Site-Specific Proposal for Modifying the Default MTCA Fish Consumption Exposure Parameters

Questions and Background Information

Prepared for the MTCA Science Advisory Board

March 2008

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Background

The Model Toxics Control Act (MTCA) Cleanup Regulation includes methods for establishing surface water cleanup levels that are based on preventing health risks associated with the consumption of contaminated fish and shellfish. Under the MTCA Cleanup Regulation, cleanup levels are based on estimates of the "reasonable maximum exposure" (RME). [1]

- The RME is designed to represent a high end (but not worst case) estimate of individual exposures. It provides a conservative estimate that falls within a realistic range of exposures.[2]
- The RME is defined as reasonable because it is a product of several factors that are an appropriate mix of average and upper-bound estimates. RME estimates typically fall between the 90th and 99.9 percentile of the exposure distribution.[3]
- The RME takes into account both current and reasonably foreseeable future conditions. (See Appendix A for more detailed information regarding RME's)

The default parameters used in calculating surface water cleanup levels (e.g. fish consumption rates, fish diet fraction, etc.) are based on a recreational angler exposure scenario. However, the rule provides the flexibility to establish more stringent surface water cleanup levels when Ecology determines that such levels are "...necessary to protect other beneficial uses or otherwise protect human health and the environment..." (WAC 173-340-730(1)(e)).

Ecology is currently overseeing the cleanup of the former Rayonier mill site located in Port Angeles. A primary concern at this site is the potential for human exposure resulting from the release of contaminants into surface water and/or sediments and the accumulation of contaminants in fish and shellfish.

In late October, the LEKT completed a report on tribal fish consumption rates applicable to the Port Angeles area. The LEKT recommends that Ecology use site-specific exposure parameters when establishing cleanup requirements for the former Rayonier mill site located in Port Angeles, WA. The LEKT believes these values are more appropriate than the MTCA default values because they take into account the tribe's treaty reserved rights, customs and fishing habits. The Usual and Accustomed fishing areas for the LEKT includes the Port Angeles Harbor area as well as large geographic areas and waters north and south of Port Angeles Harbor, selected areas of Hood Canal, and selected areas and waters along the Strait of Juan de Fuca. [4]

[1] MTCA defines the RME as the "…the highest exposure that can be reasonably expected to occur for a human or other living organisms at a site under current and potential future site use." CERCLA provides a similar definition "…the highest exposure that is reasonably expected to occur at a Superfund site…"
[2] U.S. Environmental Protection Agency. An Examination of EPA Risk Assessment Principles and Practices. EPA/100/B-04/0001. March 2004.
[3] IBID.
[4] Washington Department of Transportation Model Comprehensive Tribal Consultation Process for the National Environmental Policy Act (NEPA), Appendix B: Summaries of Usual and Accustomed Areas prepared by the Washington Attorney General's Office.

Ecology identified three broad questions for the Board's review prior to the December 14th Board meeting. Based on the Board's review, Ecology revised and expanded the list of questions.

The expanded list includes eleven questions that are identified in this document. Over the last month, Ecology has evaluated information relevant to each question. This includes information provided by the Lower Elwha Klallam Tribe and Malcolm Pirnie.

MTCA Default Exposure Parameters

Question #1

Ecology has concluded that the MTCA exposure parameters do not provide a reasonable basis for estimating fish consumption exposures for members of the Lower Elwha Klallam Tribe (LEKT). Does the Board believe this conclusion is consistent with current scientific information?

Ecology Evaluation and Rationale

The reasonable maximum exposure (RME) for MTCA surface water cleanup standards is based on a recreational exposure scenario. Ecology uses a similar approach when establishing sediment cleanup standards under MTCA and the Sediment Management Standards. However, Ecology believes that a recreational exposure scenario is not representative of the fish consuming habits of the LEKT. Ecology's conclusion is based on the following factors:

- The MTCA default exposure parameters are based on an exposure scenario (recreational fisher) that is significantly different than the exposure scenario for the LEKT. Exposure parameters based on a tribal exposure scenario are different than the MTCA default parameters (See Table 1). As noted in this table, the LEKT proposal was developed by applying the EPA Region 10 Decision-Making Framework[5].
- EPA exposure guidance materials include exposure parameters based on tribal exposure scenarios. The EPA *Exposure Factor Handbook*[6] recommends an average ingestion rate of 70 g/day and a 95th percentile ingestion rate of 170 g/day. The EPA *Child-Specific Exposure Factors Handbook*[7] identifies weighted[8] average (21 g/day), 90th percentile (60 g/day) and 95th percentile (78 g/day) values, respectively. The child-specific rates for Native American children are significantly higher than estimates for recreational fish intake. The exposure parameters specified in the EPA Region 10 Decision-Making Framework are significantly different than the MTCA default exposure parameters.
- Several Northwest tribes have developed surface water quality standards that are based on human health protection. The fish consumption rates used to develop those standards range from 6.5 to 170 g/day. As shown in Table 2, more recent standards have generally used higher fish consumption rates. The MTCA default fish

[5] U.S. Environmental Protection Agency, EPA Region 10 Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia, August 2007.
[6] U.S. Environmental Protection Agency. 1997. Exposure Factors Handbook. National Center for Environmental Assessment. Office of Research and Development. August 1997. Available at: http://www.epa.gov/ncea/efh/.
[7] U.S. Environmental Protection Agency. 2006. Child-Specific Exposure Factors Handbook (External Review Draft). National Center for Environmental Assessment. Office of Research and Development. EPA/600/R/06/096A.
[8] Weighted averages are based on information from CRITFC (1994) and Suquamish (2000).

consumption rate is lower than the rates used to establish more recent standards. (See Table 2).

- EPA and Ecology have established cleanup standards at several sites that are based on tribal fish consumption scenarios. In general, fish consumption rates used at these sites range from @ 50 to 300 g/day (Malcolm Pirnie, 2008).[9]
- The Oregon Department of Environmental Quality (ODEQ) is preparing revisions to the Oregon water quality standards. ODEQ is considering a range of tribal fish consumption rates that are higher than the MTCA default values.[10]

Table 1: Comparison Between MTCA and LEKT[a] Exposure Factors

Exposure Factor	MTCA Exposure Parameters	LEKT Proposal[b]
Fish Consumption Rate	54 grams/day	583 grams/day
Fish Diet Fraction	50%	100%
Exposure Duration	30 years	70 years
Average Body Weight	70 kg	79 kg

a. Lower Elwha Klallam Tribe – rates based on application of EPA-R.10 Framework
b. Adapted from Bill Beckley slide presentation to SAB, December 14, 2007

[9] Malcolm Pirnie. 2008. Scientific Considerations for Identifying Subsistence User Ingestion Rates in Port Angeles, Washington. Figure 1 summarizes fish consumption rates used at nine cleanup sites. One value (KPC) appears to be 6.5 g/day.

[10] Oregon Fish Consumption Rate Project, Workshop Two: Review of Water Quality Standards and Fish Consumption Data, Wednesday, May 16, 2007 – Chinook Winds Casino, Lincoln City, OR located on the following link - http://www.deq.state.or.us/WQ/standards/docs/toxics/200705notes.pdf

Table 2: Tribes With EPA Approved Water Quality Standards[11]		
Tribe & Effective Date of Water Quality Standard	**Rate (g/day)**	**Documentation**
Puyallup Tribe of Indians (1994)	6.5	EPA's National Toxics Rule, 57 Fed. Register 60848 (1992)
Confederated Tribes of the Chehalis Reservation (1997)	6.5	EPA's National Toxics Rule, 57 Fed. Register 60848 (1992)
Confederated Tribes of the Umatilla Indian Reservation of Oregon (2001)	6.5	EPA's National Toxics Rule, 57 Fed. Register 60848 (1992)
Spokane Tribe of Indians (2003)	86.3	63 Fed. Register 43756 (1998)[12]
Kalispel Indian Community of the Kalispel Reservation (2004)	17.5[13]	EPA's National Toxics Rule & 2002 AWQC Update
Confederated Tribes of the Colville Reservation (2005)	6.5	EPA AWQC 1989 (per e-mail from EPA, S.Brough to DOE,C. Niemi, 2/25/08)
Port Gamble S'Klallam Tribe (2005)	142	EPA Default Subsistence Rate
Confederated Tribes of the Warm Springs Indian Reservation of Oregon (2006)	170	CRITFC Survey
Makah Tribe (2006)	142[14]	EPA Default Subsistence Rate

[11] From web link: http://www.epa.gov/waterscience/standards/wqslibrary/tribes.html

[12] 63 Fed. Register 43768-43769(1998): The AWQC default fish consumption value of 17.80 grams/day is for the general adult population, which represents the 90th percentile consumption rate for the entire adult population and approximates the average consumption rate for sport anglers, nationally. The 86.3 grams/day default value for subsistence fishers/minority anglers, represents the 99th percentile consumption rate for the general populations and falls within the range of averages for subsistence/minority anglers.

[13] Water quality standards for nickel, arsenic and chloroform are based on a fish consumption rate of 6.5 g/day.

[14] Water quality standards for methylmercury are based on a fish consumption rate of 17.5 g/day.

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Use of Consumption Surveys from Other Tribes

Question #2

Is it scientifically defensible to use consumption surveys from other tribes with similar dietary habits to estimate fish and shellfish consumption exposures for members of the LEKT?

Ecology Evaluation and Rationale

The LEKT used the EPA-Region 10 Decision-Making Framework to develop their recommendations. The framework identifies a four-tiered hierarchy of preferred data sources[15]. Under the Framework, exposure estimates for particular tribes can be based on fish consumption surveys from other tribes (Suquamish or Tulalip Tribes) with similar dietary habits. Ecology believes this approach is consistent with current scientific information. Ecology's conclusion is based on the following factors:

- EPA's Ambient Water Quality Criteria Methodology[16] and Region X Framework outline a hierarchy of fish consumption data that includes the use of consumption surveys from similar populations. The EPA hierarchy (listed in order of preference) includes:
  - Fish and shellfish consumption surveys of local watershed representative of the people being addressed for the particular water body;
  - Fish and shellfish consumption surveys that reflect geography and population groups similar to those under evaluation;
  - National food consumption surveys; and
  - Default values.
- This approach is consistent with approaches used by different tribes to establish surface water quality standards. Tribes consider a variety of exposure-related factors when developing Tribal surface water quality standards including finfish and shellfish quantity, availability of the resources, and the quality of habitat to be protective of those aquatic resources (See Table 2 above).
- This approach is consistent with approaches used to prepare other types of exposure assessments (EPA 1997; EPA 2006). Using exposure studies performed for one study group to estimate exposure levels in other groups underlies most exposure assessments.

[15] EPA Region 10 Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia, August 2007. Page 6.

[16] U.S. Environmental Protection Agency, Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000), EPA-822-B-00-004, section 4.3.3.

- This approach is consistent with the approach being used to revise the Oregon water quality standards. As part of the revision process, risk assessment experts reviewed northwest fish consumption information and water quality standards.[17] Presentations from the May Workshop provided summary descriptive statistics from different fish consumption surveys that document the Tribal rates. (see Table 3).

Table: 3 Comparison of Different Seafood Consumption Rates

Tribe / Study	Grams/day ← Statistics →					
	Mean	**Median**	**75%**	**90%**	**95%**	**99%**
Tulalip[9]	54	30	74	139	194	273
Squaxin Island (Toy et al., 1996)[18]	51	26	71	119	167	276
Suquamish (Suquamish 2000)[19]		110.7		533.9	784.6	

[17] Oregon Fish Consumption Rate Project, Workshop Two: Review of Water Quality Standards and Fish Consumption Data, Wednesday, May 16, 2007 – Chinook Winds Casino, Lincoln City, OR located on the following link - http://www.deq.state.or.us/WQ/standards/docs/toxics/200705notes.pdf

[18] Toy K, N.L. Polissar, S. Liao, G. Mittelstaedt. 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region. http://www.deq.state.or.us/wq/standards/docs/toxics/tulalipsquaxin1996.pdf

[19] Suquamish Tribe. 2000. Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region. http://www.deq.state.or.us/wq/standards/docs/toxics/suquamish2000report.pdf

Factors to Consider When Using Surveys From Other Tribes

Question #3

What factors should Ecology consider when evaluating whether it is appropriate to use fish consumption surveys from other tribes to estimate exposures for members of the LEKT?

