2007 Georgia Basin Puget Sound

Research Conference

March 26–29, 2007

Westin Bayshore

Vancouver, British Columbia

KNOWLEDGE FOR THE SALISH SEA: TOWARD COLLABORATIVE TRANSBOUNDARY SOLUTIONS

Abstracts & Biographies

Conference Hosted by:

Puget Sound Action Team
Office of the Governor | State of Washington

Working Together for the Georgia Basin
Au travail pour le bassin de Georgia

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Knowledge for the Salish Sea: Toward Collaborative Transboundary Solutions

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2007 Georgia Basin Puget Sound

Research Conference

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Panel Descriptions

MONDAY, MARCH 26, 2007

Panel 1A: The Power of Water: Potential Clean Energy Sources

Chair: Linda Lyshall

Starting with an overview of how tidal and wave energy works, potential environmental concerns, and tribal rights, this panel will address issues such as tidal energy in the GBPS region, technology, regulatory and research issues, fundamental limits to the power potential of tidal streams, and the utilization of water from streams to produce hydrogen energy.

Panel Members:

- *Daryl Williams, Tulalip Tribe*
- *Jennifer Hennessey, Washington Department of Ecology*
- *Craig Collar, Snohomish Public Utilities District*
- *Dr. Chris Garrett, University of Victoria*
- *Patrick Cummins, Institute of Ocean Sciences*
- *Monty Raisinghani, University of British Columbia*

Tidal Energy in the Puget Sound

Craig Collar, Snohomish PUD
Roger Bedard, Electric Power Research Institute

Presentation will provide an overview of tidal energy technology and application as well as an overview of the challenges and opportunities faced by the Snohomish PUD in the face of rapid service area load growth and the implementation of Renewable Portfolio Standards. The presentation will discuss the potential of tidal energy in Puget Sound from a technological, economic, and environmental standpoint, and will discuss the current status of Snohomish PUD's efforts to responsibly study the tidal energy resource in the Sound.

Fundamental Limits to the Power Potential of Tidal Streams

Chris Garrett, University of Victoria
Patrick Cummins, Institute of Ocean Sciences

The exploitation of strong tidal currents for electricity generation is being proposed for many locations in the Salish Sea. Small-scale installations can be evaluated using standard formulae and do not have a significant impact. As more and more turbines are added, however, the flow will tend to be slowed. Quite apart from the possible environmental impact of this, it implies an upper bound to the power available. Simple general theories, supported by detailed numerical modeling, provide easily applied formulae for the maximum power available at any particular location, and for the reduction of flow that would occur in this maximizing state. The results differ from many published evaluations based on erroneous assumptions. Present models assume that a fence of tidal turbines occupies the whole cross-section of a channel, though this might be ruled out by shipping needs. Preliminary results on the loss of potential caused by partial tidal fences will be presented. The achievement of optimum configurations, and determination of environmental impact, will require further collaboration between engineers, ocean physicists, and other marine scientists. While tidal stream energy may contribute to our needs, particularly in remote locations, its limited potential and possible environmental impact suggest that we should also consider other non-fossil energy sources such as nuclear power, taking advantage of the strong tidal currents to provide a plentiful supply of cooling water.

Tidal Current Energy Technology, Regulations, and Research

Jennifer Hennessey, Washington Department of Ecology

The need for clean energy has prompted the development of various types of turbines designed to capture tidal current energy and transform it into electricity, as well as various jurisdictions requesting permits for installation of turbines. This presentation will explore the various types of turbines proposed, the current regulatory structure, and research that is needed to determine the potential environmental impacts of this new technology.

The Hydrogen Economy-Utlizing Water From Streams to Produce Clean Energy

Monty Raisinghani, UBC

Our world has been dependent on the oil and gas industry for decades. As the Kyoto Protocol becomes a growing concern, industries must do their part to ensure that the environmental standards are met. Alternative energy research has been soaring, and companies are trying to find novel solutions to the energy crisis facing our world today.

Hydrogen power, is one of those solutions. Hydrogen production process requires intense amounts of energy input, to attain the final product. Additionally, with compression at higher pressures, the tanks become volatile. Hydrogen Power Inc.'s process, however, produces hydrogen on demand in an environmentally friendly manner. There are no carbon dioxide or carbon monoxide emissions during the process, and the hydrogen can be used for everyday applications. The presentation will consist of an analysis of the process, and how it benefits from other hydrogen production mechanisms.

As chemical engineers not only are we called upon to control a chemical process, but also to ensure that every process we conduct is environmentally and economically viable. It is up to the chemical engineers of today to secure a greener future.

Session 1C: Modeling and Decision Support Tools I

Chair: Julia Bos

Green Infrastructure Assessment Tool Applied to an Alternative Futures Application

Erik Neatherlin, John Jacobson, John Carleton, Washington State Department of Fish and Wildlife*

Under the auspices of several state laws, including the Growth Management Act (RCW 36.70A) and the Shorelines Management Act (RCW 90.58), local governments in the State of Washington are responsible for making and implementing land use decisions that accommodate expected growth while limiting environmental impact. The Washington Department of Fish and Wildlife is supporting local government planners in these efforts by developing wildlife habitat suitability assessment tools and providing guidance applicable over multiple spatial scales. We introduced a Green Infrastructure Geographic Information System (GIS) assessment tool applied to an Alternative Futures application within Kitsap County, Washington. GIS data, including ecoregional assessments, road density, land use/land cover, priority habitats and species, as well as local empirical knowledge, were used to produce a map that depicts current wildlife habitat suitability for the entire county. A process that combined this suitability map with citizen input and county planned development information was used to estimate three different alternative futures for wildlife habitat suitability in the Silverdale community watershed.

Linking Lands: Integration of Wildlife Habitat Mapping into Municipal Policies and Programs

Elaine Anderson, Langley Environmental Partners Society*
Jenyfer Neumann, Patrick Marples, Township of Langley

Over the past 7 years LEPS has been working with the Township of Langley, all levels of government, as well as community groups to develop a municipal Wildlife Habitat Conservation Strategy. From the outset, the intent of the multi-stakeholder partnership was to identify habitat in the Township and work with the municipality to identify tools to protect wildlife habitat. The partnership has been extremely successful.

The entire Township has been mapped using 13 habitat classifications. A habitat-species database based on "Wildlife-Habitat Relationships in

Oregon and Washington" (O'Neil et al. 2001) links habitat types with species that use that type of habitat. The database indicates that the Township provides habitat for over 250 species of wildlife.

LEPS is working with representatives from the Township to identify municipal policies and programs that can be used to support wildlife habitat conservation, enhancement, and restoration. Goals include:

- Protection of wildlife habitat patches and connectivity
- Integration of habitat protection into policies, and programs
- Implementation program to protect wildlife habitat
- Assessment of the financial implications of wildlife habitat protection, enhancement and restoration

This initiative is an excellent example of how collaboration between government, non-government organizations, and community groups can lead to positive changes both on the ground and in government policy!

Fergus Creek Integrated Watershed Planning

Jim Dumont, McElhanney Consulting Services Ltd.*
Remi Dube, City of Surrey

The Fergus Creek Watershed within the City of Surrey is under pressure for development and requires environmental protection to assure a viable fish and wildlife presence in the future. The City of Surrey has proactively undertaken the preparation of an Integrated Plan to preserve existing areas while allowing targeted development of urban and recreational opportunities in the watershed. The Integrated Plan balances the need to maintain and enhance natural areas while providing recreational and urban development opportunities.
Urban planning for largely rural portions of the watershed includes accommodation for high density housing while protecting habitat, wildlife corridors, and critical forested areas. Large contiguous green space areas will provide opportunities to provide wildlife habitat, riparian stream setbacks and interconnect park areas for recreation.
To accommodate the requirement to maintain stream health, advances in analysis techniques have lead to a system that provides a quantitative analysis of both the potential erosion and the availability of aquatic habitat. A complex set of rainwater BMP's have been optimized for implementation within the watershed. The optimized systems provided a reduction in stream erosion potential while maintaining the stream duration of flows for aquatic habitat and volumetric runoff and reducing the sediment washoff from the watershed.

Supporting Fish-Friendly Land and Water Resource Decision Making

Keith Folkerts, Kitsap County*
Hal Beecher, WDFW
Brian Skahill, US Army Corps of Engineers
Terra Hegy, WDFW

Throughout the Puget Sound land and water resource managers plan for salmon recovery and habitat protection by addressing future urbanization and groundwater withdrawals. Often planning and development result in direct impacts to sensitive salmon streams. The time-lag between decision making and the impact to the resource can be decades; the impacts are often incremental and appear insignificant. In Kitsap County these temporal and spatial land use and environmental planning issues are being successfully bridged using "alternative futures" planning process which simulates and assesses future watershed conditions under various land use and water use scenarios.
This paper will present how policymakers use the "alternative futures" planning process to assess and make important land use and population growth decisions while protecting and conserving salmon and water resources.

Cumulative Impact Assessments for Shoreline Management

Cinde Donoghue, Thurston County Long Range Planning*
Anthony Gabriel, Central Washington University, Dept. of Geography and Land Studies Center for Spatial Information

Washington's Coastal Zone Management Program is implemented primarily through locally adopted plans and regulations approved by the state. The cumulative effects of shoreline development and activities must be addressed in the updated local Shoreline Master Programs. We have developed a conceptual model for systematic quantitative and qualitative evaluation of the cumulative impacts resulting from shoreline modifications and uses as described in the WA State Shoreline guidelines 173-26 WAC. We address the SEPA/NEPA requirements to complete Environmental Impact Statements and Environmental Assessments for SMP updates. We develope a framework for interpretation and use of existing geospatial information and suggest some preliminary case examples.

Driving Forces, Uncertainty, and the Nearshore: Scenarios for the Puget Sound Nearshore

Michal Russo, Marina Alberti, University of Washington*

As with coastal ecosystems around the globe, the Puget Sound nearshore is experiencing increasing degradation due to direct and indirect impacts of urbanization. While multiple strategies have been proposed to protect and maintain the current nearshore ecological functions, we do not know their effectiveness under alternative future conditions. In the past, planners have relied on predictive models and visions for creating management strategies. However, the major driving forces currently influencing this region may change and interact in unpredictable manners to create a suite of plausible futures. Our ability to imagine these futures will determine our capacity to plan accordingly. In this paper, we present scenario planning as a tool to delineate a set of planning strategies that seek to protect the Puget Sound Nearshore ecosystem based on the changing needs of the Region over the next 50 years. This paper highlights the first four steps of the entire scenario planning process including: selecting a focal issue, identifying driving forces, ranking importance and uncertainty, and selecting scenario logics. The results of thirty three expert interviews and a one day workshop lead to initial scenario sketches and a regional Puget Sound perspective about where we might be headed.

Session 1D: Fresh Water Quality

Chair: Zita Botelho

Island County's Surface Water Monitoring Program

Christopher Wilson, Island County*
Paul Adamus, Ph.D., Adamus Resource Assessment, Corvallis, OR

Island County, Washington, has begun a 5-year program of monitoring water quality in streams, lakes, and wetlands of Whidbey and Camano Islands. Local funds are being used partly to measure effectiveness of the County's critical areas protection ordinance and to identify and reduce pollution potentially exported to Puget Sound. During the first year, non-tidal surface waters in 45 of the County's 126 small rural watersheds are being monitored for nutrients, temperature, dissolved oxygen, coliform bacteria, turbidity, conductivity, hardness, pH, and (wetlands only) vegetation composition. Many streams flow only seasonally. Initially, most watersheds are being sampled at just one location, generally just above the marine interface. Monitoring in 24 watersheds will be conducted twice monthly each year. Eight of these watersheds are largely agricultural (mostly pasture), eight have signficant residential development, and eight are relatively natural. Other watersheds will be sampled for shorter periods until nearly all of the County's watersheds have been assessed and major sources of pollution are traced and remedied. Watersheds were prioritized systematically for monitoring based on scores for valued resources and pollution risk. Results will be reported regularly beginning next year. Response actions, including intensified monitoring, will be based on measured trends and chronic exceedences of standards.

Exploring Seasonal Dynamics of Some Antibiotic Resistance Genes and Antibiotics in an Agricultural Watershed

Patricia Keen, University of British Columbia*
Charles Knapp, David Graham, University of Kansas
Ken Hall, University of British Columbia

Located in the heart of Georgia Basin is the trans-boundary Sumas watershed. Recognized as one of the most productive agricultural regions in British Columbia and Washington State, the watershed has seen an increase in intensification of agricultural activities, especially production of food animals, over recent decades. Increase in livestock and poultry production is coupled with increased need for veterinary use of antibiotics. Concern that antibiotic use in agriculture could impact ecosystem and human health through the development of antimicrobial resistant strains of pathogens led to this study conducted in the Sumas watershed between July 2004 and March 2006. During this period, four tetracycline resistance genes and fourteen antibiotics used in veterinary medicine were monitored monthly in the Sumas River receiving environment. Microbiological methods of real-time PCR were used to measure tetracycline resistance genes and high performance liquid chromatography tandem mass spectrometry analyses determined antibiotic residues in samples from various ecosystem compartments. This paper will discuss the results of the monitoring effort that suggests the observations are a function of agricultural point source contributions, receiving water quality and hydrographic conditions in the region. Seasonal patterns of the observations appear consistent from year to year.

Status of Nitrogen, Phosphorus and Potassium in Lower Fraser Valley Agricultural Soils in Relation to Environmental and Agronomic Concerns

Orlando Schmidt, British Columbia Ministry of Agriculture and Lands*
Grant Kowalenko, Agriculture and Agri-Food Canada

Soils within the Fraser Valley of British Columbia are among the most fertile in Canada supporting a diverse range of agricultural production. As livestock density has increased, census based nutrient balance models have pointed towards nutrient surpluses within the region but there has been a lack of scientific data to quantify soil nutrient concentrations. A study was undertaken in 2005 to determine soil nitrogen, phosphorus and potassium status in the Fraser Valley for establishing baselines and monitoring the effectiveness of government activities, including the Canada-British Columbia Environmental Farm Plan Program.

Soil testing and analysis methods were already available for agronomic purposes, but methods for environmental interpretations were limiting. Residual (after-harvest) soil nitrate has been used for environmental (and agronomic) assessment but nothing was available for environmental assessment of soil phosphorus and potassium. The study included two types of sampling; 1. those to develop analytical methods and interpretations for phosphorus and potassium (Phase A) and to examine the influence of sampling time on residual soil nitrate (Benchmark), and 2. those to use the developed methods to examine the relative environmental status of nutrients in soils of six geographic zones that had previously been calculated to have contrasting nutrient balances (Phase B). All samplings were replicated to distinguish field differences from random variability.

Session 1E: Restoration Following Dam and Pier Removal

Chair: Sarah Brace

Evaluating Recovery Endpoints in a Rocky Intertidal System

Terrie Klinger, University of Washington*

Determination of recovery following pulse disturbance to marine communities requires that recovery endpoints be defined. This can be especially difficult in marine systems characterized by high spatial and temporal variability. I performed experimental removals in a rocky intertidal community to evaluate the performance of alternative methods of determining recovery. I tested whether 1) disturbed plots would resemble their starting conditions after a recovery period; 2) disturbed plots would converge with undisturbed (control) plots after a recovery period; and 3) the abundance of focal taxa in disturbed plots would fluctuate in parallel with those in undisturbed plots after a recovery period; and 4) recovery of focal taxa would indicate community recovery. Results suggest that 1) recovery to pre-disturbance conditions is not a reasonable recovery endpoint because the systems themselves are dynamic; 2) both convergence and parallelism between disturbed and undisturbed plots is reasonable endpoint at small spatial scales, but their performance declines with increasing spatial scale of comparison; and 3) recovery of focal taxa can occur in the absence of community recovery, suggesting that taxon-specific endpoints are less robust than community-level endpoints.

