

HEALTH CONSULTATION

Public Health Evaluation of Fish Tissue from O'Sullivan's Island Site, Derby CT

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**Connecticut Department of Public Health
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Statement of the Issue

O'Sullivan's Island in Derby, CT is a peninsula of land formed by the confluence of the Naugatuck and Housatonic Rivers. The area is a popular location for recreational fishing. Fire training operations and unauthorized dumping of hazardous material historically occurred on the property. In June 2015, the CT Department of Public Health (CT DPH) reviewed soil data and completed a health consultation concluding that contact with surface soil during recreation activities was unlikely to harm people's health (CT DPH 2015). In the 2015 health consultation, CT DPH recommended fish tissue testing for polychlorinated biphenyls (PCBs) and perfluorinated alkyl substances (PFAS). This health consultation is a follow-up to the 2015 consultation and evaluates the public health implications of PCBs and PFAS in fish tissue from the site.

O'Sullivan's Island Site Background

O'Sullivan's Island (the site) comprises the southwestern portion of a peninsula located in Derby, CT, where the Naugatuck and Housatonic Rivers join together (see Figure 1). From the 1950s until 2000, the northern portion of the site was used for fire training by the Valley Fire Training School. In 2007, the fire training buildings were demolished. Contaminants detected in soil in this portion of the site include petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), arsenic and lead (Valley Council of Governments, 2010).

Figure 1. O'Sullivan's Island Site



In the 1970s and early 1980s, the southern portion of the site was used as a source of sand and gravel. In 1983, digging to remove sand and gravel uncovered rusted and leaking 55-gallon drums. In 1983 and 2008, the US Environmental Protection Agency (EPA) removed over 900 drums and a large amount of contaminated soil from the southern portion of the site. Contaminants included volatile organic chemicals (VOCs), PCBs and unknown substances.

In 2008, EPA placed a marker barrier and clean soil over all the excavated areas, and planted grass and trees. The site is currently open to the public (with restrictions on activities that could disturb soil at depth). A paved greenway trail completed in the spring

2013 extends from the parking lot across the northern portion of the site (see Figure 1). The site is heavily used for recreational activities including fishing, walking and biking.

In January 2014, the City of Derby closed O'Sullivan's Island when the community raised questions about whether EPA's remediation in 1983 and 2008 had made the site safe enough for recreational use. In response to a CT DPH recommendation, the City conducted surface soil testing in 2014 on unpaved portions of the site, focusing on heavily used paths along the southern and eastern shore areas. CT DPH reviewed the soil data and completed a health consultation concluding that contact with surface soil during recreation activities is unlikely to harm people's health (CT DPH 2015). In the 2015 health consultation, CT DPH recommended sampling and analysis of fish from the site for PCBs and perfluorinated alkyl substances (PFAS). The statewide freshwater fish consumption advisory (based on mercury) applies to this site. However, there has never been site-specific fish tissue testing so it is unknown whether the statewide freshwater advisory is adequately protective for the site. We recommended PCB testing because PCBs were a primary contaminant in drums and soil removed from the site by EPA during their remedial actions. We recommended PFAS testing because of the history of fire training operations at the site and the likelihood that PFAS-containing firefighting foams were used.

In response to our recommendation, fish from the site were collected in June 2017 and analyzed for PCBs and PFAS in November 2017. This health consultation evaluates the public health implications from fish tissue results for PCBs and PFAS. In particular, we evaluate whether the existing consumption advisory is adequately protective for this site given the site-specific fish tissue results.

Discussion

O'Sullivan's Island Fish Tissue Data

Data for this health consultation consist of fish collected from the O'Sullivan's Island site by staff from the CT Department of Energy and Environmental Protection, Inland Fisheries Division (CT DEEP) in June 2017. White perch (three fish), yellow perch (ten fish) and largemouth bass (five fish) obtained from the site were sent to Axys Analytical in British Columbia, Canada for analysis of PFAS and PCBs. The three white perch and five largemouth bass were analyzed as individuals. The yellow perch were analyzed as two composites (five fish each). Laboratory analysis was completed in November 2017. The number and type of fish collected were based upon predetermined targets and also the availability of fish on the day of collection. White perch were prioritized over yellow perch due to higher lipid content and thus higher likelihood of accumulating PCBs. We made the decision to composite the yellow perch as a cost saving measure as these were not a high priority species.

