Health Consultation

Operable Unit 2 Area 8 Shellfish Evaluation

NAVAL BASE KITSAP, KEYPORT
(FORMERLY KNOWN AS NAVAL UNDERSEA WARFARE CENTER, KEYPORT)
KEYPORT, KITSAP COUNTY, WASHINGTON

EPA FACILITY ID: WA1170023419
COST RECOVERY 0076

FEBRUARY 25, 2013

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Community Health Investigations

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Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CDC	Centers for Disease Control and Prevention
CFSCAN	Center for Food Safety and Applied Nutrition
CREG	Cancer Risk Evaluation Guide
CSO	Combined Sewer Overflows
CV	Comparison Value
DCE	Dichloroethylene
DHHS	Department of Health and Human Services
DOD	Department of Defense
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
HHRA	Human Health Risk Assessment
IRAC	International Agency for Research on Cancer
LOAEL	Lowest Observed Adverse Effect Level
LTM	Long Term Monitoring
MRL	Minimum Risk Level
NBK Keyport	Naval Base Kitsap, Keyport
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
NUWC	Naval Undersea Warfare Center
OU	Operable Unit
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PHA	Public Health Assessment
PTTIL	Provisional Total Tolerable Intake Level (FDA)
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
ROD	Record of Decision
SVOC	Semi-volatile Organic Compounds
TCA	Trichloroethane
TCE	Trichloroethylene
UCL	Upper Confidence Level
UST	Underground Storage Tanks
VOC	Volatile Organic Compounds
WDOE	Washington Department of Ecology

Summary

INTRODUCTION

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this Health Consultation in response to a request from representatives of the Suquamish Tribe and the Washington Department of Ecology (WDOE). They requested ATSDR evaluate clam tissue data collected from Liberty Bay between 1996 and 2008 near the facility formerly called Naval Undersea Warfare Center (NUWC), Keyport. This report documents our evaluation of the clam tissue in the near shore areas of the base.

In the 2001 PHA, ATSDR evaluated the potential for human exposure to contaminants in shellfish harvested from Liberty Bay at NUWC, Keyport, now referred to as Naval Base Kitsap (NBK), Keyport. ATSDR concluded that "exposures to contaminants in shellfish harvested from marine waters surrounding NUWC Naval Base Kitsap, Keyport pose no apparent past or current public health hazard." However, because of difficulty in interpreting past sampling data (e.g., different laboratory methodology), ATSDR could not adequately determine the potential for future contaminant exposures associated with consuming shellfish from the marine waters surrounding NUWC Naval Base Kitsap, Keyport (i.e., the Liberty Bay shoreline).

The Suquamish Tribe includes the near-shore areas of NBK, Keyport as part of their "Usual and Accustomed" fishing grounds. Although the Tribe currently does not harvest shellfish from the NBK, Keyport near-shore areas because of the concern about contamination, they would like to begin doing so. Since the PHA was released, the Navy conducted two additional rounds of sampling which generated additional shellfish data. This report serves as a follow-up to the Liberty Bay shellfish issue presented in the September 2001 ATSDR Public Health Assessment (PHA) for NUWC, Keyport. Additionally, ATSDR reviewed the data based on the anticipated future use of near-shore areas of NBK, Keyport using the accepted Suquamish shellfish ingestion rates.

CONCLUSION 1

Shellfish from near-shore area of Area 8 OU-2 are not currently being collected for consumption. Therefore, because there is no current exposure to the contaminants detected, there is no current health hazard. However, pacific littleneck clams samples collected from seep areas near (Area 8) NBK, Keyport exceeded health-based screening levels for several heavy metals. Eating clams from this area at Suquamish tribal subsistence quantities for longer than a year could harm people's health.

BASIS FOR CONCLUSION

The inner tidal areas adjacent to NBK, Keyport are maintained by the Navy as high security areas. Those areas are patrolled by security and are marked with no trespassing signs. Fishing is not permitted.

NEXT STEPS

ATSDR recommends that consumers continue to be advised not to eat shellfish in the near-shore areas of NBK, Keyport.

CONCLUSION 2

The limitations of the shellfish data collected in the near-shore area of NBK, Keyport of Liberty Bay between 1996 and 2008 prevent us from being able to make general public health conclusions on future shellfish consumption.

BASIS FOR CONCLUSION

The limitations in the data include the following:

1. Sampling took place in a small sample area
2. Only one shellfish species was sampled
3. Analysis was limited to inorganic compounds and Semi-volatile Organic Compounds, SVOCs
4. Sampling took place during a single season

NEXT STEPS

ATSDR recommends that prior to opening the area adjacent to Area 8 for shellfish harvesting, the Navy should sample a variety of shellfish (the major shellfish species that would be consumed) at varying times of the year from a broader area representing the open areas and analyzed for inorganic (especially cadmium, chromium, lead, and mercury), SVOCs, pesticides, polychlorinated biphenyl's (PCBs), and tributyltin. These contaminants have been released in the past. Further, this area should not be re-opened until long-term monitoring of shellfish demonstrates a notable decline in cadmium, chromium, lead, and mercury levels.

Finally, portions of Liberty Bay have been impacted by biological contamination from storm water and sewage outflows. ATSDR has not evaluated the level of biological contamination in shellfish. This needs to be evaluated before shellfish harvesting can resume.

ATSDR's dose estimates are based on the Suquamish Tribe survey consumption data and Tribe-specific demographic information and are considerably higher than dose estimates presented in the Navy's Human Health Risk Assessment. ATSDR recommends that for any future HHRAs, the Navy work with the Suquamish Tribe and Washington Department of Ecology in a collaborative effort to determine a range of consumption rates for subsistence consumers both adults and children that better reflects the populations that would likely be exposed.

FOR MORE INFORMATION

If you have additional concerns about your health, please call ATSDR at 1-800-CDC-INFO and ask for information on the Naval Base Kitsap, Keyport site.

Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this Health Consultation in response to a request from representatives of the Washington Department of Ecology (WDOE) and the Suquamish Tribe. They requested ATSDR evaluate clam tissue data collected from Liberty Bay between 1996 and 2008 near the facility formerly called Naval Undersea Warfare Center (NUWC) Keyport. This report serves as a follow-up to the September 2001 ATSDR Public Health Assessment (PHA) for NUWC Keyport. This report is limited in scope in that it does not address other areas on base, other environmental media, nor does it address other edible species of shellfish.

In the 2001 PHA, ATSDR evaluated the potential for human exposure to contaminants in shellfish harvested from Liberty Bay at NUWC Keyport, now referred to as Naval Base Kitsap, Keyport (NBK at Keyport). The Naval Undersea Warfare Center Keyport (NUWC Keyport) is the major tenant command at NBK at Keyport. ATSDR concluded that “exposures to contaminants in shellfish harvested from marine waters surrounding NBK Keyport pose no apparent past or current public health hazard.” However, because of difficulty in interpreting past sampling data (e.g., different laboratory methodology), ATSDR could not adequately evaluate the potential for future contaminant exposures associated with consuming shellfish from the marine waters surrounding NBK Keyport (i.e., the Liberty Bay shoreline).

The Suquamish Tribe includes the near-shore areas of NBK, as part of their “Usual and Accustomed” fishing grounds. Although the Tribe currently does not harvest shellfish from the NBK Keyport near-shore areas because of the concern about contamination, they would like to begin doing so. Since the PHA was released, the Navy conducted two additional rounds of sampling which generated additional shellfish data. ATSDR reviewed those data and at the request of the Suquamish Tribe and reviewed the potential future use of near-shore areas of NBK Keyport incorporating the accepted Suquamish shellfish ingestion rate.

