Statewide Aquatic Tissue Toxics Assessment Report

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State of Oregon
Department of Environmental Quality

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Executive Summary

In 2015, the Oregon Department of Environmental Quality's Laboratory and Environmental Assessment Program published a statewide assessment report on toxic compounds in Oregon's waters. This report is the second of the DEQ's Toxic Monitoring Program's three part assessment of toxic contaminants in Oregon's waters. The third part, detailing toxic contaminants in sediment, will be summarized in a subsequent report. This is the first statewide assessment of toxics in fish tissue across Oregon.

From 2008 to 2015, the DEQ laboratory analyzed tissue samples from 58 sites across the state. These sites included coastal estuaries, large rivers and small streams. The laboratory analyzed these samples for more than 330 different chemicals.

Key findings:

- 268 unique chemicals detected in tissue samples
- Most detected chemicals were at very low concentrations and below applicable criteria or screening values for human consumption
- Largest variety of chemicals detected in the Willamette Basin, followed by the Rogue Basin
- Legacy pesticides detected in each basin with the highest percent of detections in the Columbia Basin
- Mercury measured at levels above OHA Fish Advisory guidelines and DEQ water quality criterion in each basin sampled
- Legacy pesticides detected at higher concentrations in mussels and oysters than in softshell clam species
- Inorganic arsenic measured at levels of concern above OHA Fish Advisory guidelines in shellfish in each coastal basin leading to issuance of OHA consumption advisory
- Highest concentrations of inorganic arsenic found in the siphon skins of gaper and softshell clams

1. Introduction

1.1 Background/Justification

In 2007, the Oregon Legislature funded the Oregon Department of Environmental Quality to begin the Statewide Water Quality Toxics Monitoring Program. Started in 2008, the program identified four main goals:

1. Gather information to characterize the presence and concentration of chemicals of concern in Oregon's waters,
2. Use this information to identify sources of these chemicals,
3. Present and make available information gathered for public benefit,
4. Work with DEQ internal groups, community groups and Oregon citizens to identify opportunities for reducing these pollutants.

To achieve these goals, the DEQ Laboratory and Environmental Assessment Program developed a monitoring plan using a rotating basin approach to conduct a reconnaissance sampling of the state's waters over five years. The monitoring, sampling and analytical methods evolved over the course of the study. Initial sampling focused solely on water and fish tissue. However, by 2013 when the water sampling was completed, collections of water, sediment, finfish and shellfish had occurred and several state-of-the-art analytical methods were added. This report details the findings of the fish tissue assessment and is the second of the DEQ's Toxic Monitoring Program's three part assessment of toxic contaminants in Oregon's waters. The third part, detailing toxic contaminants in sediment, will be summarized in a subsequent report. For a full background of the Toxic Monitoring Program's three part assessment, refer to the Statewide Water Quality Toxics Assessment (http://www.oregon.gov/deq/FilterDocs/WQToxicsAssessmentReport.pdf).

1.2 Sampling Design

The Toxic Monitoring Program's primary goal is to characterize the presence and concentration of chemicals of concern in Oregon's waters. To achieve this goal, DEQ staff, in partnership with ODFW and ODA, collected finfish and shellfish from 13 of Oregon's main geographic basins. Due to equipment and staff restrictions with partner agencies, sampling could not fully follow the rotating basin approach as the water quality portion of the monitoring program did. Instead, samples were collected as time and personnel permitted across the state. Initial sampling focused solely on the Willamette River and its major tributaries (2008-2009). Additional basins were included starting in 2010. Sampling concluded for this report in the coastal basins in 2015 (Figure 1).

Sampling focused on identifying potential risks to human health through fish consumption therefore, in finfish, skinless fillets were collected at most sites. Whole body samples from small fish were analyzed at selected sites to evaluate ecological endpoints.

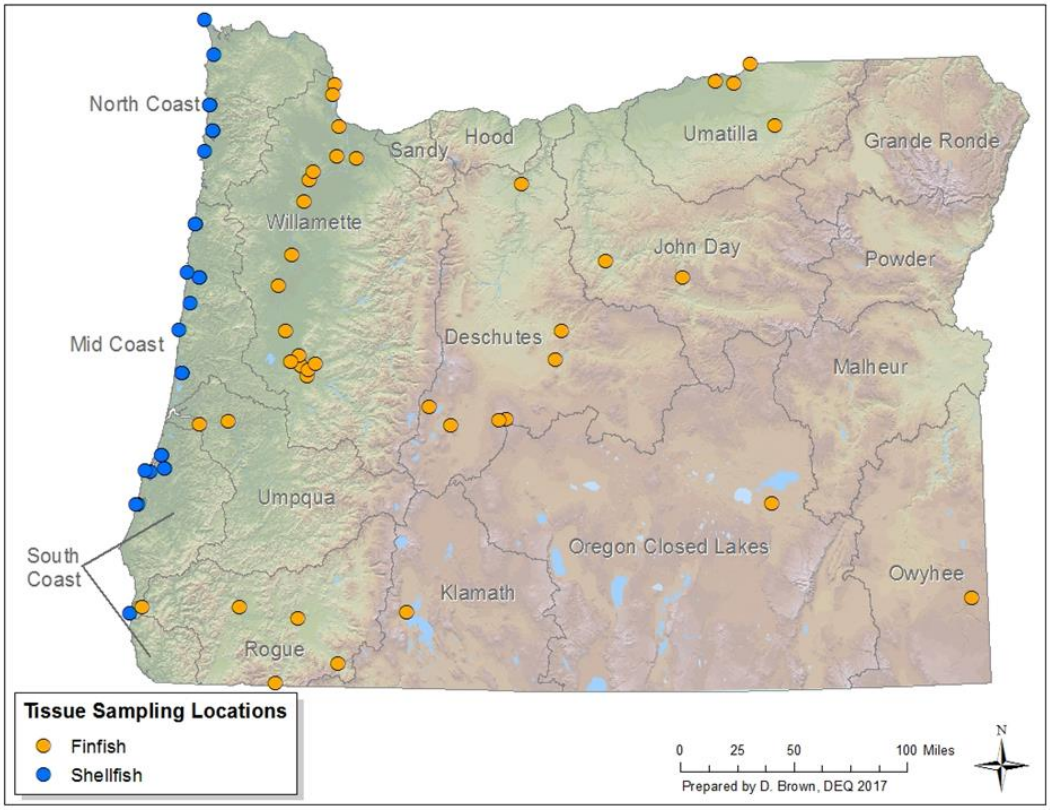

Figure 1. Tissue sampling sites (2008-2015).

1.3 Sample Collection Methods

Tissue samples were collected using a variety of methods based on the sampling protocols in use for specific partner agency projects. Collection methods ranged from electrofishing, trap netting and trammel netting for finfish. Shellfish samples were collected using conventional hand methods in estuarine and intertidal zones of coastal basins. Generally, finfish were identified to species and frozen whole for processing at the DEQ laboratory in Hillsboro. Shellfish also were identified to species and shucked before being frozen for processing.

1.4 Sample Processing Methods

Generally, finfish over 200 mm total length were filleted at the lab and only the skinned fillets were processed. Finfish under 200 mm total length were processed as whole body samples and were typically composited with

other fish of the same size and species. Shellfish were typically processed as whole body samples, with the exception of softshell clam species captured in 2015. A sub-sample of these shellfish were cleaned (siphon skin removed) in the field prior to freezing. In this case, the siphon skin and the cleaned whole body were analyzed separately.

1.5 Analytical Methods

This study analyzed over 330 unique chemicals in finfish and shellfish tissue (Appendix A). This required nine different analytical methods. Not all chemical groups included in the water quality toxics assessment were included in this study. The chemical groups not included are not known bio-accumulate in tissue or sequester in sediments where they could be incidentally ingested by finfish or shellfish. Oregon Health Authority Fish Advisory Program screening values are in milligrams per kilogram wet weight and the laboratory employed the best available technologies to analyze samples to this level. All analytical methods were completed at the DEQ laboratory with the exception of butyltin analysis which was subcontracted to ALS Laboratories in Kelso, WA. This laboratory is accredited to perform this specific analysis through the National Environmental Laboratory Accreditation Program. Specific information on methods and complete analyte lists for each method are found in the project's quality assurance plan and yearly sampling and analysis plans. These documents are available upon request from the DEQ laboratory.

1.6 Inorganic Parameters

The inorganic laboratory analyzed tissue samples for total metals, total inorganic arsenic, and mercury. In order to achieve the necessary detection limits, the laboratory used an Agilent ICPMS (inductively coupled plasma mass spectrometer) following EPA guidance (EPA method 6020A) for total metals. Total inorganic arsenic was first analyzed for in tissue samples in 2010 (EPA 1632A). Analysis for mercury occurred in all study years (EPA 7473).

1.7 Organic Parameters

The organic laboratory analyzed tissue samples for close to 330 compounds using gas chromatography high-resolution mass spectrometry. Analysis of these compounds followed EPA guidance for pesticides (EPA method 1699), PBDEs (EPA 1614A), PCBs (EPA 1668B or 1668C) and dioxins and furans (EPA 1613). ALS Laboratory in Kelso, WA, analyzed the organotin compounds. This analysis was only included for the samples collected during 2013 due to concern about butyltins in coastal waters. This analytical method was first published by Krone et al. 1989 for use in sediment and English sole livers.

1.8 Laboratory Quality Control

Each laboratory analytical batch included a method blank, laboratory control sample, matrix spike and either a sample duplicate or matrix spike duplicate. Laboratory analytical staff and the project manager evaluated the results of each quality control sample and estimated or qualified data as appropriate.

2. Results

2.1 Statewide Summary

Overall, the DEQ laboratory analyzed tissue samples from 58 sampling sites across the state (Figure 1). Appendix B shows the basin, site description, latitude and longitude for each of the tissue sampling locations. During this sampling, laboratory analyses encompassed more than 330 unique chemicals using nine different analytical

methods. This report groups these chemicals into five categories. Table 1 provides a brief description of these categories with a more thorough description in the Results: Chemical Group Summary section. Certain chemical groups analyzed in the Statewide Water Quality Toxics Assessment were not included in this study because they are not known to bio-accumulate in fish tissue or they sequester in the inedible portions of the animal (i.e., organs or fat).

In 2016, OHA published guidance regarding the consumption of fish tissue. The screening values are based on a consumption rate of 30 g/day and a body weight of 70 kg (OHA, 2017). These screening values are used throughout this report for all analytes with the exception of mercury. For mercury, the Human Health criterion adopted by DEQ in 2011 was used. This criterion was based on a consumption rate of 175 g/day rather than the OHA consumption rate of 30 g/day to protect subsistence fishers (ODEQ, 2011).

Table 1. Chemical groups of analytes as reported in this study.

Chemical Group	Description	Number of compounds analyzed
Flame Retardants	PBDEs added to a variety of common products including furniture, laptops, cars, etc. to retard combustion	46
Metals	Metals for which OHA fish advisory guidelines exist	4
Mercury	Metal found across the state	1
PCBs	Polychlorinated biphenyls used as electrical insulating fluid	249
Legacy Pesticides	Chlorinated insecticides banned in the U.S. and many other countries. Many continue to be used in some parts of the world	31
Dioxins/Furans	Chemicals formed as by-products of industrial processes, wood pulp bleaching and incomplete combustion from forest fires, volcanoes and incineration processes	46

Statewide, DEQ detected 269 unique chemicals. The most commonly detected group was mercury present at 100 percent of sites followed by flame retardants present at 95 percent of sites (Figure 2). Appendix C summarizes the chemicals detected, number of detections and maximum concentrations at each sampling location.

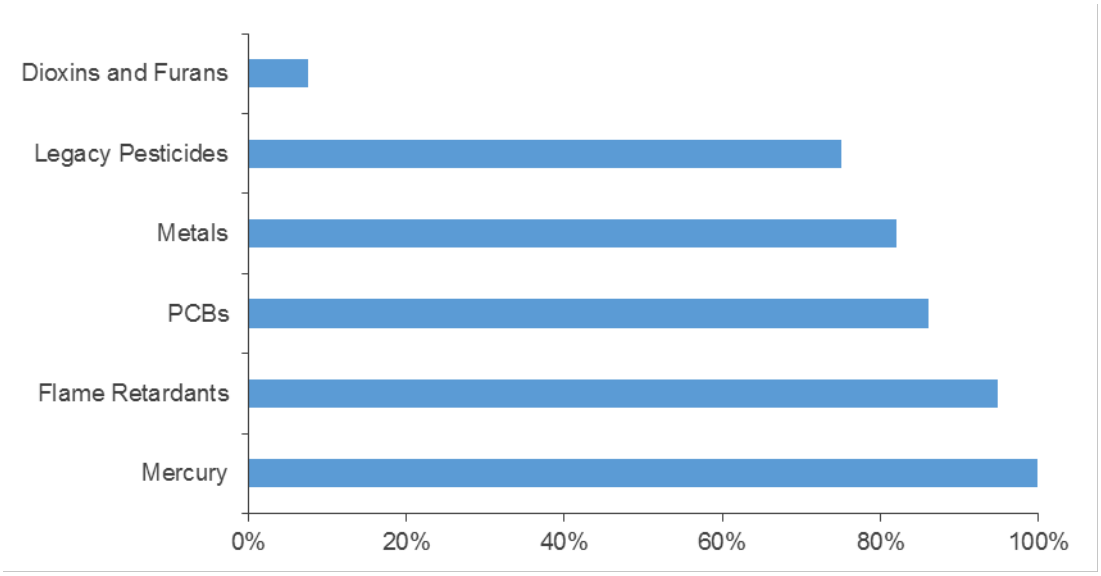

Figure 2. Percentage of sites with detections by chemical group.