Tracking Nearshore Habitat Recovery After Removal of Overwater Dock Structures

William Taylor, Jennifer Hayworth, Taylor Associates, Inc.*
James Shannon, David Evans and Associates

In February, 2006 the Port of Seattle removed 1.3 acres of an aged dock in the East Waterway of the Duwamish River. The Port of Seattle was interested in documenting the nearshore habitat recovery after removing the existing dock structure. The Port of Seattle hired Taylor Associates, Inc. (TAI) to conduct an assessment of the physical and biological effects of the dock removal. The objectives to support this assessment included:

1. Collect physical habitat data at control and impact sites.
2. Collect biological data at control and impact sites.

The impact sites included the newly removed dock area (Dock removal 2006), and a second dock removed in 2000 (Dock removal 2000). A control site was also sampled. Data collection methods were duplicated for each of the three site and included four methods:

1. Substrate and vegetation (macrophyte) monitoring transects
2. Water temperature and light intensity data loggers
3. Epibenthic invertebrate sampling
4. Insect fall-out traps

Visual observations confirm the Dock removal 2000 site has abundant macrophytes and the beginnings of a vegetated backshore. The Dock removal 2006 site had no macrophytes or vegetated backshore. Ironically, initial benthic invertebrate results indicate greater numbers of harpacticoid copepods in the Dock removal 2006 site. The site with more abundant macroalgae did have more corophium amphipods, however.

Nearshore Fish of the Strait of Juan de Fuca- Implications for Removal of Elwha Dams

Joshua Chamberlin, Kurt Fresh, Anna Kagley, NOAA Fisheries, NWFSC, Seattle, WA*
Larry Ward, LEKT, Port Angeles, Wa
Nikki Sather, Oregon State University/Battelle, PNNL, Sequim, WA
Mindy Rowse, NOAA Fisheries, NWFSC, Seattle, WA

Removal of two dams along the Elwha River, scheduled to begin in 2009, is expected to help restore natural sediment processes to the estuary and nearshore near the mouth of the river. Understanding the potential effects of increasing sediment in the nearshore is an essential part of evaluating biological responses to dam removal. Since 2006, we have been collecting data on nearshore fish communities at sites in the eastern and central Strait of Juan de Fuca from Discovery Bay to Crescent Bay. Sites were sampled on a monthly basis, as weather and tides permitted, using a 32m Puget Sound beach seine between

April and September. Overall 36 species were identified including four species of Pacific salmon, steelhead trout and cutthroat trout. We found wide distribution of several salmon species, juvenile ling cod, and all life stages of surf smelt. Pink salmon were the most abundant of the salmon species. We also found evidence that multiple spawnings of surf smelt were occurring in the same areas. Information collected during this study will provide a baseline to track the effects of dam removal on the distribution and abundance of nearshore fish communities and aid in future dam removal assessments.

Elwha River Dam Removal: An Update on Collaborative Monitoring Efforts

Sarah Morley, NOAA/NMFS/NWFSC*
Jeffrey Duda, Western Fisheries Research Center, USGS
Michael McHenry, Lower Elwha Klallam Tribe
George Pess, Northwest Fisheries Science Center, NOAA
Holly Coe, Frank Orth and Associates
Timothy Beechie, Northwest Fisheries Science Center, NOAA
Bill Eaton, Peninsula College
Martin Liermann, Northwest Fisheries Science Center, NOAA

The impending removal of two large dams from the Elwha River on Washington State's Olympic Peninsula offers a unique opportunity to study ecosystem restoration at a watershed scale. Numerous government and academic agencies have partnered with the Lower Elwha Klallam Tribe to collect critical baseline data prior to dam removal. This multidisciplinary monitoring effort is focused on understanding what impacts the two dams have had on the Elwha River ecosystem and on formulating testable hypotheses regarding river response to dam removal. Above the dams, the absence of anadromous fish has contributed to decreased marine-derived nutrient subsidies and changes to periphyton and benthic invertebrate assemblages. Below the dams, curtailed wood and sediment delivery has led to decreased channel movement, habitat complexity, and diversity of floodplain forest age. Current salmon populations below the dams have been greatly reduced from historical levels and are largely hatchery dominated. Following dam removal, many of these impacts are expected to persist and perhaps even worsen in the near term as sediment stored behind the dams moves through the system. The extended timeline predicted for ecosystem recovery highlights the need for long-term monitoring in the Elwha River Basin.

Eelgrass Mapping of the Elwha Nearshore

James Norris, Marine Resources Consultants*
Ian Fraser, Marine Resources Consultants
Anne Shaffer, Washington Department of Fish and Wildlife
Cathy Lear, Clallam County

The goal of this project was to gather pre-dam removal nearshore habitat data along the "Elwha Shoreline" by mapping the location, extent, depth, and patchiness of eelgrass (*Zostera marina*) from the west end of Freshwater Bay to the tip of Ediz Hook. Our methods were identical to the underwater videographic methods used by the Washington State Department of Natural Resources Submerged Vegetation Monitoring Project. We observed three eelgrass beds within the study area: one along the north shore of Ediz Hook and two in Freshwater Bay. No eelgrass was observed within 1 nm of the Elwha River mouth. The dominant feature of the nearshore habitat was understory kelp and large schools of juvenile Pacific sand lance (Ammodytes hexapterus). The project, funded by the Clallam Marine Resources Committee (MRC), is part of a multi-disciplinary effort to understand and optimize the nearshore restoration associated with the upcoming dam removals.

Session 1F: Impacts of Human Population Growth On the Ecosystem

Chair: Charlie O'Hara

When Concerned About Toxic Stormwater Pollutants in the Built Environment: Sweep Before You "Treat"

Roger Sutherland, Pacific Water Resources, Inc.*
Gary Minton, Resource Planning Associates

There is strong momentum towards the treatment of stormwater with wet ponds, swales, sand filters, and other structural devices. While treatment devices have their place, in new developments and certain retrofits, jurisdictions should first consider the establishment of a cost-effective pavement cleaning program to reduce toxic stormwater pollutant contributions from existing urban lands. Studies completed by the senior author clearly establish that the most cost-effective BMP from a stormwater sediment and toxic pollutant reduction standpoint and therefore the first BMP to consider is street sweeping. In fact, with the highly effective newer machines, whether those are vacuum, regenerative air or mechanical, the practice should now be called "street cleaning". Where treatment devices currently exist, street cleaning will improve their overall performance and reduce their maintenance requirements and associated costs. It is not a question of whether pavement cleaning will improve water quality, but of how to most effectively use limited public dollars to obtain the most pollutant reduction benefit. The paper will provide an overview of: the origin of the urban myth that cleaning streets is not an effective BMP, demonstrated improvements in stormwater quality due to street cleaning, other on-going street sweeping pilot projects, how street sweeping pollutant removal unit costs compare to structural BMPs, and how a cost-effective cleaning program can be developed.

Quantification of Peak Season Marine Vessel Traffic Pressure in the San Juan Islands

Jeffrey Dismukes, San Juan County*
Jonathan Riley, Western Washinghton University
David Walker

The marine waters surrounding the San Juan Islands appear to communicate high levels of vessel traffic, especially during the sunny summer days of peak vacation season. This perception is corroborated by several factors: 1. international commercial shipping lanes serving two major North American ports; 2. Alaskan Marine Highway, Washington State and several international ferry routes; 3. a plentiful sport and commercial fishery with 4 major game fish providing year round opportunities; 4. an extremely popular yachting and pleasure cruising environment featuring several nature parks accessible only by water; and, 5. Orca pods and numerous sea-foul rookeries providing very appealing on-water tourist attractions. However, prior to this study, there have been no published attempts to quantify vessel pressures in the San Juan Islands. In this pilot study we develop methods for deriving statistics on vessel traffic utilizing spotters and digital photography from fixed wing over-flights during the peak tourist season (August-September 2006). Samples were stratified by weekend/holiday days and week days. Data was collected for 4 week days and 9 weekend/holiday days. Results indicate average total of 953 vessels on water at any given daylight time for weekend/holiday days and 659 for week days. Vessels were also identified by general type as: power, sail, commercial fishing, cargo and ferry. Rough location markers were plotted in a GIS yielding relative concentration gradients.

Urbanization, Private Property Rights, and The Fate of Coho Salmon Habitat in Puget Sound

Alex Uber, Washington State Department of Fish and Wildlife*
Jennifer Trunkey, Antioch University, Seattle WA

Puget Sound coho salmon (*Oncorhynchus kisutch*), which are dependent on perennial first, second, and third order streams for reproduction and survival are in decline, and are currently listed as a ëspecies of concern' under the US Federal Endangered Species Act. Urbanization of the Puget Sound lowlands (PSL) has contributed greatly to the decline of these fish. Development and growth is occurring throughout the PSL and

the vast majority of coho salmon habitat exists on privately owned lands. Public awareness of, and support for the concept of protection and restoration of salmon habitat is generally high in the Puget Sound area. However, as government agencies increasingly rely on private landowners for the conservation of salmon habitat, and as protective regulations are imposed on these landowners, an organized resistance movement has been fostered that demands monetary compensation for development and other private property rights lost to government regulation of private lands. The colliding trends of increasing human population growth, declining coho populations, and increasing resistance to government regulation of privately owned lands in the Puget Sound basin must be reconciled if coho salmon decline is to be reversed.

Effectively and Efficiently Meeting Multiple Local Jurisdiction Resource Protection Mandates through Landscape Characterization

Stephen Stanley, Washington State Department of Ecology*
Jeff Chalfant, Whatcom County Planning Department
Susan Grigsby, Washington Department of Ecology
Dick Gersib, Washington Department of Transportation
Harriet Beale, Puget Sound Action Team
Krista Mendelman, U.S. Environmental Protection Agency
Douglas Peters, Washington Community Trade and Economic Development
Joanne Schuett-Hames, Washington Department of Fish and Wildlife
John Carleton, Washington Department of Fish and Wildlife

Whatcom County, in a partnership with Federal and State resource agencies, is developing a watershed-based management plan for the Birch Bay watershed. This innovative effort attempts to develop a unified approach for characterizing, analyzing and developing a local plan that sustains natural resources and addresses storm water while accommodating population growth. The effort will: 1) offer statewide watershed characterization tools and analysis methods that are tested and applied at a local level by a local government; and 2) demonstrate how watershed-based planning improves local planning and decision-making, reduces workload and cost, and increases predictability while meeting multiple mandates and improving the health of local and regional ecosystems.

The Birch Bay management plan uses an integrated set of watershed characterization tools that are applied from landscape to site scales. This includes assessment and analysis of watershed processes and fish and wildlife needs at the landscape to sub-basin scales, and wetland functions at the site scale. The resulting series of characterization and synthesis maps demonstrate the most appropriate areas for protection, restoration and development. This information is incorporated into development standards and regulations that guide future development more effectively than site based environmental review and permitting.

McKee Peak: Development Planning in Consideration of Ecological Sensitivities

Caroline Astley, Madrone Environmental Services Ltd.*
Darren Brown, City of Abbotsford

In early 2005 the City of Abbotsford retained Madrone Environmental Services Ltd. to complete Terrestrial Ecosystem Mapping (TEM) and a rare element survey of the McKee Peak Planning Area in Abbotsford. Located at the southwest end of Sumas Mountain, McKee Peak represents an excellent example of undisturbed deciduous and mixed forest. The area provides habitat for at least 21 threatened and endangered plant, animal, and invertebrate species, including Phantom orchid (Cephalanthera austiniae), Pacific Water Shrew (Sorex bendirii) and Oregon Forestsnail (Allogona townsendiana).

There has been a great deal of public concern in regards to the development of McKee Peak, specifically as development pertains to environmental impact. However, the majority of McKee Peak is privately owned. Real estate markets are driving the value of land in the Fraser Valley to astronomical levels and there is increasing pressure on the landscape as land owners sell, subdivide and develop to maximize their investments. Recognizing that McKee Peak is a valuable environmental asset, the City of Abbotsford took the initiative to identify the most sensitive areas of the Peak. Knowing where the most important habitat is located, will guide neighbourhood planning and ensure that habitat for rare species is considered.

Treatment of Ballast Water: Good Possibilities or a Pipe Dream

Russell Herwig, Jeffery Cordell, David Lawrence, University of Washington*

Non-indigenous aquatic species are transferred around the world in the ballast water of ships. The only "technology" presently available is mid-ocean ballast water exchange. Ships planning to discharge ballast must exchange their ballast with water collected at least 50 or 100 miles from shore. Our research team documented the presence of large numbers of non-indigenous and nearshore zooplankton in the ballast of ships that reported a mid-ocean exchange. In recent years, several different treatments were examined in experiments performed in bench to full-scale shipboard tests. The University of Washington has participated in tests of ultraviolet light, SeaKleenÆ, ozone, electrolytically produced sodium hypochlorite, and a sequential filtration and UV light system. Different treatments have different positive and negative attributes. Pending legislation and regulations have established standards that permit very low numbers of organisms in ballast water discharge. For example, proposed International Maritime Organization (IMO) regulations permit 10 or less viable organisms that are between 10 and 50 µm in their minimum dimension in 100 mL of ballast water. For organisms ?50 µm, 10 are permitted in a cubic meter. The limits proposed for the different size fractions of organisms are very challenging for treatment technologies to achieve and the numbers are much less than what would be expected in ballast water that is exchanged in the middle of the ocean.

Opening Plenary Session

Welcome and Introduction from the Co-Chairs

Justin Longo, Conference Co-Chair, Environment Canada

First Nations Welcome

Chief Leah George-Wilson, Tsleil-Waututh Nation

Welcome from the Co-Hosts

Pradeep Kharé, Regional Director General, Environment Canada
Elin Miller, Regional Administrator, Environmental Protection Agency Region 10

Keynote Address: Dr. Daniel Pauly, University of British Columbia Fisheries Centre

"The Mille-feuille Between Science and Decision Making: How Scientists Need to More Effectively Engage in Politics and Society"

Panel 2A: Puget Sound Partnership–the Path to a Healthy Sound by 2020

Chair: Kathy Fletcher

Governor Gregoire charged her Puget Sound Partnership with recommending the necessary ingredients of an effort to restore Puget Sound to health by the year 2020, addressing the action agenda, funding, science, public involvement, and how to structure the effort. The Partnership made its recommendations to the Governor in November 2006, in time for the Governor's recommendations to the 2007 session of the state legislature. What was recommended, where does it stand,

what remains to be done? What are the key ingredients for a successful effort to restore the health of Puget Sound and the Georgia Basin? Did the Partnership (and the legislature) get it right? What are the most urgent action items to restore Puget Sound's health by 2020? This panel will also address other efforts at transboundary ecosystem management in the Salish Sea.

Panel Members:

- *Brad Ack, Executive Director, Puget Sound Action Team and co-manager of Governor's Puget Sound Partnership*
- *Josh Baldi, Special Assistant to the Director of the WA Department of Ecology*
- *Jay Manning, Co-chair Puget Sound Partnership*
- *Rod Dobell, Emeritus Professor of Public Policy, University of Victoria Centre for Global Studies and former President, North American Institute – Canada*
- *Diana Gale, Faculty, Daniel J. Evans Graduate School of Public Affairs, University of Washington, and consultant on governance to the Governor's Puget Sound Partnership*

Session 2B: Salmonid Habitat Use and Recovery

Chair: Fred Goetz

The Early Bird Might Get the Worm, but the Early Sockeye Gets Wormed: Mechanisms and Consequences of Early Freshwater Entry by Fraser River Late-Run Sockeye Salmon.

