300 ppb. Bass that exceeded this recommended criterion were collected from Meridian, Newman, and Sammamish Lakes. No fish samples analyzed in 2011 exceeded the NTR water quality standard of 770 ppb.

Mercury levels in individual walleye and yellow perch were low and well below the EPA Recommended Criterion and NTR water quality standard. Walleye from Moses Lake ranged in mercury from not detected (16.3 U) – 43.4 ppb. Mercury levels in yellow perch from Mason Lake ranged from 48.0 – 179 ppb, with an average of 76.8 ppb.

Additional fish species were collected from all 6 lakes and analyzed as 3-5 fish composites for mercury. Figure 4 displays mercury concentrations measured in the composite samples. Mercury concentrations of fish composites ranged from not detected (16.6 U) – 249 ppb. Levels were highest in samples from Mason Lake and lowest in Moses Lake. None of the composite samples exceeded the EPA Recommended Criterion or the NTR regulatory criterion.

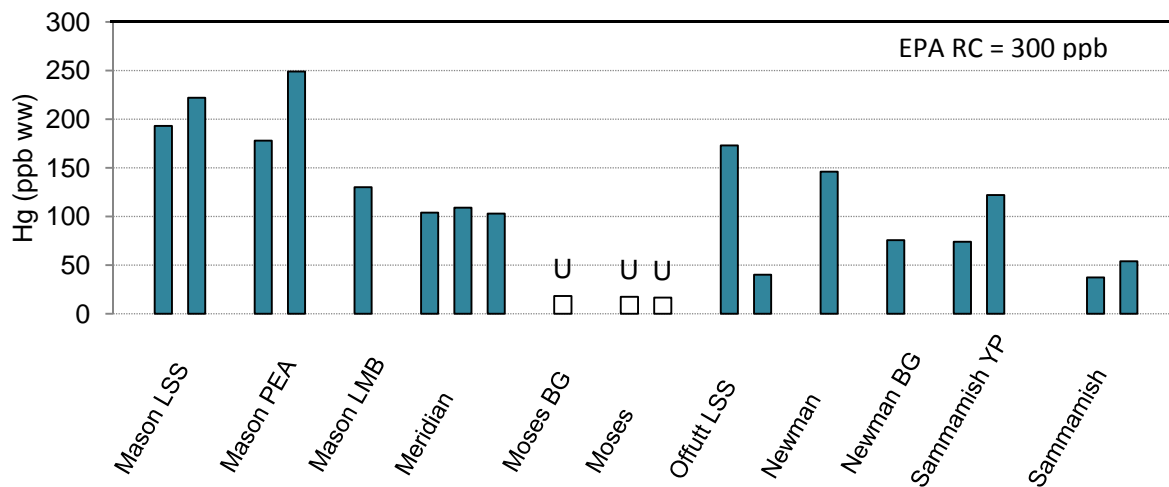


Figure 4. Mercury Concentrations of Composite Fish Samples Collected in 2011.

EPA RC: EPA Recommended Criterion; U: not detected at the level shown.

LSS: largescale sucker; PEA: peamouth; LMB: largemouth bass; KOK: kokanee; BG: blue gill; YP: yellow perch; BBH: brown bullhead.

Relationships

Linear regressions showed bass mercury concentrations increased with fish size and age at all lakes, with statistically significant relationships at all but Offutt Lake. Evidence exists for stunted bass growth in Offutt Lake (Couto and Caromile, 2007), which may account for the lack of mercury-size relationship. No relationships were apparent for Mason Lake yellow perch or Moses Lake walleye.

Relationships between bass mercury levels and water chemistry variables were evaluated through Pearson correlations to identify possible factors influencing mercury bioaccumulation in fish. Although correlations showed no significant relationships between water chemistry, the lowest mercury concentrations

were seen in Moses Lake, which contained much higher alkalinity levels than the other waterbodies. Over the first five years of monitoring for this program, bass mercury levels were found to be lower in lakes with higher alkalinity levels (Meredith et al., 2010). This relationship has been explained by enhanced microbial production in acidic water and/or increased bioavailability of mercury in low-pH lakes (Xun et al., 1987; Wiener et al., 1990).

Temporal Trends

Individual fish were analyzed for mercury concentrations in 2006 and 2011 at all six waterbodies. Additional bass mercury data from a 2002 survey was available for Newman Lake (Fischnaller et al., 2003). Water chemistry was also collected in 2006 and 2011, with results very similar between the two collection years.

Analysis of covariance (ANCOVA) with Bonferroni post-hoc tests were conducted to examine statistical differences in mercury levels of fish between the different collection years. Because bass mercury levels increase with size, fish length was used as the covariate to remove this effect. However, fish length was not used as a covariate for Mason Lake yellow perch, Moses Lake walleye, or Offutt Lake largemouth bass because length did not serve as a good predictor of mercury at these sites.

