Letter Health Consultation

Evaluation of Environmental Monitoring Data from Mussels Warm Beach, Snohomish County, Washington

March 4, 2014

Prepared by

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

334-343 March 2014

Foreword

The Washington State Department of Health (DOH) prepared this health consultation under 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. ATSDR is responsible for health issues related to hazardous substances.

The purpose of a health consultation is to assess the health threat posed by hazardous substances in the environment. If needed, a health consultation will also 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 the report was written. It 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 state or federal health agencies.

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

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For more information about ATSDR, contact the CDC Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

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March 4, 2014

Sean Edwards
Snohomish County Public Works
Surface Water Management Division
3000 Rockefeller Avenue, MS-607
Everett, Washington 98201-4046

Re: Evaluation of Environmental Monitoring data from Mussels collected for the Mussel Watch Pilot Expansion Project from Warm Beach, Snohomish County

Dear Mr. Edwards:

At the request of the Snohomish County Public Works Department, the Washington State Department of Health (DOH) has evaluated environmental monitoring data from tissues in mussels collected from Warm Beach, Snohomish County. Samples were collected by Snohomish County in partnership with the Washington Department of Fish and Wildlife (WDFW) as part of the Mussel Watch Pilot Expansion (MWPE) project. DOH reviewed chemical contaminant data from the MWPE project to determine if there is a potential human health risk from the consumption of mussels sampled from Warm Beach, Snohomish County. DOH conducts health consultations in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background and Statement of Issues

WDFW recently completed a pilot study to examine toxic contaminants in Puget Sound mussels, called the 2012/13 Mussel Watch Pilot Expansion (MWPE) project. The goal of the MWPE project was to evaluate the geographic extent and magnitude of chemical contamination in shoreline biota and compare contamination patterns in mussels with adjacent shorelines, covering a wide range of land-use types. Snohomish County Public Works partnered with WDFW to collect mussels at Warm Beach in Port Susan for the MWPE project. This was done as part of Snohomish County's Stillaguamish Shellfish Protection Program, through which the county works with local partners and stakeholders to raise public awareness about water quality and the need for shellfish protection in Port Susan and South Skagit Bay. One of the objectives of the shellfish program is to reconnect the local community to local shellfish resources through various outreach and education activities, such as shellfish gardening workshops and shellfish dinner events. By interpreting the Warm Beach MWPE data, DOH is helping Snohomish County

and the Warm Beach community to understand the potential human health risks from chemical contaminants in locally harvested shellfish [1].

Warm Beach is located along the shores of Port Susan in Snohomish County. This beach supports private, non-tribal recreational shellfish harvesting; there are approximately 230 private tideland owners in this vicinity [1].

