Program and Abstracts

16th Annual Meeting of the Pacific Northwest Chapter of the Society of Environmental Toxicology and Chemistry (PNW-SETAC)

Fort Worden Conference Center, Building 204
Port Townsend, WA
April 12 - 14, 2007

PNW-SETAC ANNUAL MEETING

April 12 to 14, 2007

Meeting Program

Cover photo taken by Rebekka Lindskoog
Beach in Port Townsend, April 2006

PNW-SETAC
Chapter Meeting Program

Thursday, April 12, 2007

12:00 PM-5:30 PM	Conference Check-in, Building 204 (after 5:30 PM, check-in during the Welcome Reception at Fort Worden Commons)
1:00 PM-5:00 PM	Short Course: *"Aquatic Toxicity Test: A Practical Guide*" Michelle Redmond and colleagues, Northwestern Aquatic Sciences, Building 204.
2:00 PM-5:00 PM	Special Session: *"Environmental Toxicology and Populations*" chair Wayne Landis, Institute of Environmental Toxicology at Western Washington University, Building 204.
3:30 PM-7:30 PM	On-site Housing Check-in, Building 204 until 5:30 PM, then at Fort Worden Commons
5:30 PM-6:30 PM	PNW-SETAC Board Meeting, Fort Worden Commons
5:30 PM-8:00 PM	Welcome Reception (5:30) & Buffet dinner (6:30), Fort Worden Commons

Friday, April 13, 2007

7:30 AM-8:30 AM	Conference check-in, poster setup, Building 204
8:30 AM-9:00 AM	Welcome: Julann Spromberg Chapter President and Bruce Hope, SETAC National Representative, Building 204
9:00 AM-12:00 PM	Platform sessions with 20 min break for refreshments and poster viewing
12:00 PM-1:30 PM	Buffet Lunch, Fort Worden Commons
1:30 PM-4:40 PM	Platform sessions with 30 min break for refreshments and poster viewing
4:40 PM-5:30 PM	Poster Social, Bulding 204
6:00 PM-8:30 PM	Barbecue at the Beach! Kitchen Shelter on the beach at Fort Worden

Saturday, April 14, 2007

7:30 AM-8:30 AM	PNW-SETAC Business Meeting, Fort Worden Commons
8:30 AM-9:00 AM	Student Award Presentations / Raffle, Building 204
9:00 AM-12:00 PM	Platform sessions with 20 min break for refreshments and poster viewing
12:00 PM	Adjourn- See you next year in CORVALLIS, OREGON

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Thursday Reception

Columbia Analytical Sciences **Northwestern Aquatic Sciences**
Hart Crowser

Friday Morning Break

Paramterix

Friday Afternoon Break

Integral Consulting

Saturday Morning Break

Windward Environmental

Raffle Donations

Michele Redmond, Scientific Notations

PNW-SETAC

Acknowledgements

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

Conference Organization:	Julann Spromberg, Contractor, NOAA/National Marine Fisheries Service Nancy Kohn, Battelle Marine Sciences Laboratory Tom Gries, Washington State Department of Ecology
Abstract Review:	Karen Bergmann, Nautilus Environmental Julann Spromberg, Contractor, NOAA/National Marine Fisheries Service Cat Curran, Nautilus Environmental
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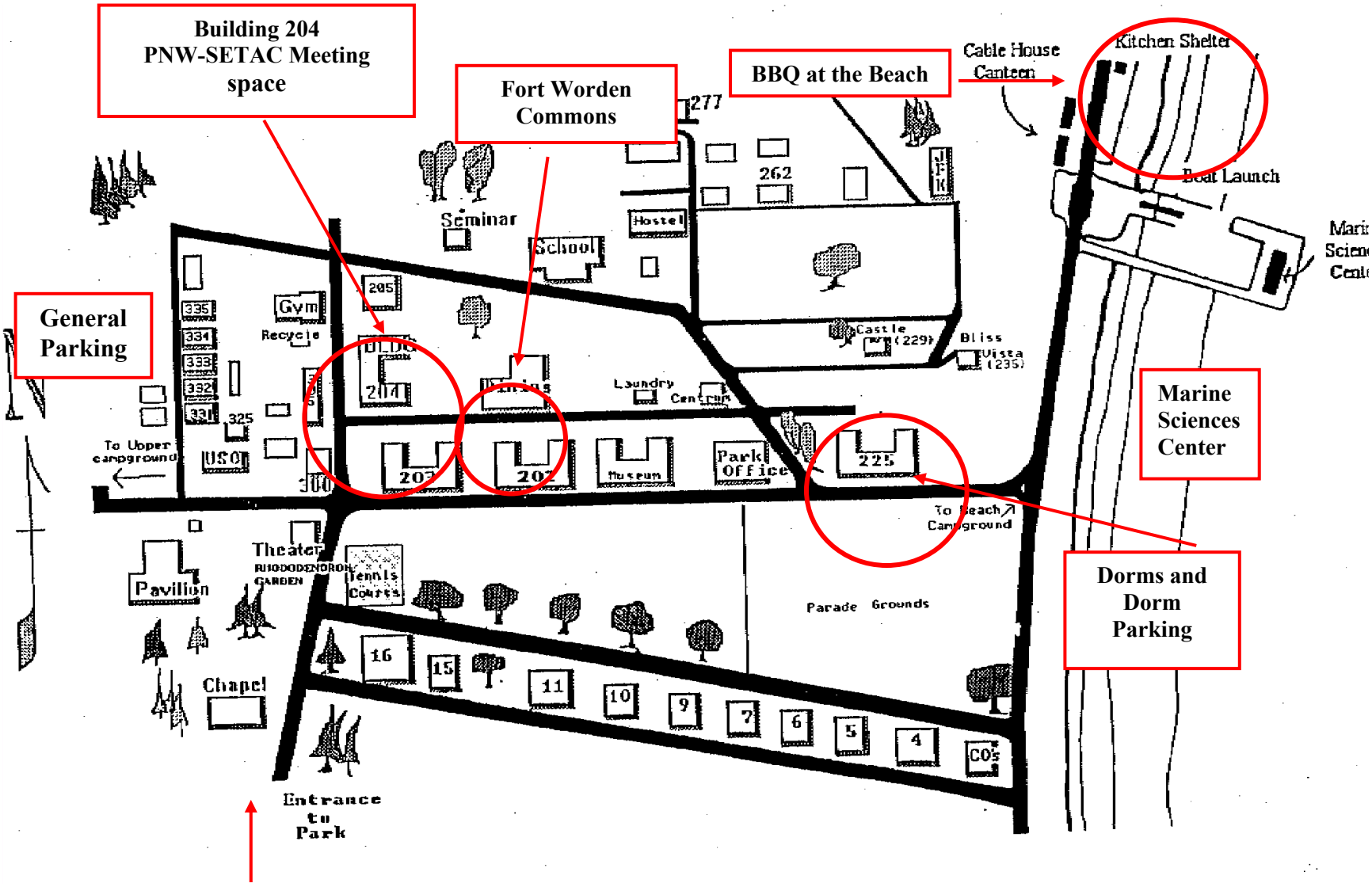
Meeting Registration:	Tom Gries, Washington State Department of Ecology
Volunteer Coordinator:	Jenifer McIntyre, University of Washington
Sponsorships:	Taku Fuji, Kennedy/Jenks Consultants
Student Awards:	Karen Watanabe, Oregon Graduate Institute
Session Chairs:	Julann Spromberg, Contractor, NOAA/National Marine Fisheries Service Taku Fuji, Kennedy/Jenks Consultants Karen Watanabe, Oregon Graduate Institute
Electronic Equipment:	April Markiewicz, Western Washington University
Student Award Judges:	Wendy Hillwalker (Oregon State University) Tony Paulson (Government - USGS) Jenifer McIntyre (University Student, not presenting - University of Washington) Chris Peredney (Hart Crowser)
Student Funding Application Reviews:	Burt Shepherd, USEPA, Region 10



For everything you need to know about Port Townsend, visit
http://www.ptguide.com
For additional information about Fort Worden State Park, visit
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Pacific Northwest Chapter
Society of Environmental Toxicology and Chemistry
(PNW-SETAC)

16th Annual Meeting

Schedule of Platform and Poster Presentations

PNW-SETAC Annual Meeting
Special Session
Thursday, April 12, 2007

Thursday Afternoon (April 12, 2007)

Session Chair: Wayne G. Landis

Special Session Population Ecotoxicology

2:00	Wayne Landis, Western Washington University	Introduction to the long road of population scale environmental toxicology.
2:10	Bruce Hope, Oregon Department of Environmental Quality	Population-level ecological risk assessment: challenges & opportunities
2:30	Chris Mebane, U.S Geologic Survey	Relating single-species toxicity datasets to population and ecosystem-level effects: examples with cadmium
2:50	John Stark, Washington State University,	Population recovery: A method to measure the effects of stressors
3:10	Break	Break
3:30	Julann Spromberg et al., NOAA/ National Marine Fisheries Service	Evaluating the sublethal impacts of current use pesticides on physiology and ecology of endangered Chinook salmon populations.
3:50	Wayne Landis, Western Washington University	Application of population modeling to establish causality using Puget Sound Pacific herring (*Clupea pallasi*) as a model system

4:10 **Panel Discussion**

PNW-SETAC Annual Meeting
Platform Presentation Schedule
Friday, April 13, 2007

Friday Morning (April 13, 2007)

Session Chair: Julann Spromberg, Contractor, NOAA / National Marine Fisheries Service

Aquatic Toxicology – Part 1

9:00	Michael Paine, Paine, Ledge and Associates (PLA)	Effects of offshore oil drilling on benthic invertebrate communities on the Grand Banks (North Atlantic)
9:20	Hugh Lefcort, Gonzaga University	Hormetic effects of heavy metals in aquatic snails: Is a little bit of pollution good?
9:40	Chris Mebane, U.S. Geologic Survey	The accuracy and protectiveness of biotic ligand model (BLM) toxicity predictions with copper
10:00	Catherine Bollinger, Western Washington University, MS Candidate	Metal speciation and toxicity in Upper Columbia River and Tributaries along the U.S.- Canadian border using the biotic ligand model and VMINTEQ
10:20	**Break/Poster Viewing**	

Aquatic Toxicology – Part 2

10:40	Gladys Yanagida, NOAA Fisheries	Recent levels of persistent organic pollutants and polycyclic aromatic compounds in outmigrant juvenile Chinook from the Lower Columbia River and Estuary
11:00	O. Paul Olson, NOAA Fisheries	Health effects of contaminant exposure in outmigrant juvenile Chinook from the Lower Columbia River and Estuary
11:20	Constance Sullivan, CANTEST Ltd., MS Candidate	Cytochrome P4501A induction and DNA damage in *Pimephales promelas* during exposure to exceptional quality biosolids
11:40	Carl Isaacson, Oregon State University, PhD candidate	Quantification of carbon based nanomaterials by LC-MS to determine up-take of fullerenes by embryonic zebrafish
12:00	**Lunch**	

PNW-SETAC Annual Meeting
Platform Presentation Schedule
Friday, April 13, 2007

Friday Afternoon (April 13, 2007)

Session Chair: Taku Fuji, Kennedy Jenks Consultants

Pesticide Toxicity

1:30	Catherine Curran, University of Washington, MS Candidate	Olfactory performance in salmonids exposed to aquatic herbicides
1:50	Morgan Sternberg, University of Washington, MS Candidate	An evaluation of mosquito larvae abundance and the efficacy of control strategies
2:10	Kerensa King, University of Washington, PhD Candidate	Brain AChE inhibition in juvenile rainbow trout exposed to pesticide mixtures within urban streams in Western Washington: Reasons for non-additive effects
2:30	Katherine Johnson, Oregon State University, PhD Candidate	Use of multiple life stages in assessing *Cinygmula* sp. Mayfly sensitivity to esfenvalerate
2:50	**Break/Poster Viewing**	

Sediment Contamination and Toxicity

3:20	Bruce Hope, Oregon Department of Environmental Quality	Relative contribution of various sources to polychlorinated biphenyl (PCB) levels in the Willamette Basin (Oregon)
3:40	Bill Williams, Port Gamble Environmental Laboratory	"It ain't the sediment, dummy": Relative contribution of sediment and water to PCBs in fish tissue
4:00	Michael Salazar, Applied Biomonitoring	Using caged mussels to characterize exposure and effects associated with water and sediment in marine and freshwater environments
4:20	Alan Mearns, NOAA	Getting better or worse? Contaminant trends in Puget Sound as viewed by mussels
4:40	**Poster Social**	

PNW-SETAC Annual Meeting
Platform Presentation Schedule
Saturday, April 14, 2007

Saturday Morning (April 14, 2007)

Session Chair: Karen Watanabe, Oregon Graduate Institute

Policy and Remediation

9:00	Robert Gensemer, Parametrix Environmental Research Laboratory	Reassessment of cyanide ambient water quality criteria: An integrated approach to protection of the aquatic environment
9:20	Burt Shephard, U.S. Environmental Protection Agency	Biological evaluation of the level of protection provided to endangered species by Oregon's water quality criteria
9:40	Tom Gries, Washington State Department of Ecology	Can sediment profile imaging surveys streamline cleanup site investigations?
10:00	Nancy Judd, Windward Environmental, LLC	Development of preliminary remediation goals using a food web model
10:20	**Break/Poster Viewing**	

Toxicology and Chemistry

10:40	Peter Mattison, Integral Consulting	Measuring and managing potential construction disturbance to nesting bald eagles on a Puget Sound naval base
11:00	Brian Hester, Port Gamble Environmental Laboratory	Sensitivity of marine organisms to hydrogen sulfide: Test design, implementation, and results
11:20	Dan Berlin, The RETEC Group, Inc.	Controlling effects of shells and sulfides on marine sediment toxicity testing
11:40	Jeff Grindstaff, Columbia Analytical Services, Inc.	The elimination of PCB congener interference in organochlorine pesticide analysis using mass spectrometry
12:00	**Wrap Up**.	

