Health Consultation

Evaluation of Exposures to Chemicals in Penn Cove Mussels After Nearby Vessel Fire and Oil Spill
Penn Cove, Island County, Washington

September 24, 2012

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

DOH 334-314 September 2012

Foreword

The Washington State Department of Health (DOH) has prepared this health consultation with funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous substances. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances.

The purpose of a health consultation is to assess the health threat posed by hazardous substances in the environment and if needed, recommend steps or actions to protect public health. Health consultations are initiated in response to health concerns raised by residents or agencies about exposure to hazardous substances.

This health consultation was prepared in accordance with ATSDR methodologies and guidelines. However, the report has not been reviewed and cleared by ATSDR. The findings in this report are relevant to conditions at the site during the time of this health consultation and should not be relied upon if site conditions or land use changes in the future.

Use of trade names is for identification only and does not imply endorsement by DOH, the Centers for Disease Control and Prevention, ATSDR, the Public Health Service, or the U.S. Department of Health and Human Services.

For additional information, please contact us at 1-877-485-7316 or visit our website at http://www.doh.wa.gov/consults.

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Summary

Introduction:
The Washington State Department of Health (DOH) top priority is to ensure that people who consume mussels from Penn Cove have the best information possible to safeguard their health. DOH Office of Health, Safety, and Toxicology prepared this health consultation at the request of DOH's Office of Shellfish and Water Protection to evaluate whether polycyclic aromatic hydrocarbons (PAHs) from an oil spill in Penn Cove, Washington are at levels of health concern in mussels harvested from the area.

Conclusion 1:
DOH concludes that eating mussels from Penn Cove is not expected to harm people's health.

Basis for Decision:
The maximum levels of PAHs are below concentrations where we would expect to see non-cancer or cancer health effects.

Conclusion 2:
DOH concludes that based on chemical testing for PAHs, the area is safe to reopen for mussel harvest pending required smell and taste testing.

Basis for Decision:
The maximum levels of PAHs do not exceed the National Oceanic and Atmospheric Administration (NOAA) criteria for reopening shellfish harvest areas closed from oil spills. However, the latter testing is needed even when seafood samples pass chemical analysis because flavor or odor still may be affected ("taint"). Taint in seafood renders it adulterated and unfit for human consumption according to U.S. law (Federal Food, Drug, and Cosmetics Act, U.S. Code 21, Chapter IV, Sec. 402[342], a.3).

Next Steps:

1. To err on the side of safety and present a conservative approach protective of public health, people should avoid eating foods in which oil can be seen, smelled, or tasted.

2. DOH will provide copies of this health consultation to the Washington Department of Ecology (Ecology) and other concerned parties.

3. A copy of this health consultation report will be placed on the DOH site assessment website: http://www.doh.wa.gov/consults

For More Information:

If you have any questions about this health consultation contact Lenford O'Garro 360-236-3376 or 1-877-485-7316 at Washington State Department of Health. For more information about ATSDR, contact the Center for Disease Control and Prevention (CDC) Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

Purpose and Statement of Issues

The Washington State Department of Health (DOH) Office of Environmental Health, Safety, and Toxicology (OEHST) has prepared this health consultation at the request of DOH Office of Shellfish and Water Protection (OSWP). The purpose is to evaluate whether polycyclic aromatic hydrocarbons (PAHs) are present in mussels from an oil spill in Penn Cove, Washington and if levels pose a health hazard to people who eat them and/or come in contact with them. In addition, OEHST is to determine if Penn Cove mussels meets the National Oceanic and Atmospheric Administration (NOAA) criteria for reopening shellfish harvest areas closed from oil spills (NOAA criteria). DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Penn Cove is located on the North Central part of Whidbey Island located in Washington's Puget Sound (see Figure 1). It's a horseshoe-shaped bay with approximately 10 miles of sheltered coastline (about 4 miles long by about 1.5 miles wide). Penn Cove is a very productive commercial shellfish growing area and is known worldwide for its production of Penn Cove Blue mussels (*Mytilus trossulus*).