Scott Hinch, University of British Columbia
Michael Cooperman, University of British Columbia*
Steven Cooke, Carleton University
Glenn Crossin, University of British Columbia
Ivan Olsson, University of British Columbia
Kyle Hanson, Carleton University
Anthony Farrell, University of British Columbia
David Patterson, Fisheries and Oceans Canada
Karl English, LGL Limited Environmental Research
David Welch, Kintama Research Corp
Rick Thomson, Fisheries and Oceans Canada
Mark Shrimpton, University of Northern British Columbia
Glen Van Der Kraak, University of Guelph
Kristi Miller, Fisheries and Oceans Canada

The Fraser River is the most productive salmon river in Canada, and sockeye are the most economically important salmon in the watershed. Prior to 1996, populations of the Fraser's late-run sockeye complex were unique in that upon arrival in the Strait of Georgia they milled within the estuary for several weeks prior to entering the Fraser and proceeding to spawning grounds. Since 1996, large proportions of late-run sockeye have entered the Fraser without holding in the estuary, resulting in pre-spawn mortality rates upwards of 95% for early-entry fish. Causes for the mal-adaptive shift in freshwater entry timing are unknown. In 2002, we initiated a multi-year interdisciplinary (ecology, physiology, oceanography, genomic) research program to explore the causes and consequences of early entry. We combine field collections, experimental manipulations, and telemetry tracking to test how individual physiological condition corresponds with timing of river entry and ultimate fate. Initial findings indicate early entry late-run sockeye are characterized by unusual ionic, osmotic, and energetic states, and that advanced sexual maturation appears incompatible with survival in marine waters. Our efforts should yield a predictive model of sockeye migration behavior and survival, which should enable resource managers to optimize management and conservation of these important runs.

Puget Sound Bull Trout Estuarine and Marine Habitat Use – What Have We Learned After Five Years of Study

Fred Goetz, U.S. Army Corps of Engineers*
Eric Jeanes, R2 Resource Consultants
Ed Connor, Seattle City Light
Russ Ladley, Puyallup Tribe
Chuck Ebel, US Army Corps
Reginald Reisenbichler, Steve Rubin, Michael Hayes, US Geological Survey

Bull trout (*Salvelinus confluentus*) are known as an apex predator in the rivers and streams of the Pacific Northwest. They are also one of three federally listed fish species that are found in the estuarine and marine waters of Puget Sound and the Pacific Coast of Washington. Until 2001 there had been no monitoring or study of these large migratory fish in marine waters of Puget Sound or British Columbia. In 2002 we began a multi-year study of bull trout in all rivers and estuaries of the Puget Sound Distinct Population Segment where bull trout are known to spawn and rear. Our work has focused on estuarine and marine behavior and habitat use of larger juveniles and adults. We use acoustic telemetry, transmitters that emit a coded signal and receivers that detect and record the signal, to follow these mobile animals. To date we have tagged over 250 fish with acoustic tags and have developed a receiver network that covers much of the eastern Puget Sound shorelines and estuaries. We will describe estuarine and marine habitat use of bull trout over the past 5 years of study.

Salmon Recovery Initiatives by the Squamish Nation

Bettina C. Sander, Golder Associates Ltd.*
Randall W. Lewis, Squamish Nation
Melissa Evanson, Golder Associates Ltd.

The Squamish Nation is deeply tied and connected to the land and waters that encompass their traditional territory and fishing is vitally important to the Squamish culture. As such, the Squamish Nation has a vital interest in management of the fishery and has been instrumental in driving a number of initiatives in the watershed. These are reviewed herein and include: an annual salmon spawner enumeration program; a salmon recovery plan, and a stock assessment framework. Throughout these processes the Squamish Nation has developed successful partnerships with community organizations and government agencies to assist with the long-term goal of salmon recovery in the Squamish River Watershed.

Movement and Behavior of Steelhead (*Onchorhynchus mykiss*) Smolts Through Hood Canal

Megan Petrie, NOAA/NMFS/NWFSC*
Skip Tezak, NOAA Fisheries
Barry Berejikian, NOAA Fisheries

Unexplained declines in Hood Canal and Puget Sound steelhead populations have been detected in the last 10 to 20 years, and have been shown to contrast markedly with the relatively stable condition of populations along the Washington and Oregon coasts. This discrepancy between the health of Coastal as opposed to Puget Sound steelhead populations indicates that nearshore smolt migration may constitute a major cause of mortality. Acoustic telemetry was used to investigate survival, migration timing, and migratory behavior of steelhead smolts from four Hood Canal streams and one Strait of Juan de Fuca stream. Estimated survival rates for wild smolts from river mouths to the northern end of Hood Canal was 71% for Skokomish, 67% for Dewatto, and 85% for Big Beef Creek, and 76% for hatchery-reared smolts released into the Hamma Hamma River. Residence time and migration patterns within Hood Canal were highly variable within and among populations. The extended duration of residence in Hood Canal exhibited by some fish suggests that it may provide growth opportunities and function as more than simply a migration corridor. Receivers positioned in nearshore habitats did not detect a disproportionately large number of migrants. Detailed knowledge of steelhead survival and patterns of nearshore habitat use not only aid in determining causes of population decline, but also help define extinction risk and recovery actions for this potentially ESA-listed species.

Puget Sound Cutthroat Trout Marine Migration and Habitat Use

Fred Goetz, U.S. Army Corps of Engineers*
Sarah Haque, Evergreen State College
Scott Steltzner, Squaxin Island Tribe
Skip Tezak, NOAA Fisheries
Thomas Quinn, University of Washington
Eric Jeanes, R2 Resource Consultants
Kyle Brakensiek, Chris Ellings, Joe Jauquet, Sayre Hodgson

Coastal Cutthroat trout (Salmon clarki clarki) are an anadromous salmonid found throughout the marine waters of Puget Sound. They are more widely distributed in streams and rivers than any other salmonid in Puget Sound. They are also highly sought after by recreational fishers in rivers and estuaries. Even with their widespread presence these fish are one of the least studied salmonids in the waters of Puget Sound. We have begun a multiyear study of the behavior and habitat use of cutthroat trout in the Puget Sound. We use acoustic telemetry, transmitters that emit a coded signal and receivers that detect and record the signal, to follow these mobile animals. We are studying all marine life-stages including smolts, sub-adult and adult cutthroat. Our study areas include Shilshole Bay in Central Puget Sound, South Puget Sound marine shoreline areas, Big Beef Creek and shoreline areas of Hood Canal, and the Skagit River delta and Skagit Bay. We will present preliminary information on the first 1 Ω years of our telemetry study. This work is a companion to a multiyear study of Puget Sound bull trout. We hope the work in this study along with study of bull trout will help inform planners and biologists of the full scope of salmonid habitat use of nearshore marine areas.

Comparison of Juvenile Salmon Diets in the Strait of Georgia and Puget Sound 1997-2006.

Ruston Sweeting, Richard Beamish, Chrys Neville, Fisheries and Oceans Canada*

Juvenile Pacific salmon (*Oncorhynchus spp.*) enter the ocean in early spring/summer. In the Strait of Georgia and Puget Sound, they generally spend several weeks to months rearing before migrating to other areas. During this time, growth and predation avoidance are the major priorities, and interspecific competition for food could be a limiting factor in successful migration and/or overwinter survival. This report will present the results of 10 years of summer (July) and fall (September) surveys in Puget Sound and the Strait of Georgia, during which stomach data was collected for several thousand juvenile coho (*O. kisutch*), Chinook (*O. tshawytscha*), and chum (*O. keta*) salmon. In addition to examining similarities and differences in dietary preferences, the influence of size, season, and environment will be discussed.

Panel 2D: Climate Change: The IPCC Fourth Assessment Report and Implications for the Salish Sea

Chair: James Tansey

The Intergovernmental Panel on Climate Change has undertaken its Fourth Assessment Report. This panel will provide an overview of the IPCC Fourth Assessment Report and will make observations on the possible implications for the Salish Sea. The panel will address mitigation efforts, but will also address adaptation through landscape and ecosystem based management, altered policy and regulation.

Panel Members:

- *Hadi Dowlatabadi, CRC Chair, Institute for Resources, Environment and Sustainability, University of British Columbia*
- *Alison Shaw, Research Associate, Forestry, at University of British Columbia*
- *Sarah Burch, PhD Candidate, Institute for Resources, Environment and Sustainability, at University of British Columbia*
- *Mark Johannes, University of Victoria and Golder Associates Ltd.*
- *Nate Mantua, University of Washington - Climate Impacts Group*

How Can We Adapt? Lessons From Pacific Salmon on the Impacts of Climate Change.

Mark Johannes, Golder Associates, University of Victoria

I present some of the important issues and lessons from Pacific Salmon to be learned on impact and adaptation responses to climate change in the Puget Sound and Georgia Basin. To improve predictions of climate change "impacts" on future resource use, management and conservation activities will require more effort and greater refinement of climate scenarios. As an immediate response, a second "adaptation" approach can be used to reduce risk and help capitalize on conservation and biodiversity initiatives by assuming and preparing for adverse effects of climate change; this approach defines vulnerability to climate change and develops anticipatory adaptation in management and conservation of important plants, animals and ecosystems in Canada. Adaptation to climate variability and change can be used to adjust perspectives, practices, processes, management and statutory and legal systems based on projected changes in climate. Early adaptation to climate change can assist in adjusting human and community expectations to sustainable resource use and development, and protection of habitats, ecosystems and sensitive species in the context of communities within the Puget Sound and Georgia Basin.

Seasonal, Interannual and Interdecadal Scales of Variability in Puget Sound Oceanography and Climate

Stephanie K. Moore, Nathan J. Mantua, Jonathan P. Kellogg, Mitsuhiro Kawase, Jan A. Newton, University of Washington

The influence of climate on Puget Sound oceanographic properties is investigated on seasonal to interannual timescales using continuous profile data from the Washington State Department of Ecology's Marine Waters Monitoring Program for the time period 1993 to 2002. Principle component analysis identified indices representing 42, 58 and 56% of the total variability at depth-station combinations for temperature, salinity and density variability, respectively, and 22% for water column stratification. Long term records of sea surface temperature and salinity from Race Rocks were used to extend the time series of the leading principal components to 1950 and allow for an examination of relationships with climate on interannual to interdecadal timescales. In general, regional climate forcings strongly influence oceanographic properties with significant relationships between air and water temperature, and between streamflow, salinity and density. Large scale patterns of climate variability such as El NiÒo/Southern Oscillation and Pacific Decadal Oscillation, also significantly influence oceanographic properties but relationships are less pronounced than those with regional factors, and exist only during winter and fall. By providing insights into the space-time patterns of physical oceanographic changes in Puget Sound this study contributes towards an enhanced understanding of linkages between climate, oceanography and the frequency, duration and magnitude of harmful algal blooms.

Session 2E: Seafood Safety and Human Health I

Chair: Joe Gaydos

Human Health Evaluation of Puget Sound Fish

Joan Hardy, Gary Palcisko, Washington State Department of Health*

Washington Department of Health conducted a human health evaluation of contaminants in Puget Sound fish. Over 100 contaminants were measured in muscle tissue (without skin) from English sole, four rockfish species, and two salmon species. DOH concluded that two contaminants were of potential public health concern: polychlorinated biphenyls (PCBs) and mercury.

Based on contaminant concentrations in fish and on estimates of consumption by recreational anglers, tribal members, and consumers of fish from the Asian Pacific Islander community, DOH determined that

frequent consumers of certain Puget Sound fish may be exposed to contaminants above a level of concern. DOH considered risks, benefits, and data uncertainties when providing meal advice for anglers and other consumers.

No meal restrictions were necessary for English sole (flatfish) from non- or near-urban areas of Puget Sound. DOH recommended one rockfish meal per week unless otherwise noted for urban areas. Puget Sound Chinook had higher levels of PCBs and mercury than coho, resulting in a recommendation of one meal per week. Additionally, those eating Chinook salmon from the Puget Sound winter fishery (blackmouth) were advised to limit consumption to two meals per month. Puget Sound coho salmon were relatively low in contaminants. A list of low contaminant fish, including those from the market, was created to assist consumers in making healthy selections.

A Survey of Cadmium in Pacific Oysters: Spatial Distribution, Influencing Factors and Ways to Minimize Concentrations

Aimee Christy, Pacific Shellfish Institute*
Ian Stupakoff, Integral Consulting Inc.
Rosalee Rasmussen, Oregon State University Seafood Lab

Cadmium (Cd) is a toxic trace metal known to bioaccumulate in molluscan shellfish, particularly Pacific oysters (*Crassostrea gigas*.) Over the past few years, several shipments of Pacific oysters from Puget Sound and Canada have been rejected by Hong Kong for exceeding the 2 µg/g import standard. This study evaluates the spatial distribution of Cd concentrations in Pacific oyster tissue harvested from 31 commercial, recreational and tribal shellfish growing areas located throughout Puget Sound and Washington State coastal estuaries. Findings indicate that a weak spatial trend exists with oyster Cd levels increasing in a northward and seaward direction with the exception of consistently elevated levels along the length of Hood Canal. Cd concentrations from 92 oyster composites ranged from 0.44 to 2.5 µg/g with a state-wide average of 1.24 ± 0.57 µg/g. Seventeen percent of composites exceeded Hong Kong's 2 µg/g import standard. Factors influencing the spatial distribution of Cd in oysters (water quality, sediment chemistry, seasonality) will be discussed as well as ways to minimize tissue concentrations (site selection, time of harvest, grow-out method, processing technique), having practical implications for growers and harvesters throughout Georgia Basin and Puget Sound.

Assessment of Trace Metals in Tissues of Geoduck Clams from Eastern Puget Sound

Tom Ostrom, Suquamish Tribe
Paul Williams, Suquamish Tribe
Gary Palcisko, Washington State Department of Health*

The Suquamish Tribe and the Washington State Department of Health recently partnered to assess the concentrations of trace metals (As, Cd, Cr, Pb, and Hg) in the tissues of geoduck clams harvested from the Richmond Beach tract, located between Edmonds and Seattle, Washington in eastern Puget Sound. The purpose of this assessment was to evaluate the human health risks associated with consumption of geoducks from this area of Puget Sound. Evaluating the human health risks associated with contaminants in fish and shellfish tissue requires that samples be processed in a manner consistent with how they would be prepared by consumers. Considering the preparation practices of end consumers, geoduck tissues from 60 geoducks collected from the Richmond Beach tract were segregated into three parts: gut ball (viscera), neck/strap (siphon and mantle), and the outer skin of the siphon. Gut ball and neck/strap tissues from each geoduck were separately analyzed for total As, Cd, Cr, Pb, and Hg. A subset of tissues from the outer skin of siphons was also analyzed. In general, trace metal concentrations were highest in the outer skin, and lowest in the neck/strap. The results from this study have helped to explain inconsistent results among past studies and suggest some important considerations in future studies of geoduck tissues, particularly when the objective is the assessment of human health risks.

Results and Discussion of the Swinomish Health Risk Assessment of Contaminated Seafood

Jamie Donatuto, Swinomish Indian Tribal Community*
Barbara Harper, AESE Inc., and Confederated Tribes of the Umatilla Indian Reservation

This presentation will summarize the Swinomish Indian Tribal Community's Bioaccumulative Toxics in Native American Shellfish Project. The project, initiated in 2002, hypothesized that Swinomish people are exposed to low level, bioaccumulative toxics when gathering and consuming local shellfish. Results will be presented from the human health risk assessment of two species of clams, associated sediment, and Dungeness crab, which were tested for heavy metals, organotins, PCBs (both aroclors and the WHO list congeners), chlorinated pesticides, polyaromatic hydrocarbons, and dioxins/-furans. The presentation will also discuss shortcomings of the current risk assessment methodology, data gaps and uncertainties, and provide more culturally appropriate alternatives to remedy some of these faults. Other topics to be touched upon include: the use of traditional harvesting techniques in sampling procedures, and culturally competent mitigation options, outreach and education efforts. The project was funded by U.S. EPA grant #R-829467.