The fish tissue analysis for PCBs and PFAS was by GC-MS. The analysis provided total PCBs as the sum of all 209 congeners. Aroclor concentrations were estimated by the laboratory based on congener results. This allows for comparison with historic PCB fish tissue data across CT. Aroclor analysis was historically the only PCB analysis available. The fish tissue analysis also provided results for 13 PFAS, including perfluorooctane sulfonic acid (PFOS) which is the primary PFAS found in fish based on surveys from around the country (Stahl et al. 2014).

PCB Levels in Fish Tissue

PCBs were detected in all fish samples. Largemouth bass and white perch had similar PCB concentrations; yellow perch were considerably lower. Estimated Aroclor data indicated that the more highly chlorinated Aroclor 1254 and 1260 dominated the PCB totals. Table 1 provides the total congener PCB concentrations detected in fish tissue samples.

Table 1. PCB Concentrations in Fish from O’Sullivan’s Island (November 2017)

Fish Species	Sample Type	Fish Length (cm)	Total PCBs¹ (ppb)[^]
White Perch	Individual	22	367
White Perch	Individual	19	239
White Perch	Individual	17	200
Yellow Perch	5-fish composite	21-23	36
Yellow Perch	5-fish composite	21-23	68
Largemouth Bass	Individual	39	328
Largemouth Bass	Individual	38	255
Largemouth Bass	Individual	38	291
Largemouth Bass	Individual	32	111
Largemouth Bass	Individual	32	371

¹Sum of all 209 PCB congeners.

[^]ppb = parts-per-billion

PFAS Levels in Fish Tissue

PFAS were detected in all fish samples. PFOS was the major PFAS detected in each sample, comprising approximately 60-85% of the total PFAS. Largemouth bass was the species with the maximum PFAS detection. Table 2 provides the PFAS results for each sample.

Table 2. PFAS Concentrations in Fish from O’Sullivan’s Island (November 2017).

Fish Species	Sample Type	Fish Length (cm)	PFOS (ppb)	Total PFAS (ppb)
White Perch	Individual	22	13.7	16.6
White Perch	Individual	19	5.8	6.8
White Perch	Individual	17	4.9	6.5
Yellow Perch	5-fish composite	21-23	9.1	14.4
Yellow Perch	5-fish composite	21-23	10.0	15.0
Largemouth Bass	Individual	39	18.1	25.8
Largemouth Bass	Individual	38	8.9	11.4
Largemouth Bass	Individual	38	14.9	20.6
Largemouth Bass	Individual	32	5.9	7.6
Largemouth Bass	Individual	32	19.2	27.6

O’Sullivan’s Island Exposure Pathways

The exposure pathway of concern for this health consultation is ingestion of fish caught at the site. Other exposure pathways for recreational visitors to the O’Sullivan’s Island site have been evaluated elsewhere (CT DPH 2015). O’Sullivan’s Island is a very popular location for recreational fishing. Anecdotal information indicates that during peak fishing season, the area receives hundreds of visitors on a daily basis. This area is tidal so it can have both freshwater and saltwater species. Therefore, O’Sullivan’s Island is posted with the CT statewide freshwater fish consumption advisory (based on mercury) and the Long Island Sound advisory for striped bass and bluefish (based on PCBs). We do not have data regarding whether people are following the fish consumption advice.

Public Health Implications of Fish Ingestion at O’Sullivan’s Island

Exposure and Risks from PCBs in Fish Tissue

Under CT’s statewide fish consumption advisory program, CT DPH has a consistent approach for setting safe levels of PCBs in fish tissue across all of CT’s waterbodies. CT DPH uses a modified version of the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (GLP) (Great Lakes Sports Fish Advisory Task Force, 1993). The GLP is a framework for setting risk-based fish consumption advisories in the Great Lakes states. A detailed description of the GLP including CT DPH’s modified version is included in Appendix A. CT’s risk-based PCB fish concentration cutoffs for different meal frequencies developed using its modified version of the GLP are listed in Table 3.