PNW-SETAC Annual Meeting
Poster Presentations

Sandra Aasen, Washington State Department of Ecology	Levels of chemical contamination and toxicity in Hood Canal sediments (1952-2005)
Sandra Aasen, Washington State Department of Ecology	Polybrominated diphenyl ethers (PBDEs) in Puget Sound sediments- A baseline update
Sandra Aasen, Washington State Department of Ecology	Infaunal invertebrate assemblage structure in Hood Canal, WA (1989-2005)
Helle Anderson, Windward Environmental LLC	Relationships between co-located chemical concentrations in Lower Willamette River sediments and aquatic organisms
Jennie Bolton, Northwest Fisheries Science Center	Spatial and temporal variation in levels of PBDEs in juvenile Chinook salmon tissues from the Lower Columbia River
Richard Caldwell, Northwestern Aquatic Sciences	Polynuclear aromatic hydrocarbon contamination of bottom sediments in Oregon estuaries, U.S.A.
Alma Cárdenas, Integral Consulting	Risk evaluation for consumption of cadmium in Pacific Northwest oysters and relevance of international maximum limits
Jamie Colman, NOAA Fisheries	Effects of 2,2',4,4'-tetrabromodiphenyl ether 47 (PBDE-47) on zebrafish development
Diana Dishman, Parametrix Environmental Research Laboratory	Evaluating sub-lethal effects of copper to salmonids using an avoidance behavior endpoint
James Elphick, Nautilus Environmental	Evaluation of water quality criteria for chloride using the acute-to-chronic ratio and species sensitivity distributions
Jason Fortner, Western Washington University, MS Candidate	Phototoxicity in whole effluent toxicity testing: Lighting considerations

PNW-SETAC Annual Meeting
Poster Presentations

William Gardiner, Port Gamble Environmental Laboratory	Sediment acclimation in marine evaluations with freshwater sediments
William Gardiner, Port Gamble Environmental Laboratory	Sensitivity of mussel (*Mytilus edulis galloprovincialis*) and abalone (*Haliotus rufescens*) larvae to hydrogen sulfide
Christian Grue, University of Washington	Exposure of salmonids to carbaryl following applications to control burrowing shrimp in Willapa Bay, Washington: Channel habitats and enzyme recovery
Wendy Hillwalker, Oregon State University	Comparison of metal speciation tools at a superfund site
Lisa Hoferkamp, University of Alaska Southeast	Polybrominated diphenyl ethers (PBDEs) in Southeast Alaska: Local sources versus long-range transport
René Jones, Parametrix Environmental Research Laboratory	Development of a biotic ligand model for predicting the chronic toxicity of cobalt to fathead minnows
Kerensa King, University of Washington, PhD Candidate	Response of juvenile Chinook to herbicide tank mixes used to control *Spartina* in Willapa Bay, Washington
Kerensa King, University of Washington, PhD Candidate	Toxicity of imidacloprid to salmonids
Lorena Lechuga, Shannon Point Marine Center and UC Santa Cruz, Undergraduate	Refinement of Pacific herring bioassay protocols: Salinity and dissolved oxygen limits and food type
Tiffany Linbo, NOAA Fisheries	Effects of hardness, alkalinity, and dissolved organic carbon on the toxicity of copper to the mechanosensory system of developing fish
Alan Mearns, NOAA	Using consensus ecological risk assessment to evaluate oil spill response options: Do more skimmers equal better response?
Angie Obery, Oregon Department of Environmental Quality	Guidance for assessing bioaccumulative chemicals of concern in sediment

PNW-SETAC Annual Meeting
Poster Presentations

O. Paul Olson, NOAA Fisheries	Health effects and potential evolutionary consequences of contaminant exposure in salmonids from Pacific Northwest rivers and estuaries
Pongsak (Lek) Noophan, Western Washington University and Silpakorn University	Orthophosphate adsorption on natural adsorbents, slag, and utelite to be modified in individual onsite wastewater systems
Toby Primbs, Oregon State University, PhD Candidate	Trans-Pacific and regional atmospheric transport of anthropogenic semivolatile organic compounds to Mt. Bachelor Observatory, U.S.A. from Spring 2004 to Spring 2006
Johanna Salatas, Exponent	Predictive ecological risk assessment for a new aluminum smelter in Iceland
Lyndsey Shorey, Oregon State University, PhD Candidate	Novel human health assessment approach bridges environmentally relevant contaminant mixtures and early life-stage developmental toxicity
Michael Smith, University of Washington, MS Candidate	Lead shot ingestion and mortality of swans wintering in Washington State and British Columbia- Is Judson Lake a primary source of shot?
Sean Sol, NOAA/NMFS/NWFSC	Biological disfunction associated with exposure to endocrine disrupting compounds in marine and estuarine fish from the Pacific Northwest, United States
Jamey Stoddard, Western Washington University	Effects of multi-generational acclimation on the toxicity of copper, cadmium, and zinc to *Daphnia magna*
Maryjean Willis, NOAA Fisheries	You are what you eat: Contaminant exposure in juvenile salmon from Columbia River hatcheries
Jay Word, Port Gamble Environmental Laboratory	The effects of low TOC sediments on the acute survival of *Leptocheirus plumulosus*
Xia Zeng, Oregon State University, PhD Candidate	Photochemical degradation of selected polybrominated diphenyl ether and GC-MS study of the products

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16th Annual Meeting

Special Session Abstracts

POPULATION-LEVEL ECOLOGICAL RISK ASSESSMENT: CHALLENGES & OPPORTUNITIES

Hope, BK, Oregon Department of Environmental Quality, Portland, OR

The release, either intentionally or unintentionally, of a chemical or non-chemical stressor into the environment can result in risk to various ecological receptors, which may be animal, plant, or microbial species present in specific habitats (e.g., wetland, floodplain, stream, estuary, grassland, etc.), organized on a scale ranging from individual organisms to ecosystems. For the great majority of species (those that are not protected or aesthetically valued), losses of individual organisms are to be expected and management action is only necessary in the face of the perceived risk of extinction or greatly reduced abundance. In short, individuals may die, but populations must persist. At present, however, the overwhelming majority of assessments of ecological risks still occur at the scale of the individual organism. This narrow focus may not provide risk managers with the breadth of information necessary to support practical, balanced risk decisions. Information from a population-level ecological risk assessment has the potential to provide support for more cost-effective, yet still protective, risk management decisions. As a result, interest among both ecotoxicologists and risk assessors in techniques for predicting responses of populations to chemical exposures has grown rapidly in recent years. There is a renewed awareness that population-level effects are important and can be quantified, even for production risk assessments. This presentation will address basic definitions, briefly describe some of the practical methods and models that are especially relevant to addressing effects at the population levels, and discuss some specific applications.

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RELATING SINGLE-SPECIES TOXICITY DATASETS TO POPULATION AND ECOSYSTEM-LEVEL EFFECTS: EXAMPLES WITH CADMIUM

Mebane, C.A. U.S. Geological Survey, Boise, ID

The U.S. Environmental Protection Agency (EPA) guidelines for deriving national water quality criteria for the protection of aquatic organisms rely on the concept of species-sensitivity distributions (SSD). The premise is that effects that occur in laboratory tests generally will occur on the same species in comparable field situations. When enough species laboratory test values are available to describe a SSD, that SSD is considered representative of natural ecosystems. The 5th percentile of the SSD defines an adequately safe criterion for ecosystems. Debates over this premise include whether haphazard collections of data from single-species laboratory toxicity tests can be considered representative of natural ecosystems, database bias in favor of short-term LC50 data, what if any amount of species loss due to a toxin is acceptable, and whether the 5th percentile of the SSD is the appropriate level of protection or just a familiar number. Using data with cadmium (Cd), these issues were evaluated through population modeling and comparisons to field surveys. The most sensitive animal tested with Cd was the amphipod *Hyalella azteca;* at the SSD 5th percentile criteria value about a 10% broodsize reduction was predicted. When extrapolated over 6 generations under continuous or variable exposure scenarios, the population modeling predicted population declines but low extinction risk. Field surveys showed amphipods persisting in lake and river settings with comparable Cd exposures. The "safe" SSD 5th percentile value was also compared with Cd effects to macroinvertebrate and fish communities in a whole-lake experiment, stream mesocosms, and field studies of a Cd-contaminated watershed. The presence or absence of observed effects in ecosystem studies and the laboratory SSD 5th percentile value agreed in 11 of 12 comparisons. In the exception, the ability of brook trout (*Salvelinus fontinalis*) to capture prey was reduced.

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POPULATION RECOVERY: A METHOD TO MEASURE THE EFFECTS OF STRESSORS

Stark, JD, Washington State University, 7612 Pioneer Way East, Puyallup, WA

Exposure of metapopulations to stressors, such as pesticides, often results in declines in population growth rates (λ). When exposure to a stressor causes reductions in λ that result in growth rates lower than 1, populations are declining exponentially and headed towards extinction. When this occurs, it is obvious that the stressor is having a serious impact and if the species is threatened or endangered, measures must be taken to reduce or eliminate the stressor in the environment. However, if declines in λ in stressed populations are lower than unstressed populations but not low enough to cause population decline (λ <1) or extinction, how do you determine whether the stressor is actually causing harm to a population? Comparing reductions in λ is not very intuitive. For example you might say that λ was reduced 10% but what does this really mean? Another way to explore stressor effects is to use population models to measure population recovery. Recovery time can be compared among stressed and unstressed populations. Additionally, recovery time can be compared to reductions in λ and generation time. This approach enables one to determine whether populations are being negatively affected and unlike comparing reductions in λ, recovery time is something that can be easily understood. In this paper, I will present several examples of populations exposed to pesticides and show how recovery time can be used to determine effects on populations.

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EVALUATING THE SUBLETHAL IMPACTS OF CURRENT USE PESTICIDES ON PHYSIOLOGY AND ECOLOGY OF ENDANGERED CHINOOK SALMON POPULATIONS

Spromberg, J.A., Baldwin, D.H. Macneale, K.H., and Scholz, N.L. NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA.

The presence of pesticides in Pacific Northwest watersheds has been acknowledged as a potential factor in the habitat degradation that has lead to the listing of salmon populations throughout the region under the Endangered Species Act. However, the consequences of pesticide exposures for salmon health and, specifically, the viability of salmon populations in the Pacific Northwest are largely unknown. This uncertainty creates challenges for the management of salmonids and the restoration of pesticide-contaminated habitats. We investigated direct and indirect effects of ecologically realistic pesticide exposures on the sensory physiology and behavior of salmon, with an emphasis on somatic growth, survival, and the long-term population productivity. Size has been linked to age-specific survival rates during juvenile life stages. Reductions in the somatic growth rate of subyearling salmon are believed to result in increased size-dependent mortality during migration, smoltification, and overwintering. Improved assessment of pesticide impacts on salmon populations requires linking suborganismal effects (e.g. AChE inhibition) and organismal effects (e.g. behavioral impairment) to population effects (e.g. reduced productivity). To evaluate impacts of anticholinesterase insecticide exposure on individual salmon and salmon populations, we developed a model that explicitly links reductions in AChE activity to reductions in the feeding behavior, somatic growth, and individual survival and then to changes in population abundance and growth rate. A chinook salmon (*Oncorhynchus tshawytscha*) life-history model was adapted to incorporate a size-dependent survival rate during migration to the ocean. In addition, since pesticides are effective at killing the salmon prey base, we also integrated pesticide impacts on salmonid prey. For example, an hour-long exposure of a pesticide mixture at a concentration sublethal to fish may reduce invertebrate densities available to fish in the drift for months following exposure and for significant distances downstream of the exposure. These indirect effects on prey were incorporated into the models analyzing direct impacts on fish behavior and population growth.

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APPLICATION OF POPULATION MODELING TO ESTABLISH CAUSALITY USING PUGET SOUND PACIFIC HERRING (*CLUPEA PALLASI*) AS A MODEL SYSTEM

Landis W. G. Institute of Environmental Toxicology, Western Washington University

The decline of the Cherry Point Pacific herring stock (CPPHS) has been determined to be due to factors not related to the spawning area. In this study age structured population modeling was incorporated into a weight of evidence framework to re-examine the risk factors contributing to the decline of the CPPHS. The model was used to calculate intrinsic rate of increase and equilibrium age structure for each year from 1974 until 2005. The resulting simulations result in declining populations with dynamics similar to that observed for CPPHS. Patterns of increase and decline in predicted population size in the simulations suggest that fishing moratoriums or other management actions had little effect. The analysis demonstrates that the causative agent for the decline of the CPPHS existed in the 1974-1975 timeframe with effects persisting until 2004. Squaxin Pass, Discovery Bay and Port Gamble also have been sampled since the mid 1970s until 2004. These stocks also demonstrate a collapse in the age structure as seen in the Cherry Point stock during the same period although the sites range the entire Puget Sound region. The results of the analysis of the criteria for causality indicate that the timing of the warming Pacific Decadal Oscillation (PDO) corresponds directly to the change in age structure resulting in a declining population. The causative mechanism may well be the change in the distribution of pathogens as suggested by Hershberger et al. due to the warm PDO. Simulations on how toxicants could affect these patterns are currently being performed.

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Platform Presentation Abstracts

EFFECTS OF OFFSHORE OIL DRILLING ON BENTHIC INVERTEBRATE COMMUNITIES ON THE GRAND BANKS (NORTH ATLANTIC)

Paine, MD*[1], DeBlois, EM[2], Taylor, DG[3,4]
[1]Paine, Ledge and Associates (PLA), North Vancouver, BC, [2]Jacques Whitford Ltd., St. John's, NL, [3]Husky Energy Inc., St. John's, NL, [4]DG Taylor Inc., Conception Bay, NL

The White Rose (WR) offshore oil development is located on the Grand Banks, 300 km east of St. John's. Drilling occurs at three different drill centres rather than beneath a single fixed platform. Husky Energy conducts an extensive environmental effects monitoring (EEM) program at the WR site. The sediment component of the program includes measurement of physical and chemical characteristics, assessment of toxicity in laboratory tests, and assessment of *in situ* benthic invertebrate communities. Baseline (pre-drilling) sampling occurred in 2000, followed by post-drilling sampling in 2004 and 2005. In each year, more than 40 sediment stations were sampled. The sediment is ~95% sand, with polychaetes (~75% of total abundance) and bivalves (~15% of total abundance) dominating invertebrate communities. Effects on those communities were assessed in two ways. First, changes in distance gradients Before versus After drilling were assessed for each drill centre. Second, dose-response relationships between community variables and concentrations of $>C_{10}$-C_{21} HCs (*n*-alkanes), a major constituent of the synthetic drilling muds used and an excellent "tracer" of drilling activity and drill cuttings dispersal, were assessed. Both distance and dose approaches indicated that amphipod abundances, and to a lesser extent total abundance and polychaete dominance, were reduced near drill centres in 2004 and especially 2005. For the WR EEM program, analyses of dose-response relationships provided stronger and less equivocal evidence of effects than analyses of distance relationships. However, distance relationships are important for defining the spatial extent of effects, and results from 2004 and 2005 need to be verified in 2006 and subsequent years. Drilling effects observed elsewhere on, e.g., richness and diversity, were *not* observed in the WR EEM program, although depth effects over a 115-140 m range were observed for those and other variables. Concluding Question: Where do/should we go from here (2005)?