On Sunday, May 13, 2012, the F/V "Deep Sea" sank at its moorings at about 6 pm after a fire started aboard the vessel 19 hours earlier. The U.S. Coast Guard and several fire rescue boats in the area responded to the fire, and the vessel was boomed off to contain contamination prior to the sinking. The cause of the blaze is unknown. The main commercial harvester, Penn Cove Shellfish, voluntarily ceased harvest of shellfish Sunday morning as a precautionary measure before the vessel sank. Penn Cove Shellfish's wet stored product was moved from Penn Cove to other facilities in Quilcene on Sunday as well

The volume of diesel spilled from the boat grew through Monday, leaving a very thin coating of oil over the commercial operation, leading the Washington Department of Health to close the area on Tuesday. Recreational shellfish harvesting in Penn Cove was also temporarily closed. Hydrocarbon ID samples taken by Ecology on May 14 identified this sheen as #2 fuel oil (red diesel). The leaks that caused this spill were plugged by May 16 and only minor leakage noted afterward. Although initial reports from the owner of the vessel indicated only a small amount of diesel fuel (50-150 gallon on board), the later estimate (on June 8, 2012) is over 7,200 gallons recovered.

In general, exposures to PAHs during and after oil spills are the main health concerns as a result of their chemical and toxicological properties [2]. NOAA and DOH jointly collected shellfish samples on May 18, two days after the oil sheen from a significant leak passed over the growing area. Eight mussel composite samples were collected and sent to Louisiana State University to test for polycyclic aromatic hydrocarbon (PAH) compounds.

Results

Mussel sampling at Penn Cove showed only three PAHs (naphthalene, fluorene, and phenanthrene) detected at or above the laboratory detection limits (Table 1). None of the seven carcinogenic polycyclic aromatic hydrocarbons (cPAHs) were detected in mussel samples from the eight locations tested. However, as prudent public health protection, DOH used a conservative approach and compared all PAHs (including method detection limits for non-detected PAH) to screening values for non-cancer and cancer health effects (Tables 2 and 3).

Figure 1: Puget Sound map showing location of Penn Cove in Island County, Washington.