Site Description

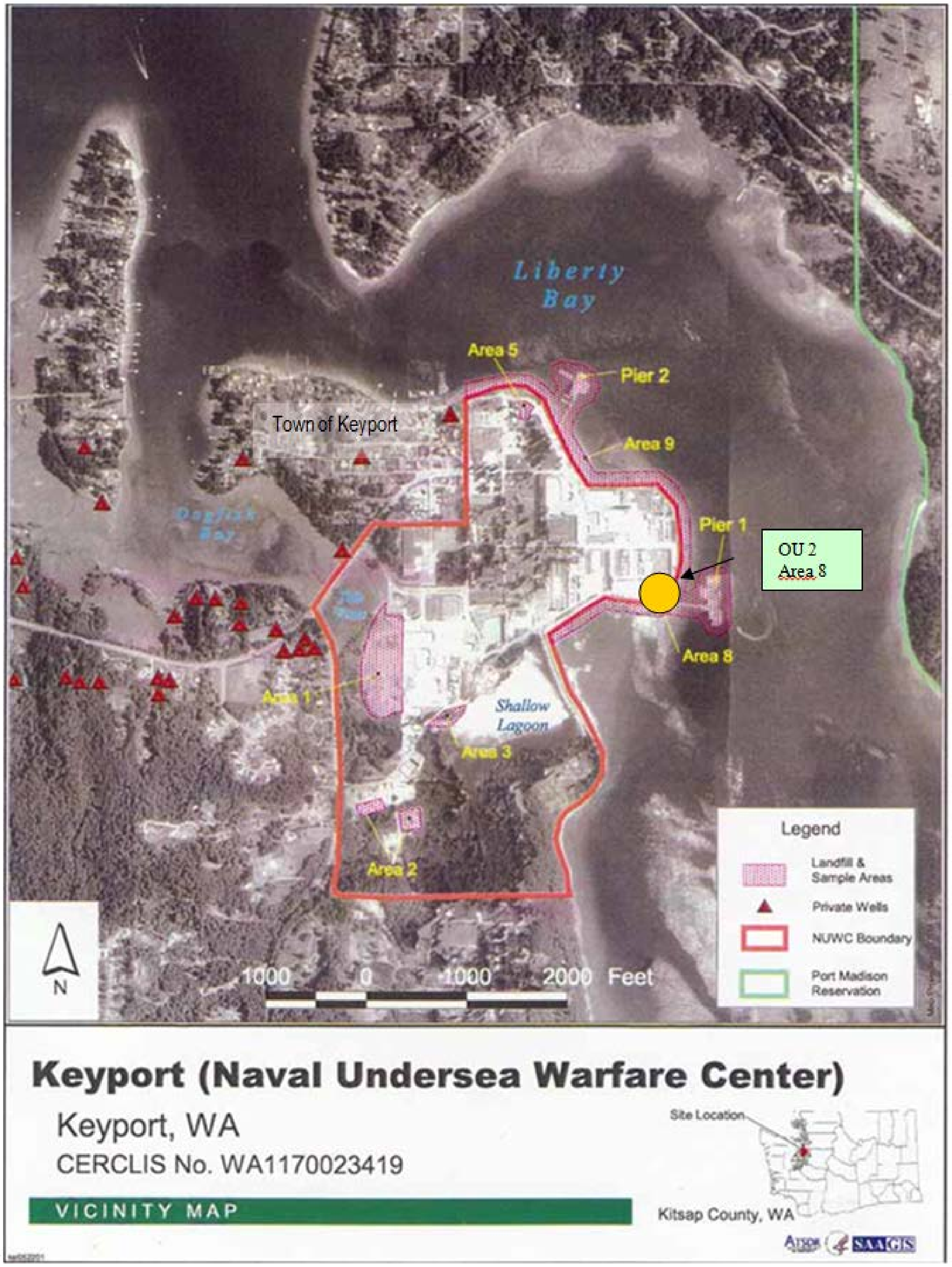
NBK, Keyport is an active U.S. Navy facility on a small peninsula in the central portion of Puget Sound adjacent to the town of Keyport in Kitsap County, Washington. It is approximately 15 miles (24 km) due west of Seattle, Washington. The nearest communities are Keyport, Silverdale, and Poulsbo, Washington. The 340-acre facility is bordered by Liberty Bay on the east and north and Port Orchard Inlet on the southeast (Figure 1). The property was acquired by the Navy in 1913, and initially used as a quiet-water range for torpedo testing. Operations currently include engineering, fabrication, assembly, and testing of underwater weapons systems [U.S. Navy 2005]. The Navy has identified Operable Unit (OU) 2 Area 8 as a point source for contamination releases into Liberty Bay. OU 2 Area 8 occupies about 1 acre in the heavily industrialized eastern portion of NBK, Keyport.

Liberty Bay is one of numerous bays within Puget Sound. It provides many recreational opportunities such as swimming, shellfish harvesting, fishing, and boating [May 2005]. Inner tidal areas adjacent to NBK, Keyport are maintained by the Navy as high security areas. Those areas are patrolled by security and are marked with no trespassing signs. As such, shellfish harvesting is not currently permitted in this area.

Across Liberty Bay from NBK, Keyport lies a portion of the 8,000 square miles of the Port Madison Indian Reservation, the home base to the sovereign nation of the Suquamish Tribe. Half of the 950 enrolled members of the tribe live on the reservation [Suquamish 2011]. The Suquamish people rely heavily on local seafood (including fish and shellfish) for subsistence needs. Subsistence foods make a substantial contribution to their nutritional needs, as well as social, mental, physical, and spiritual well-being. Harvesting the fish and shellfish is also an important element of the community's economy. Seafood serves a central role in tribal gatherings and daily nutrition. The Suquamish people consume far greater quantities of shellfish than typical recreational shellfish consumers. Commonly consumed shellfish found in this portion of Liberty Bay include clams, crabs, mussels, and oysters. The Tribe also harvests shellfish for commercial use in permitted locations [Suquamish 2012].

Biological and chemical contamination within traditional tribal fishing areas has limited the available resources for the Suquamish Tribe [ECONorthwest 2007]. Although the area adjacent to NBK, Keyport is included in the Suquamish Tribe's Usual and Accustomed fishing grounds, because of the concern about contamination, the Tribe currently does not harvest shellfish from the NBK, Keyport near-shore area.

Figure 1 - Area Map of NUWC Keyport



Background

Contamination History

The Navy has identified Operable Unit (OU) 2 Area 8 as a point source for contamination releases to Liberty Bay. OU 2 Area 8 occupies about 1 acre in the heavily industrialized eastern portion of NBK, Keyport and encompasses the location of the former plating shop (Building 72) (Figure 2). In 1999, the Navy demolished Building 72, removed associated soils, and constructed an asphalt-paved parking lot in its place. Historical documented past releases at Area 8 include spillage of chrome plating solution onto the ground; discharge of plating wastes into a utility trench; and leakage of plating solutions through cracks in the plating shop floor, waste disposal pipes, and sumps [Navy 2005]. Other releases (undocumented) such as floor drains were likely due to the nature of common practices since the time the base was built in 1914.

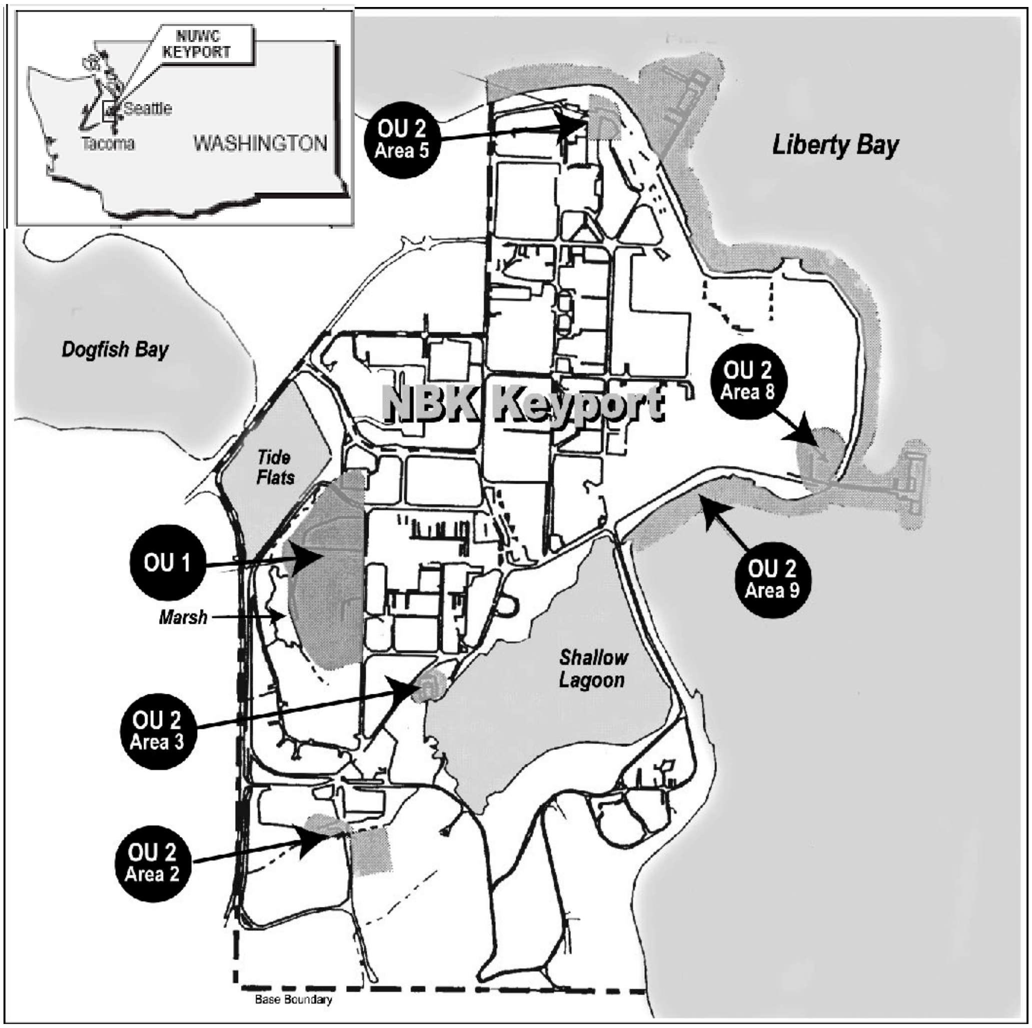
Solvents such as trichloroethylene (TCE) used in the plating shop were released to the environment during plating shop operation. Petroleum hydrocarbons (diesel and heavy oil) were released to the environment from leaky underground storage tanks (USTs) and underground concrete vaults located within Area 8 [Navy 2005].

