Consumption Advisory Guidelines for Oysters Contaminated with Polychlorinated Biphenyls

Lafayette River
Norfolk, Virginia

Letter Health Consultation

October 30, 2014

Virginia Department of Health
Division of Environmental Epidemiology
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COMMONWEALTH of VIRGINIA

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October 30, 2014

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Division of Shellfish Sanitation
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Dear Mr. Skiles,

Thank you for the opportunity to review the concentrations of polychlorinated biphenyls (PCBs) in oyster composite samples taken from the Lafayette River in Virginia Beach, Virginia in July and November 2013. In addition, oyster composite samples taken from the Lynnhaven River in July 2013 and November 2013 were are also included in this review and used to determine if an oyster consumption advisory for the Lafayette River is warranted.

I trust that this information will be of help to you. Should you have any questions please contact Dwight Flammia at (804) 864-8127 or via email at dwight.flammia@vdh.virginia.gov.

BACKGROUND

The Virginia Department of Health's Division of Shellfish Sanitation (DSS) requested that the Division of Environmental Epidemiology (DEE) evaluate the public health risk associated with the consumption of oysters from the Lafayette River contaminated with PCBs. Current regulations prohibit the taking-of-oysters from the Lafayette River; however, ongoing environmental efforts to restore the Lafayette River to its original condition have helped reduce the concentration of various contaminants in oysters. DEE understands that DSS is considering changing the status of taking-of-oysters to *restricted* if contaminants in oysters are determined not to be a public health risk.

In early November 2010, DSS met with DEE personnel to discuss oyster sampling in the Lafayette River and to discuss public health implications from consuming oysters contaminated with polycyclic aromatic hydrocarbons. Findings from that meeting are summarized in a health

consultation submitted to DSS on October 11, 2012 and titled *Consumption Advisory Guidelines for Oysters Contaminated with Polycyclic Aromatic Hydrocarbons* (PAHs). Additional background information including the Lafayette River's watershed land use and demographics can also be found in that health consultation.

Subsequent to the review of PAH concentrations in Lafayette River oysters, DEE was asked to review PCB concentrations in oysters collected from the Lafayette River, and determine if the concentration posed a health risk to oyster consumers. In the initial laboratory report reviewed, PCBs were not detected above the laboratory lower detection limit, 500 parts per billion (ppb). DEE requested that additional oysters be collected and analyzed using a lower detection level, 75 ppb, to determine health risk from consuming oysters taken from the Lafayette River (B. Croonenberghs, Personal Communication, 6/25/2013). This health consult reports those findings and provides a tiered approach for issuing an oyster consumption advisory based on PCB concentrations in oysters.

Collection Methodology and Laboratory Analysis

Oysters were collected from four sites along the Lafayette River and from one site in the Lynnhaven River in July 2013 and November 2013. Maps of the sampling locations along the Lafayette River are included in Attachment A. Oysters collected from the Lynnhaven River can provide an adequate background concentration of PCBs in oysters because of their watershed similarities. While the two rivers have a similar watershed and use, the oysters in the Lafayette River may be at greater risk for PCB contamination because it is a tributary of the Elizabeth River, a heavily traveled water body that has been subjected to creosote dumping in the past. Composite samples contained the edible portion of 10 or more oysters from each collection site. The oysters measured between two to four inches in length.

Laboratory analysis was performed by the Virginia Institute of Marine Science in Gloucester, Va. To determine PCB concentrations, tissues were first homogenized and lyophilized (freeze-dried). A representative dry aliquot was sub sampled and placed in an accelerated solvent extraction vessel. It was spiked with a surrogate standard of ^{13}C-labeled PCB congeners and extracted under elevated pressure and temperature. The resulting extract was reduced in volume. An aliquot was removed for gravimetric measurement of extractable lipid content. Each extract was then subjected to size exclusion chromatography to remove large molecular weight lipids that might interfere with subsequent gas chromatography analysis. The eluent containing the PCBs was again reduced in volume and purified by passage through a silica gel liquid chromatography column. The fraction containing the PCBs was reduced in volume under a stream of high purity nitrogen. It was then spiked with an internal standard to permit gas chromatograph/mass spectrometry (GC/MS) quantitation. An aliquot was then injected on a GC/MS, operated at unit resolution. PCB congener standard solutions covering a range of concentrations were analyzed to establish congener-specific MS responses. PCB congeners were quantitated versus an internal standard using response ratios.[1]

[1] R. Hale, Personal Communication, 7/7/2014. The laboratory analysis summary was provided by Hale.