Table 3. Fish Meal Frequencies and Risk-Based PCB Fish Concentrations Cutoffs [^]

PCB Level (ppm [*])	Consumption Advisory	
	Low Risk [@]	High Risk [#]
Less than 0.1	No Consumption Advice	No Consumption Advice
0.1 - 0.2	One meal per week	One meal per month
0.21 - 1.0	One meal per month	One meal per month
1.1 - 1.9	One meal every 2 months	Do not eat
Greater than 1.9	Do not eat	Do not eat

[^] (Ginsberg and Toal, 1999)

*Parts per million

[@] Includes all other groups not included in the high risk group

[#] Includes pregnant women, women planning to become pregnant within a year, nursing women, and children under 6 years old

To evaluate the public health implications of exposure to PCBs through consumption of fish from O’Sullivan’s Island, we compared PCB concentrations in fish tissue with our consumption advisory cutoffs in Table 3. Given the small number of fish sampled, we used the maximum detected concentration (0.371 ppm [371 ppb] in largemouth bass) rather than an average concentration or a 95% upper confidence level.

The maximum concentration of 0.371 ppm (371 ppb) falls into the consumption advice category of no more than one meal per month for both high risk and low risk consumers. Incidentally, using the average PCB concentration in largemouth bass

(0.271 ppm) and white perch (0.269 ppm) rather than the maximum does not change this advisory category. However, it is important to note that both the average and maximum concentrations are at the low end of a very wide consumption advisory range (0.210 ppm – 1.0 ppm).

The statewide freshwater fish consumption advisory based on mercury limits consumption to one meal per week for low risk consumers and one meal per month for high risk consumers (see Table 4).

Table 4. CT Statewide Freshwater Fish Consumption Advisory

Consumption Advisory	
Low Risk [®]	High Risk [#]
One meal per week	One meal per month

[®]Includes all other groups not included in the high risk group

[#]Includes pregnant women, women planning to become pregnant within a year, nursing women, and children under 6 years old

This statewide advice conforms to the O’Sullivan’s Island consumption category for high risk consumers, but not for low risk consumers. As Table 4 shows, the statewide advisory for low risk consumers allows one meal per week rather than one meal per month. However, it is instructive to examine CT’s advice for small fish species including rock bass, yellow perch and sunfish, which applies to the Housatonic River above Lake Lillinonah (north of O’Sullivan’s Island). This advice is based on a large body of fish tissue data with average PCB concentrations in the same range as O’Sullivan’s Island. This advice for small species in the Housatonic River above Lake Lillinonah is one meal per week for low risk consumers (same as the statewide freshwater fish advisory). Further, at a meal frequency of once per week, PCB non-cancer risks from O’Sullivan’s Island fish are only marginally greater than a Hazard Index of one (see risk calculations in Appendix C) and only marginally greater than the GLP goal of limiting PCB exposures to 3.5 ug/day which equates to cancer risks not exceeding 1×10^{-4} (see risk calculations in Appendix C).

Exposure and Risks from PFAS in Fish Tissue

To evaluate the public health implications of exposure to PFAS through consumption of fish from O’Sullivan’s Island, we compared PFAS concentrations in fish tissue with cutoff concentrations CT DPH has calculated (CT DPH 2017) using the current US EPA Reference Dose (RfD) of 0.00002 mg/kg/day for PFOS/PFOA (EPA 2016). The key health endpoints in animal testing which forms the basis of the RfD are *in utero* developmental effects on birth weight and immune function, as well as toxicity to the liver from adult exposure. Using the EPA RfD, a body weight of 62 kg and an assumed meal size of 227 grams, CT DPH’s PFAS fish concentration cutoffs equating to a Hazard Index of one for different meal frequencies are shown in Table 5 below. The cutoffs are for both low and high risk consumers. Documentation for the PFAS cutoffs is provided in Appendix B.