The Navy investigated and characterized OU 2 Area 8 as well as other potentially contaminated areas included in the 1993 Remedial Investigation and Feasibility Study. At that time, the Navy identified groundwater beneath Area 8 discharging into Liberty Bay. The Navy found an inorganic chemical groundwater plume extending from the western portion of Building 72 toward Liberty Bay to the east and southeast [URS 1994]. The inorganic contaminant concentrations generally decrease eastward towards Liberty Bay. Within the inorganic plume, the distribution of cadmium, chromium copper, nickel, and zinc were similar and well defined. The Navy traced the inorganics to former operations of Building 72. The most frequently detected organic compounds in samples from shallow groundwater monitoring wells and seeps(i.e., areas where the underground contamination comes to the surface) were trichloroethylene (TCE); 1,1,1-trichloroethane (1,1,1-TCA); 1,2-dichloroethene (1,2-DCE); and 1,1-DCE. These compounds form a plume in the upper aquifer that extends from the eastern and southern sides of Building 72 eastward and southeastward up to the intertidal zone of Liberty Bay [URS 1994].

Seeps that discharge into the bay were sampled and found to contain levels of metals, including cadmium which was above surface water quality standards. However, no contaminants exceeding those same standards were found in Liberty Bay surface water samples during the Remedial Investigations [Navy 2005] This may indicate that large amounts of contaminant mixing and dilution of contaminants is occurring.

The Navy finalized their Record of Decision (ROD) in 1994. In 1996, the Navy began collecting clam tissue and marine sediment samples at points near the seeps as part of the long-term monitoring (LTM) program. Data analyzed in this ATSDR health consultation came from the Navy’s data presented in the long-term monitoring reports.

Figure 2 - Area Map of NUWC Keyport with OU 2 (Area 2)



Source: U.S. Navy 2005

Microbial Contamination

Contamination from non-point sources carried by storm water runoff has degraded the general water quality in Liberty Bay. Microbial contamination is a recurring problem and often exceeds water quality standards. As a result, tribal, commercial, and recreational shellfish harvesting areas are restricted to a small fraction of the available historical areas. The Kitsap County Health Department Pollution Identification and Correction Programs and Water Quality Improvement Projects have significantly reduced microbial contamination in Liberty Bay [May 2005, DEC 2012a, DEC 2012b].

Discussion

Sample Collection

The Navy conducted sediment and shellfish tissue monitoring at OU 2 Area 8 to assess the potential long-term impacts of chemical discharge into Liberty Bay. During the 1994 ROD for OU 2, filter-feeding organisms (e.g., clams) that directly ingest contaminated particulate materials and sediment were identified as another potential human exposure pathway to base-related contaminants. "Current and future visitors to Liberty Bay and future residents in the area could be exposed to contaminants of potential concern by ingestion of shellfish" [URS 1994]. Since 1996, clam tissue sampling has been collected by NBK, Keyport every four years; data are currently available for 1996, 2000, 2004, and 2008. During each sampling event, clams are collected at the nine locations, relative to the intertidal seeps at three different intertidal elevations. Shellfish samples are collected along the same beach transects, and at the same sampling locations, used for sediment sampling [CH2M Hill 2000; U.S. Navy 2005; URS 2009]. Clam tissue was analyzed for SVOCs and inorganic metals. Samples were not analyzed for pesticides, polychlorinated biphenyls (PCBs), or VOCs because the Navy ruled out these as contaminants of concern at OU 2 Area 8 from the 1993 Remedial Investigation.

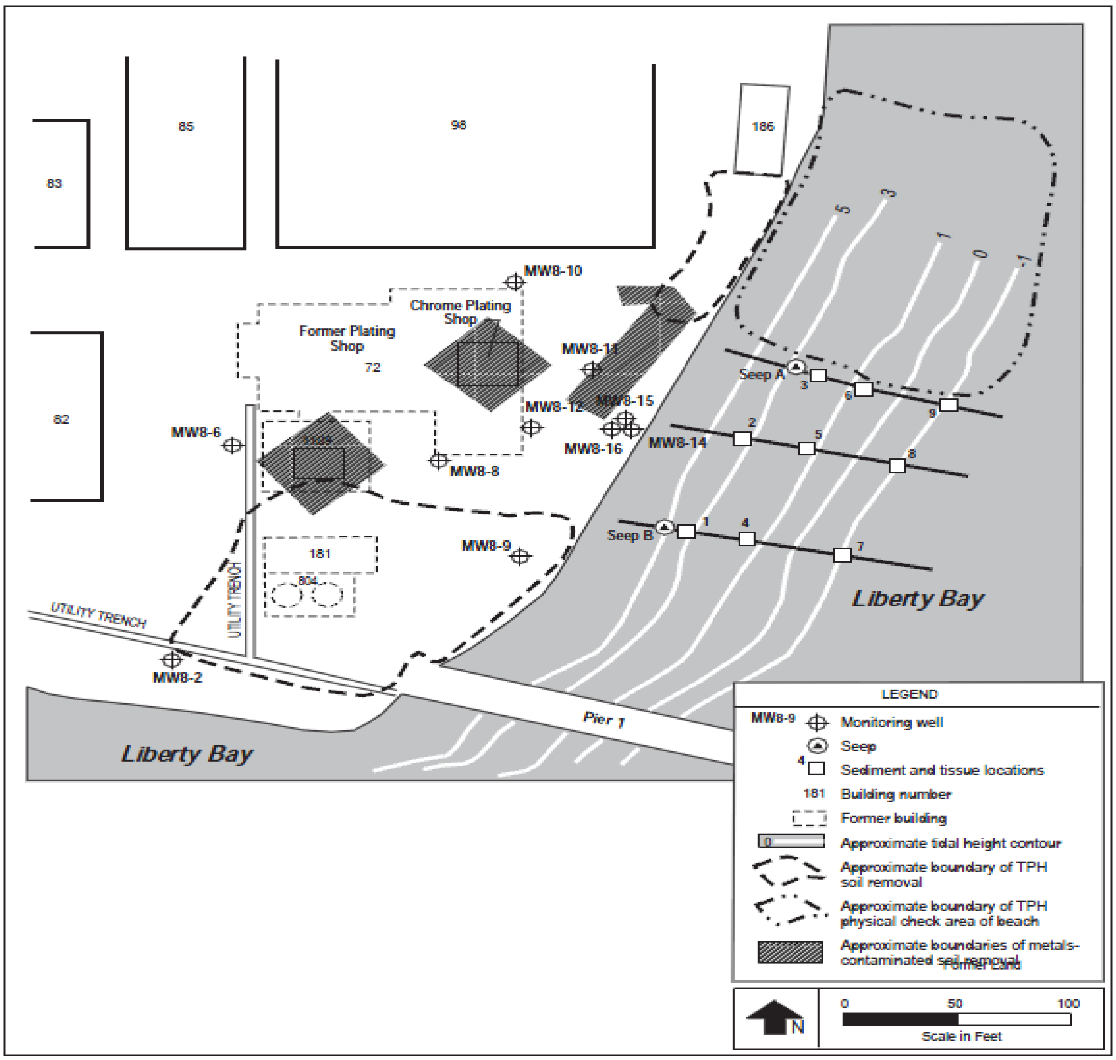

Figures 3 -5 - Local Clam Digging
Ref: Jean Boyle – Kitsap Images at http://www.go-washington.com/WA/travel/overview-shellfish.cfm?dest_id=1525
http://www.whidbeybeach.com/new_page_3.htm