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HORMETIC EFFECTS OF HEAVY METALS IN AQUATIC SNAILS: IS A LITTLE BIT OF POLLUTION GOOD?

Lefcort, HL*, Freedman, Z, House, Z, Pendleton, M
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Hormesis is the term to describe a stimulatory effects associated with a low dose of a potentially toxic substance or stress. We had anecdotal evidence of hormetic effects in some of our previous experiments concerning the influence of heavy metals on aquatic snail growth and recruitment. We therefore repeated a version of an earlier experiment but this time we expanded our low dose treatments and increased our sample size. We also explored if metals had a hormetic effect in algae. We raised snails in outdoor mini-ecosystems containing lead, zinc, and cadmium-contaminated soil from an Environmental Protection Agency Superfund site in the Silver Valley of northern Idaho. The snails came from two sites. One population (*Physella columbiana*) has evolved for 120 years in the presence of heavy metals and one (*Lymnaea palustris*) has not. We found that *P. columbiana* exhibited hormesis, with snails exposed to small amounts of metals exhibiting more reproduction and growth than snails not exposed to metals. Naturally occurring *Oscillatoria* algae also exhibited a hormetic effect of heavy metals but *L. palustris* did not display hormesis. Large doses negatively impacted all three species. Overall the levels of cadmium, lead, and zinc measured in the tissues of the snails were inversely correlated to the number of snails recruited into the tub populations. Only in comparisons of the lowest metal treatment to the control treatment is a positive effect detected.

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THE ACCURACY AND PROTECTIVENESS OF BIOTIC LIGAND MODEL (BLM) TOXICITY PREDICTIONS WITH COPPER

Mebane, CA
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The Biotic Ligand Model (BLM) of acute metal toxicity is a flexible tool that has successfully been used to predict the acute toxicity of copper to fathead minnows and Daphnids. The BLM has further been extrapolated to predict chronic copper toxicity through an acute-to-chronic ratio and is the basis of the U.S. Environmental Protection Agency's (EPA's) 2007 aquatic life criteria for copper. Here, I (1) compare BLM predicted and measured LC50s with fathead minnow, rainbow trout, and Chinook salmon using data from static, renewal, and flow-through testing methods, and (2) compare BLM-based chronic criterion concentrations (CCC) to apparent effects concentrations for copper in 3 field studies. For the acute toxicity comparisons, BLM predictions were strongly correlated with measured LC50s. However, the BLM was highly sensitive to dissolved organic carbon (DOC) content and had a steeper DOC-LC50 slope than did the measured LC50s for some data sets. For the comparisons of the BLM-based CCC with field studies, 2 of the 3 studies were from soft water mountain streams with moderate DOC levels (hardness <50 mg/L and DOC of about 1-4 mg/L), and one was from a hard water stream with higher DOC levels (hardness of about 270-320 mg/L and DOC of about 4-8 mg/L). For the hard water and high DOC stream, BLM-based chronic copper criterion concentrations (CCC) were close to the lowest apparent effects concentrations. However, for the soft water streams with moderate DOC levels, CCCs were consistently higher than ambient copper concentrations that were associated with adverse effects. These comparisons suggest that in waters with low ionic strength and moderate DOC levels, the BLM-based CCC may provide less protection than was intended by EPA's national guidelines for the development of aquatic life criteria. This apparent under-protectiveness may be related to the BLM's high sensitivity to DOC in waters of low ionic strength.

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METAL SPECIATION AND TOXICITY IN UPPER COLUMBIA RIVER AND THE TRIBUTARIES ALONG THE U.S. – CANADIAN BORDER USING THE BIOTIC LIGAND MODEL AND VMINTEQ.

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Mining practices of the past and present have resulted in persistent transport of heavy metals from mining/smelting waste into the freshwater ecosystem of the Upper Columbia River Basin. This research project focused on an intensively mined area of this region and included six tributaries around Trail, British Columbia (BC), two tributaries in northeastern Washington State and one trans-border tributary. Although extensive environmental studies have been conducted in the Columbia River Basin, most of them have focused only on the respective surface waters on either side of the Canadian – U.S. border. This research was designed to assess the effects of metal speciation on the potential toxicity contributed by the nine tributaries to the Columbia River on BOTH the Canadian and U.S. sides of the border. Surface water samples were collected at medium flow conditions and low flow conditions in 2006 from the nine tributaries and at six sites in the upper Columbia River. Acute *Daphnia magna* toxicity studies and chemical analysis were conducted on the water samples. We used the Biotic Ligand Model (BLM) to predict toxicity and compared those results to the actual toxicity data. VMINTEQ geochemical model was used to further refine the BLM predictions. Additionally spiked acute toxicity tests were conducted on a few select sites to evaluate the effects of the specific water chemistry of these streams on toxicity. The BLM predicted toxicity is generally higher in the Washington state tributaries than the British Columbia tributaries. VMINTEQ modeling predicted changes in metal speciation from July to August. The dose-response curves for three of the spiked sites provided interesting results that are continuing to be evaluated. Research on this project is still on-going and is intended to contribute to the growing body of knowledge on metal speciation and resultant toxicity in aquatic environments.

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RECENT LEVELS OF PERSISTENT ORGANIC POLLUTANTS AND POLYCYCLIC AROMATIC COMPOUNDS IN OUTMIGRANT JUVENILE CHINOOK FROM THE LOWER COLUMBIA RIVER AND ESTUARY

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In collaboration with USGS and the Lower Columbia Estuary Partnership, we are monitoring levels of persistent organic pollutants (POPs) and polycyclic aromatic compounds (PACs) in outmigrant juvenile Chinook to evaluate the potential risk to the ESA-listed Columbia River salmon stocks. Concentrations of POPs were measured in whole bodies of juvenile Chinook collected from six sites in the lower Columbia River and Estuary (from Bonneville to the mouth of the estuary). In addition, POPs and PACs were measured in stomach contents and PAC levels were determined in bile. Our study area is of particular concern due to its proximity to major industrial centers of Portland and Vancouver, and is subject to contaminant inputs from industrial discharges and surface and storm water runoff. The highest levels of PCBs in the whole bodies were measured in fish caught at tidal freshwater sites near or downstream of urban and industrial centers (e.g., Beaver Army Terminal, Willamette/Columbia Confluence). The prey (stomach contents) of these fish also contained high levels of POPs and PACs, particularly fish from Morrison Street Bridge, the Confluence, and Columbia City. DDTs were detected in stomach contents of salmon collected throughout the estuary. Metabolites of PACs in salmon bile were highest at the Morrison Street Bridge, Columbia City, Confluence and Beaver Army Terminal sites. Levels of all of these classes of contaminants were comparable to or higher than those measured in other Pacific Northwest juvenile Chinook populations.

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HEALTH EFFECTS OF CONTAMINANT EXPOSURE IN OUTMIGRANT JUVENILE CHINOOK FROM THE LOWER COLUMBIA RIVER AND ESTUARY

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The Lower Columbia from Bonneville to the estuary mouth is the most urbanized section of the Columbia River, and a variety of contaminants, have been detected in whole bodies and stomach contents of juvenile salmonids, including PCBs, DDTs, PAHs, polybrominated diphenyl ethers (PBDEs) and pesticides. Salmon were also surveyed for exposure to estrogenic compounds by screening them for production of the estrogen-regulated yolk protein, vitellogenin. One of our objectives was to evaluate the potential for adverse effects on salmon by comparing contaminant tissue and prey concentrations with levels known to be associated with adverse effects in salmon and other fish. Sampling focused on outmigrant fall Chinook because of their longer residence time in the estuary and greater potential for absorbing contaminants. The highest levels of contaminants were in or downstream of major urban centers. Whole body concentrations of PCBs and DDTs, and PAH concentrations in stomach contents and bile, from some sites were high enough to constitute a potential health risk these fish. These health effects include: immunosuppression, reduced disease resistance, reduced growth rates, impaired thyroid function, and delayed mortality in outmigrant juveniles. Abnormal vitellogenin induction was also found in fish from sites in Portland Harbor and the Columbia/Willamette confluence, indicating exposure to estrogenic compounds which could disrupt reproductive development and endocrine function. Data on the toxicity of chlordanes and HCB to juvenile salmon are limited, but the information that exists suggests that tissue concentrations in salmon from the Lower Columbia are unlikely to have significant effects on their health. Intersite differences in fish condition, lipid content, and lipid class were also observed, which could be related in part to contaminant exposure.

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CYTOCHROME P4501A INDUCTION AND DNA DAMAGE IN *PIMEPHALES PROMELAS* DURING EXPOSURE TO EXCEPTIONAL QUALITY BIOSOLIDS

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Adult male fathead minnow (*Pimephales promelas*) were exposed to EQ (exceptional quality) biosolids for 28 days in static renewal aquaria. Treatments were clean water (control), low dose (0.5 g l^{-1}), and high dose (2.5 g l^{-1}). Biosolids are stabilized sewage sludge known to contain a complex mixture of PAHs, PCBs, nonylphenols, brominated diphenyl ethers, and other contaminants. Many of these chemicals are known to impact aquatic organisms via genotoxic, endocrine disruption, and other pathways. Hepatic cytochrome P4501A (CYP1A) was elevated approximately eight- to 21-fold in fish exposed to low and high dose biosolids exposures relative to controls. DNA damage measured in hepatocytes using the Comet assay was elevated in low and high dose exposed fish at all time points measured. Our data suggest that biosolids-associated contaminants have the potential to impact aquatic organisms exposed to these contaminants.

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QUANTIFICATION OF CARBON BASED NANOMATERIALS BY LC-MS TO DETERMINE UP-TAKE OF FULLERENES BY EMBRYONIC ZEBRAFISH

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With the many possible applications of fullerenes and carbon based nanoparticles, production and use are increasing; therefore, there is the potential for environmental and human exposures. Although many groups have demonstrated toxicological responses to nanoparticle, few have focused on actually quantifying the kinetics of nanoparticle uptake and actual body burden of nanoparticles after exposure. To determine the biological up-take of nanoparticles, C_{60} was used as a model and an analytical method based on liquid-liquid extraction LC-MS was developed. The method was applied using embryonic zebrafish since zebrafish display characteristic signs of toxicity in responses to waterborne C_{60} exposure. Time-course experiments were performed by exposing zebrafish to 35, 70, 127 and 250 ppb C_{60} for 2, 6 and 12 hrs. The LC-MS method was used to determine with time the embryonic dose resulting from waterborne C_{60} exposures, the actual concentration of C_{60} in solution, and (by difference) the amount associated with the vial. The recoveries of C_{60} from embryo homogenate and artificial fish water (n=3) were 90 % and 95 %, respectively, with RSDs of 2% and 4 %, respectively. Sorption of C_{60} to the vial from solution was observed in the first 6 hrs with 36, 5 and 17% of the original dose remaining in solution after 6 hours for 70, 127 and 250 ppb, respectively, with no additional loss of C_{60} from solution from 6 to 12 hrs. After 2 hrs of exposure, the difference in the up-take of C_{60} by zebrafish exposed to 70, 127 and 250 ppb was not statistically significant. After 12 hours of exposure 0.2, 0.7 and 2.3% of the dosed C_{60} was taken up by the embryonic zebrafish from the exposures of 70, 127 and 250 ppb, respectively. These results, for the first time, demonstrate the unambiguous, rigorous quantification of C_{60} concentrations over time in water and in biological samples.

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OLFACTORY PERFORMANCE IN SALMONIDS EXPOSED TO AQUATIC HERBICIDES

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Herbicides are frequently used to control exotic or nuisance aquatic plants and their use has been hampered by concerns directed at the non-target toxicity of active ingredients. Unfortunately, adequate data on the non-target toxicity of aquatic herbicides are lacking, threatening the permitting process. In the Pacific Northwest, population declines of several species/stocks of salmon and efforts to restore these populations heighten concerns. The effects of aquatic herbicides on the olfactory system have not been studied, despite altered olfaction by exposure to other pesticides (e.g. organophosphates). Olfaction is important for fish influencing their ability to find a mate, detect prey, and avoid predators. It is additionally important in salmonids as part of imprinting during out-migration and smoltification, allowing them to return to their native streams to reproduce. Our objective was to determine if the aquatic herbicides DMA® 4 IVM (ai=2,4-D), Renovate® 3 (triclopyr), Reward® (diquat), and Sonar® AS (fluridone) effect the olfactory ability of juvenile rainbow trout (*Oncorhynchus mykiss*) when exposed to the maximum application rate for 96 hours. We used five replicate exposure and behavioral assays to determine effects. Water samples from each concentration were chemically analyzed. Juvenile rainbow trout were affected by the maximum rates of Reward.

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CATCH BASINS AS SOURCES OF MOSQUITOES AND WEST NILE VIRUS: AN EVALUATION OF MOSQUITO LARVAE ABUNDANCE AND THE EFFICACY OF CONTROL STRATEGIES

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During the summer 2005, Washington was one of only two states within the contiguous U.S. with no human cases of West Nile Virus. In anticipation of its arrival, the City of Seattle (Seattle Public Utilities) sponsored a citywide research effort in 2006 aimed at investigating environmental factors governing mosquito larvae abundance within catch basins and the efficacy of three larvicides: Mosquito Dunks® and Bits® (AI = *Bacillus thuringiensis israelensis*), VectoLex® WSP (*Bacillus sphaericus*), and Altosid® Briquets (Methoprene). Catch basins were randomly selected and were proportional to city sector and zone. Basins were monitored weekly for mosquito larvae and other characteristics. Efficacy and fate of the larvicides were monitored in a smaller set of basins. Larval counts within the West and Southwest sectors and the Single Family Zone were statistically greater ($p<0.05$) than other sectors and zones. Sector, zone, ambient air temperature, basin water temperature, and time (week) were the best predictors ($P<0.003$, $R^2=0.25$) of larval counts. Precipitation was not a factor in 2006. Sediment texture, pH, and selected roadway contaminants did not differ between basins with high or low larval counts. All of the larvicides performed according to manufacturers' expectations. All treatments resulted in a rapid reduction in number of pupae (Bti and Bs) or hatching success of pupae (Methoprene), although the Bs treatment was the most effective. Larvicides were effective for at least 7 weeks post-application. The effectiveness of Methoprene was reduced during precipitation events. Concentrations of Bti and Bs exceeded background levels for at least 35 days. Data for Methoprene are not yet available. This information will be used by the City of Seattle in the development of long-term strategy for mosquito control. Future research likely will focus on identifying habitat features associated with high larval densities and the potential for non-target effects of larvicides on salmonids.

