DEPARTMENT OF
ECOLOGY
State of Washington

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

Factors to Consider For Inclusion/Exclusion of Salmon for Tribal Fish Consumption

Prepared for the MTCA Science Advisory Board

Drafted for June 2, 2008

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Background

Background Information

The Department of Ecology (Ecology) has been meeting with the Model Toxics Control Act (MTCA) Science Advisory Board (SAB) to discuss a a series of questions on Tribal fish consumption rates. Ecology presented several fish consumption questions to the SAB because the Lower Elwha Klallam Tribe (LEKT) completed a report in October 2007 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 that these exposure values are more appropriate than the MTCA default values because they consider the tribe's treaty reserved rights, customs, and fishing habits.

The Toxics Cleanup Program (TCP) is managing the cleanup of the former Rayonier mill site located in Port Angeles. The primary concern at this site is the potential for human exposure resulting from the release of contaminants into surface water, or sediments and the accumulation of contaminants in fish and shellfish. The TCP site manager will consider the results of the Board's review when establishing cleanup requirements for the site.

At the March 2008 Board meeting, Ecology presented a series of questions to help evaluate the LEKT proposal. Although the SAB reached consensus on most of the major issues, the SAB requested Ecology to further evaluate the issue of inclusion/exclusion of Salmonids from the Tribal fish diet. In particular, the Board questioned whether it was appropriate to exclude salmonids when estimating fish consumption rates for use within the MTCA decision-making framework.

The LEKT's proposal to exclude salmonids from the site or tribal-specific fish consumption rate was based on: (1) the salmonid life-cycle, and (2) the related assumption that salmon acquire most of their body weight and contaminant body burden of persistent and bioaccumulative chemicals in marine environments distant from the contaminated site.

The Board asked Ecology to further evaluate whether an association exists between the contaminant body burden of adult salmon harvested by the LEK Tribal members and the contaminants (dioxins/furans/PCBs) from the Port Angeles site. Ecology believes the factors to consider in responding to this question are:

- Salmonid life-cycle;
- Residency time of the salmonids; and
- Transport and fate of site-specific contaminants (biological and mechanical contaminant transport).

At the conclusion of the March 2008 SAB meeting, the Board requested that Ecology:

- Schedule a conference call with Elaine Faustman, Sandra O'Neill, and Ecology and EPA representatives to discuss some of Ms. O'Neill's research on contaminants in Puget Sound and salmon contaminant body burdens;
- Evaluate criteria for including or excluding salmon from the LEK Tribal fish diet; and
- Prepare conceptual site models to be used when considering the inclusion or exclusion of salmon and fish diet fractions.

Ecology has reevaluated the issue of including / excluding salmon from the LEK Tribal fish diet. In reevaluating this issue Ecology examined or reexamined the following:

- Salmonid life-cycle;
- Residency time of the salmon;
- Abundance of salmon in and around Port Angeles Harbor area;
- Chemical contamination of Puget Sound
- Salmon chemical contaminant body burdens; and
- Transport and fate of site-specific contaminants (biological, mechanical, and atmospheric contaminant transport).

Proposal, Rationale and Summary of Factors for Exclusion/Inclusion of Salmon for Total Tribal Fish Diet

Issue

The Board expressed concerns about Ecology's proposal to exclude salmon when developing site-specific fish consumption rates for individual cleanup sites. Based on the discussions at the Board meeting, the remaining question for Ecology to further evaluate:

- Is it reasonable to conclude that there is an association between the contaminant body burden of adult salmon harvested by members of the LEKT and the contaminants (dioxins/furans) from the former Rayonier mill site?
- If yes, what is a scientifically-plausible range of risk management options for factoring in salmon consumption when developing an overall fish consumption rate that will be used to establish cleanup requirements for individual sites?

Ecology believes the factors to consider in responding to this question are:

- Salmon life-cycle;
- The residency time of the salmon; and
- The transport and fate of site-specific contaminants (biological and mechanical contaminant transport).

Ecology's Proposal and Rationale

Ecology believes it is reasonable to conclude that some non-zero amount of the contaminant body burden in salmonids harvested by members of the LEKT is associated with releases from the former Rayonier mill site. However, Ecology does not believe that current information is sufficient to precisely quantify how local releases from individual sites such as the former Rayonier mill site impact the body burdens of salmonids harvested in local areas. Consequently, Ecology plans to explore several risk management policy options when developing cleanup requirements for the former Rayonier mill site.

- **It is reasonable to conclude that there is an association between the contaminant body burden of adult salmon harvested by members of the LEKT and releases from the former Rayonier mill site in Port Angeles.**
  1. Studies indicated that adult salmonids in Puget Sound have elevated levels of a wide range of persistent and bioaccumulative chemicals.
  2. Studies indicate that the body burden of persistent and bioaccumulative chemicals in adult salmonids results from cumulative exposure in local, regional and ocean areas.

3. Recent studies indicate that local and regional exposures in the Puget Sound and surrounding areas may be more important contributors to overall body burden than indicated by earlier studies.
    - Puget Sound salmon have the highest body burdens of PCBs and dioxins of all the west coast salmonids.
    - Scientific information from O'Neill and West demonstrates that Puget Sound salmonids have the highest PCB body burdens of pacific salmon.
    - The reason the Puget Sound salmon have the highest body burdens is because Puget Sound is contaminated.
    - Puget Sound is heavily contaminated because:
        - Many sources have released toxic chemicals into the water;
        - Hazardous substances such as dioxin and PCBs are highly persistent and bioaccumulate in aquatic foodchains;
        - Several unique geologic features limit the exchange between the Sound and surrounding areas. Consequently, the contaminants in the Sound do not leave the Sound. Highly persistent contaminants are dispersed throughout the Sound.
    - Contaminants such as dioxins and PCBs bioaccumulate in the aquatic food chain. Because the Sound is contaminated, aquatic organisms living in the Sound, including salmon, become contaminated.
4. The former Rayonier mill site is one of many sources that contribute to elevated in the Puget Sound and surrounding areas.
5. It is reasonable to conclude that releases from the former Rayonier mill site contribute to elevated body burdens in adult salmonids harvested in the Port Angeles area.
    - Salmon are located in and around the Port Angeles Harbor area, including Morse Creek, the Lower Elwha River, and the Dungeness River.
    - Out migrating salmon feed on contaminated fish, including herring and smelt, located in the Port Angeles Harbor area. Contaminants from the former Rayonier mill site directly affect forage fish (herring and smelt) living in the vicinity of the site.
    - Returning salmon acclimate in the Port Angeles Harbor before ascending the rivers and streams to spawn.
    - Salmon are directly affected by contaminants found in the fish they consume, becoming part of a contaminated food web.

- **There are several scientifically-plausible risk management options for factoring in salmon consumption when developing an overall fish consumption rate that will be used to establish cleanup requirements for individual sites.**

Ecology does not believe that current information is sufficient to precisely quantify how local releases from individual sites might impact the body burdens of salmonids harvested in local areas. Consequently, Ecology and other agencies are faced with a public policy dilemma on how to take into account salmon consumption when establishing cleanup requirements for individual sites. There are several sources of uncertainty and variability that complicate the interpretation and use of available data to resolve this issue. Ultimately, resolution of this policy issue requires requires a decision on how to balance the possibilities of over-estimating and underestimating localized contributions to the contaminant body burden in adult salmonids. Current and potential options include:

- EPA Decision-Making Framework: Under this option, Ecology would not include salmon when developing site-specific fish consumption rates. This option reflects an implicit decision to avoid overestimating localized contributions to contaminant body burdens in adult salmonids. This policy option is consistent with the EPA health risk assessment prepared for the Lower Duwamish Waterway.
- Oregon Department of Environmental Quality (DEQ): Under this option, Ecology would include salmon when developing site-specific fish consumption rates. This option reflects an implicit decision to avoid underestimating localized contributions to contaminant body burdens in adult salmonids. This policy option is consistent with the emerging approach being developed by the Oregon DEQ.
- Other Policy Options: Ecology plans to explore other options that reflect different ways of balancing the potential for overestimating or underestimating localized contributions to contaminant body burdens in adult salmonids. This will be done through the normal cleanup decision-making process. When evaluating those options, Ecology believes it will be important to consider the following:
    - Available information on the relationship between local sources and contaminant body burden harvested in those areas;
    - The public policy choices on level of protection that are reflected in the MTCA statute and regulations;
    - Other regulatory requirements and the cultural importance of salmon in the Puget Sound region;
    - Practical implications including the costs and benefits associated with overestimating or underestimating localized contributions to contaminant body burdens in adult salmonids;

- Site-specific procedures being used to estimate contaminant movement in the environment and/or relative source contributions. With respect to the latter point, the Oregon DEQ appears to consider relative source contribution as a decision that is separate from the selection of a fish consumption rate.
- Site-specific features that would increase or decrease the potential for local source contributions to contaminant body burdens in adult salmonids.

Rationale: In addition to the salmonid life-cycle, Ecology has evaluated a variety of other factors that contribute to the contaminant body burden of salmon. These factors may influence the association of site-specific contaminants acquired by and contributing to the salmon contaminant body burden. The chemical contaminants located in Puget Sound are at much greater concentrations than found at other locations along the Pacific coast.[1] Persistent bioaccumulative toxics (PBTs)[2], polycyclic aromatic hydrocarbons (PAHs), selected pesticides, and metals have been identified in Pacific Coastal areas, estuaries, and bay areas from Alaska, British Columbia, Washington, Oregon, and California. The salmon chemical contaminant body burdens are a reflection of and indistinguishable from the contaminants in the Puget Sound and other Pacific coastal areas. However, the high salmon chemical contaminant body burdens for resident salmon is a direct reflection of the higher levels of contamination found throughout the Puget Sound. The site incrementally contributes to Puget Sound contamination (at unknown and unquantifiable levels) and Puget Sound contaminant levels are responsible for the extremely high contaminant concentrations found in Puget Sound salmon (and extremely high contaminant body burdens). Although it is unlikely that salmon would acquire 100% of their contaminant body burden from site-specific contaminants it is equally unlikely that they would acquire none (0%) of the site-specific contaminants. Ecology considered different options from the EPA-Region 10 Framework for rates adjusted for fish/shellfish harvests from Puget Sound only and harvests from Puget Sound and other locations. Ecology believes the rates that would apply for the LEK Tribal consumption of salmon would best be represented in consideration of harvests from Puget Sound and other locations. Furthermore, Ecology believes that is not possible to precisely associate or attribute Salmon body burdens to site-specific contaminants because:

- The cyclical nature and seasonal variations of salmon migrations and their complex life cycle affords small, but not zero, opportunity to assume site-specific contaminant body burden.
- Biological and mechanical transport of contaminants contributes to the dispersion of contaminants throughout Puget Sound and salmon assume chemical contaminant body burden that reflects the contamination of Puget Sound.
- Those salmon that spend longer periods of time in Puget Sound during their migration or are resident populations in Puget Sound have significantly higher contaminant body burdens than salmon in other Pacific coastal areas.

[1] 2007 Puget Sound Update. Ninth Report of the Puget Sound Assessment and Monitoring Program, Puget Sound Action Team, February 2007 (Publication No.l PSAT 07-02).
[2] Also referred to as Persistent Organic Pollutants (POPs)

- Similar chemical contaminants are found throughout the Puget Sound, other Pacific coastal areas, and at waste sites, making it difficult to attribute the salmon contaminant body burden to a specific location.

Factors to Consider for Inclusion/Exclusion of Salmon

Ecology considered the following factors when evaluating the inclusion/exclusion of salmon for a total Tribal fish diet.