During the 2008 long-term monitoring, the target species for tissue sampling and analysis was Pacific littleneck clam (*Protothaca staminea*). Although the Manila clam (*Tapes philippinarum*) was also collected for analysis, it was to be used only if necessary [URS 2009]. No information on how this was determined was provided. Navy contractors noted that "overall, Pacific littleneck clams were found in abundance at Stations 7, 8, and 9. Manila clams were found in greater abundance relative to Pacific littleneck clams at Stations 2 and 5. Because of the lower abundance of Pacific littleneck clams at Stations 1, 2, 3, 5, and 6, one jar of Manila clams was collected at these stations in addition to the littleneck clams collected" [URS 2009].

The report does not indicate if Manila clams were in fact included in the analysis. It appears that individual whole-body clams from each station were combined into one sample for analysis. The unshucked clams (clams with shells) were individually measured and weighed and placed in labeled, laboratory-supplied, certified clean containers and immediately placed on dry ice [URS 2009]. Neither the weight of the individual clam tissue nor the total combined weights of the composite sample were reported in the LTM report. Non- depuration[1] clams were used for analyses to represent a more health protective sample because material ingested by the clam is not removed.

Tissue samples collected for the 1993 RI were depurated and, therefore, were not used for comparisons. Only non-depurated results were used for comparison. All the clam tissue data were analyzed using dry weight and converted to wet weight. The dry weight concentration (for each sample) and the percent solid (an average at each station) were reported by the laboratory. The following formula was used to convert the dry-weight data to wet weight: wet weight = (dry weight)((1- (0.01)(percent moisture)).

Figure 6 - Seeps and Shellfish Sampling Area Map



Source: US Navy 2005; URS 2009
RBC = EPA's Risk Based Concentration for Fish Tissue
Average Concentration (n=9)

[1] Depuration involves placing the harvested shellfish into tanks of high quality water so they will purge any contaminants (including sediments) stored in their gut. Non-depurated clam sample retains the sediments along with clam tissue.

Sampling Results

ATSDR evaluated four rounds of monitoring data collected between 1996 and 2008. Clam tissue samples were analyzed for SVOCs and inorganic metals. In this health consultation, ATSDR does not report the results of all data points collected or reviewed, but rather presents only those of health significance. Please refer to the cited references for the entire set of results. ATSDR evaluated the data two ways: looking at both the media specific level (clam tissue) compared to EPA's Risk Based Concentration (adjusted for the increase in consumption and body weight for the Suquamish), and estimating an exposure dose and comparing that to either EPA's Oral Reference Dose (RfD) or ATSDR's Chronic Minimum Risk Level (MRL).

Although several SVOCs were detected in clam tissue, all were well below levels of health concern. Using Method 6010 for total inorganics, four metals were detected at levels that require further evaluation: cadmium, chromium, lead, and mercury. These metals were identified as potential contaminants of concern in the Navy's Human Health Risk Assessment (HHRA). The chromium results were assumed to be composed of 100 percent hexavalent chromium because the source of chromium from the former plating shop was hexavalent chromium. Mercury results were assumed to be methylmercury because inorganic or elemental mercury in the ocean is converted to methylmercury by phytoplankton which is eaten by clams and other organisms.

Table 1 presents the arithmetic mean (average) and maximum detected concentrations for four inorganic compounds (i.e., metals) found in clam tissue samples between 1996 and 2008, and the comparison values used for screening. For this site, we compared the results to EPA's risk-based contaminant concentration values for fish tissue. EPA's values were modified to reflect the different ingestion rates from the average U.S. fish consumption (0.054 kilograms per day) to the 95^{th} percentile Suquamish consumption of clams (0.615 kg/day).

Comparison Values (CVs), as well as all other health-based screening criteria, represent conservative levels of safety; they are not thresholds of toxicity. Although concentrations at or below a CV may reasonably be considered safe, concentrations above a CV will not necessarily be harmful.

The U.S Food and Drug Administration (FDA) Center for Food Safety and Applied Nutrition (CFSAN) safety tolerance guidance of lead in children's candy states a safety tolerance level (0.10 mg/kg). This level represents a point at or above which the agency will take action to remove products from the market. The Total Diet Study value represents the levels of lead found in the food we consume. FDA's Total Diet Study maximum lead level found was 0.18 mg/kg in boiled shrimp, mean 0.022 mg/kg [FDA 2010]. However, there is no safe level of exposure to lead.

Table 1 - Mean and Maximum Contaminant Concentrations Reported in Clam Tissue Samples									
Contaminants	Navy Monitoring Data (milligram per kilogram mg/kg)								Comparison Value (mg/kg)‡
	1996		2000		2004		2008		
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	
Cadmium	1.98	5.70	0.73	1.94	1.72	4.54	1.56	3.5	0.13
Chromium*	2.74	7.28	0.80	1.53	0.62	1.11	0.31	0.64	0.38
Lead	0.17	0.21	0.05	0.07	0.07	0.08	0.06	0.07	No Safe Level
Mercury†	0.03	0.18	0.02	0.05	0.04	0.16	0.024	0.033	0.013

Source: U.S. Navy 2005; URS 2009

* Chromium is assumed to be in the hexavalent form (chromium VI).

† Mercury is assumed to be in the methylmercury form

‡ Comparison Values are adjusted from EPA's Region III Risk-Based Concentration for Fish Tissue (updated May 2012) to reflect the increased body weight from 70 kg to 79 kg and increased ingestion rate from 0.054 kg/day to 0.615 kg/day for the Suquamish Tribe.

