***Program and Abstracts***

# 12th Annual Meeting of the Pacific Northwest Chapter of the Society of Environmental Toxicology and Chemistry (PNW-SETAC)

## *Contributions of Environmental Toxicology and Chemistry to Pacific Northwest Resource Management*

**Fort Worden Conference Center, Building 204**
**Port Townsend, WA**
**April 17 - 19, 2003**

# PNW-SETAC ANNUAL MEETING

## April 17 to 19, 2003

## Meeting Program

# PNW-SETAC
# Chapter Meeting Program

***Thursday, April 17, 2003***

| | |
|---|---|
| 8:30 - 17:30 | **Conference Check-in, Building 204** |
| 10:00 - 17:00 | Short Course: Washington's Sediment Quality Information System (SEDQUAL) |
| 12:00 - 17:00 | Northwest Toxicity Assessment Group (NWTAG) Meeting |
| 15:30 - 19:30 | **On-site Housing Check-in, Building 204** |
| 17:30 - 20:00 | Reception & Buffet, Blackberries Dining Hall next to (east of) Building 204 |

***Friday, April 18, 2003***

| | |
|---|---|
| 7:30 - 8:15 | Conference check-in, poster setup, Building 204 |
| 8:15 - 9:00 | Welcome address |
| 9:00 - 12:00 | Platform sessions with 20 min break for refreshments and poster viewing |
| 12:00 - 13:30 | Buffet Lunch, Blackberries Dining Hall |
| 13:30 - 17:00 | Platform sessions with 30 min break for refreshments and poster viewing |
| 17:30 - 19:00 | Open House: Port Townsend Marine Science Center, on the beach at Fort Worden |
| 18:00 - 20:30 | Barbecue at the Beach! Kitchen Shelter on the beach at Fort Worden |
| 20:30 | Maya Soleil Live! At Maxwell's Restaurant, 126 Quincy St., downtown Port Townsend |

***Saturday, April 19, 2003***

| | |
|---|---|
| 7:30 - 8:30 | PNW-SETAC Business Meeting |
| 8:30 - 8:45 | Student Award Presentation |
| 8:45 - 13:00 | Special Session: Development and Use of Sediment Quality Guidelines (SQGs) in the Pacific Northwest |
| 13:00 - 16:00 | Protection Island Spring Migration Cruise (Optional) |

*Thank You for*
***PNW-SETAC***
# Chapter Meeting Sponsorship

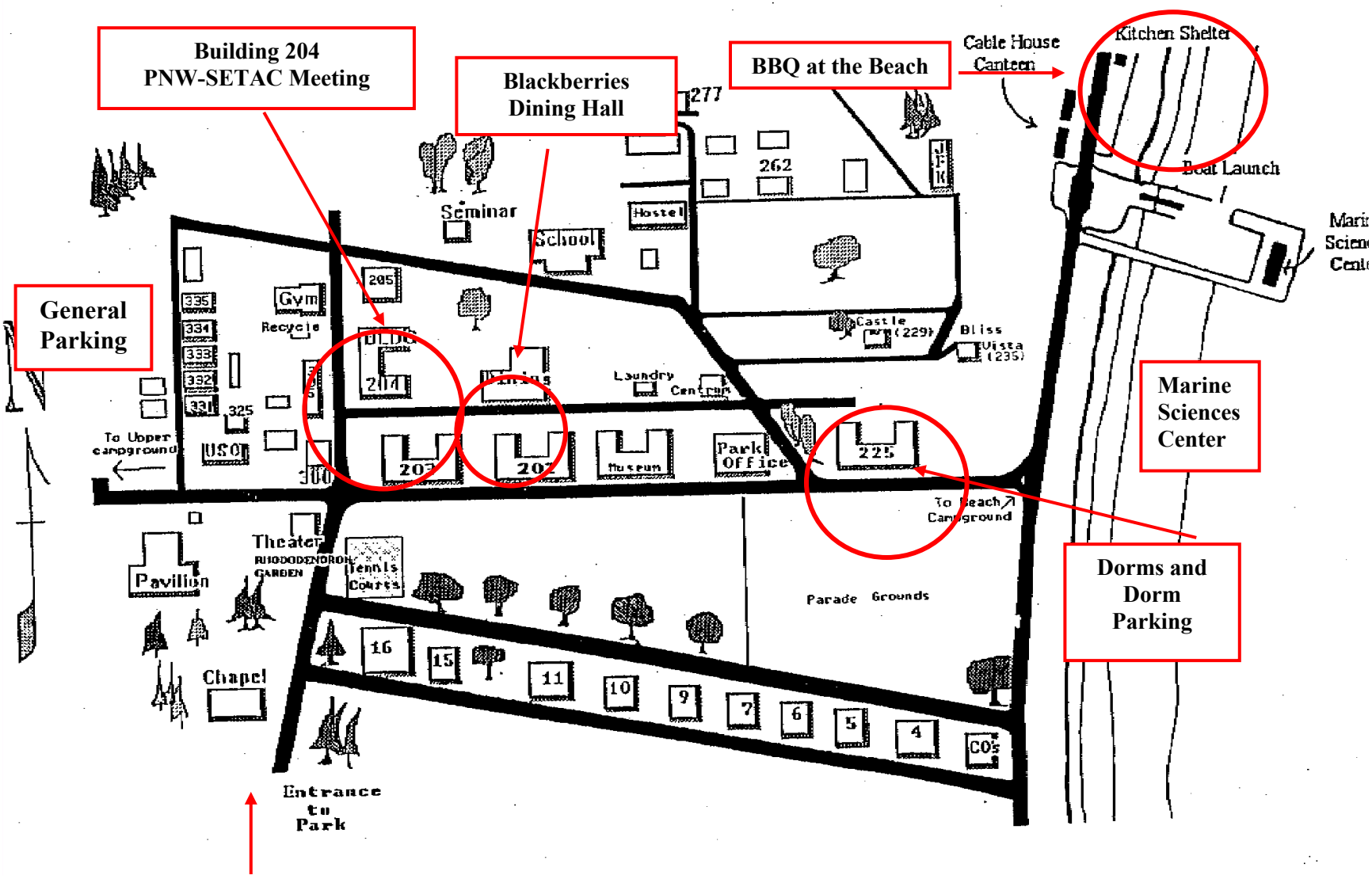
| | |
|---|---|
| *Student Awards and Travel Grants* | AMEC<br>Anchor Environmental<br>Bio-Marine Enterprises<br>Dinnel Marine Resources<br>Entrix<br>EVS<br>Exponent<br>Free Run Aquatic Research<br>Germano & Associates, Inc.<br>Pacific Northwest National Laboratory - Environmental Technology Division<br>Paladin Water Quality Consulting<br>Parametrix<br>Striplin Environmental |
| *Short Course Materials and Room* | SETAC NA |
| *Sound System* | AMEC |
| *Thursday Morning Break* | Avocet Consulting |
| *Thursday Afternoon Break* | Anchor Environmental |
| *Thursday Reception* | Pacific Northwest National Laboratory - Environmental Technology Division |
| *Friday Morning Break* | Entrix<br>Striplin Environmental |
| *Friday Lunch* | AMEC<br>The RETEC Group |
| *Friday Afternoon Break* | Pacific Northwest National Laboratory - Environmental Technology Division |
| *Friday Night Barbecue* | Hart Crowser<br>Northwest Aquatic Sciences |
| *Saturday Morning Break* | Hart Crowser |
| *Fish Sculptures* | Columbia Analytical Services |

# PNW-SETAC

*Acknowledgements*

**Thanks to all of the following who volunteered their time to make this meeting possible:**

| | |
|---|---|
| **Conference Organization:** | Nancy Kohn, Battelle Marine Sciences Laboratory |
| **Abstract Review:** | Karen Kinnee, BC Research, Inc.<br>Nancy Kohn, Battelle Marine Sciences Laboratory |
| **Meeting Program:** | Karen Kinnee, BC Research, Inc.<br>Lorraine Wilde, Western Washington University |
| **Meeting Registration:** | Angie Obery, Oregon Department of Environmental Quality |
| **Volunteer Coordinators:** | Lorraine Wilde, Western Washington University<br>Kristin Lawrence, AMEC Earth & Environmental |
| **Sponsorships:** | Paul Dinnel, Shannon Point Marine Center<br>Angie Obery, Oregon Department of Environmental Quality<br>Nancy Kohn, Battelle Marine Sciences |
| **Student Awards:** | Lorraine Wilde, Western Washington University |
| **Session Chairs:** | Gary Pascoe, EA Engineering<br>Christian Grue, University of Washington |
| **Special Session:** | Jim Meador, NOAA Fisheries<br>Tom Gries, Washington Department of Ecology |
| **Useful Advice:** | April Markiewicz, Western Washington University<br>Lorraine Wilde, Western Washington University<br>Taku Fuji, Hart-Crowser |
| **Student Award Judges:** | Karen Bergmann, AMEC Earth & Environmental<br>Andrew Deines, Western Washington University<br>Chris Peredney, Washington Department of Ecology<br>Lorne Sampson, British Columbia Institute of Technology |
| **Student Funding Application Reviews:** | Doug Henderson, King County Department of Natural Resources<br>Karen Kinnee, BC Research, Inc. |




**Park Entrance**
**Access from Cherry Street**

For everything you need to know about Port Townsend, visit
**http://www.ptguide.com**
For additional information about Fort Worden State Park, visit
**http://www.olympus.net/ftworden/**

Pacific Northwest Chapter
Society of Environmental Toxicology and Chemistry
(PNW-SETAC)

12th Annual Meeting

# Schedule of Platform and Poster Presentations

# PNW-SETAC Annual Meeting
# Platform Presentation Schedule
**Friday, April 18, 2003**

**Chair:** Gary Pascoe, EA Engineering

***Friday Morning:***

***Environmental Impacts, Risk Assessment and Management***

| | | |
|---|---|---|
| 9:00 | Michael Paine, Ledge and Associates (PLA) | Repeated Measures Regression Designs for Environmental Monitoring |
| 9:20 | Jeff Fisher, ENTRIX, Inc. | Inadvertent Application of Fire Retardant in Omak Creek: Impacts to Aquatic Biota and Habitat, and Evidence of Recolonization |
| 9:40 | Bruce Hope, Oregon Department of Environmental Quality | A Watershed-Level Narrative Analysis of Mercury Sources In The Willamette River Basin |
| 10:00 | Rick Cardwell, Parametrix, Inc. | Potential Risks Posed by Turbidity and Suspended Solids in U.S. Rivers |
| 10:20 | **Break/Poster Viewing** | |
| 10:40 | Heida Diefenderfer, Battelle Marine Sciences Laboratory | Approach for Assessing Potential Contaminant Releases From Coastal and Estuarine Habitat Restoration Projects |
| 11:00 | Bob Johnston, Space and Naval Warfare Systems Center | A Watershed-Based Approach for Improving Environmental Quality in Sinclair and Dyes Inlets, WA |
| 11:20 | Jenifer McIntyre, University of Washington | Exploring Bioaccumulation of Persistent Contaminants in Fish with a Bioenergetics Model |
| 11:40 | Wayne Landis, Western Washington University | Quantitative Weight of Evidence Approach in Establishing Causal Linkages for the Decline of the Cherry Point, WA Pacific Herring |
| 12:00 | **Lunch** | |