Salmonid Life-Cycle: Ecology reviewed during the March 11, 2008 SAB meeting the Salmon life-cycle with a focus on non-resident salmon acquiring a significant body mass (> 90%) and contaminant body burden in the ocean. Ecology has provided additional information regarding the life-cycle of different salmonids and conceptual models to better represent the complexity of the cycle of life, death, and renewal of migrating salmon. (Appendix A, Table A; Conceptual Models on pages 45 & 46)

Residency of Salmon: Ecology evaluated a variety of information related to the residence time of salmon in Puget Sound and different river systems of Puget Sound. Several factors have a bearing on the salmon residence time:

- Biological variability exists across and within salmon species regarding migratory habits and behavior patterns.
- The location of rivers or streams within Puget Sound. Locations deep within the Sound lengthen the time the salmon reside in the Sound.
- Selected salmonid species do not die after spawning, and may spawn more than once migrating to and from the same river/stream in the Puget Sound;
- With considerable species variability, selected salmonid populations do not migrate to the open ocean and instead remain in Puget Sound.

Different residency times of salmon within Puget Sound will result in more or less exposure to chemicals that contaminate the Sound and, therefore, contribute to the contaminant body burden of salmon. Some salmon (resident "blackmouth" or Chinook salmon populations) may spend significant portions of their lives in Puget Sound. (Appendix A, Table B)

Abundance of Salmon: Ecology obtained salmon abundance estimates for the Port Angeles Harbor areas using Washington Department of Fish and Wildlife Salmon Sport Catch and Salmon Stock Inventory information. Salmon abundance estimates are complicated by the cyclical nature of the salmonid life-cycle and the considerable biological variability within and across different salmon species. (Appendix B, Tables C and D; Appendix C, Table E)

Chemical Contamination of Puget Sound: Ecology presented at the March 2008 SAB meeting information related to the chemical contamination of the Puget Sound. Since that presentation Ecology has compiled additional information regarding chemical

contaminants within the Puget Sound. Besides legacy contaminants, chemical contamination of Puget Sound continues (hazardous waste site, stormwater runoff, wastewater discharges, nonpoint sources) to harm or threaten the ecosystems and health of Puget Sound.[3] (Appendix D, Table E)

Salmon chemical contaminant body burdens: Salmon contaminant body burdens are a direct reflection of the environmental contaminant levels found throughout the Puget Sound. These chemical contaminants are found throughout the entire pelagic food web in Puget Sound.[4]

The transport and fate of site-specific contaminants: Site-specific chemical contaminants may be relocated throughout the Puget Sound by mechanical or biological transport mechanisms. Based on their life-cycle, salmon play a unique role in the biological transport of contaminants in and through Puget Sound and contribute to the chemical contamination of the food web. (Conceptual Models Pages 42 & 43)

[3] 2007 Puget Sound Update. Ninth Report of the Puget Sound Assessment and Monitoring Program, Puget Sound Action Team, February 2007 (Publication No.l PSAT 07-02).
[4] Ibid.

LOWER ELWHA KLALLAM TRIBAL FISH CONSUMPTION

Brief Reiteration of Lower Elwha Klallam Tribal Fish Consumption

The Lower Elwha Klallam Tribe proposed to Ecology a fish consumption rate of 583 grams/day based on the application of the EPA-Region 10 Framework and similarities between the Suquamish and LEK Tribal fish consumption habits and patterns. The LEK Tribal proposal did not include salmon in their Tribal fish consumption rate because "The Tribe does not believe that salmon spend a sufficient amount of time within the area potentially impacted by releases from the site to provide useful information about site-related risks."[5] Using the Suquamish fish consumption survey dataset, the LEK Tribe reported the following rates, grams/day:

Fish / Shellfish Consumed	Consumption Rate, grams/day
Shell fish	498.4
Salmon	183.5
Pelagic Fish	56.0
Bottom Fish	29.1
Total LEK Tribal Fish Ingestion Rate	766.8
Proposed LEK Tribal Fish Ingestion Rate	583 (766.8 – 183.5)

At the March 2008 SAB meeting, the SAB agreed with Ecology that the Suquamish survey provided a sound basis for preparing the LEK Tribal fish consumption estimates. However, the SAB directed Ecology to reevaluate the exclusion of salmon from the Tribal fish consumption rate.

Ecology and the SAB considered several factors in considering the Suquamish consumption survey data to be used to estimate the fish/shellfish consumption of the LEK Tribal members:[6]

- Study design;
- Similarities in dietary habits;
- Similarities in harvesting techniques;
- Similarities in watershed characteristics;
- Amount and quality of shellfish habitat; and
- Harvesting potential.

[5] Lower Elwha Klallam Tribe Fish Consumption and the EPA Region 10 Framework, page 20.
[6] Additional details are provided in Ecology's March 2008, Site-Specific Proposal for Modifying the Default MTCA Fish Consumption Exposure Parameters, Questions and Background Information.

The EPA-Region 10 Framework provides fish consumption rates for fish/shellfish species groups, in grams per day, using the Suquamish Tribe survey data as a surrogate for another Tribe. The table below includes the Suquamish Tribe data from the Framework, as used by the Lower Elwha Tribe to estimate its Tribal fish and shellfish consumption rate.

Suquamish Tribal Fish Consumption Rates Used by the Lower Elwha Tribe		
Species	**Grams per Day (g/d)**	**Percent of diet**
Salmon	183.5	23.9
Pelagic Fish	56.0	7.3
Bottom Fish	29.1	3.8
Shell Fish	498.4	65
Total Ingestion Rate	766.8	100
EPA- Region 10 Framework, 2007. U.S. Environmental Protection Agency. 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. Table B-2		

The fish and shellfish consumption rate of 766.8 g/day represents the 95th percentile Tribal consumption rates after adjusting the total consumption rate of 796 g/day to include only fish and shellfish harvested from Puget Sound that are affected from releases of site-related contaminants and does not include fish or shellfish from non-Puget Sound sources. (The total fish and shellfish consumption rate from all sources is 796 g/day.)

Factors to Consider for Inclusion/Exclusion of Salmon

Abundance

Interpreting salmon abundance records and historical records on salmon counts is complicated. Salmon are difficult to count because salmon populations are variable due to continual changes in freshwater and marine environments or to the cyclic nature of salmonid behaviors. Very long time-series records (a decade or longer) of catch or escapement are required for detecting large changes (50% or greater) in population abundance. Also, long-term changes in abundance may not occur as a continuous linear series of events and, therefore, are not accounted for with standard statistical evaluations. Therefore, records of abundance for short periods of time may suggest an increase or decrease in salmonid populations when, in fact, long-term trends are the reverse. The inherent biological variability of salmonids confers a level of uncertainty about the abundance counts and records associated with the different salmonid species.[7]

Puget Sound / Salmon: A Resource In Decline

The Puget Sound Basin includes the river systems in Puget Sound, Hood Canal, and the Strait of Juan de Fuca. As Tables C and D (which provide the status of Washington and Puget Sound Salmon Stocks) below suggest, there is a wide range of salmon population conditions in the Puget Sound ranging from critical to healthy.[8] Generally, for the Puget Sound, the Washington Department of Fisheries, now referred to as Washington Department of Fish and Wildlife, in 1993 classified about 44% of the salmon stocks as healthy, about 21% as depressed, about 5% as critical, and about 30% unknown. Puget Sound is considered to have more depressed salmon stocks compared to the Washington coastal regions but fewer depressed stocks than the Columbia River Basin.[9] Many wild salmon, steelhead and bull trout stocks have been listed under the Endangered Species Act by the National Marine Fisheries Services or the U.S. Fish and Wildlife Service. As of 1998, less than 50% of Washington's salmon stocks are considered to be healthy.[10]

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[7] Upstream. Salmon and Society in the Pacific Northwest. National Research Council, National Academy of Sciences. Pages 77-79. 1996

[8] Stock is defined by Governor's Salmon Recovery Office (http://www.governor.wa.gov/gsr0/glossary/default.asp) as "fish spawning in a particular lake or stream(s) at a particular season which to a substantial degree do not interbreed with any group spawning in a different place at the same time, or in the same place at a different time." The National Research Council, Upstream. Salmon and Society In The Pacific Northwest, pages 12 to 13, notes that salmon stocks refers to a geographic aggregate of salmon populations that includes many local breeding populations of varied size and productivity.

[9] Upstream. Salmon and Society in the Pacific Northwest. National Research Council, National Academy of Sciences. pages 86 to 90, 1996.

[10] Summary Statewide Strategy to Recovery Salmon. Extinction Is Not An Option. Governor's Salmon Recovery Office. September 1999, Pages II.9 to II.10

The tables below summarize the status of salmon stocks for Puget Sound and Pacific Coastal areas and percentages associated with the different regional salmon stocks.

Status of Washington Salmon Stocks								
Status[11]	**Puget Sound**		**Washington Coasts**		**Columbia River**		**All of Washington**	
	Number of Stocks	**%**	**Number of Stocks**	**%**	**Number of Stocks**	**%**	**Number of Stocks**	**%**
Healthy	93	44.7	65	56.5	29	26.1	187	43.1
Depressed	44	21.2	8	7.0	70	63.1	122	28.1
Critical	11	5.3	0	0	1	0.9	12	2.8
Unknown	60	28.8	42	36.5	11	9.9	113	26.0
Total	208	100	115	100	111	100	434	100
Upstream. Salmon and Society in the Pacific Northwest. National Research Council, National Academy of Sciences. 1996 Adapted from Table 4-4								

Status of Puget Sound Salmon Stock							
Status	**Chinook**	**Chum**	**Coho**	**Pink**	**Sockeye**	**Steelhead**	**Total**
Healthy	10	38	20	9	0	16	93
Depressed	8	1	16	2	3	14	44
Critical	4	2	1	2	1	1	11
Unknown	7	13	9	2	0	29	60
Upstream. Salmon and Society in the Pacific Northwest. National Research Council, National Academy of Sciences. 1996 Adapted from Table 4-3							

When the geographic scale changes from the Puget Sound to broader geographic areas of Pacific salmon habitat for the Northwest, the picture of abundance changes but still reflects declining populations. There is a drop in Pacific adult salmon returning to rivers

[11] Status descriptors defined by Washington Department of Fisheries (status criteria descriptors may change depending on regulatory agency or publication); as used by National Research Council in Upstream. Salmon and Society in the Pacific Northwest follows:
Healthy: Stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.
Depressed: Stock of fish whose productions is below expected levels based on available habitat and natural variations in survival rates but above the level where permanent damage to the stock is likely.
Critical: A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.
Unknown: There is insufficient information to rate stock status.

to spawn. Historically, 56 to 65% of the Pacific salmon returned to Alaska's streams, 19 to 26% returned to streams in British Columbia, and 15 to 16% returned to streams in Oregon, Washington, Idaho, and California. Currently in the Pacific Northwest only one percent are returning.[12]

WDFW Hatchery Release Estimates to the Puget Sound: The Washington Department of Fish and Wildlife provided Ecology with hatchery releases of yearling Chinook salmon into the Puget Sound from 1993 to 2005. Chinook salmon released as yearlings tend to remain in the Sound for their entire life-cycle. Although the Chinook salmon release estimates may be subject to revision, the queried data by WDFW provide the most current estimates for Chinook salmon releases in the Puget Sound area and from the Dungeness and Elwha river hatcheries. Total hatchery releases of yearling Chinook salmon into the Puget Sound (the Straits and North and South Puget Sound) ranged from a low of 1,835,320 in 2005 to a high of 3, 367,106 in 1994.[13]

Salmon Abundance Estimates For Port Angeles Area

Port Angeles Harbor Area: Specific abundance estimates for salmon are limited to 2001 - 2002 and 2002 - 2003 Washington State Sport Catch Report, Washington State Department of Fish and Wildlife, and a technical bulletin from the Washington Pollution Control Commission. The most precise salmon abundance estimates for the Elwha and Dungeness Rivers, Morse Creek, and the Port Angeles areas are to use the Washington State sport catch estimates, noted in Tables C and D, Appendix B.