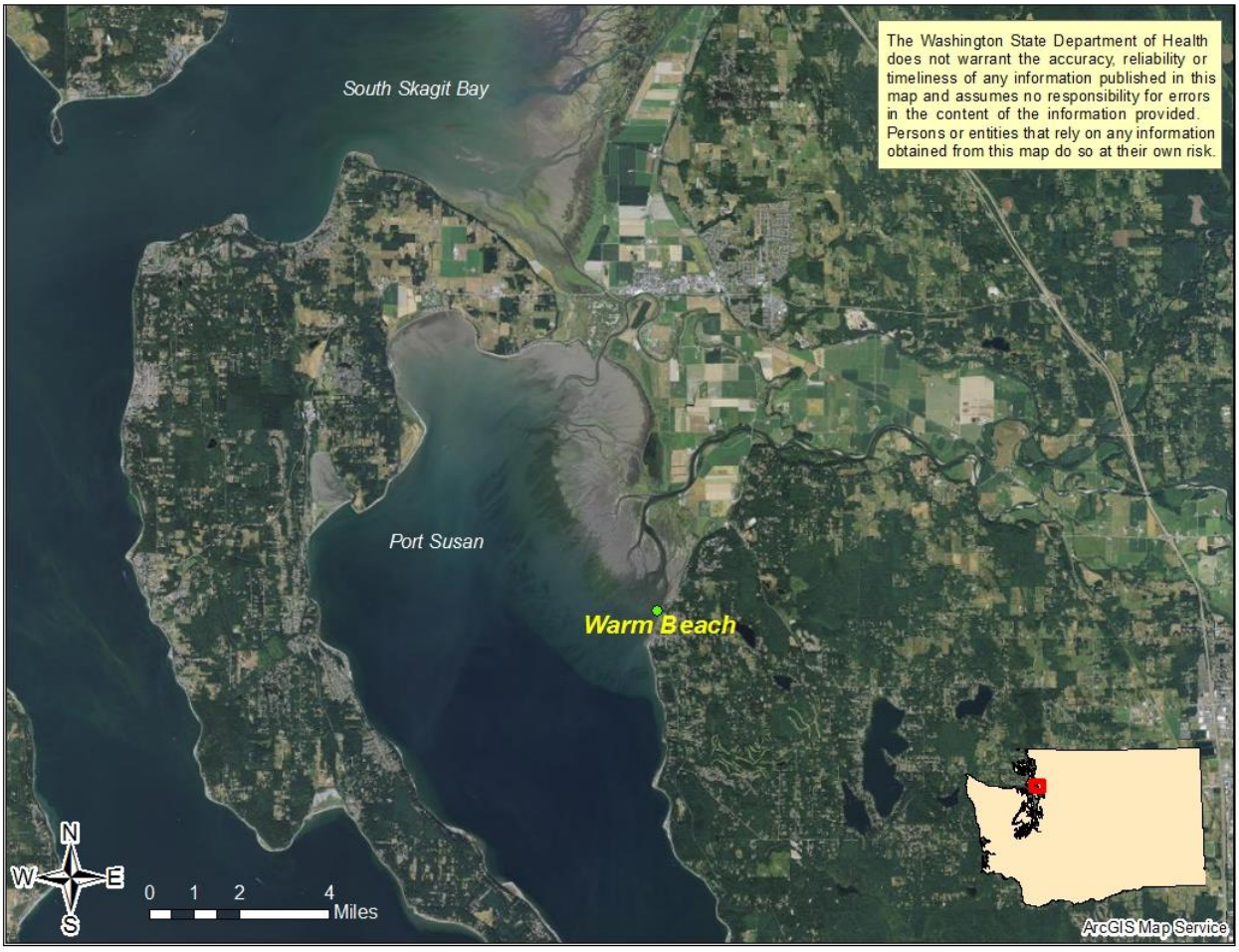

Figure 1: Warm Beach and Mussel Watch Pilot Expansion sampling site (green point) in Snohomish County, Washington

Discussion

Concentrations of metals, organochlorines, and polycyclic aromatic hydrocarbons (PAHs) were measured in mussels sampled from Warm Beach, Snohomish County for the MWPE project. DOH then evaluated all chemical concentrations from the MWPE dataset. Several of the organochlorines analyzed were detected above the Limit of Quantitation (LOQ) – the lowest concentration at which the contaminant could be reliably detected based on the calibration standard used for that contaminant. About half of the PAHs analyzed were detected above the LOQ. All metals were detected above the Method Detection Limit (MDL) – the minimum concentration that could be measured and reported with 99% confidence that the true metal concentration is greater than zero.

DOH generated screening values (see Attachment A) for each contaminant using Environmental Protection Agency (EPA) guidance method for fish advisories [2]. These risk-based screening values are a basis for assessing whether chemical contaminant concentrations present in mussel tissue are a concern to human health when consumed. All chemicals, regardless of detection limit, were further evaluated against their screening values to see if they posed a potential health problem. For the complete list of chemicals, see Attachment B. If the concentration of a chemical exceeds its calculated screening value, DOH analyzes the chemical further and categorizes it as a "chemical of concern." ATSDR Minimal Risk Levels (MRLs) for oral exposure were referenced for each chemical and inputted into screening value calculations. For chemicals that did not have MRLs, EPA Oral Reference Doses (RfDs) were used instead. Wet weight concentrations, as opposed to dry weight concentrations, were used in the screening process to reflect typical seafood consistency consumed.

Based on Warm Beach community demographics, DOH used a consumption rate based on general population shellfish consumers. For this evaluation, DOH also assumed that all shellfish consumed are mussels. The EPA has developed national recommended human health criteria (HHC) based on a general population consumption rate of 17.5 grams per day (g/day) of fish and/or shellfish for the average adult weighing 70 kg [2]. This is one meal of mussels (approximately 8 ounces of uncooked mussel meat) once every two weeks, which is a more conservative estimate compared to the HHC for Washington State. Washington's current HHC is based on a 6.5 g/day fish consumption rate for the average consumer and was adopted for the National Toxics Rule (NTR).

All concentrations in the MWPE dataset were compared to calculated screening values according to the EPA guidance method. Stakeholders also requested that the NTR "Human Health Criteria for Water and Equivalent Fish Tissue Concentrations" table also be used for comparison; however, DOH considers these values to be not as applicable to evaluating potential health effects from ingestion. NTR values are more relevant to wastewater permitting and environmental clean-up regulation. DOH examined but did not use these values in the screening process.