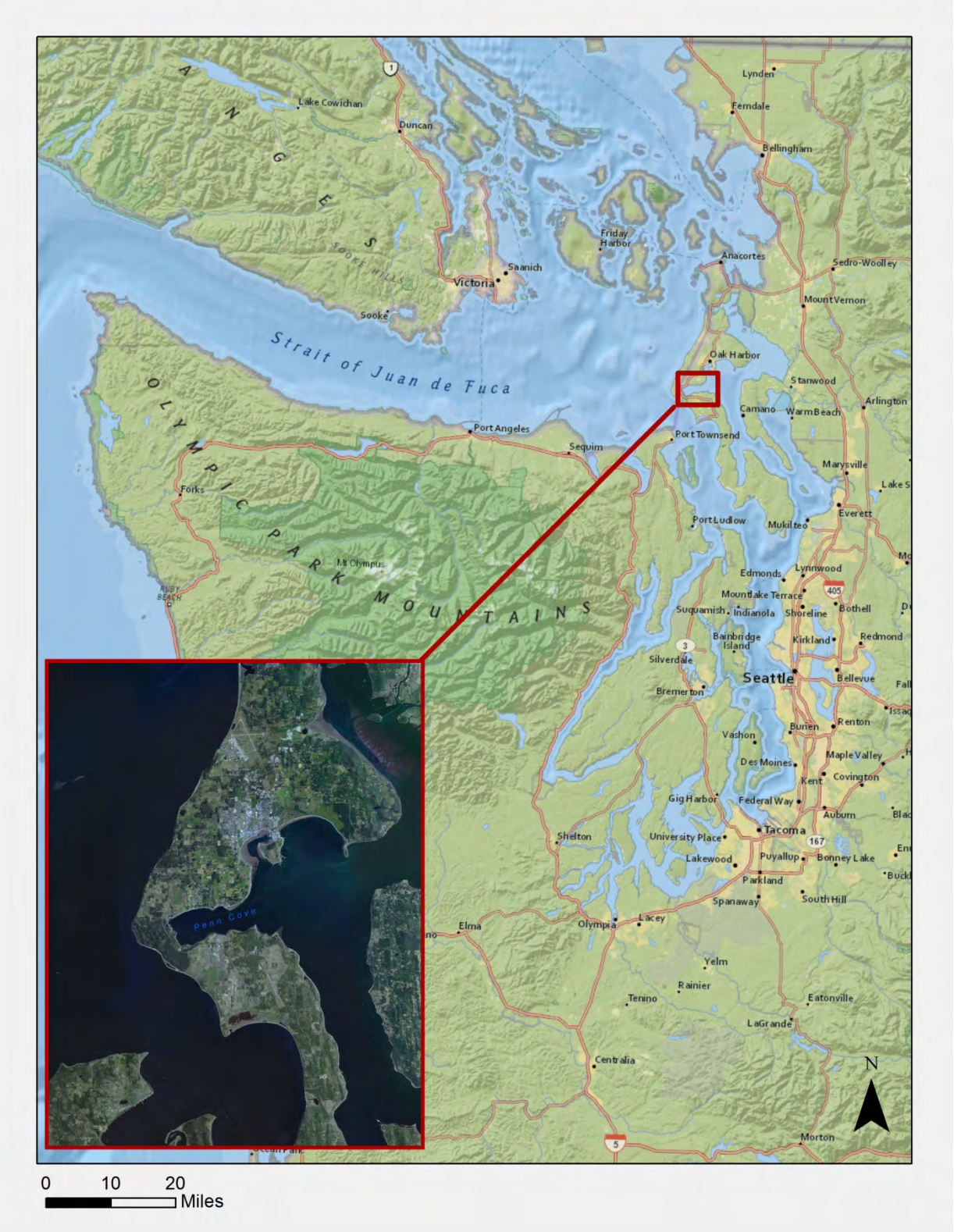

Table 1: Composite sample values of polycyclic aromatic hydrocarbons (PAHs) concentrations detected in mussels collected from Penn Cove, Island County, Washington in May 2012 after recent oil spill.

Chemicals	A-1 (ppm)	A-7 (ppm)	C-1 (ppm)	C-8 (ppm)	F-4 (ppm)	F-4 Dup (ppm)	F-8 (ppm)	MB (ppm)	WPCB (ppm)
Naphthalene	0.261	0.314	0.251	0.539	0.395	0.389	0.439	0.313	0.434
Fluorene	0.103	0.075	0.084	0.214	0.161	0.162	0.115	0.138	0.190
Phenanthrene	0.111	0.086	0.096	0.328	0.241	0.236	0.152	0.214	0.259
Anthracene	1.24E-4 U	1.24E-4 U	1.24E-4 U	1.24E-4 U	1.24E-4 U	1.24E-4 U	1.24E-4 U	1.24E-4 U	1.24E-4 U
Fluoranthene	5.30E-5 U	5.30E-5 U	5.30E-5 U	5.30E-5 U	5.30E-5 U	5.30E-5 U	5.30E-5 U	5.30E-5 U	5.30E-5 U
Pyrene	2.65E-4 U	2.65E-4 U	2.65E-4 U	2.65E-4 U	2.65E-4 U	2.65E-4 U	2.65E-4 U	2.65E-4 U	2.65E-4 U
Perylene	6.20E-5 U	6.20E-5 U	6.20E-5 U	6.20E-5 U	6.20E-5 U	6.20E-5 U	6.20E-5 U	6.20E-5 U	6.20E-5 U
Benz(a)anthracene	9.20E-5 U	9.20E-5 U	9.20E-5 U	9.20E-5 U	9.20E-5 U	9.20E-5 U	9.20E-5 U	9.20E-5 U	9.20E-5 U
Chrysene	4.60E-4 U	4.60E-4 U	4.60E-4 U	4.60E-4 U	4.60E-4 U	4.60E-4 U	4.60E-4 U	4.60E-4 U	4.60E-4 U
Benzo(b)fluoranthene	7.30E-5 U	7.30E-5 U	7.30E-5 U	7.30E-5 U	7.30E-5 U	7.30E-5 U	7.30E-5 U	7.30E-5 U	7.30E-5 U
Benzo(k)fluoranthene	4.40E-5 U	4.40E-5 U	4.40E-5 U	4.40E-5 U	4.40E-5 U	4.40E-5 U	4.40E-5 U	4.40E-5 U	4.40E-5 U
Benzo(e)pyrene	8.00E-5 U	8.00E-5 U	8.00E-5 U	8.00E-5 U	8.00E-5 U	8.00E-5 U	8.00E-5 U	8.00E-5 U	8.00E-5 U
Benzo(a)pyrene	6.70E-5 U	6.70E-5 U	6.70E-5 U	6.70E-5 U	6.70E-5 U	6.70E-5 U	6.70E-5 U	6.70E-5 U	6.70E-5 U
Indeno(1,2,3-cd)pyrene	9.30E-5 U	9.30E-5 U	9.30E-5 U	9.30E-5 U	9.30E-5 U	9.30E-5 U	9.30E-5 U	9.30E-5 U	9.30E-5 U
Dibenz(a,h)anthracene	7.00E-5 U	7.00E-5 U	7.00E-5 U	7.00E-5 U	7.00E-5 U	7.00E-5 U	7.00E-5 U	7.00E-5 U	7.00E-5 U
Benzo(ghi)perylene	6.80E-5 U	6.80E-5 U	6.80E-5 U	6.80E-5 U	6.80E-5 U	6.80E-5 U	6.80E-5 U	6.80E-5 U	6.80E-5 U