Table 5. Fish Meal Frequencies and Risk-Based PFAS Fish Concentrations Cutoffs (CT DPH 2017)

PFAS Level (ppb [*])	Consumption Advisory
< 20	No consumption advice
20 to < 40	1 meal per week
40 to < 159	1 meal per month
≥ 159	Do Not Eat

*Parts per billion

Given the small number of fish sampled, we used the maximum detected PFAS concentration (27.6 ppb in largemouth bass) from O’Sullivan’s Island rather than an average concentration or a 95% upper confidence level. Fish from O’Sullivan’s Island fall into the one meal per week advisory category (see Table 5). This conforms with the statewide freshwater fish consumption advisory for low risk consumers. The high risk group would follow the one meal per month statewide advisory which would be somewhat overprotective for PFAS concentrations in fish from O’Sullivan’s Island.

Conclusions

PCBs in Fish Tissue

Based on the maximum detected PCB concentration in fish tissue, O’Sullivan’s Island fish fall into the one meal per month cutoff for low risk and high risk consumers. This does not conform exactly to the statewide freshwater fish advisory for low risk consumers which allows one meal per week consumption. However, based on consideration of the following three factors, CT DPH concludes that the statewide freshwater fish consumption advisory will adequately protect the health of O’Sullivan’s Island fish consumers and therefore there is no need for a special waterbody advisory.

- While the maximum and average PCB concentrations in largemouth bass and white perch from O’Sullivan’s Island fall into the one meal per month advisory range for low risk consumers, they are at the low end of the range; near the cutoff that would allow one meal per week for low risk consumers.
- O’Sullivan’s Island fish tissue concentrations are in the same range as small fish species from the Housatonic River north of O’Sullivan’s Island. CT’s advice for these small fish species is identical to the statewide freshwater fish advisory. Thus, setting the O’Sullivan’s Island fish to this advisory is consistent with application of the statewide advisory at a nearby location.
- Using the average PCB concentrations in largemouth bass and white perch from O’Sullivan’s Island and exposure parameters from CT’s modified version of the GLP, cancer and non-cancer risks from eating O’Sullivan’s Island fish once per week are generally within the GLP risk limit goals.

Therefore, the fish consumption advisory for O’Sullivan’s Island is one meal per week (low risk consumers) and one meal per month (high risk consumers). This is the same as the statewide freshwater fish advisory.

PFAS in Fish Tissue

Based on the maximum detected PFAS concentration, O'Sullivan's Island fish fall into the one meal per week cutoff (for both low and high risk consumers). This conforms with the statewide freshwater fish advisory which also allows one meal per week consumption by the general population. The statewide advisory limits high risk consumers to one fish meal per month. This more restrictive advice will also be health protective for PFAS exposures from O'Sullivan's Island fish. Thus, CT DPH concludes that the statewide freshwater fish consumption advisory will adequately protect the health of O'Sullivan's Island fish consumers and there is no need for a special waterbody advisory.

The fish consumption advisory for O'Sullivan's Island is one meal per week (low risk consumers) and one meal per month (high risk consumers). This is the same as the statewide freshwater fish advisory.

Recommendations

1. Inclusion of O'Sullivan's Island fish in future CT fish sampling rounds would be prudent given the history of the site and the small numbers of fish collected there to date.
2. While the statewide freshwater fish advisory is determined to be protective for O'Sullivan's Island fish, any changes to the statewide freshwater advisory in the future should prompt a review of O'Sullivan's Island fish tissue data because the statewide freshwater fish advisory is based on mercury and the contaminants of concern at O'Sullivan's Island are PCBs and PFAS.

Public Health Actions Planned

CT DPH will continue to work with the Naugatuck Valley Health District and the Town of Derby to ensure that the CT Statewide Freshwater Fish Consumption Advisory and the Long Island Sound and Connected Rivers Consumption Advisory are posted in prominent locations at O'Sullivan's Island.

CT DPH will ask CT DEEP Inland Fisheries Division staff to add locations in the lower Housatonic River near or below O'Sullivan's Island for future PCB fish testing. Additional PCB fish tissue data from locations in the lower Housatonic River will add to the body of PCB data from the Housatonic River which will help CT DPH make better fish consumption advisory decisions.

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REPORT PREPARATION

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Appendix A

In order to set safe levels of PCBs in fish associated with fish consumption advisories (which in the Housatonic River, allows for some fish consumption while remediation to risk-based clean up levels occur), CT DPH uses a modified version of the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (GLP) (1993).