Based on the screening results of the MWPE dataset, none of the chemicals exceeded the screening values and therefore no contaminants of concern were identified for further evaluation.

Exposure Pathways

In order for any contaminant to be a health concern, the contaminant must be present at a high enough concentration to cause potential harm, and there must be a completed route of exposure to people. No one has consumed these mussels as they were kept in a cage for purposes of MWPE sampling and analysis [3]. However, assuming that MWPE-sampled mussels approximate native mussels, exposure to contaminants in native mussels at Warm Beach for the general population and a subsistence fish/shellfish consumer would occur primarily through ingestion. The potentially exposed population would consist of private tideland owners who harvest shellfish (including mussels, clams, and crabs) recreationally.

MWPE Study Design – Limitations and Assumptions

The objective of the MWPE study was to collect environmental data from mussels exposed to various conditions around Puget Sound to evaluate the degree to which animals living in nearshore habitats are exposed to pollutants from stormwater and other sources. Pacific blue mussels (*Mytilus trossulus*) were placed in predator-exclusion cages anchored in the middle intertidal zone at 108 sample sites, including one at Warm Beach. These caged mussels were thus exposed to environmental conditions during the winter of 2012-2013 (November-January), which included marine water, heavy rainfall and surface water drainage into Port Susan. At the end of the two month exposure period 32 live mussels from each cage (soft tissue only) were composited, homogenized, and analyzed for a range of contaminants [3].

As the MWPE dataset is limited to contaminants in mussels transplanted on site for two months, DOH cannot make any conclusions about the general native shellfish population at Warm Beach or potential human health effects from consuming any native shellfish from the area. However, DOH recognizes the following underlying assumptions of the MWPE project: 1) transplanted mussels will be exposed to the same suite of chemical contaminants as naturally occurring mussels living in the immediate area, 2) contaminant levels in mussel tissues respond to changes in environmental levels of contaminants, and 3) chemical contaminants in transplanted mussels may eventually reach equilibrium with their immediate environment. Therefore, chemical contaminant data from MWPE-sampled mussels should approximate native mussel contamination in the same area [4, 5].

Conclusions

DOH concludes that the concentrations of chemical contaminants found in MWPE caged mussels collected from the Warm Beach site are not expected to harm human health. Maximum levels of chemical contaminants are below concentrations where we would expect to see non-cancer or cancer health effects.

Recommendations

A site visit to Warm Beach indicated that area residents and recreational shellfish harvesters may be more interested in the sampling and analysis of intertidal clams, which are primarily the eastern softshell clam (*Mya arenaria*). In order to make conclusions about other shellfish from Warm Beach, other species of shellfish found in the area, such as clams, should be sampled and analyzed.

If future clam sampling is done, DOH recommends that a sampling plan be drafted by Snohomish County and appropriate stakeholders. DOH can be contacted to review the sampling and analysis plan. For a more conclusive health consultation, a minimum of three composite samples of shellfish tissue is recommended per site. All tissue homogenized in a composite sample should be from only one species of shellfish.

Note that a portion of Warm Beach is classified as prohibited for shellfish harvesting. This is primarily due to possible microbial contamination concerns with effluent from the Warm Beach Christian Camp Water Reclamation Facility. For a detailed map of the Warm Beach area, see Attachment C. With current chemical contaminant data, DOH recommends that normal fish consumption guidelines be followed for this region of Puget Sound. See the DOH fish advisory website for details:
http://www.doh.wa.gov/CommunityandEnvironment/Food/Fish/Advisories.aspx.

DOH appreciates this opportunity to review the Mussel Watch Pilot Expansion project dataset from Warm Beach and to assist in the evaluation of these data. A copy of this letter will be placed on the DOH Site Assessments website: http://www.doh.wa.gov/consults. If you have any questions regarding this letter please contact me at 360-236-3357 or by email at Amy.Leang@doh.wa.gov.

Sincerely,

Amy Leang
Health Assessor, Toxicologist
Site Assessments and Toxicology Section

Enclosures (3)

cc: Joanne Snarski, Department of Health

References

1. Snohomish County. 2011. Stillaguamish Shellfish Protection Program. Snohomish County Public Works, Surface Water Management. Everett, WA.

2. U.S. Environmental Protection Agency. 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories - Volume 1, Fish Sampling and Analysis, Third Edition. EPA-823-B-00-007.