A significant difference between one or more collection years was found in Newman Lake and Sammamish Lake largemouth bass. Results showing which years significantly differed are displayed in Figure 5.

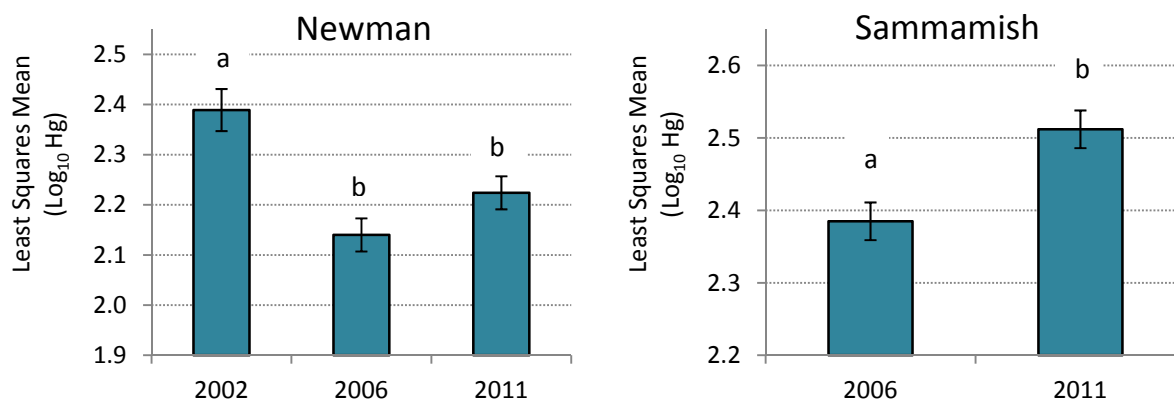


Figure 5. Results of Bonferroni Post-Hoc Tests Comparing Mercury Levels in Bass between Collection Years.

Error bars represent one standard error. A difference in letters indicates statistically significant difference in estimated group means ($p < 0.05$).

Estimated mercury means for Newman Lake bass collected in 2006 and 2011 were 10% and 7% lower than 2002 means, respectively. While most of the 2002 bass were smaller and younger than later collections, using fish age as a covariate did not change the significant difference found between years. Fish population surveys of Newman Lake indicated little change in fish communities between 2000 and 2008, although fewer largemouth bass were sampled in 2008 (Osborne and Divens, 2012). Water

quality has significantly improved since 2001 at the lake as a result of restoration efforts aimed to increase oxygen levels and reduce nutrient loading in the lake (Moore and Christensen, 2009).

Lake Sammamish bass mercury levels were 5% higher in 2011 compared to 2006, but growth rates may have complicated trend detection. Bass collected in 2011 tended to be older at longer lengths than 2006 fish, and replacing length with age as a covariate resulted in no significant difference between the years. Sediment core records showed no statistical change in mercury concentrations of Lake Sammamish sediments over the last two decades, with levels steadily declining since the mid 1960s (Furl and Roberts, 2011; Furl, 2007).

Mercury levels were not significantly different in Mason, Meridian, Moses, or Offutt Lake fish between 2006 and 2011. As part of this long-term monitoring program, Meredith and Friese (2011) reported a lack of trends in bass mercury levels at four out of five waterbodies in Washington State between 2005 and 2010. The short time period between fish collections was cited as a possible reason for the absence of detectable trends. The response time of decreased mercury emissions and lowered fish mercury levels can range up to decades or longer depending on environmental factors such as mercury mobilization rates (Munthe et al., 2007). Ten to forty years of monitoring may be necessary for quantifying mercury trends in aquatic biota (EPA, 2008).

Summary

- Bass mercury concentrations from all waterbodies ranged from not detected (16.5 U) – 607 ppb. Sammamish Lake bass contained the highest levels of mercury, and were also largest. The lowest mercury levels were measured in Moses Lake.
- Statistical tests indicated no difference in fish mercury levels between 2006 and 2011 for individual fish from Mason, Meridian, Moses, and Offutt Lakes.
- Mercury levels in Newman Lake largemouth bass were lower in 2006 and 2011 compared to data from 2002. Estimated mercury means were 7% and 10% lower for 2006 and 2011, respectively. No difference was found between 2006 and 2011.
- Lake Sammamish bass estimated mercury means were 5% higher in 2011 than 2006, but growth rates may have complicated trend detection.
- Eighteen percent of individual bass samples were above (did not meet) the EPA Recommended Criterion of 300 ppb. Bass that exceeded this recommended criterion were collected from Meridian, Newman, and Sammamish Lakes. No fish samples analyzed in 2011 exceeded the NTR water quality standard of 770 ppb.

For more information

Mercury Trends Monitoring: www.ecy.wa.gov/programs/eap/toxics/wstmp.htm#5

Mercury Information and Reductions in Washington: www.ecy.wa.gov/mercury/index.html

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