Risk Based PCB Fish Concentrations for Different Meal Frequencies Developed in the Great Lakes Protocol

- No advice for consumption for concentrations ≤ 0.05 ppm (assuming 1 meal every 1.6 days or 140 grams fish/day).
- One meal per week for concentrations 0.06 to 0.2 ppm
- One meal per month for concentrations 0.21 to 1.0 ppm
- One meal every other month for concentrations 1.1-1.9 ppm
- No consumption > 1.9 pm

The bullets above provide the risk-based PCB fish concentration cutoffs for different meal frequencies developed in the GLP. The GLP is a framework for setting risk-based fish consumption advisories in the Great Lakes states. Using the GLP, the Great Lakes Task Force developed a Health Protective Value (HPV) for PCBs of $0.05 \mu\text{g}/\text{kg}/\text{day}$ by using a “weight of evidence” approach which considered all of the existing toxicological values and studies (mostly human and monkey). The “weight of evidence” approach differs from a reference dose which typically uses a single critical study. The HPV is a unique value developed specifically for the Great Lakes sport fish advisory process (Great Lakes Sport Fish Advisory Task Force 1993). The development of the HPV was based on some key assumptions: average meal size for a 70 kg adult of one-half pound (227 grams) and a 50% reduction in PCB fish fillet content (skin on, scales off fillet) through trimming and cooking losses of fatty portions of the fish. The goal of the advisory program was to limit PCB exposure to $3.5 \mu\text{g}/\text{day}$ ($0.05 \mu\text{g}/\text{kg}/\text{day} * 70 \text{ kg} = 3.5 \mu\text{g}/\text{day}$). At this exposure level, cancer risks would not be expected to exceed 1 excess cancer in 10,000 exposed people and non cancer health effects would not be likely. Concerning non-cancer health effects, there are several animal and human studies that resulted in a variety of adverse health effects from exposure to PCBs. The main effects from exposure to PCBs in animals include hepatic, dermal, immunological, and neurobehavioral development. Because the most sensitive effects are immunological and neurobehavioral development, the GLP Task Force tended to weigh more heavily on these studies when developing its HPV (Great Lakes Sport Fish Advisory Task Force 1993).

The ATSDR minimum risk level (MRL) for chronic exposure to PCBs is $0.02 \mu\text{g}/\text{kg}/\text{day}$; less than half the HPV. Derivation of the ATSDR MRL is based on a Lowest Observed

Adverse Effect Level (LOAEL) for immunological effects of 0.005 µg/kg/day and is divided by an uncertainty factor of 300 for extrapolation from monkeys to humans, and 10 for human variability. As stated previously, development of the HPV is based on a “weight of evidence” approach and considered all toxicological values and studies. Cancer risks estimates for PCBs at the HPV of 0.05 µg/kg/day using the United States Environmental Protection Agency (US EPA) Cancer Slope Factor (CSF) of 7.7 (mg/kg/day)⁻¹ (95% upper bound confidence level estimate) and 5.5 (mg/kg/day)⁻¹ (most likely estimate) are 3.8 x 10⁻⁴ and 2.7 X 10⁻⁴ respectively. If a population were exposed to PCB levels of 0.05 µg/kg/day (HPV) every day for 70 years (a lifetime), there would be a theoretical excess cancer risk of approximately 2 persons in a population of 10,000. CT DPH considers this theoretical excess cancer risk to be on the upper end of a generally acceptable range (1 in 10,000 to 1 in 1,000,000).

CT DPH’s version of the GLP takes into account detection limit issues and the somewhat greater concern for higher risk individuals (Ginsberg and Toal, 1999). CT DPH currently issues consumption advisories for PCBs levels exceeding 0.1 ppm (parts per million), the point where practical quantification of PCBs in fish becomes certain¹, whereas the GLP recommends consumption advisories at PCBs levels exceeding 0.05 ppm.