Science, Policy and Practice: Washington's PBT Chemical Action Plans

Robert Duff, Department of Health*
Michael Gallagher, Department of Ecology
Maria Peeler, Department of Ecology
Joanne Prado, Department of Health

There are currently about 80,000 registered chemicals in the US, and 1,500 new chemicals are registered each year. A small class of these chemicals, called "persistent bioaccumulative toxics (PBTs), present a particular problem because:

- PBTs remain in the environment for a long time (Persistent).
- People and animals accumulate PBTs in their bodies (Bioaccumulative).
- PBTs threaten human health and the environment. New information points to risk to children's healthy development, since some PBTs harm the central nervous system, as well as cause reproductive and other problems (Toxic).
- PBTs readily migrate between our air, land and water

Public concern is increasing regarding exposures by children to PBTs. Children are more susceptible to PBT exposures since they are still undergoing growth and development of their bodies and brains. Children are closer to the ground and have greater "hand-to-mouth" behaviors. Many PBTs are present in breast milk, which results in additional loading of chemicals during infancy.

Special efforts to bring together the best science, the most meaningful policy and effective public health education practice are required to address the serious problems that PBTs pose. In 2000, the Washington State Department of Ecology (Ecology) drafted the nation's first PBT reduction strategy. Since that time, Ecology has partnered with the Washington State Department of Health (DOH) to create and implement chemical action plans for Mercury (2003) and PBDEs (2006) and to develop rules for PBTs in Washington. In addition, Ecology has adopted the nation's first PBT regulation.

Next steps call for Ecology and DOH to develop chemical action plans for lead in 2007, polyaromatic hydrocarbons in 2008 and perfluorooctane sulfonates in 2009. However, a much greater challenge is that current US chemical policy has resulted in:

- a lack of data on chemicals in commerce;
- high burdens for agency action;
- a focus on review of new chemicals without adequate attention to

existing chemicals; and

- chemical by chemical approach to chemicals management that is slow and cumbersome.

There has also been relatively little attention paid to chemicals in products. Due to these limitations, many efforts to reduce and substitute chemicals are largely voluntary and dependant on the willingness of industry and commerce to participate.

Cryptosporidium and Giardia Species in Marine Wildlife: Do they Present a Risk to Human Health?

Joseph Gaydos, SeaDoc Society, UC Davis Wildlife Health Center*
Woutrina Miller, UC Davis Wildlife Health Center
Kirsten Gilardi, SeaDoc Society, UC Davis Wildlife Health Center
Christine Kreuder-Johnson, UC Davis Wildlife Health Center
Patricia Conrad, UC Davis Wildlife Health Center
Ann Melli, UC Davis School of Veterinary Medicine
Heather Zornetzer, UC Davis School of Veterinary Medicine
Steven Jeffries, Washington Department of Fish and Wildlife
Monique Lance, Washington Department of Fish and Wildlife

Cryptosporidium and Giardia species are protozoal pathogens that infect humans, domestic animals and wildlife. Historically they have been thought of as terrestrial and freshwater pathogens but their infective stages can survive in marine waters for up to a year and be concentrated by filter feeding bivalves. Little is known about the epidemiology of these pathogens in marine ecosystems, especially the role that marine wildlife could play in their transmission. We tested harbor seals, marine-foraging river otters, and hybrid glaucous-winged / western gulls, three common marine wildlife species in the Georgia Basin / Puget Sound, for infection with Cryptosporidium and Giardia species. Giardia cysts were detected in 4% of gull samples (n=78), 19% of river otter samples (n=57), and 43% of seal samples (n=99). Fourteen positive seal samples were amplified by PCR and confirmed as G. lamblia. Three were from one site and were identified as the G. lamblia dog genotype, suggesting transmission to seals from coyotes or domestic dogs. Sequences from the other eleven samples represented a novel G. lamblia genotype. Cryptosporidium sp. oocysts were detected in 7% of river otters sampled but not detected in gulls or seals. The one amplified otter sample was most similar to the ferret genotype of C. parvum. Marine wildlife shed Cryptosporidium and Giardia species in the Puget Sound region but preliminary data failed to identify the genotypes most commonly infecting humans. More work is needed to better understand the zoonotic potential of the wildlife isolates identified and the potential that sewage outflows could be contaminating marine waters with Cryptosporidium and Giardia of human origin.

Panel 2F: Greening West Coast Marine Ports

Chair: Darrell Desjardins

Chaired by Vancouver Port Authority's Environmental Director, Darrell Desjardins, panelists representing British Columbia, Washington State and California (LA/Long Beach) Port Authorities will discuss the opportunities and challenges of greening marine port activities.

Session 3A: Ocean Observations

Chair: Brian Grantham

The Impacts of the Fraser Plume on the Optical Characteristics of the Strait of Georgia Waters, British Columbia, Canada

Eduardo Loos, Maycira Costa, University of Victoria Dept. Geography

Light, along with nutrients and winds, in the waters of the Central Strait of Georgia affects primary productivity directly. The availability of light is however dependent on the many dissolved and particulate materials in the water, such as photosynthetic pigments, inorganic suspended matter, and chromophoric dissolved organic matter (CDOM). Upwelling radiance, downwelling irradiance, absorption, attenuation, CDOM and chlorophyll a fluorometric data, and suspended load were collected in the waters of Central Strait of Georgia in April and July 2006 along with oceanographic data for the purpose of identifying the influence of CDOM and suspended solids on the horizontal and vertical distribution of phytoplankton. The results show a significant spatial and vertical variability of the water on the Strait. Accordingly, the waters can be divided in three main optical classes: waters highly attenuated, with a strong scattering coefficient (closer to the Fraser); water with medium attenuation coefficients; and water with relative higher absorption due to phytoplankton (farther from the Fraser). These results indicate that the influence of the Fraser River on the light fields of the Strait of Georgia waters can be tracked by the optical variables in addition to regular oceanographic variable, such as temperature and salinity.

Nutrient Levels in Puget Sound: Decadal Changes and Controlling Factors in Regional Basins and the Strait of Juan De Fuca.

Julia Bos, Skip Albertson, Carol Maloy, Adrienne Stutes, Mindy Roberts, Greg Pelletier, Washington State Department of Ecology*

One of the greatest concerns for the Puget Sound ecosystem is nutrient inputs and subsequent negative impacts on water quality. Human and natural factors all contribute to nutrient loading. In some regions, loadings of nitrogen are significant enough for it to be considered a pollutant. Historically, scientists thought that nutrient concentrations would not increase enough to be a concern in the Puget Sound system. To assess this idea of unlimited capacity, seasonal and inter-annual nutrient concentrations for the past three decades are compared to historical values in the Main, South Sound, Whidbey and Hood Canal basins and the Strait of Juan de Fuca. Data to support this analysis is from the Department of Ecology's ambient monitoring program where nutrient data is collected monthly from 40 core and rotational stations. In addition, datasets from intensive or seasonal surveys throughout Puget Sound are used. The use of nutrient levels as a measure in marine water quality and eutrophication indices will also be discussed.

Estuarine Versus Transient Flow Regimes in Juan de Fuca Strait

Richard Thomson, Steven Mihaly, Institute of Ocean Sciences*
Evgueni Kulikov, P P Shirshov Institute of Oceanology

Residual currents in Juan de Fuca Strait are observed to switch between two fundamental states: estuarine and transient. The estuarine regime – which prevails ~90% of the time in summer and ~55% of the time in winter – has a fortnightly-modulated, three-layer structure characterized by strong (~50 cms-1) outflow above 60±15 m depth, moderate (25 cms-1) core-like inflow between 60-125 m depth, and weak (~10 cms-1) inflow below 125±10 m depth. Rotational effects increase the upper layer depth by 40 m on the northern side of the channel and upwelling-favourable coastal winds augment inflow in the bottom layer by as much as 5 cms-1. Fortnightly modulation of the estuarine flow by tidal mixing in the eastern strait leads to cross-channel "wandering" of the residual current such that surface outflow leads intermediate inflow by 180° at the fortnightly period. Transient flows – which occur ~10% of the time in summer and ~45% of the time in winter – are rapidly evolving, horizontally and vertically sheared "reversals" in the estuarine circulation forced by poleward wind events along the outer coast. Major events can persist for several weeks, lead to current reversals of 25 to 50 cms-1, and generate a net volume flux into the strait. A striking feature of major events is the formation of an O(10) km wide, surface-intensified, O(100) cms-1 inflow current along the southern boundary. This "Olympic Peninsula Countercurrent" is accompanied by an abrupt decrease in salinity indicating that it is a buoyancy-driven flow originating on the outer Washington shelf.

Remote Sensing of Chlorophyll-a in the Strait of Georgia

Nicholas Komick, Maycira Costa, University of Victoria*

The Strait of Georgia is an important marine resource and is subject to significant anthropogenic forces. Satellite imagery can be a valuable tool for monitoring the Strait and its associated biophysical processes. As an important step towards this goal, an algorithm must be developed to estimate dominant optical constituents from ocean colour imagery in the Strait. This developed algorithm incorporates known optical properties of various constituents to estimate the influence of each on measured water colour. To evaluate the effectiveness of the developed algorithm, in situ radiometric and biophysical measurements collected during three research cruises carried out in winter, spring, and summer of 2006 were used. During the cruise, chlorophyll-a concentrations ranged from 1.9 to 25.0 ug l^-1 and total suspended solids ranged from 1.1 to 22.0 mg l^-1. This data set allows the chlorophyll-a algorithm to be evaluated against the range of conditions found in the Strait, including varying influence from terrestrial environments.

VENUS: A Cabled Ocean Observatory in Saanich Inlet and The Strait of Georgia

Richard Dewey, Verena Tunnicliffe, University of Victoria*

The Victoria Experimental Network Under the Sea (VENUS) is a cabled ocean observatory, with arrays in both Saanich Inlet and the Strait of Georgia. The first leg was deployed in February 2006 with an observatory node at 100m depth in Saanich Inlet. The second, deeper (300 and 175m) array will be deployed in the Strait of Georgia during the summer of 2007. The cabled observatory allows for unprecedented power and bandwidth to and from instruments connected to the observatory "nodes". Data is retrieved and available over the web in near real-time. Preliminary instruments include standard oceanographic devices such as CTDs and ADCPs, as well as inverted echo-sounders, broadband hydrophones, and user controllable pan and tilt digital cameras. Advanced systems under development include vertical profilers and a dedicated delta dynamics laboratory. The data archive and instrument access are provided through the VENUS web site (http://www.venus.uvic.ca/), where galleries can be searched and data products requested. An overview of the observatory infrastructure, some preliminary scientific results, and how new users can access the facility will be presented.

Spatial and Temporal Chlorophyll Distribution in the Straits of Georgia and Juan de Fuca

Diane Masson, Angelica Pena, Institute of Ocean Sciences*

We investigate the spatial and temporal distribution of planktonic biomass along with some factors influencing its distribution within the Straits of Georgia and Juan de Fuca. These two straits are the main constituents of a large coastal estuary system on the southern coast of British Columbia. A large amount of freshwater enters the coastal basin, with the main source being the Fraser River, and drives a two-way estuarine circulation. Complex biological dynamics (responses to light, nutrients, grazing, etc) dictate complex biomass distribution. However, a unique data set from a relatively long duration (over 5 years) and systematic (every season, at the same 70 stations) sampling program allows us to accurately describe the chlorophyll distribution in both time and space within the coastal basin. Over the study area, the main features of the spatial distribution of chlorophyll are shown to be closely related to variations in upper water column stratification. In addition, it is shown that, during the summer, plankton growth is nutrient limited within the central Strait of Georgia. Finally, the possible role of light limitation of the plankton production within Juan de Fuca Strait is discussed.

Panel 3B: International Joint Commission: Special Consultation Session on the 2006 Progress Report under the Canada-United States Air Quality Agreement

Co-Chairs: Commissioner Jack Blaney (Canada) and Commission Irene Brooks (U.S.)

The International Joint Commission is required to gather public comments on biennial progress reports under the Canada-United States Air Quality Agreement, which was put in place by the two countries in 1991 as an instrument to address shared concerns regarding transboundary air pollution.

The 2006 Progress Report was released in November and is the eighth prepared by the Air Quality Committee. It highlights actions undertaken by Canada and the United States over the past two years to address transboundary air pollution within the context of the Agreement – namely, acid rain and ground-level ozone.

Comments gathered by the Commission will assist the Air Quality Committee in implementing the Agreement and preparing the next report in 2008. As part of this broad consultation process, a special consultation session for Georgia Basin Puget Sound Research Conference delegates is being convened. Conference delegates are invited to attend this session in order to provide feedback to the Commission on the 2006 Progress Report. Delegates attending this session are asked to read the Progress Report prior to attending the session. Copies of the Progress Report are available at the conference registration desk.

Session 3C: Modeling and Decision Support Tools II

Chair: Carol Maloy

Development of a High Resolution 3-D Unstructured Grid Circulation Model of the Whidbey Basin in Puget Sound

Zhaoqing Yang, Battelle Pacific Northwest National Laboratory*
Tarang Khangaonkar, Pacific Northwest National Laboratory
Greg Hood, Skagit River System Cooperative
Kurt Fresh, NOAA
Eric Beamer, Skagit River System Cooperative
Correigh Greene, NOAA
Eric Grossman, USGS

The Whidbey Basin is Puget Sound's largest supplier of freshwater and sediments and has been identified as a key region of ecological importance, especially for salmon. It consists of three major estuaries (Skagit River, Stillaguamish River and Snohomish River) that are characterized by large intertidal zones and multiple tidal channels which provide important habitat for the production of Chinook populations within the basin.

The tidal mixing, inundation, and tidal circulation processes in each estuary, and the in-teraction among these three estuaries play important role on nearshore habitat restora-tion and fish migratory pathways. This paper describes the development of a three-dimensional (3-D) hydrodynamic model for the Whidbey Basin. A companion paper ti-tled Application of a 3-D Hydrodynamic Model of Whidbey Basin to Assess Cumulative Effects of Restoration Projects in the Snohomish River Estuary provides an example of the utility of the tool developed.

The Whidbey Basin hydrodynamic model was developed using the unstructured, finite volume, 3D coastal ocean model (FVCOM). A fine grid resolution, as small as 10 m, was specified in the in the nearshore areas. The model was driven by tides, salinity and temperature along the open boundaries, and wind and solar heating at the surface. The model was successfully calibrated against observed data for a neap-spring tidal cycle collected during fall of 2006. Model results demonstrated that the Whidbey Basin model has the capability of simulating the physical processes at the required resolution and accuracy to help assess the feasibility of nearshore restoration projects and provide useful information for marine fishery habitat research.

Application of a 3-D Hydrodynamic Model of Whidbey Basin to Assess Cumulative Effects of Restoration Projects in the Snohomish River Estuary

Tarang Khangaonkar, Battelle Pacific Northwest National Laboratory*
Zhaoqing Yang, Battelle Marine Sciences Laboratory
Maria Calvi, Tulalip Tribes
Kurt Nelson, Tulalip Tribes
Vaughn Collins, Snohomish County

The Whidbey Basin is Puget Sound's largest supplier of freshwater and sediments and has been identified as a key region of ecological importance, especially for salmon. With a high percentage of shallow, low-gradient, shorelines which are important for ju-venile salmonid rearing, Whidbey Basin provides critical habitats to several Chinook populations within this area and supports populations from other parts of Puget Sound. However, over the last century, considerable near-shore tidal marshland habitat within the Basin has been lost due to dike construction.

Efforts are underway to restore the degraded estuary habitat and re-establish migratory pathways for salmon. To help assessing the feasibility of improving these estuarine functions through proposed restoration actions, a hydrodynamic model, specifically suited for near-shore restoration design was developed for the Whidbey Basin. Details of this model are described in a companion paper titled Development of a High Resolution 3-D Unstructured Grid Circulation Model of the Whidbey Basin.