The number of different chemicals varied geographically (Figure 3). The greatest number of detections occurred in the Willamette Basin. As observed in the Statewide Water Quality Toxics Assessment the basins with the largest population tended to have a higher number unique chemical detections (ODEQ, 2015). Despite population or land use differences between the basins, nearly all chemical groups were detected in each basin. PCBs were detected in tissue from all but one basin. This differs from detections in the Statewide Water Quality Toxics Assessment in which detections of PCBs occurred in one of nine basins sampled after the updated analytical method was adopted (ODEQ, 2015). Similarly, dioxins and furans were detected in tissue from three basins (North Coast, Mid Coast and Deschutes) whereas dioxins and furans were only detected in water from the John Day Basin. The chemicals in these groups have a strong affinity to sequester in tissue rather than remain in the water column. The remaining chemical groups were detected at similar rates compared to the ODEQ 2015 report.

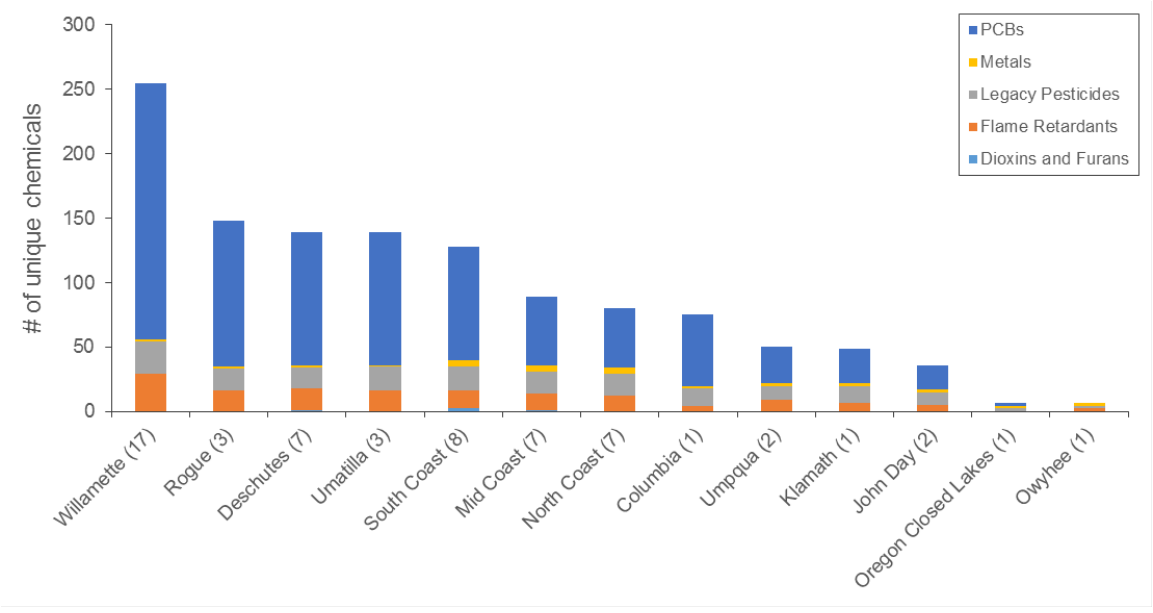

Figure 3. Number of unique chemicals detected in each basin by chemical group. Parentheses indicate the number of sampling sites per basin. Mercury is included in the Metals chemical group in this figure.

2.2 Chemical Group Summaries

This section describes the chemicals in each group, the potential effects of these chemicals and the results of this study.

2.2.1 Legacy Pesticides

Legacy pesticides include those pesticides banned from use in the United States. In some cases, these chemicals continue to be used in other parts of the world. Due to their environmental persistence (typically in sediment and soils), runoff from historically treated areas is a major source of these chemicals to aquatic systems. These compounds also bio-accumulate in organisms and pose a risk throughout the food web and, ultimately, to human health. This study measured not only the parent compounds of these pesticides but also several of the breakdown products. OHA established screening values for 13 of the 31 compounds analyzed for in this chemical group. Due to the tendency of these compounds to bio-accumulate, parent compounds are often considered along with breakdown products rather than individually. This is true for the DDT, chlordane and endosulfan families of compounds.

The overall detection rate of legacy pesticides across the state was 42 percent. Legacy pesticides were detected in each of the basins sampled with the highest number of detections occurring in the Willamette Basin followed by the Deschutes Basin (Figure 4). None of the detections across the state exceeded OHA screening values. On average, legacy pesticide concentrations were lower in shellfish samples than in finfish samples (Figure 4).

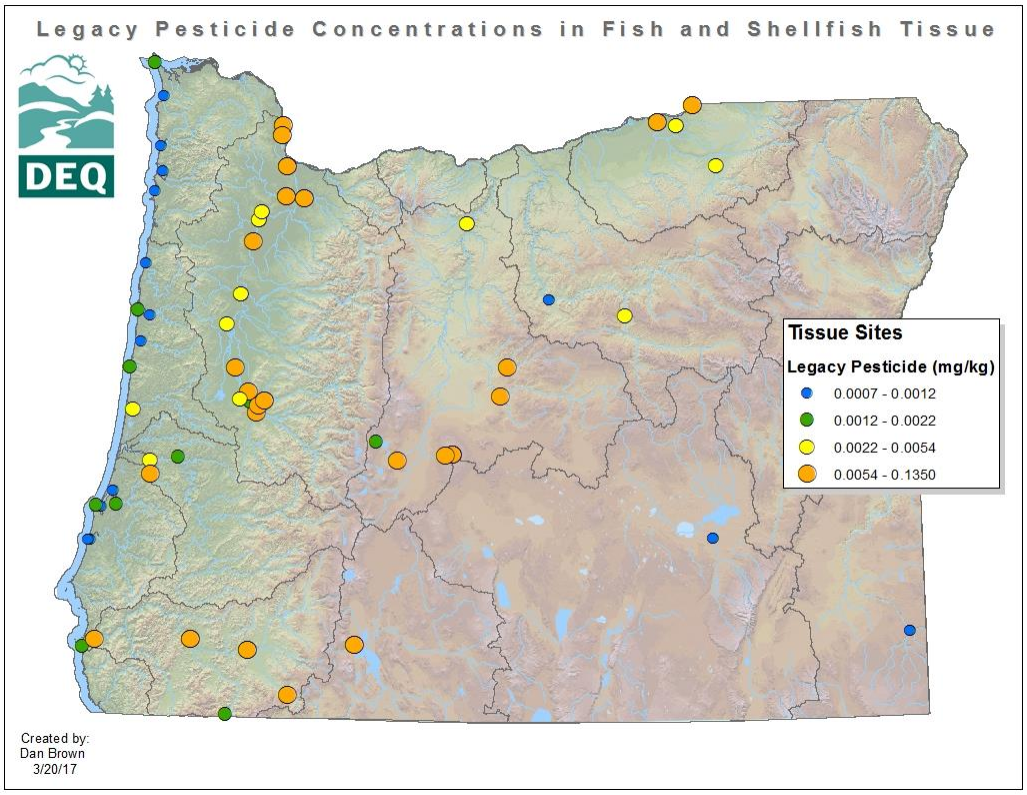

Figure 4. Geographic distribution of total legacy pesticide concentrations in finfish and shellfish.

During the water toxics study, BHC compounds, specifically alpha- and beta-BHC, were unexpectedly detected at 63 percent of estuarine sampling locations. These detections were unexpected because the use of technical BHC was banned in 1978 and current uses of lindane are being phased out. Despite the limited or banned use of these compounds, alpha- and beta-BHC were detected in shellfish samples from 16 of the 18 (89 percent) estuarine sampling locations in this study. Comparatively, these two compounds were only detected in 8 percent of finfish

samples from the rest of the state. Potential sources of these compounds along the coast include historic uses, such as wood treatment by the timber industry (Li, 1999) or airborne transport, which can occur over great distances (ASTDR, 2005; Genauldi et al., 2009). The total levels (total-BHCs) in the samples did not exceed the OHA screening guideline for lindane.

2.2.2 Flame Retardants (brominated)

Flame retardants, or PBDEs, are chemicals which are added to a variety of products such as laptops, automobiles, furniture and textiles. These chemicals release from these products and may enter the aquatic environment through air deposition, incineration, landfill leachate or wastewater discharges. Similar in structure to PCBs, they persist in the environment and tend to bio-accumulate in organisms. Studies have found these compounds in osprey eggs and eagles in the Northwest United States (Henny et al., 2009; Spears and Isanhart, 2014), breast milk in Sweden (Hooper and McDonald, 2000) and in the Canadian Arctic in animal tissue (Ikonomou et al., 2002). In addition, based on their tendency to bio-accumulate in tissue, the OHA established screening values for four congeners (PBDE-47, PBDE-99, PBDE-153, and PBDE-209) in fish tissue.

Flame retardants were detected in 25 percent of samples, statewide, and in each basin with the exception of the Oregon Closed Lakes Basin. Detection rates varied throughout the state, however the Willamette Basin (40 percent) and the Umatilla Basin (38 percent) were more than ten percentage points higher than the next highest basin (Figure 5). The presence of PBDEs across the state, even in less populated basins, indicates how prevalent and persistent flame retardants are in the environment. Potential pollution routes include aerial deposition from trash burning, seepage from landfills or illegal dumping, and improper disposal of materials.

Of the four congeners with established screening values, PBDE-47 was detected in 93 percent of samples followed by PBDE-99 with 80 percent, PBDE-153 with 65 percent and PBDE-209 with 45 percent. Despite the prevalence of these four congeners in fish tissue, none of the detections exceeded the applicable OHA screening values. In fact, the highest detection of any of these four congeners was only one percent of the applicable screening value.

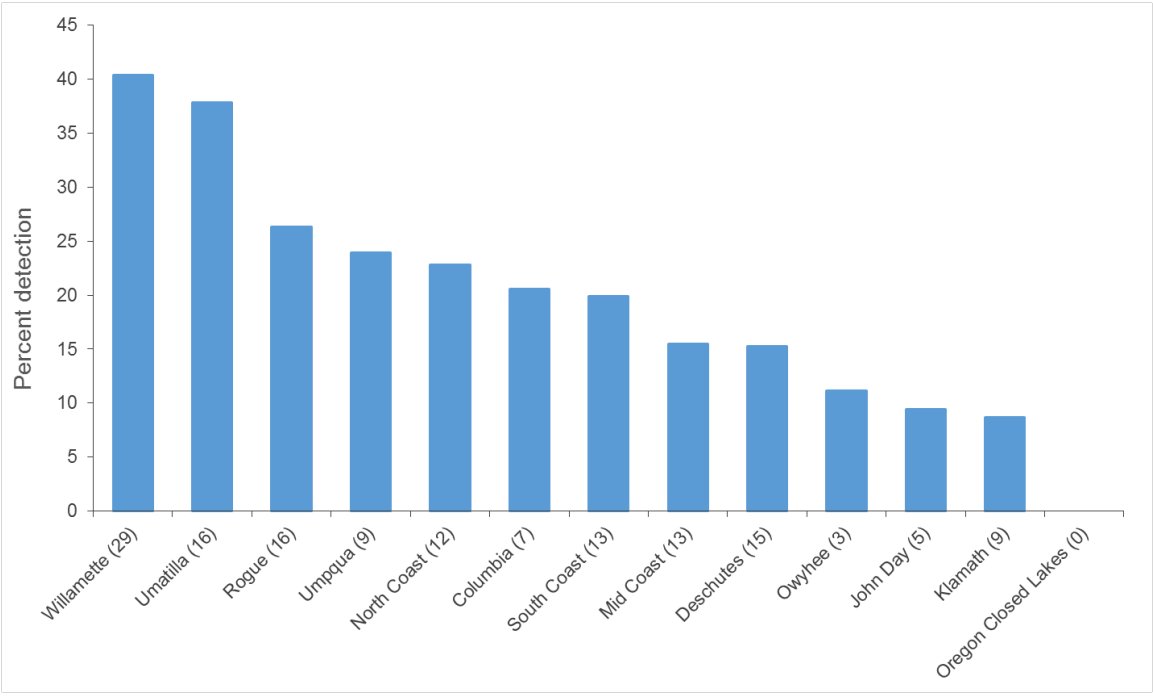

Figure 5. Percent detection of flame retardants by basin. Parentheses indicate the number of unique PBDEs detected.

