# Closing Data Gaps in Monitoring of Toxics in Partnership with Refugee and Immigrant Community Fishers



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King County

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# Summary

There are toxic chemicals in fish of King County lakes, rivers and Puget Sound that can be harmful to people who eat them. King County and Washington State monitor toxics in fish and shellfish to enable the state to issue fish consumption advisories that guide residents on how to eat fish safely. But there is a lack of information from underserved communities to adequately inform these monitoring programs about where people fish, what they fish for and how they eat their catch.

From 2021 to 2024, the Refugee Federation Service Center (RFSC) partnered with King County Water and Land Resources Division's Toxicology and Contaminant Assessment (TCA) unit and Public Health-Seattle King County (PHSKC) on the 'Refugee-Immigrant Communities Water Quality Education and Fish Sampling Project'. This project, funded in part by a grant from the King County Wastewater Treatment Division, was pursued to gather information on where people fish, what they fish for, and how they eat their catch. We first designed a fisher survey, with feedback from PHSCK and RFSC, to explore the fishing habits of south King County immigrant and refugee communities with which RFSC has established relationships. These are primarily Latino and southeast Asian refugees and immigrants.

We then used the survey results (e.g., where people fish and what they catch and eat) to design a pilot project intended to measure toxics in fish from lakes and shorelines absent from our long-term fish tissue contaminant monitoring program. The information we gathered from that pilot fishing project helped us to recommend safer fishing choices back to the RFSC communities. The RFSC and fishers within their communities helped us with the sampling to address this second objective.

**Key Findings**

- The fisher survey showed that Green Lake, Lake Meridian, Angle Lake, and Lake Desire were important freshwater fishing areas, and that people are catching and eating marine perch. These are locations and species which we are not currently tracking for contaminants.
- The fisher survey also revealed that a large proportion of the fishers typically consume the entire fish they catch and that they commonly share their catch with their friends, parents and elders, and children.
- PCB concentrations were always higher than other measured toxic chemicals across all the fish collected. At two lakes, PCBs, PBDEs, DDTs, chlordanes, and PFAS, were higher in fish carcasses compared to their fillets. This information is particularly relevant because the fisher survey revealed almost two thirds of fishers eat the whole body of their catch.
- Comparison of fish contaminant concentrations with Washington State Department of Health (DOH) fish consumption advisory screening levels revealed that fish from several of the water bodies sampled are of potential concern to human health. We highlight the fish from those locations that are likely the safer choices for consumption.

- We worked with DOH and PHSKC to develop fish consumption recommendations based on data from this project. We then worked with DOH, PHSKC, and the RFSC on how best to communicate those recommendations to the communities. As a result, King County produced a flyer called *Healthy Fish-Eating Recommendations from King County* that educates fishers about key contaminants in fish and guides them towards fishing choices that will reduce their overall exposure to contaminants in King County. The flyer was translated into nine languages and distributed to the communities.
- Based on the information from this study TCA plans to revise the locations and target fish in our long-term tissue monitoring program to make our program more equitable and provide contaminant information useful to more fishing communities in King County.

# 1 Introduction

For many immigrant and refugee communities, fishing is a cultural and family tradition, a way to relax and enjoy the outdoors, and provides a good source of lean protein. In King County, people from these communities, particularly those who are low-income and have limited English proficiency, can be disproportionately impacted by contaminants when they fish and consume catch from polluted locations. Though they often have some knowledge about toxics in fish, fishers often want more guidance on safer choices.

King County's Department of Natural Resources and Parks, Water and Land Resources Division, Toxicology and Contaminant Assessment (TCA) unit has run a long-term fish tissue contaminant monitoring program since 2013. For this program, we collect freshwater fish from three major lakes (Lakes Washington, Union, Sammamish) and two major rivers (Green and Cedar River). We also collect marine fish and crab from several bays and harbors in Puget Sound (Elliott, Shilshole and Poverty Bays, Quartermaster and Tramp Harbor). A major goal of this monitoring program is to track contaminants in King County fish and shellfish and share that information with partners, decision makers, and local fishers to reduce pollution and its human health impacts. Up to this point, our monitoring program has had limited knowledge about the specific priorities of fishers who are Black, Indigenous, or people of color, including those from immigrant and refugee communities. This knowledge gap includes locations people fish, which fish they eat, and how they prepare their catch. In addition, we have not collected fish from smaller King County lakes and our marine shoreline sampling has some large spatial holes.

The Refugee Federation Service Center (RFSC) is a community-based organization founded in 1982 and managed and staffed by refugees. Their programs serve diverse immigrant and refugee residents in King County, including Cambodian, Laotian, and Vietnamese people. In 2021, TCA and Public Health-Seattle & King County (PHSKC) assisted the RFSC in securing a King County WaterWorks grant (King County 2024a) for an education and outreach project called the *Refugee/Immigrant Communities Water Quality Education and Fish Sampling Project*. The grant supported two major efforts. The first was a partnership to provide culturally relevant pollution prevention workshops and multilingual education materials to the immigrant and refugee fishing communities of King County. The second was a fisher survey and collaborative fish sampling pilot project aimed at learning more about the fishing habits and potential contaminant exposure of traditionally underserved communities in King County.

This report shares information from the fisher survey, results from the fish sampling pilot, including chemicals detected in the fish and how they compare to human health screening levels, and how TCA communicated these findings back to fishers in the immigrant and refugee communities served by the RFSC.

# 2 Survey of Community Fishers

## 2.1 Developing and Conducting the Fisher Survey

We worked with the RFSC to develop a survey of community fishers (hereafter the fisher survey) to learn about the fishing habits of traditionally underserved communities in King County. The fisher survey targeted refugee and immigrant residents living in west and southwest Seattle and South King County (e.g., White Center, Tukwila, Renton, Kent, Auburn). Many of these community members have been advised by King County to avoid fish from the Duwamish Superfund site, but where and how much they are fishing instead was unknown. Together we prepared a survey asking King County immigrant and refugee fishers the following kinds of questions:

- Who is fishing?
- Who is eating the catch?
- Where are they fishing?
- What are they catching?
- How is the catch consumed?
- How much fish do people consume?

The full fisher survey is available in Appendix A. The RFSC interviewed fishers at local community centers and fishing locations for the fisher survey during 2022. RFSC had the fisher survey translated into three languages (Khmer, Vietnamese, and Spanish) for fishers to fill out themselves. Community leaders associated with the RFSC also did in-person interviews of fishers in Burmese, Karen, Cham, Laotian, Khmu, Hmong, and Mien, verbally translating the English version and completing the surveys with the fishers' responses. After the survey was completed, RFSC staff shared the information gathered with TCA in a series of Excel spreadsheets, with English translations. TCA staff compiled the results, checked with RFSC staff to clarify, then summarized findings from portions of the survey that were relevant to this study and useful in designing the fish sampling pilot (Section 3). Results of the fisher survey are available upon request.

## 2.2 Findings from Fisher Survey

The RFSC interviewed 113 fishers for the survey. These included anyone willing to answer questions at local fishing locations, including immigrant and refugee fishers and non-immigrant fishers (i.e., other ethnic groups). Their responses gave TCA insight into the fishers and their concerns about contamination and revealed important fishing areas and species not currently tracked for contaminants. We will be revising its programs to address gaps based on this new understanding and be more inclusive of locations and species fished by historically underserved communities in King County.

### 2.2.1 Who is fishing?

In interviews, the fishers self-identified as coming from a wide range of ethnic communities beyond the communities RFSC actively supports (Figure 1). The largest two groups of fishers identified as Vietnamese and Cambodian/Khmer. The next three

largest groups were Latino, Karen, and Khmu fishers. A number of fishers identified themselves as American or Caucasian, with English as their primary language. Other fishers identified themselves as Laotian, Chinese, Korean, Mienh, African American, and Burmese.

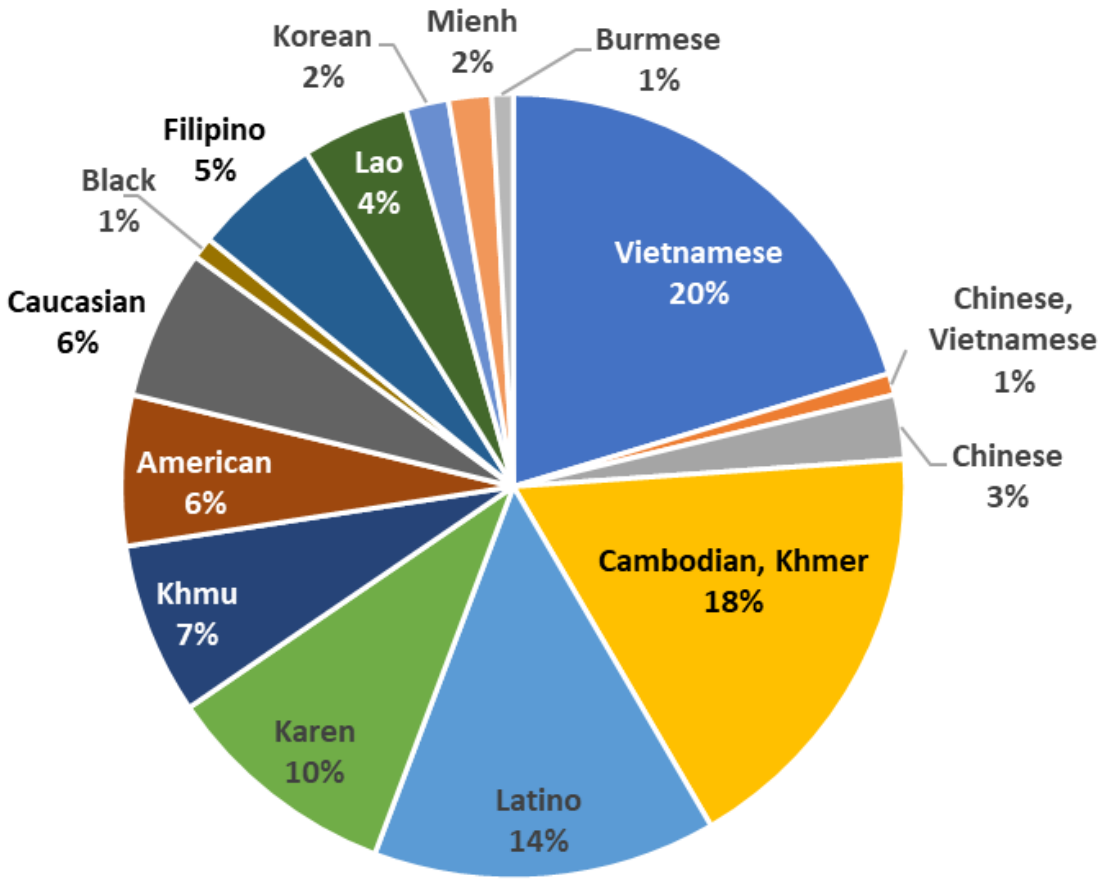



**Figure 1. Proportion of fisher survey respondents by ethnicity (n = 113 respondents).**

The fishers also reported on their ages. Four age group options were available on the survey, and responses were balanced across these groups (Figure 2).

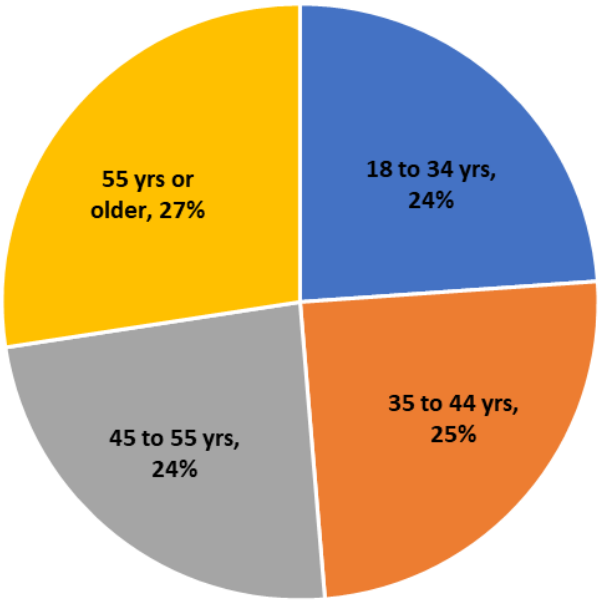



**Figure 2. Proportion of fisher survey respondents by age group (n = 113). Each respondent provided one answer on this question.**

### 2.2.2 Who is eating the catch?

The fishers were asked with whom they share their catch, and they could select one or more of the following:

- Women who are pregnant or breastfeeding
- Friends
- Parents/Elders
- Children
- Others: _____

We avoided offering “Family” as an option because we wanted more information about which parts of the family were included in sharing the catch. If we conduct more fisher surveys in the future, “Spouse” or “Partner” will also be included as an option in this question.

The proportion of respondents who reported sharing with different groups is shown on Figure 3. Since respondents often included more than one response in their answer, the values add up to more than 100%. The people fishers shared their catch with the most were their friends. Other frequent responses were parents and elders, children, and women who are pregnant or breastfeeding.

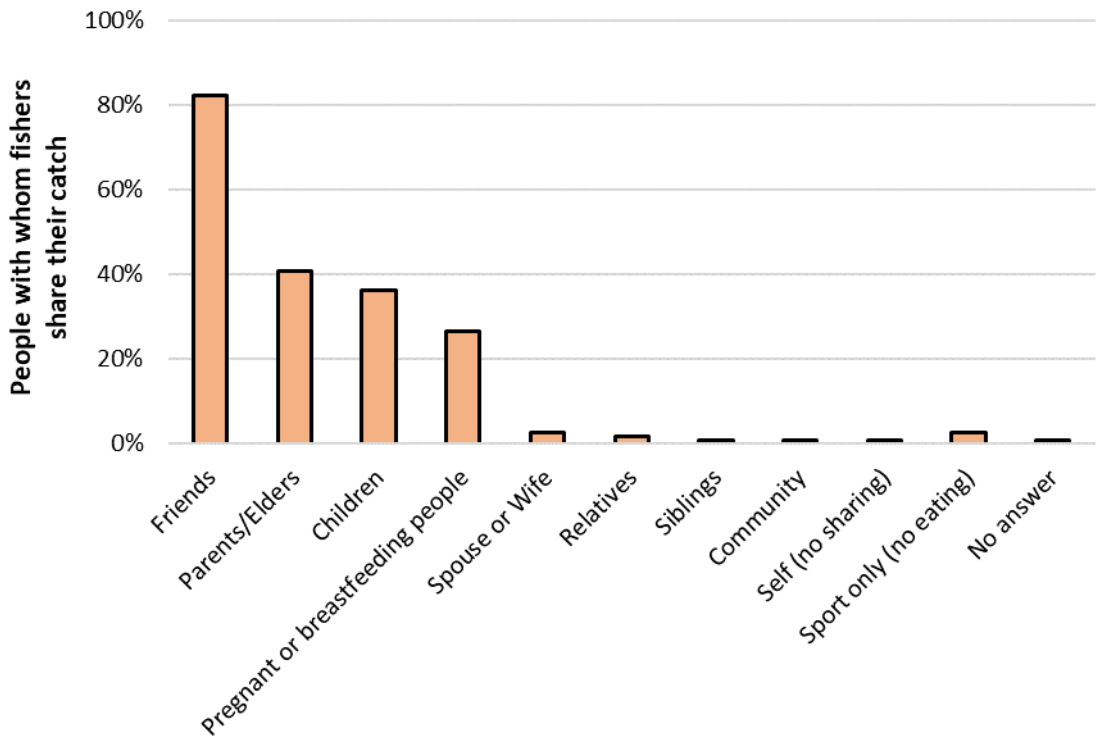



**Figure 3. Proportion of fisher survey respondents who reported sharing their catch with other people (n = 113 respondents).**

### 2.2.3 Where are they fishing?

We asked fishers where they commonly go to catch fish and/or shellfish (referred to specifically as crab, shrimp, or clams on the survey). We offered a map of King County rivers, lakes, and marine areas to help them identify places for which they may not know the name or that may have multiple names. Though the survey was designed to find out the general locations where people fish, specific fishing locations on those water bodies (e.g., fishing holes, docks, or beaches) were not specified. The proportion of survey respondents who reported fishing and/or shellfishing at different locations within and outside of King County is shown in Table 1. Since respondents often included more than one location in their answer, the values add up to more than 100%.

The fishing locations reported included some freshwater bodies already sampled by our fish tissue monitoring program, like Lakes Washington and Sammamish and the Green and Cedar Rivers. They also include some smaller lakes we have not previously sampled, like Green and Angle Lake, and Lakes Meridian, Desire, and Youngs. We already sample some marine fishing areas like Alki and Elliott Bay as part of our monitoring program, but others like Des Moines, Dash Point, and Lincoln Park are not currently monitored. We also do not currently monitor the Lower Duwamish Waterway .

Table 1. Proportion of survey respondents who reported fishing and/or shellfishing at different locations in and outside of King County (n = 113 respondents).

| County | Freshwater or Saltwater | Type of Location | Specific Location | Proportion (%) |
|---|---|---|---|---|
| King County | Freshwater | Lakes | Lake Washington | 44.2 |
| | | | Lake Sammamish | 21.2 |
| | | | Green Lake | 10.6 |
| | | | Lake Meridian | 9.7 |
| | | | Angle Lake | 8.8 |
| | | | Lake Desire | 6.2 |
| | | | Lake Youngs | 4.4 |
| | | | Fivemile Lake | 1.8 |
| | | | Lake Burien | 1.8 |
| | | | Lake Fenwick | 1.8 |
| | | | Lake Geneva | 1.8 |
| | | | Pine Lake | 1.8 |
| | | | Steel Lake | 1.8 |
| | | | Arbor Lake | 0.9 |
| | | | Beaver Lake | 0.9 |
| | | | Deep Lake | 0.9 |
| | | | Lake Morton | 0.9 |
| | | | Lake Wilderness | 0.9 |
| | | | Mirror Lake | 0.9 |
| | | Rivers | Green River | 30.1 |
| | | | Cedar River | 15.0 |
| | | | Duwamish River | 6.2 |
| | | | Issaquah Creek | 0.9 |
| | | | Snoqualmie River | 0.9 |
| | | | White River | 0.9 |
| | Saltwater | Elliott Bay | Alki | 20.4 |
| | | | Elliott Bay | 7.1 |
| | | LDW | Lower Duwamish Waterway | 12.4 |
| | | Main Basin | Des Moines | 19.5 |
| | | | Puget Sound (unspecified) | 15.9 |
| | | | Dash Point | 14.2 |
| | | | Lincoln Park | 8.0 |
| | | | Redondo | 1.8 |
| | | | Shilshole | 0.9 |
| | | | West Seattle | 0.9 |

| County | Freshwater or Saltwater | Type of Location | Specific Location | Proportion (%) |
|---|---|---|---|---|
| | Unknown | Unknown | Federal Way | 0.9 |
| | | | South King County | 0.9 |
| Not King County | Freshwater | Lakes | Alder Lake | 0.9 |
| | | | Holden Lake | 0.9 |
| | | | Lake Kachess | 0.9 |
| | | | Lake Tapps | 0.9 |
| | | Rivers | Puyallup River | 12.4 |
| | | | Columbia River | 6.2 |
| | | | Skokomish River | 0.9 |
| | | | Snake River | 0.9 |
| | | | Snohomish River | 0.9 |
| | Saltwater | Puget Sound | Edmonds | 4.4 |
| | | | Hood Canal | 3.5 |
| | | | Bremerton State Park | 1.8 |
| | | | Commencement Bay | 0.9 |
| | | | Point Defiance | 0.9 |
| | | Pacific Ocean | Pacific Ocean | 3.5 |
| Unknown | | | No answer given | 9.7 |
| | | | Unknown location described | 0.9 |
| | | | “Illegal Lake” | 0.9 |

### 2.2.4 What are they catching?

The fishers were asked what types of fish or shellfish they catch and take home to eat. The question included space for them to list up to five species of fish and five species of shellfish. Though the fishers were given a reference sheet of freshwater and marine fish and shellfish in King County waters to help them identify or remember local species (Appendix A), we do not know how accurately they identified their catches, and this could be a source of error in the results. In addition, the fishers were asked if they harvest any aquatic plants to eat, with two options to circle: seaweed and freshwater plants.

The fishers often reported catching a range of fish, shellfish, and plants. Though the survey did not specify at which locations they caught each species, it did give us a sense of the relative success fishers were having catching different species. The proportion of respondents who reported catching different fish, shellfish, and plants are shown in Figures 4 through 8.

In freshwater, the most caught fish appeared to be catfish, bass, perch (including yellow perch), pumpkinseed/bluegill, and black crappie (Figure 4). When respondents included

the term “perch” in their response without specifying the species, we counted them in both the freshwater and saltwater fish responses. Salmon appeared to be the most frequently caught anadromous fish (Figure 5). While many respondents reported only “salmon” in their answers, some mentioned species by name, most frequently coho and Chinook. Perch, including the unspecified perch and three saltwater species, were the most frequently caught saltwater fish, with flatfish/flounder and herring the next most caught fish (Figure 6). The fishers also reported gathering/catching a range of shellfish, including clams, oysters, mussels, crabs, shrimp, and squid (Figure 7). A small percent of the fishers also indicated they harvest aquatic plants, with about 10% each harvesting either freshwater plants or seaweeds (Figure 8).