Results

Concentrations of PCBs (sum of congeners) in oysters are presented in Table 1. The highest concentrations of PCBs in oysters were collected near the Hampton Boulevard Bridge in July (84.6 ppb) and near the Virginia Zoo (58.5 ppb) in November. The lowest concentrations of PCBs in oysters were collected near the Granby Street Bridge in July (19.7 ppb) and the Hermitage Museum (10.3 ppb) in November.

Table 1. Concentrations of polychlorinated biphenyls in oysters collected from the Lafayette River in July 2013 and November 2013*

Lafayette River Sampling Location	Polychlorinated biphenyls (µg/kg)	
	July 2013	November 2013
Lafayette River-Hermitage Museum	35.2	10.3
Lafayette River-Hampton Blvd. Bridge	84.6	33.6
Lafayette River-Granby St. Bridge	19.7	47.2
Lafayette River-Virginia Zoo	39.6	58.5
Background Sampling Location		
Lynnhaven River-Western Branch	0.0	
Lynnhaven River-Lease 18573		2.5

(*Source*: DSS) **µg/kg**=micrograms/kilogram or parts per billion

DISCUSSION

To determine public health implications associated with chemical contaminants in the environment, DEE first evaluates specific ways (exposure pathways) in which people might come into contact with environmental contaminants. Then, based on identified exposure pathways (e.g., consuming oysters from the Lafayette River) and the levels of contaminants (PCBs), DEE determines whether or not there is a risk to the public. Currently, it is prohibited to take oysters from the Lafayette River; therefore, the community is not being exposed to PCBs in Lafayette oysters.

In this section, guidelines for issuance of oyster-eating advisory due to contamination of oysters with PCBs are discussed. These guidelines can be used by DSS when considering oyster consumption guidelines for oysters taken from the Lafayette River contaminated with PCBs.

Polychlorinated Biphenyls Discussion[2] *and Public Health Implications*

Characteristics of PCBs

Polychlorinated biphenyls are a group of synthetic organic chemicals that contain 209 possible individual chlorinated biphenyl compounds. These chemically related compounds are called congeners, which vary in their physical and chemical properties and toxicity. PCBs are either oily liquids or solids and have no taste or smell. In general, PCBs are insoluble in water, but soluble in lipids (fat). PCBs are inert; they resist both acids and alkalis, and are stable at high

[2]Source: *Virginia Department Of Health Guidelines For Issuance Of Fish Consumption Advisories Due To Contamination Of Fish With Polychlorinated Biphenyls (Revised 2012)*

temperatures. Prior to 1977, PCBs were marketed as mixtures under the trade names Aroclor, Askarel, and Therminol.

Production and Use of PCBs

PCBs were produced commercially in the United States from 1929 until 1977. PCBs were used as coolants and lubricants in capacitors, transformers, and other electrical equipment, and as hydraulic fluids. They were also used in plasticizers, surface coatings, inks, adhesives, flame retardants, pesticide applications, paints, and microencapsulation of dyes for carbonless duplicating papers. Almost all of the PCBs used in the United States were produced by the Monsanto Chemical Company in Sauget, Illinois. Because PCBs persist in the environment, Monsanto Chemical Company ceased production of PCBs in 1977. EPA banned all manufacture and importation of PCBs in 1979.

Sources of PCBs in the Environment

There are no known natural sources of PCBs. Although banned in the United States from further production in 1979, PCB-containing materials still in service at the time of the ban were not required to be removed from use; therefore, some are still in use. PCBs have been detected in soil, surface water, air, sediment, plants, and animal tissue in all regions of the world. PCBs are highly persistent in the environment with reported half-lives in soil and sediment ranging from months to years. Because PCBs have very low solubility in water and low volatility, most PCBs are contained in sediments that serve as environmental reservoirs from which PCBs may continue to be released over a long period of time. PCBs may be mobilized from sediments if disturbed during flooding, dredging, or other activities. Volatilization from land and surface water also contributes to widespread distribution of PCBs.