The winter Chinook sport catch is a reasonable indicator of the resident (blackmouth) salmon located in the Port Angeles area. [Personal communication. S. Duncan (Ridolfi, Fish Biologist) & C.R. McCormack (Ecology) e-mail correspondence, 4/24/08] The 2001-2002 winter (January through April) sport salmon catch for East Juan de Fuca (including the Port Angeles Harbor area) was 423 Chinook out of a total of 761 Chinook caught in the East Juan de Fuca. For the January through April, 2001 to 2002 season, the resident blackmouth salmon represented over 50% of the Chinook salmon sport catch. The 2002 to 2003 winter (January through April) sport Chinook salmon catch was 239 out of a total of 313 Chinook salmon caught in the East Juan de Fuca. For the January through April, 2002 to 2003 season, the resident blackmouth salmon represented 75% of the Chinook salmon sport catch. The 2001-2002 total salmon sport catch for East Juan de Fuca (Port Angeles) area was 12, 093 fish. The 2002-2003 total salmon sport catch for the same area declined to 1,430 salmon with resident blackmouth Chinook salmon accounting for about 15% of the total 2002 -2003 sport catch. [Appendix B, tables C, C-2 and D, D-2]

[12] Salmon Without Rivers, A History of the Pacific Salmon Crisis by Jim Lichatowich, Island Press, 1999. Pages 206 to 207.
[13] Washington Department of Fish and Wildlife Hatchery Releases of Yearling Chinook into Puget Sound Brood Years 1993-2005, WDFW spreadsheet and raw data query provided to S. Duncan by Jeffrey Haymes, WDFW in e-mail correspondence dated 4/22/08

Dungeness and Elwha Rivers, Morse Creek: The total 2001-2001 freshwater salmon (coho and steelhead) sport catch for the Dungeness and Elwha Rivers and Morse Creek was 7,854 fish. The total 2002-2003 freshwater salmon (coho and steelhead) catch declined to 2,527 fish caught for the Dungeness and Elwha Rivers and Morse Creek. [Appendix B, tables C, C-2 and D, D-2]

WDFW Designated Status: The Washington Department of Fish and Wildlife as of 2002 designated the Dungeness and Elwha Rivers and Morse Creek salmon populations as critical, depressed, or unknown. The Dungeness Chinook and pink salmon are designated as critical while Elwha River Chinook and Morse Creek coho are designated as depressed. Selected seasonal runs of chum, coho, and steelhead are designated as unknown. Generally, chronically low escapements, low redd counts, or no abundance trend data available attributed to the WDFW designations. There are large variations in salmon escapement estimates with a low of 84 Morse Creek steelhead in 2003 and a high escapement estimate of over 69, 000 Upper Dungeness River pink salmon in 2001.[14]
[Appendix C, Tables E through E-3]

WDFW Hatchery Release Estimates to Dungeness/Elwha Rivers: The Washington Department of Fish and Wildlife provided yearling Chinook salmon release estimates for the Dungeness River and Elwha River hatcheries from 1993 to 2005. Between 2001 and 2005 the yearling Chinook releases ranged from a low of 37, 000 in 2004 to a high of 107, 450 in 2001 from the Dungeness River hatchery. Between 2001 and 2005 the yearling Chinook releases ranged from a low of 1, 500 in 2001 to a high of 318, 150 in 2003 from the Elwha River hatchery.[15]

Port Angeles Harbor Area Salmon Habitat: The Watershed Resource Inventory Area (WRIA) 18 and Strait of Juan de Fuca have many physical features critical to marine and anadromous species.[16] An abundant food supply, wide salinity gradients, and diverse habitats make the Port Angeles areas valuable to anadromous fish for rearing, feeding, and acclimatization during transition between freshwater and marine habitats. Health nearshore vegetation plays many critical functions in this ecosystem. The nearshore vegetation provides shelter to many species, serves as host to a wide range of invertebrate and other marine organisms, and dampens tidal and current energy in the area. The WRIA 18 Watershed Plan noted the NOPLE-North Olympic Peninsula Lead Entity-

[14] Washington Governor's Salmon Recovery Office (http://www.governor.wa.gov/gsr0/glossary/default.asp) defines Escapement as "Those fish that have survived all fisheries and will make up a spawning population." This the portion of a salmon run that is not harvested and survives to reach the spawning grounds.
[15] Washington Department of Fish and Wildlife Hatchery Releases of Yearling Chinook into Puget Sound Brood Years 1993-2005, WDFW spreadsheet and raw data query provided to S. Duncan by Jeffrey Haymes, WDFW in e-mail correspondence dated 4/22/08
[16] WRIA 18 Watershed Plan, Strait of Juan de Fuca Marine Nearshore Environment, Section 2.11, pages 2.11-1 to 2.11-11.
(http://www.clallam.net/environment/assets/applets/W18d1_2.11-Strait-of-JDF.pdf)

Salmon Habitat Recovery Project Strategy 2001 observation that the Port Angele Area nearshore has[17]:

> "*been termed the life support system for juvenile Pacific salmon feeding, rearing, and migrating. Juvenile chum (Oncorhynchus keta) and chinook (O. tshawytscha) salmon in particular are recognized as being fundamentally dependent on nearshore ecosystems. This fact is of heightened significance given that ESA-listed Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon occur throughout many of our nearshore ecosystems. Chinook and chum stocks, in the western Strait of Juan de Fuca, while not currently listed by ESA, are considered to be at critical or depressed levels. However, the importance of the nearshore is not restricted to chum and chinook salmon alone. All salmon species must migrate through the nearshore, both as juveniles heading to sea and as adults returning to spawn. Hence, the nearshore within the salmon recovery jurisdiction of HCCC and NOPLE supports multiple species and stocks of Pacific salmon that originate not only from watersheds within the Hood Canal-Straits-Pacific single geographic unit, but also from outside this area. We also know that the nearshore within this geographic unit supports the life history of forage (bait) fish species such as surf smelt (Hypomesus pretiosus), sand lance (Ammodytes hexapterus), and herring (Clupea harengus) that are critical prey for Pacific salmon. In addition, numerous other marine fish species are presently under consideration for EAS listing.*
>
> *Historically, the paradigm was that juvenile salmon could be found in nearshore environments during what has commonly been called the "fish window" from approximately April through September. Recent evidence from nearshore beach seining surveys suggests, however, that juvenile salmon can be found within the matrix of nearshore habitats (e.g., eelgrass beds, mudflats, marshes, and channels) year-round. Thus, the nearshore is increasingly recognized as a critical, year-round component of Pacific salmon life histories. Furthermore, restoration work in a specific watershed may be wasted if the estuary for that watershed is disconnected or dysfunctional."*

The forage fish located in Port Angeles Harbor area (Herring, Sand Lance, Smelt) are critical food fish for salmonids, and dictate, in part, their migration and survival. Also, juvenile pink, chum, coho, and Chinook depend on nearshore healthy wetland areas associated with Port Angeles (eelgrass and kelp beds) as they transition from fresh water to marine water environment during their migration.

Brief Historical Context

Before dams blocked the river, the 320 square-mile Elwha River system supported sizable runs of every species of Pacific salmon found in North American Waters. The most notable was the 8,000 Chinook that migrated up the Elwha River. These Chinook weighed an average of 75 to 100 pounds.[18] Pink salmon were the most numerous salmon species migrating up the Elwha River with numbers estimated as 275, 000 fish. With construction of the Elwha dam the number of salmonids was reduced by about 75%. Spring Chinook and sockeye were completely lost while coho, pink, and chum salmon

[17] WRIA 18 Watershed Plan, Strait of Juan de Fuca Marine Nearshore Environment, pages 2.11-6 to 2.11-7.
[18] Salmon Without Rivers, A Hsitory of the Pacific Salmon Crisis by Jim Lichatowich

were greatly reduced. Fall Chinook continued to spawn in the lower reaches of the Elwha River.
The Dungeness River was equally impressive with estimated historical salmonid migrations of 400, 000 salmon.[19]

[19] Mountains In The Clouds, A Search For The Wild Salmon by Bruce Brown. University of Washington Press Second Printing 2000

Chemical Contaminants - Puget Sound

Chemical Contamination of Puget Sound

Ecology noted at the March 2008 SAB meeting, that Persistent Bioaccumulative Toxics (PBTs) pose a significant threat to the Puget Sound ecosystem. In this report Ecology is providing the SAB with added information about the presence, transport, and fate of chemical contaminants in and throughout Puget Sound. These chemicals may be factors to consider when evaluating the chemical contaminant body burdens of salmon acquired on a site-specific basis.

Chemical Contaminants: Chemical contamination of Puget Sound has occurred over a long period of time (150 years by some estimates) with various chemicals posing risks to the environment, aquatic life, and humans. Some of the chemical contaminants of concern for Puget Sound are:[20]

Metals (Inorganic Contaminants)	Organic Contaminants
▪ Lead ▪ Cadmium ▪ Tributyl tins ▪ Copper ▪ Mercury ▪ Arsenic ▪ Others	▪ Polychlorinated biphenyls (PCBs) ▪ Polycyclic aromatic hydrocarbons (PAHs) ▪ Dioxins and Furans ▪ Selected pesticides ▪ Phthalate esters ▪ Polybrominated diphenyl ethers (PBDEs) ▪ Hormone disrupting chemicals (Bisphenol A) ▪ Petroleum & Petroleum by-products ▪ Pharmaceuticals

Possible sources of chemical contaminants in the Puget Sound include:[21]

- Land Surface Runoff: Land surface runoff includes non-point overland flow, groundwater discharges to surface water that flow to the Puget Sound, and stormwater runoff. These are major sources of pesticides, arsenic, PBDEs, and petroleum based products reaching Puget Sound.
- Atmospheric Deposition: Atmospheric deposition directly to the marine waters and sediments of Puget Sound is an important source of contaminants for PAHs, PBDEs, and PCBs. This source of contaminants to the Puget Sound is greater than or at least comparable to the loading from surface runoff.