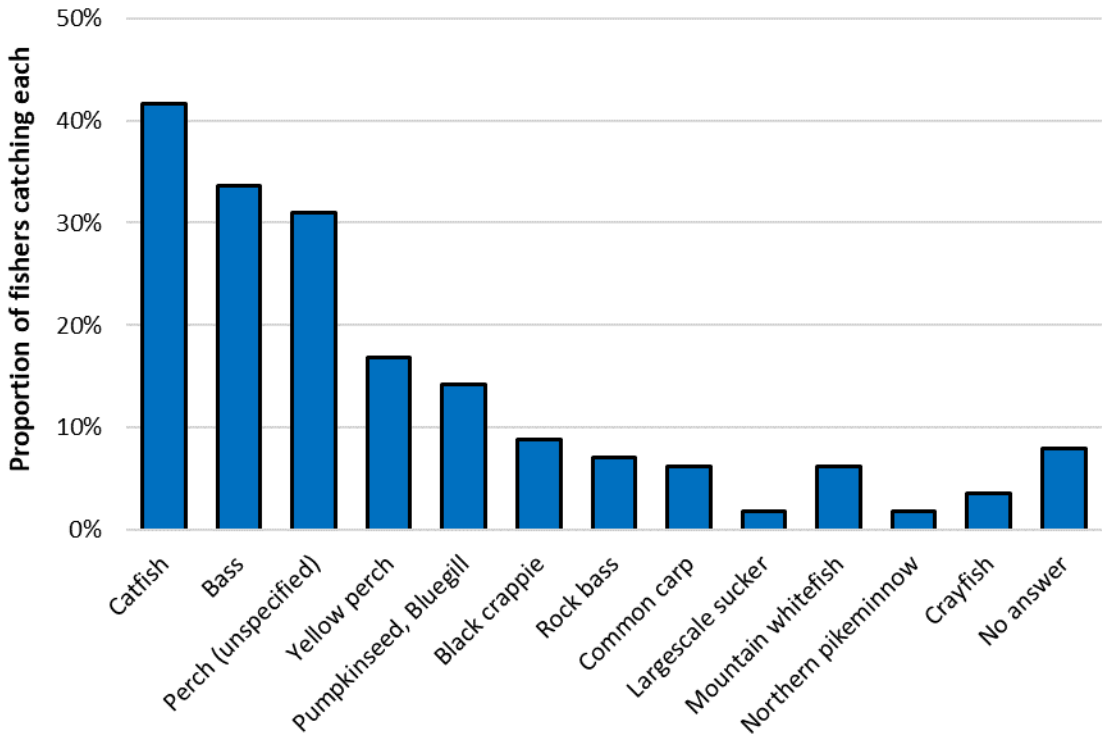



**Figure 4. Proportion of fisher survey respondents who reported catching various freshwater fish and shellfish (n = 113 respondents).**

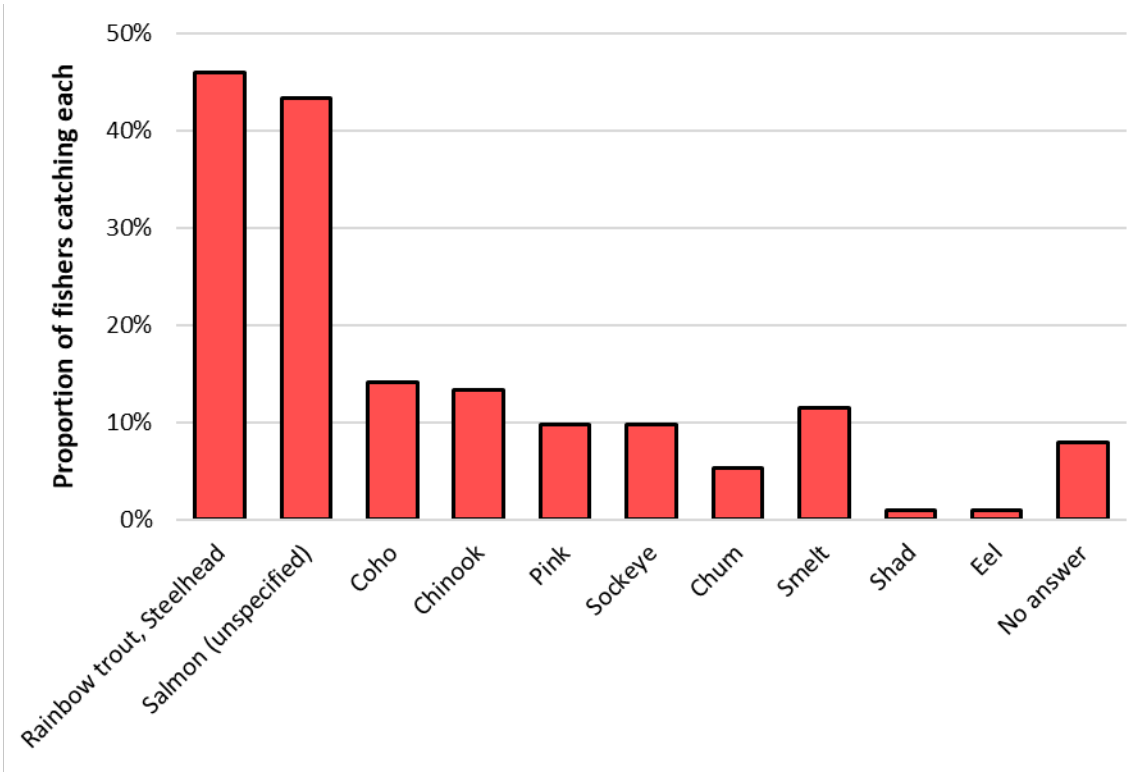



**Figure 5. Proportion of fisher survey respondents who reported catching various anadromous fish (n = 113 respondents).**

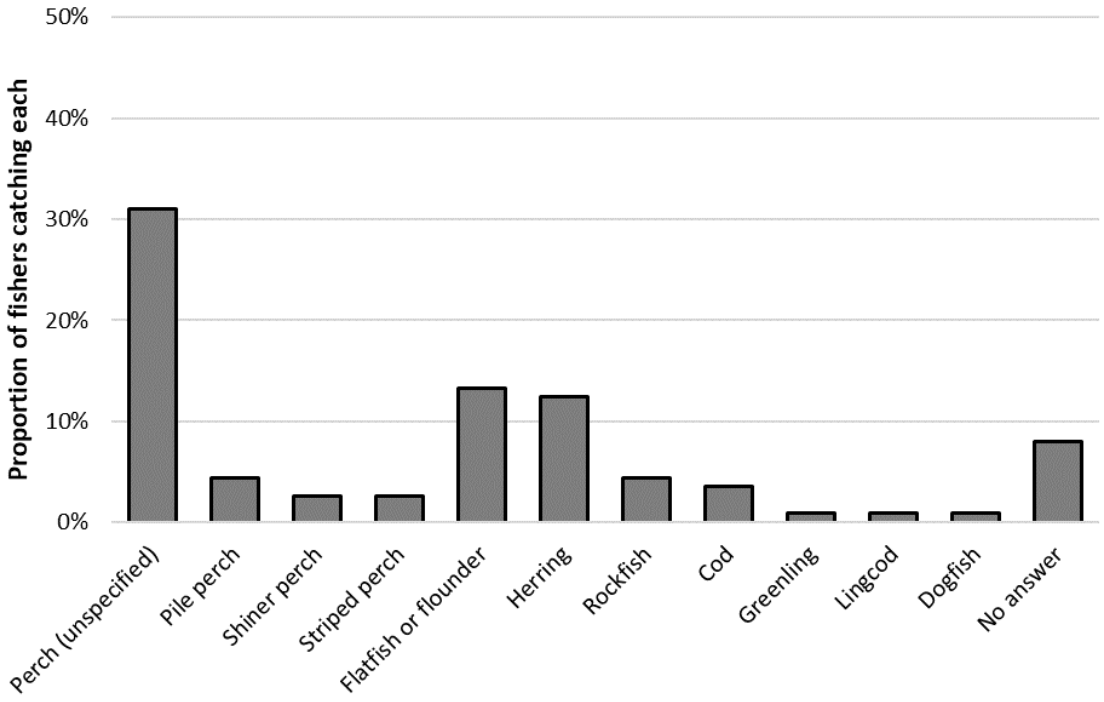



**Figure 6. Proportion of fisher survey respondents who reported catching various saltwater fish (n = 113 respondents).**

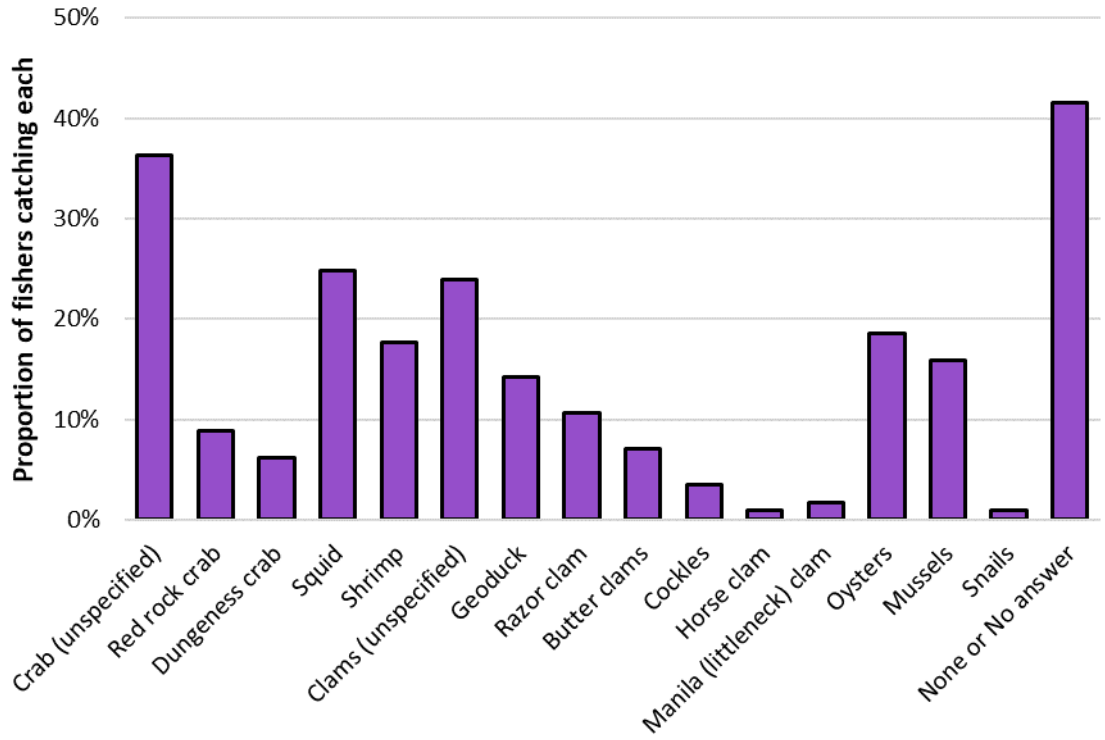



**Figure 7. Proportion of fisher survey respondents who reported catching various saltwater shellfish (n = 113 respondents).**

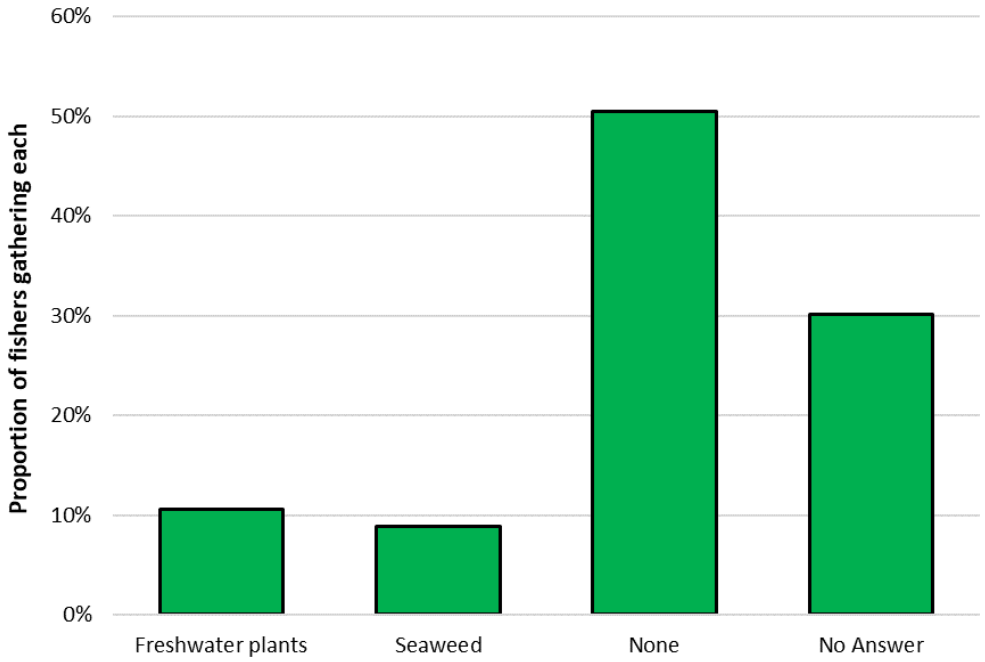



**Figure 8. Proportion of fisher survey respondents who reported gathering different kinds of edible plants (n = 113 respondents).**

### 2.2.5 How is the catch consumed?

We asked fishers how their household commonly prepares fish or shellfish to eat. The question included 11 preparation options including pan fry, deep fry, grill, bake, broil, steam, soups, stew, dry, ferment, eat raw, and an "Other" option with a blank line to fill in. Though more than one preparation technique was often reported by fishers, pan or deep frying was often the first technique listed (83%, 94 of 113 respondents). Other common preparations included grilling, broiling, or baking.

In the survey fishers were also asked which parts of the fish their household commonly eats. The question included four choices, with the option to check all that apply:

- Whole fish (with skin),
- Fillet only (no skin, no head, or organs),
- Fish head (in soups or other dishes),
- Other: _____.

Over half of the fishers included more than one of these options in their response. About 61% of the fishers reported eating the whole fish and 67% reported eating fish fillets (Figure 9). About 44% reported eating the fish heads. Based on this survey data, it appears that a large proportion of the King County immigrant and refugee community typically consumes the entire fish they catch. Our survey was not designed to distinguish fish sourced from local waters relative to non-King County or Oregon waterbodies nor from local supermarkets.

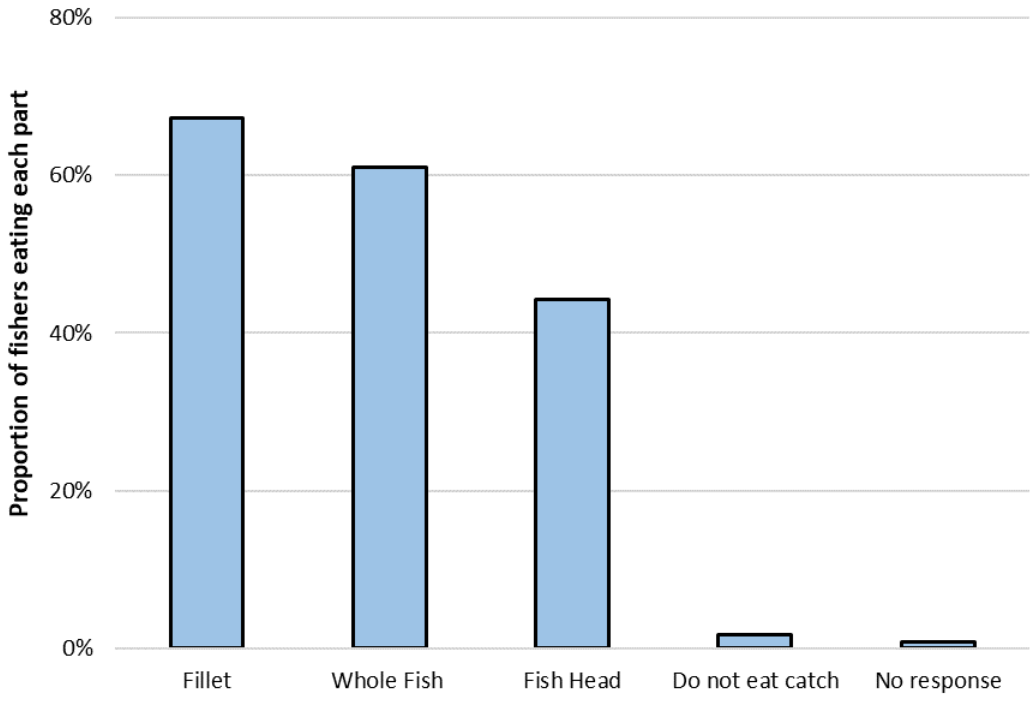



**Figure 9. Proportion of fisher survey respondents who reported eating different fish parts (n = 113 respondents).**

The survey also asked fishers catching and eating crab which parts they commonly eat. For this question there were two choices: crab meat or crab meat and guts. We learned through the RFSC that more detailed or technical terms for main body organs like the hepatopancreas[1] and the roe/eggs were likely to be very challenging to translate. The fishers' responses were evenly split between the two: 50% indicated eating just the meat and 50% indicated eating the meat and guts.

### 2.2.6 How much fish do people consume?

The survey asked fishers their typical fish/shellfish meal size and they were shown a fish portion size reference to help answer this question (Figure 10). Each respondent provided one answer on this question, with typical meal sizes ranging from 4 to 24 ounces (oz) (113 to 680 grams, g) (Table 2). The most common meal size was 10 oz (283 g) (34%), and the second most common meal size was 6 oz (170 g) (19%). Some fishers gave a more qualitative response, e.g., "small" or "medium" for meal size.

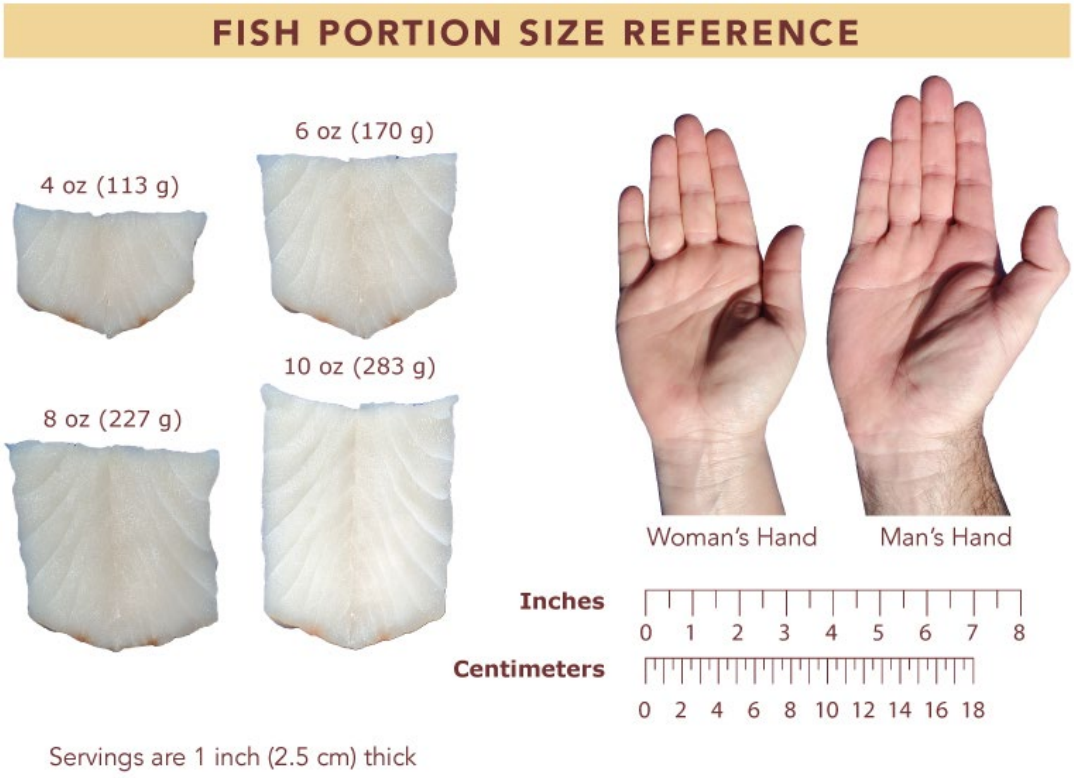



**Figure 10. Fish portion to human hand size reference used as a guide on the fisher survey[2]; oz = ounces, g = gram, cm = centimeter.**

[1] The hepatopancreas is the digestive/midgut gland in crabs and provides equivalent functions to the liver and pancreas in mammals.

[2] A later representation of the human hand used for the *Healthy Fish-eating Recommendations from King County* flyer was improved to be more inclusive (see Appendix C).