In this paper we describe the application of this model to the Snohomish River estuary. The fresh water plume interaction within the river delta region, inundation of the marsh-lands and the salinity variability in the estuary were simulated for the existing conditions. The model was then applied for the Qwuloolt Marsh, Smith Island, Union Slough, and Biringer Farm restoration projects. Located relatively close to one another near the mouth of the estuary, these projects form one of the largest restoration efforts in Wash-ington. The results provide valuable information regarding potential affects on morphol-ogy, and marine habitat conditions under the influence of restoration projects.

Landscape Metrics for Monitoring Landscape Change in Western Washington

Daniele Spirandelli, Marina Alberti, University of Washington*

This study identifies and applies a set of landscape metrics for monitoring landscape change in Western Washington over the period of 1991 to 2001. The objective was to select metrics that may be used as indicators to quantify and monitor landscape patterns trends at the basin and sub-basin scale. The study is based on a multi-year NOAA Coastal Change Analysis Program (C-CAP) Land Cover, a land cover classification of Landsat Thematic Mapper 5 imagery developed for the National Land Cover Database (NLCD). The analysis was performed at three time-steps (1991, 1996, and 2001) for Western Washington. A multi-scale analysis was conducted using two watershed basin scales using USGS hydrologic units (HUCs), 4 and 6, to evaluate landscape trends at two different scales. We quantified the sensitivity of the selected metrics to changes in land cover and population density that occurred in Western Washington to assess their usefulness as indicators for monitoring regional landscape change.

This work was conducted with support from the U.S. Environment Protection Agency, Region 10, Regional Geographic Initiative.

Sensitivity Analysis of Spatial Population Viability Models for Critical Habitat Identification

Janelle Curtis, Ilona Naujokaitis-Lewis, Peter Arcese, University of British Columbia*
Jordan Rosenfeld, British Columbia Ministry of Environment

Metapopulation dynamics are strongly influenced by the size, quality, and spatial arrangement of populations, the dispersal rates and correlations among populations and the structure of habitat surrounding populations. Varying such spatial parameters in sensitivity analyses of population viability analyses (PVAs) helps evaluate the influence of parameter uncertainty on model predictions, but few studies conduct such analyses, perhaps because no computationally-efficient tools exist to facilitate comprehensive sensitivity analyses for spatial PVAs. This paper presents GRIP 1.0 (Generation of Random Input Parameters), a program that varies both spatial and non-spatial input parameters for PVAs created in RAMAS Metapop 4.0. GRIP is used here to explore the consequences of spatial variation on the persistence of 40 threatened species and rank the influence of spatial and non-spatial parameters on extinction probability using standardized regression coefficients. Our results underscore the importance of including spatial parameters in sensitivity analyses; the most influential parameters were either spatial in nature (e.g., distance among and number of populations) or linked to the number and configuration of populations (e.g., correlation of vital rates among populations). GRIP supports computationally-efficient sensitivity analyses for spatial PVAs for prioritizing research and identifying critical habitat for species that occupy habitat patches of varying size, quality and distribution.

A Simple Population Forecast Model for Purple Martins in British Columbia

Bruce Cousens, J. Charlene Lee, Georgia Basin Ecological Assessment and Restoration Society*
Laura M. Darling, Parks and Protected Areas Branch, BC Min. of Environment
J. Cam Finlay, Independent, Victoria, BC
Thomas W. Gillespie, Independent, Victoria, BC

Western Purple Martins (*Progne subis arboricola Behle* 1968) have been the subject of an extensive and highly successful mainly volunteer-based nest box recovery program in the Georgia Depression Ecoprovince of southwest British Columbia since 1985, following major population declines after the mid-1900s, with over 600 pairs nesting in BC in 2006. Since 1997 a scientific monitoring program was implemented involving documented annual nest box inspections at almost all nesting colonies within the province to monitor and track progress of the recovery and obtain reliable data on abundance, productivity, nesting success and fledgling production for this geographically confined population. Analysis of the resulting data accumulated over a decade has allowed development of a simple population forecast model based on nesting pair abundance, fledgling production and annual survival that fairly accurately (within 5-10% so far) predicts return of breeding birds the following year. Input criteria (number of nesting pairs and number of nestlings fledged) are easily obtained from nest box inspections prior to fledging and average overall annual survival (all age classes combined) can be calculated from previous years' data. These data can be used with average fledging success to iteratively predict returns in subsequent years, with accuracy subject to primarily weather-related fluctuations in nesting and fledging success, as well as variation in annual survival.

Session 3E: Seafood Safety and Human Health II

Chair: Vera Trainer

A Public Health Approach to Low Dissolved Oxygen in Hood Canal

Leslie Banigan, Kitsap County Health District*

Hood Canal in Puget Sound has a history of low dissolved oxygen and anecdotal information suggests periodic fish kills dating back to the early 1900s. Recent oxygen levels are the lowest in recorded history, resulting in fish kills in 2002, 2003 and 2006 and prompting concerns about long-term health of the canal.

A "Preliminary Assessment and Corrective Action Plan", (PSAT, May 2004) (PACA) theorized nutrient contamination as a source of the dissolved oxygen problem because excess nutrients stimulate algal

growth, which uses oxygen as it breaks down. The PACA used mathematical estimates to identify nitrogen from onsite sewage systems (OSS) as the major anthropogenic source to Hood Canal.

The Kitsap County Health District conducted a fecal coliform Pollution Identification and Correction project in 2005 to: protect public health by correcting failing OSS; assess the relationship between FC and nitrate+nitrite nitrogen in fresh water drainages, and determine net nutrient reductions after correcting failing OSS.

Twelve failing OSS were identified and corrected in nine miles of shoreline comprising 340 residences (4% failure rate). No statistical correlation between FC and nitrate+nitrite nitrogen was found. Shoreline flows demonstrated statistically significant nitrate+nitrite nitrogen reduction after correction at two OSS correction sites.

Tracking Bacteria Sources in Oakland Bay

John Konovsky, Squaxin Island Tribe*
Debby Sargeant, Department of Health
Stephanie Harris, Environmental Protection Agency

Oakland Bay is located at the south end of Puget Sound. A very productive shellfish harvest is threatened by high bacteria levels from rural nonpoint pollution. Two areas are of immediate concernóa marine station at the upper end exhibits summer bacteria exceedances. No livestock are nearby and dye testing of nearshore on-site sewage treatment systems showed no failures. Nearby freshwater streams have relatively low bacteria levels and upwelling groundwater is bacteria free. Marine sediment has a significant bacteria reserve. In Chapman Cove, the exceedances are more closely linked to rainfall events. An obvious source is livestock grazing along the shoreline. A tributary to the cove, Uncle Johns Creek, has high bacteria levels. The local Health Department's efforts to conduct dye testing of on-site systems have not been successful, but the conservation district has been actively working with livestock owners. A microbial source tracking study sponsored by EPA using Bacterioides has identified that both ruminant and human markers are ubiquitous. A separate study by the University of Washington is looking at F+RNA coliphage typing. Stakeholders continue to meet to address the issues. While the agriculture community is responsive to pollution control actions, on-site owners continue to resist inspection of their systems. Evaluation of incentive and enforcement options is ongoing, plus additional investigation of the role of sediment bacterial reserves.

BEACH Program - A Four Year Review of Data

Lynn Schneider, Jessica Archer, Washington State Department of Ecology*

High levels of enterococcus bacteria in marine waters can be indicative of an increased risk of illness for recreational beach users. The Beach Environmental Assessment, Communication, and Health (BEACH) Program is currently being implemented in Washington State in response to the BEACH Act which was passed by the US Congress in 2000 to create a uniform system to protect users of marine waters. The Departments of Ecology and Health implement the EPA funded program in collaboration with county health jurisdictions and volunteer organizations. This presentation will include a brief overview of the Program and an analysis of four years of beach results, focusing on beaches that have levels of enterococcus above background levels. Several factors are known to cause increases in enterococci in marine waters. These factors include proximity of known contamination sources, number of swimmers, freshwater input from streams and rivers, rainfall, and sediment type. The presentation will conclude with a few examples of how an increased level of bacteria at beaches has lead to remediation efforts.

Intrusion of Domoic Acid into Puget Sound, Washington State

Vera Trainer, NOAA/NMFS/NWFSC*
Aleta Erickson, Jamestown S'Klallam Tribe
William Cochlan, Romberg Tiburon Center for Environ Studies, SFSU
Brian Bill, NOAA Fisheries, Northwest Fisheries Science Center
Frank Cox, Washington State Department of Health
Jerry Borchert, Washington State Department of Health
Kathi Lefebvre, NOAA Fisheries, Northwest Fisheries Science Center

Several species of the toxigenic diatom Pseudo-nitzschia, together with low concentrations of domoic acid in shellfish have been observed in Puget Sound, Washington State, since 1991. However, only recently have high-density blooms of Pseudo-nitzschia forced the closure of recreational, commercial, and tribal subsistence shellfish harvesting in northern Puget Sound. Here we report on the environmental conditions associated with shellfish closures in two Puget Sound embayments during the closure events in Fall 2005. In Sequim Bay, shellfish harvest losses occurred on September 12 following the measurement of elevated macronutrient levels on September 2, and a bloom of P. pseudodelicatissima (up to 13 million cells per L) on September 9. Ambient NH4 concentrations >12 µM (measured on September 2) were due to anthropogenic inputs, likely from farm runoff and/or sewage inputs near Sequim Bay. The closure of a Penn Cove commercial shellfish farm on October 16 was caused by a bloom of P. australis that followed a period of sustained precipitation, elevated Skagit River flow, and persistent southeasterly winds. The relative importance of a number of environmental factors, including ocean temperature, stratification caused by rivers, and nutrient inputs, whether natural or anthropogenic, must be carefully studied in order to better understand the recent appearance of massive blooms of toxigenic Pseudo-nitzschia in Puget Sound.

Alexandrium Cysts in Puget Sound, Washington, USA

Cheryl Greengrove, University of Washington, Tacoma*
Rita Horner, Jim Postel, University of Washington, Seattle
Sian Davies-Vollum, Jim Gawel, University of Washington, Tacoma
Annie Cox, University of Rhode Island
Simone Hoffer, Washington State Department of Ecology
Kyle Sorensen, Jeff Hubert, Jonathan Neville, University of Washington, Tacoma
Bruce Frost, University of Washington, Seattle

Alexandrium catenella bloomed in central Puget Sound in late summer 2006. Toxin levels in blue mussels reached 17,000 ug/100g resulting shellfish closures (F. Cox, Washington Department of Health). Paralytic Shellfish Poisoning is often present in shellfish in Puget Sound, but little is known about the distribution and biology of either the motile cells or cysts of the major causative species, *A. catenella*. Our survey of 32 sites in March 2005 found cysts of *A. catenella* in surface sediments throughout Puget Sound. Sequim Bay with 200 cysts/ml sediment and Quartermaster Harbor with 12,000 cysts/ml sediment had the highest abundances; other areas ranged from <10 to about 100 cysts/ml. Sediment parameters–grain size, total organic carbon (TOC) content, and metal (Cu, Cd, Zn, As, and Pb) concentrations–were measured to evaluate correlations with cyst abundance. Initial results indicate that there is no correlation between grain size, TOC content or metal concentrations with cyst abundance. Cyst concentrations and 210Pb were measured in sediment cores from some sites to determine historical cyst presence. Cysts were present to the bottom of cores from Sequim Bay and Quartermaster Harbor in abundances consistent with surface sediment counts.

Climate Variability and Paralytic Shellfish Toxins in Puget Sound Shellfish

Stephanie K. Moore, Nathan J. Mantua, University of Washington*
Vera L. Trainer, NOAA Fisheries, Northwest Fisheries Science Center
Barbara M. Hickey, University of Washington

Long term observations of Paralytic Shellfish Toxins (PSTs) in Puget Sound shellfish from the WDoH Biotoxin Program are used as a proxy to describe bloom dynamics of the harmful dinoflagellate species *Alexandrium catenella* from 1957 to 2002. Observations are selected

for trend analyses based on the ability of the shellfish species to retain or depurate PSTs, frequency of observations at individual sites, and consideration of timescales of selected climate forcings. On seasonal to interannual timescales, Blue Mussels are used to identify "PSP hot spots" at Mystery Bay, Discovery Bay, Dockton and Sequim Bay. Hot spots are used to indicate exceptionally toxic events for case studies of preceding environmental conditions, and to develop annual indices of *A. catenella* bloom behavior for quantitative comparison with regional and large scale climate forcings. On longer timescales, PST accumulation in Sequim Bay Butter Clams covaries with warm phases of the Pacific Decadal Oscillation and the window of optimal growth conditions for *A. catenella* as determined by warm sea surface temperatures. Results from this study of observed climate influences on PSTs will be used to develop PSP risk forecasts at seasonal to interannual time scales, and to evaluate the potential influence of global warming on intensity and duration of future toxic events in Puget Sound. Recommendations are made for future monitoring of shellfish toxicity and environmental parameters to improve forecasting skill.

Session 3F: Governance in Transboundary Ecosystem Management I

Chair: Rod Dobell

The Forsaken Fjord: Science, Society, and Biological Decline in Puget Sound

Casimir Rice, University of Washington and NOAA Fisheries*

Today we see severe and expanding human influence throughout most of the Puget Sound landscape, and multiple, continuing signs of biological decline. At the same time, research and monitoring to understand, protect, and recover Puget Sound is a fragmented, uneven collection of efforts, surprisingly little of which considers Puget Sound in ecosystem and landscape contexts or focuses specifically on the biological effects of human activity. As a result, we have no comprehensive, coherent narrative of how the Puget System ecosystem works, how it has been affected by human activity, and what can and should be done to improve its condition. This presentation briefly reviews the history of environmental research, assessment, and monitoring in Puget Sound; considers the strengths and weaknesses of several historical, ongoing, and proposed efforts; and offers suggestions for improvement.

Economic Development in a Tribal Community: Opportunities and Challenges to Ecotourism in Neah Bay, WA

Morgan Schneidler, School of Marine Affairs, University of Washington*

Coastal communities in Washington State have historically been dependent on natural resource extraction to support and maintain social and economic health. During the past decades many costal communities have experienced economic recessions due to natural resource policies which have increasingly regulated harvest. In turn, tourism is being explored by many as a tool to diversify coastal economies. Ecotourism is of particular interest as a means of economic growth as it has to potential to preserve natural and cultural resources, educate tourists, and employ local people.

Native American tribes have unique obstacles to economic development which includes 150 years of oscillating federal and state policies. The Makah Tribe, located on the Northwest corner of the Olympic Peninsula in Washington State, is interested in improving the economic conditions on their reservation by expanding the tourism sector. Currently, the Makah Cultural and Research Center (MCRC), a Makah run non-profit is highly regarded for its leadership in teaching and preserving Makah culture. The MCRC is pursuing opportunities to expand their tourism function by sponsoring forms of coastal and marine ecotourism.

Using the Broker-Local-Tourist sociological model, this paper examines opportunities and challenges that concern ecotourism development on the Makah reservation. Findings emphasize the importance of defining appropriate sociocultural projects, and creating broker-broker partnerships.