Ecology Evaluation and Rationale

The LEKT used the EPA-Region 10 Decision-making Framework to develop their recommendations. Under that framework, fish consumption surveys from similar tribes can be used to estimate exposures for particular tribes. Ecology believes that several factors should be considered when evaluating whether it is scientifically defensible to use fish consumption surveys from other tribes to estimate fish consumption exposures for particular tribes. These include the following factors:

- Data Hierarchy. EPA has established a hierarchy of fish consumption data that strongly emphasizes the preferential use of local or regional consumption data by States and Tribes as more representative of target populations.[20] The consumption data hierarchy, in order of preference, is:
  - Fish and shellfish consumption surveys of local watershed representative of the people being addressed for the particular water body;
  - Fish and shellfish consumption surveys that reflect geography and population groups similar to those under evaluation;
  - National food consumption surveys; and
  - Default values.
- Study Design: The study design and methodology should be considered when evaluating whether to use a study from one tribe to estimate fish consumption rates for another tribe. This includes survey methods, number of participants, potential biases and/or confounding factors.
- Similarities in Tribal Dietary Habits and Customs: The dietary habits of each tribe should be evaluated to determine whether fish consumption rates from one tribe are reasonable surrogates for estimating exposures for another tribe.
- Similarities in Harvesting Techniques. Tribal similarities and differences in the methods used to harvest fish and shellfish should be considered when evaluating whether fish consumption rates from one tribe are reasonable surrogates for estimating exposures for another tribe. This is particularly important in situations

[20] U.S. Environmental Protection Agency, Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000), EPA-822-B-00-004, section 4.3.3; and EPA Region 10 Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia, August 2007, page 6.

where certain types of fish are not present (or present in low quantities) and it is assumed that Tribal members will substitute other types of fish or shellfish (resource switching).

- Similarities in Watershed Characteristics: Several watershed characteristics influence the nature and abundance of fish and shellfish. The key issue in applying the EPA Decision-making Framework is the quality and quantity of shellfish habitat. The Washington Department of Fisheries has examined the distribution and abundance of commercial hardshell clams throughout the Puget Sound.[21] Several observations were made regarding clam abundance and shellfish habitat.
  - The abundance of hard shell clams depends on the nature of the habitat substrate. Productive shellfish habitat substrates include mud, sand, pea gravel, gravel, rocks, boulders, and shell. Shells, pea gravel and gravel appear to be the best shellfish habitat for Butter and Little-neck clams (measured in terms of clam size and abundance).
  - Clam size and abundance appear to be inversely related to water depth. Intertidal zones are kept reasonably clean of mud by wave action which produces a bed of gravel or shell which provides a good clam/shellfish habitat.
  - The abundance of hard shell clams varies with current speed. In general, higher currents result in coarser surface substrate materials that tend to support more productive clam/shellfish habitat.

[21] Distribution & Abundance of Subtidal Hardshell Clams in Puget Sound, Washington. Washington Department of Fisheries, C. Lynn Goodwin. Technical Report 14, August 1973.

Use of the Suquamish Fish Consumption Survey

Question #4

Does the SAB believe it is scientifically defensible to use the fish consumption survey completed by the Suquamish Tribe to estimate fish and shellfish consumption exposures for members of the LEKT?

Ecology Evaluation and Rationale

The EPA Decision Framework provides a process for selecting tribal fish consumption rates health risk assessments at cleanup sites in Puget Sound and the Strait of Georgia. Under that process, risk assessors may use fish consumption surveys for the Suquamish and Tulalip Tribes to estimate exposures for other tribes. The two surveys are summarized below.

The EPA Decision Framework identifies habitat quality as an important consideration in deciding whether to apply the fish and shellfish consumption rates from the Suquamish or the Tulalip Tribes to other tribal populations. EPA Region 10 states:

> *Consumption rates were derived for this Framework from participants in the Suquamish Tribe and Tulalip Tribes studies (Suquamish Tribe, 2000; Toy et al., 1996) who reported consuming shellfish or specific categories of fish that were harvested from Puget Sound. Consumption rates of fish and shellfish harvested from Puget Sound were much higher for members of the Suquamish Tribe than for the Tulalip Tribes. A large percentage of this difference is shellfish consumption, particularly clams. A careful reading of the Suquamish Tribe (2000) study presents some of the cultural and historic basis for this difference. Extensive shellfish habitat is found in many areas of Puget Sound, including the U & A of the Suquamish Tribe, but is uncommon in many other areas.*
>
> *As part of the Framework, Region 10 recommends, as a policy decision, that for CERCLA and RCRA sites in the Puget Sound or Strait of Georgia with extensive intertidal habitat, the consumption rate derived by EPA from data collected by the Suquamish Tribe represents a sustainable consumption rate suitable for estimating site-related risks. Again, as a policy decision, for sites in Puget Sound and the Strait of Georgia that lack extensive intertidal habitat, the consumption rate derived be EPA from data for the Tulalip Tribe represents a sustainable consumption rate. While less than the Suquamish Tribe, significant quantities of shellfish are included in the total consumption rate of the Tulalip Tribes. Where a Tribal-specific survey exists, and where a cleanup site is within that Tribe's exclusive U&A, the fish and shellfish consumption exposure scenarios also should include the consumption rate based on that Tribe's data." (p. 13).*

The LEKT recommends that the Suquamish consumption survey be used to estimate fish and shellfish consumption exposure for members of the LEKT. Ecology believes that the Suquamish survey provides a sound basis for preparing such estimates. Ecology's conclusion is based on the following factors:

- Study Design: The Suquamish Tribe survey is a well-conducted study that included a large number of tribal members. The survey was conducted using established survey techniques. EPA has reviewed the Suquamish study and incorporated the survey results into several guidance documents.[22]
- Similarities in Dietary Habits: The LEK Tribal staff performed a survey to compare the LEKT dietary habits with the habits of the Tulalip and Suquamish Tribes. They used fish models to represent amounts and types of fish and shellfish consumed by the Tulalip and Suquamish Tribes. The majority of Tribal members concluded that their diets were similar to the Suquamish Tribe. The LEK Tribal governing council was consulted to confirm/reaffirm the amounts and types of fish and shellfish consumed by tribal members.

Distribution of Consumption Rates for Tulalip and Suquamish Tribes (Based on Tables B1 and B-2 in EPA, 2007)

	Tulalip Tribe		Suquamish Tribe	
Species	g/day	% of diet	g/day	% of diet
Salmon	96.4	49.7	183.5	23.9
Pelagic fish	8.1	4.2	56	7.3
Bottom fish	7.5	3.9	29.1	3.8
Shellfish	81.9	42.2	498.4	65
Total Ingestion Rate	194	100	766.8	100

- Similarities in Harvesting Techniques: Both the Suquamish and LEK Tribal members harvest and consume large quantities of clams from their respective usual and accustomed fishing areas. Similar intertidal harvesting techniques are employed by both Tribes. However, it appears that the areas impacted by releases from the Rayonier mill are farther from the LEKT reservations than the intertidal beds near the Suquamish reservation.
- Similarities in Watershed Characteristics: The LEKT environmental staff have consulted with the tribe's fish biologists and concluded that there is sufficient shellfish habitat at the site to support shellfish consumption rates similar to those reported for the Suquamish Tribe. However, Malcolm Pirnie (2008) has noted that the LEKT did not provide any studies or surveys to support this conclusion. They noted that "…[t]he Suquamish Tribe owns high quality intertidal shellfish beds, and that these beds are within walking distance of homes on the reservation. This readily available, tribal owned resource appears to be unique among the tribes for which consumption data exists…" (p. 4). Ecology has compiled[23] and evaluated information on shellfish habitat in Port Angeles Harbor and adjacent areas. Based on that evaluation, Ecology agrees with LEKT's conclusions.

[22] IBID
[23] The information considered by Ecology is summarized in Appendix B and C

- Amount of Habitat: The reasonableness of using the Suquamish survey to evaluate cleanup requirements for the Rayonier site depends on the definition of the site. There is extensive intertidal and subtidal shellfish habitat in the Usual and Accustomed fishing areas between Observatory Point and Dungeness Bay. However, the areas potentially impacted by past releases from the Rayonier mill are likely to cover only a portion of this broader area.

  The exact definition of the Rayonier site is unknown. Studies to date have focused on Port Angeles Harbor. Malcolm Pirnie (2008) submitted the modeling study prepared for the Rayonier mill. They concluded that "…[t]he model results show that deposition rates rapidly dissipate to de minimus levels within 1,500 yards of both the near shore and deepwater outfall deposition areas. The model also clearly illustrates that areas outside the protection of Ediz Hook are quickly scoured by the high current velocities associated with the Strait of San Juan de Fuca…" (p. 5).

  The LEKT presented information at the December 14th SAB meeting, the Board was shown maps illustrating a potentially large area of influence by pulp mill contaminants from Point Ediz to the Dungeness Harbor area (see maps below). These maps are based on Oyster larvae testing conducted in the mid-1970s in and around Port Angeles Harbor. [24] However, Malcolm Pirnie (2008) has noted that the author of the original study published a subsequent paper that discussed role of sample filtration on the study results. They recommended that the filtration step be eliminated in future studies. Malcolm Pirnie noted that the "…[r]esults of oyster larvae testing using adjusted data show that biologically significant effects do not extend past Green Point, approximately mid-way between Port Angeles Harbor and Dungeness Spit …" (p. 5). Malcolm Pirnie also noted that the interpretation of the study results is complicated by the potential confounding effects of freshwater inputs at Lees Creek and Morse Creek.

  For screening purposes[25], Ecology has compiled information on shellfish habitat is located in Port Angeles Harbor and areas extending east to Bagley Creek. Based on that evaluation, Ecology estimates that there are 4675 acres of classified and unclassified shellfish habitat in the area in and around Port Angeles Harbor (including areas extending to Bagley Creek). Ecology also estimates that there are 98 acres of intertidal habitat in and around Port Angeles Harbor. However, a large amount of this intertidal habitat is located outside the site boundaries suggested by past modeling studies.

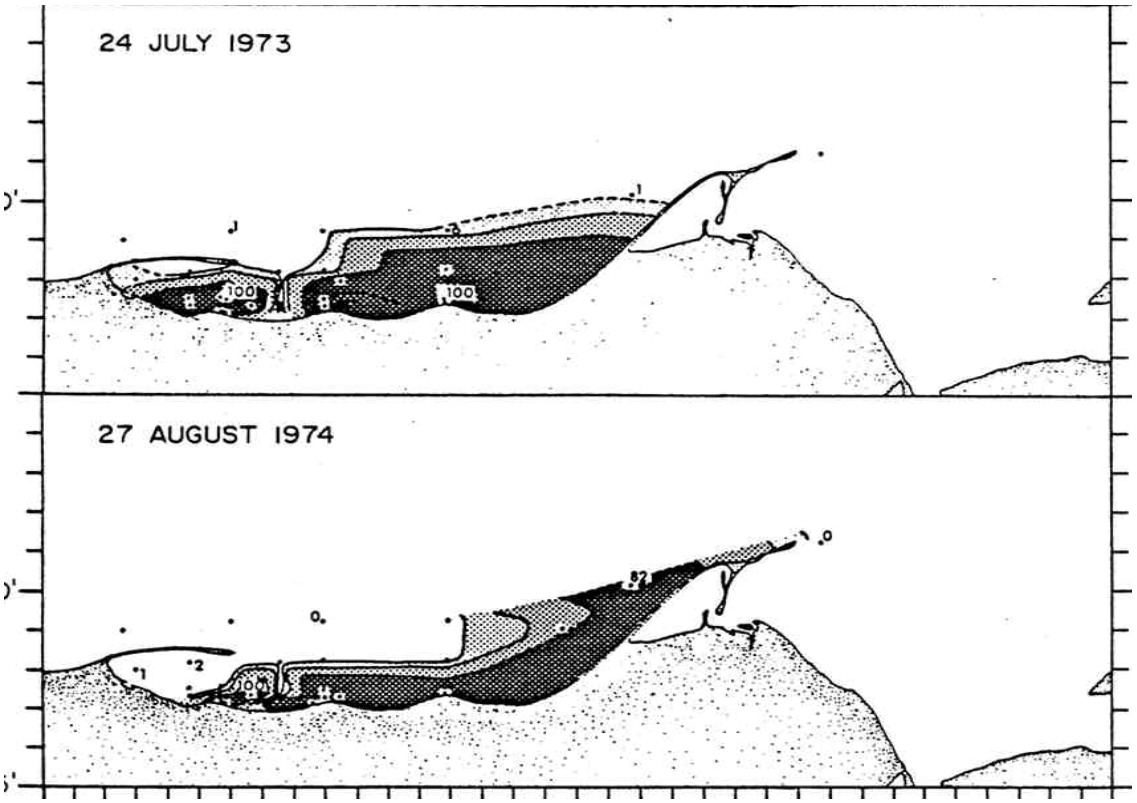
- Quality of Habitat: Ecology conducted a clam population study on three Port Angeles Harbor beaches. The abundance of intertidal clams and beach types at two different tide levels was determined. The three separate beach areas within Port Angeles Harbor were selected based on accessibility and suitable

[24] Cardwell, R.D., Woelke, C.E., Carr, M.I., and Sanborn, E. W. "*Evaluation of the Efficacy of Sulfite Pulp Mill Pollution Abatement Using Oyster Larvae*." Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, F.L. Mayer and J.L. Hamelink, Eds., American Society for Testing and Materials, 1977, pp. 281-295.