Flame retardants were far more prevalent in fish tissue than in water samples collected during the water quality toxics assessment. Figure 6 shows the number of sites with at least one detection of each PBDE congener. The increased number of congeners present and the higher number of detections compared to the water samples is very apparent. This is due to the lipophilic properties of PBDEs that enable them to readily bio-accumulate in aquatic foodwebs (Shaw and Kannan, 2009). Figure 6 also may indicate the affinity of certain congeners to be sequestered more readily than others. Less brominated PBDE congeners, such as -47 and -100, are more easily sequestered and transferred between prey and predator than more brominated PBDE congeners, such as -209, based on size and persistence of the specific congener (Shaw and Kannan, 2009).

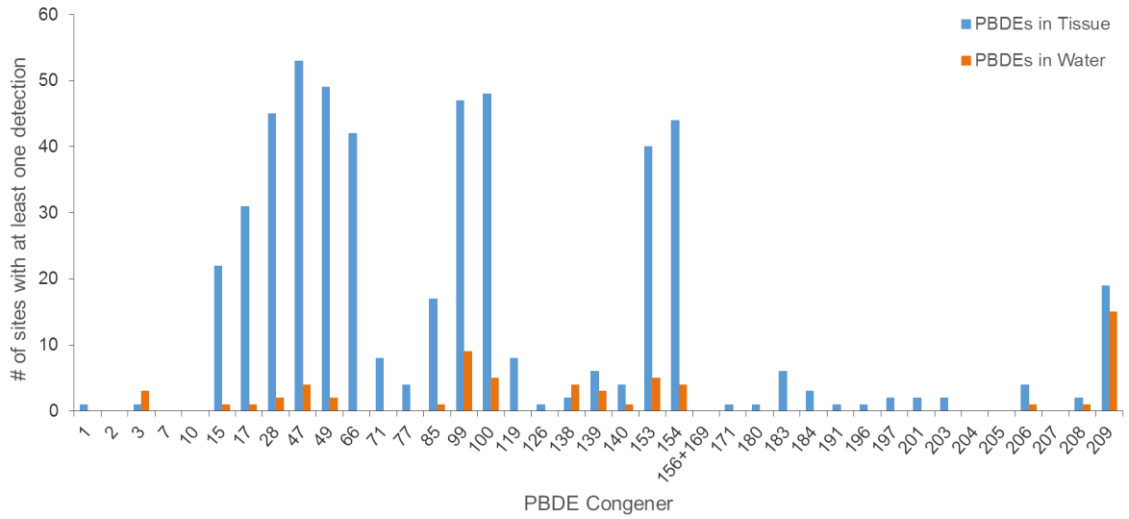

Figure 6. A comparison between the number of sites with at least on detection of each PBDE congener in tissue and water samples.

2.2.3 Dioxins and Furans

Dioxins and furans include 17 different chemicals or congeners that are similar in structure to each other but vary in their toxicity. These chemicals are not produced intentionally but rather are a by-product of industrial activities (paper bleaching, industrial production) and fossil fuel combustion from sources such as incineration, wood stoves and forest fires. These chemicals persist in the environment, bio-accumulate in organisms, and pose a risk to humans and wildlife even at very low levels. For this reason, the OHA screening value for dioxins and furans exists as an aggregate of detections based on the toxic equivalency for each compound or congener as compared to 2,3,7,8-TCDD, the most toxic congener. The screening value is also reported in nanograms per kilogram of fish tissue, whereas all of the other screening values are reported in milligrams per kilogram of fish tissue.

In total, there were seven dioxin and furan detections during this study. Four of those detections occurred in shellfish and three in finfish. The highest number of detections was observed in the South Coast Basin, while two occurred in the Klamath Basin and one each in the North Coast and Deschutes basins. The only detection to exceed the OHA screening value for dioxins and furans (1.6 ng/kg) was from a brown trout captured in East Lake in the Deschutes Basin (1.98 ng/kg). East Lake is a secluded, high mountain lake located in the Deschutes National Forest. This could indicate a potential indirect effect of forest fires on aquatic species.

2.2.4 Polychlorinated Biphenyls

PCBs are a class of industrial chemicals. Historically used as an electrical insulating fluid in transformers and capacitors, additional uses in adhesives, sealants and paints existed. Because of their persistence in the environment, toxicity to humans and possible links to cancer, the United States banned manufacture and use of these chemicals in products at levels above 50 parts per million . However, sources of PCBs still exist from products that remain in use, improper disposal practices, or as low-level (below 50 parts per million)

contaminants in other industrial chemicals or products. Similar to legacy pesticides and flame retardants, these chemicals persist in the sediment of aquatic systems and bio-accumulate in organisms. Several fish consumption advisories currently exist across the United States and in Oregon for PCBs (USEPA, 2017). Historically, detections of PCBs occurred in fish tissue in remote locations such as Crater Lake (USEPA, 2009).

Consumption advisories are based on an OHA screening value of 0.05 mg/kg wet weight. This is measured as total PCB concentration or the total sum of congener concentrations detected in a given sample. Tissue samples in this study were analyzed for 241 different PCB congeners. The highest rate of detection was in the Willamette Basin, however, PCBs were detected in each basin with the exception of the Owyhee Basin (Figure 7).

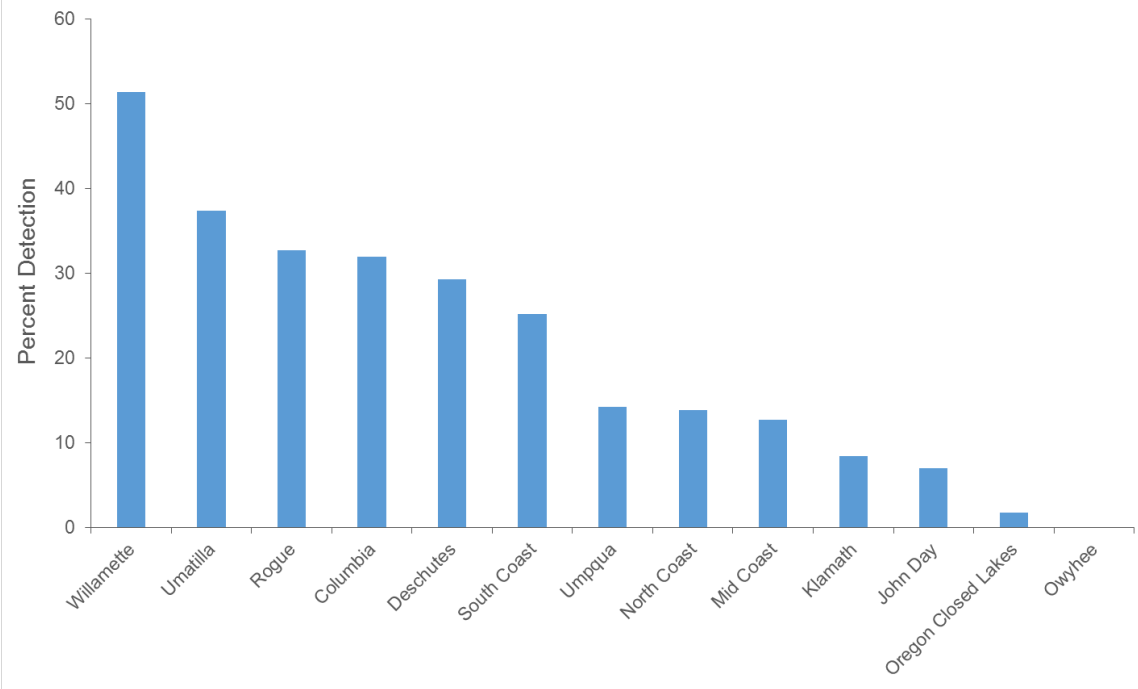

Figure 7. Percent detection of PCBs by basin.

Two finfish samples exceeded the OHA screening value. Both occurred at the same sampling point in the Willamette River near Eugene, OR (Figure 8). The first exceedance was from a large Northern Pikeminnow and the second exceedance occurred in a composite sample, which included a portion of tissue from the exceeding individual. In 2016, DEQ revisited this area to investigate these elevated results. Sediment and tissue samples (crayfish) were collected. These data are not yet available. Currently, a fish consumption advisory exists for a section of the lower Willamette River (OHA, 2017).

Two samples in the Willamette Basin, one near the SP&S Bridge and one on the McKenzie River at Coburg Road, had detections of nearly 140 unique congeners. While the total PCB concentration detected in both of these samples was below the OHA screening value, it is unknown what effect low-level PCB mixtures might have on aquatic organisms. None of the shellfish samples exceeded the OHA screening value. Generally, the shellfish samples had very low PCB concentrations. The highest concentration was detected in an oyster collected in the Isthmus Slough (0.026 mg/kg wet weight).

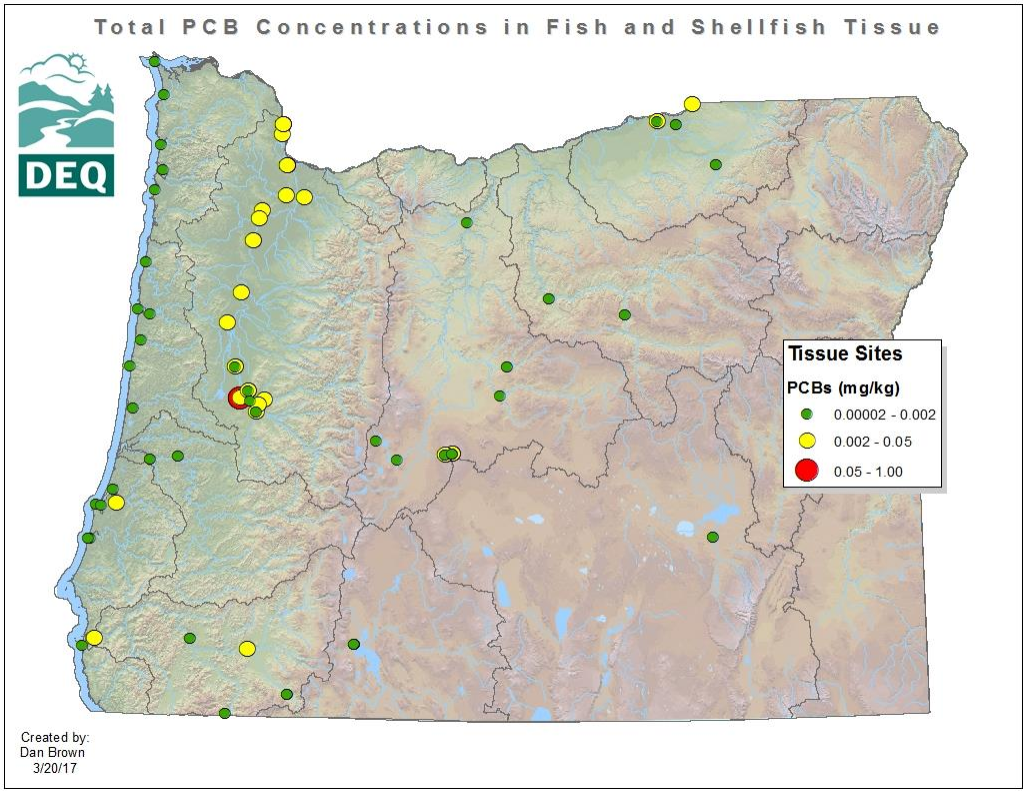

Figure 8. Geographic distribution of total PCB detections in finfish and shellfish.

2.2.5 Priority Metals

Anthropogenic sources of metals to the environment include stormwater runoff, industrial processes, boating activities, pesticides and consumer products. In addition, metals occur naturally in the earth's crust and enrichment of certain metals in rocks varies based on geologic history and formation. Metals such as cadmium and selenium may reach the environment from mining activities and fertilizers; tributyltin, from marine paints and antifouling agents; mercury and arsenic, are both naturally occurring that may also end up in aquatic systems as a result of industrial activities and legacy pesticide use.