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BRAIN AChE INHIBITION IN JUVENILE RAINBOW TROUT EXPOSED TO PESTICIDE MIXTURES WITHIN URBAN STREAMS IN WESTERN WASHINGTON: REASONS FOR NON-ADDITIVE EFFECTS

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Recent efforts have documented pesticide concentrations within surface waters of urban streams in western Washington. Although levels reported are low (most <1.0 ppb), the presence of these chemicals has generated concerns, particularly their potential effects on salmonids. Previously, we exposed juvenile (ca. 10 g) rainbow trout (*Oncorhynchus mykiss*) to a chemical cocktail representative of urban streams in western Washington. Nominal concentrations (ppb active ingredient) of 9 herbicides, 3 insecticides (ChE-inhibitors, carbaryl, diazinon, and malathion), an insecticide breakdown product, and a fungicide were the maximum reported during peak storm flow events (hereafter 1X). With the exception of the fungicide and the breakdown product, formulated products (FP, single AI) were used and if possible were selected from those available at retail outlets. Brain AChE activity was not inhibited in fish exposed to the 1X cocktail, but was in the 3.3X (23%) and 10X (84%) cocktails. Enzyme activity was not affected by the 10X concentrations of the individual cholinesterase inhibitors as AIs or FPs, but was inhibited 59 and 78 percent in fish exposed to the mixtures, respectively. Recently, we exposed juvenile rainbow trout of the same size to the same individual cholinesterase inhibitors (10X) as AIs or FPs as well as binary and tertiary mixtures in an effort to identify the combination responsible for the potentiation of AChE inhibition and the underlying physiological mechanisms. Results for the AIs and FPs were similar and indicated that the combination of diazinon + malathion (AChE inhibition = 85-88%) was responsible. Results of complementary studies of the relationships between effects on plasma BuChE and carboxylesterases and the interaction between the two AChE inhibitors will be presented. The implications of these results to urban streams, the regulation of pesticide mixtures, and assessments of the hazards pesticides pose to non-targets will be discussed.

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USE OF MULTIPLE LIFE STAGES IN ASSESSING *CINYGMULA* SP. MAYFLY SENSITIVITY TO ESFENVALERATE

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Agrichemical contamination principally occurs as seasonal pulses in aquatic systems; similarly, many aquatic insect species exhibit seasonality in their life cycles. Since sensitivity to insecticides can be influenced by the developmental stage of the exposed insect, it is plausible that aspects of a species' life history may contribute to individuals' susceptibility to agrichemicals. Susceptibility of each life stage may be defined in terms of (1) exposure potential relative to agrichemical use patterns and distribution in the aquatic environment, (2) the magnitude of uptake, metabolism, and elimination (3) target site sensitivity. Toxic effects at each life stage may differentially affect the aspects of growth, reproduction, and behavior that determine fitness and survival. We investigated the life stage specific effects of low-level esfenvalerate exposures (< 0.5 μg/L), using a native mayfly, *Cinygmula sp*. (Ephemeroptera: Heptageniidae). Two routes of exposure were considered, water-bourn and trophic. Pre-emergent nymphs were the most sensitive to water-column esfenvalerate exposures, while small nymphs' growth rate was the most severely impacted by trophic esfenvalerate exposures.

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RELATIVE CONTRIBUTION OF VARIOUS SOURCES TO POLYCHLORINATED BIPHENYL (PCB) LEVELS IN THE WILLAMETTE BASIN (OREGON)

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The Willamette River Basin covers an area of 32,000 km^2 and is drained by the Willamette River, which runs for over 180 miles from its headwaters to its confluence with the Columbia River. Polychlorinated biphenyls (PCBs) have been detected in water, sediment, and tissue samples collected in the lower river (< RM 26), principally within the Portland Harbor Superfund site where PCB point and non-point sources are either known or strongly suspected to exist. But PCBs have also been detected in resident fish tissue collected throughout the upper river. Here, over 90% of the land is devoted to agriculture or forestry, uses not typically associated with PCB releases, while urban and industrial areas, which may contain PCB sources, comprise less than 10% of total land use and occur in localized patches. What then is the source of PCBs found in the upper river? One potential non-point source is atmospheric deposition. Given the areal extent of the Basin and its high annual rainfall, relatively low atmospheric concentrations of PCBs emanating from local, regional, or global sources could result in meaningful loadings. For example, an initial estimate for PCB-118, based on U.S. EPA National Dioxin Air Monitoring Network (NDAMN) data for 2000-2002, suggests that atmospheric deposition could contribute up to ≈ 16 kg yr^{-1} to the Basin as a whole, or ≈ 1.6 kg yr^{-1} directly to water. Depending on the bioconcentration factor assumed, this loading could equate to fish tissue levels of ≈ 3000 ng kg^{-1}, within range of measured values (≈ 7000 ng kg^{-1}). The extent to which atmospheric deposition contributes to PCB loadings could influence decisions regarding the remediation of Portland Harbor. A multi-segment, dynamic, seasonally-responsive model is being developed to further explore the relative contributions of atmospheric and other source to PCB levels in the Basin.

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"IT AIN'T THE SEDIMENT, DUMMY":
RELATIVE CONTRIBUTION OF SEDIMENT AND WATER TO PCBs IN FISH TISSUE

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The primary contamination issue in many CERCLA and other clean up projects, is the concentration of PCBs in sediments and in fish, often at concentrations high enough to drive cleanup. However, it is not clear that the sediments are always the source of the PCBs in fish tissue. In many cases, there is insufficient or inappropriate media data to clearly determine the relative source(s) of PCBs that are found in fish tissue. Without this critical information, several parameters in the human and ecological risk estimates will be overly conservative, or even erroneous. Risk estimates are critical tools to be used in feasibility studies and eventually for cleanup strategies. Lack of definitive source and/or media data also adversely impacts the credibility of a food web model and its proposed use for the Human Health and Ecological risk assessments. To reduce PCB concentrations in fish, removal of river sediments is usually a preferred mitigation strategy recommended by US EPA. However, sediment removal involves dredging and massive volumes of sediment which can be destructive to the ecological habitat, and certainly very expensive. At numerous CERCLA cleanup sites, removal of sediments has not mitigated or permanently alleviated PCB concentrations in resident and non-resident fish. In this presentation we compare the results of several CERCLA projects to illustrate that the relative contribution of sediment PCBs to fish tissue is not clear. In fact, in many instances, this is an inverse relationship with no clear correlation between sediment and fish tissue PCBs. It appears that the source of PCBs in fish tissue at many sites is not sediment. We provide a hypothesis for this disparity and how a lack of understanding of this relationship has impacted ecological and human health risk assessments and food web models.

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USING CAGED MUSSELS TO CHARACTERIZE EXPOSURE AND EFFECTS ASSOCIATED WITH WATER AND SEDIMENT IN MARINE AND FRESHWATER ENVIRONMENTS

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Caged mussels were used to characterize bioaccumulation and biological effects, identify potential sources of ecological stress, and assess ecological risks associated with the Puget Sound Naval Shipyard and an abandoned mine site at Lynn Lake in Manitoba, Canada. Three conceptual models were used in both studies; 1) the caged bivalve model; 2) the ecological risk assessment model; and the critical body residue model. Strategic placement of caged bivalves along suspected chemical gradients provided data that helped identify the relative contribution of chemical exposure associated with waterborne and sediment exposure pathways. These pathways changed from water and sediment depending on water flow and season for metals in the freshwater study and the relative contribution of water and sediment differed for metals and organics in the marine study. Chemical exposure was characterized by measuring bioaccumulation in caged marine (*Mytilus galloprovincialis*) and freshwater mussels (*Elliptio complanata* and *Lampsilis radiata*). In the marine study, differences in bioaccumulation were found in caged mussels deployed 1 meter above the bottom versus two and three meters above the bottom. In the freshwater study, differences in bioaccumulation were found in caged mussels placed directly on the bottom and 1 foot above the bottom. Significant differences in mussel growth rates were also found among sites. This was the basis of an ecological risk assessment-based approach for both sites and facilitated identification of potential sources and zones of chemical influence. Finally, the critical body residue model was used to quantify potential risk at each site and relative risk associated with each chemical using stacked hazard quotients. These were combined with hazard quotients for water and sediment to harmonize water, sediment, and tissue quality guidelines.

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USING CONSENSUS ECOLOGICAL RISK ASSESSMENT TO EVALUATE OIL SPILL RESPONSE OPTIONS: DO MORE SKIMMERS EQUAL BETTER REPONSE?

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During the past decade the United States Coast Guard and NOAA have sponsored over 15 regional multi-day Consensus Ecological Risk Assessment Workshops around the US and abroad. The workshops are conducted according to EPA Risk Assessment protocols as modified by Aurand (1995). The purpose of the workshops is to enhance the ability of resource trustees to objectively evaluate, and plan for, all response options including open water mechanical, in situ burning, dispersion and shoreline clean up. Workshop participants are given training on the effectiveness and limitations of each option and on the ecological effects of oil on fish, invertebrates, plants and wildlife. Participants are then challenge with a real-time, locally-relevant, oil spill scenario subjected to alternative responses including (a) no response, (b) open water mechanical (skimming), (c) in situ burning, (d) dispersant application and (e) shoreline clean up (manual, mechanical, biological, and chemical techniques). The scenario is developed using a modification of ERD's General NOAA Oil Modeling Environment (GNOME) simulation model. In formal facilitation, participants debate the ability of each option to remove oil, modify its trajectory, reduce injury and speed ecological recovery of marine resources (birds, mammals, reptiles, fish, benthic communities, etc) and habitats (intertidal, marsh, shallow sub-tidal, reefs, kelp beds, water column). The workshops close with a listing of uncertainties and unresolved issues, many of which are lead to focused research in areas such as evaluation of the effectiveness of response tools, and needed ecotoxicology and ecosystem recovery-time information. Under the best outcomes, the workshops result in (a) increased collective trustee understanding of the benefits and limits of response options and (b) critical or at least incremental changes in regional and local response planning and preparation, focused more squarely on minimizing ecological injury and enhancing ecosystem recovery (rather than only on the amount of response equipment available.)

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REASSESSMENT OF CYANIDE AMBIENT WATER QUALITY CRITERIA: AN INTEGRATED APPROACH TO PROTECTION OF THE AQUATIC ENVIRONMENT

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Current National ambient water quality criteria (AWQC) for cyanide were developed in 1984. This study reviewed and updated our current scientific knowledge on the aquatic chemistry and toxicity of cyanide and new aquatic toxicity studies were conducted to fill critical data gaps. Recalculated acute and chronic freshwater criteria are 23 and 4.8 µg CN/L, respectively, which are similar to the current National acute and chronic criteria of 22 and 5.2 µg CN/L. The recalculated acute marine criterion of 5.5 µg CN/L is 5-fold higher than the current acute marine criterion of 1.0 µg CN/L, largely due to additional toxicity testing with the East Coast rock crab (*Cancer irroratus*) and other *Cancer* species. The recalculated chronic marine criterion of 1.1 µg CN/L is only slightly different than the current chronic marine criterion of 1.0 µg CN/L due to changes in the recalculated acute-chronic ratio used to derive the chronic criterion from acute toxicity data. Consistent with the USEPA's draft strategy for developing AWQC, this evaluation also considered whether the cyanide AWQC would be protective of benthos, threatened and endangered (T&E) species, and aquatic-dependent wildlife. Available empirical and estimated cyanide toxicity values for T&E species suggest that the recalculated freshwater criteria would protect most T&E fish species at levels required by the Clean Water Act, but any site-specific modifications (e.g., using USEPA's Recalculation Procedure) for water bodies inhabited by T&E species should still be done with caution. Benthic organisms should be adequately protected by these recalculated AWQC because they are not inordinately more sensitive to cyanide than the water column organisms that drive the basis for the proposed freshwater and saltwater criteria, and because bioavailable forms of cyanide are not expected to accumulate appreciably in sediment. Finally, the recalculated freshwater AWQC for cyanide should be adequately protective of aquatic-dependent wildlife.

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BIOLOGICAL EVALUATION OF THE LEVEL OF PROTECTION PROVIDED TO ENDANGERED SPECIES BY OREGON'S WATER QUALITY CRITERIA

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The U.S. Environmental Protection Agency (EPA) is required to develop water quality criteria and approve water quality standards for the protection of aquatic life under the Clean Water Act. Under the Endangered Species Act (ESA), U.S. federal agencies are required to ensure that their actions are not likely to jeopardize the continued existence of endangered species. EPA's approval of state water quality standards is considered an action that could potentially jeopardize endangered species, and thus requires consultation with natural resource agencies under the ESA. The state of Oregon recently submitted to EPA for approval new or modified water quality criteria for 19 freshwater chemicals and 13 saltwater chemicals. The procedures EPA Region 10 used to evaluate potential adverse effects of water quality criteria on the 16 endangered aquatic species (14 fish, 2 aquatic invertebrates) and 11 endangered wildlife species in Oregon (5 aquatic-dependent birds, 6 marine mammals) are described. Four major types of evaluations were performed: effects on aquatic species from direct exposure to chemicals in water; effects on prey of aquatic species; effects on aquatic species from multiple routes of exposure to criteria chemicals (i.e. from direct water column toxicity and toxicity from ingestion of contaminated prey); and toxicity to wildlife species whose diet consists of an appreciable proportion of aquatic prey potentially contaminated from exposure to criteria concentrations. The methodology used for each type of evaluation will be described and summaries of the 91 likely to adversely affect calls and 840 not likely to adversely affect calls will be presented. All but one of the 80 likely to adversely affect calls for aquatic species were for various freshwater criteria. Ten of 11 wildlife likely to adversely affect calls were for the saltwater selenium criterion.