High risk individuals include pregnant women, women planning to become pregnant within a year, breastfeeding women, or children under the age of six. Pregnant women or women planning to become pregnant are particularly sensitive because PCBs can be passed through the mother to the unborn fetus and can result in central nervous system (CNS) effects as well as others. Children under the age of six are also particularly vulnerable because they tend to eat more per body weight. In addition, the developing organs (brain and thyroid gland) of children can sustain permanent damage if exposure to PCBs occurs during critical growth stages. Breastfeeding women are also in the high risk group because PCBs can pass through breast milk and expose young children to PCBs. Low risk individuals include the remaining population. Table 1 gives the details of CT DPH’s fish consumption advisory as it relates to PCB levels in fish samples. In addition, CT DPH gives each fish consumption category a Restriction Category for ease of reference.

Regarding the issue of higher risk individuals, the animal toxicology studies support an HPV that is in the same range for reproductive and other (immunological, dermal) endpoints. This suggests that *in utero* development is no more sensitive to PCBs than endpoints seen in adult animals. However, the evidence of low dose effects in humans is strongest for *in utero* effects (central nervous system development). This creates a somewhat greater concern for pregnant women and women planning pregnancy (Ginsberg and Toal 1999).

Two short term studies in mink and rats also resulted in low dose developmental effects from exposure to PCBs. Therefore, CT DPH believes that there may be a greater sensitivity during *in utero* exposure such that recent exposures that do not involve a

¹ The detection limit for PCBs was 0.1 ppm when CTDPH’s Modified Great Lakes Protocol for Fish Consumption was derived in 1999. The calculated detection limit for total PCBs during this 2014 fish tissue analysis was 0.03 ppm (Patrick Center for Environmental Research, 2016).

cumulative body burden (which is important to adult toxicity) could produce an adverse health effect. This uncertainty over PCBs pharmacokinetics and developmental outcomes supports a prudent avoidance (do not eat) approach for pregnant women for markedly elevated PCB concentrations (e.g. over 1 ppm). CT DPH’s recommendation of “do not eat” for high risk groups for PCB levels in fish of 1.1-1.9 ppm differs from the GLP’s approach which recommends a “1 meal per 2 months” restriction for fish consumption for all risk groups for PCB levels of 1.1-1.9 ppm (Ginsberg and Toal 1999). In addition, CT DPH’s recommendation (Table 1) also differs from the GLP’s approach which recommends a “one meal per week” restriction for all risk groups for PCB levels of 0.06-0.20 ppm.

Setting limits based on cancer risk less than 1 in 10,000 would lead to severe restrictions on fish consumption overall (local or commercial) due to the widespread occurrence of low levels of PCBs in fish. This would result in the benefit of fish consumption to be lost in the interests of minimizing cancer risks. Given that the number of frequent consumers of locally caught fish in Connecticut may not be large, the theoretical 1 in 10,000 cancer risk is of less concern than if this were a population-wide exposure (Ginsberg and Toal 1999). Therefore, both CT DPH and The Great Lakes Protocol focus on prevention of non-cancer health effects of PCBs.

Table 1. CT DPH’s Modified Great Lakes Protocol for Fish Consumption[^]

Restriction Category (Level)	PCB Level (ppm [*])	Consumption Advisory	
		Low Risk [@]	High Risk [#]
A	< 0.1	No Consumption Advice	No Consumption Advice
B	0.1-0.2	One meal per week	One meal per month
C	0.21 - 1.0	One meal per month	One meal per month
D	1.1 - 1.9	One meal every 2 months	Do not eat
E	> 1.9	Do not eat	Do not eat

[^] (Ginsberg and Toal, 1999)

^{*}Parts per million

[@] Includes all other groups not included in the high risk group

[#] Includes pregnant women, women planning to become pregnant within a year, nursing women, and children under 6 years old

PFAS Fish Sampling Results Summary

November 22, 2017

Background

The Connecticut Department of Public Health together with the Connecticut Dept. of Energy and Environmental Protection (DEEP), Inland Fisheries, has performed fish sampling for perfluorinated alkyl substances (PFAS) in two Connecticut rivers. Emerging concerns over PFAS toxicity and persistence have led to fish sampling with consumption advisories in Minnesota, Michigan, Wisconsin and Alabama (USEPA 2016, available at: <https://www.epa.gov/sites/production/files/2016-09/documents/fish-news-aug2016.pdf>). A national survey of fish concentrations was reported by USEPA (Stahl et al. 2014) which included limited testing of Connecticut fish.