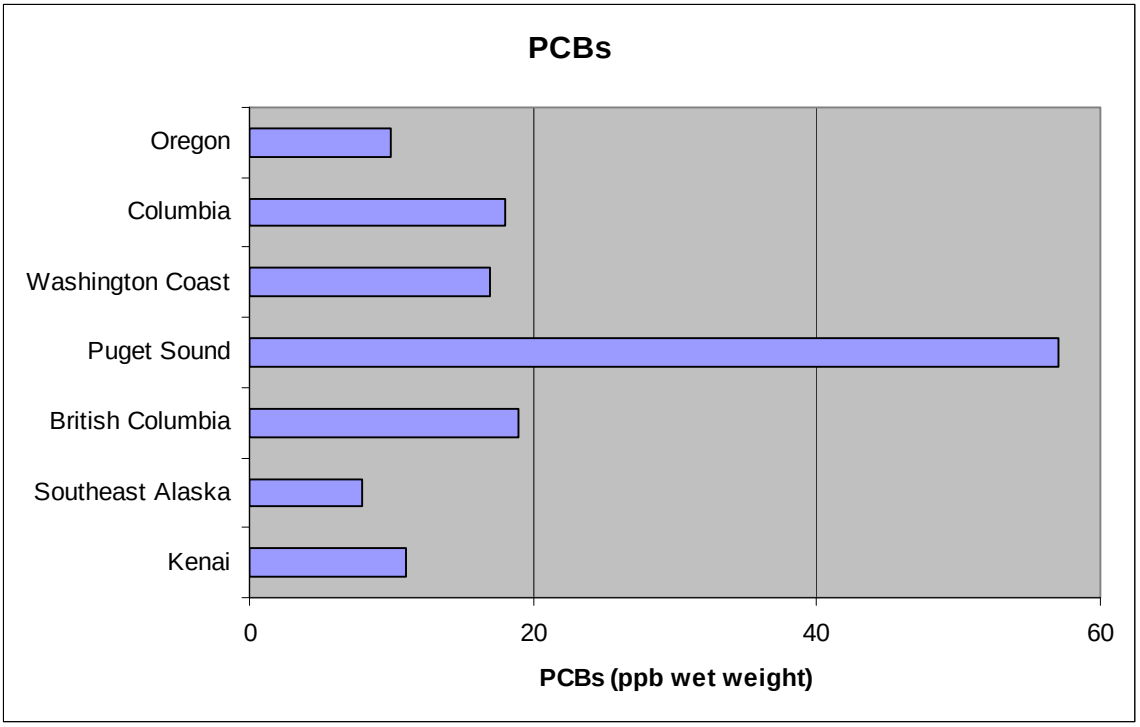
[20] 2007 Puget Sound Update. Ninth Report of the Puget Sound Assessment and Monitoring Program, Puget Sound Action Team, February 2007 (Publication No.l PSAT 07-02); Table 4-1.

[21] Control of Toxic Chemicals In Puget Sound, Phase 1: Initial Estimate of Loading. October 2007 Puget Sound Partnership (Publication number 07-10-079).

- Industrial and Municipal Wastewater: Industrial and municipal wastewater discharges contribute to the chemical contaminants in Puget Sound. Information suggests that NPDES authorized discharges are sources of toxic chemical contaminants to the Puget Sound (LaLiberte and Ewing, April 2006.)
- Combined Sewer Overflows: Episodic discharge of untreated and/or partially treated wastewaters from Combined Sewer Overflows is another source contributing to the contamination of the Puget Sound.
- Direct Spills: Direct spills of oil and petroleum products contribute to contamination of Puget Sound.

The Puget Sound Partnership, Phase 1: Initial Estimate of Loadings concluded that runoff from land surface and deposition from the air to marine waters have resulted in large amounts of contamination in Puget Sound. (See Table F, Appendix D for summary of chemical loadings into Puget Sound) The atmospheric loading rates for PCBs, dioxin, DDT, and phthalate represented about 4 to 7 percent of the land runoff pathway. Estimated air-to-water transfer rates of total PAHs was similar in magnitude to the corresponding median land runoff rates. However, the estimated atmospheric loading rate of PBDEs to the Puget Sound was ten times greater than the total land runoff loading.

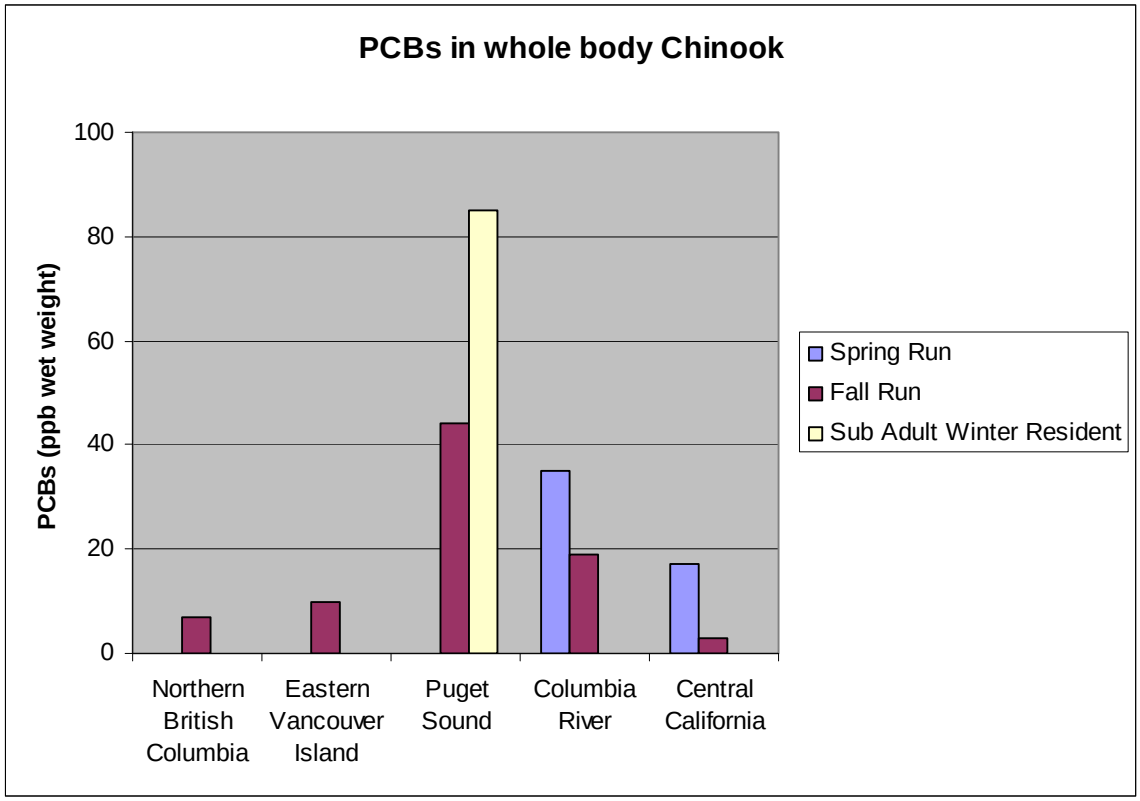
Polychlorinated biphenyls (PCBs) are persistent, bioaccumulative, and toxic chemicals found throughout Puget Sound. The bar chart below compares PCBs sampled in Chinook salmon filets from Puget Sound and Chinook salmon filets sampled for PCBs from other Pacific West Coast areas. Puget Sound Chinook salmon fillets are almost three times more contaminated than fillets of Chinook salmon from other Pacific West Coast areas.[22]

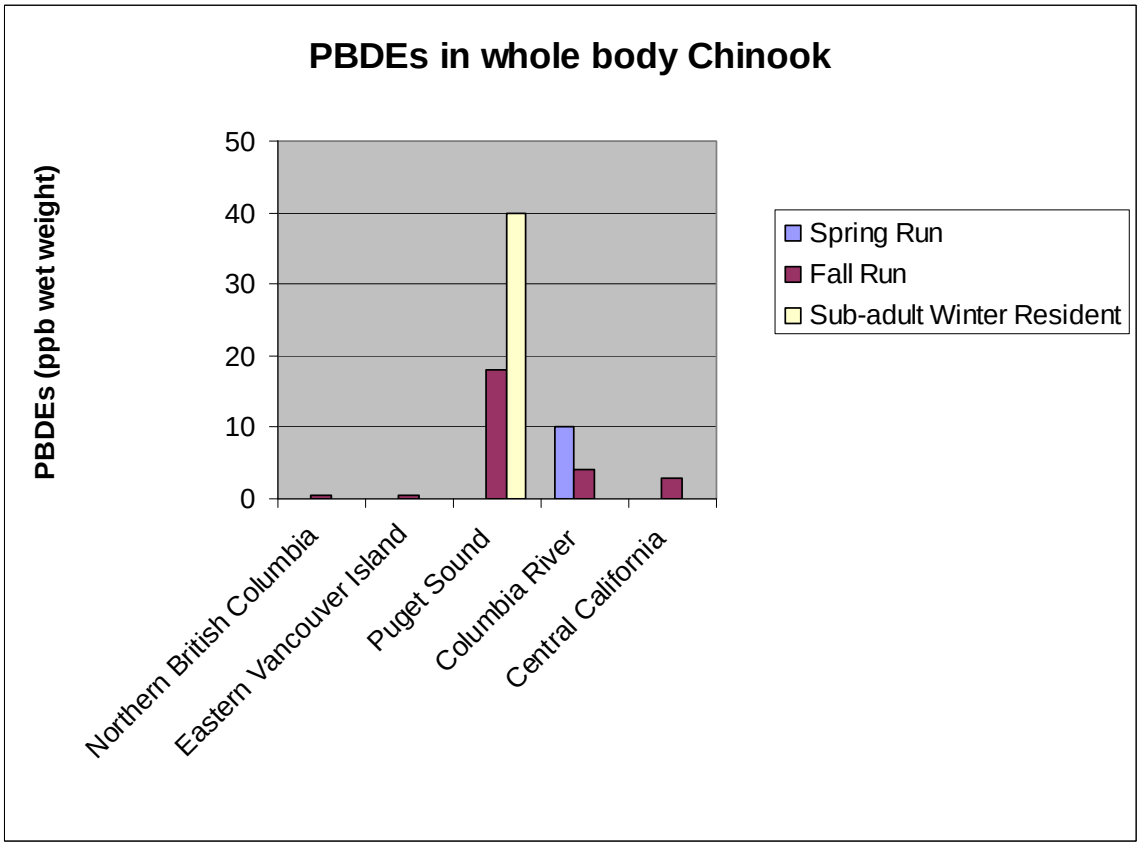


The bar charts below, page 23, illustrate differences in contaminant body burdens for salmon from Pacific West Coastal areas. The bar charts illustrate that Puget Sound resident Chinook salmon had the highest contaminant body burden of PCBs and PBDEs compared to other Pacific West Coastal areas. PCBs and polybrominated diphenyl ethers (PBDEs) in whole body samples of individual summer/fall Chinook salmon from Puget Sound were 2 to 6 times more contaminated with PCBs and 5 to 17 times more contaminated with PBDEs than other populations of Chinook salmon from the Pacific West Coastal areas.[23]

[22] 2007 Puget Sound Update. Ninth Report of the Puget Sound Assessment and Monitoring Program, Puget Sound Action Team, February 2007 (Publication No.l PSAT 07-02); adapted from Figure 4-18, page 156

[23] Ibid, page 157, figure 4-19; and O'Neill et. al., 2006. O'Neill, S., Ylitalo, G., West, J., Bolton, J., Sloan, C., and Krahn, M. 2006. "Regional patterns of persistent organic pollutants in five Pacific salmon species (Oncorhynchus spp) and their contributions to contaminant levels in northern and southern resident killer whales (Orcinus orca)." 2006 Southern Resident Killer Whale Symposium. NOAA Fisheries Service Northwest Regional Office, Seattle. Extended Abstract


PCBs in whole body Chinook
PCBs (ppb wet weight)
100
80
60
40
20
0
Northern British Columbia
Eastern Vancouver Island
Puget Sound
Columbia River
Central California
Spring Run
Fall Run
Sub Adult Winter Resident


PBDEs in whole body Chinook
PBDEs (ppb wet weight)
50
40
30
20
10
0
Northern British Columbia
Eastern Vancouver Island
Puget Sound
Columbia River
Central California
Spring Run
Fall Run
Sub-adult Winter Resident

Chemical Contaminant Transport In and Around Puget Sound

Unique Quality of Puget Sound: The Puget Sound has unique qualities among North American estuaries. These unique features confer a greater residence time for contaminants and traps them within the Sound, thereby increasing the potential for exposure.

Hydrodynamic Conditions of the Puget Sound: Unlike other North American estuaries, the flushing of chemical contaminants in the sound is minimized by shallow sills, such as Admiralty Inlet. The circular pattern of currents combined with reduced current velocity at the sills results in the contaminants being circulated for longer periods of time.