Once in the aquatic system, metals typically enter the food chain through direct consumption or uptake through the epithelia, such as the gills, skin and digestive tract (Burger et al., 2002). Bioaccumulation occurs when metals are absorbed or ingested at a faster rate than they can be evacuated, which depends on pollution level as well as fish species (Jezierska and Witeska, 2006). Consumption of fish containing metals can transfer those metals to the consumer including other fish, wildlife and humans. While different metals show affinity for certain organs, such as the liver, kidney and gills, muscle tissue is typically low in concentrations of metals, except for mercury, and safe for human consumption (Jezierska and Witeska, 2006).

Analyses for this section were based on the availability of applicable consumption guidelines and therefore do not match analyte list from the water quality toxics monitoring report. Additionally, cadmium and arsenic are known carcinogens, mercury is a known neurotoxicant and tributyltin has been found to alter reproductive success, reduce growth and upset blood and liver metabolism (Fent, 2008). Selenium, however, works as an antioxidant and studies have shown that it may reduce the risk of mercury poisoning at certain concentrations (Burger et al., 2001). Prior to 2010, mercury was the only metal analyzed for in tissue samples. For all samples in this study, OHA screening values were utilized, except for mercury. The DEQ human health criteria was updated in 2011 to more accurately reflect the consumption rate of Oregonians (ODEQ, 2011). Tributyltin was the only metal, other than mercury, that was not included in the water quality toxics report.

Cadmium, Selenium and Tributyltin

As in the water samples, cadmium and selenium detections were relatively rare in fish tissue. In fact, cadmium was not detected in finfish samples, while selenium was found in 14 of 119 total (finfish and shellfish) samples. Detections of tributyltin were equally rare. The compound was detected 4 times in 17 samples. One of the three tributyltin congeners (n-butyltin) analyzed for during this study was detected twice in the same number of samples. Tributyltin and three congers were added to the shellfish analysis in 2013, so the number of samples was quite a bit lower. Neither tributyltin nor cadmium were detected in finfish as both compounds tend to sequester in fats and organ meat rather than the muscle tissue (Jezierska and Witeska, 2006; ASTDR, 2012). The preparation method for most finfish samples in this study excluded the skin, fat and organ meats as these portions are unlikely to be consumed by recreational fishers.

None of the detections for these compounds exceeded the applicable OHA screening values. Figure 9 depicts the impact ratio (the concentration detected divided by the OHA screening value). An impact ratio of one or greater would indicate that the concentration had met or exceeded the screening value. OHA's screening value for tributyltin is 0.7 mg/kg.

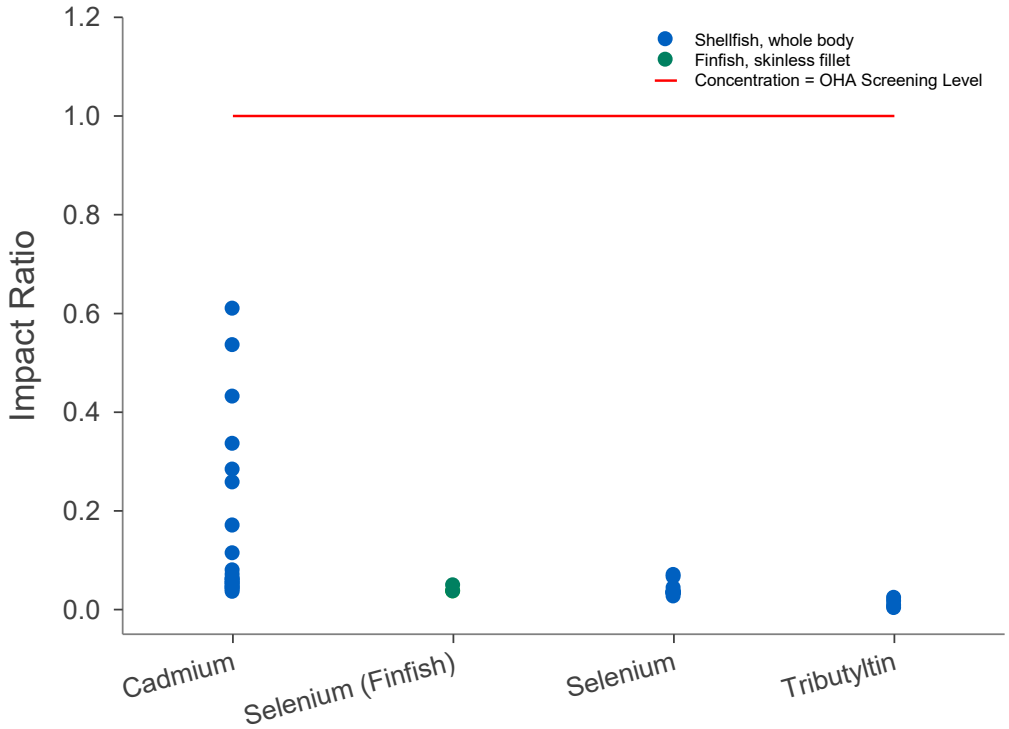

Figure 9. Impact ratio for detected priority metals in shellfish. Values above the red line would indicate a potential for impact on human health.

While these detections do not pose a threat to human health, a few of the selenium detections do exceed DEQ Environmental Cleanup Program guidance values for finfish and shellfish consumed by wildlife (Table 1). These guidance values were established in 2007, for use during removal or remediation action performed under the revised environmental cleanup law (ODEQ, 2007). Of the 14 selenium detections three exceeded the individual guidance value for birds and mammals, and three exceeded the population guidance value for birds. These detections occurred in the John Day, Owyhee, Mid-Coast and South Coast.

Table 1. DEQ Environmental Cleanup Program Guidance Values for Selenium.

	Birds (mg/kg wet weight)		Mammals (mg/kg wet weight)	
	Individual	**Population**	**Individual**	**Population**
Selenium	0.23	0.46	0.036	0.88

Mercury

Analysis of mercury was not included in the water quality toxics study due to its tendency to be sequestered in sediments and bio-accumulate in fish tissue. Mercury was detected in 100 percent of finfish and shellfish samples collected during this study. Eighty-three percent of those detections exceeded the DEQ Human Health criterion of 0.04 mg/kg wet weight. Only one shellfish sample exceeded the criterion. This exceedance occurred in an oyster sample collected along the South Coast Basin. Recently the OHA established a statewide consumption advisory for bass due to mercury (OHA, 2017).

Comparatively, exceedances of the mercury criterion in finfish samples occurred in each basin sampled, and six basins had exceedance rates of 100 percent, the Columbia, John Day, Oregon Closed Lakes, Owyhee, Umatilla and Umpqua basins. The samples sizes in these basins were fairly low, but the Willamette Basin, which had the highest number of samples (113 samples), had an exceedance rate of 99 percent (Table 2). The lowest rate of exceedance was found in the Klamath Basin, 60 percent.

Table 2. Statewide DEQ mercury Human Health criterion exceedance rate by basin. Table does not include shellfish.

Basin	Exceedances	Detections	Number of Samples	Percent Exceedance
Columbia	2	2	2	100%
John Day	8	8	8	100%
Oregon Closed Lakes	2	2	2	100%
Owyhee	5	5	5	100%
Umatilla	18	18	18	100%
Umpqua	6	6	6	100%
Willamette	112	113	113	99%
Rogue	24	27	27	89%
Deschutes	78	99	99	79%
Klamath	6	10	10	60%

Given the tendency of mercury to bio-accumulate in fish tissue, the next question to ask is whether species or length, as a surrogate for fish age, might show any differences in mercury concentration (Phillips et al., 1980). Exceedance rates did not differ by species (Table 3). Interestingly, high rates of exceedance were seen in the non-piscivorous fish sampled. Despite the small sample sizes, the high rates of exceedance for these species indicates potential high concentrations of mercury in sediments. DEQ will present a summary of sediment data in a separate report. In addition, a comparison of fish length and mercury concentration (Figure 10) did not indicate a correlation. While there appears to be an increase in mercury concentration with fish length, the coefficient of determination, or R-squared value, which indicates the strength of a relationship on a scale from zero to one, is very low (Figure 10).

Whole body samples were collected along with skinless fillet samples in three lakes across the state, allowing for a unique comparison between the two sample matrices. This sampling occurred in Upper Klamath Lake in the Klamath Basin and in East and Paulina lakes in the Deschutes Basin. At each of the three lakes, skinless fillet samples were collected from brown trout, rainbow trout or Atlantic salmon with one yellow perch sample collected in Upper Klamath Lake. The whole body samples consisted of species that typically feed lower in the food chain, including blue chub, tui chub, fathead minnow, pumpkinseed, yellow perch and brown bullhead. Whole body samples consisted of a tissue composite from 10 fish of the same species and same general size.

Table 3. Statewide DEQ mercury Human Health criterion exceedance rate in skinless fillet samples by fish species. Asterisks indicate non-piscivorous fish species.

Species	Exceedances	Detections	Number of Samples	Percent Exceedance
Atlantic Salmon	4	4	4	100%
Black Crappie*	2	2	2	100%
Bridgelip Sucker*	10	10	10	100%
Brown Bullhead	4	4	4	100%
Common Carp*	2	2	2	100%
Largemouth Bass	25	25	25	100%
Largescale Sucker*	12	12	12	100%
Northern Pikeminnow	71	71	71	100%
Smallmouth Bass	62	62	62	100%
Yellow Perch	1	1	1	100%
Brown Trout	16	20	20	80%
Rainbow Trout	35	54	54	65%
Brook Trout	4	7	7	57%

In general, whole body samples contained lower concentrations of mercury than the skinless fillet samples from the same lake. Each of the whole body samples in East (one sample) and Paulina (three samples) lakes exceeded the DEQ mercury criterion (0.04 mg/kg), while none of the whole body samples in Upper Klamath Lake (six samples) exceeded the criterion. While a majority of skinless fillet samples from these three lakes also exceeded the mercury criterion, this analysis was not rigorous enough to determine if the differences in mercury concentration were due to differences in trophic level of the fish sampled or if including the skin and organs in the whole body samples effectively lowered the mercury concentration below the criterion.

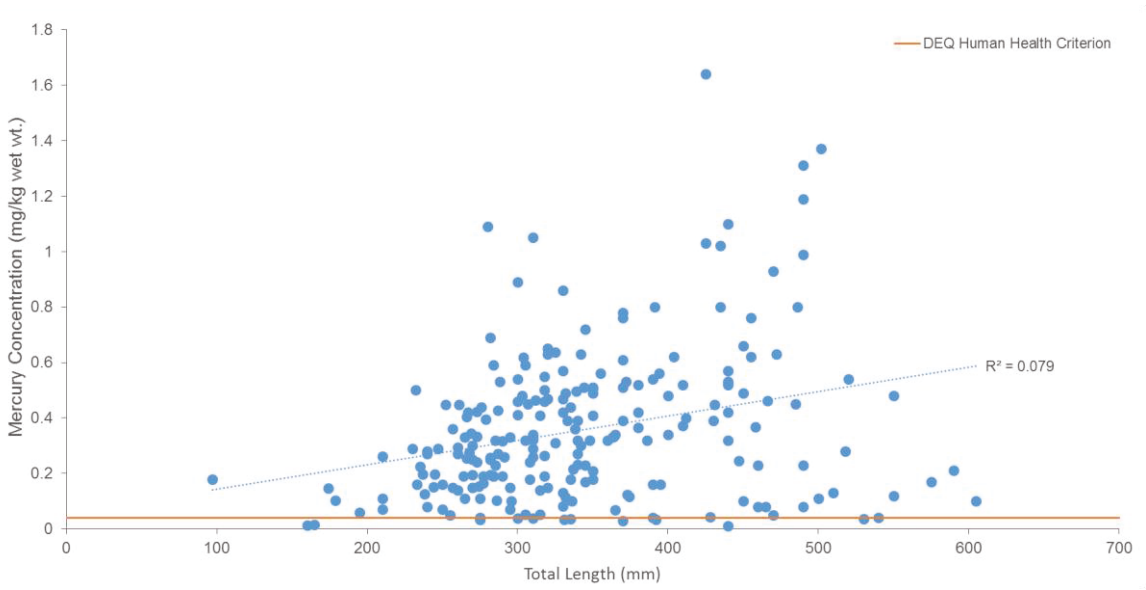

Figure 10. Mercury concentration (mg/kg wet weight) in skinless finfish fillets compared to total length (mm). The red line indicates the DEQ human health criterion for mercury (0.04 mg/kg).

Arsenic

As noted in ODEQ's 2015 water quality toxics report, arsenic is a commonly occurring metal in Oregon's surface waters. While it is naturally present in Oregon geology, its concentration varies geographically. The highest concentrations of total arsenic are generally found on the east side of the state. However, the toxic form of arsenic

to humans and aquatic life is inorganic arsenic. In situations where inorganic arsenic data is not available measurements of total arsenic can be used as a conservative surrogate. Total arsenic was detected in 20 percent of the finfish samples. A small number of finfish samples collected after 2009 were analyzed for inorganic arsenic, but none of these samples were above the minimum detection limit.