# PNW-SETAC Annual Meeting
# Platform Presentation Schedule
**Friday, April 18, 2003**

**Chair:** Christian (Chris) Grue, University of Washington

***Friday Afternoon:***

***Aquatic Toxicology and Pacific Northwest Fish Species***

| | | |
|---|---|---|
| 13:30 | Lisa Marko, Shannon Point Marine Center | Exploration of a Growth Endpoint for Early Post-Hatch Pacific Herring |
| 13:50 | Kerensa King, University of Washington | Effects of 4-NP on Smoltification in Juvenile Pacific Salmon |
| 14:10 | Cathy Curran, University of Washington | Toxicity of R-11® Surfactant to Juvenile Rainbow Trout: Does Size Matter? |
| 14:30 | Katey Grange, University of Washington | Toxicity of Rodeo® and Two Formulations of Arsenal® to Juvenile Rainbow Trout |
| 14:50 | **Break/Poster Viewing** | |

***Sediment Monitoring Programs***

| | | |
|---|---|---|
| 15:20 | Maggie Dutch, Washington State Department of Ecology | Revision of the Puget Sound Ambient Monitoring Program (PSAMP) Sediment Component Sampling Design |
| 15:40 | Sandra Aasen, Washington State Department of Ecology | Chemical Contamination in the San Juan Islands, Eastern Strait of Juan De Fuca, and Admiralty Inlet |
| 16:00 | Ed Long, Washington State Department of Ecology | Sediment Toxicity in the San Juan Islands, Eastern Strait of Juan De Fuca, and Admiralty Inlet |
| 16:20 | Michele Redmond, Northwestern Aquatic Sciences | *Eohaustorius estuarius*: A Review |
| 16:40 | Linda Mortensen, The RETEC Group, Inc. | Application of PAH Narcosis Theory to Sediment Remediation at MGP Sites |
| 17:00 | **End of Session** | |

# PNW-SETAC Annual Meeting
# Platform Presentation Schedule
## Saturday, April 19, 2003

**Chairs:** Jim Meador, NOAA Fisheries and Thomas Gries, Washington Department of Ecology

***Development and Use of Sediment Quality Guidelines (SQGs) in the Pacific Northwest***

| | | |
|---|---|---|
| 8:45 | Jim Meador, Thomas Gries | Introduction to Session |
| 9:00 | Jack Word, MEC Analytical Systems, Inc. | Use of Sediment Quality Guidelines (SQGs) and Related Tools for the Assessment of Contaminated Sediments – Pellston Workshop Group |
| 9:20 | Ed Long, ERL Environmental | Sediment Quality Guidelines Derived with the Effects-Range Approach |
| 9:40 | Thomas Gries, Washington Department of Ecology | Exploration of the Predictive Ability of Puget Sound AETS |
| 10:00 | Teresa Michelsen, Avocet Consulting | Development of Freshwater Sediment Quality Guidelines for Washington State |
| 10:20 | **Break/Poster Viewing** | |
| 10:40 | L. Jay Field, NOAA, Coastal Protection and Restoration Division | Predicting Toxicity from Sediment Chemistry using Logistic Regression Models: Regional and Site-Specific Applications |
| 11:00 | Bruce Hope, Land Quality Division, Oregon Department of Environmental Quality | Use of Sediment Quality Guidelines in Oregon's Sediment Evaluation Process |
| 11:20 | Howard Cumberland, Hart Crowser | Regional Sediment Evaluation Team (RSET) Process |
| 11:40 | William Gardiner, MEC Analytical Systems, Inc. | The S.T.A.R.R. Process: An Approach to Evaluate the Effects of Confounding Factors |
| 12:00 | Jim Meador, Thomas Gries, Moderators | Panel Discussion |
| 13:00 | **End of Meeting** | |

# PNW-SETAC Annual Meeting
# Poster Presentations

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|---|---|
| David Baldwin, NOAA Fisheries | Sublethal Impacts of Copper on Olfaction and Olfactory-Mediated Behaviors in Juvenile Coho Salmon (*Oncorhynchus kisutch*) |
| Heather Brunelle, Ecology & Environment, Inc. | Evaluating Polycyclic Aromatic Hydrocarbons Ecological Threshold Concentrations for Sediment using Logistic Regression Modeling |
| Jennifer Cabarrus, University of Washington | Toxicity of Four Surfactants to Juvenile Rainbow Trout: Implications for Over-Water Use |
| Jay Davis, US Fish and Wildlife Service | Sublethal Effects of the Carbamate Insecticide, Carbaryl, on Coastal Cutthroat Trout |
| Paul Dinnel, Shannon Point Marine Center | Development and Validation of a Pacific Herring Embryo Bioassay Protocol |
| Katherine Enns, Larkspur Biological Consultants Ltd. | Recovery and Management of Soils and Vegetation Following 100 Years of Lead Smelter Operation |
| Bruce Hope, Oregon Department of Environmental Quality | A Willamette River Basin-Specific Aquatic Food Web Biomagnification Model for Estimation of Mercury Target Levels |
| Tiffany Kao, NOAA Fisheries | Effects of Copper on Mechanosensory Structures in Developing Fish Embryos and Larvae |
| Karen Kinnee, BC Research, Inc. | Toxicity Evaluation of Sodium Sulphide Using the Acute Liquid Phase Microtox® Test |
| Rebekka Lindskoog, MacDonald Environmental Sciences Ltd. | Application of GIS-Based Tools in Sediment Quality Assessment |
| April Markiewicz, Western Washington University | Herring Today, Gone Tomorrow? A Historical Review of the Cherry Point Herring Stock In Relation to other Georgia Basin/Puget Sound Stocks |
| David Maughan, Pacific Northwest National Laboratory | Real-Time Measurement Technology for Environmental Exposures |

# PNW-SETAC Annual Meeting
# Poster Presentations

| | |
|---|---|
| Judy Nedoff, Kennedy/Jenks Consultants | Evaluation of PCB Congener Patterns in Sediment, Bivalves and Fish: A Case Study |
| Rob Pastorok, Exponent | Applying Population Models in Chemical Risk Assessment |
| Jake Perrins, University of Washington | Ozone Treatment of Ballast Water for Non-Indigenous Species on Board the *S/T Tonsina*: Bacterial Enumeration Via Flow Cytometry |
| Laura Reed, Seattle Public Utilities | High Rates o Pre-Spawn Mortality in Coho Salmon *(Oncorhynchus kisutch)* from Urban Streams in the Puget Sound Basin |
| Jason Sandahl, Oregon State University | Electrophysiological Measures of Pesticide Toxicity to the Salmon Olfactory System |
| Bridget Smith, University of Washington | Effects of Rodeo®, R-11®, LI 700®, Agri-Dex®, and Hasten® on Embryogenesis in Pacific Oysters |
| Carla Stehr, NOAA Fisheries | Rapid Phenotypic Screening in Zebrafish: A Model for Identifying Developmental Toxicity in Native Fish Species |
| Frieda Taub, University of Washington, School of Aquatic and Fisheries Sciences | Effects of Toxicants on Oxygen Dynamics in Standardized Aquatic Microcosms |
| Susan Thomas, Pacific Northwest National Laboratory | Mycoremediation of BTEX-Contaminated Sediment |
| Brent Tiller, Pacific Northwest National Laboratory | Metal Concentrations, Foraging Distances, and Fledging Success of Great Blue Herons Nesting Along the Hanford Reach of the Columbia River |
| Jeffery Ward, Battelle Marine Sciences Laboratory | Use of a Weight-of-Evidence Method in Evaluating Regulatory Programs for Contaminated Sediment Management |

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# Platform Presentation Abstracts

## REPEATED MEASURES REGRESSION DESIGNS FOR ENVIRONMENTAL MONITORING

Paine, MD*, Paine, Ledge and Associates (PLA), North Vancouver, BC

In regression or gradient designs, each replicate (e.g., sample location) represents a separate value of an *X* variable (e.g., distance from source). Regression designs test for stress-response relationships, with *X* some measure of stress (e.g., dose or exposure). Subsampling within replicates is unnecessary and rarely cost-effective. For example, it is usually better to sample more locations or distances from source than to collect multiple samples within each location or distance. In studies with multiple sample times, re-sampling the same replicates (=Repeated Measures {RM} regression design) is a convenient and powerful approach. RM designs remove systematic or persistent "nuisance" variance among replicates. In RM regression designs, *Y* is not a single response value, but some function of values for multiple times (e.g., means, variance, trends). The advantages (and disadvantages), set-up and analysis of RM regression designs will be illustrated using case studies. In most studies, *X* is usually distance from a source. Effects of direction, as well as distance, from sources can be assessed by using cos and sin values of angular deviations from N as additional *X* variables. Options for dealing with other *X* variables, such as chemical concentrations, which vary over time, will be discussed. Error variance terms in RM regression can also be used to test for and identify persistent "hot" or "cold" spots with unusually high or low *Y* ore response values, relative to *X* values.

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## INADVERTENT APPLICATION OF FIRE RETARDANT IN OMAK CREEK: IMPACTS TO AQUATIC BIOTA AND HABITAT, AND EVIDENCE OF RECOLONIZATION

Fisher, JP[1*], Fisher, C[2], Waller, D[1], Vanderpham, J[1], [1]ENTRIX, Inc., Olympia, WA, [2]Colville Confederated Tribes (CCT), Omak, WA

Omak Creek in north-central Washington State supports substantial resident trout populations and is a major focus of anadromous salmonid restoration efforts by the CCT within the Okanogan watershed. Fire retardant (active ingredient ammonium polyphosphate) was inadvertently applied to the creek in attempts to control the St. Mary's Mission Fire during August 2001. The spill occurred during the first year of verified steelhead spawning in several decades and was therefore considered to have impacted this ESA-listed species. Sediment, water and fish sampling upstream, within, and downstream of the spill zone revealed a total fish kill, estimated at over 10,000 resident rainbow and brook trout for a distance of nearly 7 miles. Water samples in which dead fish were recovered had a maximum of 58 mg/L total ammonia early after the spill. Eight days after the spill the average concentration of ammonia was still measurable at 1.31 mg/L. Sediment concentrations greatly exceeded water concentrations but were spatially heterogeneous, with pockets of concentrated retardant along the riparian corridor and within stream sediments remaining for several months after the spill. Brook trout were the initial species found to recolonize aquatic habitat downstream of the spill, although their density upstream of the spill zone was less than $1/10^{th}$ that of resident rainbow trout. One year after the spill rainbow trout had recolonized all affected areas, but densities remained significantly depressed relative to the upstream control reach examined.