Contaminant Residence Times: The residence times for contaminants in Puget sound are extended because the circulation conditions of the Sound, including the shallow sills associated with different inlets, freshwater/marine water gradients, and highly variable flow velocities in different areas of the Sound, all facilitate the trapping and mixing of toxic chemical contaminants in the Sound. Chemical contaminants spend longer in the Sound increasing exposures to aquatic organisms, humans, and the environment.

Mechanical Transport: Plastic debris may be transporting hydrophobic contaminants to sediments and sediment-dwelling (benthic infaunal communities) organisms. [24] Representative plastics (polyethylene, polypropylene, and PVC) were used to evaluate the preferential sorption of PAHs in plastics compared sediments in marine environments. The addition of small amounts of PAH contaminated plastics to sediments significantly increased the bioaccumulation of PAHs (phenanthrene) sediment dwelling organisms. In addition, sorption of hydrophobic chemicals to plastics facilitates the transport of the contaminants to other areas in marine environments and to marine aquatic life.

Contaminant Dispersal, Resuspension, and Transport: Chemical contaminants can be transported and dispersed throughout the Puget Sound by a variety of processes. Chemical contaminants within different estuaries and marine water bodies can be transported and dispersed through different watersheds, bay and harbor areas, and inlets. The implications for the transport and dispersion of chemical contaminants throughout these water bodies is an increased potential for exposure to these contaminants by aquatic life and humans, regardless of where the contaminants originated from.

Contaminant Dispersal: Sediment reservoirs of historically discharged contaminants (metals, PAHs, PCBs, selected pesticides) may be disturbed and distributed by

[24] **Teuten et. al., 2007.** Emma L. Teuten, Steven J. Rowland, Tamara S. Galloway, and Richard C. Thomposon. Potential for Plastics to Transport Hydrophobic Contaminants. Environmental Science and Technology, 2007, 41 (22) pages 7759-7764.

dioadvection, biodiffusion, and physical processes. The sediment-bound contaminants may be moved from the subsurface to upper sediments where the contamintants may undergo further resuspension and redistribution. Benthic infaunal communities (annelids, mollusks, crustaceans), storm events, and tidal influences contribute to the redistribution and dispersion of contaminated sediments. [25]

Contaminant Resuspension and Transport: Historically deposited chemical contaminants buried in sediments may be resuspended in the water column and then transported and redeposited into coastal areas distant from the bay areas where the contaminants originated. Hydrodynamic processes (diffusion, tidal dispersion and transport of chemicals, sediment-water interactions, and adsorption-desorption of chemicals to and from suspended particulate matter) have been modeled to evaluate the transport and fate of chemical contaminants from tidal estuaries and bay areas to other proximate marine environments. Empirical data supports modeled outputs related to the remobilization of sediment contaminants, resuspension of the contaminants into the water column, and the subsequent redeposition of the contaminants to distant areas.[26]

Biological Transport: As previously noted by Ecology at the March 2008 SAB meeting and indicated by the conceptual models (Pages 45 and 46), Pacific Salmon are biotransporters of pollutants to and from the Pacific Ocean and their freshwater spawning sites.

All seven Pacific salmon species are biotranporters of pollutants to and from the Pacific Ocean and their spawning sites in freshwater.[27] 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

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[25] (1) Stull et. al., 1996. Janet K. Stull, Donald J.P. Swift, Alan W. Niedoroda. Contaminant dispersal on the Palos Verdes continental margin: I. Sediments and biota near a major California wastewater discharge. The Science of the Total Environment 179 (1996) pages 73-90. (2) Swift et. al., 1996. Donald J.P. Swift, Janet K. Stull, Alan W. Niedoroda, Christopher W. Reed, George T.F. Wong. Contaminant dispersal on the Palos Verdes continental margin: II. Estimates of the biodiffusion coefficient, D_B, from composition of the benthic infaunal community. The Science of the Total Environment 179 (1996) pages 91-107. (3) Niedoroda et. al., 1996. Alan W. Niedoroda, Donald J.P. Swift, Christopher W. Reed, Janet K. Stull. Contaminant dispersal on the Palos Verdes continental margin: III. Processes controlling transport, accumulation and re-emergence of DDT-contaminated sediment particles. The Science of the Total Environment 179 (1996) pages 109-133.

[26] (1) Zeng and Venkatesan, 1999. Eddy Y. Zeng and M. I. Venkatesan. Dispersion of sediment DDTs in the Coastal Ocean off Southern California. The Science of the Total Environment, Volume 229, Issue 3, 19 May 1999, pages 195 - 208. (2). **Zeng et. al., 2005**. Eddy Y. Zeng, David Tsukada, Dario W. Diehl, Jian Peng, Kenneth Schiff, James A Noblet, and Keith A. Maruya. Distribution and Mass Invenotry of Total Dichlorodiphenyldicloroethylene in the Water Column of the Southern California Bight. Environmental Science & Technology, 2005, Volumen 39, No. 21, pages 8170-8176.

[27] 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.

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.

Chemical contaminants are exhibited through the salmon lifecycle which contributes to the transport and distribution of contaminants in Puget Sound:

- Depletion of lipid reserves in salmon during upstream migration can cause significant biomagnifications of contaminant body burdens in eggs and gonadal tissues;[28]
- Post spawning decay of Chinook salmon carcasses are sources of persistent organic pollutants (POPs-PCBs & DDTs) where body burden contaminants are released into river sediments and, furthermore, are released into the water column of tributary streams; [29]
- Areas in the Pacific Northwest where Chinook salmon are harvested may account for the variations in their PCB body burden concentrations. Although some contamination of the Chinook salmon occurs in the Pacific Ocean, a larger source of the salmon body burden occurs within Puget Sound or along the migratory route within Puget Sound for Chinook salmon; [30]
- Chemical contaminants (selected pesticides and POPs) have been documented in outmigrant juvenile Chinook salmon.[31]

[28] Kelly et. al., 2007. Barry C. Kelly, Samantha L. Gray, Machael G Ikonomou, et. al. Lipid Reserve Dynamics and Magnification of Persistent Organic Pollutants in Spawning Sockeye Salmon (Oncorhynchus nerka) from the Fraser River, British Columbia. Environmental Science and Technology, Vol. 41, No 9, 2007, pages 3083 – 3089.

[29] O'Toole et. al., 2006. Shaun O'Toole, Chris Metcalfe, Ian Craine, Mart Gross. Release of persisten organic contaminants from carcasses of Lake Ontario Chinook salmon (Oncorhynchus tshawytscha). Environmental Pollution 140 (2006) pages 102 to 113.

[30] Missildine et. al., 2005. Polychlorinated Biphenyl Concentrations in Adult Chinook Salmon (Oncorhynchus tshawytscha) Returning to Coastal and Puget Sound Hatcheries of Washington State. Environmental Science & Technology, Vol. 39, No. 18, 2005, pages 6944 to 6951.

[31] Johnson et. al., 2007. Persistent organic pollutants in outmigrant juvenile Chinook salmon from the Lower Columbia Estuary, USA. Science of the Total Environment 374 (2007) pages 342-366.

Appendix A Life Histories and Biological Variability In Life Histories of Pacific Coast Salmonids

Table A: Life Histories of Pacific Coast Salmonids					
Species Anadromous Salmon	**Spawning Migration**	**Spawning Period**	**Spawning Area**	**Life History**	**Most Common Age At Maturity (years)**
Chum salmon	Summer to Winter	Summer to Winter	Usually near tidewater	Fry go directly to sea; 2-5 years ocean	4
Pink salmon	Late summer to early Fall	Late summer to early Fall	Usually near tidewater	Fry go directly to sea; 2 years ocean	2
Sockeye salmon	Spring to fall	Late summer to fall	Tributaries of lakes	1-3 years lake 2-3 years ocean	4-5
Coho salmon	Summer to fall	Fall to early winter	Small headwater streams	1-3 years freshwater 6 months Jack ocean 18 month adult ocean	3
Chinook salmon	Spring to fall	Summer to early winter	Large rivers	3 months – 2 years freshwater 2-5 years ocean	4 -5
Species Anadromous Trout and Char	**Spawning Migration**	**Spawning Period**	**Spawning Area**	**Life History**	**Most Common Age At Maturity**
Steelhead trout	Summer to winter	Late winter to spring	Small headwater streams	2-3 years freshwater 1-3 years ocean *Repeat spawners*	4-5
Searun cutthroat trout	Fall to winter	Late winter to early spring	Small headwater streams	2-4 years freshwater 2-5 months ocean *Repeat spawners*	3-4
Dolly Varden[32]	Late summer to fall	Fall	Main channels on rivers	2-4 years freshwater 2-4 years ocean *Repeat spawners*	Mature 5-6 Die 6-7

[32] On occasion WDFW lumps bull trout and Dolly Varden together because both are listed under the Endangered Species Act and are hard to differential the two species in the field; genetic studies have found bull trout throughout Puget Sound and the Strait. (S. Duncan, personal communication with CR McCormack, May 16, 2008).

Resident Species	Spawning Migration	Spawning Period	Spawning Area	Life History	Most Common Age At Maturity
Kokanee salmon	Late summer to fall	Late summer to fall	Tributaries of lakes, lakeshores	Juveniles migrate to lakes to reside	3-4
Rainbow trout	Spring	Spring	Small headwater streams	Variable residence in natal, streams, rivers, & lakes	2-3
Cutthroat trout	Spring	Spring to early summer	Small headwater streams	Variable residence in natal, streams, rivers, & lakes	3-4
Bull trout (see footnote 30, page 32)	Fall	Fall	Large streams with groundwater infiltration	Juveniles migrate from tirbutaries to lakes or large streams at about 2 years, highly variable	4-9
Mountain white fish	Fall	Fall	Mid-sized streams, lakes	Reside in streams and lakes	3-4
Adapted from: An Ecosystem Approach to Salmonid Conservation, Part I, December 1996, Table 4-1, page 64 (NOAA's National Marine Fisheries Service)					

Table B: Biological Variability In Life Histories Of Pacific Salmonids								
Species of Salmon	**Life History**	**Spawns In**			**Rears In**			
		Lakes	**Streams**	**Intertidal**	**Lakes**	**Streams**	**Estuaries**	**Ocean**
Pink salmon	Anadromous		**X**			**X**	**X**	**X**
	Anadromous		**X**					**X**
	Anadromous			**X**			**X**	**X**
Chum salmon	Anadromous		**X**			**X**	**X**	**X**
	Anadromous		**X**			**X**		**X**
	Anadromous		**X**					**X**
	Anadromous			**X**			**X**	**X**
Coho salmon	Anadromous		**X**			**X**	**X**	**X**
	Anadromous		**X**			**X**		**X**
Sockeye salmon	Anadromous		**X**		**X**			**X**
	Anadromous	**X**			**X**			**X**
Chinook salmon (spring)	Anadromous		**X**			**X**	**X**	**X**
	Anadromous		**X**			**X**		**X**
Chinook salmon (fall)	Anadromous		**X**				**X**	
	Anadromous		**X**			**X**		**X**
Steelhead Trout	Anadromous		**X**			**X**		**X**

Species of Salmon	Life History	Spawns In			Rears In			
		Lakes	Streams	Intertidal	Lakes	Streams	Estuaries	Ocean
Dolly Varden	Anadromous		X			X	X	X
Kokanee salmon	Resident		X		X			
	Resident	X			X			
Cutthroat trout	Resident		X			X		
	Resident		X		X			
Cutthroat trout (searun)	Anadromous		X			X	X	X
	Anadromous		X			X		X
Rainbow trout	Resident		X		X			
	Resident		X		X			
	Resident	X						
Bull trout	Resident		X			X		
(see footnote 30, page 32	Resident		X		X			
Mountain whitefish	Resident		X			X		
	Resident	X			X			
Adapted from: An Ecosystem Approach to Salmonid Conservation, Part I, December 1996, Table 4-2, page 66 (NOAA's National Marine Fisheries Service)								

Appendix B 2001-2002 and 2002-2003 Freshwater Salmon Sport Catch

Table C: 2001-2002 Freshwater Salmon Sport Catch For Puget Sound River Systems														
Catch Area	Species	2001									2002			Total
		April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar	
Dungeness River	Coho							5,949	597		12			6,558
	Steelhead					9		43	22	107	58	9	4	252
Elwha River	Coho							816	127					943
	Steelhead			5	46	5	5	36						97
Morse Creek	Steelhead							4						4
													Total Salmon Sport Catch	7,854
Washington State Sport Catch Report 2001 by Terrie Manning and Sheila Smith. Washington Department of Fish and Wildlife, Fish Program Science Division, May 2005, adapted from Table 26, page 42; Table 35, page 92; Table 35, page 90.														