3. Lanksbury, J., West J. and L. Niewolny. 2012. Quality Assurance Project Plan, Mussel Watch Pilot Expansion Project. Washington State Department of Fish and Wildlife. WDFW 11-1916.

4. Bervoets, L., Voets, J., Chu, S., Covaci, A., Schepens, P. and R. Blust. 2004. Comparison of accumulation of micropollutants between Indigenous and Transplanted Zebra mussels (*Dreissena polymorpha*). Environmental Toxicology and Chemistry, 23(8); 1973-1983.

5. Nigro, M., Falleni, A., Del Barga, I., Scarcelli, V., Lucchesi, P., Regoli, F. and G. Frenzilli. 2006. Cellular Biomarkers for Monitoring Estuarine Environments: Transplanted Versus Native Mussels. Aquatic Toxicology 77:339–347.

Attachment A

Screening Value Calculations

(Based on Environmental Protection Agency methodology)

For Non-cancer Health Effects
SV = [(MRL or RfD)*BW]/CR [2]

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
CR = Mean daily consumption rate (kg/day)
General population CR = 17.5 g/day = 0.0175 kg/day
If maximum concentration is greater than screening value, further evaluation is required.

For Cancer Health Effects
SV_{cancer} = [(RL / CSF) * BW]/ CR [2]

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) - contaminants specific

BW (adult) = 70 kg
General population CR = 17.5 g/day = 0.0175 kg/day
RL = $1x10^{-5}$
If maximum concentration is greater than screening value, further evaluation is required.

Estimated Cancer Risk

Estimated Cancer risk estimates do not reach zero no matter how low the level of exposure to a carcinogen. Terms used to describe this risk are defined below as the number of excess cancers expected in a lifetime:

Term		# of Excess Cancers
moderate	is approximately equal to	1 in 1,000
low	is approximately equal to	1 in 10,000
very low	is approximately equal to	1 in 100,000
slight	is approximately equal to	1 in 1,000,000
insignificant	is less than	1 in 1,000,000

Attachment B

Screening of Chemicals

Table B1. Screening of Metal Concentrations in Mussels from Warm Beach, Snohomish County using EPA methodology Screening Values

Metals	EPA Cancer Class	Warm Beach Caged Mussel Concentration (mg/kg, ppm)	NTR Equivalent Fish Tissue Concentration (mg/kg, ppm)	MRL or Reference Dose (mg/kg/day)	Screening Value (mg/kg, ppm)	Contaminant of Concern
Arsenic	A	0.805	0.00616	0.0003	1.2	No
Cadmium	B1	0.29	n/a	0.0001	0.4	No
Copper	D	0.813	n/a	0.01	40	No
Lead	B2	0.031	n/a	n/a	[See Table B4]	No
Mercury	D	0.00705	0.56475	0.0003	1.2	No
Zinc	IN	11	n/a	0.3	1200	No

EPA – Environmental Protection Agency
NTR – National Toxics Rule
MRL – Minimal Risk Level from Agency for Toxic Substances & Disease Registry
mg/kg – milligrams per kilogram
mg/kg/day – milligrams per kilogram per day
n/a – not available
EPA Cancer Class -
A: Human Carcinogen
B1: Probable Human carcinogen based on limited evidence in humans and sufficient evidence in animals
B2: Probable human carcinogen based on sufficient evidence in animals
D: Not classifiable as to its carcinogenicity to humans
IN: Inadequate information to assess carcinogenic potential

Table B2. Screening of Organochlorine Concentrations in Mussels from Warm Beach, Snohomish County using EPA methodology Screening Values

Organochlorines	EPA Cancer Class	Warm Beach Caged Mussel Concentration (ppb)	NTR Equivalent Fish Tissue Concentration (ppb)	MRL or Reference Dose (mg/kg/day)	Screening Value (ppb)	Contaminant of Concern
hexachlorobenzene	B2	<0.23	6.6913	0.00007	280	No
Aldrin	B2	<0.23	0.6538	0.00003	120	No
Dieldrin	B2	<0.23	0.6538	0.00005	200	No
Mirex		<0.23	n/a	0.0008	3200	No
Endosulfan		<0.23	n/a	0.005	20000	No
α-hexachlorocyclohexane	B2	<0.23	n/a	0.008	32000	No
β-hexachlorocyclohexane	B2	<0.23	n/a	0.0006	2400	No
lindane		<0.23	n/a	0.00001	40	No
Sum of hexachlorocyclohexanes		<0.23	n/a	0.00861	34440	No
α-chlordane		<0.23	n/a	0.0006	2400	
cis nonachlor		<0.23	n/a	0.0006	2400	
β-chlordane		<0.23	n/a	0.0006	2400	
heptachlor		<0.23	n/a	0.0006	2400	
heptachlor epoxide		<0.23	n/a	0.0006	2400	