U- data qualifier: The analyte was not detected at this level
ppm -parts per million

Discussion

Contaminants of Concern

Contaminants of concern (COCs) in shellfish were determined by employing a screening process. Screening values (SVs) were developed according to the Environmental Protection Agency (EPA) guidance and are used to narrow the focus of evaluation to contaminants that are present at potential levels of public health concern (Appendix B) [3]. The maximum levels of PAHs in shellfish were screened against SVs for non-cancer health effects (see Table 2 and Appendix B). SVs for PAHs that do not cause cancer represent levels that are not expected to cause any health problems. In general, if a contaminant's maximum concentration is greater than its SV, then the contaminant is evaluated further. For carcinogenic PAHs (cPAHs), SVs represent levels that estimate an increase in the risk of developing one additional case of cancer in one hundred thousand people exposed (see Table 3 and Appendix B) [3]. Based on the screening limit none of the PAHs are COCs.

Chemical Specific Toxicity

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are generated by the incomplete combustion of organic matter, including oil, wood, and coal. They are found in materials such as creosote, coal, coal tar, and used motor oil. Based on structural similarities, metabolism, and toxicity, PAHs are often grouped together when evaluating their potential for adverse health effects. EPA has classified some PAHs as probable human carcinogens (B2), called cPAHs as a result of *sufficient* evidence of carcinogenicity in animals and *inadequate* evidence in humans [4].

Dietary sources make up a large percentage of PAH exposure in the U.S. population. Smoked or barbecued meats and fish contain relatively high levels of PAHs. The majority of dietary exposure to PAHs for the average person comes from ingestion of vegetables and grains (cereals)[5].

Non -carcinogenic Polycyclic Aromatic Hydrocarbons (PAHs)

Non-cancer adverse health effects associated with PAH exposure has been observed in animals but generally not in humans (with the exception of effects to the skin, bone marrow, and lymph node system) [4]. The skin is prone to PAH effects in both humans and animals. However, the observed effect level for carcinogenic endpoints is very much lower than that of the non-cancer endpoints. Therefore, it is routine to focus on the potential cancer effects of PAHs.

Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)

Although several PAHs were analyzed in tissue, only a single value, called a total cPAH toxic equivalent (TEQ), was presented in this health consultation. Benzo(a)pyrene (BaP) is the only cPAH for which EPA has derived a cancer slope factor. DOH made an adjustment for each cPAH compound based on its relative potency to BaP [4]. That is, the concentration of each

cPAH is multiplied by a Toxic Equivalency Factor (TEF) to produce a cPAH TEQ for that compound (Appendix B, Table B1). The TEQs for each cPAH compound are then summed to give a total cPAH TEQ. The TEQ approach is based on the premise that many cPAHs are structurally and toxicologically similar to BaP. TEFs are used to account for the different carcinogenic potency of other cPAHs to BaP.

Consumption Scenarios

DOH established two consumption scenarios for shellfish consumers. These were based on general population and subsistence seafood (fish and shellfish) consumption rates, conservatively assuming that all seafood is mussel meat. Both rates are based on the average quantity of total seafood consumed by each group. DOH assumed the following mussel consumption rates:

- General population consumption rate of mussel meat for an adult is 17.5 grams per day (g/day) [3]. This is one meal of mussels (approximately 8-oz uncooked mussel meat) once every two weeks.
- Subsistence fish/shellfish consumption rate for an adult is 142.4 g/day [3]. This is approximately one-third of a pound of mussel meat daily.

For comparison, the EPA Tribal framework presented consumption rates (all Puget Sound Shellfish) for risk-based decisions of 81.9 g/day and 498.4 g/day for the Tulalip and Suquamish tribes respectively [6]. The Suquamish Tribe 90^{th} percentile (including non-consumers) consumption rate for mussels is about 4 g/day [7]. If one assumes that 10 percent of the total shellfish ingested by Tribe members is mussels, consumption rates for mussels would be about 8.2 g/day and 49.8 g/day.

Table 2: Non-carcinogenic screening values and maximum concentration of polycyclic aromatic hydrocarbons (PAHs) detected in Mussels collected in Penn Cove, Island County, Washington in May 2012 after recent oil spill.

Chemicals	Maximum Concentration (ppm)	Screening Values (ppm) [3]		EPA Cancer Class	RfD (mg/kg/day)	Non-cancer Contaminant of Concern
		General Population	Subsistence consumer			
Naphthalene	0.539	80	10	CN	0.02	No
Fluorene	0.214	160	20	D	0.04	No
Anthracene	0.000124U	1200	148	D	0.3	No
Fluoranthene	0.000053U	160	20	D	0.04	No
Pyrene	0.000265U	120	15	D	0.03	No
Phenanthrene	0.328	1200	148	D	0.3*	No
Perylene	0.000062U	120	15		0.03**	No
Benzo(ghi)perylene	0.000068U	120	15	D	0.03**	No
Benzo(e)pyrene	0.00008U	120	15	N/A	0.03**	No
Benz(a)anthracene	0.000092U	120	15	B2	0.03**	No
Chrysene	0.00032U	120	15	B2	0.03**	No
Benzo(a)pyrene	0.000067U	120	15	B2	0.03**	No
Dibenz(a,h)anthracene	0.00007U	120	15	B2	0.03**	No
Indeno(1,2,3-cd)pyrene	0.000093U	160	20	B2	0.04***	No
Benzo(b)fluoranthene	0.000073U	160	20	B2	0.04***	No
Benzo(k)fluoranthene	0.000044U	160	20	B2	0.04***	No

CN - EPA: Carcinogen potential cannot be determine
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
D - EPA: Not classifiable as to health carcinogenicity
N/A – International Agency for Research on Cancer (IARC): Not classifiable as to health carcinogenicity
J - data qualifier: The associated numerical result is an estimate
U- data qualifier: The analyte was not detected at this level
RfD - EPA oral reference dose
MRL- ATSDR's Minimal Risk Level
* Anthracene RfD value was used as a surrogate
** Pyrene RfD value was used as a surrogate
*** Fluoranthene RfD value was used as a surrogate
ppm -parts per million
mg/kg/day - milligrams per kilogram body-weight per day
TEQ – Toxic Equivalent

Table 3: Carcinogenic screening values and maximum concentration of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) detected in mussels collected in Penn Cove, Island County, May 2012 after recent oil spill.