The latest round of PFAS results from fish sampling in Connecticut have come back from Axys Analytical in British Columbia. The fish were collected by CT DEEP, Inland Fisheries Division on June 15, 2017 and included 3 white perch, 10 yellow perch and 5 largemouth bass from the O'Sullivan's Island area of the Naugatuck/Housatonic Rivers. The white perch and bass were analyzed for 13 PFAS including PFOS, the major one found in fish in other surveys around the country (Stahl et al. 2014).

The 2017 sampling complemented the collection by CT DEEP from October 2016 on the Connecticut River south of the Mattabassett sewage treatment outfall. That sampling included 4 small mouth bass plus 1 yellow perch (5 fish) composite. The analytical results from Axys were reported to DPH in January of 2017 from that round.

Results

The Connecticut River and O'Sullivan's Island results are combined in Table 1. PFAS were detected in all sampled fish and consistent with Stahl et al. 2014, PFOS was the major PFAS detected in each case. The maximum PFOS detection from the 2016 sampling of the Connecticut River was 42 ppb, which occurred in a small mouth bass. The maximum detection from the O'Sullivan's Island sampling was 19.2 ppb (PFOS) in a largemouth bass. The table shows that the total PFAS level summed across all detected analytes was 20 to 40% greater than the PFOS detection.

Table 1. PFAS Concentrations in Fish (in ppb) from the Connecticut River and O’Sullivan’s Island

Location/Date	Species	Sample ID	PFOS (ppb)	Total PFAS (ppb)
O’Sullivan’s Island 6/15/17	White Perch	F_001	13.7	16.6
O’Sullivan’s Island 6/15/17	White Perch	F_002	5.8	6.8
O’Sullivan’s Island 6/15/17	White Perch	F_003	4.9	6.5
O’Sullivan’s Island 6/15/17	Yellow Perch composite	F_004 to F_008	9.1	14.4
O’Sullivan’s Island 6/15/17	Yellow Perch composite	F_009 to F_013	10.0	15.0
O’Sullivan’s Island 6/15/17	LM Bass	F_014	18.1	25.8
O’Sullivan’s Island 6/15/17	LM Bass	F_015	8.9	11.4
O’Sullivan’s Island 6/15/17	LM Bass	F_016	14.9	20.6
O’Sullivan’s Island 6/15/17	LM Bass	F_017	5.9	7.6
O’Sullivan’s Island 6/15/17	LM Bass	F_018	19.2	27.6
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CT River (Mattabasset) 10/18/16	SM Bass	CR101816-1	15.2	20.0
CT River (Mattabasset) 10/18/16	SM Bass	CR101816-2	27.9	32.5
CT River (Mattabasset) 10/18/16	SM Bass	CR101816-3	42.0	54.0
CT River (Mattabasset) 10/18/16	SM Bass	CR101816-4	18.8	26.4
CT River (Mattabasset) 10/18/16	Yellow Perch composite	CR101816-1-5 composite	8.8	11.8

USEPA’s results for fish that they sampled in Connecticut included 4 species from 5 rivers (Stahl et al. 2014) are summarized in Table 2 (unpublished results supplied by USEPA). The range of detections was similar to that found in DEEP/DPH testing with the maximum result from a largemouth bass on the CT River, 40 ppb for PFOS.

Table 2. USEPA PFAS Sampling Results for Connecticut Fish (Stahl et al. 2014)

Location/Date	Species	Sample ID	PFOS (ppb)	Total PFAS (ppb)
Connecticut River 10/6/09	LM Bass 3 fish composite	FW08CT012	40	51.5
Connecticut River 10/8/09	Yellow Perch 3 fish composite	FW08CT021	8.8	8.8
Connecticut River 10/6/09	LM Bass 3 fish composite	FW08CT025	38	50
Farmington River 8/15/09	Yellow Perch 5 fish composite	FW08CT005	26	31
Farmington River 9/30/09	Yellow Perch 5 fish composite	FW08CT016	32	35
Farmington River 9/23/09	Yellow Perch 5 fish composite	FW08CT032	21	21
Farmington River West Branch 8/21/09	Brown Trout 3 fish composite	FW08CT018	ND	ND
Housatonic River 8/15/08	SM Bass 3 fish composite	FW08CT020	9	9
Housatonic River 8/12/08	SM Bass 4 fish composite	FW08CT015	12	12
Quinebaug River 8/27/09	LM Bass 3 fish composite	FW08CT022	30	33
Quinebaug River 8/25/09	LM Bass 4 fish composite	FW08CT006	23	48
Shetucket River 8/18/09	SM Bass 4 fish composite	FW08CT017	26	30

In total we have 27 PFAS data points from fish in Connecticut as summarized in Table 3 by fish species.