Shared Decision Making Across S'aalh Tumuhw ("Our Land"): The Hul'qumi'num Approach Towards The Design of Shared Decision Making Over Land, Water and Natural Resources in Their Traditional Territory

Jess Rogers, Hul'qumi'num Treaty Group
Brian Olding, Consultant to the Hul'qumi'num Treaty Group*

The determination of how decisions are made about the use of resources across First Nation traditional territories lies at the heart of reconciliation between First Nations and other governments. The Hul'qumi'num Treaty group has been working to address this issue over the past two years. An interim strategic land use plan was completed to describe the vision of the Hul'qumi'num mustimuhw ("people") and how decisions are made about the use and protection of terrestrial and intertidal resources. An analysis of the state of particular resources (e.g. beaches, cultural heritage, rivers, fish, forestry and wildlife) was carried out to provide a status of well-being across the Hul'qumi'num tumuhw ("land"). The way in which the provincial government was organized to administer resource decisions across the territory was studied and evaluated on a sectoral basis. The key land struggles which have taken place in British Columbia over the past ten to fifteen years (Clayoquot Sound, Great Bear Rainforest, and Haida Gwaii) were studied in detail with a view towards identifying successful co-governance models for decision-making on land and resource uses. These studies provided the basis for the preliminary design of a Shared Decision Making Model between Hul'qumi'num governments and with the provincial government in particular. The Hul'qumi'num Treaty Group, with the six Hul'qumi'num Member First Nations, are working on developing the internal structure for how the six Hul'qumi'num Member First Nations will work together. The concept is to build the internal capacity of the six First Nations to make effective, efficient decisions collaboratively on land and resource decisions that affect their collective rights and title. It is envisioned this approach will prepare the Hul'qumi'num for inter-governmental discussions on Shared Decision Making across s'aalh tumuhw, working within the principle of Nutsa'maat ("working as one")

Collaborative Oceans Governance Arrangements in British Columbia

Jamie Alley, British Columbia Ministry of Environment*

Canada and British Columbia have had a variety of experiences over the past two decades in developing governance arrangements for oceans and coastal resources. Current governance arrangements range from formal, legal agreements between governments, to less formal and more inclusive arrangements among government and non-government parties. For the most part, these arrangements have evolved on an informal, ad-hoc basis to meet the needs of particular circumstances and initiatives. Recently however, more formal structures have evolved. For example, to ensure collaboration between Canada and British Columbia in the implementation of the federal Oceans Strategy, in September 2004, the two governments concluded the Canada-British Columbia Memorandum of Understanding Respecting the Implementation of Canada's Oceans Strategy on the Pacific Coast of Canada. The MOU provides for additional subsidiary agreements in six specific areas and on other matters that may be identified for future collaboration. To date, five sub-agreements are nearing completion, implementation plans are under development and joint funding agreements for specific projects have been concluded. This activity has also required the development of a more structured and disciplined approach to governance for shared policy development and joint program delivery.

This presentation describes existing institutional and organizational arrangements between Canada and British Columbia to ensure a

common understanding of what exists now, and as a contribution to the development of more permanent, practical, and effective governance arrangements for the future. An examination and analysis of existing institutional arrangements for managing coastal and marine resources will aid in the development of processes that ensure a shared vision between governments for sustainable oceans management, enhance cross-border cooperation and facilitate relationships between government and non-government parties.

Transboundary Aggregations as Learning Settings: Exploration of three Cases in the Salish Sea Watershed.

Henriette Bastrup-Birk, Catholic University of Leuven*

The presentation will outline research in progress aimimg at distilling insights useful to organizations engaged in transboundary aggregations dedicated to ecosystem and habitat restoration and stewardship. It will propose turning to the transformative learning perspective, coupled with a social learning model, social representation and multi-actor framing theory, to explore what learning processes and outcomes such settings may bring about. These outcomes may include inventive options for heeding ecological connectivity, increased acknowledgement of differences in perspectives among member organisations, greater capacity to deal constructively with such differences and a sense of collective responsibility. Closer scrutiny may disclose still other outcomes.

The transboundary aggregations proposed as showcases are the Puget Sound/Georgia Basin International Task Force, the International Orca Pass Stewardship Coalition and the Coast Salish Aboriginal Council. Comparative analysis will focus on the representations of the different member organisations north and south of the border regarding what to do together, how these representations evolve over time and in relation to each other and the extent to which different representations are acknowledged in joint statements, agreements or programmes.

Insights regarding overseen or underestimated outcomes of engaging in transboundary aggregations may spur active participation in existing settings or formation of new ones.

Session 4B: Northern Abalone Recovery

Chair: Don Rothaus

Changes in Abundance and Size of Pinto Abalone (*Haliotis kamtschatkana*) in the San Juan Archipelago (1979 to 2006)

Don Rothaus, Washington State Department of Fish and Wildlife*
Carolyn Friedman, Brent Vadopalas, University of Washington, School of Aquatic and Fishery Sciences

Pinto abalone (*Haliotis kamtschatkana*) populations in the San Juan Archipelago (SJA) have been monitored periodically by the Washington Department of Fish and Wildlife from 1979 through 2006. Alarming decadal changes in abundance and size frequency have been documented. A comparison between timed twenty minute dive surveys at 23 sites showed a roughly 50 % decrease in abalone from 1979 to 1991. In 1992 a new methodology was adopted using ten permanent index stations located throughout the SJA. These have been re-surveyed in 1994, 1996, 2003, 2004, 2005 and 2006. A decrease in total abundance occurred from 1992 to 1994 (n=351 to n=288). The fishery was closed shortly after the 1994 survey based on the continued declining trend. From 1992 to 2006 there has been a 77% reduction in abalone abundance at these index stations. A significant 10 mm right shift in mean size of abalone occurred during this same time period. Linear regression of abundance data predicts that these 10 sites will be extirpated by 2010. Literature suggests that sedentary invertebrates, such as abalone, must be at densities > 0.33-0.15 abalone/m2 for successful fertilization. Currently, all index stations have densities well below 0.15 abalone/m2. Abalone < 90 mm represent < 4 % of the individuals encountered in 2006. These data are indicative of "Allee Effect" response to low population densities. Both WDFW (in 1996) and NOAA Fisheries (in 2004) have listed pinto abalone as a "Species of Concern".

Northern Abalone and Engineering Species in the San Juan Islands: Implications for Restoration Strategies

Laura Rogers-Bennett, California Department of Fish and Game*
Brian Allen, Puget Sound Restoration Fund
Dan Rothaus, Washington Department of Fish and Wildlife

Northern abalone, *Haliotis kamtschatkana*, once common on subtidal rocky reefs may now be scarce in the San Juan Islands and throughout the Pacific Northwest. We compared the abundance of northern abalone today with data from 25 years ago in the San Juan Islands and northern California. In the San Juan Islands, we examined which habitat engineers were associated with the presence of adult northern abalone. Our results show that northern abalone have declined to critically low levels in the San Juan Islands and in northern California. Furthermore, no juvenile or small northern abalone (<75mm) were observed at any of the sites. Adult northern abalone were significantly more abundant at sites with kelp beds ($X2=18.8$, d.f.=2, $p=0.01$) compared with sites with sea urchin spine canopy. Abalone abundance was correlated with other mollusks including rock scallops and white cap limpets ($R2=0.542$, $F=9.52$, $p=0.01$). Reserve status of the site was a poor predictor of adult northern abalone and rock scallop abundance. The combination of no juvenile abalone coupled with low abundances of adults is indicative of recruitment failure and the need for aggressive conservation actions. Determining critical habitat features and associated species can guide future site selection for management and restoration efforts.

Early Life History Dynamics of the Pinto Abalone (*Haliotis Kamtschatkana*) in the San Juan Archipelago, Washington State

Joshua Bouma, Brent Vadopalas, Carolyn Friedman, University of Washington, Aquatic & Fishery Sciences*
Don Rothaus, Washington Department of Fish & Wildlife

Pinto abalone (*Haliotis kamtschatkana*) are in serious decline in Washington state, possibly due in part to Allee effects and recruitment failure. Sixty-six abalone recruitment modules (ARMs) deployed at three sites in the San Juan archipelago (SJI) and surveyed in situ six times over 26 months attracted only three juvenile abalone. Declines could also be attributed in the northern SJIs to elevated temperatures and lowered salinities observed from the Fraser River summer plume. To test this hypothesis, a 3x3 full factorial experiment was implemented to examine the influence of environmentally relevant temperature and salinity combinations on post-larval survival. By day three 100% mortality was observed in all 14psu treatment groups regardless of temperature. Mortalities in each of the remaining temperature/salinity combinations over the 14 day study were not significant. Based on these results, single-factor experiments were conducted in which post-larvae, veliger larvae, and trochophore larvae were challenged with a range of treatment salinities (14-32psu). 100% mortality was observed in all post-larval treatments below 23psu. Over 98% mortality of trochophore larvae was observed when exposed to salinities below 26psu, while larvae challenged as day three veligers showed greater tolerance of salinities between 23-26psu. These studies suggest early intolerance to salinities at or below 23psu, conditions that are often observed in the northern SJIs during summer months.

Evidence for a Cryptic Form of Abalone in Washington State, and Impact on the Census Size of Populations of Pinto Abalone in the Region

Kristina Straus, Lyndsay Newton, Robyn Estes Strenge, University of Washington*
Don Rothaus, Washington Department of Fish and Wildlife
Carolyn Friedman, Kerry Naish, University of Washington*

In Washington State, where fishery closures in the 1990s have failed to prevent the decline of pinto abalone, genetic analysis of the population structure of the species has direct relevance to its conservation. We extended the northern and southern ranges of a previous genetic survey, and detected minor differentiation between pinto populations. However, we noted that populations from the interior coasts (northern Puget Sound, Washington and Ketchikan, Alaska) were significantly different from those on the outer coast (British Columba and Sitka, Alaska). Population assignment methods discriminated a group of divergent individuals aggregated around South Long Island in northern Puget Sound. These individuals were morphologically indistinguishable from pinto abalone, and also occurred at lower frequency in samples throughout the species range. We further clarified the taxonomy of this newly identified form using maternally inherited mitochondrial DNA and reproductive proteins, and derived a full census of both forms of abalone in the region. To date, our results indicate that this form may be flat abalone, but the full range of phenotypic diversity and distribution in this species has not been previously recognized. Our findings have significant impact accuracy of population counts of pinto abalone, and highlight the reduced potential for recovery in this species.

Three Approaches to Out-Planting Hatchery-Reared Pinto Abalone (*Haliotis kamtschatkana*) British Columbia, Canada.

Robert Whyte, Pacific Trident Fishing C. Ltd.*
Dr. Dawn Renfrew

The Bamfield Huu-ay-aht Community Abalone Project has been conducting research on the out-planting of pinto abalone (*Haliotis kamtschatkana*) in Barkley Sound, B.C. Canada. BHCAP has taken a 3-pronged approach to out-planting young abalone: 1. larvae 2. 1-2 month-old juveniles, and 3. 1 year-old juveniles. Wild broodstock are collected from the field and conditioned for spawning in the hatchery. Larvae generated are raised for their 2-week planktonic phase and when competent for settlement, are either out-planted or set in the

hatchery. There are practical and biological advantages to out-planting very young animals. For larval out-planting, larval development is monitored and anatomical and behavioural characteristics indicate when they are approaching competence to settle. The larvae are counted and packaged for transport (up to 24 hours by land, sea or air). At the out-planting site, larvae are treated with GABA to trigger settlement, then put into wide-bore syringes with a dye marker, taken underwater by divers and released into crevices and spaces between rocks. Out-planting of 1-2 month old juveniles is done by settlement of the larvae onto concrete blocks contained in modules, in the hatchery. The modules are held for 1-2 months in the hatchery until the juveniles reach approximately 1 mm shell length. They are then transferred in totes of seawater, loaded onto the dive boat and placed on the sea bed by divers. The use of modules protects the fragile juveniles from handling damage, provides a refuge from predators for them in the field and increases the chance that out-plants will remain in the same location. Year-old juveniles were out-planted prior to their conversion to a kelp diet (prior to a subsequent change in shell colour in the hatchery). The juveniles are removed from hatchery plates, packaged for transport and placed on cleanly brushed substrate by divers. Since November 2003, BHCAP has out-planted 4 million larvae, 150,000 1-2 month old juveniles and 2000 year-old juveniles (8 mm mean shell length) at 3 sites. Baseline population surveys were conducted prior to out-planting and follow-up surveys will soon be completed to determine the success of the project.in British

Wild Brood-Stock Aggregations as a Recovery Tool for the Northern Abalone (*Haliotis Kamtschatkana*) in the Pacific Rim National Park Reserve of Canada, British Columbia.

Tomas Tomascik, Heather Holmes, Parks Canada*

One of the five key objectives of the National Recovery Strategy for the Northern abalone (*Haliotis kamtschatkana*) in British Columbia is to conduct research on rebuilding methods. The strategy prioritizes studies to assess the efficacy of wild abalone transplant aggregations (i.e., brood-stock aggregations) to enhance local spawning success and reproductive output. Abalone recruitment was studied at eight locations (each with two replicate stations) within the Broken Group Islands along a modeled current pathway in the fall of 2004 and the winter of 2005. The results suggest that wild brood-stock aggregations may be an effective rebuilding technique for Northern abalone. We found a significant inverse relationship ($r2 = 0.86$; $P < 0.001$) between recruit [i.e., shell length £ 30 mm] density and distance (km) from the brood-stock aggregation. A significant positive relationship ($r2 = 0.63$; $P < 0.02$) was also detected between recruit densities and the relative index of exposure. Potential effects of various habitat characteristics (e.g., abundance of competitors, predators, substrate type, etc.) are discussed. These results provide strong evidence for a downstream dispersion gradient of juvenile Northern abalone from a wild brood stock aggregation, and suggest that wild brood-stock aggregations may be a viable and cost effective rebuilding tool.

Federal Protection for Northern Abalone in the USA: Comparing and Contrasting the Process and Potential Outcomes of Species of Concern Versus ESA Listings

Scott Rumsey, NOAA/NMFS/NWFSC
Melissa Neuman, NOAA, National Marine Fisheries Service*

In 2004, the National Marine Fisheries Service (NMFS) established a Species of Concern (SOC) list for species about which NMFS has concerns regarding status and threats, but for which insufficient information is available to indicate a need to list under the Endangered Species Act (ESA). NMFS added northern abalone to the SOC list to promote research and proactive conservation efforts and potentially negate the need for ESA listing. Progress has been made to identify data deficiencies, stimulate cooperative research efforts, and foster voluntary efforts for providing stewardship. The scope of the SOC program is constrained, however, by limited funding opportunities and NMFS's inability to regulate activities that pose threats. If evidence suggests that an ESA listing is warranted, NMFS may consider initiating the listing process for a species. This process involves compiling the best available data, determining what constitutes a species, assessing extinction risk, and evaluating conservation efforts underway to determine if they mitigate extinction risk such that listing is not warranted. The goal of an ESA listing is to conserve and protect at risk species by prohibiting take and by ensuring that federal agencies do not jeopardize the continued existence of the species or adversely modify their habitat.

Developing a Sound Recovery Strategy for the First Endangered Marine Invertebrate, White Abalone (*Haliotis Sorenseni*)

Melissa Neuman, NOAA/NMFS/NWFSC*
John Butler, NOAA, National Marine Fisheries Service

White abalone, a deeper-water species inhabiting kelp forest habitats of the southern California and central Baja California coasts, became the first marine invertebrate to be added to the Endangered Species List in May 2001. Critical to developing a recovery plan for white abalone is better understanding the factors that led to its decline, improving estimates of abundance, gaining a better understanding of the species' life history, and refining the focus of future conservation efforts. A threats assessment revealed that the impact of fishery exploitation was likely the major cause for the species' decline. Recent surveys revealed that the total population size in the US may be higher than previously estimated because the amount of suitable habitat identified at these sites (3, 646 ha) is more than 10 times greater than previously estimated (202 ha). However, densities remain at least an order of magnitude lower (3-50 per ha) than pre-exploitation densities (479-2,300 per ha). Future recovery activities should focus on determining the critical densities required for successful spawning, the spatial scale over which recruitment dynamics are operating, and whether artificial enhancement may help in achieving the critical, scale-specific densities necessary for recovery and long-term viability of the species.