Shellfish collection occurred over two different sampling periods, one in 2013 then again in 2015. Results from the 2013 sampling effort found 100 percent detection of total arsenic compared to only 20 percent detection in finfish samples. Inorganic arsenic was detected in 95 percent of shellfish samples and exceeded the screening value in 45 percent of samples (Figure 11). The highest concentrations of inorganic arsenic were found in softshell clams, compared to oyster and mussel samples. DEQ, ODFW, OHA and ODA discussed the high results for softshell clams and initiated a second sampling in 2015. The objectives of this sampling included: confirming the 2013 findings, expanding the sampling to different clam species, and testing the hypothesis that cleaning of softshell clams may reduce the risk to humans from the inorganic arsenic.

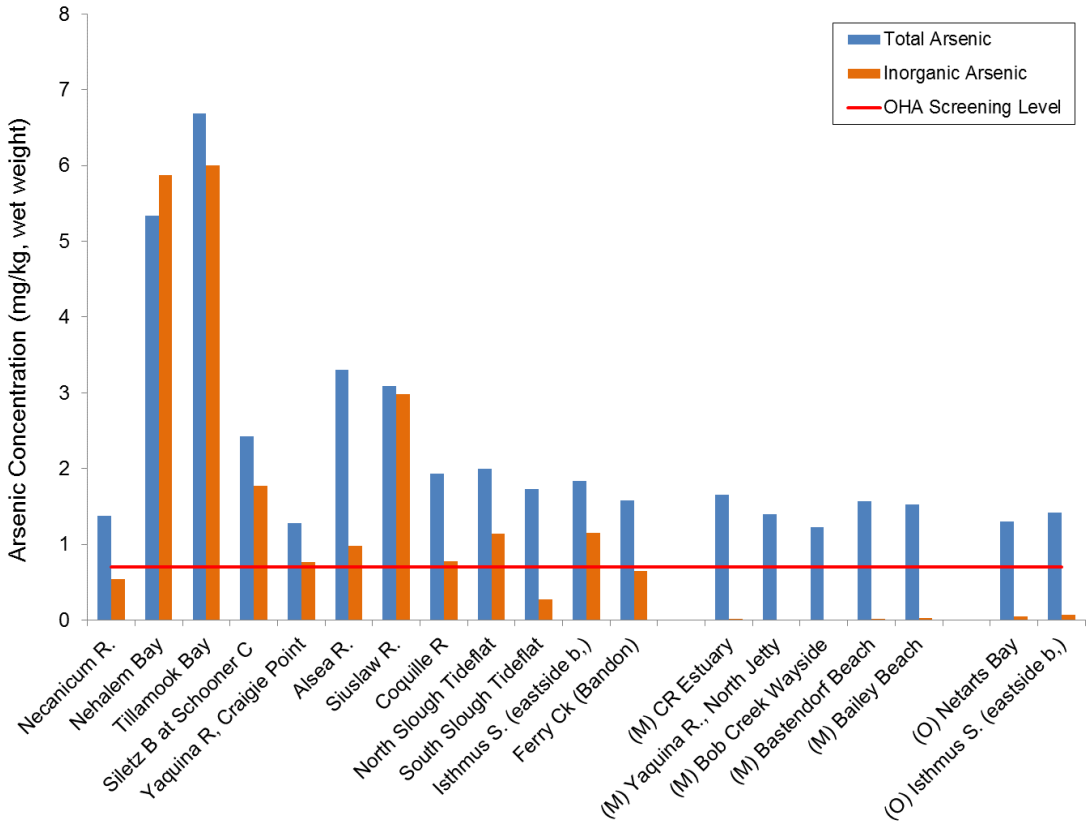

Figure 11. Total and inorganic arsenic concentrations by sampling location from the 2013 shellfish sampling effort. Samples separated into softshell clam, mussel (M) and oyster (O) sampling locations. OHA screening level is for inorganic arsenic.

The 2015 sampling effort added gaper clams (similar biological structure), cockles and butter clams. Sampling occurred at a subset of the original sampling locations that supported collection of multiple clam species per sampling location. ODFW suggested testing the effectiveness for reducing exposure to inorganic arsenic of the cleaning method for softshell clams utilized by consumers. The cleaning method involves removing the tough skin that surrounds the siphon by making a small incision along the length of the siphon skin or by scalding the intact clam in hot water before pulling the siphon skin off. This process resulted in three different sampling matrices: whole body (to confirm 2013 findings), whole body cleaned (siphon skins removed) and siphon skins.

Results from the follow-up study produced similar results for the whole body samples between the two years (Figure 12). While there was some variation, the samples collected in areas well above the OHA screening value in 2013 were well above in 2015 and vice versa. The cleaning method appears to be very effective at removing

the portion of the clam with the highest concentration of inorganic arsenic. The most drastic difference occurred in the Nehalem Bay where the inorganic arsenic concentration in the siphon skin was 46.8 mg/kg compared to 0.12 mg/kg in the cleaned body.

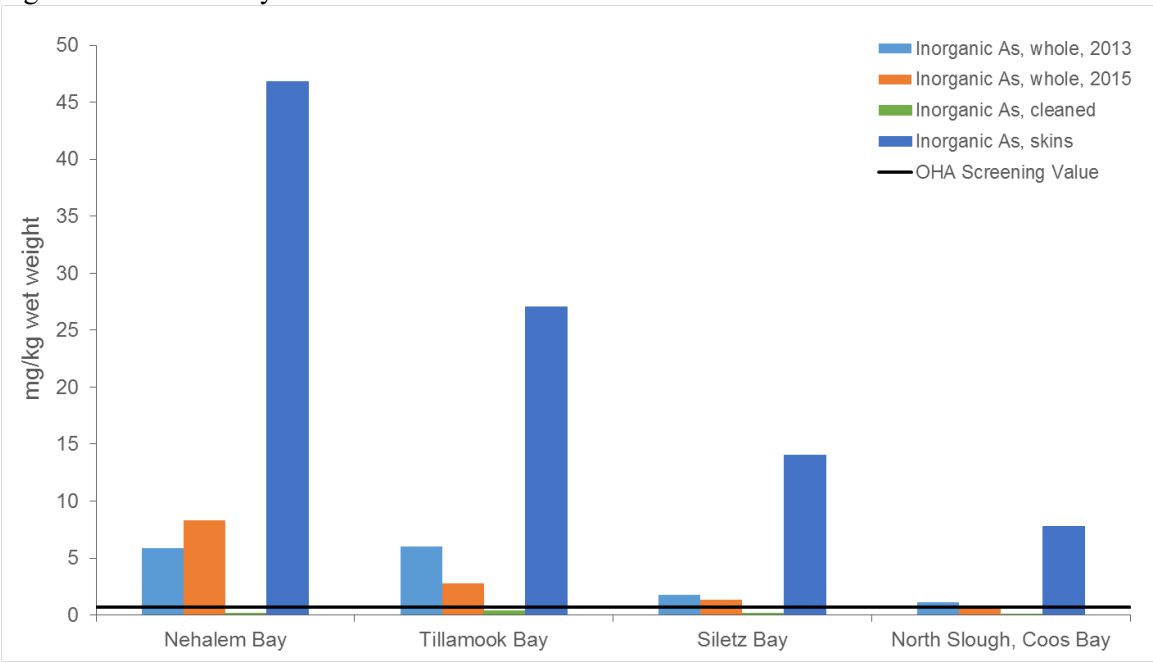

Figure 12. Inorganic arsenic concentration (mg/kg wet weight) in whole body (2013 and 2015), cleaned and siphon skin softshell clam samples from four bays along the Oregon Coast.

Morphological differences between the clam species collected in 2015 mean that the siphon skin samples are only from gaper and softshell clams. These morphological differences could also explain the differences in inorganic arsenic concentration between the species (Table 4). These data resulted in issuance of a consumption advisory for softshell and gaper clams by the OHA. This advisory includes the recommended cleaning protocol to remove the risk from consumption (OHA, 2015).

Table 4. Inorganic arsenic concentration (mg/kg wet weight) in whole body samples collected in 2015 by species.

Species	Sample Size	Average Concentration	Standard Error
Butter Clam	3	0.04	0.008
Cockle	4	0.04	0.002
Gaper Clam	3	0.84	0.289
Softshell Clam	8	2.94	0.382

3. Next Steps

DEQ will use data from this study to inform and develop future tissue sampling efforts. These efforts will again be tied to the water quality toxics monitoring efforts, which will maintain the rotating basin approach used previously. This approach aims to monitor each basin in the state over the course of five years. The current rotation began in 2015 in the Klamath, North Coast, Umpqua and Rogue basins. In 2016, crayfish samples were collected in the Willamette, John Day, Powder, Walla Walla and Grande Ronde basins in place of finfish. By sampling a relatively sedentary organism compared to most finfish, it is thought that samples will provide a more holistic representation of the aquatic environment. Additional tissue samples will be collected and analyzed in conjunction with partner agency sampling efforts.

The 2017 sampling will coincide with the DEQ laboratory's biomonitoring program and EPA's National Lakes Assessment. The biomonitoring investigations will initially be limited in scope, but this monitoring may provide

insight into effects on biological communities from low-level toxics in the environment. The National Lakes Assessment surveys lakes across the state for a variety of parameters. By including the evaluation of toxic chemicals in this survey, DEQ will gather information statewide on an aquatic resource not typically sampled for toxic chemicals.

DEQ expects to implement these monitoring programs over time. DEQ will work with its partners and stakeholders to conduct additional monitoring to potentially identify sources of toxics in their watersheds as well as assist in planning management actions.

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Appendix A – Chemicals Analyzed

Pages A-1 through A-4

List contains all compounds analyzed during the sampling period.	
Analyte group, *Analyte sub-group,* Analyte name	
Dioxins and Furans	**Flame retardants, continued**
1,2,3,4,6,7,8-HpCDD	PBDE-171
1,2,3,4,6,7,8-HpCDD as TEQ	PBDE-180
1,2,3,4,6,7,8-HpCDF	PBDE-183
1,2,3,4,6,7,8-HpCDF as TEQ	PBDE-184
1,2,3,4,7,8,9-HpCDF	PBDE-191
1,2,3,4,7,8,9-HpCDF as TEQ	PBDE-196
1,2,3,4,7,8-HxCDD	PBDE-197
1,2,3,4,7,8-HxCDD as TEQ	PBDE-2
1,2,3,4,7,8-HxCDF	PBDE-201
1,2,3,4,7,8-HxCDF as TEQ	PBDE-203
1,2,3,6,7,8-HxCDD	PBDE-204
1,2,3,6,7,8-HxCDD as TEQ	PBDE-205
1,2,3,6,7,8-HxCDF	PBDE-206
1,2,3,6,7,8-HxCDF as TEQ	PBDE-207
1,2,3,7,8,9-HxCDD	PBDE-208
1,2,3,7,8,9-HxCDD as TEQ	PBDE-209
1,2,3,7,8,9-HxCDF	PBDE-28
1,2,3,7,8,9-HxCDF as TEQ	PBDE-3
1,2,3,7,8-PeCDD	PBDE-30
1,2,3,7,8-PeCDD as TEQ	PBDE-47
1,2,3,7,8-PeCDF	PBDE-49
1,2,3,7,8-PeCDF as TEQ	PBDE-66
2,3,4,6,7,8-HxCDF	PBDE-7
2,3,4,6,7,8-HxCDF as TEQ	PBDE-71
2,3,4,7,8-PeCDF	PBDE-77
2,3,4,7,8-PeCDF as TEQ	PBDE-85
2,3,7,8-TCDD	PBDE-99
2,3,7,8-TCDD as TEQ	1,2-Bis(2,4,6-tribromophenoxy)ethane
2,3,7,8-TCDF	2,3,4,5,6-Pentabromoethylbenzene
2,3,7,8-TCDF as TEQ	Hexabromobenzene
OCDD	**Legacy Pesticides**
OCDD as TEQ	Aldrin
OCDF	*BHC-technical (HCH)*
OCDF as TEQ	BHC-alpha
Flame retardants	BHC-beta
PBDE-1	BHC-delta
PBDE-10	BHC-gamma (Lindane)
PBDE-100	*Chlordane*
PBDE-119	alpha-Chlordane
PBDE-126	cis-Chlordane
PBDE-138	trans-Nonachlor
PBDE-139	gamma-Chlordane+trans-Nonachlor
PBDE-140	Oxychlordane
PBDE-15	Dieldrin
PBDE-153	*Total Endosulfan*
PBDE-154	Endosulfan I
PBDE-156+169	Endosulfan II
PBDE-169	Endosulfan sulfate
PBDE-17	Endrin