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* Presenting Author

## A WATERSHED-LEVEL NARRATIVE ANALYSIS OF MERCURY SOURCES IN THE WILLAMETTE RIVER BASIN

Hope, BK*, Land Quality Division, Oregon Department of Environmental Quality, Portland, OR

The Willamette River Basin (WRB) occupies an area of approximately 32,000 $km^2$ in northwestern Oregon, USA. Health advisories in the WRB currently limit consumption of fish that have accumulated methylmercury to levels posing a potential health risk for humans and create the requirement for a mercury Total Maximum Daily Load (TMDL). A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources, including natural background. As part of this TMDL process, an effort is underway to characterize mercury sources in the WRB. Gaining an initial understanding of mercury on the spatial and temporal scale of a watershed requires analyzing disparate fish tissue, sediment, surface water, and air data with a semi-quantitative narrative technique. The basin-wide median tissue concentration in 18 fish species is 0.28 mg/kg, close to the tissue criterion of 0.30 mg/kg. From 1969 to 1997, mean fish tissue concentrations dropped at three locations, rose slightly at three others, and rose ~3x at one location. Elevated tissue concentrations appear related to mine, industrial, or sanitary discharges. The spatial influence of mining discharges is limited by dams. Industrial and sanitary discharges impact mainstem areas, but a decline in major industrial dischargers has been offset by an increase in sanitary ones. In 1977, industrial discharges appeared to impact sediment concentrations at several locations but, by 2002, sediment levels were lower throughout the mainstem (with one exception). Regardless of its initial origin, mercury in bed sediment may be a continuing, low-level secondary source. Mean surface water concentrations are 0.58 ng/L for dissolved total mercury and 0.08 ng/L for dissolved methylmercury. Almost all mercury surface water concentrations approach those capable of driving mercury bioaccumulation in fish. Air emissions are not a dominant mercury source. Basin-wide, mercury levels cannot be attributed to only one source.

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## POTENTIAL RISKS POSED BY TURBIDITY AND SUSPENDED SOLIDS IN U.S. RIVERS

Cardwell, RD[1]*, Volosin, JS[2], Parametrix, Inc., [1]Corvallis, OR, [2]Buffalo, NY

Sediment runoff into streams is widely viewed as an important stressor of aquatic life, and turbidity—the water's light scattering and absorption properties—traditionally has been used to index and control these risks. However, suspended solids (SS) may be a more reliable index of risks because it is more closely related to sedimentation and changes in substrate particle size composition. Accordingly, this study examined the character of risks for turbidity and SS in a subsample of 10 rivers throughout the U.S. Monitoring data from the USGS were used to develop empirical distribution frequencies (edf's) that defined exposure, and the scientific literature was searched to develop edf's based on effects to plants, invertebrates and fish. Risks were calculated using conventional probabilistic methods. Turbidity generally posed higher risks than SS, based on the endpoints used and the assumed duration of ambient SS exposures. For example, turbidity risks exceeded 25% of the species and endpoints evaluated for 5 of the 10 rivers. Plants, protozoa and benthic invertebrates were the most sensitive species with respect to SS, and fish—including salmonids—were the most sensitive to turbidity. Major issues identified in this analysis included the following:

(1) Do water quality standards based on these metrics protect streams from all sediment effects, including sedimentation and % fines?
(2) How to account for natural background?
(3) Does protection of (clear water) species most sensitive to SS and turbidity select against species that require more turbid waters?
(4) Deciding what endpoints to use: Discriminating particulate (SS) from turbidity (light scattering/absorption) effects, and defining what endpoints have potentially consequential effects to organisms and species populations;
(5) Defining the averaging times for exposure and effects for risk estimation.

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## APPROACH FOR ASSESSING POTENTIAL CONTAMINANT RELEASES FROM COASTAL AND ESTUARINE HABITAT RESTORATION PROJECTS

Diefenderfer, HL*, Ward, JA, Battelle Marine Sciences Laboratory, Sequim, WA

Restoration in coastal areas may cause unintended landscape-scale effects by exposing sensitive marine or estuarine organisms to toxic residues. A general approach to this problem was developed and tested in a case study of the Willapa River Estuary Restoration Project, in Willapa Bay, Washington. The project would remove a century-old dike to permit tidal inundation of a grazed pasture, and create 450-acres of tidal marsh upriver of economically significant oyster beds. The study objective was to determine whether the site, in its present or post-restoration condition, posed adverse human health or environmental risk associated with release of contaminants or constituents into the Willapa River and Bay. Potential pre- and post-restoration exposure pathways were identified through analysis of chemical, biological, and soils data; field observations; topography; and engineering design information. Data generated through pre-restoration soil, sediment and water sampling were compared with regulatory criteria applicable to pre-restoration (freshwater) and post-restoration (estuarine) conditions. The systematic approach identified potential issues of concern, gathered appropriate data and observations, and assessed the potential effects of dike removal. It was determined to be unlikely that a complete exposure pathway would create unacceptable ecological risk at organism, community, or population levels, either before or after dike breaching; nor was there evidence that inundating the study area and enhancing contact to the Willapa River and Bay would pose a human health risk relative to shellfish harvesting. The approach shows promise as a tool for assessing potential ecological effects prior to implementing coastal and estuarine habitat restoration projects.

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## A WATERSHED-BASED APPROACH FOR IMPROVING ENVIRONMENTAL QUALITY IN SINCLAIR AND DYES INLETS, WA

Johnston, RK[1]*, Sherrell, GM[2], Kendra, W[3], Garland, D[3], Lawrence, S[3], Rylko, M[4], Turvey, M[4], May, CW[5], Richter, KE[1], Ostrom, T[6], Mecham, M[7], [1]Space and Naval Warfare Systems Center, [2]Puget Sound Naval Shipyard, [3]Washington Department of Ecology, [4]Environmental Protection Agency Region X, [5]Pacific Northwest National Laboratory, [6]Suquamish Tribe, [7]City of Bremerton

Under Section 303(d) of the Clean Water Act, Sinclair and Dyes Inlets and many tributary streams are listed as "impaired water bodies" by the State of Washington. To develop and demonstrate alternative strategies for protecting and improving the ecological integrity of the Sinclair/Dyes Inlet Watershed, the Puget Sound Naval Shipyard, the Environmental Protection Agency, the Washington State Department of Ecology, and other technical stakeholders are cooperating in an ENVironmental inVESTment (ENVVEST) project to develop Total Maximum Daily Loads (TMDL) and assess ecological risk within the watershed. By basing the assessment at the watershed scale, technical studies are providing data to address key issues identified by the ENVVEST technical working groups, improving the understanding of how the ecosystem functions, and increasing the ability to solve environmental problems. In November 2002, a collaborative TMDL study among participating stakeholders was initiated for fecal coliforms in Sinclair and Dyes Inlets. A three-dimensional model for simulating tides and currents within the Inlets is being linked to a unified watershed model to simulate loading of fecal coliform and other pollutants into the receiving waters. Ongoing work is being conducted to model combined sewer overflows, assess fecal coliform listings in tributary streams, address heavy metal listings in the sediments, and estimate the mass balance and historical loading of contaminants into the Inlets. The technical working groups are fostering partnering among stakeholders and establishing the technical and scientific basis to better protect and improve the health of the watershed.

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## EXPLORING BIOACCUMULATION OF PERSISTENT CONTAMINANTS IN FISH WITH A BIOENERGETICS MODEL

McIntyre, JK*, Beauchamp, DA, University of Washington, Washington Cooperative Fisheries and Wildlife Research Unit, School of Aquatic and Fishery Science, Seattle, WA

Persistent contaminants such as methylmercury and organochlorines accumulate in individuals and magnify in food webs. In Lake Washington, studies in the 1970s found elevated levels of mercury in upper trophic level fishes. Recent measurements of mercury and organochlorines in sediments and select biota suggest that levels of mercury may remain high. To better understand the current dynamics of persistent contaminants in the lake, an individual-based bioenergetics model of bioaccumulation is being developed. Historical data on prey mercury, lake temperature, food preferences, and life history were used to calibrate a bioenergetics model to historic mercury levels in yellow perch and northern pikeminnow. The current status of the model is discussed. A trend-line version of the model was used to explore two application scenarios; 1 - the effect of changes in prey mercury concentration on the proportion of yellow perch that are dangerous to fish-eating wildlife, and 2 - the effect of changes in the prey base on the proportion of the pikeminnow population that is dangerous to human health.

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## QUANTITATIVE WEIGHT OF EVIDENCE APPROACH IN ESTABLISHING CAUSAL LINKAGES FOR THE DECLINE OF THE CHERRY POINT, WA PACIFIC HERRING

Landis, WG*, Institute of Environmental Toxicology, Huxley College of the Environment, Western Washington University, Bellingham, WA

A classic problem in aquatic toxicology is the estimation of the causes of impacts observed in aquatic populations and communities. I used a weight of evidence (WoE) approach based upon our relative risk model in order to estimate the cause of the decline of the Cherry Point Pacific herring since the early 1970s. This WoE approach is based upon a risk assessment type conceptual model in order to link potential sources of stressors to the effects seen in the population. Ranking criteria are used to assign weights to the potential sources and stressors. Other criteria are used to establish filters to establish linkages between the stressors and the observed effects. A Monte Carlo analysis is applied to represent the uncertainty in each of the ranks and filters and to estimate the sensitivity of the models. This technique results in a series of multinomial distributions representing the likelihood of a stressor causing an impact. In the case of the Cherry Point herring, climate change, habitat alteration and widespread contamination were identified as important stressors. The method also pointed to key uncertainties that require further laboratory and field investigation. This case study demonstrates that a clearly derived and quantified WoE is a useful approach to investigating casual links.

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## EXPLORATION OF A GROWTH ENDPOINT FOR EARLY POST-HATCH PACIFIC HERRING

Marko, L*, Dinnel, P, Shannon Point Marine Center, Anacortes, WA

Shannon Point Marine Center has been developing Pacific herring (*Clupea pallasi*) embryo and larval bioassay protocols that might eventually be used for Whole Effluent Toxicity (WET) testing in the State of Washington. Ideally, a survival and growth larval test using feeding larvae will be developed as per a Consent Decree between the State of Washington and the oil industry. However, development of this specific protocol is uncertain due to difficulties in finding an appropriate food for larval herring and because larval herring can be adversely affected by handling stresses once they begin feeding. Therefore, the goal of this research was to investigate the utility of a growth endpoint for non-feeding herring. This is possible because larvae hatch with substantial endogenous energy reserves in the form of yolk. Thus, we are investigating the ability of larvae to convert yolk reserves to larval growth prior to their initiation of exogenous feeding. A key step will be the comparison of the sensitivity to toxicants of larval growth under both endogenous and exogenous feeding regimes.