Session 4C: Seagrass Biology and Ecology

Chair: Sandy Wyllie-Escheverria

Lipid Biomarkers as Proxies of Past Eelgrass Abundance and Organic Matter Composition of Sediment in the Nearshore of Puget Sound, WA

Robert Rosenbauer, Eric Grossman, Renee Takesue, U.S. Geological Survey, Santa Cruz, CA*

The widespread loss of eelgrass in Puget Sound has ecological implications including loss of essential habitat for juvenile salmon. We developed and applied a multi-index technique using lipid biomarkers for investigating the paleo-occurrence of eelgrass to help determine whether these losses are naturally occurring or have been exacerbated by anthropogenic activities. Specific hydrocarbons, in particular C17 and C19 n-alkanes with an odd-over-even carbon number preference in combination with higher-plant sterols: stigmasterol, fl-sitosterol, and campesterol, are good indicators of eelgrass. Analyses of sediment cores from Westcott and Padilla Bays show variation in these compound concentrations downcore suggesting the biomass of eelgrass has varied over the past 150 years. This interpretation may be confounded by a C19 n-alkane derived from algae, and terrigenous plant sterols suggested by the presence of C27 and C29 n-alkanes. Algae, often but not always, can be identified by a bell-shaped pattern of n-alkanes, C20 and C25 highly branched isoprenoids, or sterols such as cholesterol, desmosterol, and brassicasterol. Compound specific isotope ratios may help resolve these interferences because *Z. marina* is a C3 plant with some C4 characteristics such as 13C-enriched n-alkanes. Measurements of ?13C for the C17, and C19 n-alkanes from leaves of *Z. marina* were

12â, in contrast with typical ranges of 18-22â for algae-derived n-alkanes and 20-27â for terrigenous-plant n-alkanes.

Variation in Floral and Seedling Development as Indicators of Seagrass Meadow Condition.

Loreen Allphin, Department of Plant and Animal Sciences, Brigham Young University*
W. Judson Kenworthy, Center for Fisheries and Habitat Research, NCCOS, NOS, NOAA

Whereas the condition of seagrass meadows is often linked to variation in the density of sterile shoots, even though these plants flower rarely is floral development, seed viability or the potential of seedling recruitment considered as indicator of the status and health of the meadow. Using field-collected samples and laboratory experiments we describe the potential of these biotic processes as potential indicators of meadow condition. In 2006 floral development after fertilization was assessed at eight sites throughout the range of *Zostera marina* (eelgrass) within the continental United States. Laboratory experiments, with seeds collected in 2005, were designed to test germination frequency and seedling development of individual seeds from three sites in the San Juan Archipelago in Washington State. Results from the floral condition study indicate differences in seed set due to variation in the rate of abortion among developing seeds across the study populations. We also found significant differences for seed/ovule ratios between sites and habit (perennial vs. annual). Moreover results from laboratory experiments revealed significant differences in germination rates, seedling development and condition of seeds remaining in the sediment. This study demonstrates the importance of factoring sexual reproduction data into programs designed to assess the condition of seagrass meadows.

Population Status of the Seagrass Zostera Marina in the San Juan Archipelago

Ginger Shoemaker, Sandy Wyllie-Echeverria, University of Washington, Seattle*
Victoria Wyllie-Echeverria, University of Victoria

Zostera marina meadows in the San Juan Archipelago contribute to nearshore biodiversity and productivity and are protected by a no-net-loss policy in Washington State. In 2003/04, retrospective analysis, using historical aerial photos revealed substantial losses had occurred within several small embayments. As a consequence a monitoring study was initiated in 2005 to track population status within the shallow subtidal region at 11 sites as part of a larger project to determine causative factors of population decline. All sites were re-sampled in 2006. At each site, shoot densities, flowering frequency, rhizome internode lengths, sediment grain size and percent organic matter were sampled. In addition, during 2005, leaf tissue was collected and archived for genetic analysis. Shoot density and flowering frequency increased in 2006 but leaf length appeared to correlate more closely with stress level as measured by sediment grain size than with the year. In addition to providing baseline information at the site level, these results can be used to interpret results of genetic analysis. Project objectives are to provide baseline ecological information to guide restoration efforts once factors in decline are known. We demonstrate the value of monitoring at the site level for species under threat in the Salish Sea.

Fish Assemblages Found in Eelgrass Meadows (*Zostera marina*) of the New Gulf Islands National Park Reserve of Canada

Cliff Robinson, Guy Martel, Parks Canada*

The Gulf Islands National Park Reserve of Canada (GINPRC) encompasses about 35 km2 of near shore marine ecosystems within its boundaries. There are many ecosystems in GINPRC that will require monitoring to ensure for the conservation of ecological integrity. However, one ecosystem in particular, namely eelgrass (*Zostera marina*), is arguably the most productive and sensitive to a wide variety of land-use and marine activities. In this talk, we present results from an assessment of eelgrass properties, environmental conditions and fish assemblages collected at 16 eelgrass beds during August 2004-2006. Overall, we conclude that fish assemblages in eelgrass beds in the southern Gulf Islands tend to be in relatively poor health compared to other Parks Canada regions on the west coast of British Columbia. We discuss some possible reasons for the observed poor health in the fish assemblages.

Assessing the Ecological Connectivity of Eelgrass Habitats and Protected Areas: a Tail of the Population Structure of the Eastern Pacific Bay Pipefish, *Syngnathus Leptorhynchus*.

Ramona de Graaf, Eric Taylor, University of British Columbia*

Populations require a network of interconnected habitats to maintain biological processes such as reproduction. Defining the spatial scale and patterns of exchange among interbreeding groups is critical to establish breeding units and population boundaries. Investigating genetic connectivity (dispersal) of individuals among habitat patches is an effective way to measure these population parameters and assess the ability of protected areas to maintain population processes.

Eelgrass habitats play a critical role for nearshore and offshore marine ecosystems as nurseries, spawning habitats, and as habitat for resident species. Locally, significant losses of eelgrass habitat have been documented and ultimately these losses will affect ecological function and species diversity. Monitoring eelgrass habitat function can be achieved by studying populations of such eelgrass specialists as the eastern Pacific bay pipefish, *Syngnathus leptorhynchus*.

My masters' research focuses on measuring the ecological connectivity of eelgrass beds by investigating the genetic population structure of *Syngnathus leptorhynchus* in Barkley Sound, British Columbia. I will present my findings of pipefish population boundaries and breeding units. This will include an assessment of the degree of connectivity (gene flow) of the bay pipefish within and outside of a de facto marine reserve, the Broken Group Islands, Pacific Rim National Park Reserve of Canada. The influence of seascape features on gene flow will also be discussed.

Panel 4D: The San Juan County Marine Stewardship Area: A Local Approach to Ecosystem-Based Management

Chair: Jody Kennedy

Located at the convergence of Puget Sound and Georgia Basin, the San Juan archipelago is characterized by its rich diversity of marine life and is one of the best functioning marine systems in Puget Sound. In response to regional population pressures and declining health of local marine species, County Commissioners declared the county a Marine Stewardship Area and tasked the local Marine Resources Committee (MRC) with identifying voluntary and regulatory management measures that would protect and restore the marine ecosystem for the needs of wildlife and humans. In partnership with the Northwest Straits Commission and The Nature Conservancy, the MRC engaged scientists, managers, citizens and stakeholders in a strategic conservation planning process, adapting The Nature Conservancy's site-based conservation action planning approach. The outcome is a list of conservation strategies upon which to base actions, measurable benchmarks and research priorities. To be effective, the plan will require a coordinated effort of local, state, federal and tribal managers, the science community, stakeholders, and citizens who reside and vacation in the San Juan Islands. Panelists will describe this local approach to Ecosystem-based Management, the resulting strategies and the necessary next steps for successful implementation.

Facilitator: Jody Kennedy, Surfrider Foundation

Panel Members:

- *Kevin Ranker, San Juan County Council*
- *Jacques White, The Nature Conservancy*
- *Ginny Broadhurst, Northwest Straits Commission*
- *Kit Rawson, Tulalip Tribes, San Juan County Marine Resources Committee*

Panel 4E: PCBs and PBDEs in the Strait of Georgia Ecosystem

Chairs: Patrick Shaw and Peter Ross

Concerns about legacy contaminants in marine organisms in Puget Sound and the Strait of Georgia were focussed with the discovery of harmful levels of PCBs and elevated levels of PBDEs in resident killer whales. Since 2004 a multiagency effort has been underway, with funding from Environment Canada's Georgia Basin Action Plan, to look at sources and fate of these contaminants in the Strait of Georgia, and making progress on modelling their movement in the environment.

Panel Members:

- *Peter Ross, Fisheries and Oceans Canada*
- *Patrick Shaw, Environment, Canada*
- *Sophia Johannessen, Fisheries and Oceans Canada*
- *Robie Macdonald, Fisheries and Oceans Canada*
- *Mike Sanborne, UMA Engineering Ltd.*
- *Frank Gobas, Simon Fraser University*

Towards an Understanding of Sources, Fate and Effects of PCBs and PBDEs in the Strait of Georgia Ecosystem

Patrick Shaw, Environment Canada
Peter Ross, Sophia Johannessen, Robie Macdonald, Department of Fisheries and Oceans Canada
Frank Gobas, Simon Fraser University

While PCB levels worldwide have declined with regulatory action and restriction in use, their legacy persists in biota within the Strait of Georgia and Puget Sound ecosystem. This was evident when it was discovered that the transboundary southern resident killer whales were "the most PCB-contaminated marine mammals in the world". Subsequently, related studies have shown elevated levels of brominated flame retardants, polybrominated diphenyl ethers (PBDEs) in both local seals and killer whales. A 2004 SETAC workshop at Friday Harbor Marine Laboratory was convened to develop plans for a PCB modelling effort in Georgia basin and Puget Sound. Efforts since then have led to an increased understanding of PCBs and related contaminants in this region. Funding through the Georgia Basin Action Plan was made available in 2004 to study this issue in the Strait of Georgia. Partnering with multiple agencies, including Environment Canada, Fisheries and Oceans Canada, Simon Fraser University, Greater Vancouver Regional District and Capital Regional District, has generated new understanding of the loadings, history and fate of these contaminants in the Strait. This presentation will describe the genesis of the project and the activities presently underway.

The Long Reach of PCBs and PBDEs in the Georgia Basin: What are Blue Mussels Telling us?

Mike Sanborn, Institute of Ocean Sciences
Pat Shaw, Environment Canada
Mark Yunker
Peter Ross, Institute of Ocean Sciences. Fisheries and Oceans Canada

Blue mussels (*Mytilus sp.*) are sessile, filter-feeding shellfish that sample the water column for environmental contaminants. We measured congener-specific PCBs and PBDEs in pooled mussel samples that were collected from 22 sites around the Georgia Basin. Sample sites were selected to 1) generate a spatial overview of contamination of the Georgia Basin by banned PCBs and by currently used PBDEs; and 2) comprise nearshore areas adjacent to major human use categories, including urban, agricultural, industrial, and remote locations. Total PCB concentrations in blue mussels range from 62 – 5472 ng/g wet weight, and were dominated by the penta- and hexa- congeners. Total PBDE concentrations ranged from 32 – 1234 ng/g wet weight, and were dominated by BDE-47 and BDE-99 (accounting for ~70% of the total PBDE concentrations). Principal components analysis (PCA) of the PCB and PBDE data revealed little inter-site variation, indicating that PCBs and PBDEs in the Georgia Basin may be largely influenced by broad regional signals rather than discreet point sources associated with particular activities. Deca-BDE was detected in 100% of tissue samples, indicating its bioavailability to the marine food web. Blue mussels are a keystone species in the marine foodweb of the Georgia Strait. Increasing concentrations in this organism of currently used Persistent Organic Pollutants (POPs), such as PBDEs, may be an important barometer of future trends in the contamination of higher trophic level organisms.

What are Harbour Seals Telling us About PCBs and PBDEs in the Georgia Basin Food Web?

Peter Ross, Fisheries and Oceans Canada
Donna Cullon, University of Victoria
John Calambokidis, Cascadia Research
Neil Dangerfield, Fisheries and Oceans Canada
Steven Jeffries, Washington Department of Fish and Wildlife

As high trophic level, non-migratory mammals, harbour seals can provide an integrated measure of aquatic food web contamination by persistent organic pollutants (POPs) in coastal regions. Our spatial research indicates that Puget Sound harbour seals are highly contaminated with ëlegacy' PCBs compared to Georgia Basin seals. However, while the levels of unregulated PBDEs are higher in Puget Sound harbour seals compared to their Georgia Basin counterparts, differences are less pronounced than for the PCBs (2x higher for PBDEs compared to 7x higher for banned PCBs), likely reflecting widespread current use of PBDEs in both BC and Washington. Harbour seal ëfood baskets' indicate that PBDEs are now the 2nd and 3rd ranked POP by concentration in Puget Sound and Georgia Basin, respectively. Studies using stable carbon and nitrogen isotope ratios reveal that PBDEs are accumulating more slowly in the harbour seal food web, possibly reflecting current use, rapid contamination of shorter-lived organisms at the bottom of the food web, and/or the larger molecular size of PBDEs relative to PCBs, which may impede trophic transfer. However, the exponential increase of PBDEs in the region's harbour seals over the past two decades underscores the emergence of a new conservation threat at the top of the coastal food web.

A Comparison of PCBs and PBDEs in Strait of Georgia Sediments

Sophia Johannessen, Fisheries and Oceans Canada
Robie Macdonald, Fisheries and Oceans Canada
Cynthia Wright, Contractor
Albert van Roodselaar, Greater Vancouver Regional District

PCBs are relict contaminants in coastal British Columbia, while PBDEs are in increasing use. Both classes of chemical are highly particle active, so coastal sediments provide a useful archive of their historical and current deposition. In Strait of Georgia sediments, PBDE congeners 47, 99, 100 and 209 predominate, as has been observed in local biota. The concentration of BDE-209 is generally at least two orders of magnitude higher than that of the others. Using seven sediment cores collected in the Strait of Georgia, we demonstrate how local sediment accumulation and mixing rates affect the observed surface concentrations of these contaminants. We discuss local pathways of PCBs and PBDEs and compare their distribution, depositional history, and likely future trends.

Mass Balance Model of the Movement of Toxic Contaminants in the Georgia Basin Food-Web

Frank Gobas, Colm Condon, Diego Natale, Simon Fraser University
Peter Ross, Deprtment of Fisheries and Oceans

As part of the Georgia Basin Modeling Initiative and related initiatives in BC to improve the management of toxic chemicals in Vancouver Harbour and the Straight of Georgia, we have conducted field studies and mass balance modeling studies to better understand the movement of potentially toxic contaminants in the Georgia Basin food-web. The need for the study arose as a result of observations that showed that concentrations of PCBs and other contaminants in Killer whales of the Georgia Basin are among the highest concentrations observed worldwide. It is expected that current concentrations of several contaminants are sufficiently high to cause adverse effects in certain upper-trophic level mammals. To address this problem and work towards solutions to reduce contaminant concentrations in the GB food-web we have developed a preliminary model of the food-web transfer of PCBs in the Georgia Basin food-web. The results show that current environmental quality criteria for the protection of aquatic life are not able to protect higher trophic level species from the adverse effects of PCBs and possibly other bioaccumulative contaminants. Model results are generally consistent with PCB measurements in free-ranging Harbour seals, although some variation in patterns and among sites is evident. A strategy for developing environmental quality criteria for bioaccumulative substances that are protective of upper trophic level species in the GB food-chain is proposed and the application of mass balance models to improve environmental quality of existing substances and chemicals of emerging concern are discussed.

A Preliminary Mass Balance for Selected PCB and PBDE Congeners in the Strait of Georgia

Robie Macdonald, Fisheries and Oceans Canada
Brenda Burd, Research Associate, Institute of Ocean Sciences
Niel Dangerfield, Department of Fisheries and Oceans
Sophia Johannessen, Department of Fisheries and Oceans
Peter Ross, Department of Fisheries and Oceans
Patrick Shaw, Environment Canada
Albert van Roodselaar, Greater Vancouver Regional District
Cynthia Wright, Contractor

During the past several years, we have collected data for PCB and PBDE congeners from media in the Strait of Georgia including water, sediments and air. Additional measurements have been made of organochlorine composition in municipal effluent entering the Strait of Georgia. Using these data together with dated sediment core profiles, and building on a budget for sediment and organic carbon in the Strait of Georgia, we will present a first estimate of budgetary components for these contaminants with the intent of establishing the dominant regional controls for PCB/PBDE cycling within this system.