Health Effects of PCBs

Human exposure to PCBs predominantly occurs through the diet, especially from fish and seafood products. Red meat, poultry, eggs, and dairy products may also be important dietary sources of PCBs. Groups who may be exposed to higher than average levels of PCBs include recreational and subsistence fishers who routinely consume large amounts of locally caught fish; subsistence hunters who routinely consume the meat and organ tissues of marine mammals; and persons living near hazardous waste sites contaminated with PCBs.

PCBs are absorbed through the gastrointestinal tract and distributed throughout the body. Because of their lipophilic nature, PCBs tend to accumulate in fatty tissues. Greater relative amounts of PCBs are usually found in the liver, adipose tissue, skin, and breast milk. It has been shown that nursing infants absorb PCB congeners from breast milk. An unborn child can also be exposed to PCBs through placental transfer.

In experimental animals, PCB exposure is associated with a wide array of adverse health effects. These studies have shown toxic effects to the liver, gastrointestinal system, blood, skin, endocrine system, immune system, nervous system, and reproductive system. In addition, developmental effects and liver cancer have been reported.

Despite the variety of adverse effects observed in animals exposed to PCBs, overt adverse effects in humans have been difficult to ascertain and are not well understood. This has been attributed

to the fact that in most cases, the dosages tested in animals were considerably higher than those found in occupational exposures. Also, epidemiologic studies have been inconclusive due to multiple confounding factors, uncertain exposure estimates, and statistical limitations. Skin rashes and a persistent and severe form of acne (chloracne) have been reported following direct contact with PCBs. Laboratory studies suggest that PCBs are not likely to be genotoxic to humans.

PCBs administered in large doses orally have been shown to cause liver tumors in rats and mice. Evaluation of the animal data indicates that PCBs with 54% chlorine content induce a higher yield of liver tumors in rats than other PCB mixtures. Based on studies in experimental animals, EPA has classified PCBs as probable human carcinogens.

A few recent studies suggest that PCB exposure in pregnant women, at levels significantly lower than occupational exposures, may affect physical and neurobehavioral fetal development. These studies have several methodological problems, lack a dose-response relationship, and are controversial and contradictory. Confirmation of these results is not available at this time, but studies are underway which should help to determine whether or not these reported effects are valid public health concerns.

Derivation of Acceptable Concentration of PCBs in Oysters for Human Consumption[3]

The potential to cause cancer in humans is considered to be the most important toxic endpoint for PCBs. The formula for calculating an acceptable concentration for protecting consumers from potential carcinogenic effects is as follows:

$$C = \frac{RLxBWxEDFxT}{CSFxMSxNM}$$

Where:

Abbreviation	**Parameter**	**Value & Units**
C	Concentration	(mg/kg)
RL	Risk level	1×10^{-5} (1 in 100,000)
BW	Body weight	80 kg
EDF	Exposure duration factor	2.4 (unitless)
T	Time	30 days/month
CSF	Cancer slope factor	$2.0\ (mg/kg/day)^{-1}$
MS	Meal size	0.168 kg/meal
NM	Number of meals	2 meals/month

[3] PCB risk assessment used is consistent with VDH's approach to fish consumption advisories and is more health protective than using the World Health Organization's Toxicity Equivalent Quotient methodology due to undetectable concentrations of all PCB congeners used in their method.

Substituting for assumptions and factors in the above equation, an acceptable concentration of equal to or less than 0.085 mg/kg or 85 parts per billion (ppb) of PCBs in oysters was derived corresponding to the consumption of two meals per month.

$$0.085\ mg/kg = \frac{1x10^{-5}\ x\ 80\ kg\ x\ 2.4\ x\ 30\ days}{2.0\ (mg/kg/day)^{-1}\ x\ 0.168\ kg/meal\ x\ 2\ meals/month}$$

Various assumptions used in deriving the acceptable concentration are described as follows:

Risk Level (RL)

Typically for carcinogens, acceptable risk levels for incremental increase in cancer over the background incidence ranging between 10^{-4} (one additional cancer in a population of ten thousand people) to 10^{-6} (one additional cancer in a population of one million people) have been used in making risk management decisions. Derivation of an acceptable concentration in oyster tissue using a risk level within this range is considered conservative and protective of human health. DEE used the risk level of 10^{-5}, or one additional cancer over the background incidence expected to be found in a population of 100,000 people.