Figure 7 - Concentration of Cadmium in Clam Tissue Over Time from OU 2 Area 8

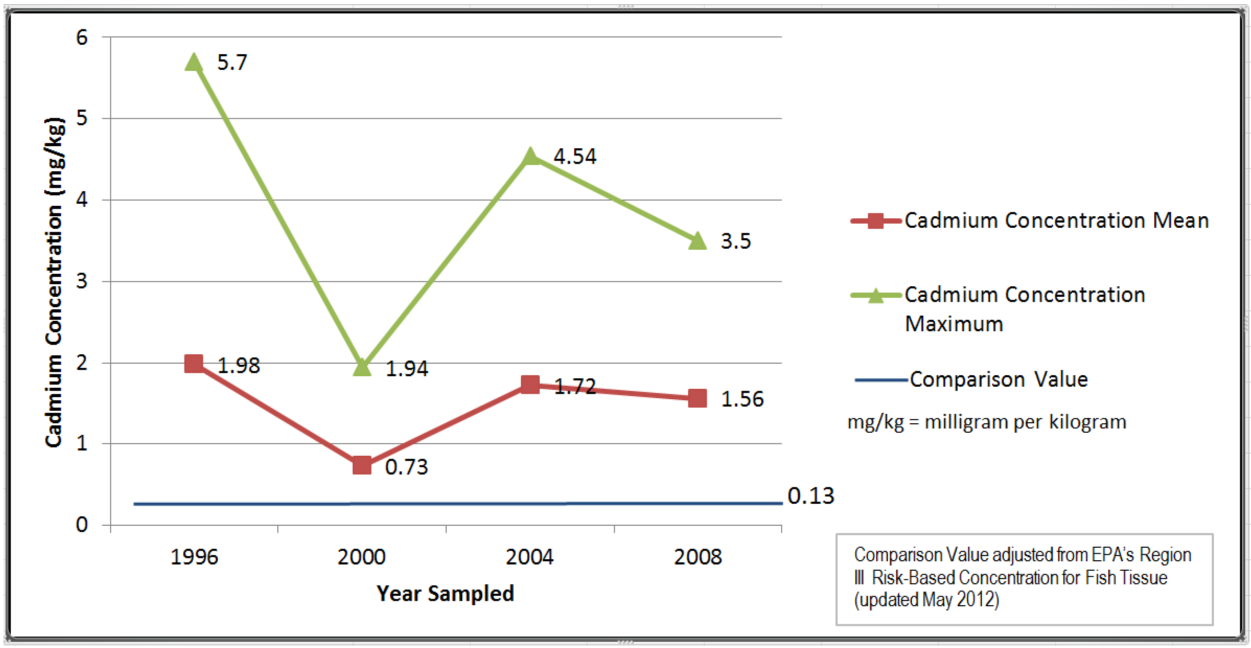


Figure 8 - Concentration of Chromium in Clam Tissue Over Time from OU 2 Area 8

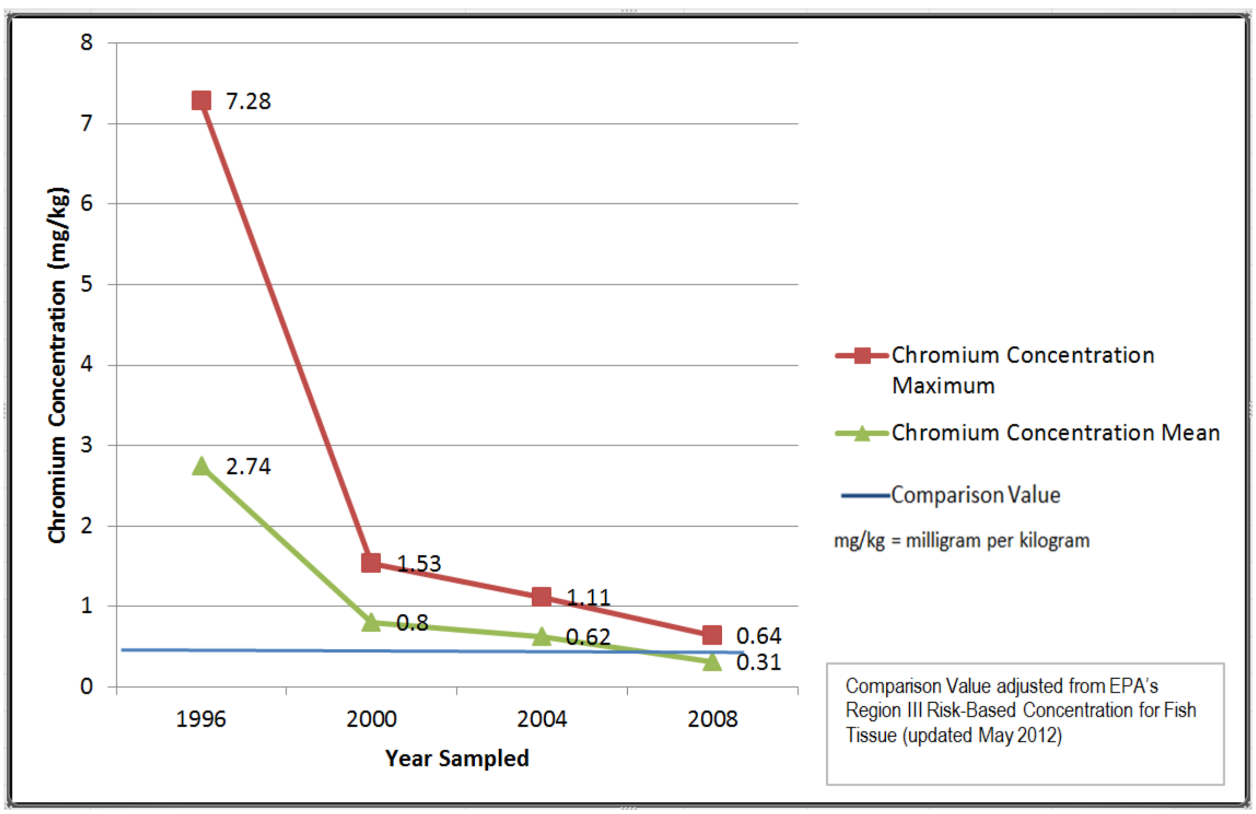


Figure 9 - Concentration of Lead in Clam Tissue Over Time from OU 2 Area 8

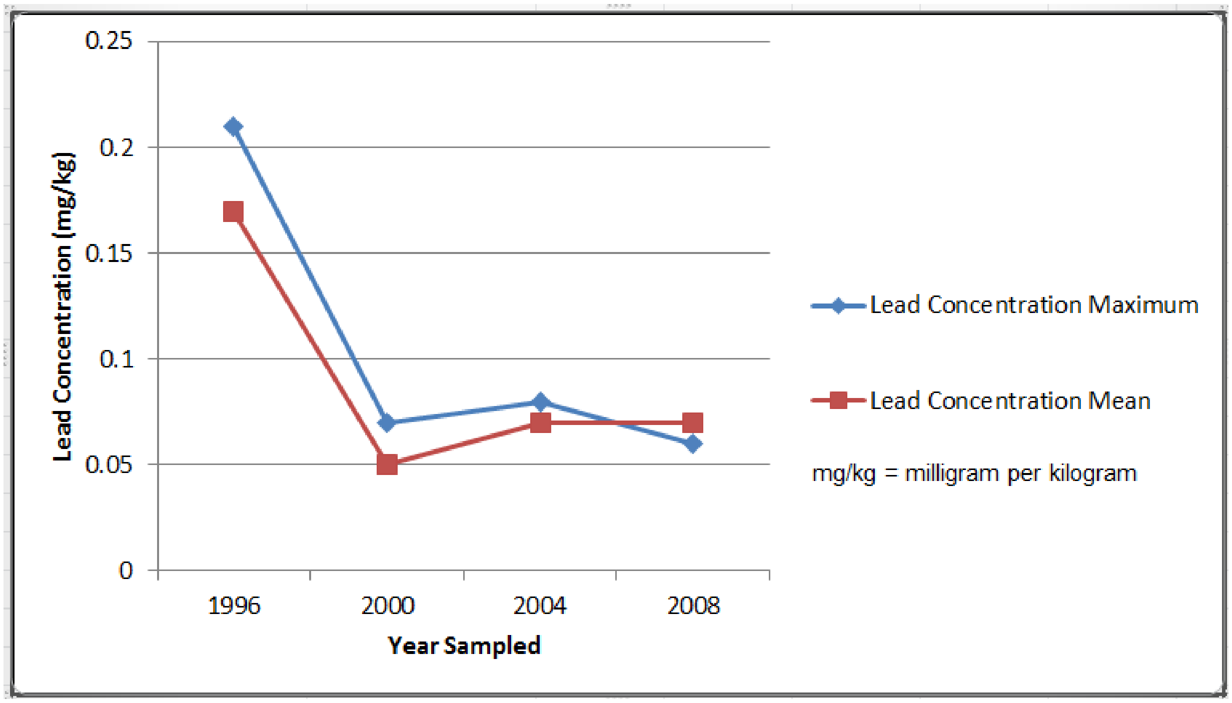
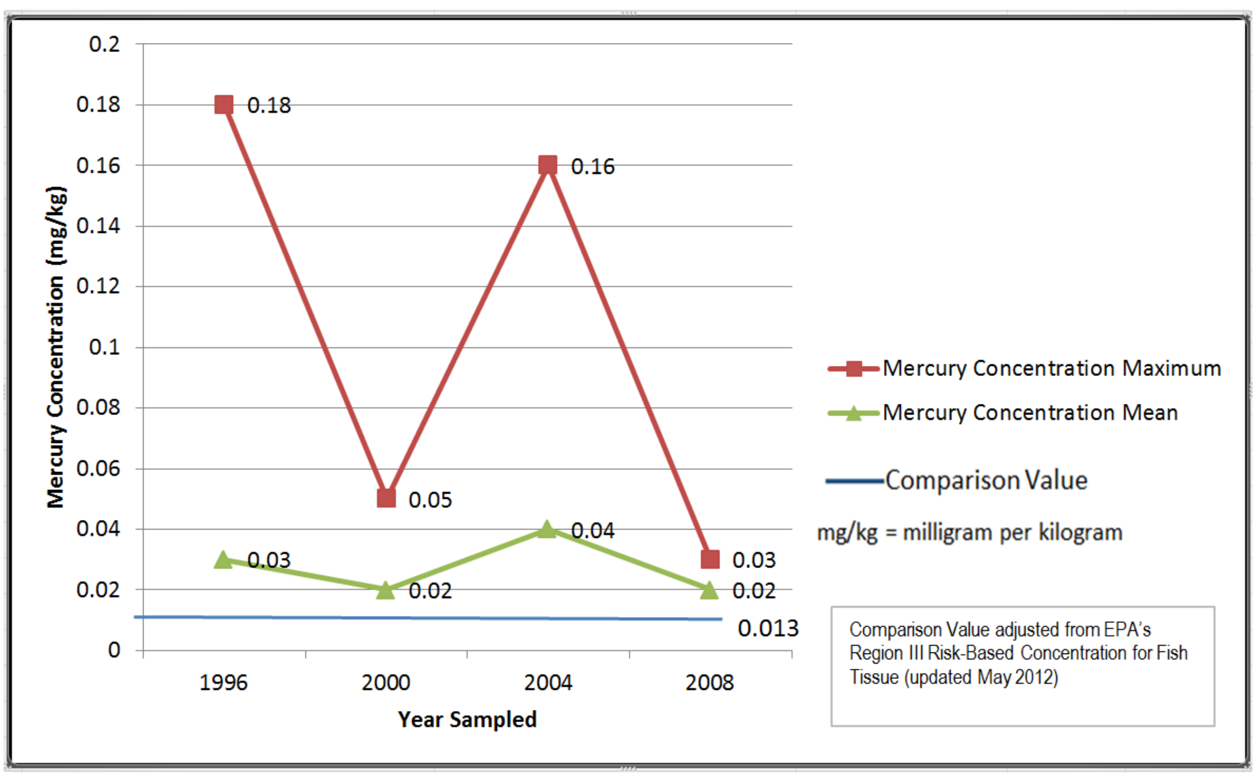