[25] Ecology recognizes that the screening level evaluation may over-estimate or under-estimated the size of the area impacted by releases from the Rayonier mill. .

clam/shellfish habitat. A total of 229 clams were collected with 12 different species observed in the intertidal habitat. Staff biologists from the Washington Departments of Fisheries and Ecology "agreed that Port Angeles Harbor has all the requirements and no natural barriers for intertidal clam populations."[26] Ecology updated the 1970 Port Angeles intertidal clam survey in 1976 using three beaches sampled per the Bishop and Devitt survey. Clams were present at all sampling locations from the three beaches in Port Angeles Harbor with an average clam density of 9.5 m^2. The three beaches were characterized as to clam habitat ranging from excellent to "little in the way of clam habitat."[27]

- Harvesting Potential: The shellfish harvesting potential within Port Angeles Harbor is limited by several factors. Some of these factors are likely to diminish in importance in the future (e.g. chemical contamination from the Rayonier site and other industrial operations, bacterial contamination associated with operation of the Port Angeles waste water treatment plant, etc.). Other factors may further limit the development of shellfish beds[28]. However, habitat losses and/or beach access issues associated with developments by the city, port and businesses will continue to limit harvesting potential. Shellfish harvesting will also be limited by the presence of eelgrass beds located to the west of the Rayonier property.



[26] A Report on The Port Angeles Harbor Intertidal Clam and Biological Survey. By Robert A Bishop and Ron Devitt. August 1970. Page 4.
[27] Intertidal Clam Survey of Port Angeles Harbor by Lew Kittle. Washington Department of Ecology. January 1976. Page 37.
[28] Goodwin (2008) concluded that removal of the mill dock and jetty would probably increase the wave climate and further inhibit the development of shellfish beds at site.

Fish Diet Fraction – General Considerations

Question #5

What factors should Ecology consider when selecting a fish diet fraction that will be used to estimate fish consumption exposures for tribal populations?

Ecology Evaluation and Rationale

The fish diet fraction is one of the parameters in the equation used to calculate surface water and sediment cleanup levels. The MTCA rule defines "fish diet fraction" as "….the percentage of the total fish and/or shellfish in an individual's diet that is obtained or has the potential to be obtained from the **site**[29]." (WAC 173-340-200, emphasis added)

The MTCA rule establishes a default fish diet fraction (50%) that is generally used when calculating surface water cleanup levels. However, the rule provides the flexibility to modify the fish diet fraction when necessary to establish a more stringent cleanup level to protect human health" (WAC 173-340-708(10)(b)). Ecology believes that the following factors should be considered when selecting a fish diet fraction for a particular tribal population:

- Current Tribal fish and shellfish harvesting and consumption habits and patterns;
- Reasonably anticipated future Tribal fish and shellfish harvesting and consumption habits and patterns;
- Legal agreements, advisories, or restrictions that define or limit fish and shellfish harvesting at particular sites or areas;
- The nature and extent of fish and shellfish habitat at the cleanup site (both current and reasonably anticipated future habitat conditions);
- Sustainable levels of fish and shellfish harvesting relative to the fish consumption rates used to estimate tribal fish consumption exposures
- Federal and state regulations and guidance materials.
- The combination of parameters used to estimate reasonable maximum exposures.

[29] "Site" is defined in WAC 173-340-200 to mean the same as "facility," which is defined to mean the following (emphasis added):

> "Any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, vessel, or aircraft; or any site or area **where a hazardous substance**, other than a consumer product in consumer use, **has** been deposited, stored, disposed of, or placed, or otherwise **come to be located**."

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Fish Diet Fraction

Question #6

Does the MTCA default fish diet fraction provide a reasonable basis for estimating fish consumption exposures for the Lower Elwha Klallam Tribe? If not, what value or range of values is consistent with current scientific information?

Ecology Evaluation and Rationale

The LEKT recommends that a fish diet fraction of 100% be used when estimating fish and shellfish consumption exposures for members of the LEKT. Ecology believes that the selection of an appropriate fish diet fraction for the Rayonier site will ultimately depend on the extent of contamination associated with the site. However, Ecology believes that the current MTCA default value (50%) falls within the range of scientifically defensible values and that current information provides an insufficient scientific basis for modifying the default value. Ecology considered the following factors when evaluating this issue:

- MTCA Decision-Making Framework: The MTCA rule provides a decision-making framework for establishing cleanup requirements for individual sites. The fish diet fraction is one of the parameters in the equation used to calculate surface water and sediment cleanup levels. The MTCA rule defines "fish diet fraction" as "….the percentage of the total fish and/or shellfish in an individual's diet that is obtained or has the potential to be obtained from the **site**[30]." (WAC 173-340-200, emphasis added).
- Shellfish Harvesting Patterns: Ecology considered the relationship between the fish consumption rate and fish diet fraction and whether it was reasonable to assume that 100% of the shellfish would be harvested from the Rayonier site. Ecology recognizes that there are highly productive shellfish beds in the Port Angeles area (e.g. Green Point). Based on the available information, these areas appear to be outside of the areas affected by releases from the Rayonier facility. [Additional information is needed on the extent of contamination associated with releases from the Rayonier mill.] More generally, it does not appear that any single harvestable shellfish bed or habitat could be relied upon to sustain this level of shellfish consumption rate over an extended period of time. Consequently, the LEK Tribal fishers would need to migrate from one shellfish bed to another to obtain sufficient shellfish. Much of the intertidal shellfish habitat in the Usual and Accustomed area for the LEKT is located outside of the areas thought to have been affected by releases from the Rayonier

[30] "Site" is defined in WAC 173-340-200 to mean the same as "facility," which is defined to mean the following (emphasis added):

"Any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, vessel, or aircraft; or any site or area **where a hazardous substance**, other than a consumer product in consumer use, **has** been deposited, stored, disposed of, or placed, or otherwise **come to be located**."

facility. Malcolm Pirnie (2008) has noted that rotational harvests are a well-established management approach to assure shellfish beds can be sustained[31]. Shellfish habitats require a certain recuperation time between shellfish harvests to replenish the shellfish stocks and/or biomass.

- Range of Fish Diet Fraction Values Used at Cleanup Sites: The LEKT proposal is consistent with the EPA Region 10 Framework which recommends the use of a relative source contribution equal to 100%[32]. Ecology and EPA have used this value when evaluating health risks for tribes at several cleanup sites in Washington (e.g. Bellingham Bay, Lower Duwamish Waterway). Ecology has also used or is considering using fish diet fraction less than 50% in some areas used by different tribes. Malcolm Pirnie (2008) noted that the Alaska Department of Environmental Conservation (ADEC) and EPA Region 10 had used site-specific information on harvesting activities to estimate the percent of a resource which would be obtained from localized sources. Estimates for different resources ranged from 0.07% to 5%[33].
- Practical Considerations: The use of a fish diet fraction greater than the MTCA default value is unlikely to significantly alter cleanup requirements that are based on the Suquamish study. From a practical standpoint, risk-based concentrations will generally fall below background concentrations present in areas not affected by releases from the Rayonier mill or other urban activities. In these situations, cleanup requirements will be developed using a background-based approach.
- Definition of Reasonable Maximum Exposure: Under the MTCA Cleanup Regulation, cleanup levels are based on estimates of the "reasonable maximum exposure" (RME). [34] The RME is designed to represent a high end (but not worst case) estimate of individual exposures. It provides a conservative estimate that falls within a realistic range of exposures.[35] The RME is defined as reasonable because it is a product of several factors that are an appropriate mix of average and upper-bound estimates. RME

[31] Malcolm Pirnie (2008) states that the annual sustainable commercial harvest rates varies among clam species. Examples include 2.7 percent for geoduck and 13.5 for horse clams.

[32] EPA (2007) states "Although the degree to which site-related risks could be overestimated by the use of any of the fish and shellfish consumption rates presented in this Framework cannot be known precisely, these methods are preferable to alternatives that would be likely to underestimate site-related risks, such as basing a consumption rate (or site-related estimates of risk) on the size of the cleanup site, or reducing the site's estimated contribution to fish and shellfish contamination because nearby sites or sources are associated with similar contaminants." This Framework includes the assumption that the selected Tribal fish and shellfish consumption rates and their associated risk estimates will not be reduced based on consideration of the size of the cleanup site or the presence of additional sources of contamination. (Page 23)

[33] Using these percent resource estimates (0.07% to 5%), the total marine finfish and shellfish consumption would approximate one pound per year using the Suquamish dataset. Using the lower fish consumption rate for Tulalip Tribe these percent resource estimates would approximate a consumption rate of less than one pound of seafood every 2.5 years. The shellfish consumption rate used in the Human Health Risk Assessment for the Alaska Pulp Corporation Sitka Mill site was about one 8-ounce fish meal serving every three years.

[34] MTCA defines the RME as the "…the highest exposure that can be reasonably expected to occur for a human or other living organisms at a site under current and potential future site use." CERCLA provides a similar definition "…the highest exposure that is reasonably expected to occur at a Superfund site…"

[35] U.S. Environmental Protection Agency. An Examination of EPA Risk Assessment Principles and Practices. EPA/100/B-04/0001. March 2004.

estimates typically fall between the 90th and 99.9 percentile of the exposure distribution.[36] As noted under Question #4, Ecology believes that it is appropriate to use the fish and shellfish consumption rates from the Suquamish study when evaluating fish and shellfish exposures for members of the LEKT. However, the use of a fish diet fraction of 1 in combination with the Suquamish consumption rates could lead to exposure estimates that fall above the 95th percentile value generally used by Ecology when establishing cleanup levels.

[36] IBID.

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Exposure Duration

Question # 7

Does the MTCA default duration of exposure provide a reasonable basis for estimating fish consumption exposures for the Lower Elwha Klallam Tribe? If not, what value or range of values is consistent with current scientific information?

Ecology Evaluation and Rationale

The MTCA rule establishes a default duration of exposure (30 years) that is used in the equations for establishing ground water and surface water cleanup levels for carcinogens. The LEKT recommends the use a duration of exposure of 70 years when estimating fish and shellfish consumption exposures for tribal members. Ecology believes this approach is consistent with current scientific information. Ecology's conclusion is based on the following factors:

- Tribal Census and Demographic Information: The 30 year exposure duration specified in the MTCA rule is the 90th percentile residence time in the same household (in other words, 90 percent of the US population reside in the same household for 30 years of less). EPA's Exposure Factors Handbook reports that the U.S. population has a 95th percentile residence time of 41 years. The LEKT has provided Ecology with information that indicates that Tribal members live on or near the LEKT reservation for periods longer than 30 years (See Attachment A):
  - LEKT environmental staff interviewed registered tribal elders (those over 55 years of age) who live on or adjacent to the LEK Tribal reservation. Of the 128 Tribal elders interviewed, 35 (27%) have never lived on or near the LEK Tribal reservation while 93 (73%) have resided on or near the reservation. Tribal elders had a range of 10 to 97 years residency time on the reservation with 52% of the elders falling between 54 and 75 years in residence. Of the 73% of Tribal elders that have lived on or near the Reservation at some point in their lives, the 90th percentile residence time is 72 years.
  - The LEKT registry officer (Lola Moses) indicated that over 95% of those Tribal members under the age of 45 have lived on or near the reservation their entire lives. The LEK Tribal review of their census and demographic information is attached to this issue paper.
- Consistency with EPA Region X Decision-Making Framework**:** The LEKT proposal is consistent with the EPA Region 10 Framework.
- Consistency with Exposure Assumption Used at Recent Cleanup Projects: The baseline risk assessment prepared by the Lower Duwamish Waterway Group used a 70 year exposure duration to estimate baseline health risks associated with ingestion of contaminated seafood.