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CAN SEDIMENT PROFILE IMAGING SURVEYS STREAMLINE CLEANUP SITE INVESTIGATIONS?

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Sediment Profile Imaging (SPI) has been used in the Puget Sound to a) identify disposal sites for clean dredged material, b) confirm accurate placement of dredged material, c) evaluate dredged material impacts on benthic communities at disposal sites, and d) evaluate sediment quality and benthic communities at contaminated sediment cleanup sites. Cleanup site studies, however, have been designed to map areas impacted by contaminants/wood waste or assess benthic community recovery after remedial actions. During the summer of 2006, the State of Washington began one of the first investigations of whether or not preliminary SPI survey results might reduce the need to measure common indicators of sediment quality at cleanup sites. Two sediment cleanup sites were chosen for an exploratory investigation: the Lower Duwamish Waterway (LDW) and Port Gamble. Sampling was conducted during July and August, 2006. A nonrandom, stratified design was developed to maximize utility of the limited data to be collected. SPI surveys included more than 80 stations in the LDW and over 30 stations in Port Gamble. Based on interim SPI results, sediment conventionals and *in situ* benthic community characteristics were measured at 50 of these stations. Contaminant chemistry and laboratory toxicity were also measured in 30 LDW samples. This presentation will describe results of analysis of relationships between SPI data and conventionals, contaminant chemistry, toxicity and benthic community data.

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DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS USING A FOOD WEB MODEL

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An updated version of the Gobas food web bioaccumulation model was applied to the Lower Willamette River (Oregon) to characterize relationships between the chemical concentrations present in sediment, water, and tissue. The primary purpose of the food web model (FWM) was to derive initial preliminary remediation goals (iPRGs) for chemicals in sediment, including PCBs and DDTs. Sediment iPRGs are specific concentrations of chemicals in sediment associated with target tissue concentrations based on human health and ecological target risk estimates. A probabilistic approach was used for general model calibration and for sensitivity and uncertainty analyses. Once all model parameters had been defined, a probabilistic approach was again used to select sediment iPRGs. Sediment iPRGs were selected from distributions of model-predicted chemical concentrations in tissue and the corresponding model input concentrations for chemicals in sediment. Assumptions of relationships (or lack thereof) between water and sediment chemical concentrations were important in determining iPRGs. In some cases, assumed contributions from water alone (i.e., sediment chemical concentration equal to zero) resulted in predicted tissue concentrations in excess of risk-based targets, and iPRGs for sediment could not be determined. In future applications, the FWM will be used to set final PRGs for the identification of areas of potential concern and the definition of sediment management areas and for the evaluation of residual risks.

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MEASURING AND MANAGING POTENTIAL CONSTRUCTION DISTURBANCE TO NESTING BALD EAGLES ON A PUGET SOUND NAVAL BASE

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The Puget Sound region serves as home to both nesting bald eagles (*Haliaeetus leucocephalus*) and several active military installations. Due to their locations, sizes, and limited public access, military bases often provide favorable bald eagle habitat. Like other disturbed habitats, however, military bases are potential sources of anthropogenic disturbance for nesting bald eagles. Under the Endangered Species Act and the Bald Eagle Protection Act, it is illegal to disturb nesting bald eagles. Construction on bases often occurs within buffer zones stipulated for nesting eagles under these acts. Active bald eagle nests within these buffer zones must be monitored for signs of disturbance during construction activities, and activities that cause disturbance must be stopped and rescheduled for the non-nesting season. We discussed methodologies for identifying and categorizing eagle disturbance behaviors, choosing relevant disturbance metrics, and establishing controls for qualitative comparison. Preliminary comparisons of disturbance metrics between a treatment and control nest showed that construction activities and bald eagles may peacefully coexist on Naval installations. Several potential factors contributed to this outcome including thorough construction planning, the availability and location of potential eagle foraging habitat, and annual eagle productivity. Our results elucidated potential construction-related disturbance factors which informed our recommendations for both those performing construction in proximity to bald eagle nests and those monitoring them.

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SENSITIVITY OF MARINE ORGANISMS TO HYDROGEN SULFIDE: TEST DESIGN, IMPLEMENTATION, AND RESULTS

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Hydrogen sulfide (undissociated H_2S) is a soluble highly toxic compound that occurs naturally in anaerobic marine sediments. It can also be introduced directly into the aquatic environment through the discharge of domestic wastes, industrial wastes, and produced waters from the oil and gas industry. While there have been some evaluations of hydrogen sulfide toxicity, many of these exposures have been in the presence of complex mixtures or have not been in continuous exposures. The objective of this investigation was to evaluate the H_2S sensitivity to a variety of water-column and benthic organisms. This program was developed to evaluate existing data regarding H_2S toxicity and to conduct acute and chronic flow-through testing with a constant exposure concentration to targeted water-column and benthic organisms. A critical challenge in dealing with H_2S in aerobic marine systems is that the half life of the H_2S ranges from 1 hour or less depending on the concentration. This posed potential problems in experimental design when conducting toxicity tests ranging from 48-hours to 7-days. A continuous-flow dosing apparatus was developed specifically for this program in order to maintain continuous levels of H_2S within the test treatments. A laboratory modification incorporating unique fume hoods, treatment of waste water and air, and monitoring devices helped maintain a safe environment for laboratory staff. The results of this program suggest that an H_2S is acutely toxic to marine organisms at concentrations ranging from 7µg/L (larval mussels) to 6000µg/L (adult clams). Larval echinoderms and bivalves used in many regulatory tests appear to be the most sensitive; however, this sensitivity appears to be limited to the first 6 hours of the test period. This program also reinforced the concept that the mechanism for H_2S toxicity occurs acutely, resulting in an acute to chronic ratio of 1:1.

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CONTROLLING EFFECTS OF SHELLS AND SULFIDES ON MARINE SEDIMENT TOXICITY TESTING

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Previous marine toxicity testing on sediments with high sulfide and shell content collected from the southeast Strait of Georgia demonstrated increased toxicity despite low concentrations of measured contaminants of concern. Sediment was collected in 2006 from 14 stations to measure toxicity when controlling for high interstitial sulfide and shell content. Shell content was above 30% at three stations and was controlled by splitting samples from the same homogenized sample into fractions passing a 1-inch sieve ("unsieved" samples) and fractions passing a 4-mm sieve ("sieved" samples). Paired "unsieved" and "sieved" samples from six stations in the study area (four with elevated polycyclic aromatic hydrocarbons) and three reference stations from Samish Bay were submitted for toxicity testing using two acute tests (10-day *Rhepoxynius abronius* survival, 48-hour *Mytilus galloprovincialis* larval development) and one chronic test (20-day Neanthes *arenaceodentata* growth). Elevated interstitial sulfide concentrations were controlled in additional toxicity testing on "unsieved" samples by delaying addition of test species for the *R. abronius* and *N. arenaceodentata* tests until normal aeration decreased interstitial sulfide to below 10 ppm. Results from 2006 testing indicated decreased *N. arenaceodentata* growth with increased bulk sulfide and ammonia content in "sieved" and "unsieved" paired samples. In samples with high bulk ammonia (>25 ppm) and sulfide (>800 ppm), high shell content in "unsieved" samples (>33% shells) contributed to lower *N. arenaceodentata* growth than in paired "sieved" samples (13% shells) despite higher PAH concentrations in "sieved" samples. Aeration prior to test initiation for "unsieved" samples resulted in increased *N. arenaceodentata* growth for all but one sample. *R. abronius* demonstrated lower survival with increased percent fines, but neither *R. abronius* survival nor *M. galloprovincialis* normal survivorship appeared to be affected by sulfide, ammonia, or PAH concentrations.

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THE ELIMINATION OF PCB CONGENER INTERFERENCE IN ORGANOCHLORINE PESTICIDE ANALYSIS USING MASS SPECTROMETRY

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The analysis of organochlorine pesticides using traditional EPA methodologies that employ electron capture detectors (ECD) are often affected by PCB congener contamination causing the overestimation of some compounds. High biased results for oganochlorine pesticides can lead to an overall lack of data confidence and unnecessary environmental actions. To eliminate the congener interference an Ion Trap GC/MS/MS methods was developed and evaluated. Using standard extraction procedures combined with large volume injection, the method able to achieve detection levels equivalent to those typically observed by ECD detection. The method was applied to water, soil/sediment and tissue matrices. Ion trap GC/MS/MS showed additional advantages in complex matrices by further reducing co-extractable interferences. The use of ion trap GC/MS/MS for chlorinated pesticide analysis provides superior analyte selectivity resulting in increased data defensibility.

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Poster Presentation Abstracts

LEVELS OF CHEMICAL CONTAMINATION AND TOXICITY IN HOOD CANAL SEDIMENTS (1952 – 2005)

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Levels of chemical contamination and toxicity measured in Hood Canal sediments were examined by Ecology's Puget Sound Assessment and Monitoring Program Sediment Monitoring Team as part of an effort to assess the effects of low dissolved oxygen on benthos in Hood Canal for the Hood Canal Dissolved Oxygen Program. Examination of all available data collected from 1952 through 2005 revealed a number of spatial patterns. Chemical contamination and toxicity were generally low in Hood Canal and were usually confined to Port Ludlow, Port Gamble, and Dabob Bay. Metals were detected more frequently (81% of samples tested) than organic pollutants (0%-64% of samples tested). Chemicals rarely exceeded Washington State Sediment Quality Standards, but did for a suite of metals, PCBs, and benzenes at stations collected in 2000 in Port Gamble; for naphthalene (an LPAH) at one station in 1999 in Port Ludlow; and for butylbenzylphthalate at one station in 1990 in Dabob Bay. Several toxicity tests (amphipod survival, sea urchin fertilization, bivalve larval morphological development, cytochrome P450 RGS) indicated toxic sediments in Port Ludlow, Port Gamble, Dabob Bay, just south of Dabob Bay, and in southern Hood Canal near Lilliwaup. Existing temporal data were limited and were insufficient to indicate trends.

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POLYBROMINATED DIPHENYL ETHERS (PBDES) IN PUGET SOUND SEDIMENTS – A BASELINE UPDATE

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Polybrominated diphenyl ethers (PBDEs), synthetic flame retardants introduced in the late 1970s to reduce the flammability of household and commercial products, are a new pollution concern facing Puget Sound. Structurally similar to polychlorinated biphenyls (PCBs), it is now known that PBDEs break down and enter the ecosystem, bioaccumulating in humans and other organisms, causing serious health concerns. In 2004, the Washington State Department of Ecology's Marine Sediment Monitoring Team added PBDEs to the list of chemicals measured in sediments collected for the Puget Sound Assessment and Monitoring Program (PSAMP). Five congeners, including BDE-47, 99, 100, 153, and 154 were measured for 30 sediment samples collected from Hood Canal in June 2004. These, and 7 additional congeners, BDE-49, -66, -71, -138, -183, -184, and -209, were measured at 10 long-term sediment monitoring stations collected throughout Puget Sound in April 2005. In June 2006, PBDEs were sampled at 40 spatial sediment monitoring stations in Georgia Basin. Levels of PBDEs in these sediments are reported here, updating the baseline of data indicating current levels and the distribution of PBDEs in Puget Sound sediments.

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INFAUNAL INVERTEBRATE ASSEMBLAGE STRUCTURE IN HOOD CANAL, WA (1989 – 2005)

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The structure of invertebrate assemblages in Hood Canal sediments was examined by Ecology's Puget Sound Assessment and Monitoring Program's Sediment Monitoring Team as part of an effort to assess the effects of low dissolved oxygen on benthos in Hood Canal for the Hood Canal Dissolved Oxygen Program. Examination of benthic indices calculated from all available data collected from 1989 through 2005, revealed a number of spatial patterns. Unique infaunal assemblages were distinguished for nine sub-regions of Hood Canal. Infaunal abundance, diversity, and dominance decreased from north to south along the canal's main axis and in the deepest stations, as levels of near-bottom dissolved oxygen decreased and sediments increased in silt-clay and organic carbon content. Stations in northern Hood Canal and in shallow, nearshore locations, with relatively low percent fines and TOC values, had the most diverse assemblages, with a well-balanced mix of annelids, arthropods, and bivalves. Less stress-tolerant arthropods, echinoderms, and miscellaneous taxa generally became rare or absent from north to south, and in the deepest locations, while more stress-tolerant polychaetes and several ubiquitous bivalves (*Axinopsida serricata*, *Macoma carlottensis,* and *Macoma* sp.) became dominant. Existing temporal data were limited and were insufficient to indicate trends.

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RELATIONSHIPS BETWEEN CO-LOCATED CHEMICAL CONCENTRATIONS IN LOWER WILLAMETTE RIVER SEDIMENTS AND AQUATIC ORGANISMS

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Characterizing the relationship between chemicals in sediments and the tissue of aquatic organisms is a common problem at locations with sediment contamination. At the Portland Harbor Superfund site, located on the Lower Willamette River, multiple approaches were employed as part of the remedial site investigation to evaluate this issue. Benthic invertebrates (i.e., clams and crayfish) and sculpin were collected in the field along with co-located sediment samples. Sufficient sediment also was collected at each clam sampling location to perform laboratory bioaccumulation tests with two organisms: *Corbicula fluminea* and *Lumbriculus variegatus*. The tissue and sediment samples were analyzed for a wide range of chemicals, including metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. Biota-sediment accumulation factors (BSAFs) and a food web model were employed to analyze the data. The results provided important preliminary insights for assessing ecological risks and making initial estimates of preliminary remediation goals for sediments at the site. This poster presents highlights of the results from these benthic invertebrate studies.