Table 2. Proportion of survey respondents who reported typical fish/shellfish meal sizes (n = 113 respondents).

| Typical meal size | Proportion (%) |
|---|---|
| 4 oz (113 g) | 12 |
| 6 oz (170 g) | 19 |
| 6 to 8 oz (170 to 227 g) | 7 |
| 8 oz (227 g) | 10 |
| 8 to 10 oz (227 to 283 g) | 2 |
| 10 oz (283 g) | 34 |
| 12 oz (340 g) | 2 |
| 24 oz (680 g) | 1 |
| Small | 3 |
| Medium | 1 |
| Don't eat | 1 |
| Don't know | 1 |
| No answer | 8 |

oz = ounces, g = gram

The survey also asked fishers how often their household eats fish or shellfish caught by them or someone they know. For this question they were told to provide a general estimate and given four options:

- More than 12 meals per month,
- 8 to 12 meals per month,
- 1 to 4 meals per month,
- Never

These specific meal-per-month options were chosen to match the ranges used by the Washington Department of Health (DOH) in their fish consumption advisories, which use 1, 2, 4, and 8 meals per month as cut off points (Christie, E. 2023). For the fisher survey, we combined the 1, 2 and 4 meals per month from DOH into the “1 to 4 meals per month” category and added “more than 12 meals per month” to explore whether fishers from these communities were consuming higher amounts of caught fish/shellfish. A majority of the fishers (64%) reported typically eating about 1 to 4 meals per month (Figure 11). The next highest chosen category was about 8 to 12 meals per month (26%).

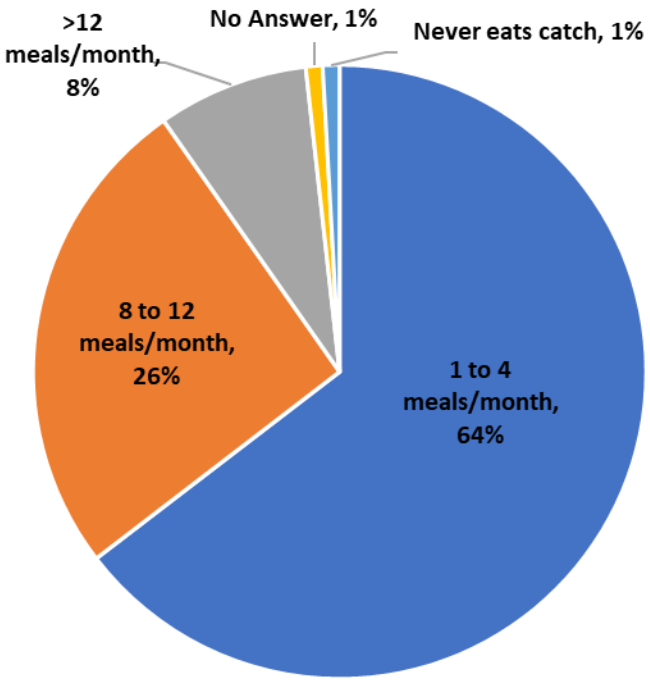



**Figure 11. Proportion of fisher survey respondents who reported on how often their household eats fish/shellfish caught by them or someone they know (n = 113 respondents). Each respondent provided one answer on this question.**

We compared the amount of fish/shellfish meals per month reported in this survey with the consumption rates used by DOH for developing their fish advisories. The DOH publishes two fish consumption advisory screening levels based on two exposure circumstances: 1) a general consumer who eats 59.7 g (2.1 oz) wet weight (ww) per day of fish/shellfish, and 2) a high consumer who eats 175 g (6.2 oz) ww per day of fish/shellfish. These correspond to about 8 meals per month for the average consumer and about 23 meals per month for the high consumer, assuming the typical meal size is 226.7 grams (8 oz). To make this comparison, we multiplied the high end of each adult respondent's reported monthly meal consumption range by 226.7 grams (8 oz meal) to calculate their consumption per month in grams. We divided the product by an average of 30.4 days (standard EPA and DOH methods and assumptions) in a month to derive a daily consumption rate in grams.

Based on the data from this survey, about 80% of the fishers and/or their households consumed less than DOH's definition of the average consumer and none reached the high consumer consumption level (Figure 12). The highest consumption rate we calculated based on the survey results was 112 grams/day. However, our survey was not phrased to capture the highest fish consumers and our number of respondents was relatively small as well. We have not fitted a distribution to these data although the nature of the number of meals (but not the size of them) likely truncated the highest consumers. Because of the DOH meal frequency categories we used in our surveys, our data are not directly comparable to previous published surveys of Asian and Pacific

Islander (API) fish consumption in King County (EPA 1999), especially for those people consuming 12 or more fish meals per month. That 1999 EPA survey is the only other study we are aware of that describes seafood consumption rates, species, and seafood parts commonly consumed in API communities from King County.

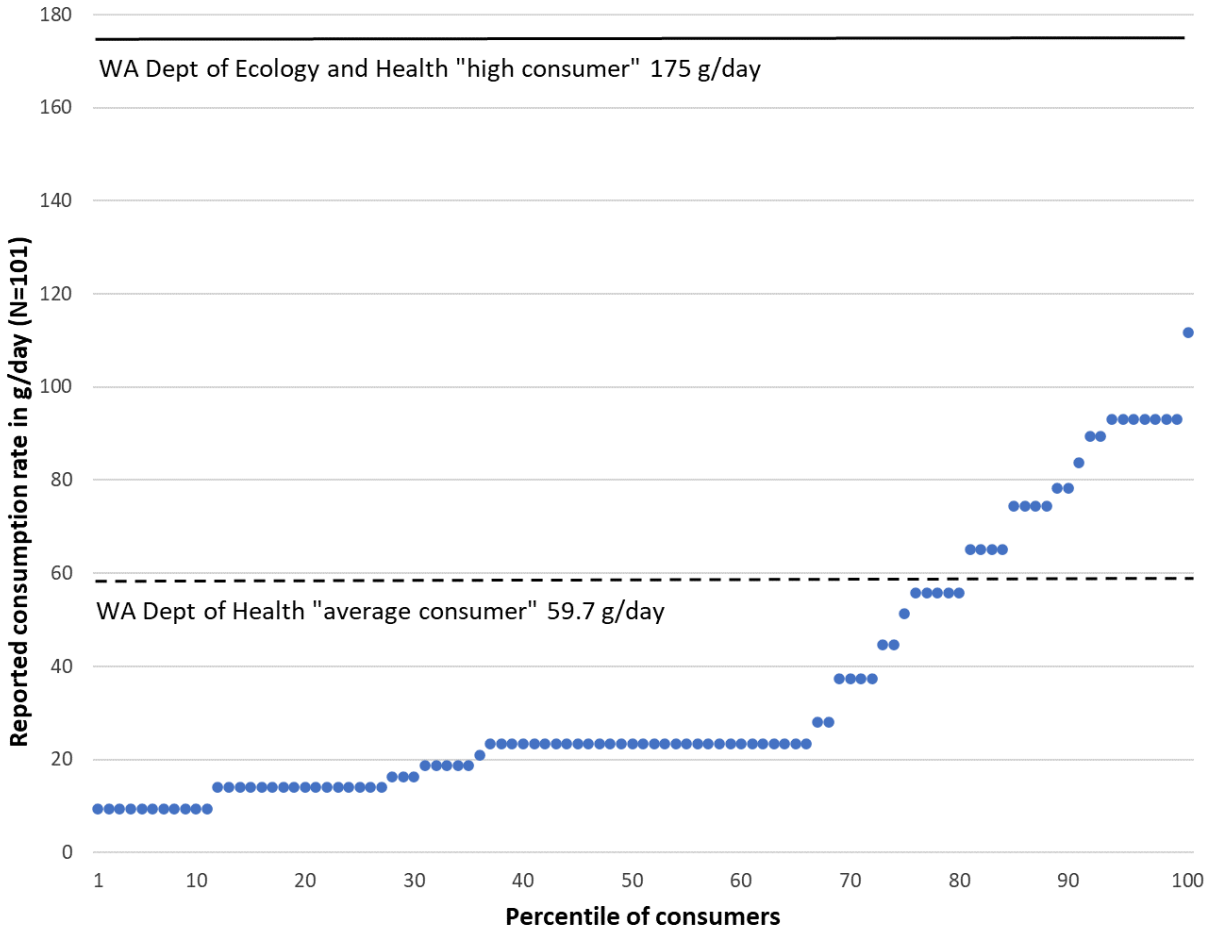



**Figure 12. Calculated fish/shellfish consumption rates based on data from the fisher survey.**

# 3 Fish Sampling Pilot

We used the fisher survey results on fishing locations and species caught to identify large information gaps in our monitoring program. Then, we used this information to select fish species in specific lakes and marine shorelines that would provide new information useful to fishers from south King County immigrant and refugee communities. Fishers from these communities were contracted by the RFSC to collect fish for this pilot effort. The contracted community fishers captured fish at our preferred locations during the spring and summer of 2023 and transferred them to King County for chemistry analysis. In addition to locations and species to target, we guided fishers on how to handle and preserve the captured fish. With translation support by RFSC, we led a training workshop for the fishers in the spring of 2023 on sample handling, labeling and storage. This section describes how the fish sampling pilot was conducted and summarizes the resulting data.

## 3.1 Fishing Locations and Species

Using the data collected from the fisher survey (Section 2), we compared the most popular fishing locations and species captured to those monitored in our long-term fish tissue monitoring program. Fishing locations identified as popular in the fisher survey that were not part of WLRD's fish tissue monitoring program were identified as candidates for the fish sampling pilot.

We identified four freshwater locations to target: Green Lake (in north Seattle), Angle Lake (SeaTac), Lake Desire (southeast of Renton), and Lake Meridian (east of Kent, Figure 13). At these locations we asked the fishers to capture yellow perch, bullhead, or catfish (Figure 14). The fishers were encouraged to also keep any legal fish caught based on Washington Department of Fish and Wildlife (WDFW) fishing regulations.

We targeted yellow perch, bullhead, and catfish for two reasons; 1) they were listed as species consumed in the fisher survey, and 2) because we expected yellow perch to be on the low end of the spectrum for chemical contamination and bullhead/catfish to be slightly higher on the contaminant concentration spectrum. We were interested in testing species that might be safe alternatives to eat in addition to contaminated and unsafe species. Yellow perch live in the water column, are mid-food web fish and usually not top lake predators and are low in lipids. Therefore, we generally expect them to have relatively low contaminant concentrations. Bullhead and catfish are scavengers and opportunistic feeders, often low in lipids yet are in direct contact with the more contaminated sediments. We generally expect them to contain more concentrated contaminants than yellow perch due to their exposure to sediments.

While we were uncertain about which species would be caught, we hoped that contaminant data on these species would help us identify safer choices for fishers at these locations.

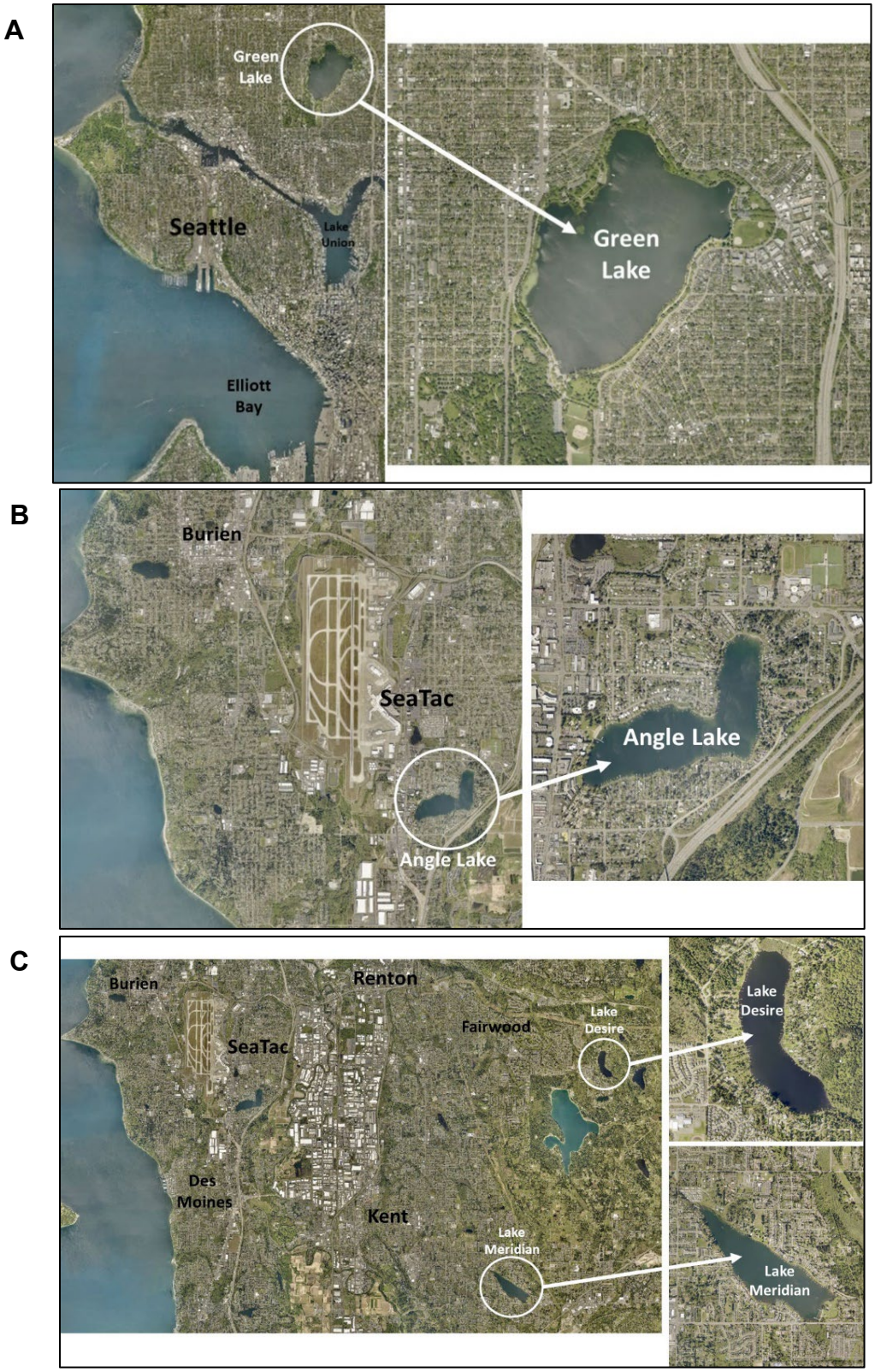



**Figure 13. Four freshwater fishing locations targeted for 2023 fish collection: Green Lake (A), Angle Lake (B), Lake Desire and Lake Meridian (C).**

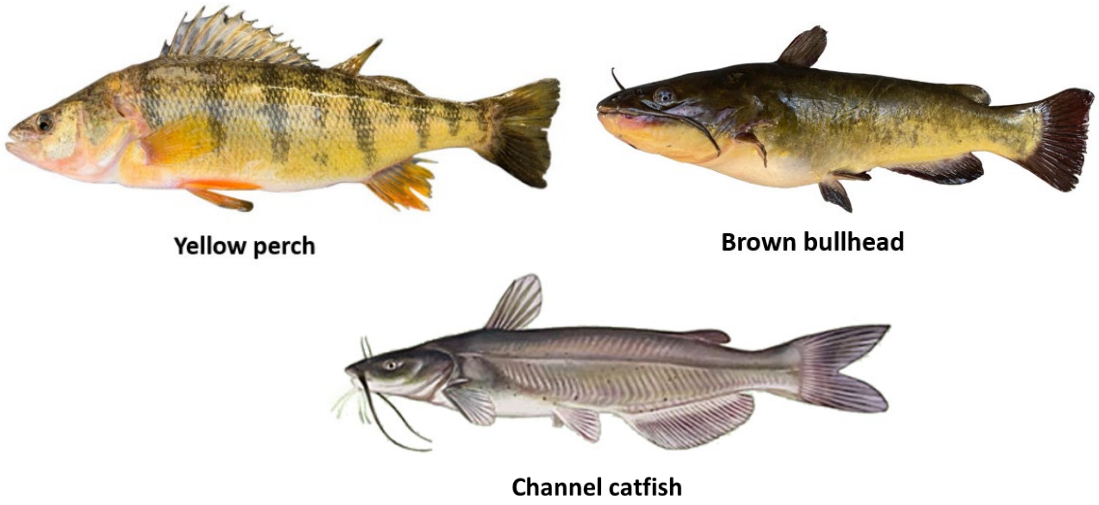



**Figure 14. Freshwater fish species targeted for this study.**

We also asked the fishers to target five saltwater locations for fish collection: Pier 62 (Seattle waterfront), Alki Beach (West Seattle), Lincoln Park (Fauntleroy), and Des Moines Pier (Des Moines), and Dash Point State Park (Federal Way, Figure 15). The fishers ended up using the pier at Seacrest Park (south Elliott Bay) instead of Alki Beach for fishing, likely because this fishing pier is located near Alki Point and is a popular fishing location (Section 3.3). Fishers were asked to target pile perch and shiner perch at these marine fishing locations (Figure 16). Both species were identified as consumed by fishers and their families in the fisher survey. There were no contaminant data for these species in our long-term fish tissue monitoring program nor in Ecology's Environmental Information Management (EIM) database.




**Figure 15. Saltwater fishing locations targeted for 2023 fish collection: Pier 62, Alki Beach*, Lincoln Park, Des Moines Pier, and Dash Point State Park. Locations marked with white stars included enough fish for chemical analysis, locations marked with an X either were not fishable (due to restricted access that summer) or there were not enough fish collected there for chemical analysis (see Section 3.3 for details). *The fishers used Seacrest Park instead of Alki Beach, likely because Seacrest Park has a popular fishing pier, and it is near Alki Point.**



Pile perch



Shiner perch (surfperch)

**Figure 16. Two saltwater perch species targeted for this study.**

## 3.2 Fisher Recruitment and Training

The RFSC recruited eight local immigrant and refugee fishers from South King County to participate in the 2023 fish sampling pilot. The fishers were compensated for their efforts through RFSC's WaterWorks Grant. We held a Fisher Training Workshop[3] in early March 2023 (Figure 17). The RFSC organized the workshop and provided interpreters from the local communities to translate. During the workshop, we explained the reasons for conducting the fish sampling pilot and how the results will contribute valuable information to the local fishing community. Also described were the goals of our long-term fish tissue monitoring program and how the information gained from this project was intended to help guide changes to that program. We showed the fishers which locations and species to target and how to properly bag and label any captured fish. The fishers were also directed to keep fish on ice prior to transfer to a RFSC freezer.




**Figure 17. Photos from the Fisher Training Workshop**

## 3.3 Summer of Fishing

From May to August 2023 the fishers collected fish from Angle Lake, Green Lake, Lake Desire, and Lake Meridian (Figure 18). They also fished at Seacrest Park (instead of Alki Beach[4]), Lincoln Park, Dash Point State Park, and the Des Moines Pier. After a single day of fishing at Dash Point State Park (one fish caught), fishing at that location was discontinued due to a broken fishing pier. Unfortunately, fishing at Pier 62 in Elliott Bay was also infeasible due to construction at the Seattle waterfront. Fishers used their own fishing gear and tackle (e.g., poles, hooks, bait, nets, etc.) for the fish collections.

[3] The workshop presentation is available upon request to Jennifer Lanksbury (jlanksbury@kingcounty.gov).
[4] Fishers were instructed to target Alki Beach as fishing area. They interpreted the pier at Seacrest Park as an acceptable proxy location. Thus, Seacrest Park is a sample location we report for this study.






**Figure 18. Some of the fishers recruited by the RFSC to fish in select freshwater and marina locations of King County. Top photo taken at Lake Meridian, bottom photo at Seacrest Park pier.**

Though yellow perch, brown bullhead, channel catfish, pile perch, and shiner perch were the priority species for collection, the fishers were encouraged to also keep any legal fish, based on WDFW fishing regulations, that they would consider eating. Table 3 shows the number and types of fish collected by the RFSC fishers over the spring and summer of 2023.

Table 3. Number and type of fish collected at each location.

| Freshwater or Saltwater | Location | Fish | Fish Collected |
|---|---|---|---|
| Freshwater | Angle Lake | Kokanee, *Oncorhynchus nerka* | 18 |
| | | Rainbow trout, *O. mykiss* | 10 |
| | | Sculpin, Cottidae family | 6 |
| | | Rock bass, *Ambloplites rupestris* | 3 |
| | Green Lake | Brown bullhead, *Ameiurus nebulosus* | 3 |
| | | Channel catfish, *Ictalurus punctatus* | 1 |
| | Lake Desire | Yellow perch, *Perca flavescens* | 24 |
| | | Bluegill, *Lepomis macrochirus* | 6 |
| | Lake Meridian | Yellow perch, *P. flavescens* | 16 |
| | | Brown bullhead, *A. nebulosus* | 7 |
| Saltwater | Seacrest Park | Shiner perch, *Cymatogaster aggregata* | 41 |
| | Lincoln Park | Shiner perch, *C. aggregata* | 26 |

After they caught a fish, the fishers placed it into double Ziplock bags either individually or as a group (by location) along with a between-bag label they completed showing the fishing location, date, species caught, and the fishers' names (Figure 19). The bags, labels, and pencils for this purpose were provided by King County. The bags and labels were proofed as contaminant-free by King County Environmental Lab (KCEL) before being provided to the fishers.

The fishers kept their catch in their own coolers with cubed ice and transported them within 24 hours to a freezer provided by the RFSC, where they were frozen to -16 to -18° Celsius (C). Approximately once every two weeks, we picked up the collected frozen fish from the RFSC freezer and transferred them in a cooler with ice to KCEL, where they were stored frozen at -18° C until processing in September 2023.