List contains all compounds analyzed during the sampling period.	
Analyte group, *Analyte sub-group,* Analyte name	
Legacy Pesticides, continued	**PCBs, continued**
Endrin ketone	PCB-119+112
Endrin+cis-Nonachlor	PCB-12
Heptachlor	PCB-120
Heptachlor epoxide	PCB-121
Hexachlorobenzene	PCB-122
Methoxychlor	PCB-123
Mirex	PCB-124
Total DDT	PCB-125
2,4′-DDD	PCB-125+86
2,4′-DDE	PCB-126
2,4′-DDT	PCB-127
4,4′-DDD	PCB-128
4,4′-DDE	PCB-128+162
4,4′-DDT	PCB-129
Metals	PCB-13
Di-n-butyltin	PCB-130
n-Butyltin	PCB-131
Tetra-n-butyltin	PCB-131+133
Tri-n-butyltin	PCB-132
Total Arsenic	PCB-132+153
Total Inorganic Arsenic	PCB-133
Total Cadmium	PCB-133+131+142
Total Mercury	PCB-134
Total Selenium	PCB-135
PCBs	PCB-136
PCB-1	PCB-137
PCB-100	PCB-138
PCB-10+4	PCB-138+163
PCB-101	PCB-139
PCB-101+113	PCB-14
PCB-102	PCB-140
PCB-103	PCB-141
PCB-104	PCB-142
PCB-105	PCB-143
PCB-106	PCB-144
PCB-107	PCB-145
PCB-107+123	PCB-146
PCB-108	PCB-147
PCB-109	PCB-148
PCB-109+123	PCB-149
PCB-11	PCB-15
PCB-110	PCB-150
PCB-111	PCB-151
PCB-112	PCB-152
PCB-112+119	PCB-153
PCB-113	PCB-154
PCB-114	PCB-155
PCB-115	PCB-156
PCB-115+111	PCB-157
PCB-116	PCB-158
PCB-117	PCB-158+160
PCB-117+87	PCB-159
PCB-118	PCB-16
PCB-119	PCB-16+32

List contains all compounds analyzed during the sampling period.	
Analyte group, *Analyte sub-group,* Analyte name	
PCBs, cont'd	**PCBs, cont'd**
PCB-160	PCB-205
PCB-161	PCB-206
PCB-162	PCB-207
PCB-163	PCB-208
PCB-163+138	PCB-209
PCB-164	PCB-21
PCB-165	PCB-22
PCB-166	PCB-23
PCB-167	PCB-24
PCB-168	PCB-25
PCB-169	PCB-26
PCB-17	PCB-27
PCB-170	PCB-28
PCB-171	PCB-29
PCB-172	PCB-3
PCB-173	PCB-30
PCB-174	PCB-31
PCB-175	PCB-32
PCB-175+182	PCB-33
PCB-176	PCB-34
PCB-177	PCB-35
PCB-178	PCB-36
PCB-179	PCB-37
PCB-18	PCB-38
PCB-180	PCB-39
PCB-180+193	PCB-40
PCB-181	PCB-41
PCB-182	PCB-41+72
PCB-183	PCB-42
PCB-184	PCB-43
PCB-185	PCB-43+52
PCB-186	PCB-44
PCB-187	PCB-45
PCB-188	PCB-46
PCB-189	PCB-47
PCB-19	PCB-48
PCB-190	PCB-49
PCB-191	PCB-5
PCB-192	PCB-50
PCB-193	PCB-51
PCB-194	PCB-52
PCB-195	PCB-52+43
PCB-196	PCB-53
PCB-197	PCB-54
PCB-198	PCB-55
PCB-199	PCB-56
PCB-2	PCB-57
PCB-20	PCB-58
PCB-20+21+33	PCB-58+67
PCB-200	PCB-59
PCB-201	PCB-6
PCB-202	PCB-60
PCB-203	PCB-61
PCB-204	PCB-62

List contains all compounds analyzed during the sampling period.	
Analyte group, *Analyte sub-group,* Analyte name	
PCBs, cont'd	**PCBs, cont'd**
PCB-63	PCB-81
PCB-64	PCB-82
PCB-64+68	PCB-83
PCB-65	PCB-84
PCB-65+75	PCB-85
PCB-66	PCB-86
PCB-67	PCB-87
PCB-67+58	PCB-87+111+116+117
PCB-68	PCB-88
PCB-69	PCB-88+91
PCB-70	PCB-89
PCB-71	PCB-9+7
PCB-72	PCB-90
PCB-73	PCB-91
PCB-74	PCB-92
PCB-74+76	PCB-93
PCB-75	PCB-94
PCB-75+65	PCB-95
PCB-76	PCB-95+121
PCB-77	PCB-96
PCB-78	PCB-97
PCB-79	PCB-98
PCB-8	PCB-99
PCB-80	

Appendix B – Complete Site List

Pages B-1 through B-3

Station	Basin Name	Site Description	Latitude	Longitude
37819	Columbia	Columbia R at RM 303	45.99000	-119.0000
11777	Deschutes	Prineville Reservoir at Pow der House Cove	44.11034	-120.7760
13767	Deschutes	East Lake at deepest point	43.72870	-121.2034
13844	Deschutes	Paulina Lake at deepest point	43.72330	-121.2663
37618	Deschutes	Little Cultus Lake	43.80550	-121.8840
37619	Deschutes	Ochoco Reservoir	44.29742	-120.7146
37817	Deschutes	Deschutes R at RM 47.2	45.23000	-121.0800
37821	Deschutes	Deschutes R at RM 222 DS of Wickiup Reservoir	43.69000	-121.6900
37719	John Day	John Day R at Burnt Ranch & Byrd's Point	44.73944	-120.3283
37720	John Day	John Day R at Cathedral Rock & Hw y 19	44.63180	-119.6373
37868	Klamath	Upper Klamath Lake near Fish Banks	42.49000	-122.0500
25662	Mid Coast	Yaquina River at River Mile 9.8 north shore off Craigie Point	44.58770	-123.9550
28989	Mid Coast	Siuslaw River at RM 0.1 at NF Confluence	43.97496	-124.0758
37515	Mid Coast	Alsea River North of Eckman Lake	44.41640	-124.0310
37516	Mid Coast	Siletz Bay at mouth of Schooner Creek	44.92439	-124.0158
37517	Mid Coast	Bob Creek w ayside at MM 170, Highw ay 101	44.24458	-124.1138
37518	Mid Coast	North Jetty of Yaquina River at mouth	44.61690	-124.0683
13649	North Coast	Columbia River Estuary at the south jetty	46.22610	-124.0114
37513	North Coast	Tillamook Bay at Patterson Creek behind Pacific Oyster	45.52423	-123.8938
37514	North Coast	Nehalem Bay at RM 2.15	45.68668	-123.9245
37609	North Coast	Necanicum River in Seaside 101 Under N end of bridge on Lew is and Clark Road	46.01115	-123.9113
37610	North Coast	Netarts Bay	45.39363	-123.9560
37616	Oregon Closed Lakes	Donner and Blitzen River at RM 11.9	43.18124	-118.8779
37617	Ow yhee	Ow yhee River mainstem at RM 165.3 dow nstream of MF/NF Confluence	42.54605	-117.1690
10418	Rogue	Rogue River at Robertson Bridge (Merlin)	42.49683	-123.4873

Station	Basin	Description	Latitude	Longitude
10422	Rogue	Rogue River upstream of Raygold Dam	42.43720	-122.9822
18390	Rogue	Ashland Emigrant Lake	42.15110	-122.6250
36283	Rogue	Applegate Reservoir, SW Arm (Inlet of Cougar and Carberry Creeks)	42.02000	-123.1600
37826	Rogue	Rogue River at RM 7.4	42.47000	-124.3300
11879	South Coast	S. Slough 50 m NW of mouth of Joe Ney	43.33500	-124.3180
13388	South Coast	Isthmus Slough at Eastside Bridge	43.35667	-124.1928
37511	South Coast	Bastendorf Beach / Lighthouse Beach near Yoakum Point State Park	43.34132	-124.3628
37519	South Coast	Bailey Beach 300 yards north of North Jetty, Rogue River	42.42436	-124.4321
37611	South Coast	North Slough tideflat 1st pullout on Transpacific Ln.	43.44400	-124.2230
37612	South Coast	Ferry Creek Bandon	43.11980	-124.4092
37613	South Coast	Coquille River - gravel area ~500 m West of Boat Ramp	43.12076	-124.4250
12090	Umatilla	Umatilla River upstream of Three Mile Dam	45.88250	-119.3217
36362	Umatilla	Cold Springs Reservoir	45.86370	-119.1495
36363	Umatilla	McKay Reservoir	45.59520	-118.7855
37615	Umpqua	Umpqua River at RM 37.7	43.67540	-123.6538
37818	Umpqua	Umpqua R at RM 21.4	43.65000	-123.9000
10332	Willamette	Willamette River at SP&S RR Bridge (Portland)	45.57790	-122.7475
10344	Willamette	Willamette River at Wheatland Ferry	45.09060	-123.0443
10355	Willamette	Willamette River at Hwy 99E (Harrisburg)	44.26720	-123.1737
10359	Willamette	Willamette River at Hwy 126 (Springfield)	44.04560	-123.0268
10376	Willamette	McKenzie River at Coburg Road	44.11270	-123.0462
10379	Willamette	Coast Fork Willamette River at Hwy 58	43.98100	-122.9655
10456	Willamette	Tualatin River at Boones Ferry Road	45.38610	-122.7563
10549	Willamette	Multnomah Channel at St. Helens	45.84580	-122.7986
10550	Willamette	Multnomah Channel at Coon Island	45.78180	-122.8073
10648	Willamette	Yamhill River at mouth	45.22980	-122.9971
10774	Willamette	Santiam River at mouth	44.75030	-123.1404
11233	Willamette	Clackamas River at High Rocks (Old Hwy 213)	45.37870	-122.5831

Station	Basin	Description	Latitude	Longitude
11990	Willamette	Middle Fork Willamette River at Clearwater Boat Ramp	44.02440	-122.9552
26339	Willamette	Willamette River upstream of Newberg Bridge at Rogers Landing	45.28570	-122.9658
29043	Willamette	Willamette River at Willamette Park boat ramp, Corvallis	44.55180	-123.2519
29044	Willamette	Willamette River at Greenway bike bridge, Eugene	44.06740	-123.1119
37820	Willamette	McKenzie R at RM 16.2	44.06000	-122.9000

Appendix C – Detected Chemicals

Pages C-1 through C-8

List contains only detected analytes.	No. of detections	No. of samples	Percent detection	Number of samples over the screening value	Maximum value (mg\kg)	Matrix: Whole body	Matrix: Skinless Fillet	Matrix: Whole body, Cleaned	Matrix: Siphon Skins	Oregon Health Authority Target Analytes for Oregon's Fish Advisory Program (mg/kg)	Primary use
Analyte group, *Analyte sub-group*, Analyte name											
Dioxins and Furans											
Total 2,3,7,8 Substituted TEQ (ng/kg)	7	91	0.1	1	1.98	x	x			1.6	None (Combustion/Industrial byproduct)
Flame Retardants											
PBDE-1	1	63	1.6		0.0000142		x			*nsv*	Flame retardant
PBDE-100	67	83	80.7		0.00379	x	x			*nsv*	Flame retardant
PBDE-119	13	100	13.0		0.0000238		x			*nsv*	Flame retardant
PBDE-126	1	100	1.0		0.0000393	x				*nsv*	Flame retardant
PBDE-138	8	100	8.0		0.0000123		x			*nsv*	Flame retardant
PBDE-139	15	100	15.0		0.0000234		x			*nsv*	Flame retardant
PBDE-140	13	100	13.0		0.0000103		x			*nsv*	Flame retardant
PBDE-15	40	99	40.4		0.0000481	x	x			*nsv*	Flame retardant
PBDE-153	66	105	62.9	0	0.000612	x	x			0.2	Flame retardant
PBDE-154	72	98	73.5		0.00047	x	x			*nsv*	Flame retardant
PBDE-17	43	67	64.2		0.000774	x	x			*nsv*	Flame retardant
PBDE-171	1	100	1.0		0.00000242		x			*nsv*	Flame retardant
PBDE-180	1	100	1.0		0.00000224		x			*nsv*	Flame retardant
PBDE-183	16	100	15.0		0.00000657		x			*nsv*	Flame retardant
PBDE-184	9	100	9.0		0.00000333		x			*nsv*	Flame retardant
PBDE-191	1	100	1.0		0.00000251		x			*nsv*	Flame retardant
PBDE-196	1	69	1.4		0.00000484		x			*nsv*	Flame retardant
PBDE-197	5	86	5.8		0.00000394		x			*nsv*	Flame retardant
PBDE-201	5	86	5.8		0.00000771		x			*nsv*	Flame retardant
PBDE-203	5	86	5.8		0.0000443	x	x			*nsv*	Flame retardant
PBDE-206	4	86	4.7		0.000196	x	x			*nsv*	Flame retardant
PBDE-208	11	86	12.8		0.000121	x	x			*nsv*	Flame retardant
PBDE-209	30	66	45.5	0	0.00346	x	x			16.3	Flame retardant