Table B2 continued

Organochlorines	EPA Cancer Class	Warm Beach Caged Mussel Concentration (ppb)	NTR Equivalent Fish Tissue Concentration (ppb)	MRL or Reference Dose (mg/kg/day)	Screening Value (ppb)	Contaminant of Concern
nonachlorIII		<0.23	n/a	0.0006	2400	
oxychlordane		<0.23	n/a	0.0006	2400	
transnonachlor		<0.23	n/a	0.0006	2400	
Sum of chlordanes	KL	<0.23	8.319	0.0006	2400	No
o,p-DDD		<0.23		0.0005	2000	
o,p-DDE		<0.23		0.0005	2000	
o,p-DDT		<0.23		0.0005	2000	
p,p-DDD		<0.23		0.0005	2000	
p,p-DDE		0.35		0.0005	2000	
p,p-DDT	B2	<0.23		0.0005	2000	
Sum of DDTs		0.35	31.624	0.0005	2000	No
Total PCBs (reported estimate)	B2	3.05	5.304	0.00002	80	No
Total PBDEs	D	0.77	n/a	0.007	28000	No

EPA – Environmental Protection Agency
NTR – National Toxics Rule
MRL – Minimal Risk Level from Agency for Toxic Substances & Disease Registry
ppb – parts per billion
mg/kg/day – milligrams per kilogram per day
n/a – not available
EPA Cancer Class -
B2: Probable human carcinogen based on sufficient evidence in animals
D: Not classifiable as to its carcinogenicity to humans
KL: Known/Likely human carcinogen

Table B3. Screening of Polycyclic Aromatic Hydrocarbon (PAH) Concentrations in Mussels from Warm Beach, Snohomish County using EPA methodology Screening Values

PAHs	EPA Cancer Class	Warm Beach Caged Mussel Concentration (ppb)	NTR Equivalent Fish Tissue Concentration (ppb)	MRL or Reference Dose (mg/kg/day)	Screening Value (ppb)	Contaminant of Concern
Naphthalene	CN	1.5	n/a	0.02	80000	No
C1-Naphthalene		1.3	n/a	0.02	80000	No
C2-napthalenes		2.1	n/a	0.02	80000	No
C3-naphthalenes		2.1	n/a	0.02	80000	No
C4-napthalenes		1.7	n/a	0.02	80000	No
acenapthalene		<0.67	n/a	0.03	120000	No
acenaphthene		<0.73	n/a	0.6	2400000	No
fluorene	D	0.79	420000	0.04	160000	No
C1-fluorenes		<0.69	n/a	0.04	160000	No
C2-fluorenes		0.8	n/a	0.04	160000	No
C3-fluorenes		1.3	n/a	0.04	160000	No
dibenzothiophene		<0.63	n/a	0.01	40000	No

Table B3 continued

PAHs	EPA Cancer Class	Warm Beach Caged Mussel Concentration (ppb)	NTR Equivalent Fish Tissue Concentration (ppb)	MRL or Reference Dose (mg/kg/day)	Screening Value (ppb)	Contaminant of Concern
C1-dibenzothiophene		<0.69	n/a	0.01	40000	No
C2-dibenzothiophene		<0.69	n/a	0.01	40000	No
C3-dibenzothiophene		<0.69	n/a	0.01	40000	No
C4-dibenzothiophene		<0.69	n/a	0.01	40000	No
phenanthrene	D	6.5	n/a	0.3	1200000	No
anthracene	D	0.63	3300000	0.3	1200000	No
C1-phenanthrenes/anthracenes		4.2	n/a	0.3	1200000	No
C2-phenanthrenes/anthracenes		2.6	n/a	0.3	1200000	No
C3-phenanthrenes/anthracenes		0.79	n/a	0.3	1200000	No
C4-phenanthrenes/anthracenes		2.3	n/a	0.3	1200000	No
fluoranthene	D	7.7	n/a	0.04	160000	No
pyrene	D	5	330000	0.03	120000	No
C1-fluoranthenes/pyrenes		1.7	n/a	0.3	1200000	No
C2-fluoranthenes/pyrenes		<0.69	n/a	0.3	1200000	No
C3-fluoranthenes/pyrenes		<0.69	n/a	0.3	1200000	No
C4-fluoranthenes/pyrenes		<0.69	n/a	0.3	1200000	No
benz(a)anthracene	B2	0.99	0.93	0.03	120000	No
chrysene	B2	2.4	0.93	0.03	120000	No
C1-benzanthracenes/chrysenes		0.67	n/a	0.03	120000	No
C2-benzanthracenes/chrysenes		<0.40	n/a	0.03	120000	No
C3-benzanthracenes/chrysenes		<0.40	n/a	0.03	120000	No
C4-benzanthracenes/chrysenes		<0.40	n/a	0.03	120000	No
benzo(b)fluoranthene	B2	0.78	0.93	0.04	160000	No
benzo(j,k)fluoranthene	B2	0.93	n/a	0.04	160000	No
benzo(e)pyrene		<0.58	n/a	0.03	120000	No
benzo(a)pyrene	B2	<0.58	0.93	0.03	120000	No
perylene		0.54	n/a	0.03	120000	No
indeno(1,2,3-c,d)pyrene	B2	<0.52	0.93	0.04	160000	No
dibenz(a,h)anthracene	B2	<0.44	0.93	0.03	120000	No
benzo(g,h,i)perylene	D	<0.52	n/a	0.03	120000	No