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## EFFECTS OF 4-NP ON SMOLTIFICATION IN JUVENILE PACIFIC SALMON

King, KA[1]*, Grue, CE[1], Winton, JR[2], Dickhoff, WW[3], Kocan RM[4], [1]University of Washington, Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fishery Sciences, Seattle, WA, [2]USGS, Western Fisheries Research Center, Seattle, WA, [3]National Marine Fisheries Service, Montlake Laboratory, Seattle, WA, [4]University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA

Primary sources of surfactants in aquatic systems are sewage effluent and the use of these chemicals in conjunction with aquatic herbicides. Surfactants and their breakdown products, such as 4-NP, are currently not regulated by the Federal government or most State governments, in part because sufficient data on effects are lacking. With the recent listing of several runs of Pacific salmon within the Northwest including Puget Sound, recovery efforts are focusing on improving the quantity and quality of freshwater and estuarine habitats. Concerns over the potential effects of sewage effluent on freshwater and estuarine habitats in Puget Sound in connection with the Sound's shellfish industry and juvenile salmon habitats were recently highlighted by the press. Our objective was to determine the aqueous exposures of 4-nonylphenol (4-NP) which impair smoltification in outmigrating Pacific salmon using coho (*Onchorynchus kisutch*) as a model. Median lethal concentrations (96-h) were determined using hatchery and wild coho smolts and flowing water conditions. Survivors were subjected to a 14-d seawater challenge or clean freshwater. Endpoints were mortality and gill damage in addition to body weight and length, plasma vitellogenin, and hepatosomatic index. LC50s for wild smolts (189 ppb) were less than that for hatchery smolts (334 ppb), but the wild fish were substantially smaller and therefore probably received a greater exposure to the chemical. Mortality during the seawater challenge exceeded that of fish maintained in clean freshwater following the 96-h test. Nearly all mortality subsequent to the 96-h test occurred within the next 7 days. Results suggest that the ability of smolts to adapt to seawater following exposure to 4-NP is only impaired at concentrations that are themselves lethal in freshwater. Mortality occurred at concentrations that are 1-2 orders of magnitude greater than proposed water quality criteria (1-5 ppb).

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## TOXICITY OF R-11® SURFACTANT TO JUVENILE RAINBOW TROUT: DOES SIZE MATTER?

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Few studies have examined the relationship between fish size and the results of standardized toxicity tests. Available data suggest large fish may respond differently than small fish to chemicals under comparable test conditions, and that the relationship is not consistent. Comparisons for surfactants are lacking. Surfactants are added to herbicide tank mixes to improve the wetting, spreading, and dispersing properties of the active ingredient. They frequently represent the most toxic component of tank mixes and can be orders of magnitude more toxic than the active ingredient. Our objective of was to compare the toxicity of the surfactant R-11® to two different sizes of juvenile rainbow trout (O*ncorhynchus mykiss)*. Static 96-h acute toxicity tests were conducted. The 96-h LC50s for our large juveniles (15.46 g; 6.57 ppm) was statistically greater than that for their smaller (X=0.39 g; 5.18 ppm) counterparts. The absolute difference in the toxicity of R-11 to the two sizes of trout we tested was small (27%) in comparison to the difference in the size of the fish (ca. 40x). Results suggest that within the EPA test criterion (<3 g), differences in 96-h LC50s due to fish size may be as great as 200%. Two behavioral effects were observed: erratic swimming (ES) and on bottom gilling (OBG). ES was characterized by an inability to maintain correct horizontal or vertical orientation. Fish displaying OBG lay on their side or back with the only movement the opening and closing of the mouth and gills. Some were able to swim when disturbed, but quickly returned to the bottom. Similar narcoses have been reported in other taxa including amphipods and snails exposed to nonylphenol, and tadpoles exposed to nonylphenol ethoxylate and alkoxylate surfactants. The survival implications of ES, OBG, and similar narcoses are not known, but may not necessarily translate to death.

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## TOXICITY OF RODEO® AND TWO FORMULATIONS OF ARSENAL® TO JUVENILE RAINBOW TROUT

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Efforts to utilize herbicides in aquatic environments as part of Integrated Pest Management (IPM) Plans have been hampered by court injunctions over the potential non-target effects of active ingredients. However, adjuvants, chemicals added to formulations or tank mixes to increase the efficacy of active ingredients (e.g., surfactants) can represent the most toxic component of herbicide tank mixes and can be orders of magnitude more toxic than the active ingredients. Data on the relative toxicity of tank mixes (formulated herbicide product + adjuvants + carrier) to salmonids are lacking for herbicides with existing aquatic labels (e.g., Rodeo®) and those being considered for aquatic use (e.g., ARSENAL®). The aquatic toxicity of tank mixes to non-targets needs to be assessed, particularly in light of new State permitting processes in response to the most recent Federal Court injunction (9th Circuit Court, 2001) prohibiting the use of pesticides and surfactants in aquatic systems without a NPDES permit. Recent declines in several salmon runs increase concerns. The lack of data on toxicity of tank mixes threatens the permitting process and the success of IPM strategies. As an initial step in evaluating tank mixes of Rodeo® (ai=glyphosate) and ARSENAL® (ai=imazypyr), we determined 96-h static LC50s for Rodeo® and two formulations of ARSENAL® (ARSENAL® Herbicide [28.7 % ai] and ARSENAL® AC [53.1% ai] using juvenile rainbow trout (O*ncorhynchus mykiss*, ca. 0.65 g). Preliminary results suggest that all three formulations have relatively low toxicity to juvenile rainbow trout and that the LC50s differ by an order of magnitude (LC50 Rodeo = 631 ppm; LC50 ARSENAL Herbicide = 7,629 ppm; data for ARSENAL AC not yet available). Comparable data for several surfactants suggest that depending on the surfactant selected and its percentage of the tank mix, surfactants may pose a greater hazard to non-target species than the herbicide formulations tested.

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## REVISION OF THE PUGET SOUND AMBIENT MONITORING PROGRAM (PSAMP) SEDIMENT COMPONENT SAMPLING DESIGN

Dutch, ME*, Aasen, S, Partridge VA, Welch, KI, Long, ER, Washington State Department of Ecology, Olympia, WA

The Washington State Department of Ecology's Marine Sediment Monitoring Team (MSMT) is currently revising the Puget Sound Ambient Monitoring Program (PSAMP) Sediment Component. With assistance from EPA and regional stakeholders, the current probabilistic sampling design has been refined using a spatially-balanced, generalized random tessellation stratified (GRTS) multi-density survey design, and a revised list of sampling parameters is being generated. A nested set of sampling frames, including the whole sound, eight Puget Sound sediment sampling regions, and 5 strata within each of the 8 regions has been defined and will be sampled on a rotational cycle, alternating 8 years of regional sampling with 2 years of focus embayment sampling or special projects. Results will include annual spatial extent characterization of sediment quality (based on the sediment triad of toxicity, chemistry, and benthic infauna), along with temporal comparison of annual data and analyses to sediment baseline data. Details of this refined study design are described, and comment on the design is solicited.

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## CHEMICAL CONTAMINATION IN THE SAN JUAN ISLANDS, EASTERN STRAIT OF JUAN DE FUCA, AND ADMIRALTY INLET

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The quality of sediment is monitored by the Department of Ecology annually as a component of the Puget Sound Ambient Monitoring Program (PSAMP). The primary objectives of this monitoring program are to quantify the spatial extent and geographic patterns in degraded sediment quality. Using the Sediment Quality Triad approach, data are evaluated on the chemical contamination and toxicity of sediments along with analyses of the composition of the resident infaunal benthos. During June of 2002, Ecology collected 40 samples in the bays and inlets of the San Juan Islands, eastern Strait of Juan de Fuca, and Admiralty Inlet. A stratified-random method was used to identify sampling locations to ensure a lack of bias. Included in the analyses, was a quantitation of 118 chemicals. Preliminary evaluation of these data include generation of graphical displays to illustrate the spatial distribution of chemical contamination in these three sediment monitoring regions, and to identify stations where concentrations exceeded either Washington State sediment quality standards and/or national sediment guidelines. These data will later be combined with other sampling data collected by Ecology to generate estimates of both the spatial extent of contamination and overall sediment quality in these three sediment monitoring regions.

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## SEDIMENT TOXICITY IN THE SAN JUAN ISLANDS, EASTERN STRAIT OF JUAN DE FUCA, AND ADMIRALTY INLET

Long ER*, Aasen S, and Dutch ME, Washington State Department of Ecology, Olympia, WA.

The quality of sediment is monitored by the Department of Ecology annually as a component of the Puget Sound Ambient Monitoring Program (PSAMP). The primary objectives of this monitoring program are to quantify the spatial extent and geographic patterns in degraded sediment quality. Using the Sediment Quality Triad approach, data are evaluated on the chemical contamination and toxicity of sediments along with analyses of the composition of the resident infaunal benthos. During June of 2002, Ecology collected 40 samples in the bays and inlets of the San Juan Islands, eastern Strait of Juan de Fuca, and Admiralty Inlet. A stratified-random method was used to identify sampling locations to ensure a lack of bias. Included in the analyses, was a battery of four laboratory toxicity tests. Preliminary evaluation of the data from these tests indicated a small minority of samples was toxic in all four tests and there was relatively little overlap or concordance in results among the four tests. These observations suggest that the quality of sediments in these three regions was comparable to that of some of the least degraded regions previously studied by this program in Puget Sound.

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## *EOHAUSTORIUS ESTUARIUS*: A REVIEW

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The infaunal amphipod *Eohaustorius estuarius* is widely used in marine sediment toxicity tests. Recently, questions have been raised regarding this amphipod's sensitivity to contaminants, and to a number of potentially confounding factors that may mask responses to chemical exposure. We conducted a review of the available literature and in-house laboratory data to evaluate these issues. *E. estuarius* showed tolerance to a number of factors unrelated to toxicant exposure, such as salinity, temperature, ammonia, sulfide, and grain size, suggesting that few false positive results would be expected with this species. The *Eohaustorius* test has successfully detected field contamination gradients and shown agreement with other amphipod species tests in comparative sediment assessments. Single-chemical water-only tests have sometimes shown *Eohaustorius* to be less sensitive than other species (e.g. to cadmium, compared to *Rhepoxynius*), and sometimes more sensitive (e.g. to TBT, compared to *Rhepoxynius*). Review of data generated at our laboratory from 1994 to the present, where the *Eohaustorius* 10-day test, the *Neanthes* 20-day survival and growth test, and the sediment larval test were conducted on the same samples showed that the *Eohaustorius* test was sometimes the only test which detected toxicity, and frequently agreed with at least one of the other tests in assessment of sediments. In summary, *Eohaustorius estuarius* is a hardy test species, and the *E. estuarius* test is one of a battery of sensitive tests that can be used with other tests and tools to create a complete picture of an environmental situation.

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**APPLICATION OF PAH NARCOSIS THEORY TO SEDIMENT REMEDIATION AT MGP SITES**

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This paper examines the applicability of the US EPA draft Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures to developing site-specific cleanup values for sediments at Manufactured Gas Plant (MGP) sites. Remediation goals for sediments at MGP sites for PAHs are frequently set based upon bulk sediment criteria derived from the literature, without consideration of the potential bioavailability of those compounds. Analysis of two case studies suggests that depending upon the source, partitioning of PAHs into the porewater does not follow that predicted by the Equilibrium Partitioning (EqP) theory. Residual PAHs in sediments at MGP sites typically consist of weathered non-aqueous phase liquids (NAPLs), old oil pockets, coke, soot, or other similar fractions. These fractions tightly bind PAHs, making them biologically unavailable. Thus, while bulk sediment measurements at an MGP site may contain elevated levels of PAHs, data will be presented that demonstrate that only a portion of the sediment-bound PAH fractions partition into the porewater. Remedial action decisions should then be based on actual, measured concentrations of dissociated PAHs. This paper will present case study results, as well as how ESBs can be interpreted to derive site-specific risk and remediation goals.