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Body Weight

Question #8

Does the MTCA default body weight provide a reasonable basis for estimating fish consumption exposures for the Lower Elwha Klallam Tribe? If not, what value or range of values is consistent with current scientific information?

Ecology Evaluation and Rationale

The LEKT recommends the use of an average body weight of 79 kg when estimating fish consumption exposures for tribal members. Ecology has reviewed the available information on this issue and agrees with the LEKT recommendation. Ecology's conclusion is based on the following factors:

- Basis for Suquamish Fish Consumption Rates: LEK Tribal members and the LEKT governing council was consulted regarding appropriate Tribal body weight estimates during the development of the Tribal proposal submitted to Ecology. The mean body weight for the Suquamish tribe is 79 kg.
- Information on Body Weights for LEKT Members: The May 2007 LEK Tribal report - "*Lower Elwha Klallam Tribal Fish Consumption & Tribal Health*" – indicated that 68% of the Tribal members are clinically over weight while 48% of the Tribal members are clinically obese. In contrast to these Tribal body weight percentages, 55% of the U.S. national body weight average is clinically over weight and 22% of the U.S. national body weight average is clinically obese.
- EPA Guidance Materials: An adult body weight of 70 kg is used to establish risk based screening levels or risk based cleanup levels.[37] EPA guidance provides procedures for adjusting the toxicity values when evaluating the population groups with different average body weights.
- Other Puget Sound Sites: Under MTCA, the adult default body weight is 70 kg. The human health risk assessment for the Lower Duwamish Waterway adjusted the adult body weights consistent with Tribal populations (82 kg) or other ethnic groups (63 kg for Asian Pacific Islanders).

[37] U.S. Environmental Protection Agency. Region 6 Human Health Medium – Specific Screening Levels. December 2007.

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Salmon

Question #9

Ecology and the LEKT have concluded that site-specific exposure from the former Rayonier Mill site is unlikely to significantly contribute to the contaminant body burden for salmon and other anadromous species that are harvested from local waters affected by site releases. Does the Board agree that this conclusion is consistent with current scientific information?

Ecology Evaluation and Rationale

The Lower Elwha Klallam Tribe (LEKT) concluded that the resident time of salmonids in the Port Angeles harbor areas is low and the contribution of the salmonid body burden from the former Rayonier Mill site is small. Based on these conclusions, the LEKT did not use the salmon consumption rates from the Suquamish survey when preparing their recommendations.[38] (LEKT Fish Consumption Rates, see table 5)

Ecology has reviewed available information on this issue. Based on that review, Ecology agrees with the LEKT recommendations. Ecology's conclusion is based on the following factors:

- This approach is consistent with current scientific information on the life-cycle of these species. Studies report that salmon attain more than 98% of their body weight at sea and their contaminant body burden attributable to freshwater and estuarine environments is negligible. Consequently, the bulk of the body burden in adult salmon is unlikely to result from releases from the Rayonier site.
- This approach is consistent with the EPA Region-10 Framework and approaches being used at other cleanup sites in Puget Sound. For example, the baseline risk assessment prepared by the Lower Duwamish Waterway Group did not include consumption of anadromous fish in the tribal exposure and risk assessment because the bulk of the body burden is unlikely to be obtained from the Lower Duwamish Waterway site.

Pacific Salmonid lifecycle: Salmonids have a very complex life cycle and survival strategies with large variations across and among different species.[39] The geographic distribution of Pacific salmonids extends from San Francisco Bay northward along the Canadian and Alaskan coasts to rivers draining into the Arctic Ocean, and southward down the Asian coastal areas of Russia, Japan, and Korea. Although variation exists, generally, Chinook, Coho, and Steelhead have migratory patterns along the Pacific continental shelf and remain in a freshwater and estuarine environments for longer periods of time than other Pacific salmonid species. After pink, chum, and sockeye

[38] Lower Elwha Klallam Tribe Fish Consumption and the EPA Region 10 Framework. Written by Larry Dunn, Lower Elwha Klallam Tribe, & William Beckley, Ridolfi, Inc. Edits by Matt Beirne. October 17, 2007.

[39] Quinn, Thomas P. 2005. *The Behavior and Ecology of Pacific Salmon & Trout.* American Fisheries Society. University of Washington Press. 2005

salmon enter the ocean environment, they rapidly migrate northward and westward through coastal waters of North America and are found in the open waters of the North Pacific, Gulf of Alaska, and the Bering Sea by the end of their first year at sea. (See table 6 below)

Table: 6 Pacific Salmon Life Cycle

Salmonid Life-cycle Environment	← Salmon Species →						
	Chinook	**Coho**	**Sockeye**	**Chum**	**Pink**	**Steelhead**	**Cutthroat**
Riverine Rearing	X	X	X			X	X
Estuarine Rearing	X	X	X			X	X
Lacustrine Rearing			X				X
Near Shore Migration	X	X	X	X	X	X	X
Continental Shelf Migration	X	X				X	
Mid-Oceanic Migration			X	X	X		

All seven Pacific salmon species are biotranporters of pollutants to and from the Pacific Ocean and their spawning sites in freshwater.[40] During river ascent, salmonids use their muscle lipid and triacyglycerol deposits for energy and gonadal development. Particularly in female salmonids, the organic pollutant body burden redistributes and accumulates in the lipid rich gonads and salmon roe. Furthermore, the lipid depletions and redistribution during the river ascent is not coupled with a simultaneous elimination of the organic pollutant body burden in the salmonids. The pollutants in the salmonids are readily available for bioaccumulation because the migrating salmonids, the salmon roe, and salmon carcasses are a direct food source for predators (birds, mammals and other fish). Hence, salmonids redistribute their pollutant body burdens back to their spawning grounds, to the open ocean predators, or bioaccumulate in the food web. The redistribution, biotransportation, and bioaccumulation of the salmonid pollutant body burden helps contribute to contaminated food webs.

Salmonid Contaminant Body Burden: Because of their chemical-physical properties, Persistent Bioaccumulative Toxics (PBTs) are a group of chemicals that exists within the environment for long periods of time, are lipophilic and bioaccumulate in fish tissue and animal fat, and are highly toxic to animals and humans.[41] The unique geologic and

[40] Ewald, GÖran, Per Larsson, Henric Linge, Lennart Okla, and Nicole Szarzi. Biotransport of Organic Pollutants to an Inland Alaska Lake by Migrating Sockeye Salmon (Oncorhynchus nerka) Arctic, Volume 51, No. 1, pages 40-47. March 1998.

[41] 2007 Puget Sound Update. Ninth Report of the Puget Sound Assessment and Monitoring Program. Puget Sound Action Team. Publication No. PSAT 07-02.

hydrogeologic nature of the Puget Sound in combination with the bioaccumulative, persistent, and toxicity of the PBT - type contaminants creates additional risks to the Puget Sound ecosystem. Some of the PBTs that continue to contaminate, threaten, or harm the Puget Sound ecosystem include: polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbons (PAHs); dioxins and furans; polybrominated diphenyl ethers (PBDEs); and hormone-disrupting chemicals (e.g., bisphenol A). PBTs are contaminants throughout the entire pelagic food web in the Puget Sound.[42]

Of the different PBTs that permeate the Puget Sound food web, polychlorinated biphenyls (PCBs) are well documented contaminants in Coho and Chinook Pacific salmon.[43] Pacific salmon exposure to PBTs, and PCBs in particular, are, in part, contingent on migratory patterns, residency time in Puget Sound, proximity of the salmon to contaminated sediments, waste sites, and different behavior and dietary patterns as the fish mature. [44] PCBs were detected in composite samples of adult Chinook and Coho salmon collected from various in-river and marine locations in Puget Sound. Chinook salmon PCB tissue concentrations were greater than Coho salmon PCB concentrations collected from in-river and marine locations. (See table 7 below)

Table 7: Average PCB Concentrations (µg/kg) For Coho & Chinook Salmon From In-river & Marine Locations, Puget Sound

Salmon Species	Location		Mean Concentration
	Marine	In-River	
Chinook	74.2	49.1	53.9
Coho	35.1	26.5	28.3
Mean	55.3	38.6	41.85
Adapted from O'Neill et. al., 1998, page 316, Table 1			

After investigating different factors and correlates associated with PCBs in muscle tissue of Chinook and Coho salmon from marine and in-river locations in Puget Sound, O'Neill et. al., 1998, page 323, observed "…that chinook salmon had significantly higher PCB concentrations than coho salmon and within each species, PCB concentrations were higher in fish caught in marine areas than in river areas." Taking into account differences in their anadromous life cycles, age, and information from other studies evaluating contaminant exposures of salmon in the Puget Sound estuaries, O'Neill et. al., 1998, page 323, suggested "…that chinook and coho salmon accumulate most of their PCB body-

[42] 2007 Puget Sound Update. Ninth Report of the Puget Sound Assessment and Monitoring Program. Puget Sound Action Team. Publication No. PSAT 07-02.
[43] O'Neill, Sandra M., James E. West, James C. Hoeman. Spatial Trends in the Concentration of Polychlorianted Biphenyls (PCBs) in Chinook (Oncorhynchus tshawytscha) and Coho Salmon (O. kisutch) in Puget Sound and Factors Affecting PCB Accumulation: Results from the Puget Sound Ambient Monitoring Program. Published in Puget Sound Research '98 Proceedings, Seattle, Washington, Volume 1, pages 312-328, 1998.
[44] 2007 Puget Sound Update. Ninth Report of the Puget Sound Assessment and Monitoring Program. Puget Sound Action Team. Publication No. PSAT 07-02. and O'Neill et. al., 1998.

burden in the marine waters of Puget Sound and the ocean, and because chinook salmon live longer and stay at sea longer than coho salmon they accumulate higher PCB concentrations in their muscle tissues."[45] The authors further noted that the salmon contaminant body burden attributable to freshwater and estuarine environments was negligible compared to residency time, growth patterns, and feeding habits of the salmon at sea. T. Quinn, 2005, noting that salmon have high metabolic rates, feed heavily and grow fast in the ocean.[46] Salmon can double their body length and increase their body weight by tenfold during their first summer at sea. More than 98% of the final body weight of most salmon is attained at sea. For example, pink salmon entering the ocean may have a body weight of 0.2 grams but return from the sea weighing 2 kilograms, a ten thousandfold increase. A further study by O'Neill et. al., 2006, also associates the percent contaminant body burden with fish biology.[47] Coho and Chinook salmon populations that have more coastal migratory distributions have higher tissue concentrations of PCBs compared to those salmonids with more oceanic migratory distributions (chum, pink, and sockeye). Variations in the contaminant body burdens were noted and attributed to the marine distribution of the species.

> *…Chinook salmon returning to Puget Sound had significantly higher concentrations of PCBs and PBDEs compared to other Pacific coast salmon populations we sampled. Furthermore, Chinook salmon that resided in Puget Sound in the winter rather than migrate to the Pacific Ocean ("residents") had the highest concentrations of POPs, followed by Puget Sound fish populations believed to be more ocean-reared. Fall Chinook from Puget Sound have a more localized marine distribution in Puget Sound and the Georgia Basin than other populations of Chinook from the west coast of Nort American and are more contaminated with PCBs (2 to 6 times) and PBDEs (5 to 17 times).*[48]

[45] Chinook and coho salmon occupy three distinct habitat types during their lifecycle: a. Freshwater habitats (eggs hatch & fry develop); b. Puget Sound (smolts enter marine waters to feed & reside during migration); c. Ocean habitat (O'Neill et. al., 1998)

[46] Quinn, Thomas P. 2005. *The Behavior and Ecology of Pacific Salmon & Trout*. By Thomas P. Quinn, American Fisheries Society in Association with University of Washington Press. 2005.

[47] O'Neill et. al., 2006. Regional patterns of persistent organic pollutants in five Pacific salmon species (Oncorhynchus spp) and their contributions to contaminant levels in northern and sourthern resident killer whales (Orcinus orca). Extended Abstract in 2006 Southern Resident Killer Whale Symposium. April 3-5, 2006.