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						Whole body	Skinless Fillet	Whole body, Cleaned	Siphon Skins		
Analyte group, *Analyte sub-group*, Analyte name											
Flame Retardants, continued											
PBDE-28	68	79	86.1		0.00221	x	x			*nsv*	Flame retardant
PBDE-3	2	63	3.2		0.00000535		x			*nsv*	Flame retardant
PBDE-47	76	82	92.7	0	0.0209	x	x			0.2	Flame retardant
PBDE-49	83	99	83.8		0.00148	x	x			*nsv*	Flame retardant
PBDE-66	65	99	65.7		0.00108	x	x			*nsv*	Flame retardant
PBDE-71	16	99	16.2		0.000133	x	x			*nsv*	Flame retardant
PBDE-77	9	99	9.1		0.00000385		x			*nsv*	Flame retardant
PBDE-85	31	83	37.3		0.000239	x	x			*nsv*	Flame retardant
PBDE-99	66	82	80.5	0	0.00951	x	x			0.2	Flame retardant
Pentabromoethylbenzene	6	14	42.9		0.0000099		x			*nsv*	Flame retardant
Legacy Pesticides											
Aldrin	1	92	1.1	0	0.0000146	x	x			0.07	Pesticide (insecticide)
alpha-BHC	14	84	16.7		0.000201	x	x			*nsv*	Pesticide (insecticide)
alpha Clordane	78	92	84.8		0.00027	x	x			*nsv*	Pesticide (insecticide)
beta-BHC	20	92	21.7		0.000541	x	x			*nsv*	Pesticide (insecticide)
Total Chlordane	79	94	84.0	0	0.002784	x	x			1.2	Pesticide (insecticide)
cis Nonachlor	58	92	63.0		0.000455	x	x			*nsv*	Pesticide (insecticide)
trans Nonachlor	14	33	42.4		0.00118		x			*nsv*	Pesticide (insecticide)
Oxychlordane	31	92	33.7		0.000148	x	x			*nsv*	None (chlordane degradate)
Dieldrin	74	90	82.2	0	0.000476	x	x			0.1	Pesticide (insecticide)
Endosulfan I and II	23	94	24.5	0	0.001052	x	x			14	Pesticide (insecticide)
Endosulfan I	23	77	29.9		0.000476	x	x			*nsv*	Pesticide (insecticide)
Endosulfan II	3	77	3.9		0.000904	x	x			*nsv*	Pesticide (insecticide)
Endosulfan sulfate	4	77	5.2		0.000237	x	x			*nsv*	None (endosulfan degradate)
Endrin	19	33	57.6	0	0.000242		x			0.7	Pesticide (insecticide)
Endrin+cis-Nonachlor	23	59	39.0		0.000828	x	x			*nsv*	Pesticide (insecticide)
gamma-BHC (Lindane)	8	91	8.8	0	0.0000391	x	x			0.7	Pesticide (insecticide)
gamma-Chlordane	29	33	87.9		0.000946		x			*nsv*	Pesticide (insecticide)
gamma-Chlordane+trans-Nonachlor	41	59	69.5		0.00162	x	x			*nsv*	Pesticide (insecticide)
Heptachlor	6	92	6.5		0.00006	x	x			*nsv*	Pesticide (insecticide)
Heptachlor epoxide	16	92	17.4	0	0.000124	x	x			0.03	None (heptachlor degradate)
Hexachlorobenzene	29	49	59.2	0	0.000785	x	x			1.9	Pesticide (microbiocide, fungicide, insecticide)
Methoxychlor	20	56	35.7	0	0.00451	x	x			11.7	Pesticide (insecticide)
Mirex	27	92	29.3	0	0.0000437	x	x			0.5	Pesticide (insecticide)
Total DDT	91	95	95.8	0	0.0437467	x	x			1.2	Pesticide (insecticide)
2,4´-DDD	52	92	56.5		0.000419	x	x			*nsv*	Pesticide (insecticide)

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Analyte group, *Analyte sub-group*, Analyte name											
Legacy Pesticides, continued											
2,4´-DDE	39	92	42.4		0.000158	x	x			*nsv*	Pesticide (insecticide)
2,4´-DDT	42	92	45.7		0.000257	x	x			*nsv*	Pesticide (insecticide)
4,4´-DDD	81	92	88.0		0.00209	x	x			*nsv*	Pesticide (insecticide)
4,4´-DDE	92	92	100.0		0.0405	x	x			*nsv*	Pesticide (insecticide)
4,4´-DDT	39	89	43.8		0.00276	x	x			*nsv*	Pesticide (insecticide)
PCBs											
Total PCBs	103	105	98.1		0.0923	x	x			0.05	Closed electrical equipment
PCB-10+4	2	14	14.3		0.0000199		x			*nsv*	Closed electrical equipment
PCB-100	2	111	1.8		0.00000403		x			*nsv*	Closed electrical equipment
PCB-101	31	31	100.0		0.00334		x			*nsv*	Closed electrical equipment
PCB-101+113	69	80	86.3		0.00268	x	x			*nsv*	Closed electrical equipment
PCB-102	14	111	12.6		0.0000333	x	x			*nsv*	Closed electrical equipment
PCB-103	19	111	17.1		0.0000226	x	x			*nsv*	Closed electrical equipment
PCB-104	1	111	0.9		0.00000152		x			*nsv*	Closed electrical equipment
PCB-105	88	105	83.8		0.0047	x	x			*nsv*	Closed electrical equipment
PCB-107	30	45	66.7		0.000938		x			*nsv*	Closed electrical equipment
PCB-107+123	18	66	27.3		0.000141	x	x			*nsv*	Closed electrical equipment
PCB-109	1	97	1.0		0.000000979		x			*nsv*	Closed electrical equipment
PCB-109+123	14	14	100.0		0.0014		x			*nsv*	Closed electrical equipment
PCB-11	12	14	85.7		0.0000613		x			*nsv*	Closed electrical equipment
PCB-110	105	111	94.6		0.00333	x	x			*nsv*	Closed electrical equipment
PCB-112	20	31	64.5		0.000105		x			*nsv*	Closed electrical equipment
PCB-112+119	1	66	1.5		0.0000178	x				*nsv*	Closed electrical equipment
PCB-114	41	101	40.6		0.000619		x			*nsv*	Closed electrical equipment
PCB-115	22	97	22.7		0.0000766		x			*nsv*	Closed electrical equipment
PCB-115+111	10	14	71.4		0.000104		x			*nsv*	Closed electrical equipment
PCB-117+87	14	14	100.0		0.0013		x			*nsv*	Closed electrical equipment
PCB-118	96	107	89.7		0.0157	x	x			*nsv*	Closed electrical equipment
PCB-119+112	11	14	78.6		0.00012		x			*nsv*	Closed electrical equipment
PCB-120	19	111	17.1		0.000146		x			*nsv*	Closed electrical equipment
PCB-121	14	45	31.1		0.000147		x			*nsv*	Closed electrical equipment
PCB-122	5	111	4.5		0.0000155		x			*nsv*	Closed electrical equipment
PCB-124	41	111	36.9		0.000182	x	x			*nsv*	Closed electrical equipment
PCB-125	5	97	5.2		0.00000587		x			*nsv*	Closed electrical equipment
PCB-125+86	1	14	7.1		0.0000075		x			*nsv*	Closed electrical equipment
PCB-126	22	111	19.8		0.000479		x			*nsv*	Closed electrical equipment

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						Whole body	Skinless Fillet	Whole body, Cleaned	Siphon Skins		
Analyte group, *Analyte sub-group*, Analyte name											
PCBs, continued											
PCB-127	3	111	2.7		0.00000431		x			*nsv*	Closed electrical equipment
PCB-128	75	97	77.3		0.000869	x	x			*nsv*	Closed electrical equipment
PCB-128+162	14	14	100.0		0.00151		x			*nsv*	Closed electrical equipment
PCB-129	47	111	42.3		0.000391		x			*nsv*	Closed electrical equipment
PCB-13	2	14	14.3		0.0000061		x			*nsv*	Closed electrical equipment
PCB-130	66	111	59.5		0.000551	x	x			*nsv*	Closed electrical equipment
PCB-131	8	31	25.8		0.0000455		x			*nsv*	Closed electrical equipment
PCB-132	31	45	68.9		0.0104		x			*nsv*	Closed electrical equipment
PCB-132+153	60	64	93.8		0.00224	x	x			*nsv*	Closed electrical equipment
PCB-133+131+142	12	14	85.7		0.000189		x			*nsv*	Closed electrical equipment
PCB-134	42	111	37.8		0.000202	x	x			*nsv*	Closed electrical equipment
PCB-135	71	111	64.0		0.000203	x	x			*nsv*	Closed electrical equipment
PCB-136	12	111	10.8		0.00000977		x			*nsv*	Closed electrical equipment
PCB-137	60	111	54.1		0.00181	x	x			*nsv*	Closed electrical equipment
PCB-138	31	31	100.0		0.00712		x			*nsv*	Closed electrical equipment
PCB-138+163	56	64	87.5		0.00137	x	x			*nsv*	Closed electrical equipment
PCB-139	14	111	12.6		0.000112	x	x			*nsv*	Closed electrical equipment
PCB-140	19	111	17.1		0.0000187		x			*nsv*	Closed electrical equipment
PCB-141	78	111	70.3		0.000583	x	x			*nsv*	Closed electrical equipment
PCB-142	35	97	36.1		0.000139	x	x			*nsv*	Closed electrical equipment
PCB-144	52	111	46.8		0.000122	x	x			*nsv*	Closed electrical equipment
PCB-145	1	111	0.9		0.00000106		x			*nsv*	Closed electrical equipment
PCB-146	98	111	88.3		0.00169	x	x			*nsv*	Closed electrical equipment
PCB-147	43	111	38.7		0.000219	x	x			*nsv*	Closed electrical equipment
PCB-148	64	111	57.7		0.000187	x	x			*nsv*	Closed electrical equipment
PCB-149	104	109	95.4		0.0017	x	x			*nsv*	Closed electrical equipment
PCB-15	2	14	14.3		0.0000433		x			*nsv*	Closed electrical equipment
PCB-150	7	111	6.3		0.00000273		x			*nsv*	Closed electrical equipment
PCB-151	90	111	81.1		0.000594	x	x			*nsv*	Closed electrical equipment
PCB-152	2	111	1.8		0.00000372		x			*nsv*	Closed electrical equipment
PCB-153	14	45	31.1		0.0148		x			*nsv*	Closed electrical equipment
PCB-154	31	111	27.9		0.0000805	x	x			*nsv*	Closed electrical equipment
PCB-155	3	111	2.7		0.00000394		x			*nsv*	Closed electrical equipment
PCB-156	66	103	64.1		0.00293	x	x			*nsv*	Closed electrical equipment
PCB-157	47	100	47.0		0.000559	x	x			*nsv*	Closed electrical equipment
PCB-158	45	45	100.0		0.00104		x			*nsv*	Closed electrical equipment