**Figure 19. Examples of fish bagged together or as single fish, with their labels.**

## 3.4 Fish Processing and Analysis

In October 2023, TCA and KCEL staff processed fish into homogenized (i.e., ground up) tissue samples for chemical analysis. A combination of target and non-target species (i.e., kokanee, rock bass, rainbow trout, and bluegill) were analyzed for contaminants (Table 4). Several of the non-target species captured were rejected from the analysis because there was not enough tissue for a viable sample (minimum 100 grams); this included the smallmouth bass from Lake Desire, all of the flatfish and rockfish from Des Moines Pier, and all the sculpins. Because all the fish collected from Dash Point State Park and the Des Moines Pier were rejected for analysis, these two sites are not included in Table 4.

Table 4. Number and type of fish samples created for analysis

| Location | Fish | Number of Tissue Samples (Number of Fish/Sample) | Composite or Single Fish | Tissue Type in Sample |
|---|---|---|---|---|
| Angle Lake | Kokanee | 6 (3) | Composites | Whole body |
| | Rock bass | 1 (3) | Composite | Whole body |
| | Rainbow trout | 4 (1)<br>6 (1)<br>6 (1) | Single fish<br>Single fish<br>Single fish | Whole body<br>Fillet*<br>Carcass* |
| Green Lake | Brown bullhead and channel catfish | 1 (3 bullhead, 1 catfish) | Composite | Whole body |
| Lake Desire | Bluegill | 1 (6) | Composite | Whole body |
| | Yellow perch | 6 (4) | Composites | Whole body |
| Lake Meridian | Brown bullhead | 2 (3)<br>1 (1)<br>1 (1) | Composites<br>Single fish<br>Single fish | Whole body<br>Fillet*<br>Carcass* |
| | Yellow perch | 4 (4) | Composites | Whole body |
| Seacrest Park** | Shiner perch | 7 (5 to 7) | Composites | Whole body |
| Lincoln Park | Shiner perch | 6 (4 to 5) | Composites | Whole body |

*Fillet (skin on) and carcass were taken from the same fish and analyzed separately; carcass was the remaining fish after the fillet was removed.

**Fished instead of Alki Beach, see Section 3.3.

The protocols used for fish processing and analysis are documented in a technical memorandum (King County, 2023). In short, we partially thawed the fish stored at KCEL, confirmed their identities, weighed, and measured them, assigned each a Sample ID, and then refroze them. Depending on the number of fish available from each location, we assigned the fish to either single fish samples or composites of several fish together. In a few cases, some large fish were split into pairs of matching samples, one sample containing the fillet tissue (including skin) and the other containing the remaining carcass tissue (i.e., head, guts, bones, and skin left over after the fillets were removed). This fish splitting was done to facilitate exploration of human health

contaminant exposure via eating the fish fillet versus the whole body. All fish tissues selected for processing were homogenized (Figure 20) and then refrozen for later contaminant analysis.

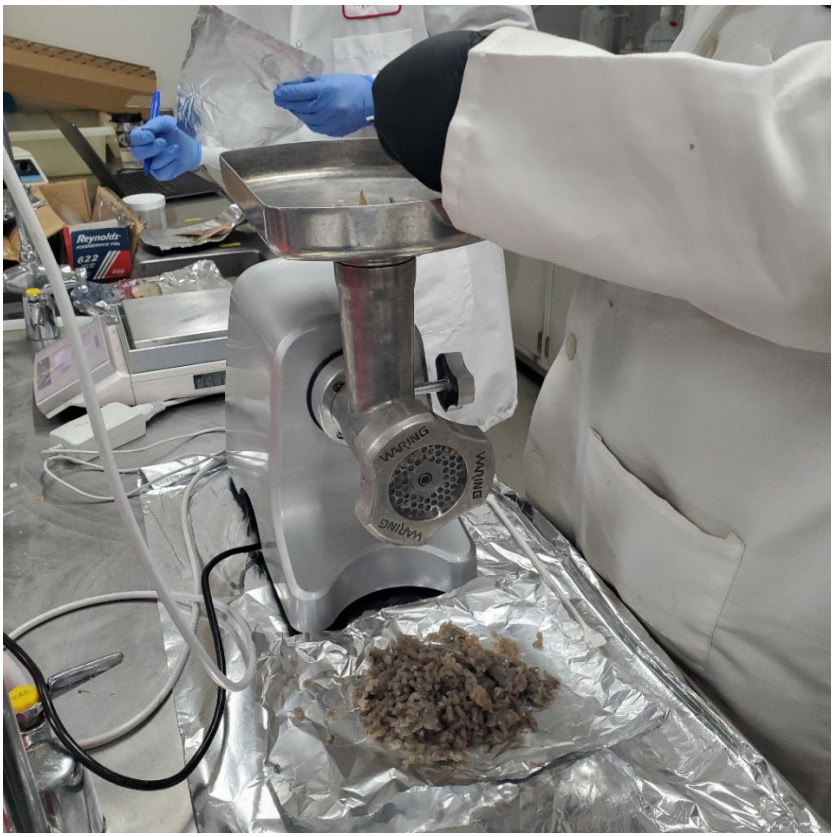



**Figure 20. Fish were homogenized into tissue composites for chemical analysis at the King County Environmental Lab**

Fish samples were analyzed for the following contaminants and contaminant groups:

- polychlorinated biphenyls (PCBs),
- polybrominated diphenyl ethers (PBDEs),
- organochlorine pesticides,
- per- and polyfluoroalkyl substances (PFAS),
- total mercury,
- solids and lipids.

The specific chemical compounds analyzed in each of the contaminant groups are shown in Appendix B.

### PCBs

*PCBs are synthetic chemicals that were produced in the U.S. for industrial use (e.g., transformers and capacitors) and consumer products (e.g., carbonless copy paper) until 1979. Though production has been banned for over 30 years, they are still found in the environment because they are extremely difficult for microbes, like bacteria, to break down. Because of this, they are considered legacy pollutants.*

*PCBs are toxic and can cause harmful impacts to humans and fish. They can cause cancer and lead to impairments in the immune system, nervous system, hormone production and reproduction. PCBs tend to accumulate to high levels in species high in the food chain, like smallmouth bass, largemouth bass, Puget Sound resident Chinook salmon (i.e., Blackmouth), and Orcas.*

## 3.5 Chemistry Results

This section summarizes the chemicals detected[5] in the fish tissue samples. We present here the contaminant or pesticide groups that had at least one chemical within their group detected in the fish tissue samples. These included the PCBs[6], PBDEs, chlordanes, total PFAS (sum PFOS and PFOA), and mercury. For each of the grouped chemicals, we summed all chemicals within the group, substituting one-half (½) the laboratory method detection limit (MDL, i.e., limit of quantitation) any time a chemical within the group was not detected. In this way ½MDL values were used in the summations for the total PBDEs, total DDTs, total chlordanes, and total PFAS. We did this to follow EPA (1989) and DOH (Christie, 2023) guidance for risk assessments as closely as possible.

[5] Several chemicals were not detected in any tissue sample. These included four of the seven PCB Aroclors analyzed (Aroclors 1016, 1221, 1232, 1248), the PCB homolog group monochlorobiphenyls, and two PBDE congeners (TetraBDE-71 and HeptaBDE-190). Of the organochlorine pesticides, Endosulfan, Aldrin, both heptachlors, and all four BHCs were not detected. One of the three DDT isomers (4,4'-DDT) was also not detected. PFOA was not detected in any sample.

[6] PCBs exist in up to 209 different forms called congeners. The now-banned commercial mixtures of these PCB congeners were called Aroclors. KCEL estimates the concentration of Aroclors in fish tissue and these results are generally used by DOH to make decisions about fish consumption. KCEL also measures the concentration of PCBs in homolog groups. Though the homolog method is more precise than the Aroclor method, it is harder to compare with established toxicological values, which are based on Aroclors. We analyzed PCBs by both methods to allow for comparison with DOH health-based screening values (Aroclors) and provide more precise estimates of PCBs for tracking trends (homologs).

Tables 5 to 10 summarize the tissue concentration ranges and averages, and the percent of times a chemical group was detected in the fish tissue samples. Detailed chemistry results will be uploaded to and available in Ecology's Environmental Information Management (EIM) database or can be shared upon request.

### 3.5.1 Highest Concentrations

Of the fish collected for this project, the shiner perch from both Seacrest Park and Lincoln Park had the highest mean (average) total PCB concentrations (Table 5). The combined brown bullhead/channel catfish whole fish composite sample from Green Lake also had relatively high total PCB concentrations and the highest total DDT concentration (Table 7).

We made separate fillet and carcass samples from a single Lake Meridian bullhead. The carcass sample from that fish had the highest measured total PBDEs, the second highest total DDTs, and the second highest total PFAS concentration[7] (Tables 6 and 9, respectively). Lake Meridian yellow perch had the highest mean total PFAS concentrations (Table 9).

The Angle Lake Kokanee had the highest mean concentration of total Chlordanes, though the single highest measured value occurred in one the six Lake Desire yellow perch samples (Table 8). This pattern was mirrored with the mercury results, where the Angle Lake Kokanee again had the highest mean concentration, but one of the Lake Desire yellow perch samples had the highest maximum mercury value, which

## PFAS

*PFAS are synthetic chemicals, containing the element fluorine, that are used in many industrial processes and in products that are resistant to water, grease, and stains. One chemical in this group is perfluorooctane sulfonic acid (PFOS), which is one of the most extensively produced and studied among the PFAS chemicals.*

*PFAS do not breakdown easily in the environment and have been found in human blood, drinking water, soils, air, and animal tissues. PFAS chemicals, including PFOS, can bioaccumulate in fish tissues. They impact immune and thyroid function, liver and kidney health, reproduction, and development and can cause cancer.*

## Mercury

*Mercury occurs naturally in the earth's crust, but human activities, such as mining and fossil fuel combustion, have led to widespread global mercury pollution (EPA, 2024). Natural sources of mercury include volcanic eruptions and emissions from the ocean. Human-caused emissions include releases from fuels, mining, or other industrial processes and mercury contained in consumer products like thermometers, thermostats, and switches.*

*Mercury exposure can threaten human health, with irreversible toxic effects. Developing fetuses and young children are most at risk, but mercury pollution also harms wildlife and ecosystems.*

[7] The Lake Meridian single brown bullhead carcass sample had the highest PFOA method detection limit (MDL) in this study (125 µg/kg, ww). Thus, it is possible this carcass sample had a higher overall PFAS concentration.

was an order of magnitude higher than nearly any other fish (Table 10).

### 3.5.2 Lowest Concentrations

Fish from both Angle Lake and Lake Desire had usually the lowest measured concentrations of organochlorine contaminants. These included the lowest total PCBs (Angle Lake rainbow trout, Table 5), total PBDEs (Angle Lake rainbow trout and Lake Desire yellow perch, Table 6), and total DDTs (Lake Desire yellow perch, Table 7). Angle Lake rainbow trout and Lake Desire yellow perch were also lowest in detected total PFAS (Table 9), and Angle Lake rainbow trout had the lowest detected total Chlordane concentration (Table 8).

Shiner perch from Lincoln Park and Seacrest Park had the lowest mercury values (Table 10), comparatively low total PBDEs concentrations (Table 6), and no detected total Chlordanes or total PFAS[8]. No PFAS were detected in the Lake Desire bluegill sample or the Lake Meridian single bullhead fillet sample[9] (Table 9).

[8] One of the Lincoln Park shiner perch samples had the second highest PFOA MDL in this study (62.5 µg/kg, ww). The MDLs for the other Lincoln Park and Seacrest Park shiner perch samples were relatively low: PFOA MDLs ranged from 5 to 25 µg/kg, ww, PFOS MDLs from 2.5 to 5 µg/kg, ww.
[9] These samples had PFOA and PFOS MDLs of 2.5 µg/kg, ww.

Table 5. Summary of total Aroclor and total homolog PCB concentrations in fish collected from each location.

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Total Aroclors (µg/kg, ww) | | | | Total Homologs (µg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects* (%) | Min | Max | Mean | Detects (%)* |
| Angle Lake | Kokanee | Composite | WB | 6 (3) | 39.6 | 54.5 | 46.9 | 100 | 28.5 | 38.6 | 33.9 | 100 |
| | Rainbow trout | Single Fish | Carcass | 6 (1) | 16.0 | 31.7 | 23.2 | 100 | 9.6 | 18.8 | 14.6 | 100 |
| | | Single Fish | Fillet | 6 (1) | 10.5 | 14.7 | 12.3 | 100 | 5.4 | 10.6 | 7.2 | 100 |
| | | Single Fish | WB | 4 (1) | 12.2 | 17.6 | 15.4 | 100 | 6.9 | 11.5 | 9.5 | 100 |
| | Rock bass | Composite | WB | 1 (3) | 59.2 | | | 100 | 44.1 | | | 100 |
| Green Lake | Brown bullhead and Channel catfish | Composite | WB | 1 (4) | 94.4 | | | 100 | 68.5 | | | 100 |
| Lake Desire | Bluegill | Composite | WB | 1 (6) | 17.8 | | | 100 | 12.3 | | | 100 |
| | Yellow perch | Composite | WB | 6 (4) | 4.0 | 32.3 | 16.1 | 100 | 1.2 | 22.7 | 10.0 | 100 |
| Lake Meridian | Brown bullhead | Composite | WB | 2 (3) | 26.6 | 31.4 | 29.0 | 100 | 17.6 | 18.5 | 18.0 | 100 |
| | | Single Fish | Carcass | 1 (1) | 70.7 | | | 100 | 53.4 | | | 100 |
| | | Single Fish | Fillet | 1 (1) | 58.3 | | | 100 | 40.7 | | | 100 |
| | Yellow perch | Composite | WB | 4 (4) | 24.1 | 36.1 | 28.3 | 100 | 16.6 | 26.6 | 20.0 | 100 |
| Lincoln Park | Shiner perch | Composite | WB | 6 (4 to 5) | 84.1 | 124 | 98.7 | 100 | 80.0 | 118 | 94.3 | 100 |
| Seacrest Park | | Composite | WB | 7 (5 to 7) | 60.9 | 161 | 86.9 | 100 | 55.6 | 157 | 80.5 | 100 |

ww = wet weight, WB = whole body

* Percent of times any chemical within the contaminant group was detected in the samples.

Table 6. Summary of total PBDE concentrations in fish collected from each location

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Total PBDEs (µg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects (%)* |
| Angle Lake | Kokanee | Composite | WB | 6 (3) | 6.55 | 8.74 | 7.91 | 100 |
| | Rainbow trout | Single Fish | Carcass | 6 (1) | 1.21 | 4.30 | 2.75 | 100 |
| | | Single Fish | Fillet | 6 (1) | 0.940 | 2.03 | 1.35 | 100 |
| | | Single Fish | WB | 4 (1) | 1.21 | 2.13 | 1.63 | 100 |
| | Rock bass | Composite | WB | 1 (3) | 9.69 | | | 100 |
| Green Lake | Brown bullhead and Channel catfish | Composite | WB | 1 (4) | 1.88 | | | 100 |
| Lake Desire | Bluegill | Composite | WB | 1 (6) | 4.36 | | | 100 |
| | Yellow perch | Composite | WB | 6 (4) | 0.082 | 4.48 | 1.42 | 50 |
| Lake Meridian | Brown bullhead | Composite | WB | 2 (3) | 5.69 | 7.48 | 6.59 | 100 |
| | | Single Fish | Carcass | 1 (1) | 17.3 | | | 100 |
| | | Single Fish | Fillet | 1 (1) | 10.3 | | | 100 |
| | Yellow perch | Composite | WB | 4 (4) | 5.35 | 7.44 | 6.17 | 100 |
| Lincoln Park | Shiner perch | Composite | WB | 6 (4 to 5) | 1.19 | 1.92 | 1.51 | 100 |
| Seacrest Park | | Composite | WB | 7 (5 to 7) | 1.16 | 2.20 | 1.44 | 100 |

ww = wet weight, C = composite, WB = whole body

* Percent of times any chemical within the contaminant group was detected in the samples.

Table 7. Summary of total DDT concentrations in fish collected from each location

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Total DDTs (µg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects (%)* |
| Angle Lake | Kokanee | Composite | WB | 6 (3) | 10.3 | 14.9 | 13.0 | 100 |
| | Rainbow trout | Single Fish | Carcass | 6 (1) | 3.38 | 7.62 | 5.60 | 100 |
| | | Single Fish | Fillet | 6 (1) | 2.39 | 3.54 | 3.05 | 100 |
| | | Single Fish | WB | 4 (1) | 2.05 | 4.03 | 3.30 | 100 |
| | Rock bass | Composite | WB | 1 (3) | 8.40 | | | 100 |
| Green Lake | Brown bullhead and Channel catfish | Composite | WB | 1 (4) | 26.2 | | | 100 |
| Lake Desire | Bluegill | Composite | WB | 1 (6) | 2.53 | | | 100 |
| | Yellow perch | Composite | WB | 6 (4) | 0.100 | 4.21 | 1.84 | 50 |

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Total DDTs (µg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects (%)* |
| Lake Meridian | Brown bullhead | Composite | WB | 2 (3) | 3.32 | 4.93 | 4.13 | 100 |
| | | Single Fish | Carcass | 1 (1) | 15.5 | | | 100 |
| | | Single Fish | Fillet | 1 (1) | 9.10 | | | 100 |
| | Yellow perch | Composite | WB | 4 (4) | 3.93 | 5.51 | 4.79 | 100 |
| Lincoln Park | Shiner perch | Composite | WB | 6 (4 to 5) | 3.78 | 5.45 | 4.53 | 100 |
| Seacrest Park | | Composite | WB | 7 (5 to 7) | 3.22 | 6.74 | 4.46 | 100 |

ww = wet weight, C = composite, WB = whole body

* Percent of times any chemical within the contaminant group was detected in the samples.

Table 8. Summary of total Chlordane in fish collected from each location

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Total Chlordanes (µg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects (%)* |
| Angle Lake | Kokanee | Composite | WB | 6 (3) | 3.86 | 5.33 | 4.94 | 100 |
| | Rainbow trout | Single Fish | Carcass | 6 (1) | 0.739 | 1.74 | 1.26 | 100 |
| | | Single Fish | Fillet | 6 (1) | 0.067 | 0.990 | 0.594 | 67 |
| | | Single Fish | WB | 4 (1) | 0.067 | 0.734 | 0.234 | 25 |
| | Rock bass | Composite | WB | 1 (3) | 1.60 | | | 100 |
| Green Lake | Brown bullhead and Channel catfish | Composite | WB | 1 (4) | 2.61 | | | 100 |
| Lake Desire | Bluegill | Composite | WB | 1 (6) | 1.81 | | | 100 |
| | Yellow perch | Composite | WB | 6 (4) | 0.0667 | 12.53 | 3.63 | 50 |
| Lake Meridian | Brown bullhead | Composite | WB | 2 (3) | 1.07 | 1.15 | 1.11 | 100 |
| | | Single Fish | Carcass | 1 (1) | 3.06 | | | 100 |
| | | Single Fish | Fillet | 1 (1) | 1.29 | | | 100 |
| | Yellow perch | Composite | WB | 4 (4) | 1.09 | 1.63 | 1.37 | 100 |
| Lincoln Park | Shiner perch | Composite | WB | 6 (4 to 5) | ND (2) | | | 0 |
| Seacrest Park | | Composite | WB | 7 (5 to 7) | ND (0.667) | | | 0 |

ww = wet weight, C = composite, WB = whole body

* Percent of times any chemical in the chemical group was detected in the sample(s).

ND = not detected, i.e., neither of the two chemicals (alpha-Chlordane and trans-Chlordane) in this contaminant group was detected in the sample(s). Highest method detection limit (MDL) for all samples is shown in parenthesis.

Table 9. Summary of total PFAS concentrations in fish collected from each location

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Total PFAS (µg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects (%)* |
| Angle Lake | Kokanee | Composite | WB | 6 (3) | 6.53 | 15.0 | 11.4 | 100 |
| | Rainbow trout | Single Fish | Carcass | 6 (1) | 0.250 | 19.1 | 9.35 | 83 |
| | | Single Fish | Fillet | 6 (1) | 0.250 | 4.27 | 1.43 | 33 |
| | | Single Fish | WB | 4 (1) | 3.19 | 11.25 | 6.36 | 100 |
| | Rock bass | Composite | WB | 1 (3) | 17.8 | | | 100 |
| Green Lake | Brown bullhead and Channel catfish | Composite | WB | 1 (4) | 13.8 | | | 100 |
| Lake Desire | Bluegill | Composite | WB | 1 (6) | ND (2.5) | | | 0 |
| | Yellow perch | Composite | WB | 6 (4) | 0.250 | 4.10 | 1.92 | 50 |
| Lake Meridian | Brown bullhead | Composite | WB | 2 (3) | 5.80 | 7.17 | 6.48 | 100 |
| | | Single Fish | Carcass | 1 (1) | 21.0 | | | 100 |
| | | Single Fish | Fillet | 1 (1) | ND (2.5) | | | 0 |
| | Yellow perch | Composite | WB | 4 (4) | 20.4 | 37.5 | 26.3 | 100 |
| Lincoln Park | Shiner perch | Composite | WB | 6 (4 to 5) | ND (62.5) | | | 0 |
| Seacrest Park | | Composite | WB | 7 (5 to 7) | ND (2.5) | | | 0 |

ww = wet weight, C = composite, WB = whole body

* Percent of times any chemical in the chemical group was detected in the sample(s).