Chemicals	Maximum Concentration (ppm)	Screening Values (ppm) [3]		EPA Cancer Class	Cancer Potency Factor ($mg/kg/day^{-1}$)	Cancer Contaminant of Concern
		General Population	Subsistence consumer			
Benz(a)anthracene	0.000092U	cPAH	cPAH	B2	cPAH	cPAH
Chrysene	0.00032U					
Benzo(a)pyrene	0.000067U					
Dibenz(a,h)anthracene	0.00007U					
Indeno(1,2,3-cd)pyrene	0.000093U					
Benzo(b)fluoranthene	0.000073U					
Benzo(k)fluoranthene	0.000044U					
Total cPAH TEQ	1.6E-4	5.5E-3	6.7E-4	B2	7.3	No

B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
U- data qualifier: The analyte was not detected at this level
ppm -parts per million
cPAH - carcinogenic polycyclic aromatic hydrocarbons
mg/kg/day - milligrams per kilogram body-weight per day
Total cPAH TEQ – sum of all carcinogenic polycyclic aromatic hydrocarbons (cPAH), toxic equivalent (TEQ), all cPAH in COC are added using the TEQ approach to obtain Total cPAH TEQ.

NOAA Criteria Comparison to PAHs in Penn Cove Mussels:

NOAA criteria for reopening areas closed from oil spills (NOAA criteria) is based on chemical contaminant concentrations in seafood and a consumption rate of 30 g/day of seafood [8]. The Maximum Permissible Level (MPL) criteria for naphthalene, fluorene, and anthracene/phenanthrene are based on an adult daily consumption and RfD.

Fluoranthene and pyrene are considered to be non-carcinogenic PAHs [4]. However, under the NOAA criteria they are considered cPAHs. Therefore, similar to the cPAH TEF approach, the NOAA criteria uses a carcinogen potential based on benzo(a)pyrene to calculate a MPL. The MPL is based on a five year effect of the spill on shellfish and an increase risk of developing one additional case of cancer in one million people exposed over a lifetime. Maximum PAH values in mussels from Penn Cove were compared to NOAA Criteria and all values are below those set for reopening areas closed from oil spills (see Table 4).

Table 4: Polycyclic aromatic hydrocarbons (PAHs) in mussels from Penn Cove, Island County, Washington May 2012 after recent oil spill compared to National Oceanic and Atmospheric Administration (NOAA) Criteria for reopening shellfish harvest areas closed from oil spills.

Chemical	Maximum Permissible Level (MPL) (ppm) [8]	Penn Cove Mussels Maximum (PCMM) (ppm)	Carcinogenic Ratio (PCMM/MPL)	Meet NOAA Criteria (Pass/Fail)
Naphthalene	90	0.539	NA	Pass
Fluorene	90	0.214	NA	Pass
Anthracene/phenanthrene	700	0.328	NA	Pass
Fluoranthene	0.8	0.000053U	0.00006625	Pass
Pyrene	0.1	0.000159*U	0.00159	Pass
Benz(a)anthracene	1	0.000092U	0.000092	Pass
Chrysene	1	0.000092U	0.000092	Pass
Benzo(a)pyrene	0.02	0.000067U	0.00335	Pass
Sum of carcinogenic ratio <1			0.00519025	Pass

NA – not applicable
ppm – parts per million
U- data qualifier indicating non-detect at method detection level
* - sum of method detection level at non-detect for Pyrene, C-1, and C-2 Pyrenes
< - less than

Children's Health Considerations

The potential for exposure and subsequent adverse health effects often increases for younger children compared with older children or adults. ATSDR and DOH recognize that children are susceptible to developmental toxicity that can occur at levels much lower than in adults. The following factors contribute to this vulnerability:

- Children are more likely to play outdoors in contaminated areas by disregarding signs and wandering onto restricted locations.
- Children often bring food into contaminated areas, resulting in hand-to-mouth activities.
- Children are smaller and receive higher doses of contaminant exposures per body weight.
- Children are shorter than adults, therefore they have a higher possibility of breathing in dust and soil.
- Fetal and child exposure to contaminants can cause permanent damage during critical growth stages.