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SPATIAL AND TEMPORAL VARIATION IN LEVELS OF PBDEs IN JUVENILE CHINOOK SALMON TISSUES FROM THE LOWER COLUMBIA RIVER

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Polybrominated diphenyl ethers (PBDEs) have been recently recognized as a potential threat to outmigrating juvenile salmon due to increasing environmental levels and demonstrated toxic effects such as thyroid hormone disruption and immunosuppression. PBDEs are used in a wide variety of consumer products, and their levels in the environment are in some cases approaching those of PCBs. As part of a study with the Lower Columbia River and Estuary Partnership to determine levels and potential sources of contaminants in juvenile Chinook salmon (*Onchorynchus tshawytscha*), we measured PBDE, PCB and other persistent organic pollutant (POP) levels in whole bodies and stomach contents of juvenile Chinook salmon collected from sites along the Columbia River during Spring and Summer of 2005, including fish from various hatcheries. Fish collected from urban sites (e.g., Portland Harbor) contained higher levels of PBDEs than fish from more remote areas. In some cases, concentrations of PBDEs actually exceeded those of PCBs. Some temporal variation was evident, with the highest PBDE and PCB levels in stomach contents measured in spring samples (April, May, June). Concentrations of PBDEs and PCBs in bodies were lowest in June, with PBDEs present in larger proportions with respect to PCBs in April and May, and in lower proportions in summer (July, August). PBDEs were very low in fish food sampled at the hatcheries and mostly not detected in bodies of hatchery fish. Juvenile Chinook collected from Puget Sound sites had similar or higher PCB levels but generally had lower PBDE levels than the Columbia River Chinook. Tissues of juvenile Chinook salmon from the Columbia River indicate that they are being exposed to PBDEs through their diets as they migrate downstream, especially near urbanized sites, and that they are taking up these contaminants. This exposure may have impacts on their health and survival.

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POLYNUCLEAR AROMATIC HYDROCARBON CONTAMINATION OF BOTTOM SEDIMENTS IN OREGON ESTUARIES, U.S.A.

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The Oregon coast has numerous small estuaries serving as important spawning and nursery areas for marine fisheries species. Economic development pressures continually threaten these important natural habitats. One such recent event prompted us to undertake this study to characterize existing polynuclear aromatic hydrocarbon (PAH) concentrations in the Alsea and Yaquina estuaries located on the central Oregon coast. The Yaquina is one of only three Oregon estuaries suitable for ocean-going vessels, hosts a large commercial fishing fleet, a pulp and paper mill, and other small industries. The Alsea estuary, in contrast, hosts only a limited recreational fishery and is accessed only by small personal boats. Total parent PAH (16) concentrations in Yaquina estuary sediments range from 1.6-540 ng/g dry wt.; in the Alsea estuary they range from 0.7-70 ng/g dry wt. Total measured PAHs for the Yaquina and Alsea are 1.9-640 ng/g dry wt. and 1.7-79 ng/g dry wt., respectively. When TOC normalized, the Yaquina is 4.6 and 5.7 times as contaminated as the Alsea with respect to total and parent PAHs, respectively. Vessel moorage areas tend to be more contaminated than other sites in Yaquina Bay. The ratio of methyl phenanthrenes to phenanthrene (0.3-0.9) was highly characteristic of pyrogenic sources of PAHs in Yaquina Bay. In comparison with sediment PAHs from a small selection of other world geographic sites, PAHs in the Yaquina and Alsea estuaries are considered low and are less than 16% of a commonly used biological effects threshold, NOAA's effects range low (ERL) level of 4,020 ng/g dry wt (Long *et al.,*1995).

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RISK EVALUATION FOR CONSUMPTION OF CADMIUM IN PACIFIC NORTHWEST OYSTERS AND RELEVANCE OF INTERNATIONAL MAXIMUM LIMITS

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Cadmium has been detected in U.S. Pacific Coast oysters at concentrations exceeding international maximum limits (ML). These cadmium concentrations may impact not only human health but result in decreased interstate and international sales of oysters. To address this issue, the U.S. Department of Agriculture granted funds to evaluate the spatial and temporal distribution of cadmium in commercially-important, Pacific Coast molluscan shellfish and to evaluate the human health risk to oyster consumers. Composite oyster samples were collected from 42 locations along the Pacific Coast. The risk evaluation focused on two Pacific Northwest populations with high oyster consumption rates in addition to a "typical" U.S. consumer population. Population-specific seafood consumption studies were used to estimate oyster consumption for a tribal population and the Asian and Pacific Islander communities while U.S. EPA standard consumption rates were selected for the typical consumer. Probabilistic risk assessment methods were used to estimate noncancer risks associated with consumption of oysters harvested in the Pacific Northwest. Consumption of cadmium in oyster tissue did not result in unacceptable risks for the general population nor populations consuming greater quantities of locally-harvested oysters. Cadmium concentrations were compared to MLs established by the Codex Alimentarius Commission (FAO/WHO) and alternative MLs were estimated.

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EFFECTS OF 2,2',4,4'-TETRABROMODIPHENYL ETHER 47 (PBDE-47) ON ZEBRAFISH DEVELOPMENT

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Polybrominated diphenyl ethers (PBDEs) are routinely added to a myriad of consumer products, where they successfully reduce fire related damage and injury. However, these widely produced compounds have become pervasive organic contaminants in the environment and in the tissues of fish, birds, marine mammals, and humans. Little information is available regarding the potential toxicity of these chemicals on humans and animals. Studies in rodents suggest subtle neurodevelopmental defects resulting from embryonic exposure. Using the zebrafish model, we are investigating the impacts of embryonic exposure to PBDE-47, the most abundant PBDE congener found in tissue samples from wild fish. Embryos exposed continuously to aqueous PBDE 47 beginning 3-5 hrs post-fertilization (hpf) showed no gross defects through organogenesis, but displayed functional and morphological abnormalities, and ultimately lethality, by the larval period. By 72-96 hpf larvae showed dorsal curvature which developed into a flexion at the hindbrain. Elevated heart rate was observed by 96 hpf, which often progressed into an atrioventricular block arrhythmia. The timing of these effects is potentially coincident with development of autonomic innervation of the heart. Consistent with a neurodevelopmental defect, injection of fluorescent dextran into the hindbrain ventricle demonstrated reduced cerebrospinal fluid flow. In order to identify cellular or molecular targets for PBDEs, we are currently investigating an anatomical basis for these defects.

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EVALUATING SUB-LETHAL EFFECTS OF COPPER TO SALMONIDS USING AN AVOIDANCE BEHAVIOR ENDPOINT

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The presence and toxicity of metals, such as copper (Cu), have often guided the management practices of several threatened and endangered species, including salmonids native to the Pacific Northwest. In addition, recent evidence suggests that Cu concentrations below current water quality criteria may impose sub-lethal effects (e.g. neuroreceptor death, olfactory inhibition, etc.) on listed species, and contribute to their decline. Previous studies of behavioral response to Cu exposure have found that multiple species of salmonids significantly avoid Cu concentrations as low as 0.1 µg/L. However, inconsistencies in the experimental design, toxicant exposure, and data analysis among studies necessitate further investigation and validation of these findings. Preliminary testing using a flow-through Y-maze exposure system suggests that schooling behavior may have been a confounding variable in the interpretation of previous avoidance testing. In addition, the target Cu concentration is achieved gradually in this exposure system allowing Cu acclimation to occur, which may confound the results through olfactory inhibition effects. In replicating previous work, specific behavioral avoidance endpoints for rainbow trout (*Oncorhynchus mykiss)* will be presented relative to the current chronic ambient water quality criterion for Cu (8.2 µg/L dissolved Cu) and the observed 96-h median-lethal concentration for rainbow trout, under similar water quality conditions. Additional information from ongoing Cu bioavailability testing will also be compared to Biotic Ligand Model predictions to determine whether a mechanistic model can predict the effects of Cu on behavioral response in rainbow trout and other true surrogates such as pink salmon (*Oncorhynchus gorbuscha*).

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PHOTOTOXICITY IN WHOLE EFFLUENT TOXICITY TESTING: LIGHTING CONSIDERATIONS

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In the standard Whole Effluent Toxicity (WET) test method protocol, USEPA recommends the use of ambient laboratory lighting during toxicity tests. No recommendations are made for the specific spectral distribution or relative wavelength irradiance of the light emitted by laboratory light sources. This lack of specific recommendation for laboratory lighting may result in underestimates of toxicity when PAHs are present. In this study, a simulated solar radiation light source was constructed to provide illumination for future WET tests. The spectral distribution and irradiance of light emitted by sunlight and by several fluorescent light sources were characterized using a spectroradiometer. Total UV-A (320-400nm) and total PAR (400-700nm) irradiance were calculated for each light source. Using spectral and neutral density filters, cool white fluorescent (CWF) and UV-A bulbs were combined to create a light source that: 1) Produces UV-A light with a spectral distribution similar to that of natural sunlight; 2) Produces ecologically-relevant levels of UV-A; and 3) Approximates the ratio of total PAR to total UV-A emitted by sunlight. Challenges inherent in simulating the spectral distribution and irradiance of sunlight in the laboratory to account for phototoxic effects are discussed. Considerations and recommendations for future lighting systems are presented.

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SEDIMENT ACCLIMATION IN MARINE EVALUATIONS WITH FRESHWATER SEDIMENTS

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A series of laboratory toxicity tests of freshwater sediments in marine water have indicated that changes in the physical and chemical characteristics of the test sediment can interfere with marine biological assessments. Microbial communities that control the natural breakdown of organic material and the nitrification processes must either adapt or be replaced with marine microbial communities. During that adjustment period there is a reduction in the health of the original freshwater microbial communities and a disruption in nitrogen processing, resulting in increasing ammonia concentrations. In addition, the availability of certain chemicals is altered when the freshwater sediment is placed in marine waters. In order to address issues chemical stability and microbial communities, test sediments were acclimated in marine water prior to testing with standard bioassay test procedures. Sediment samples were immediately placed in marine waters to begin the acclimation process. Ammonia concentrations were evaluated as an indicator of the acclimation process. Once ammonia concentrations had increased, peaked, then decreased, tests were initiated with both acclimated and unacclimated test treatments using a 10-day amphipod test, 20-day polychaete test, and 48-hour larval tests. Concurrent to biological tests, samples were analyzed for priority pollutants. Acclimated treatments showed improved survival, meeting disposal criteria; whereas the unacclimated treatments did not pass for ocean disposal. In addition, pore water in the unacclimated treatments showed tributyltin concentrations that exceeded bioaccumulation trigger values. However, following acclimation to marine waters, pore water TBT concentrations were below the trigger values and no bioaccumulation tests were required.

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SENSITIVITY OF MUSSEL (*MYTILUS EDULIS GALLOPROVINCIALIS*) AND ABALONE (*HALIOTUS RUFESCENS*) LARVAE TO HYDROGEN SULFIDE

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Hydrogen sulfide (H_2S) is a soluble, highly toxic compound that can occur naturally in anaerobic aquatic sediments, can also be released into the aquatic environment with domestic and industrial wastes, as well as produced waters from the oil and gas industry. The objective of this investigation was to evaluate the sensitivity of different stages of larval molluscs to H_2S. Because the half-life of H_2S is short in aerobic systems (<1 hour), tests were conducted as static-renewal exposures, with hourly renewals throughout the test. Exposure periods (0, 6, 12, 24, and 36 hours) targeted initial cellular division, gut formation, and shell development. For the mussel, extreme H_2S sensitivity occurred only during initial cell division. The 0 – 6 hour EC_{50} was 6.9 µg/L. The next phase of development (approximately 12 to 24 h) was dominated by cell differentiation, with the formation of the mouth, gut, and anus. The EC_{50} during this phase was 17 µg/L. Shell development follows after approximately 24 hours of development. No significant decreases in normal development were observed during shell development, with EC_{50}s of 16 to 35 µg/L H_2S. Larval tests with abalone showed a similar pattern to that of the mussel test, however, the abalone larvae were less sensitive than the mussel. Both mussel and abalone larvae appear to be acutely sensitive to H_2S only during the short, initial burst of development involving very high cell division. Typically the larval test is included as an indication of potential toxicity to small, highly sensitive water-column or benthic organisms. However, in the presence of H_2S, these tests may have somewhat limited regulatory applicability.

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EXPOSURE OF SALMONIDS TO CARBARYL FOLLOWING APPLICATIONS TO CONTROL BURROWING SHRIMP IN WILLAPA BAY, WASHINGTON: CHANNEL HABITATS AND ENZYME RECOVERY

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Efforts to restrict the use of carbaryl to control burrowing shrimp in Willapa Bay, Washington have been in part driven by concerns over potential effects on salmonids. Previously, we studied the use of treated oyster beds in the Bay by salmonids in an effort to quantify their actual exposure to carbaryl. The only salmonid captured above the beds before or after treatment were juvenile Chinook (*Oncorhynchus tshawytsha*). Brain AChE was inhibited in Chinook above 2 of 6 treated oyster beds (means = 12-18%) during the first tide post treatment with recovery to pre-spray levels of AChE by the second or third tide post-treatment, respectively. In 2006, we studied the use of channel habitats adjacent to treated oyster beds by fishes, quantified their exposure to carbaryl, and exposed Chinook smolts to carbaryl in the laboratory to determine time to recovery of brain actylcholinesterase (AChE) activity, the target enzyme of the pesticide. Floating and sinking gill nets (272 net hours, daylight high tides) and beach seines (daylight low tides) were used to capture fish within five channels across two spray events before and after pesticide applications. Chinook, primarily smolts, were the only salmonid captured; the results of AChE analyses in these and other fishes captured have not been completed. In most cases, concentrations of carbaryl in the water column at high tide (6-h postspray) were <0.2 ppb, maximum = 29.1 ppb. Concentrations at low tides (12 or 24 h postspray) were greater, 0.6-38 ppb. AChE activity in Chinook smolts exposed to 1,520 ppb carbaryl (Sevin® 80 WSP) in seawater for 6 h (> 80% enzyme inhibition) reached normal levels within 48 h. Results will be discussed within the context of concerns over non-target effects of the pesticide on salmonids in the Bay.

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COMPARISON OF METAL SPECIATION TOOLS AT A SUPERFUND SITE

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The purpose of our study was to assess seasonal and episodic influences on dissolved metal species,,including Cu^{2+}, Cd^{2+}, and Zn^{2+},in a model urban river (the lower Willamette) during a multi-year study. We compared the metal species concentrations obtained from diffusive gradients thin film (DGT) samplers, a time-averaged *in situ* collection device, to the biotic ligand model (BLM), modeled using river water chemistry data. Though the results from these site-specific metal assessment tools were not similar for each metal species studied, they did reveal the relationship between water chemistry parameters and metal species in real-time dynamic aquatic systems.