ND = not detected, i.e., neither of the two chemicals (perfluorooctanoic acid [PFOA] or perfluorooctanesulfonic acid [PFOS]) in this contaminant group was detected in the sample(s). Highest method detection limit (MDL) for all samples is shown in parenthesis.

Table 10. Summary of total mercury concentrations in fish collected from each location

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Mercury (mg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects (%)* |
| Angle Lake | Kokanee | Composite | WB | 6 (3) | 0.0769 | 0.0983 | 0.0902 | 100 |
| | Rainbow trout | Single Fish | Carcass | 6 (1) | 0.0126 | 0.0317 | 0.0229 | 100 |
| | | Single Fish | Fillet | 6 (1) | 0.0210 | 0.0370 | 0.0300 | 100 |
| | | Single Fish | WB | 4 (1) | 0.0167 | 0.0359 | 0.0273 | 100 |
| | Rock bass | Composite | WB | 1 (3) | 0.0557 | | | 100 |
| Green Lake | Brown bullhead and | Composite | WB | 1 (4) | 0.0142 | | | 100 |

| Location | Species | Sample Type | Tissue | Number of Samples (Fish/Sample) | Mercury (mg/kg, ww) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | Mean | Detects (%)* |
| | Channel catfish | | | | | | | |
| Lake Desire | Bluegill | Composite | WB | 1 (6) | 0.0415 | | | 100 |
| | Yellow perch | Composite | WB | 6 (4) | 0.0464 | 0.134 | 0.0899 | 100 |
| Lake Meridian | Brown bullhead | Composite | WB | 2 (3) | 0.0187 | 0.0202 | 0.0195 | 100 |
| | | Single Fish | Carcass | 1 (1) | 0.0133 | | | 100 |
| | | Single Fish | Fillet | 1 (1) | 0.0178 | | | 100 |
| | Yellow perch | Composite | WB | 4 (4) | 0.0592 | 0.0903 | 0.0681 | 100 |
| Lincoln Park | Shiner perch | Composite | WB | 6 (4 to 5) | 0.0131 | 0.0240 | 0.0190 | 100 |
| Seacrest Park | | Composite | WB | 7 (5 to 7) | 0.0168 | 0.0237 | 0.0195 | 100 |

ww = wet weight, C = composite, WB = whole body

* Percent of times the chemical was detected in the sample(s).

### 3.5.3 Fillet vs. Remaining Carcass

In this study, we explored differences in contaminant concentrations between matching fillet and carcass samples taken from the same fish. To do this we made samples from the fillet and carcass of a single brown bullhead from Lake Meridian and fillet and carcass samples from six individual rainbow trout from Angle Lake (Table 4). As expected, concentrations of all the detected organic chemicals were lower in the fillet samples compared to the carcass samples (Figure 21). This is because organic contaminants tend to be lipophilic, they are attracted to and consequently become bound to the lipids (fats and oils) in an animal. Differences in concentrations were greatest for total PFAS, with a 98.8% reduction from carcass to fillet for the brown bullhead[10], and an 84.7% mean reduction for the rainbow trout. Reductions from carcass to fillets ranged from 17.5 to 57.7% for the other organic chemicals (PCBs, PBDEs, DDTs and chlordanes). Only mercury concentrations were higher in the fillets compared to the carcasses (not shown) - most likely because mercury has a higher affinity for the amino acid building blocks of proteins than fats. Fillets are nearly all muscle tissue with lower lipid levels than the carcass. Mercury increased by 31% from carcass to fillet in the Angle Lake rainbow trout and by 33.8% for the Lake Meridian brown bullhead.

To reduce organic contaminant exposure from all fish caught in Washington waters, DOH advises removing the skin and visible fat before cooking a fish and eating only the

[10] The Lake Meridian brown bullhead carcass sample had the highest PFOA method detection limit (MDL) in this study (125 µg/kg, ww). Thus, it is possible this carcass sample had a higher overall PFAS concentration.

fillet and no other parts (DOH, 2024).Our results confirm this general recommendation for Lake Meridian and Angle Lake fish. Avoiding the whole body will significantly reduce people's exposure to organic chemicals (especially PFAS) in fish from these locations.

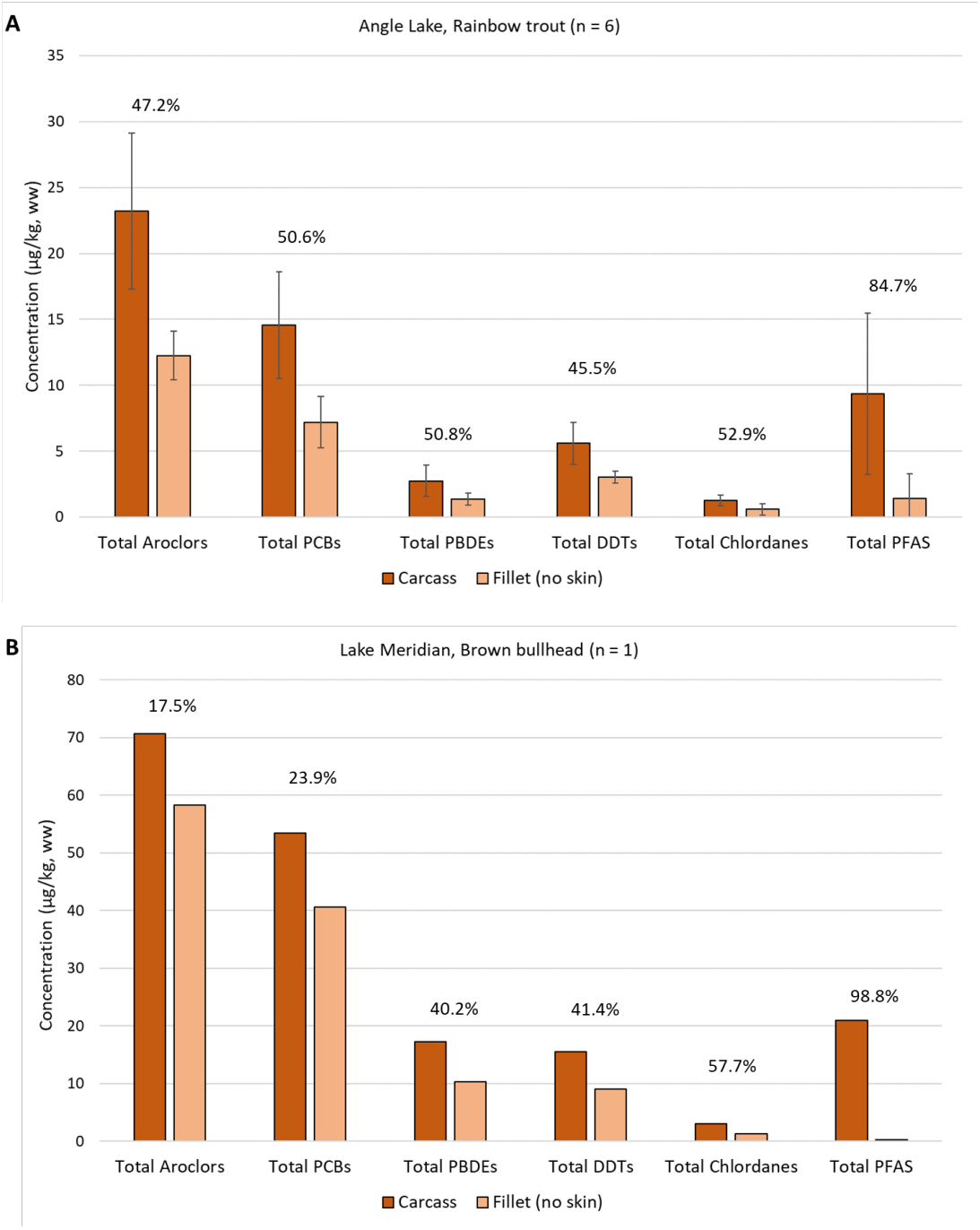



**Figure 21. Differences in chemical concentrations between matching fillet and carcass samples from Angle Lake rainbow trout (A) and Lake Meridian brown bullhead (B). Percent (%) difference from carcass to fillet shown above each matching set of tissues.**

# 4 Screening Level Comparisons

To determine whether any fish consumption recommendations may be warranted based on the results of this study, we compared the fish tissue contaminant concentrations to fish consumption advisory screening levels from the DOH. The screening levels used were established by DOH for issuing fish and shellfish consumption advisories (Table 11; McBride, 2018). The DOH advisories are intended to protect people, including women who are or may become pregnant, nursing mothers, and children from harmful effects due to eating fish from specific waterbodies. The limit on contaminant levels for average consumers can be higher than for high consumers because they eat less fish. High consumers eat more fish and therefore the limit for contaminant concentrations need to be lower to protect them. All advisories provided by DOH are available at this website: Fish Consumption Advisories.

Table 11. Washington DOH reference dose[11] screening levels used for comparison to fish tissue data collected in this study

| Chemical Group | Chemical Name | Screening Level (µg/kg) | |
|---|---|---|---|
| | | Average Consumer | High Consumer |
| Chlordanes | Alpha-Chlordane | 586 | 200 |
| Chlordanes | Trans-Chlordane | 586 | 200 |
| Mercury | Mercury, Total | 0.101 | 0.0343 |
| PBDEs | DecaBDE-209 | 8208 | 2800 |
| PBDEs | HexaBDE-153 | 235 | 80 |
| PBDEs | PentaBDE-99 | 117 | 40 |
| PBDEs | TetraBDE-47 | 117 | 40 |
| PCBs | Total PCBs | 23.5 | 8 |
| Pesticides | 4,4'-DDT | 586 | 200 |
| PFAS | Total PFAS | 23 | 8 |

**Fish from this study were below DOH's screening levels (SL) for all contaminants measured except for PCBs, PFAS, and total mercury.** We summarize the data and findings from the SL comparisons these three contaminants below for the Angle Lake fish, Lake Desire fish, Lake Meridian fish, and for the shiner perch from Seacrest and Lincoln Parks.

For Angle Lake, Lake Desire, and Lake Meridian, where multiple types of fish were caught, we discuss which fish are likely the safer choices for reducing contaminant exposure. Note we can only speak to safer choices amongst the fish caught in each location, not for other species that may reside there. For Green Lake we cannot make comparisons because only one fish was captured. For the two marine areas, Seacrest and Lincoln Parks, only one type of fish was analyzed, and the findings were very similar between locations. For all locations we indicate whether a DOH advisory is already in place for the fish we captured.

[11] The DOH fish consumption advisory screening levels address non-cancer effects of contaminant exposure using established Environmental Protection Agency (EPA) toxicity thresholds called "reference doses" or RfDs. An RfD is an estimate of a daily exposure to the human population, including sensitive subgroups such as children and nursing mothers, that is likely to be without an appreciable risk of harmful effects during a person's lifetime (EPA 2002). The DOH fish consumption advisory screening levels do not address potential carcinogenic (cancer-causing) or mutagenic (genetic mutation-causing) effects of contaminants. Cancer risks are addressed by DOH on a case-by-case basis through a detailed risk assessment which is beyond the scope of this report.

## Angle Lake

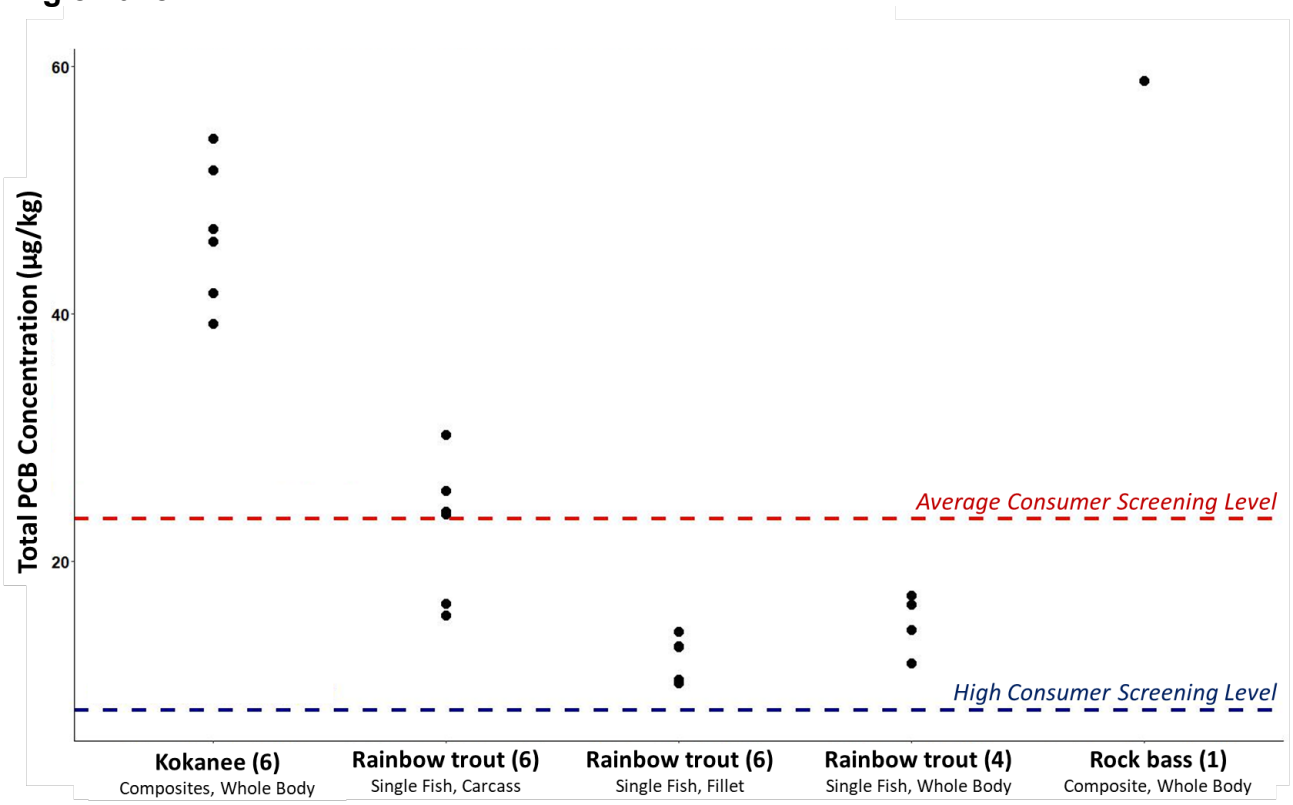



**Figure 22. Total PCBs (as Aroclors) in fish from Angle Lake. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

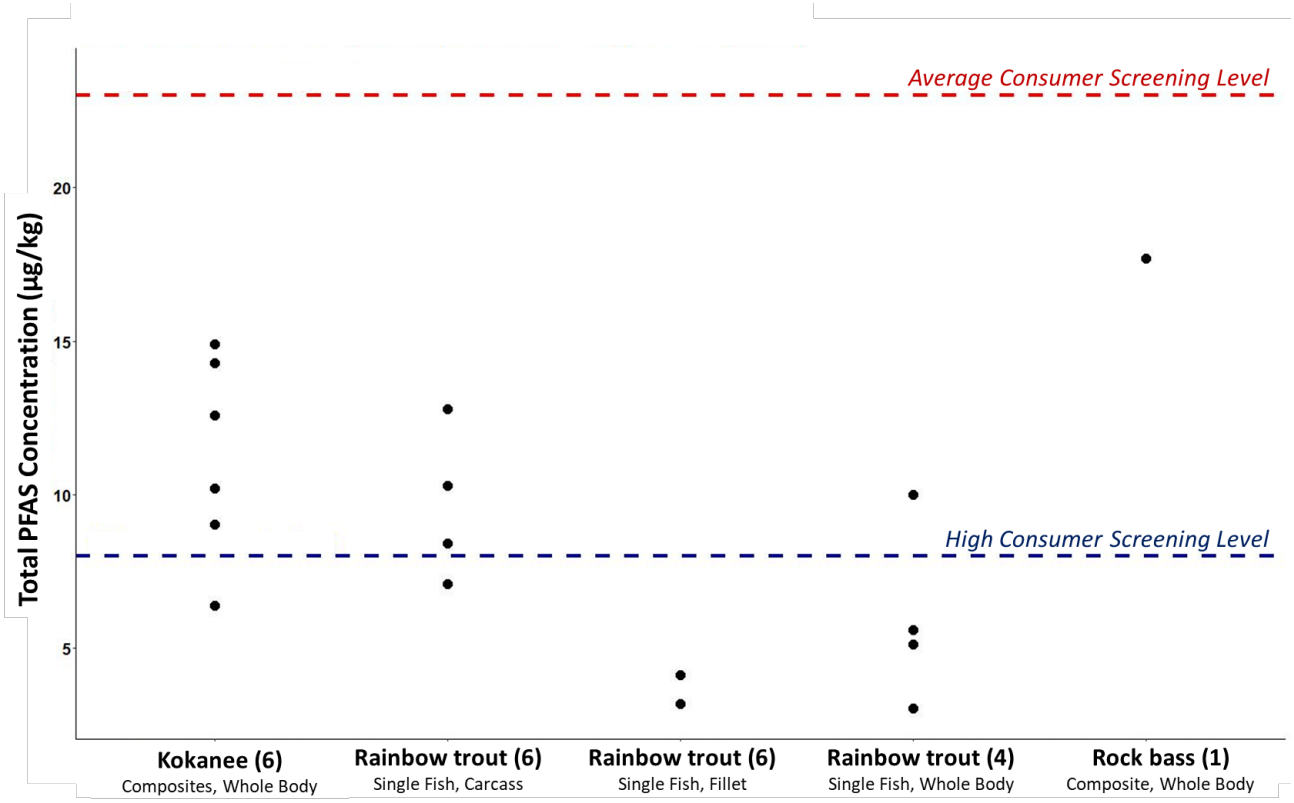



**Figure 23. Total PFAS in fish from Angle Lake. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

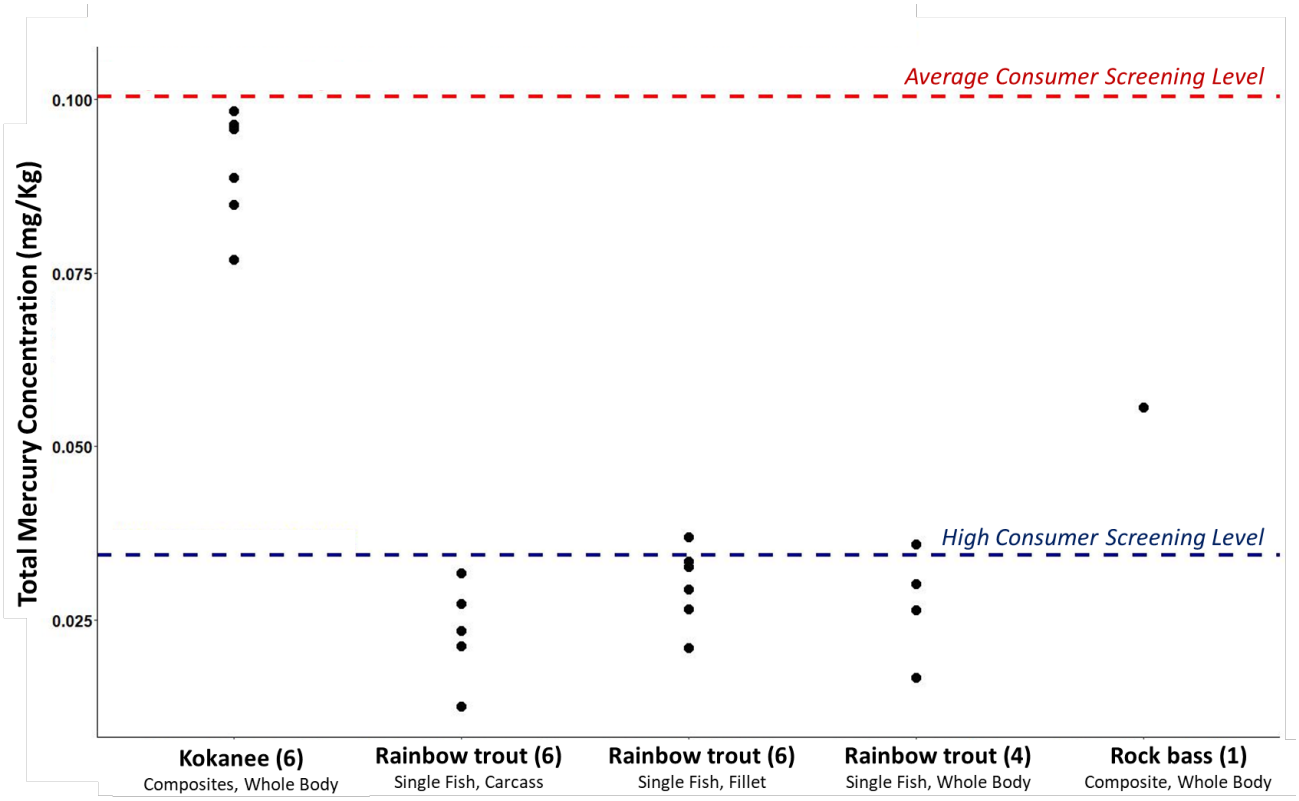



**Figure 24. Total mercury in fish from Angle Lake. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

Based on the SL comparisons in Figures 22, 23, and 24, we would order fish taken from Angle Lake for this study from safest to least safe as follows:

- Rainbow trout (fillet) > Rainbow trout (whole body) > Kokanee (whole body) > Rock Bass (whole body).