EPA – Environmental Protection Agency
NTR – National Toxics Rule
MRL – Minimal Risk Level from Agency for Toxic Substances & Disease Registry
ppb – parts per billion; mg/kg/day – milligrams per kilogram per day
n/a – not available
EPA Cancer Class -
B2: Probable human carcinogen based on sufficient evidence in animals
D: Not classifiable as to its carcinogenicity to humans
CN: Carcinogenic potential cannot be determined

Table B4. Screening of Lead Concentration in Mussels from Warm Beach, Snohomish County using Integrated Exposure Uptake Biokinetic (IEUBK) Model

Warm Beach Caged Mussel Lead Concentration (ppm)	Percent Meat Intake as Fish (%)	Children* with Blood Lead Levels ≥ 5 µg/dL (%)	Concern (5% or above)
0.031	7.5	0.008	No

Results are based on the IEUBK Model Version 1.1 Build 11; input parameters from Environmental Protection Agency.
MWPE – Mussel Watch Pilot Expansion
ppm – parts per million
µg/dL – micrograms per deciliter of blood
% - percent
≥ - greater than or equal to
*Ages 0-7 years old

The Centers for Disease Control has a blood lead reference level of 5 µg/dL; when 5% of children are predicted to have 5 or more micrograms of lead per deciliter of blood, CDC recommends initiating public health action. Based on output data from the Integrated Exposure Uptake Biokinetic (IEUBK) model, only 0.008% of children are predicted to have elevated blood lead levels when consuming mussels from Warm Beach as their primary source of seafood. In contrast, a sample containing 3.37 ppm lead would result in a 5% predicted occurrence level in children with blood lead levels greater than or equal to 5 µl/dL. Therefore, any sample with a lead concentration over 3.37 ppm would be a public health concern. There are no elevated blood lead level health concerns for this community since 0.008% is well below the 5% threshold.

For cancer health effects of metals, analytes with probable or likely cancer class categorization were analyzed further. Cadmium is known to be carcinogenic, but only when inhaled. For Lead, see Table B4. Arsenic was the only metal to be screened for cancer via oral exposure route. The arsenic concentration was given as total arsenic in the data set, although only inorganic arsenic is known to be carcinogenic. To account for this, the arsenic concentration was multiplied by 1%[a] as studies have shown that this is the estimated proportion of inorganic arsenic in shellfish.

Initial cancer screening in Table B5 resulted in a "Yes" for inorganic arsenic as a contaminant of concern (COC), assuming that all fish and shellfish consumed are caged mussels from Warm Beach. As previously stated, if the concentration of a chemical exceeds its screening value, DOH categorizes it as a COC and analyzes the chemical further. Further analysis in Table B6 used an adjusted screening value using a high-end 90th percentile mussel consumption rate estimate from the Suquamish Tribe[b]. With this mussel-specific screening value, inorganic arsenic would not be a COC at this site for mussel consumers.

[a] Washington State Department of Ecology, Environmental Assessment Program: Inorganic arsenic levels in Puget Sound fish and shellfish from 303(d) listed water bodies and other areas, Prepared by Art Johnson and Morgan Roose: Publication No. 02-03-057. Olympia: Washington State Department of Ecology, December 2002.