Table 3. Summary of Connecticut fish sampled for PFAS by Species

Species	Number Samples ¹	PFOS Average (ppb)	PFOS Maximum (ppb)	PFAS Maximum (ppb)
LM Bass	9	22.0	40	52
SM Bass	7	21.6	42	54
Yellow Perch	7	16.5	32	35
White Perch	3	8.1	13.7	16.6
Brown Trout	1	ND	ND	ND

¹Many of the results represent a composite of 3 to 5 fish, but here are shown as a single data point.

The amount of data is too small to make statistical comparisons between species or water bodies, although an informal inspection would suggest no obvious differences. To put these results into a risk and fish ingestion context, one can use the highest total PFAS concentration (54 ppb) to evaluate the level of fish advisory that might be needed based upon the current

USEPA RfD for PFOS/PFOA (USEPA 2016). That RfD is 0.00002 mg/kg/d and was used by USEPA to set the drinking water health advisory of 70 ppt. The key health endpoints in animal testing which forms the basis of the RfD are in utero developmental effects on birth weight and immune function, as well as toxicity to the liver from adult exposure.

Based upon the USEPA RfD and an assumed meal size of ½ pound (227 grams), Table 4 shows fish concentrations associated with different levels of consumption advice.

Table 4. CT DPH fish consumption limits for PFOS/PFOA

Fish Consumption	Calculated Meals	Fish concentration ¹ (ppb)
Unlimited	> 2/week	< 20
1 meal/wk	1 to 2 / week	≥ 20 to < 40
1 meal/month	< 1/week	≥ 40 to < 159
Do not eat	< 1/month	≥ 159

¹Fish concentration limits are based upon PFOA and PFOS toxicology (US EPA RfD, 2016).

In this screening approach the USEPA RfD is applied to the sum of all PFAS in a fish sample even though the RfD was targeted to PFOS and PFOA. The highest total PFAS fish result in Connecticut thus far is 54 ppb, which being greater than 40 ppb is above the cutpoint for 1 meal/week and so would default to 1 meal/month. This consumption limit matches the CT DPH statewide advisory for freshwater fish that was developed for mercury. The once per month statewide advise is for the high risk group (women of child-bearing age and young children) while the general population is advised to ingest no more than one meal per week.

Since the PFAS results were all below 159 ppb, they would not warrant a “do not eat” advisory. However, they do provide additional reason for the statewide advice for pregnant women and young children of no more than 1 freshwater fish meal per month. The general population also technically falls within that category since one of the key endpoints for PFAS is liver toxicity from adult exposure. This would further limit our statewide general population advice from one meal per week to once per month. However, that is based upon the highest PFAS result with most of the results below 40 ppb, the cutoff for 1 meal/week. Thus, the currently available PFAS data for Connecticut fish do not provide a basis for more restrictive consumption advice making it reasonable to keep the statewide advisory unchanged. Additional fish sampling can be considered if there is evidence of PFAS releases that could affect surface water bodies in Connecticut.

Appendix C – Risk Calculations

Chemical	Fish Species	Average Fish Tissue Conc. (ug/kg)	Meal Size (kg/meal)	Consumption Frequency (meals/month)	Body Weight (kg)	month/yr	yr/days	mg/ug	ADD (mg/kg/d)	RfD (mg/kg/d) or HPV (PCBs)	HI	PCB Cooking Loss	PCB Exposure (ug/day)
PCBs	LMB	271	0.227	4	70	12	0.00274	0.001	5.78E-05	0.00005	1.16	0.5	4.04
PCBs	White Perch	269	0.227	4	70	12	0.00274	0.001	5.74E-05	0.00005	1.15	0.5	4.02