Average Body Weight (BW)

The average adult body weight (80 kg) is widely accepted by many regulatory agencies for risk assessment and establishing guidelines and standards for chemical exposure.[4]

Exposure Duration Factor (EDF)

The exposure duration factor is the ratio of a lifetime exposure to a chemical and the actual exposure. The life expectancy of the U.S. population is 78 years. The 90th percentile estimate of residence time is 32 years (length of time an individual lives in an area before moving). This assumes that a person will consume oysters from the Lafayette River for 32 years and live to be 78 years old (78 ÷ 32 = 2.4).[4]

Time Period (T)

Time period of 30 days per month was used to calculate the allowable concentration of PCBs in oysters.

Cancer Slope Factor (CSF)

The cancer slope factor (CSF) represents an assumption about cancer risk associated with low levels of exposure. It is an upper-bound estimate of the probability that an individual will develop cancer over a lifetime as a consequence of exposure to a given dose and is expressed as (milligram/kilogram/day)$^{-1}$. EPA has derived an upper bound cancer slope factor of 2.0

[4] U.S. EPA Exposure factors handbook 2011. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=236252

(milligram/kilogram/day)$^{-1}$ for PCBs. The upper bound value provides assurance that the risk is not likely to be underestimated and is considered appropriate for *food chain exposure*.[5]

Meal Size (MS)

An average meal size of 0.168 kg was assumed in calculating the acceptable concentration of PCBs in oysters. DEE recognizes that an average oyster meal would consist of a dozen oysters each weighing 14 grams (12 x 14 grams = 168 grams or 0.168 kg).[6] This is consistent with other governmental agencies that use an oyster consumption rate of 12 g/day or 180 grams/meal (12 g/day x 30 days/month = 360 grams/month; 360 grams/month ÷ 2 meals/month = 180 gram/meal) for risk assessment.[7]

Number of Meals (NM)

An acceptable concentration of PCBs in oysters was derived assuming two oyster meals during a period of 30 days (24 meals per year). It is expected that oyster harvesters may consume more oysters than the general public. A baseline survey of raw oyster consumers in four coastal states reported that the average number of oyster meals per year was six.[8]

DEE uses a multi-tier approach when providing guidelines for fish consumption advisories. A multi-tier approach should also be used for consuming oysters taken from the Lafayette River (see Table 2). When PCB concentrations are 85 ppb to less than 200 ppb, the risk level from consuming two oyster meals per month is two additional cancers for 100,000 people. When PCB concentrations are 200 to less than 400 ppb, the same risk level is used when advising individuals to limit oyster meals to one per month.

Table 2. Oyster consumption guidelines for PCBcontaminated oysters*

PCBs concentration in oysters	Advisory
Less than 85 ppb	No advisory
85 to less than 200 ppb	Two meals per month
200 to less than 400 ppb	One meal per month
400 ppb and above	Do not eat oyster from the advisory area

*One meal consists of 12 oysters. **PCBs**=polychlorinated biphenyls. **ppb**=parts per billion or µg/kg.

To determine if updated consumption advisories should be considered for PCBs, DEE applied the multi-tier oyster consumption guidelines to the average composite samples collected July 2013 and November 2013 (Table 3). The PCB concentration in oysters in the Lafayette would not have resulted in a consumption advisory.

[5] U.S. EPA Integrated risk information system. http://www.epa.gov/iris/index.html
[6] United States Department of Agriculture. National Nutrient Database for Standard Reference Release 24. http://ndb.nal.usda.gov/ndb/foods/list
[7] U.S. EPA Exposure factors handbook 2011. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=236252
[8] ISSC On Point. A baseline survey of raw oyster consumers in four states. http://www.issc.org/client_resources/education/BaselineSurvey.pdf

Table 3. Lafayette River oyster consumption advisory for samples collected July 2013 and November 2013*

Collection Period	Maximum PCBs Concentration Reported	Oyster Consumption Advisory
July 2013	84.6 ppb	No advisory
November 2013	58.5 ppb	No advisory

*One meal consists of 12 oysters. **ppbm** = parts per billion or µg/kg

Child Health and Special Populations

DEE recognizes that children, because of their behavior, size and growing bodies, may be particularly vulnerable to site-related exposures. Developing fetuses may particularly be more vulnerable to such exposures. Thus, the impact to children is considered first when evaluating the health threat to a community. The health impacts to other potentially high-risk groups within the community (such as the elderly, the chronically ill, and people who may have higher exposure potential) were also taken into account during this evaluation.