[b] The Suquamish Tribe. 2000. Fish consumption survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region. August 2000. The Suquamish Tribe. 15838 Sandy Hook Road, Post Office Box 498, Suquamish, WA 98392.

Table B5. Summary of Carcinogenic Metals Screening for Cancer – All Shellfish Screening, Warm Beach, Snohomish County

Metals	Warm Beach Caged Mussel Concentration (ppm)	Screening Value (ppm)	EPA Cancer Class	Cancer Slope Factor ($mg/kg/day^{-1}$)	Carcinogenic Contaminant of Concern
Arsenic (Inorganic)*	0.00805	0.007	A	5.7	Yes**

* Only inorganic arsenic is known to be harmful, so total arsenic concentration was multiplied by 1% to obtain approximate inorganic arsenic concentration.
** If maximum concentration is greater than screening value, further evaluation is required (See Table B6).
ppm – parts per million
$mg/kg/day^{-1}$ – milligrams per kilograms body weight-day
EPA Cancer Class A: Human Carcinogen

Table B6. Summary of Carcinogenic Metals Screening for Cancer – Species-specific Mussels, Warm Beach Snohomish County

Metals	Warm Beach Caged Mussel Concentration (ppm)	Screening Value (ppm)	EPA Cancer Class	Cancer Slope Factor ($mg/kg/day^{-1}$)	Carcinogenic Contaminant of Concern
Arsenic (Inorganic)*	0.00805	0.037	A	5.7	No

* Only inorganic arsenic is known to be harmful, so total arsenic concentration was multiplied by 1% to obtain approximate inorganic arsenic concentration.
ppm – parts per million
$mg/kg/day^{-1}$ – milligrams per kilograms body weight-day
EPA Cancer Class A: Human Carcinogen

Table B7. Summary of Carcinogenic Organochlorines Screening for Cancer, Mussels from Warm Beach, Snohomish County

Organochlorines	Warm Beach Caged Mussel Concentration (ppm)	Screening Value (ppm)	EPA Cancer Class	Cancer Slope Factor ($mg/kg/day^{-1}$)	Carcinogenic Contaminant of Concern
Hexachlorobenzene	<0.00023	0.02500	B2	1.6	No
Aldrin	<0.00023	0.00235	B2	17	No
Dieldrin	<0.00023	0.00250	B2	16	No
Total Hexachlorocyclohexanes*,**	<0.00023	0.00635	B2	6.3	No
Total Chlordanes*	<0.00023	0.11429	KL	0.35	No
Total DDTs*	0.00035	0.11765	B2	0.34	No
Total PCBs (reported estimate) ***	0.00305	0.02000	B2	2	No

*Only a subset is EPA Cancer Class B2 or KL
** α-hexachlorocyclohexane cancer slope factor used
***upper-bound cancer slope factor
ppm – parts per million
$mg/kg/day^{-1}$ – milligrams per kilograms body weight-day
EPA Cancer Class -
B2: Probable human carcinogen based on sufficient evidence in animals
KL: Known/Likely human carcinogen

Benzo(a)pyrene (BaP) is the only carcinogenic polycyclic aromatic hydrocarbons (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. That is, the concentration of each cPAH is multiplied by a Toxic Equivalency Factor (TEF) to produce a cPAH Toxic Equivalency Quotient (TEQ) for that compound. The TEQs for each cPAH compound are then summed to give a total cPAH TEQ (see Table B8). 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.

Table B8. Summary of Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) Screening for Cancer, Mussels from Warm Beach, Snohomish County

cPAHs	Concen-tration (ppm)	TEF[c]	Concentration × TEF = TEQ (ppm)	Screening Value (ppm)	EPA Cancer Class	Cancer Slope Factor ($mg/kg/day^{-1}$)	Carcinogenic Contaminant of Concern
benz(a)anthracene	0.00099	0.1	0.000099				
chrysene	0.00240	0.001	0.0000024				
benzo(b)fluoranthene	0.00078	0.1	0.000078				
benzo(j,k)fluoranthene	0.00093	0.01	0.0000093	**0.0055**	B2	7.3	No
benzo(a)pyrene*	0.00053	1	0.00053				
indeno(1,2,3-c,d)pyrene*	0.00052	0.1	0.000052				
dibenz(a,h)anthracene*	0.00044	1	0.00044				
Total cPAH TEQ (ppm)**			**0.0012**				

* Analyte was not detected at the level; reported value is the method Limit of Quantitation.
** Detected analytes accounted for only 0.00019 of Total cPAH TEQ.
ppm – parts per million
$mg/kg/day^{-1}$ – milligrams per kilograms body weight-day
EPA Cancer Class B2: Probable human carcinogen based on sufficient evidence in animals

[c] Environmental Protection Agency (EPA). *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*. EAP/600/R-93/089. 1993.