Figure 10 - Concentration of Mercury in Clam Tissue Over Time from OU 2 Area



The 2008 sampling results show cadmium, chromium, and mercury present in clam tissue from all of the nine sampling stations. Lead was found in samples from eight of the sampling stations. Detected concentrations of cadmium ranged from 0.6 to 3.5 mg/kg. Detected concentrations of chromium ranged from 0.19 to 0.64 mg/kg. Detected concentrations of lead ranged from 0.048 to 0.072 mg/kg. Detected concentrations of mercury ranged from 0.016 to 0.033 mg/kg.

Highlighted levels in Table 1 represent values greater than screening level comparison values. Cadmium, chromium, and mercury consistently exceeded adjusted screening comparison values. Generally, metal concentrations do not show a consistent declining trend over the 12-year sampling period. Values did not show notable decline as distance from seeps increased indicating that seeps may not be the sole contributor to inorganic concentrations in clam tissue. However, because the sampling area was limited to the localized area surrounding the seeps, it is difficult to make generalizations regarding the extent of contamination of clams from the larger Liberty Bay area adjacent to NBK, Keyport.

Population Seafood Consumption Data

In 2000, ATSDR sponsored a project in cooperation with the Suquamish Tribe and the Washington Department of Health for a scientifically-based seafood consumption survey of local members of the Suquamish Tribe. The purpose of the survey was to gather consumption information that could be used in risk assessments being conducted by EPA, DOD, and WADEP and ATSDR's public health assessments at hazardous waste sites in Kitsap County.

The final report, *Fish Consumption Survey of the Suquamish Indian Tribe of Port Madison Indian Reservation*, is unique in that it includes consumption information for varying age groups including children. It also includes species specific and combined seafood species consumption information including number of meals per month and portion size. For this health consultation, ATSDR used consumption information included in the 2000 Suquamish Tribe report. For adults, we used the consumption rate of 615 g/day (0.615 kg/day) which represents the 95 percent upper confidence limit (UCL95) of the shellfish consumption rate. For children, ATSDR used the consumption rate of 84 g/day (0.084 kg/day) which represents the UCL95 of all shellfish consumption. Also included in the Suquamish report was the weight and age distribution of the participants. ATSDR used 79 kg body weight for adults and 16.8 kg body weight for children and used the arithmetic mean (average) of contaminant concentration results in dose estimate calculations. Results of the estimated doses appear in Table 2.

NBK, Keyport Human Health Risk Assessment

In 2005, the Navy released their Human Health Risk Assessment for Sediment and Clam Tissue at OU 2 Area 8 that used sampling data from the 1996, 2000, and 2004 long-term monitoring. The risk assessment evaluated potential health risks for two populations — subsistence and recreational users — who harvest and eat clams from Area 8. They used a recreational consumption rate of 54 g/day and a subsistence rate of 132 g/day for adults with a body weight of 70 kg [Navy 2005]. They did not evaluate the risk to children as a subsistence population although they noted them as a population of concern.

The Navy estimated health risk using the UCL95 of the mean concentration for each chemical, not the maximum concentration. The Navy's estimated doses appear below ATSDR's estimated doses in Table 2 below.

The Suquamish Tribe provided comments to the Navy on the draft HHRA and stated that they believe the contamination within traditional fishing areas limits the Tribe's ability to safely gather resources. The Tribe stated that risk assessment scenarios should include the Suquamish consumption survey data. The final HHRA did not reflect Suquamish specific consumption.

Table 2 - Estimated Contaminant Doses for Adult and Child Subsistence Seafood Consumers

Contaminants	Estimated Dose Based on Suquamish Tribe Ingestion Rates (mg/kg/day)‡								Comparison Values mg/kg/day§
	1996		2000		2004		2008		
	Adult	Child	Adult	Child	Adult	Child	Adult	Child	
Cadmium	0.016	0.0099	0.006	0.0037	0.014	0.0086	0.012	0.008	0.001 (0.0001)
Chromium*	0.022	0.0137	0.006	0.0040	0.005	0.0031	0.0024	0.002	0.003 (0.001)
Mercury†	0.00024	0.0002	0.00016	0.0001	0.0003	0.0002	0.0002	0.0001	0.0001 (0.0003)
	Estimated Dose Based on Navy HHRA Ingestion Rates (mg/kg/day)‡								Comparison Values mg/kg/day§
	1996		2000		2004		2008		
	Adult	Child	Adult	Child	Adult	Child	Adult	Child	
Cadmium	0.0009	NE	0.0003	NE	0.0008	NE	0.0007	NE	0.001 (0.0001)
Chromium*	0.001	NE	0.0004	NE	0.0003	NE	0.0001	NE	0.003 (0.001)
Mercury†	0.00001	NE	0.000009	NE	0.00002	NE	0.00001	NE	0.0001 (0.0003)

* Chromium is assumed to be in the hexavalent form (chromium VI)
† Mercury is assumed to be in the form of methylmercury
‡ Estimated dose is based on the mean concentration detected in clam tissue calculated for that sampling round (n=9). See Appendix A for calculation methodology. mg/kg/day = milligrams per kilogram per day
§ Comparison Values are EPA Reference Doses. Those in parentheses represent ATSDR's chronic oral minimal risk level (MRL)

mg/kg/day = milligrams per kilogram per day

HHRA = Human Health Risk Assessment

NE = Not Evaluated

Highlighted values exceed comparison values

Public Health Implications

Our calculations show doses of cadmium, chromium, and mercury for people eating clams collected from OU 2 Area 8 above health-based screening values. These screening values are very conservative by nature with uncertainty factors built into their derivation. The values are for screening purposes only and do not represent a level at which health effects will occur. Comparison values are continually updated based on the latest scientific research findings. The evaluation of exposure to lead is handled differently because there is no known safe level of lead exposure.

In the discussion that follows, ATSDR presents the latest scientific information. As a public health agency, we make recommendations here to protect the health of adults and children in the public sector. *Since Area 8 is not open to shellfish harvesting, no exposures are currently occurring.* Should the area be opened in the future, more sampling information would be needed before ATSDR can determine safe consumption levels for subsistence consumers.

Cadmium: Cadmium is used primarily for the production of nickel-cadmium batteries, in metal plating, and for the production of pigments, plastics, synthetics and metallic alloys. Cadmium has been shown to be toxic to human populations from occupational inhalation exposure and accidental ingestion of cadmium-contaminated food [ATSDR 2008a]. All people ingest some levels of cadmium in food and water. Whether adverse effects occur, depends on the amount of cadmium ingested.