CONCLUSIONS

Oysters contaminated with PCBs in the Lafayette River are not harming public health because the taking-of-oysters from the river is currently prohibited.

PCB concentrations in oyster tissue were different between oysters collected in the fall and summer, with neither result warranting consumption advisory.

Based on the PCB concentration in oysters collected in July 2013 and November 2013, the concentrations of PCBs in oysters are not a health concern.

RECOMMENDATIONS

DEE recommends limiting the number of oyster meals to two per month when the PCB concentration in oysters is greater than or equal to 85 ppb but less than 200 ppb.

DEE recommends limiting the number of oyster meals to one per month when the PCB concentration in oysters is greater than or equal to 200 ppb but less than 400 ppb.

DEE recommends not eating oysters when the PCB concentration in oysters is 400 ppb or greater.

DEE recommends that pregnant women, women of child-bearing age, nursing mothers, infants, and young children should avoid eating oysters when the PCB concentration in oysters is 85 ppb or greater.

DEE recommends that DSS continues to sample the Lafayette River oysters year round (with a focus on typical harvesting months) to better delineate the seasonal variability of PCB levels.

REPORT PREPARATION

This Health Consultation for the Lafayette River was prepared by the Virginia Department of Health. This report was supported by funds from a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

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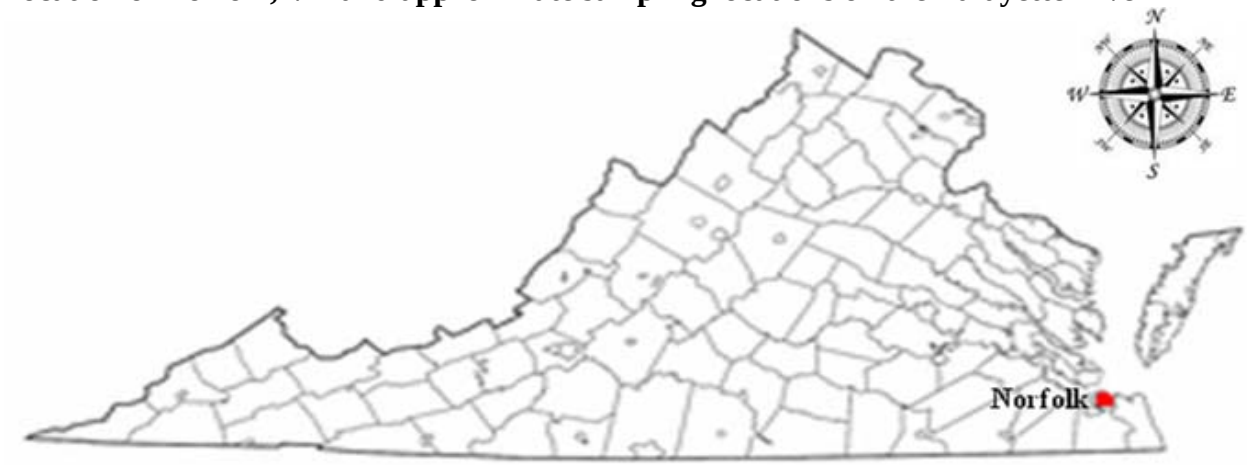
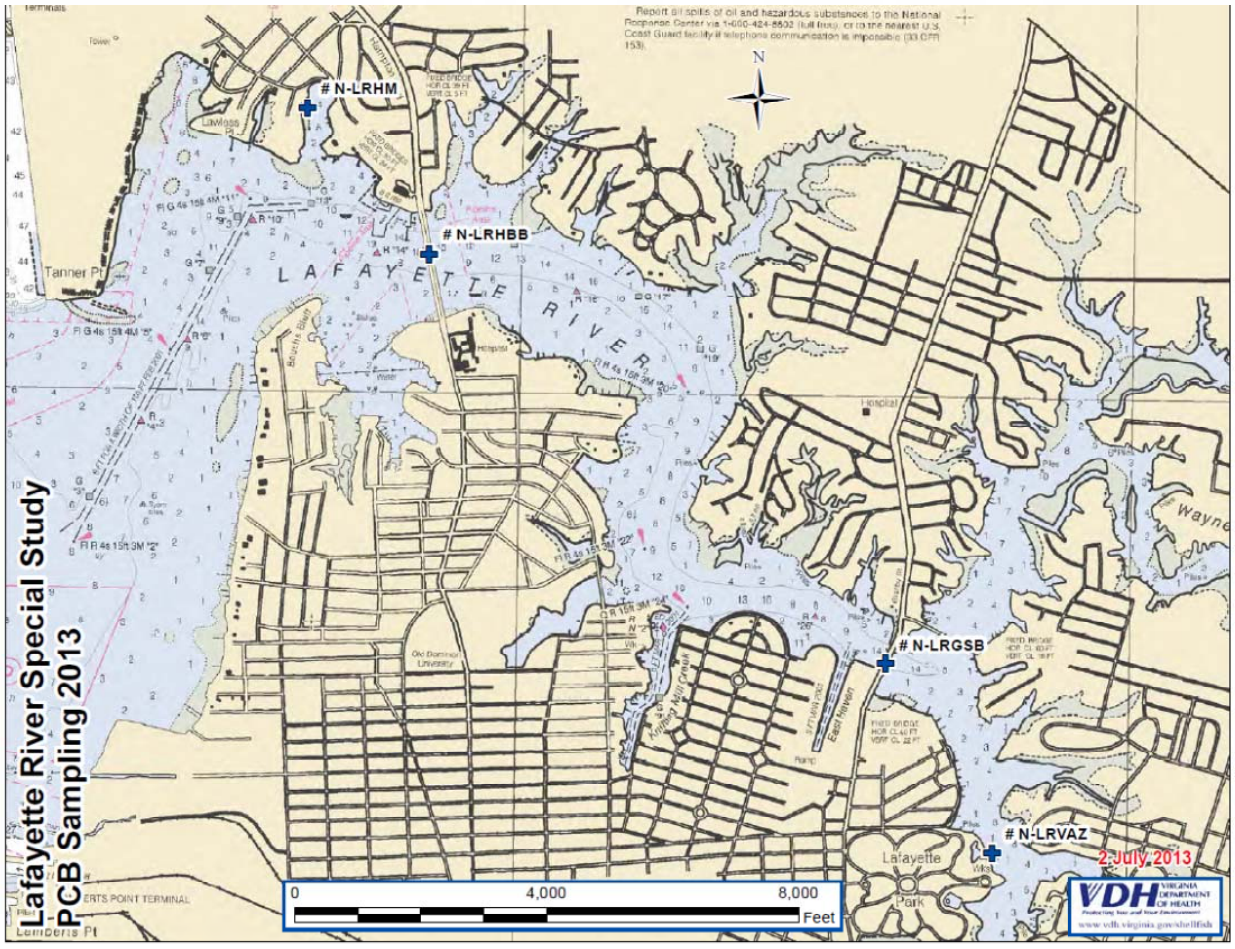
Attachment A