Table C-2: 2001-2002 Sport Salmon Catch For East Juan de Fuca (Port Angeles Areas)											
	2001								2002		Total
Species	April	May	June	July	August	Sept	Oct	Nov	Feb	Mar	
Chinook	136				18	17	132	171	172	115	761
Coho			10	239	1,492	1,806	199	8			3,754
Pink			21	840	5,742	951					7,554
Sockeye					2						2
Chum						3	3	4			10
Steelhead			6			6					12
							Total Salmon Sport Catch For Area				12,093
Washington State Sport Catch Report 2001 by Terrie Manning and Sheila Smith. Washington Department of Fish and Wildlife, Fish Program Science Division, May 2005,, adapted from Table16, page 25 & Table 35, page 101.											

Table D:2002-2003 Freshwater Salmon Sport Catch For Puget Sound River Systems														
Catch Area	Species	2002									2003			Total
		April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar	
Dungeness River	Coho							398	711	25				1134
	Steelhead							4	3	5	15	15	3	45
Elwha River	Coho							948	175					1123
	Steelhead				2	1	1	9	59	92	17	9	2	192
Morse Creek	Steelhead								3	15	5	10		33
									Total Salmon Sport Catch					2527

Washington State Sport Catch Report 2002 by Eric Kraig and Sheila Smith. Washington Department of Fish and Wildlife, Fish Program Science Division, April 2008, Adapted from Table 25, page 41; Table 34, page 87; Table 34, page 88.

Table D-2: 2002-2003 Sport Salmon Catch For East Juan de Fuca (Port Angeles Areas)											
	2002								2003		Total
Species	April	May	June	July	August	Sept	Oct	Nov	Feb	Mar	
Chinook	55					3	12	59	103	81	313
Coho				43	281	713	35				1072
Pink				21							21
Sockeye											0
Chum							12				12
Steelhead				3			3	3(Dec)	3(Jan)		12
							Total Salmon Sport Catch For Area				1430

Washington State Sport Catch Report 2002 by Eric Kraig and Sheila Smith. Washington Department of Fish and Wildlife, Fish Program Science Division, April 2008, Adapted from Table 16, page 25; Table 34, page 97.

Appendix C: Salmonid Stock Inventory for Port Angeles Harbor Area

Table E: Salmonid Stock Inventory For The Port Angeles Harbor & Adjacent Areas						
Anadromous Fish		Total Escapement Estimates		WDFW Designated Status		Comments
Species	Stock			1992	2002	
		From Year: Est. #	To Year: Est. #			
Chinook	Dungeness Chinook	1986 : 238	2003 : 640	Critical	Critical	Critical due to chronically low escapements below goal of 925 adults; increased escapement #'s due to continuing hatchery supplementation; spawning mainstream Dungeness River
	Elwha Chinook	1986 : 3,127	2003 : 1,045	Healthy	Depressed	Depressed due to long-term negative trend and chronically low escapements since 1992; Spawning lower 4.9 mile of river below Elwha Dam.
Chum	Dungeness Summer Chum	1992: Unknown	2002: Unknown	Not Rated	Unknown	No abundance trend data available; Numbers so low that may not represent a self-sustaining stock; Summer timed limited #'s observed in Dungeness River
	Dungeness Fall Chum	1992: Unknown	2002: Unknown	Unknown	Unknown	Live + dead counts in one day, one mile section of (Lower Dungeness tributary) Beebe Creek 1997: 303, 1998: 1,025; 2001: 1,062.
	Elwha Fall Chum	1992: Unknown	2002: Unknown	Unknown	Unknown	No abundance trend data available;

Information obtained from: Salmon stock Inventory. Washington Department of Fish and Wildlife. Water Resource Inventory Area (WRIA) 18 – Elwha-Dungeness.
Web link: http://wdfw.wa.gov/cgi-bin/database/sasi_search_new_db.cgi?keyword=18&field=4&search_sort=sort&srchtype=within&job=search&wria=wria

Table E-2: Salmonid Stock Inventory For The Port Angeles Harbor & Adjacent Areas						
Anadromous Fish		**Total Escapement Estimates**		**WDFW Designated Status**		**Comments**
Species	**Stock**			**1992**	**2002**	
		From Year: Est. #	To Year: Est. #			
Coho	Dungeness Coho	1992: Depressed	2002: Unknown	Unknown	Unknown	No abundance trend data available; Limited recent-year estimates of smolt production suggest significant natural production Dungeness R. watershed.
	Morse Creek Coho	1998: 488 adults and 511 smolts	2002: 676 adults and 2, 966 smolts	Depressed	Depressed	Spawning distribution: McDonald, Siebert, Morse, Ennis, Valley and Tumwater Creeks; Depressed because of chronically low "redd" counts; mixture of wild & farm raised stock
	Elwha Coho	Unknown	Unknown	Healthy	Unknown	No abundance trend data available; Healthy rating based on escapement estimates from Strait of Juan de Fuca tributaries

Anadromous Fish		Total Escapement Estimates		WDFW Designated Status		Comments
Species	Stock			1992	2002	
		From Year: Est. #	To Year: Est. #			
Pink	Lower Dungeness Pink	1985: 966;	2001: 11, 072; 2003: 3,540	Critical	Critical	Estimates based on counts from mainstem of Dungeness R., Gold Creek, & Gray Wolf river; Critical designation due to chronically low escapements
	Upper Dungeness Pink	1985: 3,764 1989: 10,579	2001: 69,272 2003: 11,576	Depressed	Depressed	Prior to 1981 escapements usually in excess of 20,000; stock status depressed because of chronically low escapements
	Elwha Pink	1985: 30 1991: 0	2001: 605 2003: 32	Critical	Critical	In early '70s instantaneous counts over a thousand pinks were made; since 1981 not more than 30 pinks have been seen on any one day; stock status depressed because of chronically low escapements

Table E-3: Salmonid Stock Inventory For The Port Angeles Harbor & Adjacent Areas						
Anadromous Fish		**Total Escapement Estimates**		**WDFW Designated Status**		**Comments**
Species	**Stock**			**1992**	**2002**	
		From Year: Est. #	To Year: Est. #			
Steelhead	Dungeness Summer Steelhead	Unknown	Unknown	Depressed	Unknown	No abundance trend data available. Due to fisheries closures and low harvest numbers sport harvest is no longer adequate to assess stock status.
	Dungeness Winter Steelhead	1988: 438 1993: 338	2000: 165 2001 183	Depressed	Depressed	Depressed status because of long term negative trends
	Morse Creek Winter Steelhead	1986: 105 1988: 138	1997: 183 2003: 84	Depressed	Depressed	Escapement estimates based on redd counts;Depressed due to chronically low escapements
	Elwha Summer Steelhead	Depressed	Unknown	Depressed	Unknown	No abundance trend data available;
	Elwha Winter Steelhead	1986: 834 1989: 416	1992: 560 1997: 153	Depressed	Unknown	Access to historic spawning areas blocked by Elwha Dam; Average of 50 redds/year; Lack of systematic abundance trend data;

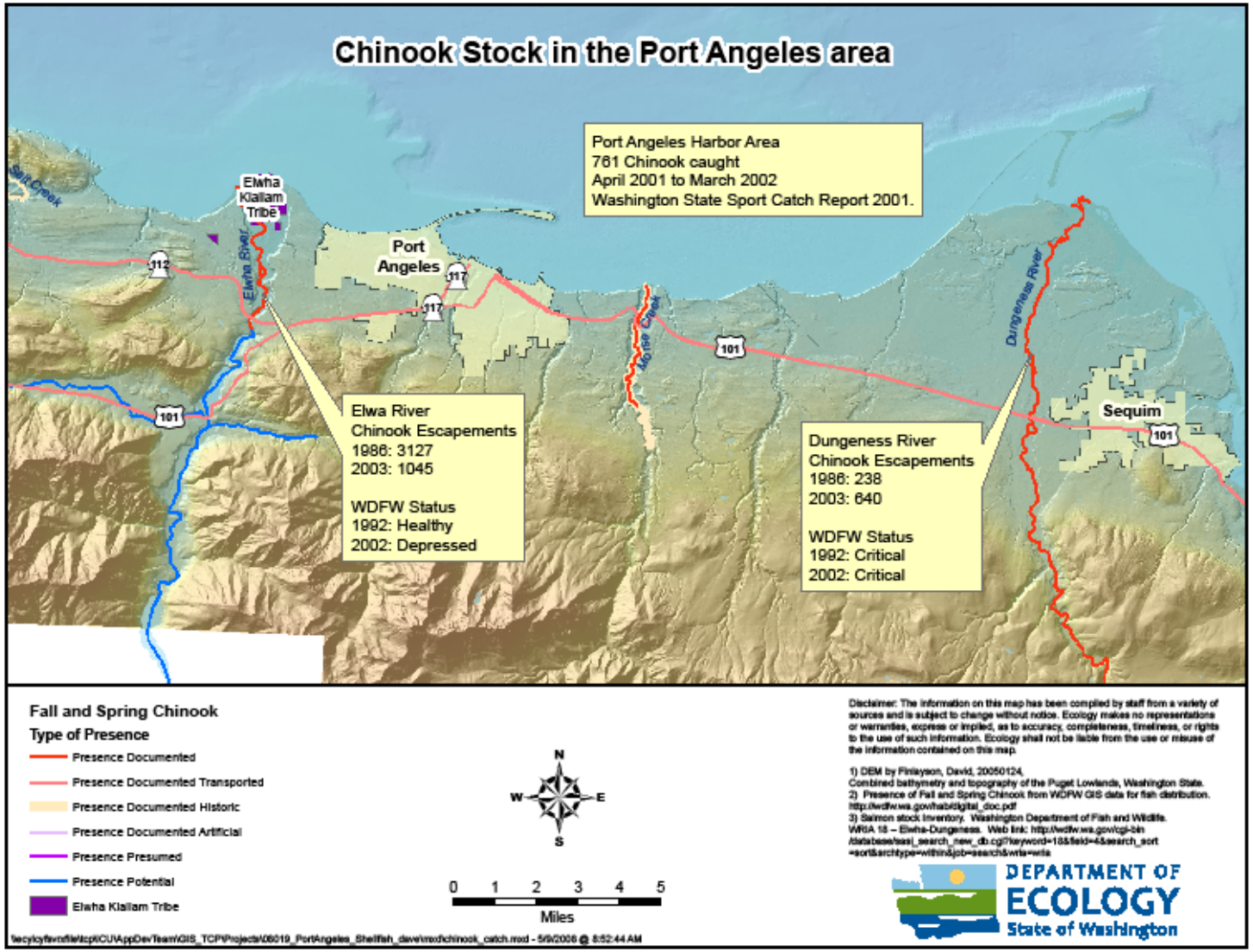
Information obtained from: Salmon stock Inventory. Washington Department of Fish and Wildlife. WRIA 18 – Elwha-Dungeness.
Web link: http://wdfw.wa.gov/cgi-bin/database/sasi_search_new_db.cgi?keyword=18&field=4&search_sort=sort&srchtype=within&job=search&wria=wria