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POLYBROMINATED DIPHENYL ETHERS (PBDES) IN SOUTHEAST ALASKA: LOCAL SOURCES VERSUS LONG-RANGE TRANSPORT

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Polybrominated diphenyl ethers are a group of compounds used as flame retardants in a wide range of consumer products. The persistent nature of these compounds has led to environmental contamination in many parts of northern Europe and America. That same persistence has also allowed for long-range transport of PBDEs, resulting in detectable levels in pristine areas not immediately subject to industrial influence. Alaska watersheds originating from high altitude glaciers are particularly susceptible to contamination from long-range transport of persistent organic pollutants. These same watersheds may be subject to limited point sources of pollutants as well but these sources can be easily identified. The ability to differentiate pollutant source was one motivation for a 2004 study that quantified PBDE levels in two Southeast Alaska estuarine watersheds. In this study significant levels of PBDEs were found in tissue and sediment samples from an estuary near a municipal landfill in Southeast Alaska. Significantly lower but still detectable PBDE levels were found in samples (sediment and biota) obtained from a control site consisting of a watershed with similar hydrologic features but well-removed from industrial/urban influence, i.e. a pristine southeast Alaskan watershed. Landfill leachate is associated with the high PBDE levels in samples near the landfill while the source of PBDEs in the samples from the control site is less obvious. The presence of detectable levels at the pristine site, suggest non-local sources of PBDEs and may be tied to atmospheric transport to sub-polar glaciers followed by physical transport to the receiving waters. This poster describes current research aimed at clarifying various PBDE sources in Southeast Alaska. Studies focusing on contaminant input due to glacial melt and urban point sources such as landfills and wastewater treatment plants will be discussed and the threat those inputs pose to lucrative Alaskan commercial fishery stocks.

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DEVELOPMENT OF A BIOTIC LIGAND MODEL FOR PREDICTING THE CHRONIC TOXICITY OF COBALT TO FATHEAD MINNOWS

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Water quality criteria/standards for cobalt have yet to be developed for the European Union, Canada, or the United States. Efforts are underway to determine the toxicity of cobalt to freshwater biota and to characterize the influence of various water quality parameters on cobalt toxicity. These investigations are intended to contribute to the development of a Biotic Ligand Model (BLM) for site-specific cobalt criteria derivation. Results for fathead minnows (*Pimephales promelas*) suggest that acute results, similar to other divalent metals, were dependent on organism age. A substantial difference between dissolved Co 96-h LC50 values was observed between juvenile (54.1 mg/L) and larval (1.64 mg/L) fish. Long-term studies suggest that 7-d short-term chronic tests, conducted under flow-through conditions, were predictive of standard early-life stage studies. For example, under similar water quality conditions, EC10 values calculated for the 7-d and 34-d studies were 0.852 mg/L and 0.823 mg/L dissolved Co, respectively. Based on these findings, 7-d flow-through short-term chronic tests were used to generate the range of empirical data necessary to develop a BLM for fathead minnows. Preliminary results from this effort suggest that water hardness, alkalinity, and pH significantly influence the toxicity of Co to fathead minnows.

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RESPONSE OF JUVENILE CHINOOK TO HERBICIDE TANK MIXES USED TO CONTROL SPARTINA IN WILLAPA BAY, WASHINGTON

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To address continuing concerns over the potential non-target toxicity of herbicides used to control smooth cordgrass (*Spartina alterniflora*) in Willapa Bay to salmonids, we exposed Chinook (*Oncorhynchus tshawytsha*) smolts to one of five herbicide tank mixes used operationally in the Bay in 2006. Tank mixes included one or two active ingredients (glyhosate [AquaNeat® or GlyPro®] and/or imazapyr [Habitat®]), one of two surfactants (Agri-Dex® or Competitor®), and one of two marker dyes (Blazon® or Hilite®) at concentrations used in the Bay. Tank mixes included those used with hand-held sprayers, broadcast (aerial application), and high precision ground application. Smolts (n=10, three replicates) were exposed to each tank mix in seawater at a concentration equal to that if the herbicides were applied directly to 10 mm of surface water (worse case scenario) three times for 6 h over a 72-h period. This cycle mimicked fish exposed to the tank mixes during the first tidal inundation following each of three consecutive spray events followed by 18 h of clean seawater. Behavior and survival were monitored and plasma samples collected at the end of the test to assess osmoregulatory function (plasma sodium and chloride concentrations). All but one treated fish survived and no behavioral abnormalities were detected in the remaining fish. Plasma sodium and chloride analyses are underway. Results will be discussed relative to predictions based on the results of median lethal toxicity tests, progress in controlling *Spartina* in Willapa Bay, and growing concerns over the spread of smooth cordgrasses in Puget Sound.

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TOXICITY OF IMIDACLOPRID TO SALMONIDS

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Carbaryl has been used to control burrowing shrimp within oyster beds in Willapa Bay and Gray's Harbor, Washington for 5 decades. These shrimp destabilize the sediments onto which young Pacific oysters are seeded. A legal settlement requires growers to reduce the annual use of carbaryl such that use of the pesticide is discontinued by 2012, and to seek alternatives. Imidacloprid has been shown to be effective in controlling burrowing shrimp and its toxicity to non-target fishes appears to be less than that of carbaryl. The static 96-h LC50 for juvenile rainbow trout (*Oncorhynchus mykiss*) exposed to technical grade imidacloprid is 211 ppm, ca. 2 orders of magnitude less toxic than carbaryl to juvenile trout and Chinook (*Oncorhynchus tshawytsha*). The toxicity of imidacloprid as formulated products to salmonids, particularly juvenile Chinook that occupy waters above the treated beds and adjacent channels, is not known. In an initial effort to determine the relative toxicity of a widely used formulation of imidacloprid (Admire® 2F, Bayer CropScience), we exposed juvenile trout (ca. 14 g) to 0, 75, 107, 151, 215, and 305 ppm AI for 96 h (static) and quantified behavior and mortality; a previous study indicated concentrations $\leq$15 ppm did not result in overt toxicity. All fish exposed to 75 ppm survived, but were lethargic and exhibited erratic swimming. The LC50 was 163 ppm (95% CI=148-177 ppm). Results are comparable to those reported previously for the AI and 1.3 g trout. Under a worse case scenario, i.e. application at 0.2 lbs AI/ac to a mudflat with 10 mm of water prior to tidal inundation, the maximum concentration of imidacloprid would be 0.5 ppm, suggesting a significant margin of safety. Future studies will quantify effects of formulated products on behavior, osmoregulatory function, and survival in seawater adapted Chinook smolts and olfactory-mediated behavior in juvenile rainbow trout.

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REFINEMENT OF PACIFIC HERRING BIOASSAY PROTOCOLS: SALINITY AND DISSOLVED OXYGEN LIMITS AND FOOD TYPE

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The Pacific herring, *Clupea pallasi*, is an important forage fish and fishery resource that ranges from California to Alaska on the Pacific Coast. Several stocks of herring in the Puget Sound region have suffered substantial declines, including the Cherry Point stock, which is at about 10% of its historical spawning biomass. Although these population declines may be related to natural causes, concerns exist about potential contamination of spawning and larval rearing areas from industrial discharges, especially in the Cherry Point area. Because of these concerns, WDOE has commissioned personnel at Shannon Point Marine Center to develop bioassay protocols for using herring embryos and larvae to test industrial effluents and ambient seawaters. Three test protocols have successfully been developed and are in the final stages of refinement and validation: 1) a 12 to15-day embryo development test, 2) a 4-day acute larval test, and 3) a 10-day larval survival and growth test. My poster will present the results of three sets of refinement tests conducted in 2007. The first set of tests evaluated the lower and upper salinity limits for conducting both embryo and larval survival and growth tests by exposing embryos or larvae to salinities ranging from 1 to 40 ‰. A second set of tests evaluated various dissolved oxygen concentrations in order to set a protocol lower DO limit for the larval survival and growth test. The third test compared the use of sea urchin pluteus larvae and *Artemia* nauplli as food rations for the survival and growth test.

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EFFECTS OF HARDNESS, ALKALINITY, AND DISSOLVED ORGANIC CARBON ON THE TOXICITY OF COPPER TO THE MECHANOSENSORY SYSTEM OF DEVELOPING FISH

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As a common non-point source pollutant, dissolved copper is of increasing concern for watersheds and their stream-dwelling fish. The biotic ligand model (BLM) was developed to predict toxicity in fish as measured by the accumulation of a certain metal at the gill, while considering the effects of traditional water chemistry (e.g. hardness, pH, alkalinity, organic carbon) on fish health. Using an *in vivo* fluorescent marker, we measured the effect of various water parameters on short-term (3 h) copper toxicity at sublethal concentrations ($\leq$ 40 µg/L) in the peripheral mechanosensory system of larval zebrafish (*Danio rerio*). Increasing hardness (via $CaCl_2$, $MgSO_4$, and a combination at a 2:1 molar ratio), alkalinity (via $NaHCO_3$), sodium (via NaCl), and organic carbon lowered copper toxicity in the zebrafish mechanosensory system. However, when compared to the copper-BLM predictions for fathead minnow (*Pimephales promelas*) using the same water quality parameters, the magnitudes of copper toxicity in the mechanosensory system were substantially lower than those predicted by the BLM. These results show that the gill-based BLM does not adequately describe the effects of water chemistry on copper toxicity in the fish mechanosensory system. Accordingly, the BLM would underestimate the effects of copper toxicity on mechanosensory system-mediated behaviors that are essential for fish survival.

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USING CONSENSUS ECOLOGICAL RISK ASSESSMENT TO EVALUATE OIL SPILL RESPONSE OPTIONS: DO MORE SKIMMERS EQUAL BETTER REPONSE?

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During the past decade the United States Coast Guard and NOAA have sponsored over 15 regional multi-day Consensus Ecological Risk Assessment Workshops around the US and abroad. The workshops are conducted according to EPA Risk Assessment protocols as modified by Aurand (1995). The purpose of the workshops is to enhance the ability of resource trustees to objectively evaluate, and plan for, all response options including open water mechanical, in situ burning, dispersion and shoreline clean up. Workshop participants are given training on the effectiveness and limitations of each option and on the ecological effects of oil on fish, invertebrates, plants and wildlife. Participants are then challenge with a real-time, locally-relevant, oil spill scenario subjected to alternative responses including (a) no response, (b) open water mechanical (skimming), (c) in situ burning, (d) dispersant application and (e) shoreline clean up (manual, mechanical, biological, and chemical techniques). The scenario is developed using a modification of ERD's General NOAA Oil Modeling Environment (GNOME) simulation model. In formal facilitation, participants debate the ability of each option to remove oil, modify its trajectory, reduce injury and speed ecological recovery of marine resources (birds, mammals, reptiles, fish, benthic communities, etc) and habitats (intertidal, marsh, shallow sub-tidal, reefs, kelp beds, water column). The workshops close with a listing of uncertainties and unresolved issues, many of which are lead to focused research in areas such as evaluation of the effectiveness of response tools, and needed ecotoxicology and ecosystem recovery-time information. Under the best outcomes, the workshops result in (a) increased collective trustee understanding of the benefits and limits of response options and (b) critical or at least incremental changes in regional and local response planning and preparation, focused more squarely on minimizing ecological injury and enhancing ecosystem recovery (rather than only on the amount of response equipment available.)

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GUIDANCE FOR ASSESSING BIOACCUMULATIVE CHEMICALS OF CONCERN IN SEDIMENT

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In January 2007, Oregon Department of Environmental Quality (DEQ) issued guidance for assessing bioaccumulative chemicals of concern in sediment. The goal of the guidance is to provide a step-wise strategy for determining if concentrations of contaminants in sediment are high enough to bioaccumulate. The guidance describes several ways to determine if hazardous substances released to the sediment have the potential to bioaccumulate to the point where the contaminants adversely affect either the health of the fish or other aquatic organisms, or the health of humans or animals that consume them. The screening step includes comparing measured concentrations in sediment to sediment screening levels for humans and relevant classes of wildlife. For chemicals that do not have sediment screening levels or if concentrations exceed sediment screening levels, fish tissue levels can be compared to acceptable tissue levels for humans and relevant classes of wildlife and/or to critical tissues levels in fish. If screening steps identify one or more bioaccumulative chemicals, bioaccumulation bioassays can be used for decision-making. The guidance provides specific species and methodology recommendations for laboratory and in situ testing. In addition, advanced bioaccumulation modeling with site-specific fish or benthic invertebrate tissue data and food web modeling can be used for decision-making. If bioaccumulative chemicals are not present, or do not pose an unacceptable risk, no further action is required with respect to bioaccumulation. If bioaccumulative chemicals are present, a removal or remedial action is required to address the risk.

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HEALTH EFFECTS AND POTENTIAL EVOLUTIONARY CONSEQUENCES OF CONTAMINANT EXPOSURE IN SALMONIDS FROM PACIFIC NORTHWEST RIVERS AND ESTUARIES

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We have monitored a number of sites throughout the Pacific Northwest in recent years for the presence of chemical contaminants and their potential health effects on juvenile salmonids. These sites include sites in Commencement Bay, WA, Puget Sound, the Columbia River, and other Oregon river and estuary systems. Results of these studies and potential health effects due to chemical contaminant exposure at an early life stage are presented. Our results suggest that the likelihood of contaminant exposure varies with species and stock. Generally, contaminant concentrations are highest in species with an extended estuarine residence time, such as chum and fall Chinook salmon. Contaminant body burdens are typically lower in species and stocks with a stream-type life history, such as coho salmon. Contaminant body burdens varied in different stocks in the Pacific Northwest. Willamette River Chinook generally had high body burden of PCBs, DDTs, and PBDEs, while Upper Columbia River fall Chinook did not. The persistent presence of chemical contaminants at Pacific Northwest sites may pose a threat to the survival of affected stocks. Concentrations of PACs, PCBs, and DDTs in sediment, prey, and fish at some sites are above concentrations associated increased risk of immunosuppression, impaired thyroid function, reduced growth, and delayed mortality in outmigrant juveniles. Exposure of returning adults to contaminants in stormwater may be associated with pre-spawn mortality in coho salmon, but not other stocks. Exposure to contaminants might exert evolutionary pressure on affected stocks in several ways. Adverse health effects due to continued contaminant exposure at these sites may over time select for fish that are more resistant to these contaminants, and may also select for juvenile Chinook that spend less time in the estuary to avoid contaminant exposure, contributing to reductions in the life history diversity of salmon stocks.