[48] O'Neill et. al., 2006. Regional patterns of persistent organic pollutants in five Pacific salmon species (Oncorhynchus spp) and their contributions to contaminant levels in northern and sourthern resident killer whales (Orcinus orca). Extended Abstract in 2006 Southern Resident Killer Whale Symposium. April 3-5, 2006, pages 3 to 4.

Additional Information to Reduce Uncertainties

Question #10

What additional information could be collected during the baseline risk assessment to reduce the uncertainty surrounding current estimates of fish consumption exposures?

Ecology Evaluation and Rationale

Ecology acknowledges different sources of uncertainty in the LEK Tribal proposal to Ecology.

Sources of Uncertainty: There are several sources of uncertainty that complicate the preparation and interpretation of risk assessments designed to evaluate the health risks associated with the consumption of contaminated fish and shellfish. These include:

- Uncertainties associated with the application of the Suquamish dataset to establish the LEK Tribal fish consumption rate (quantity and type of fish/shellfish consumed)
- Uncertainties associated with the quality/quantity shellfish habitat in Port Angeles Harbor and adjacent tidal areas comparable to the Suquamish Tribal shellfish habitat and harvestable areas
- Uncertainties associated with the exclusion of Salmon from the total fish diet of LEK Tribal members
- Uncertainties associated with the relative percent contribution of fish/shellfish contaminant body burden attributed from the "site" compared to other marine environments or from the Puget Sound;
- Uncertainties associated with harvesting fish/shellfish from Port Angeles Harbor or adjacent areas that have been influenced, directly or indirectly, by the former Royonier Mill site
- Uncertainties associated with fish/shellfish harvested from areas other than Puget Sound by LEK Tribal members
- Uncertainties associated with sustaining and managing harvestable shellfish habitat in consideration of LEK Tribal fish consuming habits and behaviors
- Uncertainties associated with defining intertidal zones and the spatial scales used to define areas resulting from tidal variations
- Uncertainties associated with the spatial distributions of specific benthos species (intertidal and subtidal) based on greater than 16 year old field survey data and the best professional judgment of the marine biologists conducting the surveys

- Actions/Studies to Reduce Uncertainties: Ecology believes the following information collection activities would help reduce the uncertainties associated with the LEK Tribal proposal:
  - Survey of LEK Tribal areas used to harvest fish and shellfish in the Strait of Juan de Fuca and adjacent areas east and west of Port Angeles Harbor
  - Survey of intertidal and subtidal shellfish habitat to better define the extent of the habitat, quality of shellfish habitat, and quantity of shellfish (biomass) harvestable from Port Angeles Harbor and adjacent areas east and west of Port Angeles Harbor
  - Conduct a well designed and executed sampling and analysis study to better characterize the nature and extent of chemical contamination for the Port Angeles Harbor and upland areas
  - Document the areas where LEK Tribal member harvest fish and shellfish throughout the year
  - Conduct a well designed and executed sampling and analysis study to better characterize the nature and extent of chemical contamination in areas used by LEK Tribal members to harvest fish and shellfish
  - Conduct a well designed and executed sampling and analysis study to better characterize the nature and extent of chemical contamination for the Port Angeles Harbor, adjacent areas east and west of Port Angeles Harbor, and upland areas
  - Perform field studies to define tidal zones, intertidal and subtidal, in Port Angeles Harbor and tidal areas adjacent to Port Angeles Harbor
  - Perform field studies to determine the quality of intertidal and subtidal shellfish habitat and the influence of tidal variations associated with the quality of the intertidal and subtidal shellfish habitat
  - Perform field studies to define harvestable intertidal and subtidal shellfish habitat for Port Angeles Harbor and adjacent areas

Appendix A – Reasonable Maximum Exposure

Reasonable Maximum Exposure: One of the mutual policy goals of the Superfund program and under the MTCA Cleanup Regulations is to protect a high-end, but not worst-case, individual exposure: the reasonable maximum exposure (RME). The RME is similarly defined for both the Superfund program and under MTCA. The RME, as defined by EPA, "is the highest exposure that is reasonably expected to occur at a Superfund site." [49] (EPA, 2004, page 102-103) Under MTCA, the Reasonable Maximum Exposure "means the highest exposure that can be reasonably expected to occur for a human or other living organisms at a site under current and future site use." [WAC 173-340-200] The worst-case exposure represents an extreme set of exposure conditions, usually not observed in an actual population, which is the maximum possible exposure where everything that can plausibly happen to maximize exposure, happens. (U.S. EPA Guidelines For Exposure Assessment, Federal Register Notice, Vol. 57, No. 104, May 1992, pages 22888-22938).

The preamble to the National Contingency Plan further describes the RME will:

> *…result in an overall exposure estimate that is conservative but within a realistic range of exposure. Under this policy, EPA defines "reasonable maximum" such that only potential exposure that are likely to occur will be included the in the assessment of exposures. The Superfund program has always designed its remedies to be protective of all individuals and environmental receptors that may be exposed at a site; consequently, EPA believes it is important to include all reasonably expected exposures in its risk assessments…*

[49] U.S. Environmental Protection Agency. An Examination of EPA Risk Assessment Principles and Practices. EPA/100/B-04/0001. March 2004. pages 102-103.

Appendix B – GIS Evaluation of Port Angeles Harbor Area

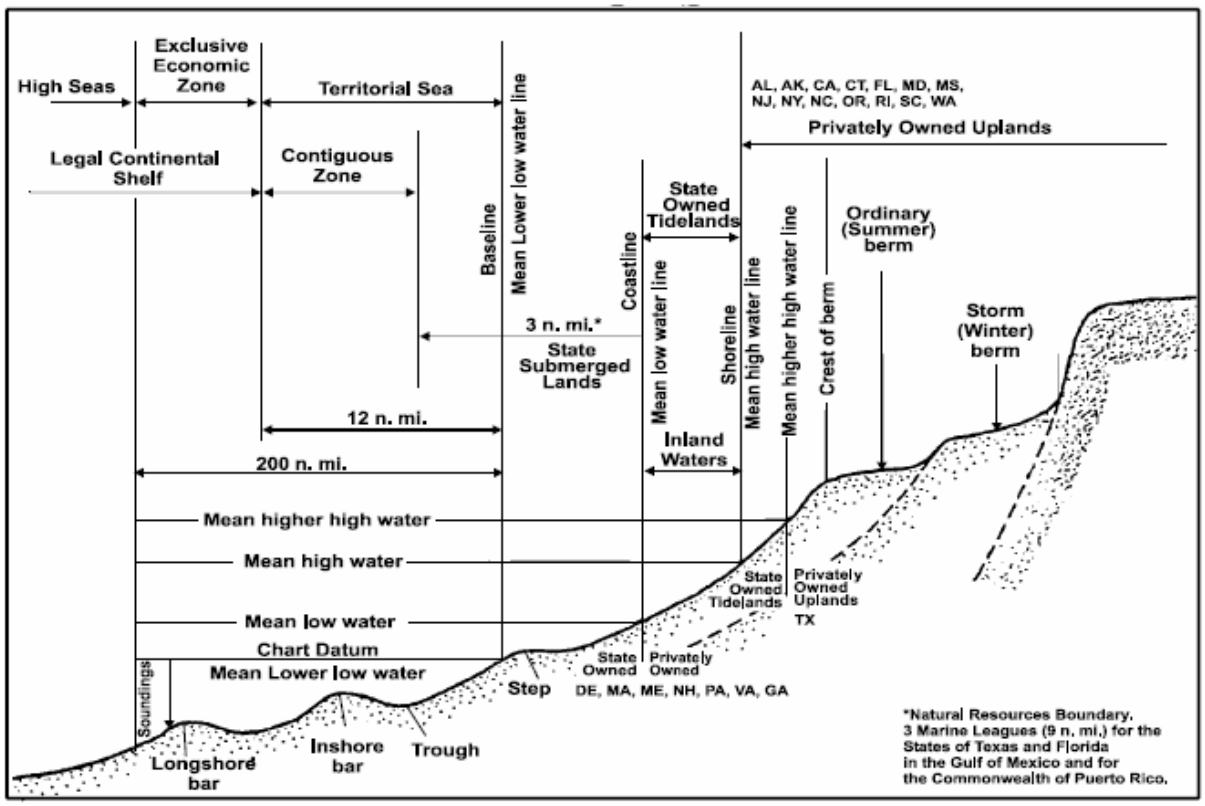
Ecology has evaluated the commercial shellfish areas, tidal land influences or benchmarks, and harvestable shellfish beds in the Port Angeles Harbor area using data from: (1) the Washington Department of Health (DOH) classifications for commercial harvestable shellfish beds[50]; (2) the Washington Department of Natural Resources (DNR) for the types of shellfish inhabiting the Port Angeles Harbor area[51]; (3) National Oceanic and Atmospheric Administration (NOAA) Tidal Bench Mark Data Sheets[52]; and (4) the Digital Elevation Model, developed by David Finlayson, January 24, 2005[53]. Using data from these four sources Ecology has constructed Geographical Information System (GIS) maps describing the Port Angele area harvestable shellfish beds. National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, Tidal Bench Mark Data Sheets for Ediz Hook and Port Angeles, Washington, were evaluated to map tidal variations and intertidal sediment zones potentially available for harvesting shellfish. This information was used to examine each of the areas adjacent to the Port Angeles Harbor area. A range of values were used based on tidal variations for the Mean Low Water Level to the Mean High Water Level. The Mean Low Water Level to the Mean High Water Level tidal variations was used by Ecology to define the intertidal zones and areas. The National Oceanic and Atmospheric Administration defines intertidal variations and areas using the Mean Lower Low Water to Mean Higher High Water which significantly increases the intertidal zones and intertidal areas because the increased tidal variations are defined by the extreme low and high tides.

[50] Commercial Shellfish Growing Areas. Metadata Link: http://ww4.doh.wa.gov/gis/metadata/growingareas.htm

[51] Documented Shellfish Areas from the Washington Department of Fish and Wildlife Marine resources data, for the most part, have not been updated since the publication of the 1992 Technical Report No. 79. http://wdfw.wa.gov/hab/digital_doc.pdf

[52] Combined bathymetry and topography of the Puget Lowlands, Washington State (January 2005) Metadata Link: http://www.ocean.washington.edu/data/pugetsound/datasets/psdem2005/rasters/complete/metadata.htm

[53] Combined bathymetry and topography of the Puget Lowlands, Washington State (January 2005) Metadata Link: http://www.ocean.washington.edu/data/pugetsound/datasets/psdem2005/rasters/complete/metadata.htm



Four descriptive maps have been developed by Ecology to illustrate the Port Angeles shellfish areas, tidal zones, and harvestable shellfish beds. The tables below summarize the information that each of the maps illustrates. The first map provides an overview of the Port Angeles Harbor areas Ecology evaluated. The second map illustrates the Port Angeles Harbor area from Ediz Hook to Bagely Creek and related shellfish habitat. The third and fourth maps illustrates shellfish habitat areas east and west of Port Angeles Harbor, respectively.

Table B-1, below, describes the tidal datums for Ediz Hook and Port Angeles along with the resulting differences in water volume measured in meters (feet) and the estimated exposed sediments resulting from these tidal variations.