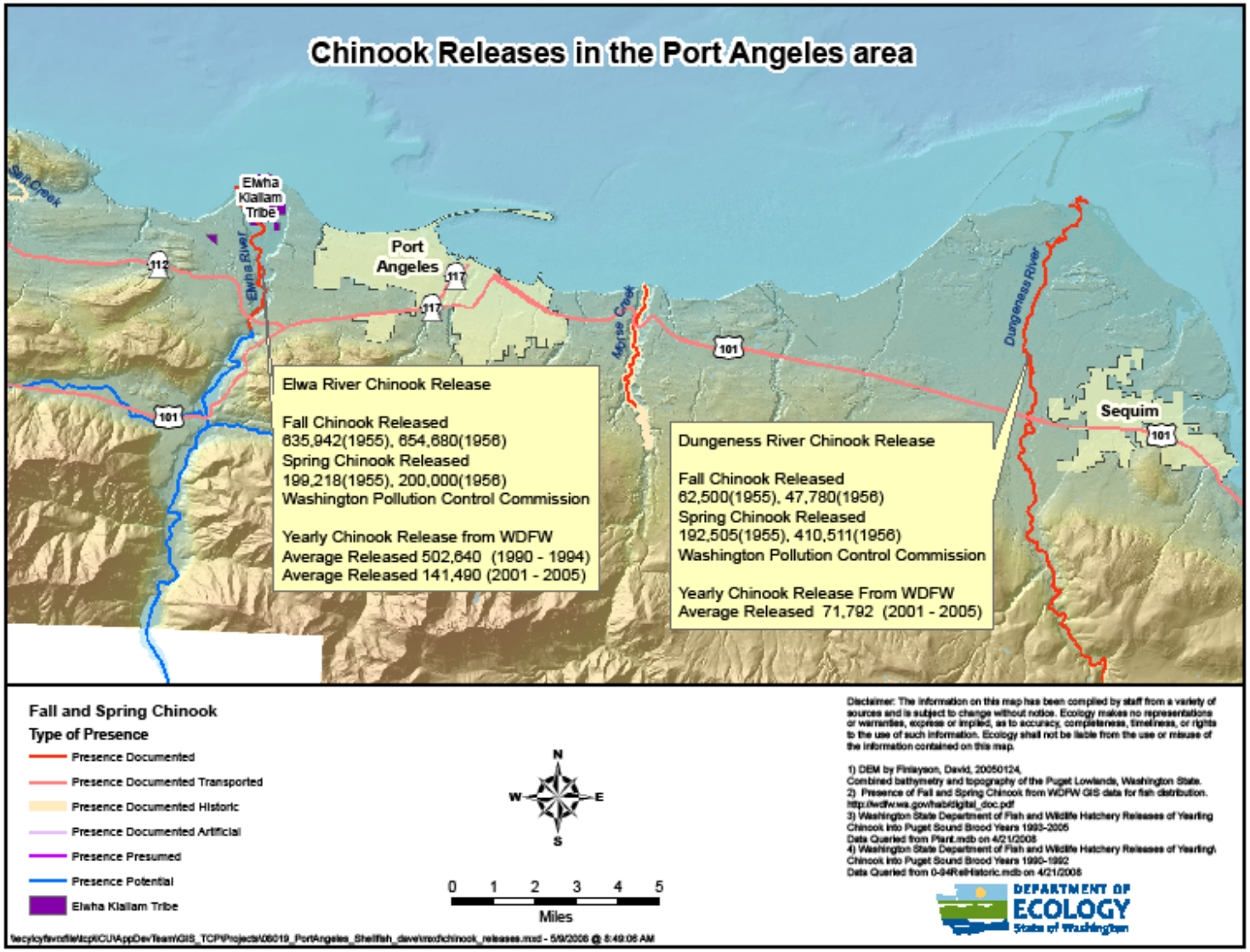
Appendix D: Selected Toxic Chemical Loadings For Puget Sound Basin

Table F: Summary Of Selected Toxic Chemical Loadings For Puget Sound Basin (metric tons per year)

Chemical or Group	Runoff	Atmospheric Deposition	Wastewater		Combined Sewage Outfalls
			POTWs	Industrial	
Arsenic	62 (32 to 118)	3.1 (0.3 to 16)	0.0005(0.0000 to 0.0010)	7.4 (0.20 to 14.6)	0.014
Mercury	0.52 (0.19-1.4)	0.031 (0.0062 to 0.16)		0.015 (0.0000-0.029)	0.00069
Total PCBs	0.17 (0.040 to 0.72)	0.0062(0.0016 to 0.062)			
Total PBDEs	6.0E-04 (1.7E-04 to 2.2E-03)	0.0062(0.0016 to 0.019)			
c-PAHs	2.3 (0.81 to 6.6)	3.1 (0.31 to 16)		0.024(0.00018 to 0.048)	0.00093
High MW - PAHs	1.7 (0.61 to 5.0)	1.6 (0.31 to 6.2)		0.0070 (0.00079 to 0.013)	0.0017
Low MW - PAHs	5.9 (2.1 to 17)	1.6 (0.31 to 6.2)		0.014 (0.00099 to 0.026)	0.0021
Phthalate (BEHP)	74 (19 to 289)			0.082	0.047
Total Dioxin TEQs	4.5E-05 (1.1E-05 to 1.8E-04)	3.1E-06 (3.1E-07 to 3.1E-05)			2.3E-08
DDT	0.16 (0.042 to 0.63)	0.0062 (0.0012 to 0.031)			
Oil / Petroleum Product	22,580 (9,580 to 55,750)		6.1	51.3 (38.6 to 66.7)	36

Control of Toxic Chemicals In Puget Sound, Phase 1: Initial Estimate of Loading. October 2007 Puget Sound Partnership (Publication number 07-10-079). Adapted from summary table on pages 5 & 6


Chinook Stock in the Port Angeles area
Port Angeles Harbor Area
761 Chinook caught
April 2001 to March 2002
Washington State Sport Catch Report 2001.
Elwha Klallam Tribe
Port Angeles
Elwha River
Morse Creek
Dungeness River
Sequim
112
117
101
Elwa River
Chinook Escapements
1986: 3127
2003: 1045
WDFW Status
1992: Healthy
2002: Depressed
Dungeness River
Chinook Escapements
1986: 238
2003: 640
WDFW Status
1992: Critical
2002: Critical
Fall and Spring Chinook
Type of Presence
Presence Documented
Presence Documented Transported
Presence Documented Historic
Presence Documented Artificial
Presence Presumed
Presence Potential
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) DEM by Finlayson, David, 20050124, Combined bathymetry and topography of the Puget Lowlands, Washington State.
2) Presence of Fall and Spring Chinook from WDFW GIS data for fish distribution. http://wdfw.wa.gov/hab/digital_doc.pdf
3) Salmon stock inventory. Washington Department of Fish and Wildlife. WRIA 18 – Elwha-Dungeness. Web link: http://wdfw.wa.gov/cgi-bin/database/sasi_search_new_db.cgi?keyword=18&field=4&search_sort=sort&archtype=within&job=search&wria=wria
DEPARTMENT OF ECOLOGY
State of Washington