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Analyte group, *Analyte sub-group*, Analyte name											
PCBs, continued											
PCB-158+160	11	61	18.0		0.000123	x	x			*nsv*	Closed electrical equipment
PCB-159	3	111	2.7		0.00000157		x			*nsv*	Closed electrical equipment
PCB-16	26	45	57.8		0.0000527		x			*nsv*	Closed electrical equipment
PCB-16+32	26	66	39.4		0.0000707	x	x			*nsv*	Closed electrical equipment
PCB-162	6	97	6.2		0.00000376		x			*nsv*	Closed electrical equipment
PCB-163+138	14	14	100.0		0.0112		x			*nsv*	Closed electrical equipment
PCB-164	60	111	54.1		0.000364	x	x			*nsv*	Closed electrical equipment
PCB-165	4	111	3.6		0.0000274	x	x			*nsv*	Closed electrical equipment
PCB-166	25	111	22.5		0.000148		x			*nsv*	Closed electrical equipment
PCB-167	57	101	56.4		0.00113	x	x			*nsv*	Closed electrical equipment
PCB-168	2	111	1.8		0.000196		x			*nsv*	Closed electrical equipment
PCB-169	16	111	14.4		0.000369		x			*nsv*	Closed electrical equipment
PCB-17	57	111	51.4		0.0000419	x	x			*nsv*	Closed electrical equipment
PCB-170	81	111	73.0		0.00137	x	x			*nsv*	Closed electrical equipment
PCB-171	60	111	54.1		0.000309	x	x			*nsv*	Closed electrical equipment
PCB-172	54	111	48.6		0.000183	x	x			*nsv*	Closed electrical equipment
PCB-173	11	111	9.9		0.0000107		x			*nsv*	Closed electrical equipment
PCB-174	72	111	64.9		0.000304	x	x			*nsv*	Closed electrical equipment
PCB-175	28	45	62.2		0.0000297		x			*nsv*	Closed electrical equipment
PCB-175+182	4	66	6.1		0.00002	x	x			*nsv*	Closed electrical equipment
PCB-176	35	111	31.5		0.0000665	x	x			*nsv*	Closed electrical equipment
PCB-177	79	111	71.2		0.000308	x	x			*nsv*	Closed electrical equipment
PCB-178	63	111	56.8		0.000242	x	x			*nsv*	Closed electrical equipment
PCB-179	62	111	55.9		0.000188	x	x			*nsv*	Closed electrical equipment
PCB-18	72	110	65.5		0.0000932	x	x			*nsv*	Closed electrical equipment
PCB-180	31	31	100.0		0.00295		x			*nsv*	Closed electrical equipment
PCB-180+193	58	80	72.5		0.00316	x	x			*nsv*	Closed electrical equipment
PCB-181	19	111	17.1		0.0000648		x			*nsv*	Closed electrical equipment
PCB-183	88	111	79.3		0.000712	x	x			*nsv*	Closed electrical equipment
PCB-184	3	111	2.7		0.00000239		x			*nsv*	Closed electrical equipment
PCB-185	41	111	36.9		0.0000456		x			*nsv*	Closed electrical equipment
PCB-186	1	111	0.9		0.0000011		x			*nsv*	Closed electrical equipment
PCB-187	100	111	90.1		0.00115	x	x			*nsv*	Closed electrical equipment
PCB-188	3	111	2.7		0.000003		x			*nsv*	Closed electrical equipment
PCB-189	38	111	34.2		0.000196		x			*nsv*	Closed electrical equipment
PCB-19	20	111	18.0		0.0000398		x			*nsv*	Closed electrical equipment

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Analyte group, *Analyte sub-group*, Analyte name											
PCBs, continued										*nsv*	
PCB-190	58	111	52.3		0.000296	x	x			*nsv*	Closed electrical equipment
PCB-191	31	111	27.9		0.000069	x	x			*nsv*	Closed electrical equipment
PCB-194	64	111	57.7		0.000471	x	x			*nsv*	Closed electrical equipment
PCB-195	47	111	42.3		0.000196		x			*nsv*	Closed electrical equipment
PCB-196	54	111	48.6		0.000301	x	x			*nsv*	Closed electrical equipment
PCB-197	24	111	21.6		0.0000204		x			*nsv*	Closed electrical equipment
PCB-198	3	111	2.7		0.0000061		x			*nsv*	Closed electrical equipment
PCB-199	70	111	63.1		0.000283	x	x			*nsv*	Closed electrical equipment
PCB-2	2	14	14.3		0.0000067		x			*nsv*	Closed electrical equipment
PCB-20	30	31	96.8		0.0000994		x			*nsv*	Closed electrical equipment
PCB-20+21+33	37	80	46.3		0.0000993		x			*nsv*	Closed electrical equipment
PCB-200	23	111	20.7		0.00000823		x			*nsv*	Closed electrical equipment
PCB-201	37	111	33.3		0.0000371	x	x			*nsv*	Closed electrical equipment
PCB-202	56	111	50.5		0.000102	x	x			*nsv*	Closed electrical equipment
PCB-203	67	111	60.4		0.000289	x	x			*nsv*	Closed electrical equipment
PCB-204	3	111	2.7		0.000000607		x			*nsv*	Closed electrical equipment
PCB-205	23	111	20.7		0.0000211		x			*nsv*	Closed electrical equipment
PCB-206	59	111	53.2		0.000133	x	x			*nsv*	Closed electrical equipment
PCB-207	32	111	28.8		0.0000292		x			*nsv*	Closed electrical equipment
PCB-208	44	111	39.6		0.0000554		x			*nsv*	Closed electrical equipment
PCB-209	55	111	49.5		0.0000731	x	x			*nsv*	Closed electrical equipment
PCB-22	72	111	64.9		0.0000724	x	x			*nsv*	Closed electrical equipment
PCB-25	43	111	38.7		0.0000326	x	x			*nsv*	Closed electrical equipment
PCB-26	63	111	56.8		0.0000992		x			*nsv*	Closed electrical equipment
PCB-27	18	111	16.2		0.00000852		x			*nsv*	Closed electrical equipment
PCB-28	95	105	90.5		0.000398	x	x			*nsv*	Closed electrical equipment
PCB-29	5	111	4.5		0.0000062		x			*nsv*	Closed electrical equipment
PCB-31	93	105	88.6		0.000192	x	x			*nsv*	Closed electrical equipment
PCB-32	9	45	20.0		0.0000258		x			*nsv*	Closed electrical equipment
PCB-34	1	111	0.9		0.00000121		x			*nsv*	Closed electrical equipment
PCB-35	8	111	7.2		0.00000462		x			*nsv*	Closed electrical equipment
PCB-36	1	111	0.9		0.000000705		x			*nsv*	Closed electrical equipment
PCB-37	57	111	51.4		0.0000462	x	x			*nsv*	Closed electrical equipment
PCB-39	21	111	18.9		0.0000161		x			*nsv*	Closed electrical equipment
PCB-40	49	111	44.1		0.0000633	x	x			*nsv*	Closed electrical equipment
PCB-41	15	31	48.4		0.0000432		x			*nsv*	Closed electrical equipment

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Analyte group, *Analyte sub-group*, Analyte name											
PCBs, continued											
PCB-41+72	7	80	8.8		0.0000316		x			*nsv*	Closed electrical equipment
PCB-42	58	111	52.3		0.000147	x	x			*nsv*	Closed electrical equipment
PCB-43	31	31	100.0		0.0011		x			*nsv*	Closed electrical equipment
PCB-43+52	51	66	77.3		0.000825	x	x			*nsv*	Closed electrical equipment
PCB-44	88	111	79.3		0.000462	x	x			*nsv*	Closed electrical equipment
PCB-45	36	111	32.4		0.0000313	x	x			*nsv*	Closed electrical equipment
PCB-46	8	111	7.2		0.00000744		x			*nsv*	Closed electrical equipment
PCB-47	9	111	8.1		0.000342		x			*nsv*	Closed electrical equipment
PCB-48	42	111	37.8		0.0000653	x	x			*nsv*	Closed electrical equipment
PCB-49	92	111	82.9		0.000658	x	x			*nsv*	Closed electrical equipment
PCB-50	1	111	0.9		0.00000323		x			*nsv*	Closed electrical equipment
PCB-51	44	111	39.6		0.000097	x	x			*nsv*	Closed electrical equipment
PCB-52+43	13	14	92.9		0.000677		x			*nsv*	Closed electrical equipment
PCB-53	38	111	34.2		0.0000434	x	x			*nsv*	Closed electrical equipment
PCB-54	4	111	3.6		0.00000807		x			*nsv*	Closed electrical equipment
PCB-55	4	111	3.6		0.00000287		x			*nsv*	Closed electrical equipment
PCB-56	71	111	64.0		0.000104	x	x			*nsv*	Closed electrical equipment
PCB-57	4	111	3.6		0.00000632		x			*nsv*	Closed electrical equipment
PCB-58	15	31	48.4		0.0000163		x			*nsv*	Closed electrical equipment
PCB-59	30	111	27.0		0.0000313	x	x			*nsv*	Closed electrical equipment
PCB-6	8	14	57.1		0.0000124		x			*nsv*	Closed electrical equipment
PCB-60	79	111	71.2		0.000277	x	x			*nsv*	Closed electrical equipment
PCB-61	1	111	0.9		0.00000102		x			*nsv*	Closed electrical equipment
PCB-62	1	111	0.9		0.00000106		x			*nsv*	Closed electrical equipment
PCB-63	38	111	34.2		0.0000728	x	x			*nsv*	Closed electrical equipment
PCB-64	43	45	95.6		0.000282		x			*nsv*	Closed electrical equipment
PCB-64+68	33	66	50.0		0.00036	x	x			*nsv*	Closed electrical equipment
PCB-65	31	31	100.0		0.0006		x			*nsv*	Closed electrical equipment
PCB-65+75	33	66	50.0		0.000465	x	x			*nsv*	Closed electrical equipment
PCB-66	97	111	87.4		0.00129	x	x			*nsv*	Closed electrical equipment
PCB-67+58	1	14	7.1		0.0000126		x			*nsv*	Closed electrical equipment
PCB-68	7	45	15.6		0.0000081		x			*nsv*	Closed electrical equipment
PCB-69	3	111	2.7		0.00000296		x			*nsv*	Closed electrical equipment
PCB-70	96	111	86.5		0.00101	x	x			*nsv*	Closed electrical equipment
PCB-71	59	111	53.2		0.000123	x	x			*nsv*	Closed electrical equipment
PCB-73	3	111	2.7		0.00000345		x			*nsv*	Closed electrical equipment

List contains only detected analytes.	No. of detections	No. of samples	Percent detection	Number of samples over the screening value	Maximum value (mg\kg)	Matrix				Oregon Health Authority Target Analytes for Oregon's Fish Advisory Program (mg/kg)	Primary use
						Whole body	Skinless Fillet	Whole body, Cleaned	Siphon Skins		
Analyte group, *Analyte sub-group*, Analyte name											
PCBs, continued											
PCB-74	45	45	100.0		0.00137		x			*nsv*	Closed electrical equipment
PCB-74+76	37	66	56.1		0.000264	x	x			*nsv*	Closed electrical equipment
PCB-77	41	104	39.4		0.000325	x	x			*nsv*	Closed electrical equipment
PCB-78	2	111	1.8		0.00000149		x			*nsv*	Closed electrical equipment
PCB-79	4	111	3.6		0.00000422		x			*nsv*	Closed electrical equipment
PCB-8	4	14	28.6		0.0000642		x			*nsv*	Closed electrical equipment
PCB-80	2	111	1.8		0.0000011		x			*nsv*	Closed electrical equipment
PCB-81	23	104	22.1		0.000424		x			*nsv*	Closed electrical equipment
PCB-82	41	111	36.9		0.000289	x	x			*nsv*	Closed electrical equipment
PCB-83	32	111	28.8		0.000104	x	x			*nsv*	Closed electrical equipment
PCB-84	59	111	53.2		0.00012	x	x			*nsv*	Closed electrical equipment
PCB-85	87	111	78.4		0.000855	x	x			*nsv*	Closed electrical equipment
PCB-87	31	31	100.0		0.00124		x			*nsv*	Closed electrical equipment
PCB-87+111+116+117	23	66	34.8		0.000193	x	x			*nsv*	Closed electrical equipment
PCB-89	84	111	75.7		0.000564	x	x			*nsv*	Closed electrical equipment
PCB-90	23	111	20.7		0.000394	x	x			*nsv*	Closed electrical equipment
PCB-91	60	97	61.9		0.000258	x	x			*nsv*	Closed electrical equipment
PCB-92	13	111	11.7		0.000117		x			*nsv*	Closed electrical equipment
PCB-94	17	111	15.3		0.0000788	x	x			*nsv*	Closed electrical equipment
PCB-95	45	45	100.0		0.00139		x			*nsv*	Closed electrical equipment
PCB-95+121	46	66	69.7		0.000353	x	x			*nsv*	Closed electrical equipment
PCB-96	9	111	8.1		0.0000075		x			*nsv*	Closed electrical equipment
PCB-97	89	111	80.2		0.00148	x	x			*nsv*	Closed electrical equipment
PCB-99	103	111	92.8		0.00344	x	x			*nsv*	Closed electrical equipment
Metals											
Total Arsenic	74	153	48.4		50.5	x	x	x	x	*nsv*	Pesticide (herbicide, insecticide), naturally occuring
Total Inorganic Arsenic	54	145	37.2	23	46.8	x		x	x	0.7	Pesticide (herbicide, insecticide), naturally occuring
Total Cadmium	20	119	16.8	0	1.4	x				2.3	Batteries, pigments, metals industries
Total Mercury	317	317	100.0	262	2.53	x	x			0.04**	Human activities, occurs naturally **DEQ Consumption Criteria
Total Selenium	14	119	11.8	0	0.81	x	x			11.7	Glass industry, trace nutrient
Tri-n-butyltin	4	17	23.5	0	0.016	x				0.7	Biocide (Wood preservative)