Table B-1 Port Angeles Harbor & Ediz Hook to Bagely Creek, Tidal Variations and Map Observations

	Mean Low Water Level Meters (feet)	Mean High Water Level Meters (feet)	Exposed Sediment Due to Tidal Variations
Ediz Hook Station ID 9444122	0.684 (2.24 ft)	1.926 (6.32 ft)	From the tip of Ediz Hook thru PA Harbor approximates 98 intertidal acres of exposed
Port Angeles Station ID 9444090	0.586 (1.92 ft)	1.987 (6.52 ft)	

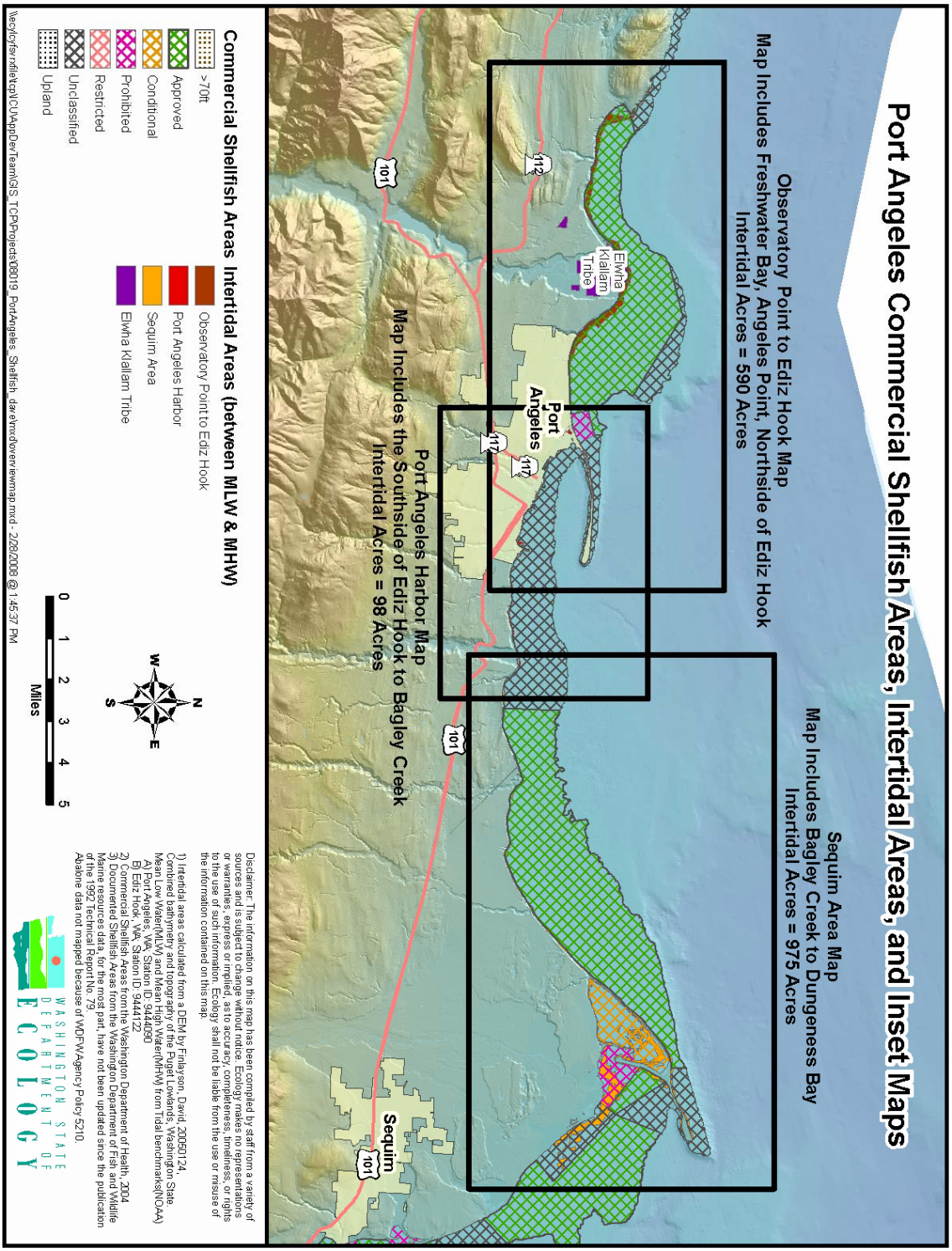
			sediment/shellfish beds
Map Observations			
Shellfish Harvestable Area		**Area (acreage) noted on map**	**Comment**
Commercial Harvest Prohibited (bacteria)		48 acres	Fecal coliform
Unclassified commercial shellfish areas		3,159 acres	
Hardshell Clams Beds		304 acres	
Geoduck		35 acres	
Abalone		304 acres	Not shown on map
Crabs		825 acres	

Table B-2, below, describes the tidal datums for area east of Port Angeles Harbor along with the resulting differences in water volume measured in meters (feet) and the estimated exposed sediments resulting from these tidal variations.

Table B-2 East of Port Angeles Harbor Area From Bagely Creek to Eastern Edge of Dungeness Bay, Variations and Map Observations			
	Mean Low Water Level Meters (feet)	**Mean High Water Level Meters (feet)**	**Exposed Sediment Due to Tidal Variations**
Ediz Hook Station ID 9444122	0.684 (2.24 ft)	1.926 (6.32 ft)	From Bagely Creek to Eastern Edge of D. Bay approximates 975 intertidal acres of exposed sediment/shellfish beds
Port Angeles Station ID 9444090	0.586 (1.92 ft)	1.987 (6.52 ft)	
Map Observations			
Shellfish Harvestable Area		**Area (acreage) noted on map**	**Comment**
Approved Commercial Shellfish Areas		11,705 acres	Unrestricted harvest
Hardshell Clams Beds		1573 acres	
Geoduck Beds		4,375 acres	
Oysters Beds		29 acres	
Crab Beds		3,027 acres	
Abalone Beds		1,710 acres	Not shown on map
Prohibited commercial shellfish harvest area		561 acres	Dungeness Bay
Conditional commercial shellfish harvest area		1154 acres	Dungeness Bay
Unclassified commercial shellfish area		2511 acres	

Table B-3, below, describes the tidal datums for area west of Port Angeles Harbor along with the resulting differences in water volume measured in meters (feet) and the estimated exposed sediments resulting from these tidal variations.

Table B-3 West of Port Angeles Harbor Area Observatory Point to Ediz Hook, Tidal Variations and Map Observations			
	Mean Low Water Level Meters (feet)	**Mean High Water Level Meters (feet)**	**Exposed Sediment Due to Tidal Variations**
Ediz Hook Station ID 9444122	0.684 (2.24 ft)	1.926 (6.32 ft)	From Obs. Pt. to Ediz Hook approximates 590 intertidal acres of exposed sediment/shellfish beds
Port Angeles Station ID 9444090	0.586 (1.92 ft)	1.987 (6.52 ft)	
Map Observations			
Shellfish Harvestable Area		**Area (acreage) noted on map**	**Comment**
Approved Commercial Shellfish Harvest		5,647 acres	Unrestricted harvest
Prohibited Commercial Shellfish Harvest		185 acres	
Unclassified Commercial Shellfish Harvest		1272 acres	
Abalone Beds		382 acres	Not shown on map
Crabs Beds		1470 acres	
Geoduck Beds		81 acres	