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## USE OF SEDIMENT QUALITY GUIDELINES (SQGS) AND RELATED TOOLS FOR THE ASSESSMENT OF CONTAMINATED SEDIMENTS – PELLSTON WORKSHOP GROUP

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This presentation summarizes the results of a SETAC Pellston Workshop on the use of sediment quality guidelines (SQGs) for evaluating contaminated sediments. The workshop was held in August 2002 at the Fairmont Hot Springs Resort in Fairmont, Montana USA. The full proceedings of the workshop will be published at the end of 2003. The workshop included nearly 60 invited experts from 8 countries representing academia, industry, government, non-governmental environmental organizations, and private research organizations. The SQG Workshop was the latest in a series of SETAC-sponsored meetings of experts to review the state-of-the-science of different assessment tools such as toxicity testing, benthic community evaluations, bioaccumulation studies, higher trophic level evaluations, and food web modeling. Previous SETAC workshops focused on sediment ecological risk assessment (Dickson *et al.*, 1987; Ingersoll *et al.*, 1997) and pore water toxicity testing (Carr and Nipper, 2003). Another recent workshop addressed the application of weight-of-evidence methods in ERA (Burton *et al.*, 2002). This workshop focused on evaluation of the scientific foundations supporting different numeric SQG approaches, and on methods to improve the integration of SQGs into different sediment quality assessment frameworks that include information derived from multiple chemical and biological lines of evidence. By building consensus on specific technical questions, experts were tasked to provide recommendations for improving methods for assessment of sediment quality and evaluating ecological risks. This interactive poster session highlights the discussions and conclusions reached in five key aspects of the current debate on sediment quality assessment, including (a) the scientific underpinnings and uncertainties associated with SQGs; (b) whether SQGs adequately represent the potential for effects or no effects observed on aquatic biota; (c) the role of SQGs in sediment assessment frameworks; (d) consideration of other assessment tools in combination with SQGs; and, (e) the use of SQGs and other tools in different aquatic systems.

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## SEDIMENT QUALITY GUIDELINES DERIVED WITH THE EFFECTS-RANGE APPROACH

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To aid in the interpretation of sediment chemistry data from the National Status and Trends Program of NOAA, numerical guidelines were derived for 25 substances plus three classes of PAHs. Guidelines were derived using matching chemistry and biological effects data compiled from nearly 100 individual studies completed along all three North American coastlines. Chemical data for each substance were sorted in ascending order and the $10^{th}$ percentiles and $50^{th}$ percentiles of concentrations associated with adverse biological effects were determined. Effects – Range Low (ERL) values ($10^{th}$ percentiles) were intended to represent concentrations below which toxicity would be rarely expected, whereas the Effects – Range Median (ERM) values were intended to represent concentrations above which effects would be expected more frequently. Both sets of guidelines were intended to be used as informal (i.e., non-regulatory) tools. Nevertheless, they have been used in the USA and other countries for a variety of purposes, including litigative, regulatory and enforcement actions. The ability of the ERLs to successfully predict the absence of toxicity and the ability of the ERMs to correctly predict the presence of toxicity and adverse benthic impacts have been evaluated in numerous trials nationwide and in other countries, using independent databases. In addition, a multi-chemical index derived as mean ERM quotients has been shown to be predictive of acute toxicity. The ERL and ERM values have not been used extensively in Puget Sound because of the existence of the sediment quality standards derived with local data by the state of Washington, but many of the values for the same chemicals are similar.

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## EXPLORATION OF THE PREDICTIVE ABILITY OF PUGET SOUND AETS.

Gries, TH*, Washington Department of Ecology, Lacey, WA

The Apparent Effects Threshold (AET) approach to establishing sediment quality guidelines was developed in the mid-1980s. AET values based on synoptic chemical and biological data from the Puget Sound sediments were calculated and evaluated for their ability to predict several measures of toxicity as well as benthic community level effects. These Puget Sound AETs have never undergone a comprehensive revision. Moreover, the predictive ability of the original AET values, on which current guidelines and State sediment quality criteria are based, has not been evaluated in manners analogous to those commonly used by developers of other sediment quality guidelines, e.g., Effects Range Median (ERM), Probable Effects Concentration (PEC). The author will present recent results from an examination of the relationship between number of chemicals exceeding State criteria and biological effects considered to be unacceptable. Results from predicting significant adverse effects using a mean AET quotient approach will also be presented.

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## DEVELOPMENT OF FRESHWATER SEDIMENT QUALITY GUIDELINES FOR WASHINGTON STATE

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An overview will be provided of progress to date in developing freshwater sediment quality guidelines for Washington State. Phase I work has been completed, and includes assembly and quality assurance evaluation of an up-to-date freshwater database, assessment of the reliability of eight sets of existing freshwater sediment quality guidelines against the regional data set, evaluation of the marine AETs against the regional freshwater data set, the relative reliability of comparison to control vs. comparison to reference, and exploratory work into updating the 1997 freshwater AETs and using recently developed approaches such error rate minimization techniques. Phase II results to date will also be presented, including updating of AETs and PAETs, and calculation of alternative guidelines using error rate minimization techniques, narcosis-based PAH summing, quotient methods, and/or logistic regression modeling, depending on which combination of approaches results in guidelines with the best reliability.

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## PREDICTING TOXICITY FROM SEDIMENT CHEMISTRY USING LOGISTIC REGRESSION MODELS: REGIONAL AND SITE-SPECIFIC APPLICATIONS

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Individual chemical logistic regression models were developed for 37 chemicals of potential concern (COPCs) in contaminated sediments to predict the probability of toxicity, based on the standard 10-d survival test for the marine amphipods *Ampelisca abdita* and *Rhepoxynius abronius*. These models were derived from a large database of matching sediment chemistry and toxicity data, which includes chemical gradients from a variety of habitats in coastal North America. The regression models for each COPC were combined into a single model by using the maximum probability predicted from the chemicals analyzed in a sample. This combined model, referred to as the P_Max model, provides an estimate of the probability of toxicity for a sample. The average predicted probability of toxicity closely matched the incidence of toxicity within probability intervals, demonstrating the overall reliability of the P_Max model for the database that was used to derive the model. The magnitude of the toxic effect (decreased survival) in the amphipod test also increased with increasing predicted probability of toxicity, indicating that samples with the highest probability of toxicity are also likely to be extremely toxic. These models provide a framework for regional and site-specific applications. Examples of applications of this approach to independent regional data sets and other marine and freshwater test endpoints will be discussed.

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## USE OF SEDIMENT QUALITY GUIDELINES IN OREGON'S SEDIMENT EVALUATION PROCESS

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In late 2001, the Oregon Department of Environmental Quality (DEQ) began developing a *Sediment Evaluation Guidance* to: (1) assist DEQ project managers in making decisions at State cleanup sites with contaminated sediment issues, (2) facilitate gathering and interpretation of data needed to assess attainment of sediment management goals, and (3) provide information to assist in identifying and selecting appropriate remedial action(s), if necessary, to "…protect human health and the environment…" An external review draft was released for public comment in July 2002. For toxicity, if individual bulk sediment chemistry values are below the threshold effects level (TEL), no further investigation is needed or, if they are above the probable effects level (PEL), bioassay testing is necessary. Between the TEL and PEL, bioassay testing is recommended to address uncertainty in receptor response. For bioaccumulation, if sediment chemistry values are below a bioaccumulation SLV or there is no detection (i.e., if the detection limit is greater than the SLV) no further investigation is needed; otherwise bioaccumulation bioassays are recommended. Of the 355 substantive public comment received, 51% were directed at the derivation and use of toxicity and bioaccumulation SLVs. These comments, work recently completed by the Washington Department of Ecology, and an August 2002 SETAC Pellston workshop, suggest that DEQ adopt another approach to toxicity evaluation. Current thoughts are to pre-screen based on frequency of detection, background concentrations, and ambient levels. Then, for toxicity, if the average contaminant/TEL ratio is $\leq 1$, no further investigation is needed or, if the average contaminant/PEL ratio is $\geq 0.5$, bioassay testing would be necessary. Between these ratios, there would be narrative guidance indicating to a project manager that the need for bioassays diminishes as the average contaminant/PEL ratio falls below 0.5. These numeric criteria would be used in the context of a risk-based, weight-of-evidence process.

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## REGIONAL SEDIMENT EVALUATION TEAM (RSET) PROCESS

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The appropriate assessment of the sediment quality of dredged material is a critical component to all dredging and disposal management activities regardless of whether the dredging is for routine maintenance of a navigation channel or remediation of contaminated sediments. The Regional Sediment Evaluation Team (RSET) is an interagency team, co-chaired by the EPA, Region 10 and the Northwestern Division of the Corps, consisting of federal and state agencies with regulatory responsibilities for managing sediments. The RSET effort is a specific task being performed for the Northwest Regional Dredging Team (RDT). The original intention of the Regional Dredging Team (RDT) was to facilitate coordination and resolution of dredging issues at the federal agency level. However, the Corps and EPA agree that direct state and tribal participation in the dredging/sediment dialogue is critical to the success or failure of the RDT process. The RDT's intention is to have a revised Dredged Material Evaluation Framework (DMEF) manual, which could consolidate existing regional guidance manuals (e.g., PSSDA, Grays Harbor and Willapa Bay, Washington, Lower Columbia River, McNary and Lower Snake River Reservoirs, etc.), that will be technically applicable throughout the Pacific Northwest for both freshwater and marine sediments and could include upland disposal as well as in-water disposal. Therefore, RSET conducted a three-day technical scoping workshop in September 2002 to identify technical and policy issues required to update the existing Columbia River DMEF. The general consensus was that developing a regional DMEF for the Northwest was an extremely worthwhile process even though there are a number of policy and technical challenges to resolve. The current status of the RSET process will be presented with a discussion of the technical challenges (e.g., the development, applicability, and use of sediment quality guidelines) facing the successful completion of the regional DMEF.

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## THE S.T.A.R.R. PROCESS: AN APPROACH TO EVALUATETHE EFFECTS OF CONFOUNDING FACTORS

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Those properties of a test matrix or testing process that affect our interpretations of "cause and effect" relating observed toxicity and its relationship to contaminants of concern are considered "confounding factors" (CFs). The appropriate response to confounding factors will vary depending upon the nature of the assessment and the class of confounding factor. This paper will present a systematic approach for determining the class of confounding factor that may be present in a sediment matrix and determining what interpretive or testing method that may be appropriate. The four classes of sediment characteristics that may cause toxicity are persistent physical characteristics, persistent chemical characteristics, non-persistent sediment characteristics, and non-matrix characteristics. The S.T.A.R.R. process is a stepwise approach that builds upon previous information on confounding factors and provides a decision tree for responding to CFs. The steps are: **Select** the appropriate test species for the specific toxicity assessments type that is being addressed. **Test** under the appropriate conditions provided for the test species and this toxicity assessment type. **Account** for the influence of the CF by direct comparison to established references or compare the test results with reference tests conducted at the same time to evaluate the CF being addressed. **Remove** the CF and test, and then **Replace** the CF and test to determine if the same response is obtained relative to the presence or absence of the CF. The goal of this process is to provide information that correctly attributes toxicity to a particular sediment characteristic(s). Application of this knowledge will then depend upon the purpose of the sediment evaluation and the associated regulatory framework.