These unique vulnerabilities of infants and children demand special attention in communities that have contamination of their water, food, soil, or air. DOH did not estimate risks for children because of lack of children's ingestion rates for the general population and subsistence shellfish (mussel) scenarios. However, very conservative/protective screening values were used for the adult general population and for a subsistence shellfish consumer eating mussels at a 17.5 g/day and 142.4 g/day from Penn Cove. Although children are smaller and receive higher doses of contaminant exposures per body weight, it is likely that children may be more susceptible to disease than adults if they eat shellfish at these rates.

Conclusions

1. DOH concludes that eating mussels from Penn Cove is not expected to harm people's health because the maximum levels of PAHs are below concentrations where we would expect to see non-cancer or cancer health effects.

2. DOH concludes that based on chemical testing for PAHs, the area is safe to reopening for harvest, pending smell and taste testing. The maximum levels of PAHs do not exceed the NOAA criteria for reopening shellfish harvest areas closed from oil spills. However, the latter testing is needed even when seafood samples pass chemical analysis because flavor or odor still may be affected ("taint"). Taint in seafood renders it adulterated and unfit for human consumption according to U.S. law (Federal Food, Drug, and Cosmetics Act, U.S. Code 21, Chapter IV, Sec. 402[342], a.3).

Recommendations

1. To err on the side of safety and present a conservative approach protective of public health, people should avoid eating foods in which oil can be seen, smelled, or tasted.

Public Health Action Plan

1. DOH will provide copies of this health consultation to Ecology and other concerned parties when the report is approved.

2. A copy of this health consultation report will be placed on the DOH site assessment website: http://www.doh.wa.gov/consults

Report Preparation

This health consultation for the Penn Cove was prepared by the Washington State Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. This report was (supported/supported in part) by funds from a cooperative agreement with the Agency for Toxics 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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Appendix A Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil, or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor (CSF)	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with **acute**].
CERCLA	Comprehensive Environmental Response Compensation and Liability Act.
Comparison Value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a comparison value used to select contaminants of potential health concern and is based on ATSDR's minimal risk level (MRL).
Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [see **acute exposure**], of intermediate duration, or long-term [see **chronic exposure**].
Hazardous Substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].
Ingestion Rate (IR)	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter per day (1/day) for water and milligrams per day (mg/day) for soil.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Parts Per Billion (ppb)/Parts Per Million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [see **inhalation**], eating or drinking [see **ingestion**], or contact with the skin [see **dermal contact**].

Appendix B Screening Value Calculations

For Non-cancer Health Effects

SV = [(MRL or RfD)*BW]/CR [3]

SV = Screening value (mg/kg or ppm)
MRL = Minimal risk level (mg/kg/day)
RfD = Reference dose (mg/kg/day)
BW = Mean body weight (kg)
CR = Mean daily consumption rate (kg/day)

BW (adult) = 70 kg
General population CR = 17.5 g/day = 0.0175 kg/day
Subsistence Consumer CR = 142.4 g/day = 0.1424 kg/day

If maximum concentration is greater than screening value, further evaluation is required.

For Cancer Health Effects

SV_{cancer} = [(RL / CSF) * BW]/ CR [3]

SV_{cancer} = Cancer screening value (mg/kg or ppm)
RL = Risk level (life time cancer risk)
BW = Mean body weight (kg)
CR = Mean daily consumption rate (kg/day)
CSF = Oral cancer slope factor (mg/kg/day)

BW (adult) = 70 kg
General population CR = 17.5 g/day = 0.0175 kg/day
Subsistence Consumer CR = 142.4 g/day = 0.1424 kg/day
RL = $1x10^{-5}$
CSF = contaminants specific

If maximum concentration is greater than screening value, further evaluation is required.

Table B1: Toxic Equivalency Factors (TEFs) For Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) [9]

Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) [9]	TEF
Benzo(a)anthracene	0.1
Chrysene	0.001
Benzo(a)pyrene	1
Dibenz(a,h)anthracene	1
Indeno(1,2,3-cd)pyrene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01

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