Port Angeles Commercial Shellfish Areas, Intertidal Areas, and Inset Maps
Observatory Point to Ediz Hook Map
Map Includes Freshwater Bay, Angeles Point, Northside of Ediz Hook
Intertidal Acres = 590 Acres
Port Angeles Harbor Map
Map Includes the Southside of Ediz Hook to Bagley Creek
Intertidal Acres = 98 Acres
Sequim Area Map
Map Includes Bagley Creek to Dungeness Bay
Intertidal Acres = 975 Acres
Elwha Klallam Tribe
Port Angeles
Sequim
101
112
117
Commercial Shellfish Areas Intertidal Areas (between MLW & MHW)
>70ft
Approved
Conditional
Prohibited
Restricted
Unclassified
Upland
Observatory Point to Ediz Hook
Port Angeles Harbor
Sequim Area
Elwha Klallam Tribe
N
W
E
S
0 1 2 3 4 5
Miles
Disclaimer: The information on this map has been compiled by staff from a variety of sources and is subject to change without notice. Ecology makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. Ecology shall not be liable from the use or misuse of the information contained on this map.
1) Intertidal areas calculated from a DEM by Finlayson, David 20060124. Combined bathymetry and topography of the Puget Lowland, Washington State. Mean Low Water(MLW) and Mean High Water(MHW) from Tidal benchmarks(NOAA)
A) Port Angeles, WA, Station ID: 9444090
B) Ediz Hook, WA, Station ID: 9444122
2) Commercial Shellfish Areas from the Washington Department of Health, 2004
3) Documented Shellfish Areas from the Washington Department of Fish and Wildlife Marine resources data, for the most part, have not been updated since the publication of the 1992 Technical Report No. 79.
Abalone data not mapped because of WDFW Agency Policy 5210.
WASHINGTON STATE DEPARTMENT OF ECOLOGY
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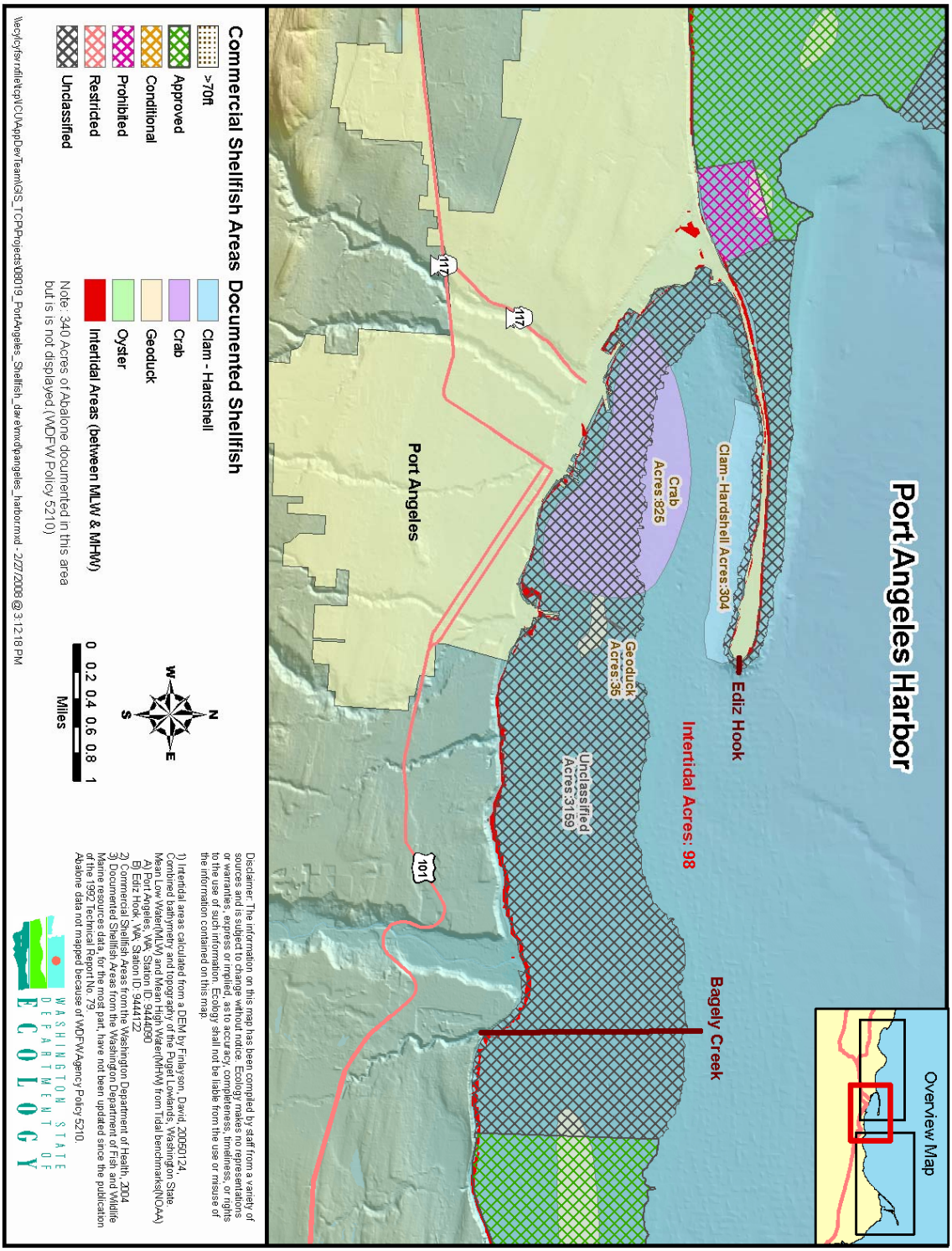
Port Angeles Harbor
Overview Map
Clam - Hardshell Acres:304
Ediz Hook
Intertidal Acres: 98
Bagely Creek
Crab
Acres:825
Geoduck
Acres:35
Unclassified
Acres:3159
Port Angeles
112
117
101
Commercial Shellfish Areas Documented Shellfish
>70ft
Approved
Conditional
Prohibited
Restricted
Unclassified
Clam - Hardshell
Crab
Geoduck
Oyster
Intertidal Areas (between MLW & MHW)
Note: 340 Acres of Abalone documented in this area but is not displayed.(WDFW Policy 5210)
N
W
E
S
0 0.2 0.4 0.6 0.8 1
Miles
Disclaimer: The information on this map has been compiled by staff from a variety of sources and is subject to change without notice. Ecology makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. Ecology shall not be liable from the use or misuse of the information contained on this map.
1) Intertidal areas calculated from a DEM by Finlayson, David 20060124. Combined bathymetry and topography of the Puget Lowlands, Washington State. Mean Low Water(MLW) and Mean High Water(MHW) from Tidal benchmarks(NOAA)
A) Port Angeles, WA, Station ID: 9444090
B) Ediz Hook, WA, Station ID: 9444122
2) Commercial Shellfish Areas from the Washington Department of Health, 2004
3) Documented Shellfish Areas from the Washington Department of Fish and Wildlife Marine resources data, for the most part, have not been updated since the publication of the 1992 Technical Report No. 79.
Abalone data not mapped because of WDFW Agency Policy 5210.
WASHINGTON STATE DEPARTMENT OF ECOLOGY
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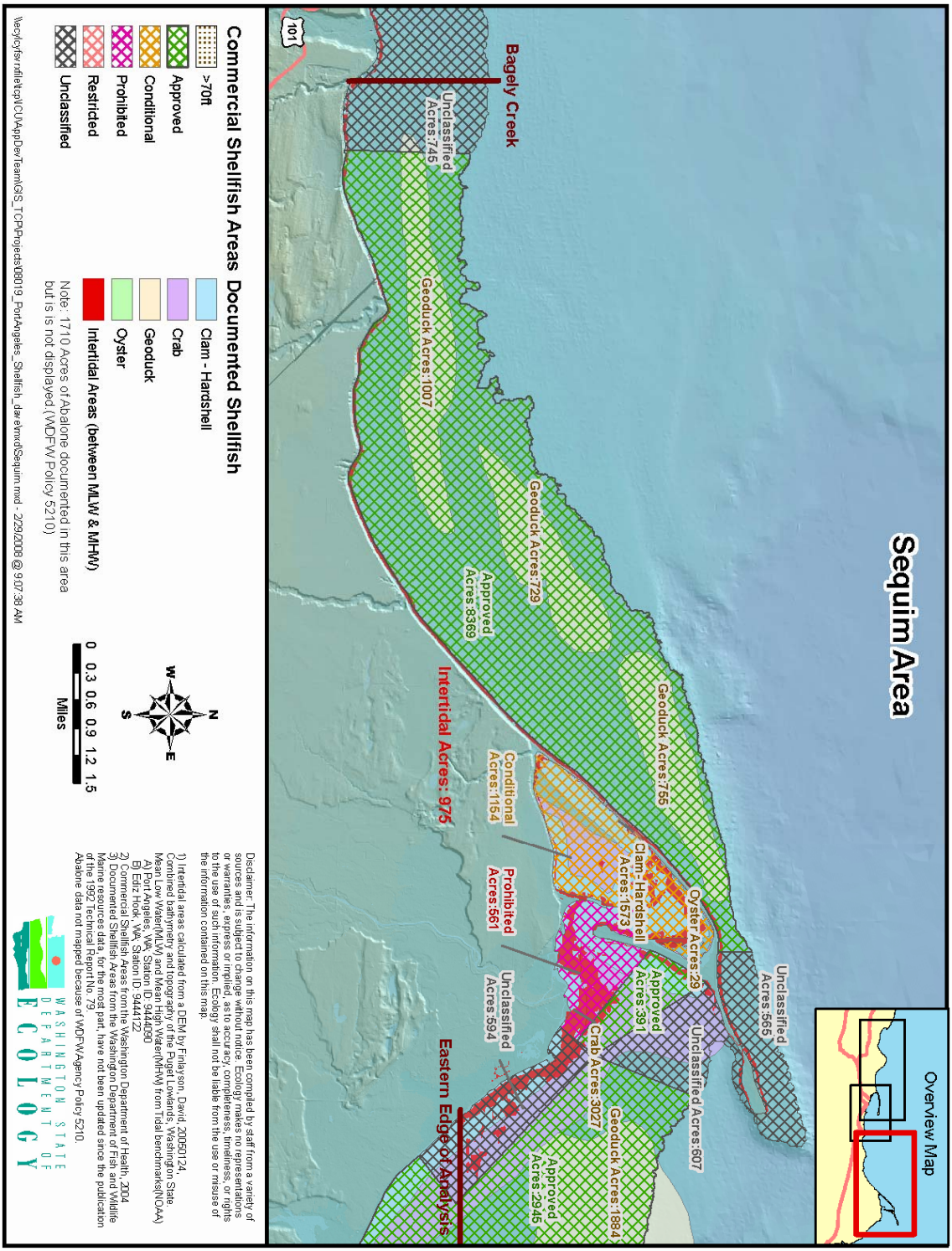
Sequim Area
Overview Map
Bagely Creek
Unclassified Acres:745
Geoduck Acres:1007
Geoduck Acres:729
Approved Acres:8369
Intertidal Acres: 975
Conditional Acres:1154
Prohibited Acres:561
Unclassified Acres:594
Eastern Edge of Analysis
Geoduck Acres:755
Clam - Hardshell Acres:1573
Oyster Acres:29
Approved Acres:391
Crab Acres:3027
Unclassified Acres:565
Unclassified Acres:607
Geoduck Acres:1884
Approved Acres:2945
101
Commercial Shellfish Areas Documented Shellfish
>70ft
Approved
Conditional
Prohibited
Restricted
Unclassified
Clam - Hardshell
Crab
Geoduck
Oyster
Intertidal Areas (between MLW & MHW)
Note: 1710 Acres of Abalone documented in this area but is not displayed.(WDFW Policy 5210)
N
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S
0 0.3 0.6 0.9 1.2 1.5
Miles
Disclaimer: The information on this map has been compiled by staff from a variety of sources and is subject to change without notice. Ecology makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. Ecology shall not be liable from the use or misuse of the information contained on this map.
1) Intertidal areas calculated from a DEM by Finlayson, David 20060124. Combined bathymetry and topography of the Puget Lowlands, Washington State. Mean Low Water(MLW) and Mean High Water(MHW) from Tidal benchmarks(NOAA)
A) Port Angeles, WA, Station ID: 9444090
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Abalone data not mapped because of WDFW Agency Policy 5210.
WASHINGTON STATE DEPARTMENT OF ECOLOGY
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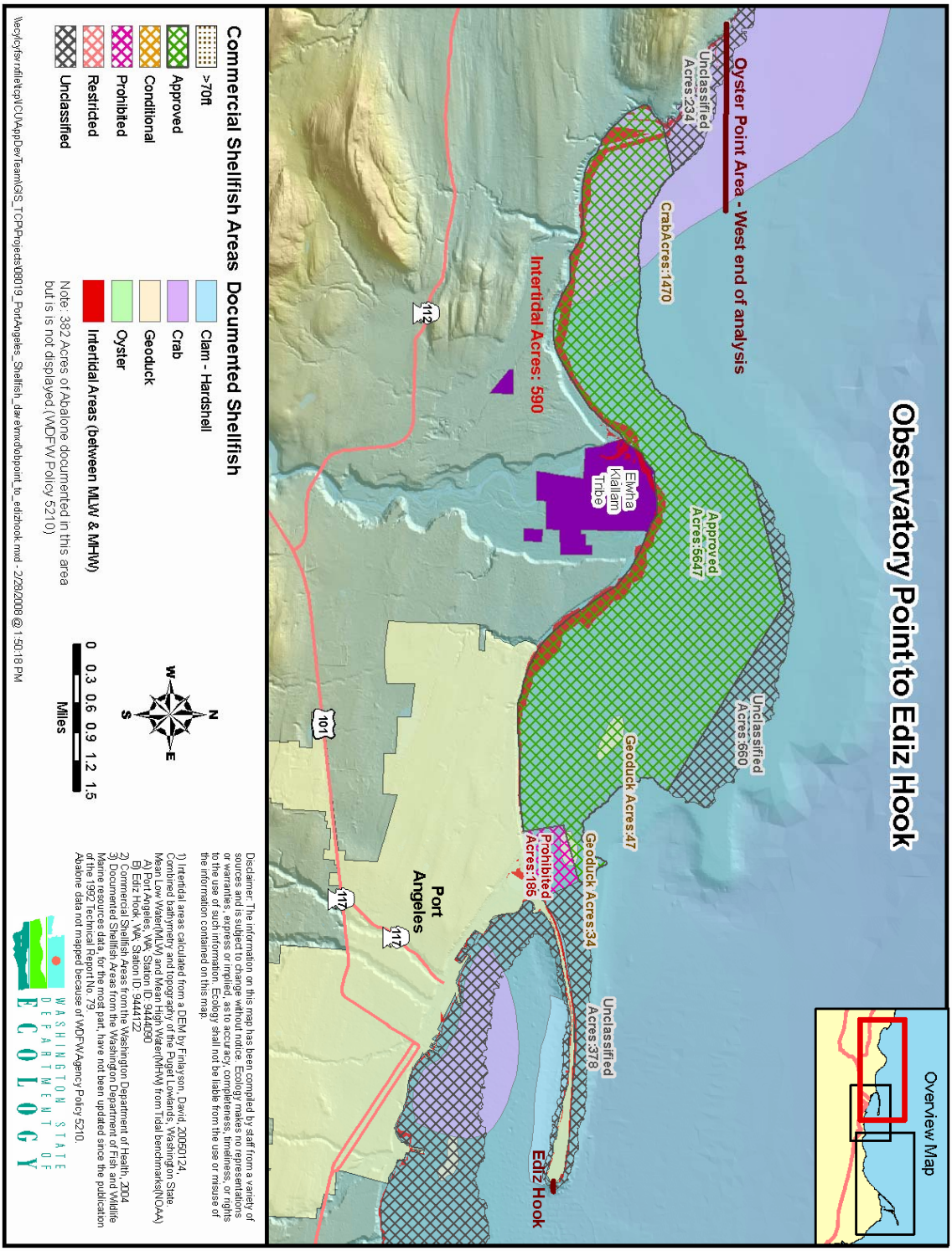
Observatory Point to Ediz Hook
Overview Map
Oyster Point Area - West end of analysis
Unclassified Acres:234
CrabAcres:1470
Approved Acres:5647
Elwha Klallam Tribe
Intertidal Acres: 590
Unclassified Acres:660
Geoduck Acres:47
Prohibited Acres:185
Geoduck Acres:34
Unclassified Acres:378
Ediz Hook
Port Angeles
112
101
117
Commercial Shellfish Areas Documented Shellfish
>70ft
Approved
Conditional
Prohibited
Restricted
Unclassified
Clam - Hardshell
Crab
Geoduck
Oyster
Intertidal Areas (between MLW & MHW)
Note: 382 Acres of Abalone documented in this area but is not displayed.(WDFW Policy 5210)
N
W
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0 0.3 0.6 0.9 1.2 1.5
Miles
Disclaimer: The information on this map has been compiled by staff from a variety of sources and is subject to change without notice. Ecology makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. Ecology shall not be liable from the use or misuse of the information contained on this map.
1) Intertidal areas calculated from a DEM by Finlayson, David 20060124. Combined bathymetry and topography of the Puget Lowlands, Washington State. Mean Low Water(MLW) and Mean High Water(MHW) from Tidal benchmarks(NOAA)
A) Port Angeles, WA, Station ID: 9444090
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Abalone data not mapped because of WDFW Agency Policy 5210.
WASHINGTON STATE DEPARTMENT OF ECOLOGY
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Appendix C: Shellfish Habitat

The EPA Decision Framework identifies habitat quality as an important consideration in deciding whether to apply the fish and shellfish consumption rates from the Suquamish or the Tulalip Tribes to other tribal populations. EPA Region 10 states:

> *Consumption rates were derived for this Framework from participants in the Suquamish Tribe and Tulalip Tribes studies (Suquamish Tribe, 2000; Toy et al., 1996) who reported consuming shellfish or specific categories of fish that were harvested from Puget Sound. Consumption rates of fish and shellfish harvested from Puget Sound were much higher for members of the Suquamish Tribe than for the Tulalip Tribes. A large percentage of this difference is shellfish consumption, particularly clams. A careful reading of the Suquamish Tribe (2000) study presents some of the cultural and historic basis for this difference. Extensive shellfish habitat is found in many areas of Puget Sound, including the U & A of the Suquamish Tribe, but is uncommon in many other areas.*
>
> *As part of the Framework, Region 10 recommends, as a policy decision, that for CERCLA and RCRA sites in the Puget Sound or Strait of Georgia with extensive intertidal habitat, the consumption rate derived by EPA from data collected by the Suquamish Tribe represents a sustainable consumption rate suitable for estimating site-related risks. Again, as a policy decision, for sites in Puget Sound and the Strait of Georgia that lack extensive intertidal habitat, the consumption rate derived be EPA from data for the Tulalip Tribe represents a sustainable consumption rate. While less than the Suquamish Tribe, significant quantities of shellfish are included in the total consumption rate of the Tulalip Tribes. Where a Tribal-specific survey exists, and where a cleanup site is within that Tribe's exclusive U&A, the fish and shellfish consumption exposure scenarios also should include the consumption rate based on that Tribe's data." (p. 13).*

The LEKT concluded that the current (or reasonably foreseeable) shellfish habitat is sufficient to support a sustainable level of shellfish consumption similar to the rates reported for members of the Suquamish Indian Tribe. Ecology has reviewed information regarding shellfish habitat in the Port Angeles Harbor and adjacent areas.