Chinook Releases in the Port Angeles area
Elwha Klallam Tribe
Port Angeles
Elwha River
Morse Creek
Dungeness River
Sequim
112
117
101
Elwa River Chinook Release
Fall Chinook Released
635,942(1955), 654,680(1956)
Spring Chinook Released
199,218(1955), 200,000(1956)
Washington Pollution Control Commission
Yearly Chinook Release from WDFW
Average Released 502,640 (1990 - 1994)
Average Released 141,490 (2001 - 2005)
Dungeness River Chinook Release
Fall Chinook Released
62,500(1955), 47,780(1956)
Spring Chinook Released
192,505(1955), 410,511(1956)
Washington Pollution Control Commission
Yearly Chinook Release From WDFW
Average Released 71,792 (2001 - 2005)
Fall and Spring Chinook
Type of Presence
Presence Documented
Presence Documented Transported
Presence Documented Historic
Presence Documented Artificial
Presence Presumed
Presence Potential
Elwha Klallam Tribe
N
W
E
S
0 1 2 3 4 5
Miles
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1) DEM by Finlayson, David, 20050124,
Combined bathymetry and topography of the Puget Lowlands, Washington State.
2) Presence of Fall and Spring Chinook from WDFW GIS data for fish distribution.
http://wdfw.wa.gov/hab/digital_doc.pdf
3) Washington State Department of Fish and Wildlife Hatchery Releases of Yearling Chinook into Puget Sound Brood Years 1993-2005
Data Queried from Plant.mdb on 4/21/2008
4) Washington State Department of Fish and Wildlife Hatchery Releases of Yearling Chinook into Puget Sound Brood Years 1990-1992
Data Queried from 0-94RelHistoric.mdb on 4/21/2008
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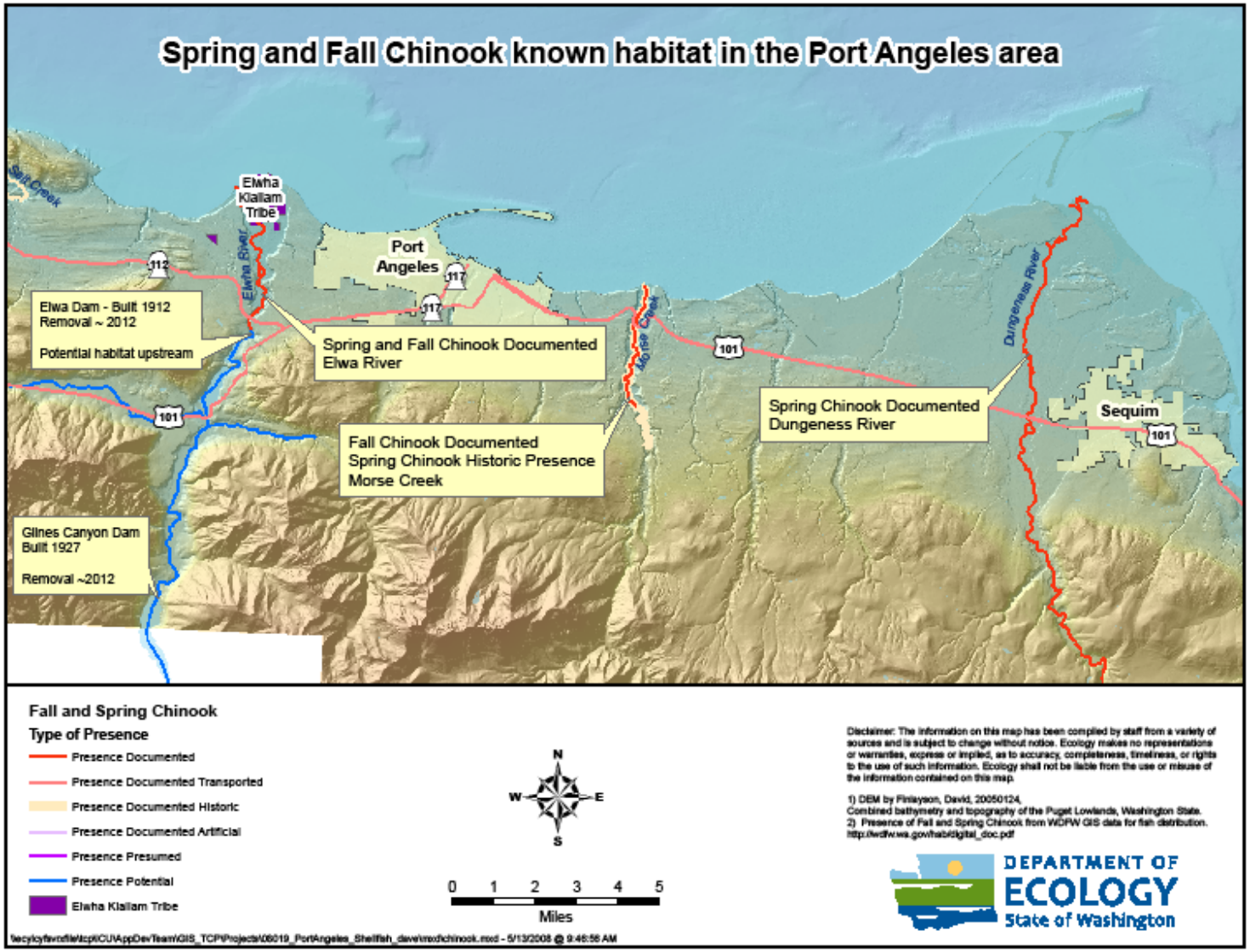
Spring and Fall Chinook known habitat in the Port Angeles area
Elwha Klallam Tribe
Port Angeles
Elwha River
Morse Creek
Dungeness River
Sequim
112
117
101
Elwa Dam - Built 1912
Removal ~ 2012
Potential habitat upstream
Spring and Fall Chinook Documented
Elwa River
Fall Chinook Documented
Spring Chinook Historic Presence
Morse Creek
Spring Chinook Documented
Dungeness River
Glines Canyon Dam
Built 1927
Removal ~2012
Fall and Spring Chinook
Type of Presence
Presence Documented
Presence Documented Transported
Presence Documented Historic
Presence Documented Artificial
Presence Presumed
Presence Potential
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.
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2) Presence of Fall and Spring Chinook from WDFW GIS data for fish distribution.
http://wdfw.wa.gov/habitat/digital_doc.pdf
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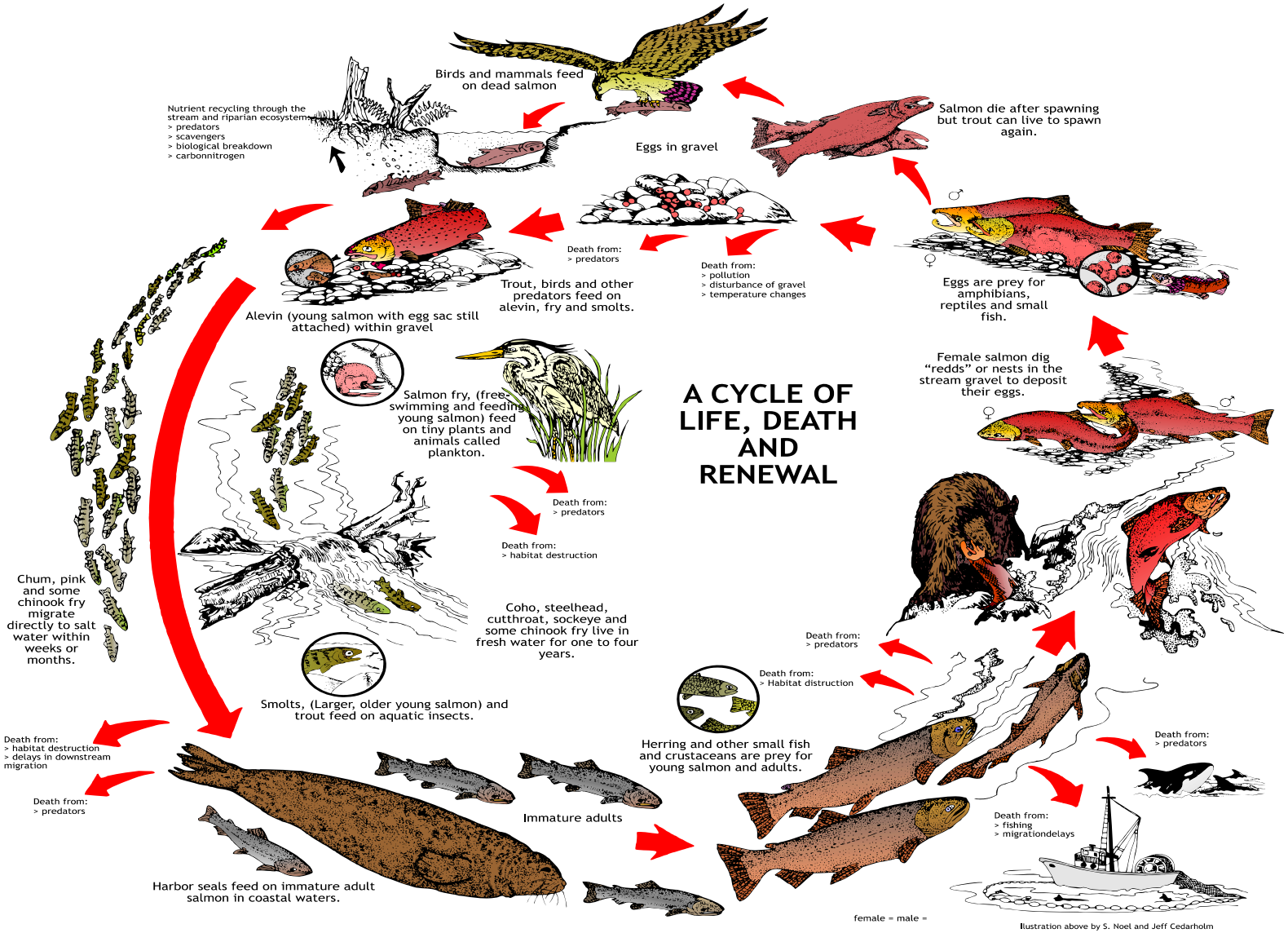
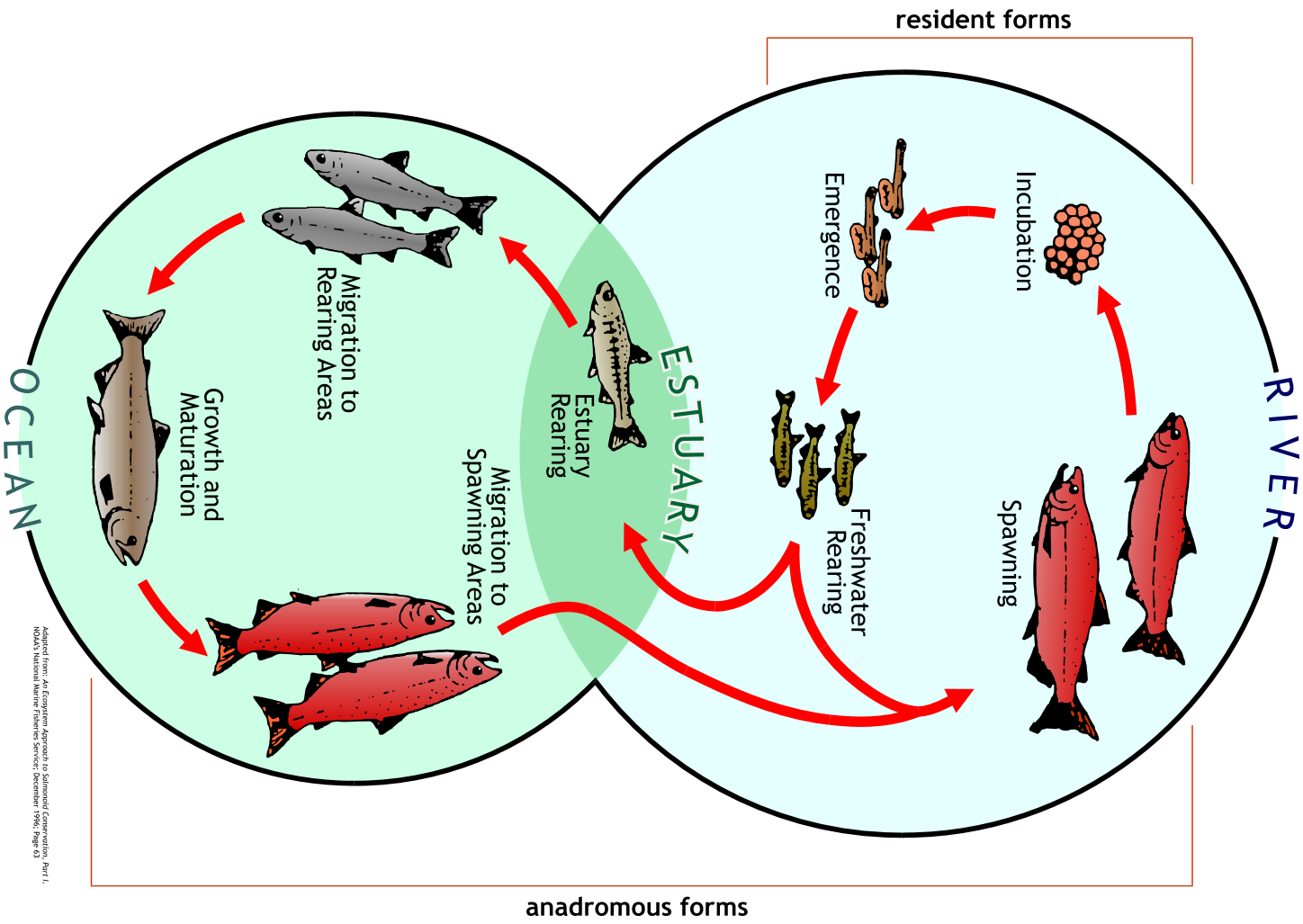
State of Washington


A CYCLE OF LIFE, DEATH AND RENEWAL
Birds and mammals feed on dead salmon
Nutrient recycling through the stream and riparian ecosystem
> predators
> scavengers
> biological breakdown
> carbonnitrogen
Salmon die after spawning but trout can live to spawn again.
Eggs in gravel
Death from:
> predators
Death from:
> pollution
> disturbance of gravel
> temperature changes
Eggs are prey for amphibians, reptiles and small fish.
Trout, birds and other predators feed on alevin, fry and smolts.
Alevin (young salmon with egg sac still attached) within gravel
Female salmon dig "redds" or nests in the stream gravel to deposit their eggs.
Salmon fry, (free-swimming and feeding young salmon) feed on tiny plants and animals called plankton.
Death from:
> predators
Death from:
> habitat destruction
Chum, pink and some chinook fry migrate directly to salt water within weeks or months.
Coho, steelhead, cutthroat, sockeye and some chinook fry live in fresh water for one to four years.
Death from:
> predators
Death from:
> Habitat distruction
Smolts, (Larger, older young salmon) and trout feed on aquatic insects.
Herring and other small fish and crustaceans are prey for young salmon and adults.
Death from:
> predators
Death from:
> habitat destruction
> delays in downstream migration
Death from:
> predators
Immature adults
Death from:
> fishing
> migrationdelays
Harbor seals feed on immature adult salmon in coastal waters.
female = male =
Illustration above by S. Noel and Jeff Cedarholm


resident forms
RIVER
Incubation
Spawning
Emergence
Freshwater Rearing
ESTUARY
Estuary Rearing
Migration to Spawning Areas
Migration to Rearing Areas
Growth and Maturation
OCEAN
anadromous forms
Adapted from: An Ecosystem Approach to Salmonid Conservation, Part I, NOAA's National Marine Fisheries Service; December 1996, Page 63