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Society of Environmental Toxicology and Chemistry
(PNW-SETAC)

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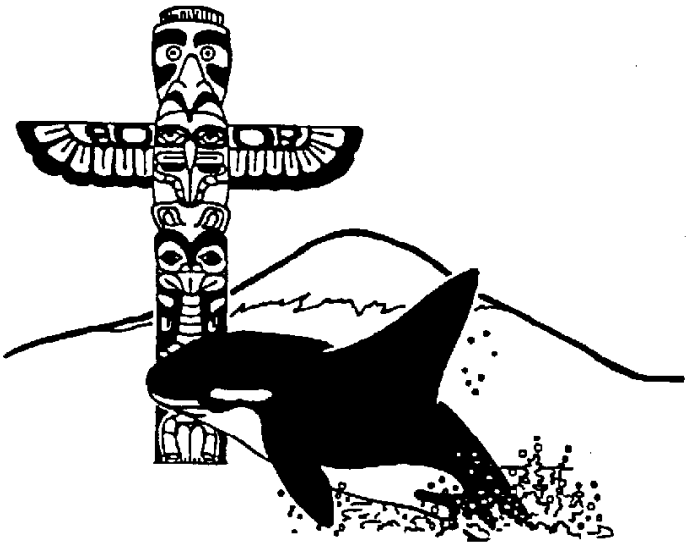

# Poster Presentation Abstracts

## SUBLETHAL IMPACTS OF COPPER ON OLFACTION AND OLFACTORY-MEDIATED BEHAVIORS IN JUVENILE COHO SALMON (*ONCORHYNCHUS KISUTCH*)

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Copper is one of the most frequently detected trace elements in surface waters from agricultural and urbanized watersheds. Here we evaluated the sublethal effects of short-term copper exposures on the olfactory neurophysiology and olfactory-mediated behaviors of juvenile coho salmon. Recordings from the olfactory epithelium (electro-olfactograms) were used to measure the inhibitory effects of copper on the responses of olfactory receptor neurons to natural odorants (amino acids, the bile salt taurocholic acid, and a conspecific skin extract). Copper reduced the responsiveness to all odorants within 20 minutes of exposure. The inhibitory effects of copper were dose-dependent and they were not influenced by water hardness. Toxicity thresholds for the different receptor pathways were determined using the benchmark dose method and found to be similar (~ 6 µg/L total dissolved copper). For salmon, olfactory function underlies a wide range of behaviors that are import for survival, migration, and reproductive success. To address the impacts of copper on salmon behavior, we are currently exploring the consequences of sensory impairment for behaviors that are related to predator avoidance and juvenile survival.

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## EVALUATING POLYCYCLIC AROMATIC HYDROCARBONS ECOLOGICAL THRESHOLD CONCENTRATIONS FOR SEDIMENT USING LOGISTIC REGRESSION MODELING

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This poster describes the use of logistic (logit) regression modeling for evaluating relationships between sediment chemistry and toxicity data in the development of ecological threshold concentrations (ETCs) for polycyclic aromatic hydrocarbons (PAHs) in sediment. ETCs will be used in the development of performance standards for the design of a sediment cap. E & E's comparison of two data sets illustrates an important application of the logit model approach, which enables the determination of the probability of a biological effect given a chemical concentration. The logit models were initially developed by PTI Environmental Services during the 1992 remedial investigation (RI) of the McCormick & Baxter Creosoting Company (McCormick & Baxter) National Priority List site, located on the Willamette River in Portland, Oregon. E & E evaluated the goodness of fit and ETCs using data collected during the 1992 RI (organic carbon normalized and dry-weight concentrations reported) and the 1999/2001 remedial design (RD) sampling (dry-weight concentrations reported). E & E used numerical estimation to solve for the ETC given the logit model equation and a significant *Hyalella azteca* (*Hyalella*) mortality of 25 percent. The Spearman rank correlation coefficients were higher for 1992 RI dry-weight concentrations, rather than 1992 RI organic carbon normalized values. Lower ETCs were developed using the 1999/2001 RD data, which consisted of much lower PAH concentrations than the 1992 RI data and were less correlated with *Hyalella* mortality than the 1992 RI data. The site-specific ETCs developed using logit models are in general higher than PAH sediment benchmarks developed from other databases, which indicate that factors at the McCormick & Baxter site may limit bioavailability of PAHs. The logit models also displayed false negatives, which indicate that other factors, rather than PAH concentrations alone, may lead to *Hyalella* mortality, particularly at low PAH concentrations.

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## TOXICITIY OF FOUR SURFACTANTS TO JUVENILE RAINBOW TROUT: IMPLICATIONS FOR OVER-WATER USE

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Herbicides are frequently used to control exotic or nuisance aquatic plants. Utilization of herbicides in Integrated Pest Management Plans to control aquatic weeds has been hampered by court injunctions directed at the non-target toxicity of the active ingredients. However, surfactants frequently represent the most toxic component of herbicide tank mixes. The objective of our study was to develop dose response curves for juvenile rainbow trout (O*ncorhynchus mykiss*) exposed to four surfactants either currently in use (R-11®, LI 700®) or proposed for use (AGRI-DEX®, HASTEN®) in Washington State. Standardized static 96-h acute toxicity tests were conducted. Median lethal concentrations for the four surfactants were R-11, 6.0; LI 700, 17; HASTEN 74; and AGRI-DEX 271 ppm. Most fish succumbed within the first 24 h. This was particularly true for R-11 and is reflected in the ratio of the 96:24-h LC50s (1.02). Two behavioral effects were observed: erratic swimming (ES) and on bottom gilling (OBG); although only OBG was consistently recorded in R-11 and LI 700 treatments. ES was characterized by an inability to maintain correct horizontal or vertical orientation. Fish displaying OBG lay on their side or back with the only movement the opening and closing of the mouth and gill covering. Some were able to swim when disturbed, but quickly returned to the bottom. Similar narcoses have been reported in other taxa including amphipods and snails exposed to nonylphenol, and tadpoles exposed to nonylphenol ethoxylate and alkoxylate surfactants. Some recovery to normal was observed at the three lowest concentrations of R-11. LI 700 has been considered the safest of the surfactants currently approved for over-water use. However, our results indicate that it is more toxic than HASTEN and AGRI-DEX and depending on concentrations in the tank mix, LI 700 may pose the greater environmental hazard.

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## SUBLETHAL EFFECTS OF THE CARBAMATE INSECTICIDE, CARBARYL, ON COASTAL CUTTHROAT TROUT

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Willapa Bay is a coastal estuary in Washington State that provides habitat for cutthroat trout (*Onchorhynchus clarki clarki).* In the estuary, schools of trout forage in shallow water along beaches, around oyster beds, and in patches of eel grass. Cutthroat trout use the estuary in the summer months when carbaryl, a carbamate insecticide, is applied to oyster beds to control burrowing shrimp populations. Carbaryl is a neurotoxicant that inhibits acetylcholinesterase, an enzyme that hydrolyzes the transmitter acetylcholine at neuronal and neuromuscular synapses. In the present study we assessed whether cutthroat trout can detect and avoid carbaryl in seawater. We also evaluated the effects of carbaryl on acetylcholinesterase activity using exposure concentrations and durations that are representative of conditions in the estuary on the day of pesticide application. We find that carbaryl does not evoke a measurable response from the cutthroat olfactory epithelium, and that animals do not avoid carbaryl-contaminated seawater in two-choice laboratory tests. Six hour carbaryl exposures significantly reduced acetylcholinesterase activity in both brain and muscle in a dose-dependent manner. Therefore, carbaryl applications in the estuary may impair the behavioral performance of cutthroat trout and increase the predation vulnerability of exposed animals.

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## DEVELOPMENT AND VALIDATION OF A PACIFIC HERRING EMBRYO BIOASSAY PROTOCOL

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Shannon Point Marine Center has been developing both embryo and larval Pacific herring (*Clupea pallasi*) bioassay protocols for possible use as Whole Effluent Toxicity (WET) tests in the State of Washington. The embryo bioassay has been under development for several years and is now undergoing intra-laboratory validation. The embryo test is conducted over a 16-day exposure period starting with newly fertilized eggs. Ovaries and testes can be harvested locally or shipped from locations up and down the Pacific coast via an overnight express service. Test exposures to toxicants and control seawater take place in Petri dishes with the following exposure conditions: 16 ‰ seawater, 10 ˚C, light intensity of 20 to 100 lux, and a photoperiod of 16 hours light:8 hours dark. Test and control solutions are changed at 2-day intervals through Day 10. Possible test endpoints include: Percent normal hatch, heart rate at about day 8, embryo movement rate at day 8, time to 50% hatch, larval length at hatch, larval yolk sac size at hatch and larval dry weight at hatch. Data for about a half dozen reference toxicants will be presented.

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## RECOVERY AND MANAGEMENT OF SOILS AND VEGETATION FOLLOWING 100 YEARS OF LEAD SMELTER OPERATION

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An ecological risk assessment has been undertaken to determine risk of heavy metals contamination to vegetation and wildlife near the Teck Cominco Metals Ltd lead and zinc smelter at Trail British Columbia, Canada. Several consulting groups, as well as B.C. and U.S. regulators and stakeholders have contributed to this process. The smelter has run continuously since 1897. During the first and second World War, it produced a maximum of 750 tonnes of sulphur dioxide per day. Damage to vegetation was extensive. In the 1930's a large area was completely de-vegetated within the 'fume zone'. Sulphur dioxide recovery and the installation of a KIVCET smelter has reduced emissions to less than 10 tonnes per day, and dramatic recovery of the vegetation as been evident since 1975. However, remediation of areas that have unacceptable levels of persistent damage from past emissions is an endpoint of the risk assessment. An extensive field program to determine concentrations of heavy metals in soils and the biophysical characteristics of the area has been completed. Kriging interpolation has been used to define the spatial extent of metal concentrations. A biophysical habitat map, based on terrain, soils and vegetation communities has been compiled and is in the final draft stage. Past and recent remediation has been undertaken by Teck Cominco Metals Ltd and it's previous parent company (Cominco Ltd., Trial Operations). This body of information and the biophysical database and maps are being used, with public and other stakeholder involvement to assist in the recovery of vegetation and wildlife habitat in the Trail area. This paper presents the process we have followed, some of the problems facing remediation, and the contribution the biophysical database and mapping has made to remediation planning and activities.

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## A WILLAMETTE RIVER BASIN-SPECIFIC AQUATIC FOOD WEB BIOMAGNIFICATION MODEL FOR ESTIMATION OF MERCURY TARGET LEVELS

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In Oregon's Willamette River Basin (WRB), health advisories currently limit consumption of fish that have accumulated methylmercury to levels posing a potential health risk for humans. Under the Clean Water Act, these advisories create the requirement for a Total Maximum Daily Load (TMDL) for mercury in the WRB. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Because methylmercury is known to biomagnify in aquatic food webs, a biomagnification factor can be used, given a protective fish tissue criterion, to estimate total mercury concentrations in surface waters required to lower advisory mercury concentrations currently in fish in the WRB. This paper presents a basin-specific aquatic food web biomagnification model that simulates inorganic (Hg[II]) and methylmercury accumulation in fish tissue and estimates WRB-specific biomagnification factors for resident fish species of concern to stakeholders. It was calibrated with WRB-specific fish tissue and surface water data. Probabilistic (two-dimensional Monte Carlo) techniques propagate stochastic variability and uncertainty throughout the model, providing decision makers with credible range information and increased flexibility in establishing a specific mercury target level. The model predicts the probability of tissue mercury concentrations in eight fish species within the range of concentrations actually measured in these species during 25+ years of water quality monitoring. Estimated mean biomagnification factor values range from $1.12 \times 10^6$ to $7.66 \times 10^6$ and are within the range of such values estimated by U.S. EPA on a national basis. Several WRB-specific mercury target levels are generated, which vary by their probability of affording human health protection relative to the U.S. EPA methylmercury tissue criterion of 0.30 mg/kg. Establishing a specific numeric target level is, however, a public policy decision, and one that will require further discussions among the various WRB stakeholders.