Attachment C

Prohibited Shellfish Harvesting

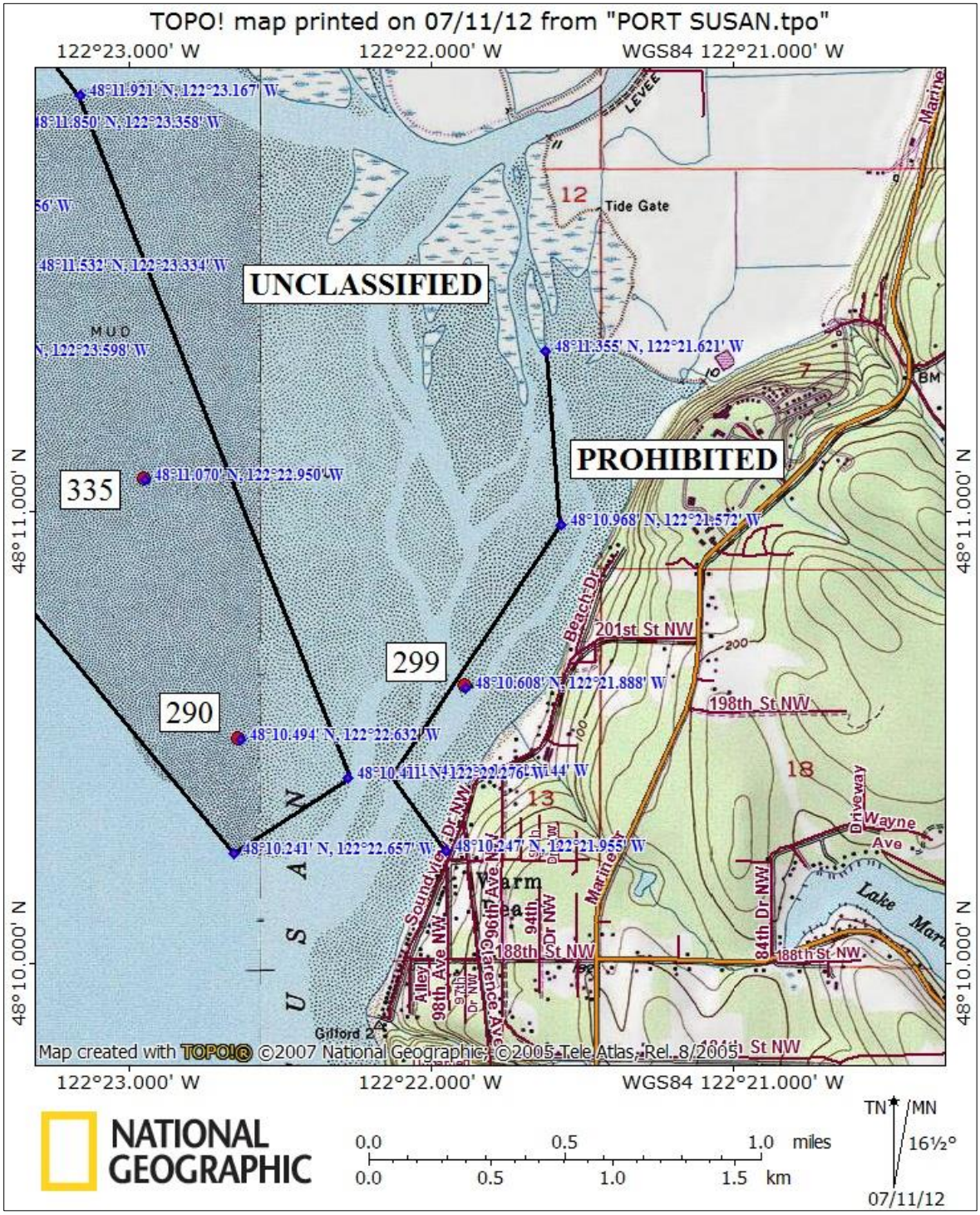

Figure C1: Topographic Map of Prohibited Shellfish Harvesting Area in Port Susan from Washington State Department of Health Office of Shellfish and Water Protection, URL: http://www.doh.wa.gov/Portals/1/Documents/4400/portsusan.pdf