We stress that consuming the fillet and discarding the rest of the body is always a safer choice to reduce exposure to organic contaminants. There are currently no DOH advisories on fish from Angle Lake.

## Lake Desire

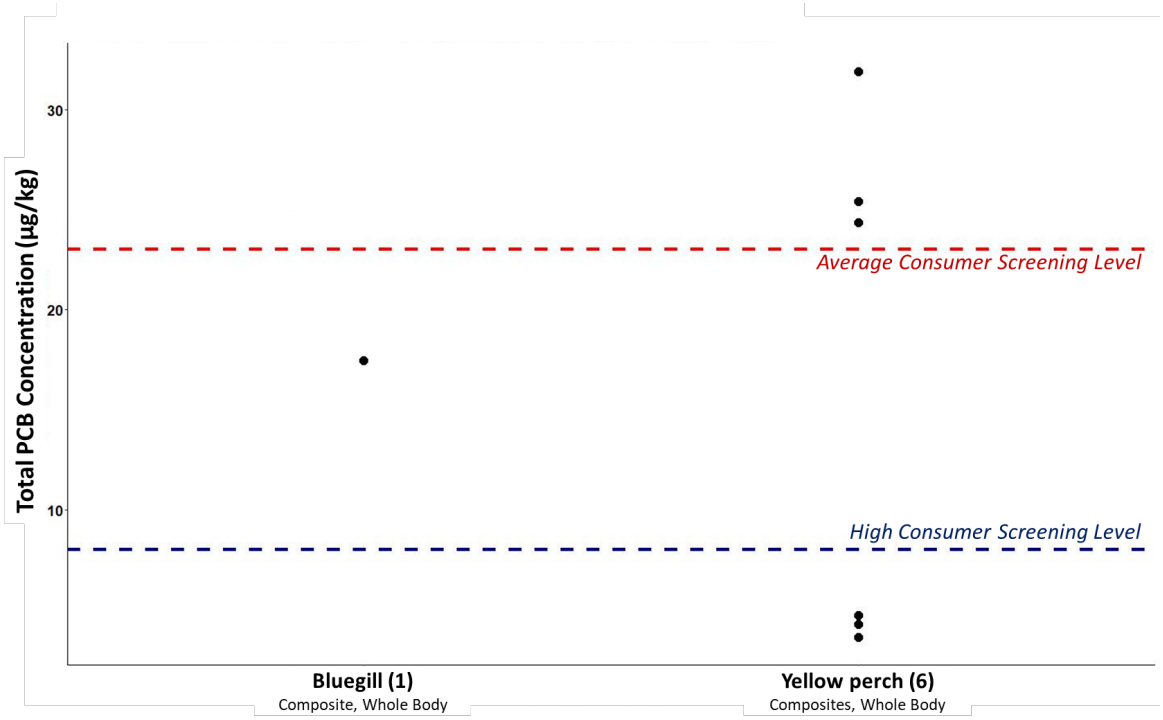



**Figure 25. Total PCBs (as Aroclors) in fish from Lake Desire. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

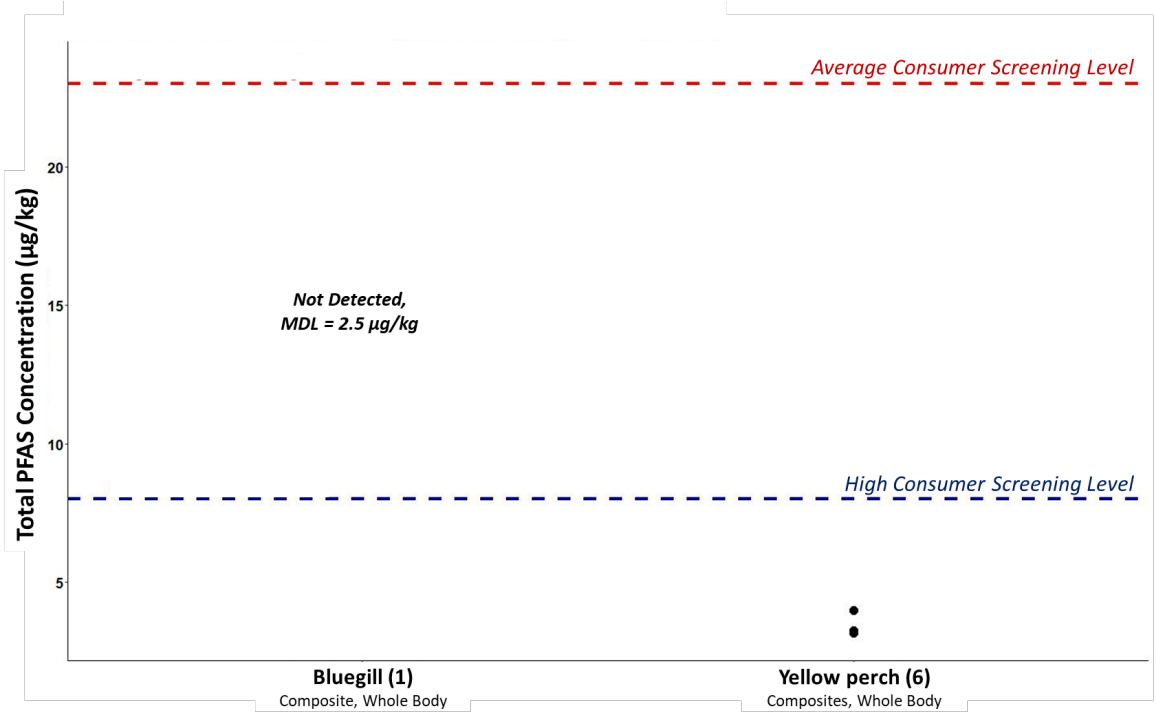



**Figure 26. Total PFAS in fish from Lake Desire. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

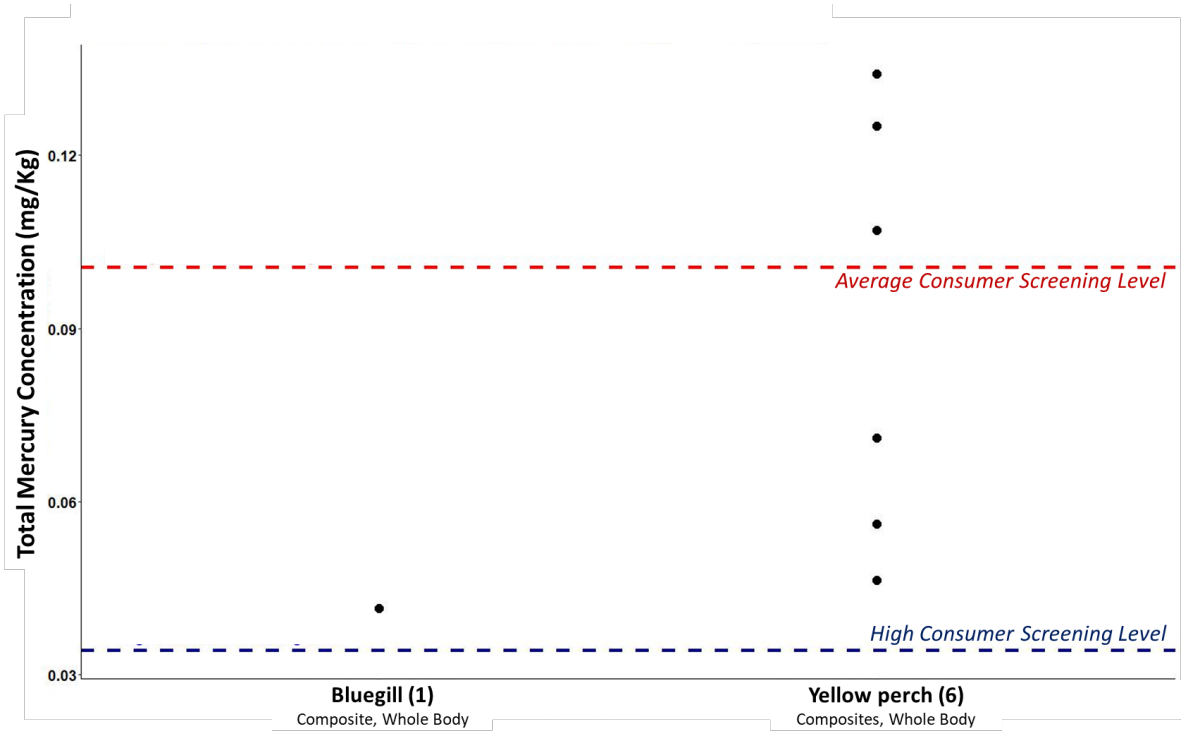



**Figure 27. Total mercury in fish from Lake Desire. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

In Lake Desire, we would order fish from safest to least safe as follows (Figures 25, 26, and 27):

- Bluegill (whole body) > Yellow perch (whole body).

Again, we stress that consuming the fillet and discarding the rest of the body is always a safer choice to reduce exposure to organic contaminants. There are currently no DOH advisories on fish from Lake Desire.

## Lake Meridian

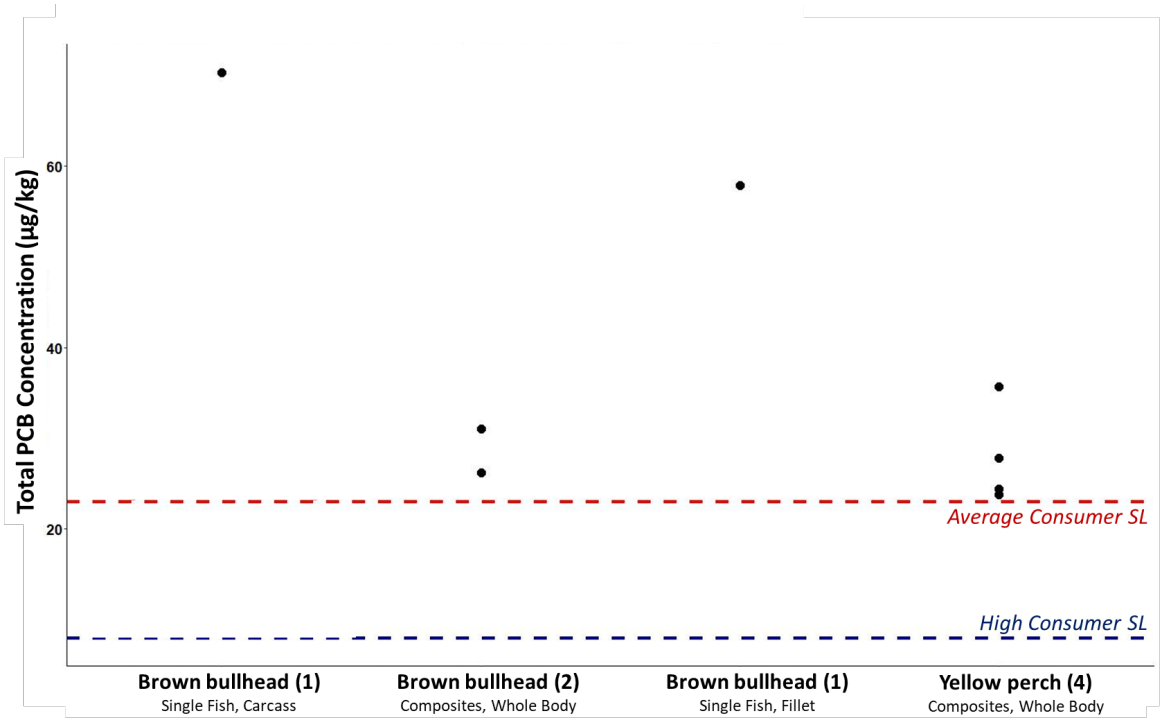



**Figure 28. Total PCBs (as Aroclors) in fish from Lake Meridian. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

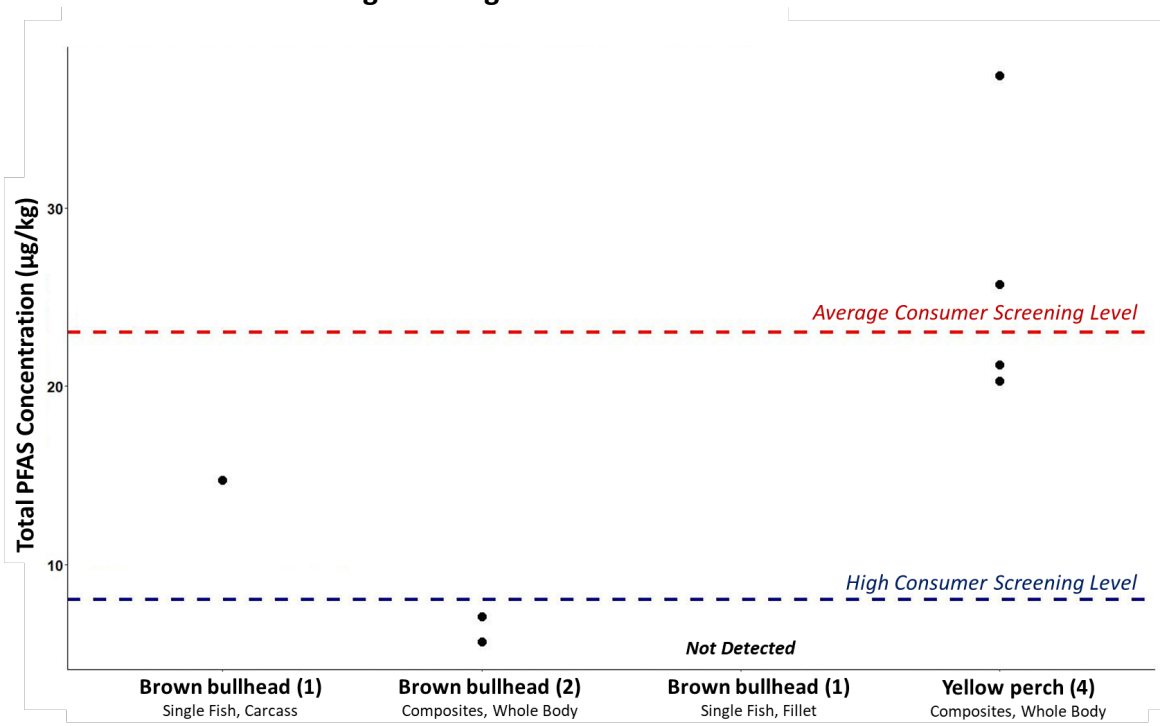



**Figure 29. Total PFAS in fish from Lake Meridian. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

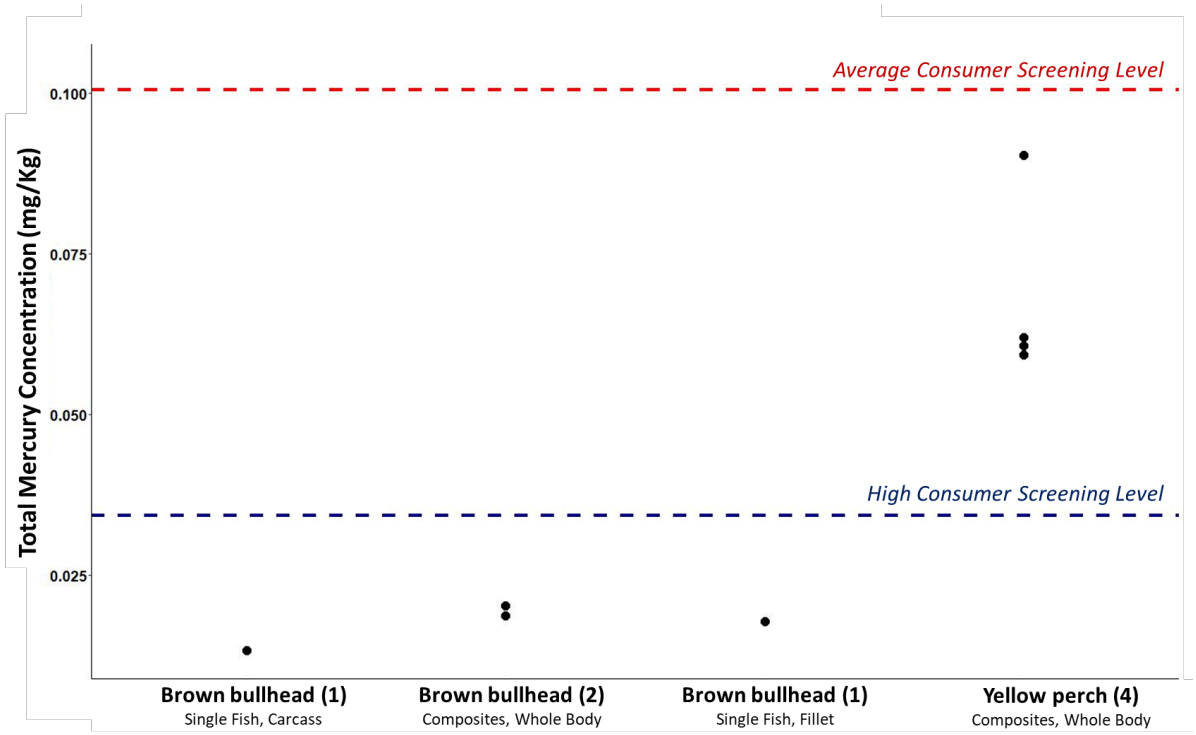



**Figure 30. Total mercury in fish from Lake Meridian. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

Results from Lake Meridian provide mixed messages (Figures 28, 29, and 30). The PCB results indicate the bullhead and yellow perch are of a similar concern as they are both above the average SL (Figure 28). However, based on the PFAS and mercury results, the bullhead appears to be a safer choice than the yellow perch (Figure 29).

There is a DOH advisory in place for Lake Meridian yellow perch based on PFOS, with a limit of up to 1 meal per month (Fish Consumption Advisories in Washington State). The DOH advise for brown bullhead from Lake Meridian is that they are unrestricted (healthy choice).

### Green Lake

A figure for Green Lake is not shown because only one composite sample of brown bullhead/channel catfish was produced. Below are the contaminant concentrations compared to the SLs for this fish:

- Total PCBs = 94 ug/kg (above both high and average consumer SLs).
- Total PFAS = 13.7 ug/kg (above high consumer SL, below average consumer SL).
- Total mercury = 0.0142 mg/kg (below both high and average consumer SLs).

There is currently no DOH advisory on brown bullhead or channel catfish from Green Lake, but there are advisories on common carp and rainbow trout from that location (Fish Consumption Advisories in Washington State).