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## EFFECTS OF COPPER ON MECHANOSENSORY STRUCTURES IN DEVELOPING FISH EMBRYOS AND LARVAE

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Copper is a common contaminant in urban stormwater runoff. There are many sources of copper in urban watersheds, including residential pesticide use, vehicle brake pads, and stormwater drainage systems. It has previously been shown that copper is highly toxic to ciliated sensory neurons in fish, and the periodic transport of copper to surface waters could impair the health and survival of salmonids or other fish species that spawn in urbanized habitats. In the present study we use the zebrafish (*Danio rerio*) as a surrogate model to examine the effects of copper on the development and function of the lateral line system in fish. We used *in vivo* fluorescent imaging in combination with a vital dye (DASPEI) that stains ciliated lateral line neurons and neuromasts to examine the impacts of copper on the development of ciliated mechanosensory neurons. We find that short-term copper exposures at concentrations that are representative of urban stormwater runoff in Puget Sound streams are sufficient to induce cell death and a loss of peripheral sensory structures in developing zebrafish. Consequently, short-term exposures to copper in urban stormwater runoff may impair a sensory system that plays an essential role in orientation, schooling, and predator avoidance in salmon and other fish species.

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## TOXICITY EVALUATION OF SODIUM SULPHIDE USING ACUTE LIQUID PHASE MICROTOX® TEST

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A pulp and paper mill was examining toxicity problems using Microtox® tests, and sulphide was suspected as the toxic agent. No literature data concerning the toxicity of sulphide towards marine bacteria was obtainable so BC Research was contracted to assess the effect of sulphide to *Vibrio fischeri*. -The acute liquid phase Microtox® basic test was conducted, with some deviations, on salinity (20 ‰ w/v) and pH-adjusted (7.5), MOPS (3-[N-Morpholino]propanesulfonic acid) buffered sodium sulphide ($Na_2S$-$9H_2O$) solutions. A total of four Microtox® tests were conducted. For each test, six sulphide concentrations and duplicate negative controls were prepared using buffered pH and salinity adjusted dechlorinated Vancouver city water. Light readings were measured at 5, 15, and 30 minutes of exposure, using a Microtox® 500 analyzer. The pH and salinity of each of the sulphide solutions was measured before and after the tests were completed. Sulphide concentrations in the test solutions were determined iodometrically. The measured concentrations of sulphide in the test solutions were used to calculate the EC50 values. The mean EC50 values, based on reduction in light production, and standard deviations for 5, 15 and 30 minute exposures to MOPS buffered sodium sulphide solutions (pH 7.5) were 91.4 ± 10.6; 57.7 ± 5.5; and 49.5 ± 3.0 mg $S^{2-}$/L respectively.

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## APPLICATION OF GIS-BASED TOOLS IN SEDIMENT QUALITY ASSESSMENT

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To support geographic analysis of sediment chemistry and toxicity data, a relational database was developed in MS Access format and populated with georeferenced data from a Great Lakes Area of Concern. Next, theme and attribute data, as well as a map background, were obtained from various sources and combined in an ESRI ArcView format project file. Subsequently, the data were evaluated using consensus-based sediment quality guidelines (SQGs) and the results were geographically presented by characterizing sampling sites in terms of (1) contaminant concentrations (represented as mean SQG-quotients) and (2) toxic or non-toxic toxicity test results. The resultant ArcView generated maps provide powerful tools for conducting assessments of sediment quality conditions by providing a means of evaluating the areal extent of sediment contamination or toxicity. The key factors to consider when constructing ArcView projects are discussed.

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## HERRING TODAY, GONE TOMORROW? A HISTORICAL REVIEW OF THE CHERRY POINT HERRING STOCK IN RELATION TO OTHER GEORGIA BASIN/PUGET SOUND STOCKS

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A regional ecological risk assessment was conducted for the Cherry Point area in northern Puget Sound, Washington. The objective was to determine the most probable causes for the twenty-year decline in Pacific herring abundance at Cherry Point, as well as the loss of older age-class fish. A literature review was also conducted to ascertain the historical and current status of other Georgia Basin and Puget Sound herring stocks in relation to the Cherry Point stock. The relative risk model (RRM) was used to rank potential sources and types of stressors in the Cherry Point region in relation to type and magnitude of observed effects to the Pacific herring stock. Risk hypotheses and estimates of uncertainty for each of the risk factors were also formulated during the assessment process.

Retrospective risk assessment results indicate that warmer sea surface temperatures due to the warm Pacific Decadal Oscillation (PDO) regime from 1977 to the present, as well as historical overexploitation of herring were the primary risk factors contributing to the decline in Cherry Point herring. These factors could account for both the decline in abundance and compression of age-class structure observed in the Cherry Point herring stock and could account for similar declines in other Georgia Basin/Puget Sound stocks as well. Other potential contributing factors that could have specifically affected the Cherry Point stock included possible exposure to contaminants in foraging and spawning areas, as well as higher natural mortality rates due to increased predation. The contributions of these secondary risk factors to the decline are highly uncertain due to the lack of data so were not included in the risk calculation.

The greatest potential future risk that threatens the preservation and sustainability of the Cherry Point, as well as the other Georgia Basin/Puget Sound herring stocks, is destruction of their spawning habitat.

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## REAL-TIME MEASUREMENT TECHNOLOGY FOR ENVIRONMENTAL EXPOSURES

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A new technology, in the form of an atmospheric chamber, advances the state-of-art in atmospheric and analytical chemistry with its capability to measure higher molecular weight, semi-volatile chemicals, aerosols, biological surrogates and chemical mixtures. This chamber was designed to measure chemical concentrations and exposures and has the ability to determine chemical kinetics and track changes over time. **It is currently the only known large research chamber capable of doing this type of research.** This large room-sized, Teflon chamber allows chemicals to interact and react in a natural way in response to light energy, photochemical reactants, and various environmental media. The chamber's special analytical instruments have low detection limits and long path-lengths to allow measurements of chemicals at or near ambient concentrations (e.g., background levels). In addition, a unique large-volume pre-concentrator has been incorporated to draw chemicals directly from the chamber (using heated fused-silica lines with small inner diameters), to minimize residence times, and enhance GCMS analysis. It is also possible to place selected environmental media (vegetation, water, etc) into the chamber and examine single and multiple chemical reactions. A geographic location can be simulated using a variety of plants, soils, water and surfaces to investigate specific exposures. Previous work involving the fate and transport of chemicals indicated that large data gaps existed for characterizing the less-volatile to minimally-volatile compounds of interest. These durable compounds included herbicides, pesticides, terrorist and warfare chemicals, and cancer-causing, compounds that will persist in the environment and on exposed surfaces. The chamber is also capable of tracking the behavior of aerosols as they intereact with chemicals and surfaces. This chamber technology will provide a real-time analytical tool for environmental measurements and exposures.

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## EVALUATION OF PCB CONGENER PATTERNS IN SEDIMENT, BIVALVES AND FISH: A CASE STUDY

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The primary objective of the study in which these data were collected was to more clearly define the extent of sediments that pose an unacceptable risk to the environment and require evaluation in a feasibility study for offshore sediments. Co-located sediment chemistry and bivalve tissue (*Macoma nasuta* 28-day bioaccumulation assays) were acquired for 23 stations in one area of the site. Forage fish tissue (gobies and sculpins) were collected within the area, and sports fish (surfperch and jacksmelt) were collected nearby. Sediments and tissue were analyzed for numerous compounds, including 22 individual PCB congeners. A principal components analysis (PCA) was conducted on the sediment and tissue PCB congener data. Different congener patterns in sediments were observed in different portions of the area, reflecting distinct source inputs. A similar spatial pattern of congeners was seen in the tissue data, but tissues exhibited a lighter congener distribution than the sediments.

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## APPLYING POPULATION MODELS IN CHEMICAL RISK ASSESSMENT

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Ecological risk assessments play an increasingly important role in environmental regulatory programs. However, most assessments fail to address key ecological information and instead rely on simplistic hazard quotient approaches with toxicological endpoints that relate only to the survival, growth, and reproduction of individual organisms. Ecological models may be used to extrapolate effects on individual-level endpoints to predict the responses of population, ecosystem, and landscape endpoints. Thus, the primary purpose of ecological models is to quantitatively evaluate the *ecological significance* of observed or estimated effects on individual organisms. Ecological models can be applied at several points in a baseline risk assessment and evaluation of remedial actions at hazardous waste sites, as well as in analyses of risks associated with new chemical products or new uses of existing chemicals. Steps in applying a population model to assess chemical risks will be examined, from developing the conceptual model to defining objectives and endpoints, to choosing a risk expression, to selecting and parameterizing a specific model.

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## OZONE TREATMENT OF BALLAST WATER FOR NON-INDIGENOUS SPECIES ON BOARD THE *S/T TONSINA*: BACTERIAL ENUMERATION VIA FLOW CYTOMETRY

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Global shipping is essential to world trade and moves nearly 80% of the worlds commodities, and transports roughly 10 billion tons of ballast each year which transports thousands of species around the world daily. The *S/T Tonsina* is an oil tanker that transports oil from Alaska to the Puget Sound and California. The ship can carry over 11 million gallons of ballast. This ship is equipped with an experimental ozone distribution system to treat the ballast tanks for the reduction of non-indigenous species. The objective of a larger study is to determine the concentration of ozone and its by-products necessary to inactivate organisms equal to or greater than ballast water exchange. Analyses require the enumeration of microbial populations, including bacteria and phytoplankton, before and after ozonation. Cultural methods, such as inoculating agar plate media with environmental samples, do not provide the total number of organisms present in a community. Microbial population may also exist in a viable but nonculturable state. Flow cytometry method (FCM) is an enumeration technique, which increases the accuracy of total bacterial counts compared to cultural methods. FCM is faster and has less enumeration bias than epifluorescent microscopy. FCM protocols include preserving the sample with 1% formaldehyde for 15 min followed by storage at -20$^{o}$C. SYBR II (Molecular Probes Inc.) dye at a 1:10,000 concentration was used to stain microorganisms. Samples were analyzed by a FacScan cytometer for 1-min intervals that represented a 60µl aliquot. A suspension of 0.93µm red fluorescent microspheres was added as an internal reference and size verification. A typical 60µl sample of seawater showed initial counts well above 3,000 for high DNA density particles (5.0 x $10^4$ counts per ml) and over 1,000 for low DNA density particles (1.6 x $10^4$ counts per ml).