Cadmium is poorly absorbed into the bloodstream from the gastrointestinal tract. Absorption of cadmium from food is estimated to be about 2.5 percent lower than absorption from water. Deficiencies in dietary iron, calcium, and proteins can influence cadmium absorption into the body. For example, individuals with low iron levels exhibit higher absorption of cadmium [ATSDR 2008a].

Long-term exposure to low levels of cadmium in food or water leads to a build-up of cadmium in the kidneys. Continuous exposure to cadmium is also associated with fragile bones and an elevated incidence of hypertension and cardiovascular disease [ATSDR 2008a]. In the scientific literature, the no observed adverse effect level (NOAEL) for chronic cadmium exposure in humans range from 0.0003 to 0.0078 mg/kg/day [ATSDR 2008a]. The chronic (> 1 year) oral minimal risk level (MRL) of 0.0001 mg/kg/day is based on a study that identified a NOAEL of 0.0003 mg/kg/day. The lowest observed adverse effect level (LOAEL) from cadmium exposure in humans is 0.0078 mg/kg/day which is associated with an increased excretion of low molecular weight proteins. Other observed effects in studies on rats have been shown with cadmium doses at 0.08 showing decrease in bone mineral and at 1.51 mg/kg/day showed proximal tubule lesions. Renal dysfunction has been reported in Rhesus monkeys exposed to 1.2 mg/kg/day for 9 years, but not at 0.4 mg/kg/day [ATSDR 2008a]. Research in one study has shown that consumption of shellfish, which may contain naturally high levels of cadmium, can double the intake of dietary cadmium without producing significant impacts upon blood cadmium [Vahter 1996]. However, we found no other studies that validate this finding.

The highest estimated cadmium dose from subsistence consumption of shellfish from OU 2 Area 8 is 0.016 mg/kg/day, which is based on the average concentration of 1.98 mg/kg detected in clam tissue samples collected in 1996 and assumes daily consumption. This estimated dose is 2 times greater than the LOAEL for humans. Therefore, ATSDR recommends OU 2 Area 8 remain closed to shellfish harvesting until cadmium levels come down.

Chromium: Chromium-containing compounds are used in many industrial processes, such as, stainless steel welding, chrome plating, and leather tanning. The most common environmental forms are chromium (0) (i.e., the metal form), trivalent chromium (III), and hexavalent chromium (VI). The three major forms can all cause health effects at high doses, but chromium (VI) can cause toxicity at relatively low exposure levels and is classified as a carcinogen when inhaled. Trivalent chromium (III) is considered an essential nutrient that helps to maintain normal metabolism of glucose, cholesterol, and fat in humans. The minimum human daily requirement of chromium (III) for optimal health is not known, but a daily ingestion of between 0.05 and 0.2 mg/day (0.0007 to 0.003 mg/kg/day) is believed to be safe [NRC 1989, IM 2001].

Ambient chromium concentrations in seawater are low, with a range of 0.25 to 0.5 mg/L [Bond 1973]. Hexavalent chromium rarely occurs naturally because it is readily reduced in the presence of organic matter. However, after introduction by man, hexavalent chromium often remains unchanged in many natural waters because of low concentrations of reducing matter [Mertz 1974]. Chromium in seawater can be either tri- or hexavalent. In 1967, Fukai suggested that the stable chromium species in seawater was hexavalent. However, insufficient information is available regarding which chromium species would be predominant in seawater. Therefore speciation from clam tissue would provide more useful information in assessing the human health hazard from the consumption of clam tissue.

The main health problems seen in animals following ingestion of chromium (VI) are irritation and ulcers in the stomach and small intestine, anemia, and damage to the kidney and liver. Most of the NOAELs established from studies on humans indicate these types of effects may begin to occur at chronic doses around 0.5 mg/kg/day. Exposure to chromium (III) does not typically result in adverse health effects, especially at the doses likely from eating chromium containing shellfish at OU 8.

ATSDR's chronic (> 1 year) oral MRL of 0.001 mg/kg/day was derived for exposure to chromium (VI). Exposure to well water containing 20 mg/L chromium (VI) with an estimated dose of 0.57 mg/kg/day was associated with a higher incidence of stomach and lung cancer in humans [ATSDR 2008b]. The highest estimated chromium (VI) dose from consuming shellfish from OU 2 Area 8 is 0.02 mg/kg/day, which is based on the average concentration of 2.74 mg/kg detected in tissue samples collected in 1996 and assumes daily consumption of shellfish collected from the contaminated location. The highest estimated dose of chromium detected in shellfish from OU 2 Area 8 is more than 25 times lower than estimated dose levels associated with increased risk of stomach and lung cancer. The estimated subsistence consumption dose for the Suquamish is 20 times higher than the comparison value used for screening. Therefore, ATSDR recommends OU 2 Area 8 remain closed to shellfish harvesting until chromium contaminant values decrease.

Lead: Lead is a naturally occurring soft, blue-gray metal that does not degrade over time. Historic use in paint, gasoline, fishing weights, pipe fittings and plumbing solder has lead to environmental contamination. It has been used for many industrial purposes for centuries and is found in a variety of products and materials including paint, vinyl mini-blinds, pipes, crystal, dishware, pottery coatings, and ammunition. Although no longer used in paint or pipes sold today, lead is still used widely in commercial products such as automobile batteries, lead-crystal, and television and computer screens to shield users from radiation and ammunition. Because of its past and current wide spread use, small amounts it can be found in everyone's body today. Lead interferes with unborn children, infants, and young children's development and functioning of almost all body organs, particularly the kidneys, red blood cells, and central nervous system. In children, high levels of lead in their bodies can cause: behavior and learning problems, such as delays in learning and low intelligence ratings, hyperactivity, slowed growth, and anemia [ATSDR 2007]. However, it is unknown at what level of lead exposure may show low intelligence ratings in part due to the subjective nature of the tests and other factors that have more profound impact on the tests such as hunger. It has been shown that children who consume a healthy breakfast within 3 hours perform better on these and other tests then children who are hungry.

Because there is no known safe level of exposure, neither ATSDR nor EPA has established comparison values for lead. In January 2012, the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) released their report, Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. Based on its conclusions that blood lead levels < 10 µg/dL harm children, the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended "elimination of the use of the term 'blood lead level of concern'" and instead, the use of a reference value based on the 97.5th percentile of the NHANES-generated blood lead distribution in children age 1-5 years (currently 5 μg/dL) to identify children with elevated blood lead levels. [ACCLPP 2012].

Changes to CDC's policy were initiated in 2012. The reference level at which CDC recommends public health actions be initiated is 5 micrograms per deciliter.

It is widely accepted by CDC and others that "no evidence exists of a threshold below which adverse effects are not experienced" regarding the intellectual impairment in children. Much controversy exits over the determining of a "safe" level of lead exposure. Because of the scientific controversial nature surrounding lead exposure levels, prudent public health practice is to avoid or reduce lead exposure whenever possible. Levels of lead and other metals in shellfish remain too high to be safely consumed. Therefore, ATSDR recommends OU 2 Area 8 remain closed to shellfish harvesting.

Mercury: The largest use of mercury is for electrolytic production of chlorine and caustic soda. Other uses include electrical devices, switches and batteries, measuring and control instruments, medical and dental applications, and electric lighting [ATSDR 1999]. It is the organic form of mercury, methylmercury that is the predominant mercury species found in seafood and is considered to be more toxic than the inorganic form found in soil [ATSDR 1999]. Mercury occurs naturally in the environment and can also be released into the air through industrial pollution. It falls from the air and can accumulate in streams and oceans. Fish absorb the mercury and convert it into methylmercury. As bigger fish feed on smaller fish, mercury levels increase up the food chain being highest in the larger predatory fish. Almost all fish contain some methylmercury, and that amounts vary by type of fish and the waters in which they are caught. US FDA recommends avoiding certain fish, such as shark, tilefish, swordfish, and King Mackerel and varying the types of fish eaten [CFSAN 2010].

Most of what we know about the effects of prolonged exposure to mercury in fish comes from studies of children (the most sensitive population) exposed before and after birth, up to 6 years of age, living in the Seychelles and Faroe Islands [Davidson 1995; 1998 and Grandjean 1997; 1998]. People of these islands have high seafood intake. These studies found no adverse association between maternal methylmercury exposure from eating fish containing up to 0.75 mg/kg mercury and any developmental outcomes. Although that value is 4 times greater than the maximum mercury level found in clams from OU 2 Area 8, there are many uncertainties about how these two sampling studies compare. Being within the same order of magnitude, the relative dose of methylmercury could potentially be high enough to present a health hazard.