## Seacrest Park and Lincoln Park

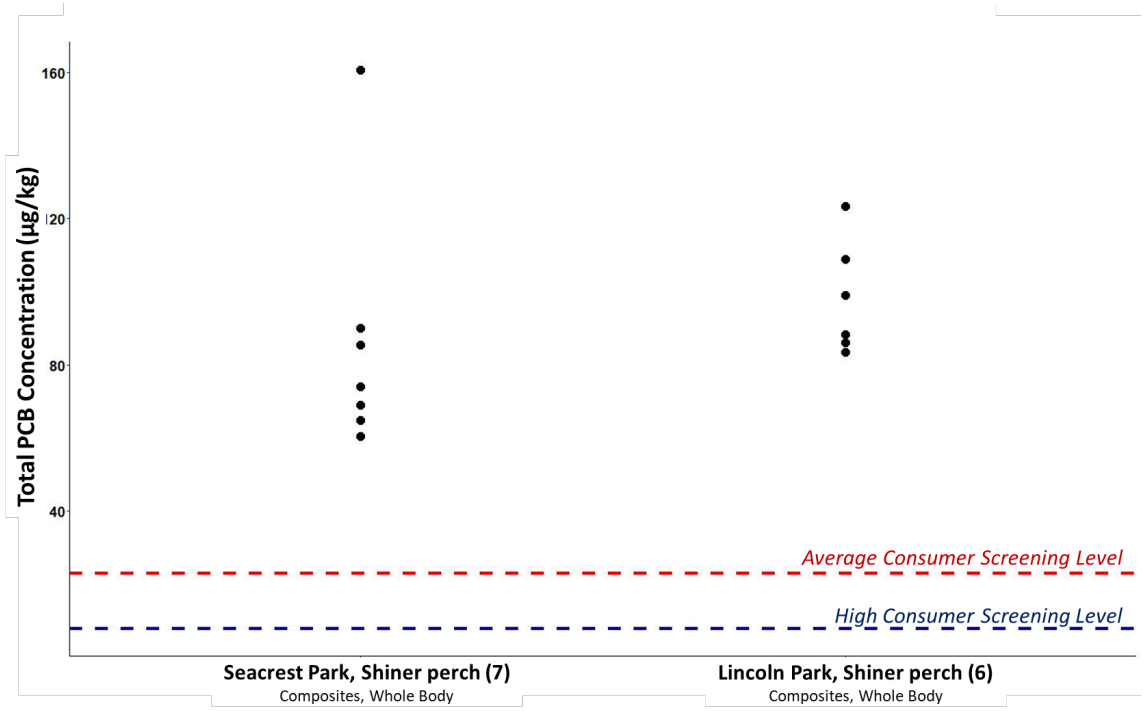



**Figure 31. Total PCBs in shiner perch from Seacrest Park and Lincoln Park. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

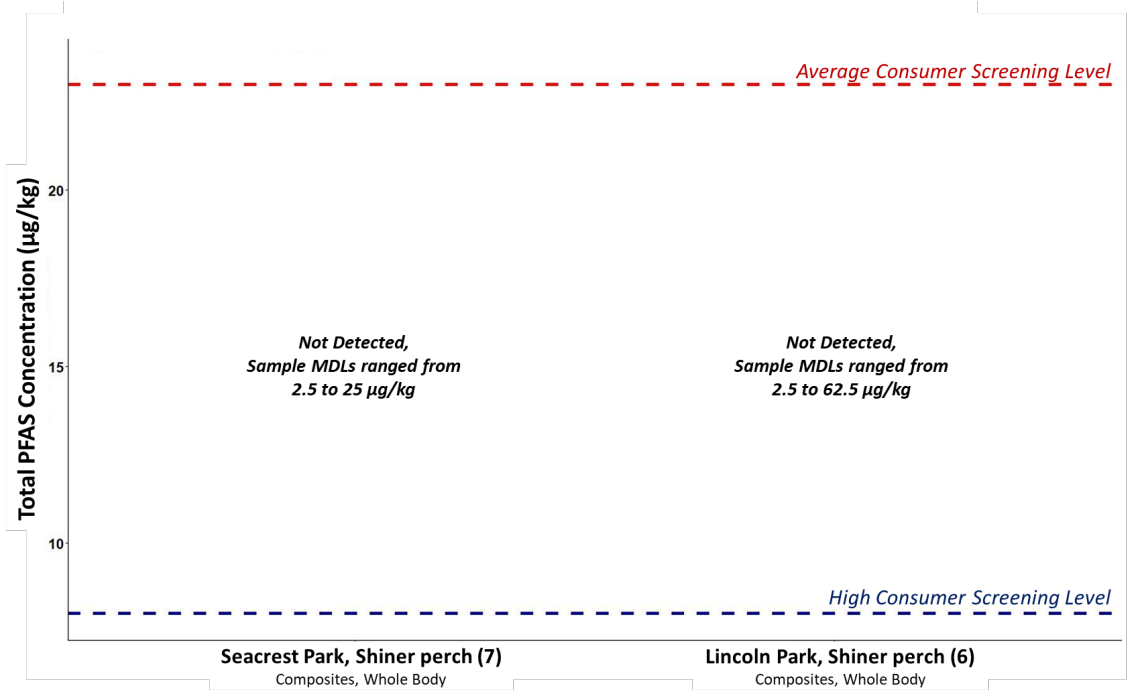



**Figure 32. Total PFAS in shiner perch from Seacrest Park and Lincoln Park. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

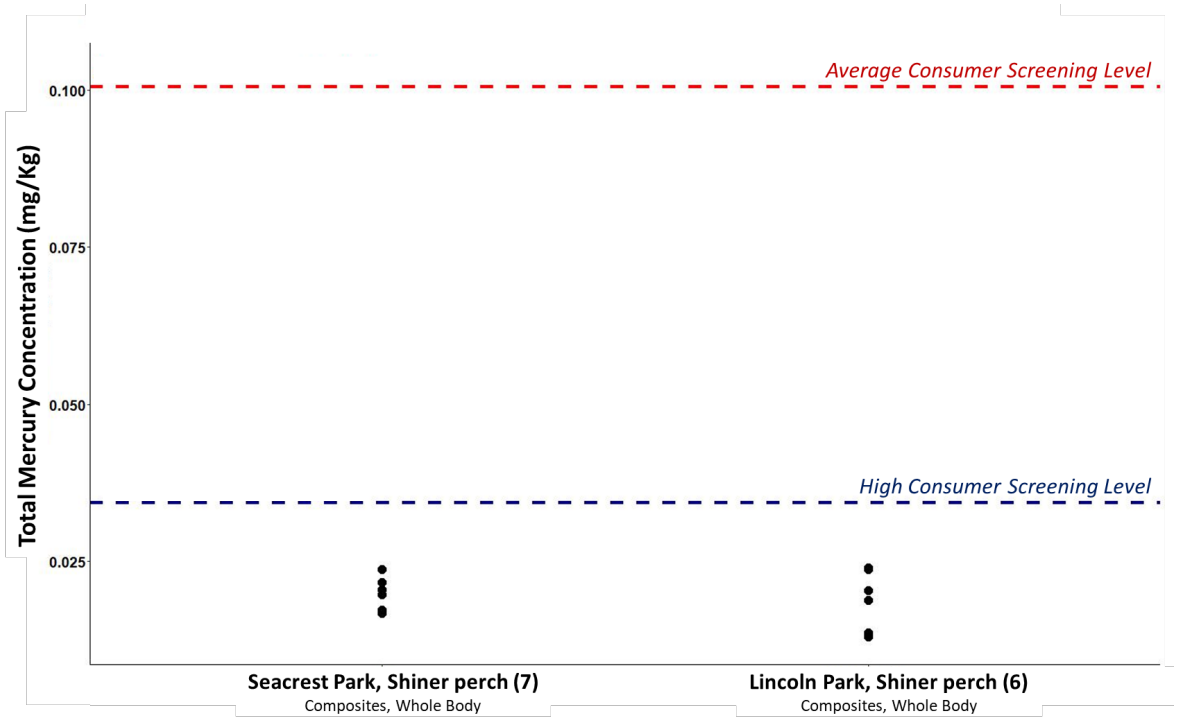



**Figure 33. Total mercury in shiner perch from Seacrest Park and Lincoln Park. The number of samples analyzed for each species is shown in parenthesis after the species name. The DOH screening level for average and high consumers are included for context.**

All the shiner perch samples from Seacrest Park and Lincoln Park had PCB concentrations above both the high consumer and average consumer SLs (Figure 31). However, their total PFAS and total mercury concentrations were below both the high and average consumer SLs (Figures 32 and 33). This data suggest it may be best to avoid consuming shiner perch from Seacrest and Lincoln Parks and choose a different species instead. Fish consumption guidance on several of the species discussed above is provided in the following section (Section 5).

There are currently no DOH fish consumption advisories in place for shiner perch from the area surrounding Seacrest Park, i.e., Marine Area 10, Elliott Bay (Duwamish Head to Pier 91), or the area surrounding Lincoln Park, i.e., Marine Area 10, Entire Marine Area – Seattle-Bremerton Area. There are advisories for other fish and shellfish species from both of those areas, which can be found at DOH's Fish Consumption Advisories in Washington State website.

# 5 Fish Consumption Guidance from King County

There was sufficient data available from the fish sampled in this study for us to develop several fish consumption recommendations, using formulas provided by DOH[12]. For each location, the limits on number of meals per month recommended varies according to the contaminant concentrations in the fish sampled:

- Angle Lake Sockeye salmon/kokanee – 4 meals per month maximum.
- Lake Desire yellow perch – Up to 12 meals per month (caution eating more than 12)[13].
- Lake Meridian yellow perch – 4 meals per month maximum.
- Seacrest Park shiner perch – 2 meals per month maximum.
- Lincoln Park shiner perch – 2 meals per month maximum.

We did not have enough samples to calculate fish consumption recommendations for the other fish collected from the above locations or for the bullhead from Green Lake. Currently, DOH prefers to have data on 25 fish (ideally 5 composites of 5 fish each) available for their meal recommendation calculations to provide as robust an estimate of the average contaminant concentration as possible. Our study was unable to achieve this in many cases. In the past, the Office of Environmental Public Health Sciences, Environmental Public Health Division, Washington State Department of Health advised if fish data were limited, we should use 15 fish as the minimum number for a meal calculation. Our recommendations above always met this lower data availability standard.

## 5.1 Healthy Fish-Eating Recommendations flyer

We worked with PHSKC, DOH, and the RFSC to develop culturally appropriate fish advisory messaging to communicate the fish consumption recommendations based on this study. The result was a two-sided 11x17-inch flyer produced by TCA/King County and titled *Healthy Fish-Eating Recommendations from King County* (King County, 2024b; Appendix C). The flyer includes recommendations for the fish and locations listed above, as well as consumption recommendations for other freshwater fish and marine fish and shellfish that have been collected as part of King County's long-term fish monitoring program. The flyer was produced in English and translated into nine languages (Burmese, Ilocano, Karen, Khmer, Khmu, Laotian, Spanish, Tagalog, Vietnamese) for distribution to the immigrant and refugee fishing community of King County. Languages chosen for translation were based on ethnicities reported on the fisher survey and advice about community needs from our partners at the RFSC.

[12] The fish tissue chemistry data, calculations, and our subsequent recommendations were reviewed by Emerson Christie, Toxicologist at the Office of Environmental Public Health Sciences, Environmental Public Health Division, Washington State Department of Health.

[13] Based on the tissue samples collected in this study, consuming more than 12 meals per month of yellow perch from Lake Desire may result in PCB contaminant exposure exceeding the DOH advisory screening levels.

We used formulas provided by DOH to calculate the fish consumption recommendations on the flyer. We received preliminary review of the data and recommendations to Emerson Christie, Toxicologist at the Office of Environmental Public Health Sciences, Environmental Public Health Division, Washington State Department of Health. We also worked with him to determine flyer language that was accurate, consistent, and within the bounds of our authority. We also met with staff from PHSKC to review the recommendations and wording for the flyer. Though the data and recommendations for this King County-produced flyer were reviewed by DOH, they are not the same as DOH fish advisories. DOH plans to review the data further and may issue similar or different advisories in the future regarding the fish from these locations. A disclaimer to this effect is included on the *Healthy Fish-Eating Recommendations from King County* flyer (Appendix C).

## 5.2 Presentation at RFSC Community Meeting

On September 21, 2024, TCA presented the *Healthy Fish-Eating Recommendations from King County* flyer to the fishers, their families, and local leaders from their communities at a meeting hosted by the RFSC at the Duwamish Community Hub in Seattle, Washington. We provided an overview of the project tasks and goals, shared our findings and recommendations, including hard copies of the flyer, and acknowledged the fishers' partnership in the research. The RFSC provided five interpreters at the meeting who translated the presentation simultaneously to about 45 attendees of all ages. Fish and fishing are important to the diets and cultures of the attendees, and they were very engaged and eager to hear the findings; to learn how to make safer choices for themselves and their families; and how the data might influence the health of others in their communities.

After our presentation, we answered questions from the audience, heard additional community needs, and discussed ideas for how we can work together to distribute the recommendations even more broadly. One fisher asked if we could provide digital copies of the *Healthy Fish-Eating Recommendations from King County* flyer in all the available languages. Though we had planned to post the digital versions to our King County website, he asked us to send the files directly to them (i.e., the fishers and RFSC), so they could share them on their own social media networks. As one fisher told us, "Nobody I know is looking at King County's website, but they all read what I post on Facebook."

In addition to digital versions of the flyer, we heard from the audience that physical copies are still very important to have available for people without phones or computers, for people who cannot read, for older people, and for those who get information at community centers, churches, grocery stores, or by word of mouth. We also heard that in-person gatherings like the meeting we were having are reliable and effective ways to reach community members who are not on computers or cell phones. In the days after the community meeting, we shared digital copies of the flyers with the RFSC and provided 100 print copies of it in each of the 10 languages for distribution to their extended in-person networks.

# 6 Discussion

Our work together with the RFSC and community fishers on the *Refugee/Immigrant Communities Water Quality Education and Fish Sampling Project* is a good example of how partnerships between government and community groups can be mutually beneficial. It provided valuable information to King County about how different ethnic groups catch and eat fish and allowed us to make targeted recommendations to benefit the health of historically underserved communities.

## 6.1 Survey of Community Fishers

From the fisher survey we gained some valuable insights into the fishing habits of immigrant and refugee communities in King County. We learned the fishers come from a variety of ethnic groups and that the most popular places for fishing amongst these communities included locations already sampled by our tissue monitoring program (i.e., Lakes Washington and Sammamish, the Green and Cedar Rivers, and Elliott Bay). However, a number of other popular King County fishing locations identified through the survey are not currently monitored (i.e., Green Lake, Lakes Meridian, Angle, and Desire, Des Moines beach, Lincoln Park beach, and Dash Point State Park) (Section 2.2.3, Table 2). These data point to geographical gaps that will be useful to consider as we revise our tissue monitoring program.

The fisher survey also identified popular fishes targeted in the immigrant and refugee communities of South King County, and how they are shared and prepared for consumption. Popular fish species included some that we regularly monitor, like bullhead, bass, and yellow perch, as well as some not currently monitored, like rainbow trout, various salmon species, and marine perch. The survey also revealed strong community interest in shellfishing, including for crab, squid, and a variety of marine bivalves, like clams, mussels, and oysters. The fishers reported sharing their catch mostly with friends, and a large proportion typically consume the entire fish they catch. Many fishers also reported consuming the non-meat parts of crabs (i.e., crab guts or “crab butter”). This is of particular concern given that most fish consumption advisories are based on contaminant concentrations in fillets (see discussion below).

## 6.2 Fish Sampling Pilot

Four freshwater locations were successfully sampled for this project, including Green Lake, Angle Lake, Lake Desire, and Lake Meridian. Freshwater fish species caught and analyzed included yellow perch, bullhead, kokanee, rainbow trout, rock bass, and bluegill. Seacrest Park and Lincoln Park, two saltwater locations, were also successfully fished for shiner perch. Of the chemicals analyzed, PCB concentrations were the highest, though DDTs, PBDEs, chlordanes, PFAS, and mercury were also detected in the fish.

We compared chemical concentrations between fillets and the remaining carcasses from several fish collected in Lake Meridian and Angle Lake. In all cases,

concentrations of PCBs, PBDEs, DDTs, chlordanes, and PFAS were higher in the carcasses compared to the fillets, in some cases by as much as 99%. This information is particularly relevant for the communities targeted by the fisher survey. The survey revealed almost two thirds of immigrant and refugee fishers reported eating the whole body of their catch, and that they are sharing/consuming those whole fish with their friends, their parents or elders, and their own children. We believe this information highlights the need to potentially expand what is considered the fish parts evaluated when developing fish consumption recommendations or advisories, especially for these traditionally underserved communities.

## 6.3 Comparison to Screening Levels and Fish Consumption Guidance

We compared the contaminant concentrations of fish caught in this project to DOH's fish consumption advisory screening levels. Our comparison revealed that fish from several of the waterbodies sampled are of potential concern to human health. There was sufficient data available from the pilot fish collection to develop fish consumption recommendations for the following locations and fish:

- Angle Lake, Kokanee – 4 meals per month, maximum.
- Lake Desire, Yellow perch – up to 12 meals per month (caution eating more than 12).
- Lake Meridian, Yellow perch – 4 meals per month maximum.
- Seacrest Park, Shiner perch – 2 meals per month maximum.
- Lincoln Park, Shiner perch – 2 meals per month maximum.

We recommend returning to the locations where we didn't get adequate samples to make meal recommendation calculations to collect more samples and determine whether more fish consumption recommendations are warranted.

We worked with PHSKC, DOH, and the RFSC to develop culturally appropriate fish advisory messaging based on data from this pilot fish collection project. The result was a flyer produced by King County and entitled *Healthy Fish-Eating Recommendations* (King County 2024b, Appendix C), produced in English, and translated into nine languages. The flyer includes recommendations for the fish shown above as well as consumption recommendations for *other* species collected from TCA's long-term fish monitoring program (data not shown in this report but available upon request)[14].

We successfully presented the project findings and the fish consumption recommendations via the flyer to the fishers, their families, and local community leaders at a meeting held by the RFSC in September 2024. We look forward to nurturing these relationships further in the future, possibly through more community meetings and/or new research projects together.

[14] Though the data and recommendations for this King County-produced flyer were reviewed by DOH, they are not the same as DOH fish advisories. The DOH plans to review the data further and may provide additional guidance in the future regarding the fish from these locations. A disclaimer to this effect is included on the flyer.

## 6.4 Lessons Learned and Next Steps

The following insights and recommendations came during and after the planning and execution of this project:

- **Fisher Survey** - We were not able to connect the locations fishers fished with which species they caught at each location. In other words, we asked the question about locations separately from the question on species fished. Next time we would design the survey so that fishers can specify which species they caught in the specific locations they fished. This would provide us more valuable information about fishing preferences and success in King County.
- **Fish Sampling Pilot** - The fishers were instructed by us to target Alki Beach (a large beach in West Seattle) as a priority fishing location for this fish sampling project based on survey results. However, Alki Beach was not sampled as originally intended because when fishing was completed and when we asked the fishers to show us the specific location where they fished at Alki Beach, they indicated Seacrest Park as their fishing location. In the future, it would be helpful to clarify the fishing locations with the fishers more clearly and confirm where they would fish ahead of time, particularly if the target fishing area is large. In addition, it would be helpful to more closely monitor the actual locations fished during the course of the fishing period to improve match between study design and execution.
- **Fish Consumption Guidance** - For fish at several locations there were too few samples for the meal recommendation calculations. The rock bass samples and some of the rainbow trout samples from Angle Lake were above the average consumer SL for PCBs, which suggests a human health hazard for consumption of those fish. However, we did not have enough samples to make robust meal recommendations for those fish. In addition, bullhead from both Green Lake and Lake Meridian were above the average consumer SL for PCBs, but we also did not have enough samples to make meal recommendations. We recommend additional fishing at Angle Lake, Green Lake, and Lake Desire within the next five years to allow for more meal recommendations protective of human health in those locations. All three of these lakes are stocked by WDFW and harmonizing future monitoring with these fish planting efforts is also recommended.

### Improving our monitoring program

In the past, we have focused our monitoring efforts on the largest lakes and rivers in King County, assuming they provide many recreational fishing opportunities to people in our County. However, our knowledge about where people fish and what they eat, particularly fishers from immigrant and refugee communities in King County, including Black, Indigenous, or other people of color, is limited. There is some data available about three fish consumption surveys King County supported between 1997 to 2003 at locations in Lake Union, Lake Washington, Lake Sammamish, the Duwamish River, Elliott Bay, and two marine areas north of Shilshole Bay (Mayfield et al. 2007). However, their report indicated that a majority of the respondents in those surveys were Caucasian (30–71%). Though at least one of the surveys was translated into other languages (Vietnamese, Korean, and Filipino), the interviewers spoke only English. There was a fisher survey conducted in 2014 as part of the Lower Duwamish Waterway

(LDW) Superfund cleanup effort (Windward 2016). It specifically targeted people who either harvest or consume seafood from the LDW. The survey was conducted via interviews and self-administered questionnaires available in English, Korean, Chinese, Spanish, Tagalog, and Vietnamese. In addition, the interviewers “spoke the languages and were from the communities of many of the fishers who were encountered along the Duwamish” (Windward 2016). Though the 2016 survey provided valuable information about how local people use the LDW for fishing and what they do with their catch, it was limited to the LDW.

This project provided valuable new data on the King County-wide fishing habits of refugee and immigrant residents living in Seattle and South King County, especially those from Asian and Pacific Islander communities. Our survey provides evidence that fishers are using a number of smaller lakes and marine areas in King County not covered in previous surveys. We will use this information to make improvements to our contaminant monitoring program. However, we recognize that more information is still needed on the fishing habits of other underserved communities in King County, including those with Black, Indigenous, other people of color, and other ethnic communities that were not well represented by our survey.

This project is our first effort at community engagement with an eye towards establishing relationships with communities that could benefit from the data we collect. It has provided valuable input from and involvement with communities that have been disproportionately impacted by pollution in King County. For instance, early on in our partnership on this project, RFSC staff told us that immigrant and refugee community fishers in King County are interested in learning safer places to fish and which types of fish are safest to feed their families. This project allowed us to start answering these kinds of questions. Based on data collected from this study and other relevant information, we are revising the locations and fish represented in our long-term tissue monitoring program to make it more equitable and to provide contaminant information useful to more King County fishers.

# 7 Acknowledgements

This project is funded in part by the King County Wastewater Treatment Division.

We thank Sophorn Sim and the staff of the RFSC, including Veda Ting, Kevin Duong, Rath Lay, Floyd Davis, Ngy Hul (Ed), and Rathida Phimveingham for their work organizing the fisher training workshop and the fishing expeditions, for their valuable feedback during development of the *Healthy Fish-Eating Recommendations* flyer, and for organizing the community meeting. Thanks also to RFSC community partners including Emma Maceda Marla (Latinx community), Tracie Friedman (Lao and Khmu communities), Hi Taw Paw (Karen/Burmese community), Maramy Mohamathno (Cham community), Kevin Duong (Vietnamese community) and Rath Lay (Khmer community). And special thanks to the fishers: Rath Lay, Kloem Phon, Sean Phuong, Rattana Huong, José Carlos, Noé Caceres, Phat Oum, and Neng Kinkason.

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Thanks to King County staff Saffa Bardaro, Mary Rabourn, Josh Latterell, and Michelle Green for feedback on the flyer. Thanks to King County's Ken Christensen for interviews and video footage during the summer of fishing and the community meeting. Thanks also to Elizabeth Loudon from the King County Wastewater Treatment Division.

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Thanks to current and former TCA staff for their review and help on this report and on the flyer: Jenée Colton, Chelsea Mitchell, Carly Greyell, and Samreen Siddiqui.