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ORTHOPHOSPHATE ADSORPTION ON NATURAL ADSORBENTS, SLAG, AND UTELITE TO BE MODIFIED IN INDIVIDUAL ONSITE WASTEWATER SYSTEMS

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Historically, centralized wastewater treatment systems have been the focus of the treatment efforts. These systems, however, have not always been used successfully. The centralization causes many problems, such as consuming large amounts of energy and chemicals. They can also degrade water quality and public health because the system can release of raw sewage into the environment by sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). Individual onsite or decentralized wastewater treatment systems are a popular alternative to centralization because SSOs and CSOs are avoided. Additionally, they reply on natural systems for treatment instead of chemical and energy intensive arrangements. However, there are many research needs for application of onsite (septic) systems. For example, septic tanks cannot completely remove nitrogen (N) and phosphorus (P). These effluent pollutions should be removed before the effluent is discharged into the environment. Phosphorus is a major nutrient that enhances eutrophication of freshwater lakes. In this investigation, the P adsorption capacity of Utelite from Utah, United States of America, slag (an industrial by-product), and natural adsorbents (ball clay, kaolin, diatomite, perlite, and zeolite) was determined with Langmuir and Freundlich adsorption isotherms. All these natural adsorbents are naturally found in Thailand. The 5-10 mm grain size for each of these materials was examined for their potential use as substrates to remove P and as growth media for nitrifying bacteria in onsite wastewater treatment. The Langmuir adsorption isotherm, used to calculate the maximum P adsorption capacity of these adsorbents, resulted in orthophosphate adsorption capacities of 0.43 g P/Kg Utelite, 0.31 g P/Kg slag, and, 0.10 g P/Kg natural zeolite. Not only did Utelite have the highest P adsorption capacity, but it is a very good medium to support growth of nitrifying bacteria. These results may be used to modify the process of individual onsite wastewater treatment systems.

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TRANS-PACIFIC AND REGIONAL ATMOSPHERIC TRANSPORT OF ANTHROPOGENIC SEMIVOLATILE ORGANIC COMPOUNDS TO MT. BACHELOR OBSERVATORY, U.S.A. FROM SPRING 2004 TO SPRING 2006

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Anthropogenic semivolatile organic pollutants (SOCs) undergo long-range atmospheric transport to the western U. S. from global and Eurasian sources as well as regional atmospheric transport from North American sources. High elevation sites in the western U.S. may be in the free troposphere more often than lower elevation sites, and allow for more conclusive identification of trans-Pacific transport events to the western U.S. Atmospheric measurements of anthropogenic SOCs were made at Mt. Bachelor Observatory (MBO) located in Oregon's Cascade Range (43.98°N, 121.69°W, 2.7 km a.s.l.) to further understand the trans-Pacific transport of SOCs. High volume air sampling (~644 m^3 for 24 hour periods) of both the gas and particulate phases was conducted from April 2004 to May 2006 at MBO. The presence of 81 SOCs was investigated in the 69 air samples collected. Air trajectories were calculated using data from NOAA's HYSPLIT and imported into the ARC/GIS program for spatial representation. Differences in SOC compositions between long range and regional atmospheric transport events were investigated.

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PREDICTIVE ECOLOGICAL RISK ASSESSMENT FOR A NEW ALUMINUM SMELTER IN ICELAND

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The protection and maintenance of local populations and communities of plants and wildlife is gaining importance in corporate decision-making regarding industrial development. During the facility design phase for an aluminum smelter in East Iceland, it became necessary to determine if a wet (seawater) scrubber system should be installed to reduce overall sulfur dioxide emissions. In this case, predictive risk assessment was used to determine whether there would be a consequential difference in the level of risk to human and ecological receptors from constituents in air emissions from the aluminum smelter either with or without wet scrubbers. Benchmark exposure concentrations corresponding to negligible ecological risk were established for each receptor group based on the toxicity literature. These benchmark exposure concentrations were then converted to concentrations in air and compared to air modeling predictions to develop risk estimates. The quantitative risk assessment determined that actual exposures under both scenarios are likely to be much lower than concentrations corresponding to risk thresholds and that overall risk was lower for a smelter operating without wet scrubbers. Thus, although mass loading of sulfur dioxide (and other constituents) would be reduced using wet scrubbers, corresponding risk to the ecosystem would actually be higher due to higher exposure-point concentrations in air.

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NOVEL HUMAN HEALTH ASSESSMENT APPROACH BRIDGES ENVIRONMENTALLY RELEVANT CONTAMINANT MIXTURES AND EARLY LIFE-STAGE DEVELOPMENTAL TOXICITY

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The unique bio-analytical approaches of passive sampling devices (PSD) and the zebrafish (*danio rerio)* developmental model have been combined to bridge measurements of environmental contaminants with their potential biological responses. For these preliminary experiments, a range of dilutions from extracts of PSD deployed within, and upriver of, the Portland Harbor Superfund site, Willamette River during Spring 2006 were used to expose early life stage zebrafish embryos to determine if these environmentally relevant mixtures were developmentally toxic. Dilutions of the extracts were nominally equivalent to a contaminant concentration range from 1 to 1/100 times that of the river water. Initial experiments for repeated exposures (n>3) demonstrate concentration-response increases in the appearance of a diverse collection of toxic endpoints including: notochord malformations, growth retardation, pericardial edema, delayed hatching, and gene induction. These initial experiments indicate that environmentally relevant concentrations of mixtures have the potential to adversely impact early-life stage vertebrate development. Most importantly, these studies highlight the utility of bridging environmental passive sampling with in vivo assessments as a tool to better protect human and environmental health.

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LEAD SHOT INGESTION AND MORTALITY OF SWANS WINTERING IN WASHINGTON STATE AND BRITISH COLUMBIA — IS JUDSON LAKE A PRIMARY SOURCE OF SHOT?

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Between 1999 and 2006, swan populations in northwest Washington and on the Sumas Prairie, British Columbia have lost at least 1,700 members to lead poisoning caused by the ingestion of spent lead shot. In 2001, an international effort was initiated to locate the source(s) of the lead. Participants include the Washington Department of Fish and Wildlife, U. S. Fish and Wildlife Service, Canadian Wildlife Service, Trumpeter Swan Society and the University of Washington (Washington Cooperative Fish and Wildlife Research Unit). A total of 251 trumpeter swans (*Cygnus buccinator*) were outfitted with radio transmitters. A blood sample was collected at capture and analyzed for lead content. Sick and dead swans were collected throughout the winter, and carcasses examined to determine cause of death and to identify gizzard contents. Results suggest that swans arrive on the wintering grounds with low blood lead levels, but subsequently are exposed to lethal amounts of shot. The locations of collared swans were used to identify forage areas and roost sites, and data for swans that subsequently died from lead poisoning were used to identify and prioritize areas for soil/sediment samples. Analyses of soil/sediment samples collected in 2005-06 suggest that Judson Lake is a primary source of lead shot for the swans. In 2006-07, swans were hazed from the lake in an effort to verify it as a primary source of lead shot. Data leading to the identification of the focal areas, and results of the coring and hazing efforts will be presented.

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BIOLOGICAL DISFUNCTION ASSOCIATED WITH EXPOSURE TO ENDOCRINE DISRUPTING COMPOUNDS IN MARINE AND ESTUARINE FISH FROM THE PACIFIC NORTHWEST UNITED STATES

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NOAA's Northwest Fisheries Science Center in Seattle has been documenting the impacts of endocrine disrupting compounds on Pacific Northwest fish for over twenty years, with a focus on conducting ecologically relevant assessments. Initial studies in Puget Sound showed that exposure to industrial contaminants, such as PCBs and PAHs was associated with altered reproductive hormones, inhibited gonadal growth, and reduced fertilization success in English sole and other Puget Sound bottomfish. In collaboration with the Washington Department of Fish and Wildlife, sole from a number of Puget Sound sites were screened for xenoestrogen exposure, using vitellogenin production in males as an indicator. Significant levels of vitellogenin were found in male fish from urban embayment, especially near downtown Seattle. Xenoestrogen exposure was also associated with altered reproductive timing in female sole. In a collaborative project with USGS and the Lower Columbia River Estuary Partnership, we are monitoring effects of endocrine disruptors on endangered Pacific Northwest juvenile salmon. Preliminary data show that juvenile Chinook salmon from the Columbia River are exposed to PCBs, DDTs, PBDEs and PAHs via their diet, with especially high concentrations of these contaminants in stomach contents and whole bodies of fish from the Portland/Vancouver area. Salmon from this area also showed signs of exposure to estrogenic compounds, based on vitellogenin induction. Potentially estrogenic compounds detected by USGS in the water column included bisphenol A and synthetic musks. Studies are underway to develop and apply more effective methodologies to measure emerging endocrine disruptors in fish and environmental samples.

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EFFECTS OF MULTI-GENERATIONAL ACCLIMATION ON THE TOXICTY OF COPPER, CADMIUM, AND ZINC TO *DAPHNIA MAGNA*

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To assess possible changes in tolerance of *Daphnia magna* to heavy metals, a multi-generational acclimation study is being performed. It was hypothesized that as successive generations of organisms were exposed to metals the tolerance of the acclimated organisms would increase when compared to non-acclimated organisms and the level of tolerance would increase as the background concentrations of the metals increased. *Daphnia magna* were chronically exposed to low-level environmentally relevant background concentrations of single metal, as well as mixtures, of copper, cadmium and zinc. The organisms were cultured in the metals spiked media and allowed to reproduce and complete successive life-cycles. Standardized 48-hour acute toxicity tests were performed on each generation to assess whether a change in tolerance was occurring over the successive generations as well as to assess the effects that acclimation to different ratios of metals, compared to single metals, had on the toxicity of these metals. This research is ongoing, the results will be presented at the conference.

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YOU ARE WHAT YOU EAT: CONTAMINANT EXPOSURE IN JUVINILE SALMON FROM COLUMBIA RIVER HATCHERIES

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Previous studies have shown that outmigrant juvenile salmon from the Lower Columbia River and Estuary are absorbing chemical contaminants, but the sources of these compounds are not entirely clear. One potential pathway of exposure is through hatchery rearing, as PCBs and other contaminants have been reported is hatchery fish and feed from other regions. To address this problem, we sampled juvenile salmon from seven hatcheries that release Chinook salmon (*Oncorhynchus tschawytscha*) into the Columbia River (Cowlitz Hatchery, Elochoman Hatchery, Klickitat Hatchery, Little White Salmon National Fish Hatchery, Priest Rapids Hatchery, Spring Creek National Fish Hatchery, Washougal Hatchery). Our objective was to evaluate the potential contribution of hatchery feed to contaminant body burdens of outmigrant salmon in the estuary. Concentrations of several classes of contaminants were measured in salmon whole bodies and hatchery feed. DDTs, PCBs, and polycyclic aromatic hydrocarbons (PAHs) were found at measurable concentrations in feed from all hatcheries. Concentrations of ∑PCBs ranged from 5 to 25 ng/g, wet wt., ∑DDT concentrations ranged from 10 to 38 ng/g, wet wt., and ∑PAH concentrations ranged from 100 to 550 ng/g, wet wt. In salmon bodies, concentrations of ∑PCBs ranged from 7.3 ng/g, wet wt. to 58 ng/g, wet wt., while ∑DDTs ranged from 4.8 ng/g, wet wt. to 15 ng/g, wet wt. Other organochlorine pesticides and PBDEs were also detected at low levels in feed samples from the hatcheries but were mostly undetectable in whole bodies. The analysis suggested that when salmon growth was taken into account, the hatchery was an important source of PCBs in salmon from sites with limited industry, but the river and estuary were more important in salmon from sites where industrial activity was high. The river and estuary appeared to be the major contributors of DDTs in salmon from at both urban and non-urban sites.

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THE EFFECTS OF LOW TOC SEDIMENTS ON THE ACUTE SURVIVAL OF *LEPTOCHEIRUS PLUMULOSUS*

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Several recent site investigations have indicated that sediments low in total organic carbon (TOC) may be responsible for a decrease in acute survival of test organisms. This investigation specifically examines the effect of low TOC sediments on the marine amphipod *L. plumulosus*. These investigations were triggered by low amphipod survival accompanied by a lack of significant levels of contaminants in the sediment, a low bioaccumulation potential, and a high acute survival of other test species. In these cases low TOC, or lack of food, was a suspected cause of concern. A suite of toxicity tests were developed to compare the survival in fed and un-fed fine grain sediments. The fed treatments were given 4 mg of ground Tetramin® delivered in a slurry on days 0 and 5. All other parameters were run under standard test conditions. Survival in the un-fed samples ranged from 16-81% while the fed sediment survival ranged from 62-88%. The recovered amphipods from the unfed sediment were visibly smaller, of a lighter carapace color, and less active than those recovered from the fed sediments, which were larger, with a well stratified carapace, and normally active. This data, along with the supporting chemical and biological data, suggest that mortality observed in the test was driven by low TOC, and was not contaminant driven. Additional lab studies conducted on low TOC marine sand included treatments where the test organisms were segregated in a water only container and fed prior to exposure and treatments that were fed only on day 0. Overall, these results suggest that supplying additional food to low TOC sediments tested with *L. plumulosus* may reduce the occurrence of false positives.

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PHOTOCHEMICAL DEGRADATION OF SELECTED POLYBROMINATED DIPHENYL ETHER AND GC-MS STUDY OF THE PRODUCTS

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Polybrominated Diphenyl Ether (PBDE) flame retardants are widely used as additives in polymers for textiles, electronics, and home furnishings. As the use of PBDEs has increased in recent years, their concentrations in the environment have also increased. Theoretical calculations are of interest for estimating the thermodynamic properties of PBDEs. To better understand and describe the environmental fate of PBDEs, studies were performed on the photodegradation of selected PBDEs dissolved in isooctane under UV light. The stepwise debromination to form lower brominated diphenyl ethers was observed by GC-high resolution MS. The mechanism of the photodegradation of PBDEs and relative abundance of photodecomposition products, are explained by theoretical calculations. The photodegradation model, together with the GC retention time prediction, provides a way to identify unknown products from PBDE photodegradation.

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