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## HIGH RATES OF PRE-SPAWN MORTALITY IN COHO SALMON *(ONCORHYNCHUS KISUTCH)* FROM URBAN STREAMS IN THE PUGET SOUND BASIN

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Spawning surveys in some urbanized creeks around Puget Sound have documented high rates of pre-spawn mortality for coho salmon. Acute mortality ranges from 20-90% of the returning adults in these creeks. Juvenile coho and other species of adult spawners do not appear to be affected. The causal factors have not been identified, but they are likely to be related to water quality. Symptomatic fish exhibit gaping, loss of equilibrium and, in some cases, convulsions. There is no indication from pathological analyses that pathogens or disease is the cause of death. However, preliminary analyses have shown that affected fish have significantly altered brain and bile chemistry. This is consistent with an exposure to hydrocarbons and other contaminants that are typically found in non-point source runoff. Coho pre-spawn mortality may be connected to the increasing urbanization of coastal watersheds, and the National Marine Fisheries Service, City of Seattle, City of Bellevue, Port of Seattle, and the Stillaguamish Tribe are working together to investigate this problem. In the fall of 2002, indicators of contaminant exposure will be compared among pre-spawning coho, juvenile coho, and other species of spawning salmonids in urban and non-urban creeks.

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## ELECTROPHYSIOLOGICAL MEASURES OF PESTICIDE TOXICITY TO THE SALMON OLFACTORY SYSTEM

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Three classes of current use pesticides altered peripheral and central neurophysiological responses of the coho salmon olfactory system to two natural odorants (L-serine and taurocholic acid). Juvenile salmon were exposed for seven days to 0.625 to 5.0 µg/L chlorpyrifos (organophosphate), 0.05 to 0.20 µg/L esfenvalerate (pyrethroid) or 5.0 to 20 µg/L copper (metal), and *in-vivo* field potential recordings were then measured from the olfactory epithelium (electro-olfactogram, EOG) and the olfactory bulb (electro-encephalogram, EEG), simultaneously. The pesticides altered odorant-evoked responses by reducing peak amplitude of the EOG and EEG, and/or by inducing post-stimulus burst activity measured in the olfactory bulb. Collectively, these data indicate that the salmon olfactory system is vulnerable to the neurotoxic effects of certain current use pesticides, and that *in vivo* electrophysiological recordings can provide a sensitive, quantitative, and reproducible measure of sensory impairment under environmentally realistic exposure conditions.

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## EFFECTS OF RODEO®, R-11®, LI 700®, AGRI-DEX®, AND HASTEN® ON EMBRYOGENESIS IN PACIFIC OYSTERS

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The invasion and expansion of exotic aquatic plants is a problem for resource managers in many estuarine and coastal environments. Utilization of herbicides to control Spartina in Washington State have been controversial, resulting in court injunctions directed at the non target toxicity of active herbicidal ingredients. However, little attention has been given to the toxicity of surfactants added to herbicide tank mixes, which can represent the most toxic component of tank mixes and be orders of magnitude more toxic then the active ingredient. The objective of our study was to develop EC50s and dose response curves for the herbicide Rodeo® and several surfactants that are either currently in use or being considered for use in the Spartina control efforts. To achieve this, we conducted several embryo/larval toxicity tests with Pacific oyster (*Crassostrea gigas*) embryos. The treatments examined were tank mixes of Rodeo and R-11®, the most common herbicide/surfactant combination to control Spartina, as well as the following surfactants individually: R-11, LI 700®, AGRI-DEX®, HASTEN® and HASTEN without nonylphenol. The EC50s (expressed in mg/kg) for the treatments were as follows: Rodeo = 126.9; R-11 = 1.0; Rodeo + R-11 = 68.8; LI 700 = 5.1; AGRI-DEX = 60.2; HASTEN = 11.3; HASTEN without nonlyphenol = 20.6. In all cases, the surfactants were more toxic (up to >100x) than the herbicide formulation. LI-700, considered the safest of the surfactants currently labeled for aquatic use in Washington, was more toxic (2-10x) than those (HASTEN and AGRI-DEX) for which aquatic labels are being considered. Additional studies on the non-target effects of surfactants are necessary to balance efficacy of chemical control and the protection aquatic resources.

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## RAPID PHENOTYPIC SCREENING IN ZEBRAFISH: A MODEL FOR IDENTIFYING DEVELOPMENTAL TOXICITY IN NATIVE FISH SPECIES

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Many native fish species in Puget Sound and the Georgia Basin are exposed to anthropogenic contaminants and marine biotoxins during early stages of development. The impacts of degraded water quality are a particular concern for at-risk stocks such as herring and Pacific salmon. However, detailed developmental investigations are difficult because precise staging and molecular tools have not been worked out for native species. Moreover, marine fish embryos are often difficult to obtain and rear under laboratory conditions. To address these logistical difficulties, we are using the zebrafish (*Danio rerio)* as a model system for rapid, high throughput phenotypic screens of fish embryos and larvae. Zebrafish are an important system for biomedical research, and there is now an array of molecular and genomic tools available for developmental studies. We are adapting phenotypic screens that were originally used to identify developmental mutants to evaluate the effects of toxins and toxicants on sensitive life history stages of teleosts. These screens fall into three categories: (1) anatomical, (2) physiological, and (3) behavioral. Our goal is to use zebrafish to identify specific pathways of developmental toxicity for common contaminants, and then validate the findings in native species of concern.

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## EFFECTS OF TOXICANTS ON OXYGEN DYNAMICS IN STANDARDIZED AQUATIC MICROCOSMS

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Although Eugene Odum predicted that stress would reduce Productivity and increase Respiration, few experiments have demonstrated a consistent reduction in P:R ratios. We here present responses to 3 toxicants, the antibiotic Streptomycin; the insecticide Malathion; and the combined algicide and zooplankton toxicant, CuSO4. In all cases when P was reduced, R was also reduced so that the P:R ratio was rarely changed for more than one sampling period. The P:R daily ratio was almost always close to one. However, by accumulating (summing) the daily Net Ecosystem Production (NEP) which is calculated by P (net oxygen production during the lighted period) minus R (nightime oxygen use), consistent patterns were obvious. As expected, Streptomycin (a selective algicide as well as a antibiotic), reduced the Accumulated NEP. Malathion temporarily eliminated *Daphnia*, and an algal bloom occurred; Accumulated NEP was greater than in the controls. CuSO4 increased accumulated NEP in some experiments (where toxicity to grazers was greatest, and decreased it in other experiments (where the algicidal properties were dominant. Oxygen changes can be used to estimate the energy transfers in ecosystems as they are used for organism bioenergetics. The Accumulated NEP may be a useful parameter for describing ecosystem energetic responses to toxic chemicals.

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## MYCOREMEDIATION OF BTEX-CONTAMINATED SEDIMENT

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Current options for contaminated sediment are expensive, time-consuming, and can require specialized facilities and equipment. Because the contaminants are still present in the disposed sediment, there is potential for contaminants to reenter the environment. Pacific Northwest National Laboratory's Marine Sciences Laboratory (MSL) in Sequim, Washington, developed a technique called *mycoremediation* that uses natural fungal systems to degrade contaminants and that results in clean sediment for beneficial uses. It provides a low-cost solution without need for specialized facilities. Following completion of preliminary, midscale studies, the MSL joined with Northwest Natural to conduct a pilot-scale, *ex situ* demonstration. The demonstration took place adjacent to the Willamette River in Portland, Oregon, at the site of a former residual oil gasification facility that operated from 1913 to 1955. Typical of manufactured gas plants (MGPs), it generated a residual tar byproduct that contaminated soil, sediment, and groundwater on the site. Unlike other MGPs, it also refined the gasification byproducts to produce gasoline and other light endproducts at the same location and therefore has high concentration and persistence of benzene and other monoaromatic hydrocarbons along with polynuclear aromatic hydrocarbons of concern. The site is currently used for liquid natural gas storage and transfer, and for other industrial purposes. The MSL applied its proprietary, conditioned, living fungal system with a passive aeration system to remediate 9000 kg of sediment heavily contaminated with benzene, toluene, ethyl benzene, and xylene (BTEX), and with other petroleum hydrocarbons. Because of its hazardous condition, the sediment was contained in a covered bin for treatment. After an 8-month treatment, the original 2600 ppm BTEX level met the Environmental Protection Agency's target value for industrial sediment, and the material was no longer considered hazardous. Future plans for the site include possible combined chemical or thermal and fungal, and buffer zones.

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## METAL CONCENTRATIONS, FORAGING DISTANCES, AND FLEDGING SUCCESS OF GREAT BLUE HERONS NESTING ALONG THE HANFORD REACH OF THE COLUMBIA RIVER

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An ecological risk assessment of metal concentrations along the Hanford Reach of the Columbia River in south-central Washington, identified nesting great blue herons at potential risk through the ingestion of riverine biota, especially fish. We measured metal concentrations in livers of pre-flight herons and excrement samples taken from the same nests. Nests were located at three colonies situated upstream and downstream from retired plutonium production reactors along the river where metals in reactor coolant waters had been released directly into the river, or disposed to shoreline retention basins and ditches. Distances traveled by parent herons to foraging areas along the river shore were determined by visually tracking parent birds as they flew from nests to foraging sites. Flight distances varied between colonies with mean distances ranging between 0.7 and 3.1 km. Cadmium, Cr, and Pb concentrations were higher in excrement than in the livers of preflight herons but the opposite was noted for Cu, Hg, and Zn. Highest metal concentrations were measured in excrement taken from heron nests at the colony located upstream from reactors. Fledging success and eggshell thickness measurements were used to assess population health of herons nesting along the Reach. Results indicated great blue herons nesting success along the Hanford Reach was among the highest reported throughout the continental United States to date.

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**USE OF A WEIGHT-OF-EVIDENCE METHOD IN EVALUATING REGULATORY PROGRAMS FOR CONTAMINATED SEDIMENT MANAGEMENT**

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National and regional dredging guidance requires biological and chemical testing of marine, estuarine, and freshwater sediment prior to disposal in unconfined, open-water environments. Regulatory guidance varies, however, at both national and regional levels, leading to inconsistencies in environmental evaluations and subsequent management actions. Further, many of the evaluations required in guidance manuals are dated and may have limited environmental relevance, given more recent information relative to the assessment of environmental risk. The purpose of this paper is to systematically explore the utility and relevance of current regulatory guidance involving environmental investigations, and to suggest ideas for the development of a more consistent set of evaluations that are protective of the environment. Selected national and regional guidance documents are evaluated to determine whether species selection and test recommendations are applicable and appropriate to safeguard environmental quality. National guidance manuals include EPA/USACE publications associated with dredged material testing in marine, estuarine, and freshwater environments; regional practices include current guidance for New York (*NY Regional Testing Manual*) and for Puget Sound, Washington (*PSDDA*). The evaluative model that is applied to these regulations is a weight-of-evidence approach, a relatively new process developed to integrate the results of multiple measurements in ecological risk assessments. The author describes how a weight-of-evidence approach might be used to assess current environmental testing guidelines and serve as a basis for potential changes in environmental legislation and testing manual guidance relative to the assessment of dredged material.

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