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# Appendix A – Community Fisher Survey

**Dear Participant - Thank you for participating in this quick survey. Please complete and return it to RFSC staff.**

**The purpose of this survey is to gather information about where people fish locally, what types of fish and shellfish are being caught, and consumption practices in King County and nearby areas. There are no right or wrong answers. Please answer as best you can. We will not take your personal information and your responses will be kept confidential. To thank you for your time, you will receive a $15 gift card after completing this survey.**

**Please answer all questions. Mark an X in the appropriate box or fill in the blanks.**

1. Which age group are you in?
   - ☐ 18 - 34 yrs old
   - ☐ 35 - 44 yrs old
   - ☐ 45 - 55 yrs old
   - ☐ 55 yrs and older

2. What is your ethnicity? Choose all that apply.
   - ☐ Bhutanese
   - ☐ Burmese
   - ☐ Cambodian/Khmer
   - ☐ Chinese
   - ☐ Filipino
   - ☐ Hmong
   - ☐ Indian
   - ☐ Japanese
   - ☐ Korean
   - ☐ Lao
   - ☐ Latino
   - ☐ Mienh
   - ☐ Mongolian
   - ☐ Samoan
   - ☐ Thai
   - ☐ Vietnamese
   - ☐ Other: _____

3. What is your primary language? _____

4. Who do you share your catch with:
   - □ Women who are pregnant or breast feeding
   - □ Friends
   - □ Parents/Elders
   - □ Children

   Others: _____

5. What city do you live in and what is your zip code?

   _____

6. Where do you commonly go to catch fish/crab/shrimp/clams? Look at the map and circle the location(s). You can also Refer to the poster if needed.

(Picture of king county map) (smaller maps that are detailed)

7. What time(s) of the year do you go fishing/crabbing/shell fishing? Circle your answers.
   Season: winter spring summer fall

   Month: Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

   Circle how many hours in a day you typically spend fishing:
   0-2 2-4 4-8 More than 8

8. How many different places have you tried to catch fish in the last month? ("Different places mean fishing locations on the same or different lake/river/marine area that are more than easy walking distance apart").
   0 1 2 3 4 5 6 7 8 9 10 More than 10

9. Do you throw any catch back into the water?

   □ Yes □ No
   Why?_____
   _____
   _____
   _____
   _

10. How often does **your household eat fish or shellfish** caught by you or someone you know? You can provide a general estimate.
    - □ More than 12 meals per month
    - □ 8-12 meals per month
    - □ 1-4 meals per month
    - □ Never

*11.* Point to your typical fish/shellfish meal size? How big is it? (show picture of portion size palm) – *[Author's note - see Figure 10 in Section 2.2.6 of report for picture of portion size palm used for this survey.]*

- ■ _____

*12.* What are the **common types of fish or shellfish** you catch that you cook and eat at

home? If you don't know the name of the fish, please refer to the pictures – *[Author's note - pictures provided below survey in this Appendix.]*

13.

**Fish caught from local waters:**

1. _____
2. _____
3. _____
4. _____
5. _____

**Shellfish harvested from local waters:**

1. _____
2. _____
3. _____
4. _____
5. _____

14. Do you harvest any aquatic plants to eat? Circle all that apply.
    - Seaweed
    - Freshwater plants

15. How does your household commonly prepare your fish or shellfish to eat? Check all that apply.

| | | |
|---|---|---|
| □ Pan fry | □ Deep fried | □ Grill |
| □ Bake | □ Broil | □ Steam |
| □ Soups | □ Stew | □ Dry (dry fish) |
| □ Ferment | □ Eat raw | □ Other: _____ |

16. What parts of the fish does your household commonly eat? Check all that apply.

□ Whole fish (with skin) □ Fillet only (no skin, no head or organs)
□ Fish head (in soups or other dishes) Other: _____

17. What parts of the crab does your household commonly eat? (the green guts are also called the "crab butter")

□ Crab meat (without guts) □ Crab meat with guts

16. Are there shellfish you catch that you do not eat whole (except the shell)? If so, please name the shellfish:

_____
_____
_____

For shrimp, circle the part(s) you eat: head body shell

# FRESHWATER FISH



**Bass**



**Catfish**



Cutthroat Trout



**Black Crappie**



Brook Trout



**PumpkinSeed-Bluegill**



Rainbow Trout - Steelhead



**Trout/Salmonids**

**Yellow Perch**

# FRESHWATER FISH



Common Carp



Largescale Sucker

Photo credit: JoesephTomalleri

## Carps/Suckers



N. Pikeminnow



Peamouth

Photo credit: Pikeminnow.org

## Minnows



Pink



Chinook



Coho



Sockeye

## Salmon (River Phase)



Photo credit: WDFW

## Mountain Whitefish



## Rock Bass

Photo credit:
The Columbian
Associated Press



## Lamprey

# SALTWATER FISH



Cutthroat



Cabazon



Greenling



Lingcod



Hake



Skate

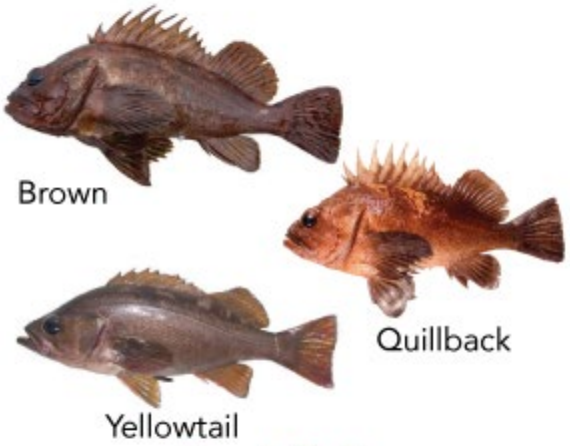


Dogfish

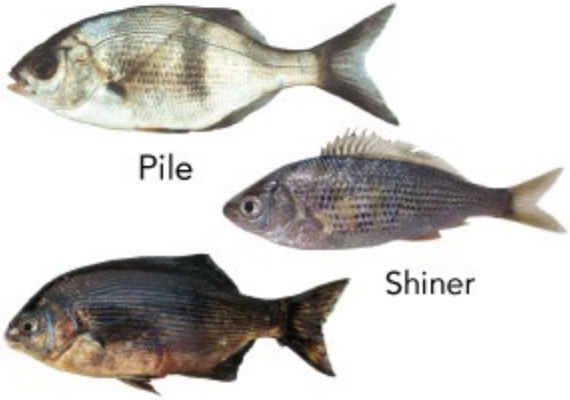
# SALTWATER FISH



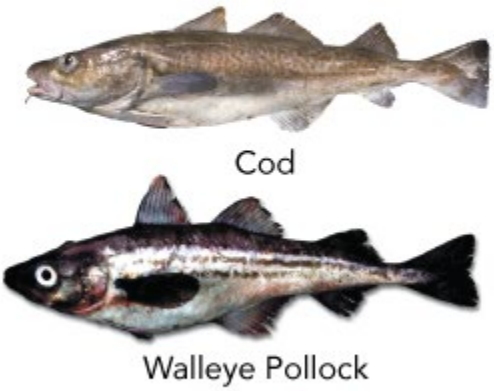

## Salmon



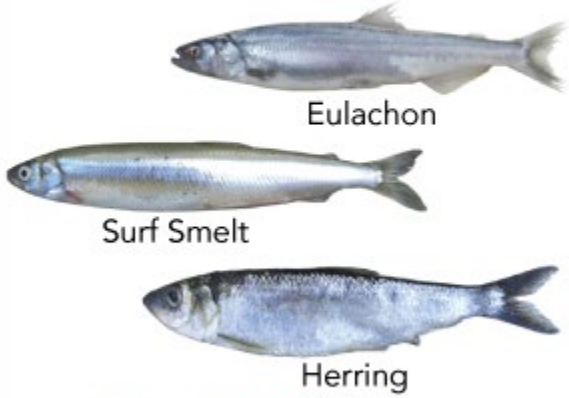

## Rockfish




## Perch




## Whitefish

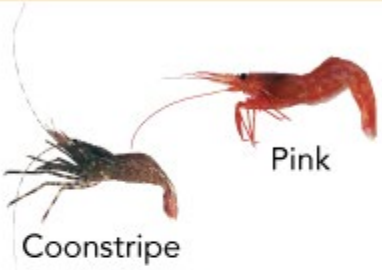



## Small Schoolers

# SHELLFISH/SEAWEED



## Crawfish/Crayfish




## Shrimp



## Geoduck













## Clams



Photo credit: Mike Carey, published by Digital Anglers LLC

## Squid



Dungeness



Red Rock Crab

## Crab

# SHELLFISH/SEAWEED



Photo credit for Mussels - Emily Carrington

## Mussels

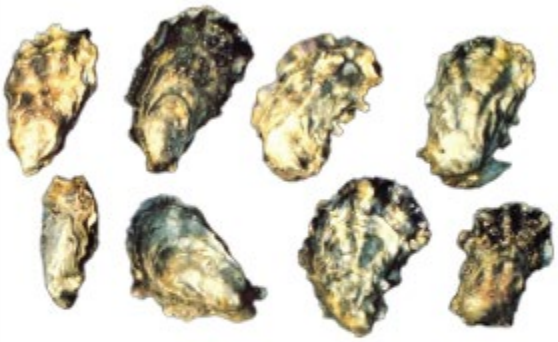


Photo credit: WADNR

## Oysters

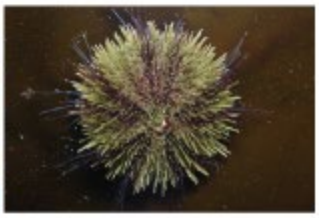


Photo credit: Gabriel Lascu

## Sea Cucumber



Purple
Photo credit: Kurt L. Onthank



Green
Photo credit: Hannah Robinson

## Sea Urchins



Photo credit: Dennis Paulson

## Snails



Photo credit: Cinda Chavich, published by Page One Publishing Inc.

## Seaweed

# Appendix B – Number and Type of Contaminants Analyzed

Below are the contaminant groups and specific chemicals analyzed in fish tissues for the fish sampling pilot collection project.

Table 12. Major contaminant groups analyzed

| Contaminant Group | Chemical Name |
|---|---|
| PCBs (as Aroclors) | Aroclor 1016 |
| | Aroclor 1221 |
| | Aroclor 1232 |
| | Aroclor 1242 |
| | Aroclor 1248 |
| | Aroclor 1254 |
| | Aroclor 1260 |
| PCBs (as homologs) | Monochlorobiphenyls |
| | Dichlorobiphenyls |
| | Trichlorobiphenyls |
| | Tetrachlorobiphenyls |
| | Pentachlorobiphenyls |
| | Hexachlorobiphenyls |
| | Heptachlorobiphenyls |
| | Octachlorobiphenyls |
| | Nonachlorobiphenyls |
| | Decachlorobiphenyl |
| PBDE congeners | TriBDE-17 |
| | TriBDE-28/-33 |
| | TetraBDE-47 |
| | TetraBDE-66 |
| | TetraBDE-71 |
| | PentaBDE-85 |
| | PentaBDE-99 |
| | PentaBDE-100 |
| | HexaBDE-138 |
| | HexaBDE-153 |
| | HexaBDE-154 |
| | HeptaBDE-183 |
| | HeptaBDE-190 |
| | DecaBDE-209 |
| | Heptachlor Epoxide |
| PFAS | PFOA (Perfluorooctanoic acid) |
| | PFOS (Perfluorooctanesulfonic acid) |
| Metals | Total Mercury |

Table 13. Organochlorine pesticides analyzed

| Pesticide Group | Chemical Name |
|---|---|
| Benzene hexachorides (BHCs) | Alpha-BHC |
| | Beta-BHC |
| | Delta-BHC |
| | Gamma-BHC (i.e., Lindane) |
| Chlordanes | Alpha-Chlordane |
| | Trans-Chlordane |
| DDTs | 4,4'-DDD (Dichlorodiphenyldichloroethane) |
| | 4,4'-DDE (Dichlorodiphenyldichloroethylene) |
| | 4,4'-DDT (Dichlorodiphenyltrichloroethane) |
| Heptachlors | Heptachlor |
| | Heptachlor Epoxide |
| Aldrin | Aldrin |
| Endosulfan | Endosulfan I |

# Appendix C – Healthy Fish-Eating Recommendations from King County Flyer

The English-language version of the Healthy Fish-Eating Recommendations Flyer is included on the next page.

For digital access to the flyer in English or the nine other languages produced for this project, please go to the link below:

https://m10082.eos-intl.net/M10082/dnrp/Details/Record.aspx?BibCode=5601780

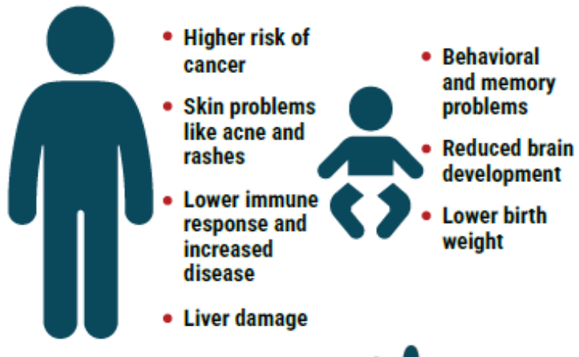
# King County Healthy Freshwater Fish-Eating Recommendations from King County

**Eating fish is good for you and has important health benefits. But some fish from lakes and rivers in King County can be high in harmful chemicals that you cannot see (like mercury, PFAS, and PCBs). Mercury is a heavy metal, PFAS are known as "forever chemicals", and PCBs are discussed below. These chemicals are of most concern for pregnant people, babies, children, and adults considering pregnancy. Protect your health by following these recommendations for fish caught in the areas highlighted on the map.**

## How are PCBs harmful?

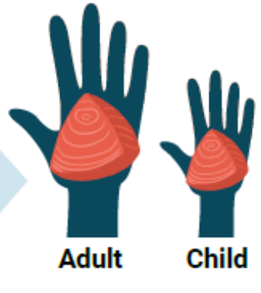
PCBs (polychlorinated biphenyls) are synthetic chemicals that were banned in 1979 but remain in our environment. PCBs can have toxic effects on the immune, reproductive, nervous, and hormone systems in people. They have also been linked to cancer in people and animals.

## Studies suggest PCBs are related to:



- Higher risk of cancer
- Skin problems like acne and rashes
- Lower immune response and increased disease
- Liver damage
- Behavioral and memory problems
- Reduced brain development
- Lower birth weight

**1 meal =**
**1 uncooked fillet**
(the size & thickness of your palm)







**Whole fish contain more contaminants.**
**EAT ONLY THE MEAT.**



### 1 Angle Lake

Sockeye salmon / Kokanee



4 meals per month maximum

Largescale sucker



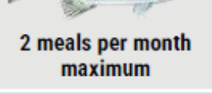
Up to 22 meals per month (Caution eating more than 22)

Northern pikeminnow



DO NOT EAT

Smallmouth bass



2 meals per month maximum

Cutthroat trout



4 meals per month maximum

Mountain whitefish



4 meals per month maximum

### 2 Lake Desire

Yellow perch



Up to 12 meals per month (Caution eating more than 12)

Yellow perch



1 meal per month maximum

Largemouth bass



2 meals per month maximum

Smallmouth bass



2 meals per month maximum

Rainbow trout



4 meals per month maximum

### 3 Lake Meridian

Yellow perch



1 meal per month maximum

### 4 Green River

Mountain whitefish



Up to 21 meals per month (Caution eating more than 21)

Okay to eat
Caution
Do not eat

Current DOH fish advisories

King County recommendations based on PCBs

*This is not a Washington Department of Health (DOH) fish advisory. These King County recommendations use DOH methods and are from test sampling. DOH will review the data and may provide further guidance.*

### 5 Lake Sammamish

Smallmouth bass



2 meals per month maximum

### 6 Lake Union

Black crappie



4 meals per month maximum

Yellow perch



4 meals per month maximum

Northern pikeminnow



DO NOT EAT

Largemouth bass



2 meals per month maximum

Largescale sucker



2 meals per month maximum

### 7 Cedar River

Sockeye salmon / Kokanee



Up to 13 meals per month (Caution eating more than 13)

Rainbow trout



4 meals per month maximum

Mountain whitefish



4 meals per month maximum

Cutthroat trout



4 meals per month maximum

Northern pikeminnow



DO NOT EAT

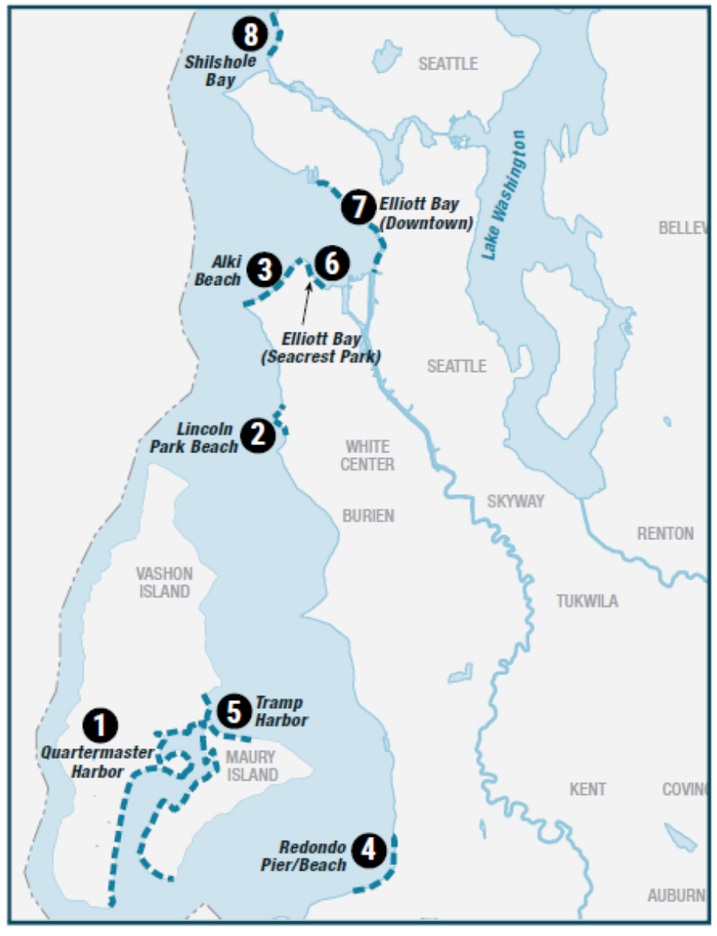
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2024 wlrtoxicology@kingcounty.gov

# King County Healthy Seafood-Eating Recommendations from King County

Some seafood from Puget Sound can contain harmful chemicals. Protect your family's health by following these recommendations for fish and crab caught in the areas highlighted on the map.

| 1 Quartermaster Harbor | 2 Lincoln Park Beach | 3 Alki Beach | 4 Redondo Pier/Beach | 5 Tramp Harbor | 6 Elliott Bay (Seacrest Park) | 7 Elliott Bay (Downtown) | 8 Shilshole Bay |
|---|---|---|---|---|---|---|---|
| English sole<br>Up to 8 meals per month (Caution eating more than 8) | Shiner perch<br>2 meals per month maximum | English sole<br>Up to 15 meals per month (Caution eating more than 15) | Dungeness crab<br>*DON'T EAT GUTS!*<br>More than 23 meals per month | Dungeness crab<br>*DON'T EAT GUTS!*<br>More than 23 meals per month | Shiner perch<br>2 meals per month maximum | English sole<br>2 meals per month maximum | English sole<br>Up to 18 meals per month (Caution eating more than 18) |
| Red rock crab<br>*DON'T EAT GUTS!*<br>More than 23 meals per month | Red rock crab<br>*DON'T EAT GUTS!*<br>More than 23 meals per month | Dungeness crab<br>*DON'T EAT GUTS!*<br>2 meals per month maximum | Dungeness crab<br>*DON'T EAT GUTS!*<br>2 meals per month maximum | Dungeness crab<br>*DON'T EAT GUTS!*<br>Up to 8 meals per month (Caution eating more than 8) | | | |
| Red rock crab<br>*DON'T EAT GUTS!*<br>2 meals per month maximum | Red rock crab<br>*DON'T EAT GUTS!*<br>2 meals per month maximum | Red rock crab<br>*DON'T EAT GUTS!*<br>Up to 8 meals per month (Caution eating more than 8) | | | | | |




- Okay to eat
- Caution
- Do not eat
- Current DOH fish advisories
- King County recommendations based on PCBs

*This is not a Washington Department of Health (DOH) fish advisory. These King County recommendations use DOH methods and are from test sampling. DOH will review the data and may provide further guidance.*

## DO NOT EAT CRAB GUTS.

**They are high in contaminants.**
**Eat ONLY the meat.**





### Follow the Fishing Rules

**Fishing rules help protect fish populations so future generations can enjoy fishing too!**

Scan this code for Fish Consumption Advisories in other Washington State waterbodies.

*(link in English only)*

Scan this code to find where to buy Washington Department of Fish and Wildlife (WDFW) fishing licenses and their costs.

*(link in English only)*

2407_13602E_RFSC_Fish_Guidance_Flyer.ai

*King County is grateful to the Refugee Federation Service Center and local fishers for their partnership in supporting community health.*