Location of Norfolk, VA and approximate sampling locations on the Lafayette River





(*Source*: DSS)

Attachment B

Fish consumption advisories for the Lafayette River*

Contaminant	Fish Species	Consumption Advisory
PCBs	Gizzard Shad	DO NOT EAT
PCBs	Carp	
PCBs	Blue Catfish ≥ 32 inches	
PCBs	Flathead Catfish ≥ 32 inches	
PCBs	Blue Catfish < 32 inches	No more than two fish meals/month
PCBs	Flathead Catfish < 32 inches	
PCBs	Channel Catfish	
PCBs	White Catfish	
PCBs	Largemouth Bass	
PCBs	Bluegill Sunfish	
PCBs	American Eel	
PCBs	Quillback Carpsucker	
PCBs	Smallmouth Bass	
PCBs	Creek Chub	
PCBs	Yellow Bullhead Catfish	
PCBs	White Perch	
PCBs	Striped Bass	
PCBs	Bluefish	
PCBs	Croaker	
PCBs	Spot	
PCBs	Blueback Herring	
PCBs	Hickory Shad	
Kepone	All Species	PCBs advisory is more restrictive. Follow the PCBs advisory for the species listed. Any fish species not listed, limit consumption to one meal per day.

(*Source: Virginia Department of Health).* Visit www.vdh.virginia.gov/Epidemiology/dee/PublicHealthToxicology/Advisories/ for additional fish consumption advisories in Virginia.