EPA established a chronic oral reference dose (RfD) of 0.0001 mg/kg/day for methylmercury. ATSDR derived a chronic oral Minimal Risk Level (MRL) of 0.0003 mg/kg/day for methylmercury based on information from human populations. Assuming that all the mercury in samples is methylmercury, estimated doses based on average mercury concentrations (detected) in samples collected at NBK, Keyport are higher than ATSDR's chronic oral MRL for adults in all years and for children for the years 1996 and 2004. Therefore, ATSDR recommends OU 2 Area 8 remain closed to shellfish harvesting until the levels are deemed safe for consumption.

For purposes of comparison, Table 3 presents typical mercury levels commonly detected in fish and shellfish across the U.S. The maximum concentration of mercury detected in clam tissue from OU 2 Area 8 was 0.18 mg/kg with an average of 0.03 mg/kg. The average levels found in shellfish are quite similar to those levels detected at OU 2 Area 8. Even though the maximum levels detected are much lower than levels found in swordfish and tuna, health advisories call for limiting the intake of those fish in order to reduce the risk of mercury exposure.

Table 3 - Mercury Levels in Commonly Consumed Fish and Shellfish in the U.S.

Species - Fish	***Average Mercury Concentration (milligram per kilogram = mg/kg)***
Swordfish	0.99
Tuna (Fresh/Frozen, Bigeye)	0.64
Tuna (Canned, Fresh/Frozen, Albacore)	0.36
Halibut	0.25
Tuna (Canned, Light)	0.12
Salmon (Canned, Fresh/Frozen)*	ND–0.01
Species - Shellfish	***Average Mercury Concentration (mg/kg)***
Lobster	0.3
Crab (includes blue, king, and snow)	0.06
Scallop	0.05
Oyster	0.01
Clam*	0.009 †
Shrimp*	0.009

Source: CFSAN, US FDA, Feb. 2010

ND = Mercury concentration below detection level

* Mercury was measured as methylmercury for species with a (*), otherwise as total Mercury.

† Average Mercury Levels in clams from NBK, Keyport 2008 (0.024 mg/kg). Added to show comparison between US and NBK, Keyport.

Limitations

There are limitations that prevent ATSDR from making general public health statements for the Suquamish Tribe about the safety of future consumption of shellfish from Liberty Bay in areas adjacent to NBK, Keyport. The limitations include the following:

1. Sampling took place in a small sample area: The sample area did not include other areas in the near shore locations of NBK, Keyport.
2. Only one shellfish species was sampled: Commonly consumed shellfish from Liberty Bay include clams, crabs, mussels, and oysters. These data only represent Pacific littleneck clams. Other species may have more or less contamination.
3. Analysis was limited to inorganic compounds and SVOCs: Although the Navy determined that inorganic compounds and SVOCs would be the only contaminants attributable to their

past waste disposal, shellfish should also be analyzed for pesticides, PCBs, and tributyltin because of their historical use and accidental release to the environment at NBK, Keyport.

4. Sampling took place in a single season: Contaminant concentrations may vary from season to season due to weather conditions such as the amount of rainfall that effect levels in water bodies.

Should the area be opened up for shellfish harvesting in the future, the above limitations need to be considered to determine shellfish consumption safety.

Additionally, portions of Liberty Bay have been impacted by biological contamination from storm water and sewage outflows. ATSDR has not evaluated the level of biological contamination in shellfish. This would also need to be evaluated before shellfish harvesting can resume.

Conclusions

1. Shellfish from near-shore area of Area 8 OU-2 are not currently being collected for consumption. Therefore, because there is no current exposure to the contaminants detected, there is no current health hazard. However, pacific littleneck clams samples collected from seep areas near (Area 8) NBK, Keyport exceeded health-based screening levels for several heavy metals and could present a health hazard to subsistence and recreational shellfish consumers.

2. Limitations in the shellfish data collected in the near-shore area of NBK, Keyport of Liberty Bay between 1996 and 2008 prevent us from being able to make general public health conclusions on future shellfish consumption.

Recommendations

1. Although ATSDR's assumptions are very conservative and are likely to overestimate exposure for most shellfish consumers, we recommend that shellfish harvesters continue to be advised that the near-shore areas of NBK, Keyport have shown contaminants in shellfish and should not be consumed.

2. Prior to opening the area adjacent to Area 8 for shellfish harvesting in the future, the Navy should sample a variety of shellfish (the major shellfish species that would be consumed) at varying times of the year from a broader area representing the open areas and analyzed for compounds (especially cadmium, chromium (VI), lead, and methylmercury), SVOCs, as well as pesticides, polychlorinated biphenyl's (PCBs), tributyltin, and biological contamination. Further, OU 2 Area 8 should not be re-opened until long-term monitoring of shellfish demonstrates a decline in cadmium, chromium, lead, and mercury levels that no longer present a health concern. Speciation of chromium and methylmercury should also be included to better quantify the hazard.

3. For any future HHRAs, the Navy should work with the Suquamish Tribe and Washington Department of Ecology in a collaborative effort to determine a range of consumption rates

for subsistence consumers both adults and children that better reflects the populations that would likely be exposed.

Public Health Action Plan

Shellfish harvesters should continue to be advised that the near-shore areas of NBK, Keyport have shown contaminants in shellfish and should not be consumed.

The Navy used the results of their risk assessment assessing whether further remedial actions are needed for groundwater entering Liberty Bay. Based on their, the Navy determined that no additional remediation measures were deemed necessary to protect human health from exposures in Liberty Bay. However, because concentrations in clam tissue have not declined and because there is evidence of increasing concentrations of chromium and cadmium at Seeps A and B, the Navy will continue monitoring the level of certain contaminants in shellfish and sediments.

If requested, ATSDR will review future shellfish monitoring results and evaluate potential public health hazards.

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Appendix A

This appendix details the assumptions and calculations that ATSDR used to estimate potential exposure doses from the consumption of contaminated shellfish. To be protective and account for the uncertainty surrounding how representative the exposure factors are for the members of the Suquamish Tribe, ATSDR used health-protective assumptions to estimate the reasonable maximum exposure level. This estimate calculates a daily exposure dose in milligrams of contaminant per kilogram of body weight per day (mg/kg/day). It is intentionally protective and likely overestimates the amount of chemical exposure from eating shellfish.

When estimating exposure doses, health assessors evaluate chemical concentrations to which people could be exposed, together with the length of time and the frequency of exposure. Collectively, these factors influence an individual's physiological response to chemical exposure and potential outcomes. The following equation was used to estimate human exposure from consuming shellfish:

$$\text{Estimated exposure dose} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Table A-1: Suquamish Tribe and Navy Exposure Dose Assumptions: Cadmium in Shellfish

Parameter	***Symbol***	***Suquamish Tribe***	***U.S. Navy***
Chemical concentration in littleneck clam tissue	C	1.98 = mean for 1996 sampling round. The highest cadmium concentrations were detected during this sampling event.	1.88 = 95th percent upper confidence limit for cadmium in all long-term monitoring samples
Ingestion rate	IR	Adult: 615 g/day (i.e., 0.615 kg/day) - This is based on the 95%tile of "All Shellfish" consumption for Suquamish adults (8.10 g/kg/day). Child: 84 g/day (i.e., 0.084 kg/day). - This is based on the 95%tile of "All Shellfish" consumption for Suquamish children under age 6 (4.994 g/kg/day) in Table C-6 of the Suquamish Tribe Fish Consumption Survey.	Adult: 132 g/day (i.e., 0.132 kg/day) The clam ingestion rate used in the baseline HHRA was 132 g/day for adults (subsistence). These rates were used to quantify subsistence exposures to chemicals in clam tissue. The value for adults is considered to be a reasonable maximum estimate of clam ingestion rates by subsistence populations in the Liberty Bay area.
Ingestion fraction	IF	100% (1.0)	25% (0.25)
Exposure frequency	EF	365 days/year	350 days/year
Exposure duration	ED	Adult: 30 years Child: 6 years	Adult: 30 years
Body weight	BW	Adult: 79 kg Child: 16 kg	Adult: 70 kg
Averaging time (days)	AT	Adult: 10,950 Child: 2,190	Adult: 10,950
Oral reference dose (mg/kg/day)	RfDo	0.001	0.001