Based on the information reviewed, Ecology reached several conclusions:

- Commercial shellfish harvesting from Port Angeles Harbor is prohibited
- Information suggests a wide range of sediment quality and harvestable shellfish habitat available in areas adjacent (east and west) of Port Angeles Harbor
- Information from Ecology's Environmental Assessment Program, the Washington Department of Fish and Wildlife, a DRAFT Environmental Impact Statement and older biological studies suggests a diverse and sometimes robust shellfish habitat in selected areas of the Strait of Juan de Fuca and adjacent tidal areas to Port Angeles Harbor
- Ecology's GIS mapping of the Port Angeles Harbor area suggests there is a range of available commercial intertidal shellfish harvestable areas and that there are selected shellfish areas that are unclassified by DOH.

Environmental assessment Program: The Department of Ecology, Environmental Assessment Program (EAP), has developed estimates of sediment quality in the Puget Sound from 1997 to 2003.[54] Assessment of sediment quality is based on a weight-of-evidence approach that combines the results of sediment chemistry, toxicity, and benthic invertebrate community structure. Using this weight-of-evidence approach, EAP defines sediment quality for each sediment monitoring region based on four descriptors or categories of sediment quality. These four categories of sediment quality are:

- High quality – no degradation detected;
- Intermediate/high quality – degradation detected in one of the three test parameters;
- Intermediate/degraded quality – degradation detected in two of the three test parameters; and
- Degraded quality – degradation detected in all three test parameters.

Sediment quality data was collected in 2002 and 2003 from Puget Sound regions in the San Juan Archipelago, the eastern Strait of Juan de Fuca, and Admiralty Inlet. The Eastern Strait of Juan de Fuca includes sampling stations located in Port Angeles harbor. The percent of areas within the Eastern Strait of Juan de Fuca for estimates of sediment quality are:

- 32% Intermediate/high quality;
- 33% Intermediate/degraded quality;
- 35% High quality.

Provisional data from 12 sampling stations located in Port Angeles harbor had mean Effect Range Median (ERM) quotients ranging from 0.03 – 0.19. Values less than 1.0 suggest high sediment quality associated with those sampling locations.[55] One sampling station, however, had an adversely affected infaunal community, suggesting a response to an environmental stressor other than a chemical contaminant.

Two stations showed other signs of impairment, including: 1) station 557 with toxicity above the critical value for the Echinoderm larval survival and development test, and 2) station 449 with levels of the PAH Fluoranthene above Washington State Sediment Management Standards.

Department of Health (DOH): The Washington Department of Health (DOH) monitors shellfish and shellfish habitat throughout the Puget Sound for bacterial or viral contamination. In 2005, nearly one-third of the Puget Sound's shellfish growing areas had harvest restrictions due to fecal coliform contamination.[56] From 1995 to 2005, DOH

[54] 2007 Puget Sound Update. *Ninth Report of the Puget Sound Assessment and Monitoring Program*. Puget Sound Action Team. February 2007. Publication No. PSAT 07-02.

[55] Mean ERM quotients were calculated as the mean of the quotients derived by dividing the chemical concentrations in the samples by their respective ERM values. Mean ERM quotients are used to account for both the presence and concentrations of mixtures of these potential toxicants. The greater the mean ERM quotient, the greater the overall contamination of the sample as determined by the mixture of substances, and the greater risk of toxicity and/or benthic effects.

[56] State of the Sound 2007. Puget Sound Action Team. Publication No. PASAT 07-01. May 2007

reclassified more than 20 commercial shellfish growing areas in Puget Sound. Improved water quality allowed 12, 617 acres of shellfish growing areas to be upgraded for commercial harvesting, while 5, 218 acres were downgraded due to bacterial contamination. Large areas adjacent to Port Angeles harbor are approved or are unclassified (closed) for commercial shellfish harvesting. Commercial shellfish harvesting is prohibited in the Port Angeles harbor due to chemical and/or bacterial contamination. Although shellfish harvesting is either unclassified (closed) west of Port Angeles Harbor or prohibited in Port Angeles Harbor, there are viable and harvestable shellfish beds located along the Eastern Strait of Juan de Fuca.

Department of Fish and Wildlife (WDFW): The Washington Department of Fish and Wildlife (WDFW) has made some observations of the shellfish habitat during diving operations in the Port Angeles Harbor area.[57] No recent diving operations have been conducted in the Port Angeles Harbor. However, some diving has occurred off the "spit" in the Port Angeles harbor with geoduck, abalone, and urchins observed. No diving research operations are planned for the foreseeable future in the Port Angeles Harbor by WDFW.

DRAFT Environmental Impact Statement (EIS): A DRAFT Environmental Impact Statement (EIS) for a proposed transmission cable approximately 32 miles long starting from Victoria, B.C., Canada and terminating at a substation in Port Angeles, Washington provides information regarding Port Angeles marine habitat and wildlife.[58] The DRAFT EIS affirms the observations made by the Washington Department of Fish and Wildlife (WDFW) describing the Port Angeles harbor and Strait as Essential Fish Habitat for numerous species of Pacific salmon, coastal pelagic species, and benthic habitat. The EIS noted information from WDFW Priority Habitats and Species data that showed areas in the project vicinity that contain clams, geoducks, and sea urchins. Based on a 1999 study, the EIS noted that about 25% of the Port Angeles Harbor was covered with wood waste with shrimp, crabs, and fish residing in the wood waste areas. The nature of the infaunal community near the former Rayonier Mill site could not be determined due to limited access with underwater gear. Again based on the 1999 study, the EIS noted that . . . "most of Port Angeles Harbor was considered to have healthy and undisturbed benthic conditions." (page 3-25, DRAFT EIS) Clallam County, including parts of the Strait and Port Angeles, has many shellfish resources including bivalves, crustaceans, and sea urchins. Some of the shellfish species and important habitat considerations are noted in Table 4, below.

Table: 4 Shellfish Found in Clallam County[59]

Selected Bivalves	Located along beaches & tide flats
Abalone	Located along beaches & tide flats
Cockle	Located along beaches & tide flats

[57] Personal communication. Craig McCormack and Bob Sizemore, Director, Diving Operations, Washington Department of Fish and Wildlife, February 19, 2008.
[58] Port Angeles-Juan de Fuca Transmission Project. Draft Environmental Impact Statement. DOE/EIS-0378. March 2007.
[59] Port Angeles-Juan de Fuca Transmission Project. Draft Environmental Impact Statement. DOE/EIS-0378. March 2007; Table developed from information on pages 3-44 & 3-45 and Table 3-3.

Geoduck	Found at depths of 10 to 80 feet; density of clams (0.086 – 0.26 clams/m^2) lower compared to average density (1.7 clams/m^2) of geoduck; lives in sandy mud lower intertidal & subtidal zones
Butter clam	Located along beaches & tide flats
Manila clam	Located along beaches & tide flats
Various mussel species	Located along beaches & tide flats
Olympia & Pacific oysters	Located along beaches & tide flats
Crustaceans	**Port Angeles Harbor area**
Dungeness crab	Sport harvest: 80,000 to 90, 000 pounds/yr; widely distributed subtidally; found in water less 90 feet
Spot Shrimp	Associated w/ rock piles and debris covered bottoms, found in range of 12 to 1500 foot debths;
Coonstripe Shrimp	
Sea Urchins	**Distributed in the Strait & Spit of PA Harbor**
Purple Sea Urchins	
Red Sea Urchins	Harvested for food, occur on rocky subtidal habitats below tide line up to depth of 295 feet
Green Sea Urchins	

Between 1967 and 1971 the Washington Department of Fisheries surveyed selected areas of the Puget Sound to determine the distribution and abundance of clams and factors that affect their distribution and abundance.[60] The 1973 Department of Fisheries report provided valuable information regarding characteristic of benthic substrates for clam habitat and historical information on clam crop yields for Port Angeles Harbor. Clam surveys and observational dives in Port Angeles Harbor showed benthic substrates of soft silt, mud and sand at 12 to 75 foot depths and shell, gravel, pea gravel, and scattered boulders at 6 to 53 foot depths. Based on the Department of Fisheries 1973 survey the standing hardshell crop estimates for Port Angeles Harbor was 2,030,000 pounds of Butter clams and 1,110,000 pounds of Little-neck clams. Similarly, Green Point, located about 5 miles east of the former Rayonier Mill site along the Port Angeles Harbor shoreline, the standing hardshell crop estimates was 27,690,000 pounds of Butter clams and 2,000,000 pounds of Little-neck clams.

Additional Technical Information: Ecology conducted a clam population study on three Port Angeles Harbor beaches.[61] The abundance of intertidal clams and beach types at two different tide levels was determined. The three separate beach areas within Port Angeles Harbor were selected based on accessibility and suitable clam/shellfish habitat. A total of 229 clams were collected with 12 different species observed in the intertidal habitat. Staff biologists from the Washington Departments of Fisheries and Ecology "agreed that Port Angeles Harbor has all the requirements and no natural barriers for

[60] Washington Department of Fisheries. Distribution and Abundance of subtidal hard-Shell clams In Puget Sound, Washington. August 1973. (Clam crop yields obtained from Table1, page 9)
[61] A Report on The Port Angeles Harbor Intertidal Clam and Biological Survey. By Robert A Bishop and Ron Devitt. August 1970

intertidal clam populations."[62] Ecology updated the 1970 Port Angeles intertidal clam survey in 1976 using three beaches sampled per the Bishop and Devitt survey. Clams were present at all sampling locations from the three beaches in Port Angeles Harbor with an average clam density of 9.5 m^2. The three beaches were characterized as to clam habitat ranging from excellent to "little in the way of clam habitat."[63]

An additional study provides some insights into the quality of the subtidal habitat. At the request of Washington State Senator Gordon Sanderson, Ecology initiated studies in 1975 to duplicate the 1970 clam survey and a 1964 salmon bioassay study. The extensive sludge beds created by direct discharges to the Port Angeles Harbor (approximately 60 million gallons per day of pulp mill effluents) from Crown Zellerback, Old Fibreboard pulp mill, and the ITT Rayonier Mill resulted in mortalities to juvenile migrating salmon. The report notes that the toxic conditions in the harbor may continue for many years until the sludge beds are either dredged or reduced in size by decomposition. Although no significant differences in clam survey results were noted between 1970 and 1975, the quantities of sludge were identified at Ediz Hook which had not been observed in 1970. Substantial reductions of mill effluents to the harbor has contributed to the to increased shrimp and crab populations in Port Angeles Harbor. Despite the persistence of hydrogen sulfide problems in Port Angeles Harbor shrimp and crabs continue to repopulate the harbor.[64]

Geographical Information System (GIS) Evaluation: For GIS evaluation and mapping of the Port Angeles Harbor Area please refer to Appendix B. Depending on the area and assumptions made regarding tidal variations the commercially harvestable shellfish beds ranged from less than 100 acres to several thousand acres.

[62] A Report on The Port Angeles Harbor Intertidal Clam and Biological Survey. By Robert A Bishop and Ron Devitt. August 1970. Page 4.
[63] Intertidal Clam Survey of Port Angeles Harbor by Lew Kittle. Washington Department of Ecology. January 1976. Page 37.
[64] Port Angeles Harbor Biological Studies, Spring 1975. D.O.E 76-4. January 1976