Session 4F: Governance in Transboundary Ecosystem Management II

Chair: Erik Karlsen

Collaborative Planning as a Catalyst for Transboundary Environmental Governance

James Carruthers, University of British Columbia*

International/transboundary environmental issues are increasing and governance regimes are inadequate to deal with them. Governance dimensions comprise: international/transnational; state/substate; market-economy; civil society; and individual agency. Collaborative planning is proposed to enhance governance response to international transboundary environmental issues, and existing Georgia Basin/Puget Sound (GB/PS) international/transnational environmental governance regimes are examined to illustrate this potential.
Three shortcomings of international/transnational regimes are: (1) lack of horizontal and (2) vertical coordination between regimes, and (3) lack of internal consensus within, and enforceability of regimes. A conceptual transboundary collaborative planning environmental governance framework is formulated and applied to actual GB/PS governance regimes, confirming that the three shortcomings exist and reduce regime effectiveness, and that North American regional transboundary governance regimes tend to be single-issue and spatially flow-oriented. Minimal scope and depth is exhibited by GB/PS transboundary institutions and individual agents are impeded by lack of institutional leverage. The conceptual framework lacks some necessary attributes and is corrected. Recommendations are proposed for using collaborative planning to improve GB/PS international/transnational governance and for further research. Contribution to collaborative planning knowledge is made by showing that collaborative planning can address international and transboundary environmental issues.

Environmental Governance in Georgia Basin/Puget Sound: the Roles of Tribes and First Nations

Sara Singleton, Garrett Bouldin, Western Washington University*

The project analyzes the effect of the expanding role of First Nations/Native American tribes in environmental and natural resource planning processes affecting transboundary environmental resources and problems. A primary goal of the study is to provide managers on both sides of the border with a better understanding of the constraints within which each operates in terms of the obligations and opportunities created by aboriginal treaties and/or treaty negotiations. The project looks at how management responsibilities are shared among tribal/nontribal managers, including the differences/similarities on either side of the border; and how the inclusion of tribes/first nations is affecting other collaborative planning processes organized by federal and state/provincial managers. The project focuses on current processes to plan and implement marine protected areas (MPAs) in and around the Puget Sound/Georgia Strait transboundary marine zone.

Lessons in Accountability and Governance of Large-Scale Ecosystem Recovery Efforts

Kathy Fletcher, People For Puget Sound*

The US General Accountability Office has been severely critical of large-scale ecosystem recovery efforts in Chesapeake Bay, the Everglades and the Great Lakes, because of lack of accountability for results and the absence of effective governance structures. This issue was (will be) explored by representatives of GAO, the Great Lakes, the Gulf of Mexico and San Francisco Bay at the Restore America's Estuaries national conference in December 2006 in a panel (to be) moderated by the author. What can we learn from these discussions, and how can we apply the lessons learned to Puget Sound?

The International Watersheds Initiative

Commissioner Irene Brooks, International Joint Commission*

Population growth and urbanization, climate change, and changing uses of water put new stresses on watersheds. These, along with pollution from both air and from land uses, and exotic species Population growth and urbanization, climate change, and changing uses of water put new stresses on watersheds. These, along with pollution from both air and from land uses, and exotic species introductions bring a continued and growing threat to water supply and quality, habitat, and biological diversity within watersheds. To better meet these challenges in the boundary waters shared by both the United States and Canada, the International Joint Commission (IJC), in its 1997 publication entitled The IJC and the 21st Century, proposed the creation of international watershed boards. The IJC is a binational Canada-U.S. organization created by the Boundary Waters Treaty of 1909, and is independent of the Canadian and U.S. Governments. With its successful history and over twenty binational boards and task forces active in boundary waters from the Pacific to the Atlantic, the IJC is in a unique position to transform some in various basins into eco-system based

watershed boards. Such boards would adopt an integrative, ecosystem approach to transboundary water issues, involve local interests, and build local capacity at the watershed level. They would offer a proven means for dealing with situations of asymmetrical governance in the two countries and an improved mechanism for avoiding and resolving transboundary disputes. In 1999, the governments gave a reference to the IJC to advance the concept. In reporting on its further development of the concept, and progress on the development of watershed capacity, the IJC published Transboundary Watersheds in December 2000 and A discussion paper on the International Watersheds Initiative: Second report to the governments of Canada and the United States in June 2005. The presentation will also cover progressive steps of the international watersheds initiative, particularly in the St. Croix, Red, and Rainy River watersheds.

Tides of Change: Place Meanings and Social Ecological Systems in the Broughton Archipelago

Matthew Bowes, University of Victoria*

Understanding the concepts of "place" can enable natural resource managers to interpret more clearly the relationships people have to the land. However, inclusion of "place" in the dominantly technical milieu of planning often poses interesting problems in appropriate and sensitive representation.

In this qualitative study conducted in the Broughton Archipelago near the north eastern tip of Vancouver Island, map-based interviews enabled narrative data to spatially represent sense of place or landscape meanings and values. This technique created a perceptive and creative medium for the elicitation of landscape values which revealed socioeconomic and environmental transformation.

As the greater story of place meanings in the Broughton Archipelago unfolded as salmon emerged as a symbol of the cultural landscape, ecology and economy of the Broughton Archipelago. Moreover, salmon surfaced as a metaphor for traditional rural livelihoods and a way of life but also for globalization and its processes. Such symbols become more important when threatened and the consequences of the loss of salmon challenge the resiliency of a complex social ecological system in the Broughton Archipelago. A call for adaptive management emphasizes feedback from the environment and the state of the resource through social and ecological memory over time to develop policy. Moreover, social networks that inform each other from a wide range of local and international governance create an overall adaptive governance system.

Estuaries, and the Entire History and Future of Humans on Earth

David Henry, Padilla Bay National Estuarine Research Reserve*

Estuaries have been the gathering spot for human civilizations for 9,000 years. Will they continue to be? The historical use of estuaries by humans is traced through time to present day estuary megacities. A review is given of human impacts to estuaries and scenarios for the future, including solutions for the present situation.

Session 5A: Point Source Pollution: Outfalls

Chair: Christianne Wilhelmson

Siting a New Wastewater Treatment Facility Marine Outfall: a Comprehensive, Ten-Year Study

Scott Mickelson, King County Marine and Sediment Assessment Group*

Population growth in King County necessitated planning a new wastewater treatment plant with a marine outfall to Puget Sound. The County undertook a ten-year program of studies designed both to appropriately locate the marine outfall and to meet outfall lease and permit requirements.

Field studies began in 1998 to evaluate potential sites for the outfall. Physical oceanography studies included deployment of current meters, drift cards, and drogues, along with fluorescent dye releases. Submarine geophysical studies included sidescan sonar, sub-bottom profiling, high-resolution seismic reflection, and precision bathymetric mapping. Nearshore and offshore water quality studies included analysis of microbiological, conventional, metal, and organic parameters. Offshore water-column profiling also included a primary productivity study. Nearshore habitat studies included vegetation and substrate mapping with sidescan sonar and videography, along with biota surveys of geoducks, spot prawns, and forage fish.

Information from these studies was used in the project environmental impact statement and the site selection process. The final outfall site was chosen in December 2003, at Point Wells on the King/Snohomish county line.

Baseline studies performed to meet outfall lease and permit requirements included sediment characterization at the outfall diffuser, nearshore benthic infauna characterization at the outfall construction trench, an intertidal biota survey, an eelgrass survey, a Dungeness crab survey, and water column monitoring.

Estimating the Impacts of Domestic Discharges to the Ocean - A Case Study from Indian Arm

Ian Dyck, M.Sc., P.Eng., WorelyParsons Komex*
Stephen Pond, Ph.D., University of British Columbia
Don Dunbar, Ph.D., Lorax Environmental Services Ltd.
Alexi Zawadzki, M.E.S., WorleyParsons Komex
Jay McNee, Ph.D., Lorax Environmental Services Ltd.
Peter Howland, B.Sc., WorleyParsons Komex

Indian Arm is a small fjord connected to Burrard Inlet which enters the Strait of Georgia; together they are Vancouver Harbour. A study to investigate the discharge of domestic wastewater into Indian Arm was initiated by the Vancouver Port Authority, the agency responsible for discharge of effluent into the Harbour. Funding for the study was provided by the Burrard Inlet Environmental Action Program. The study included hydrologic, sediment and nutrient loading assessments, combined with modelling to assess potential impact and mitigation of future effluent loading. Existing discharge was estimated at 64 homes discharging 95 m3/day and a future worst case discharge scenario was estimated at 233 homes discharging 380 m3/day. Hydrologic analyses indicated that the 380 m3/day represents <0.06% of 100-year dry weather freshwater inputs to Indian Arm. Annual effluent sediment was estimated to be <0.03% of natural sediment. For worst case nutrient inputs, domestic effluent would account for 5.4% of nitrate and 8.7% of phosphate inputs to the surface layer. A 2-D (vertical and along channel) model of Arm circulation and a local dilution model were used for a range of discharge scenarios. There is little potential for accumulation of wastewater constituents within Indian Arm, provided outfalls discharge at 10 m depth.

Linked Biotic/Geochemical Indicators of Organic Enrichment: Case study Using a Ubiquitous Bivalve

Albert van Roodselaar, Greater Vancouver Regional District
Brenda Burd, Ecostat Research Ltd*

The observation of certain shell staining patterns for a small ubiquitous bivalve in the southern Strait of Georgia can be directly related to sediment geochemical changes due to organic enrichment. The relationship depends on background levels of certain redox metals as well. The distribution of shell staining types responds in a somewhat sporadic manner until a threshold level of geochemical change (as measured by AVS) is reached, beyond which the change is rapid and dramatic. The staining patterns are different in scale for adults and sub-adults.

The shell staining may be a useful indicator of temporal patterns of geochemical conditions over the lifespan of the bivalves. However, the usefulness of this shell indicator would be greatly enhanced by the concurrent understanding of the tolerance of the species to varying levels of organic enrichment. This is discussed in context with other

important habitat constraints using multi-year data from ambient and outfall monitoring programs from the southern Strait of Georgia.

Subtidal Benthos of the Southern Strait of Georgia in Relation to Natural and Anthropogenic Particulate Seidmentation, Transport and Burial

Brenda Burd, Robie Macdonald, Sophia Johannessen, Institute of Ocean Sciences*
Phillip Hill, Natural Resources Canada

Data on the soft-bottom communities of the southern Strait of Georgia has been accumulating from various studies and monitoring programs over the past 25 years. These data have been collated into a database cross-linked using a taxonomic coding system developed for BC. As part of the GVRD/DFO/NRCan collaborative Ambient Monitoring program for the Strait, biotic patterns will be assessed in relation to mass balance models of organic and inorganic cycling, sedimentation and burial in the strait, as well as patterns of contaminant distributions.

As part of this exercise, the relative importance to the biota of the major drivers in the sedimentary ecosystem will be discussed, including; the Fraser River; ocean dumping; outfalls; multiple discharge sources in Burrard Inlet; unquantifiable potential hazards such as bottom trawling or dredging, methane seeps, slope failures, etc.

Session 5B: Marine Debris Removal Programs in Washington

Chair: Ginny Broadhurst

A Tool for Local Agencies: the Derelict Vessel Removal Program

Melissa Montgomery, Sarah Dzinbal, Washington State Department of Natural Resources*

Abandoned and derelict vessels often pose hazards to navigation, detract from the aesthetics of our waterways and threaten the environment with the potential release of hazardous materials. The 2002 Legislature passed the Derelict Vessel Act, which provided the basis for the Derelict Vessel Removal Program. Administered by the Washington Department of Natural Resources, this program provides local and certain state government entities with the authority and funding to resolve derelict and abandoned vessel issues within their jurisdictions. The program is funded primarily by a $2 fee on recreational vessel licensing. Since the program's inception, approximately 200 vessels have been successfully removed.

The derelict vessel statutes (RCW 79.100) authorize certain entities to take temporary possession of vessels in danger of sinking or breaking up and therefore allow vessel removal in collaboration with emergency response by Ecology and the US Coast Guard.

The 2006 Legislature improved the derelict vessel statutes by making it a misdemeanor to cause a boat to become derelict or abandoned and by allowing vessel owners to request a hearing to challenge a custody decision. Though challenges still remain, this program is a useful tool that agencies can use to resolve derelict vessel issues.

Survey and Removal of Creosote Debris from the Northwest Straits

Lisa Kaufman, Washington State Department of Natural Resources*
Ginny Broadhurst, Northwest Straits Commission

The Washington Department of Natural Resources (DNR) and Northwest Straits Commission (NWSC) are working to remove creosote and other treated wood debris from beaches throughout the Northwest Straits.

Wood debris naturally occurs on beaches throughout the Northwest Straits region. A significant portion of this debris however, comes from derelict piers, docks and other structures and is heavily laden with creosote. Creosote contains several hundred chemicals, many of which are known to be hazardous. Creosote wood debris exposed to the sun and elements on the shoreline is potentially harmful to forage fish and other marine life that utilize the beach for spawning.

Initial field surveys showed approximately 20-30% of accumulated wood debris at some sites was treated with creosote. Further surveys and removal operations have produced data on actual tonnage of creosote and other treated wood debris at levels above initial estimates. Maps are being produced that illustrate different accumulations at different sites.

Since 2002, this partnership has removed over 600 tons of contaminated materials from shorelines in a highly cost effective manner. Surveys utilized trained volunteers and collected data on GPS units. Removal operations employ work crews and either barges or helicopters to transport wood to disposal containers. DNR is also removing creosote pilings throughout Puget Sound in order to eliminate a major source of this marine debris.

The Impacts of Derelict Fishing Gear to Species and Habitats in Puget Sound

Ginny Broadhurst, Northwest Straits Commission*
Jeff June, Natural Resources Consultants

The Northwest Straits Initiative developed a derelict fishing gear survey and removal program in Puget Sound with funding from Federal, Tribal, State, and local governments and private foundations. Initial accomplishments included establishing protocols for safe gear removal and a reporting system for fishermen and the public to report lost gear. Over the past few years the program has focused on removing gear and quantifying the impacts that derelict is having to the Puget Sound ecosystem. During173 days of removal effort, divers have removed 461 derelict nets covering 94 acres of habitat and containing 13 dead marine mammals, 111 dead seabirds, 779 live and dead fish and 4,971 live and dead invertebrates. Of 1,179 derelict crab and shrimp pots removed, 39% were still actively fishing and contained 1,690 live and 334 dead crab and other animals. These numbers provide just a snapshot in time of the species being harmed by derelict gear. New methods to genetically identify bones are providing improved understanding of which bird species are most impacted by derelict nets. In addition to entangling animals, derelict nets and pots frequently smother and degrade the marine habitats in which they were found and pose safety threats to humans.

Out of Sight, Out of Mind: Derelict Fishing Gear and its Impacts on Marine Fauna of the Puget Sound-Georgia Strait Basin

Thomas Good, NOAA/NMFS/NWFSC*
Jeffrey June, Natural Resource Consultants, Inc.
Mike Etnier, Applied Osteology

Derelict fishing gear–lost or abandoned commercial and recreational fishing nets, lines, pots, and traps that sit or float underwater–can remain in the marine environment for years. Unseen and thus largely unquantified, this type of marine debris can trap and kill a variety of marine organisms. Recovery and removal of derelict gillnets and crab pots and traps from Puget Sound and the Straits of Georgia and Juan de Fuca since 2002 has enabled us to document the capture and mortality of marine taxa. Specimens collected during gear recovery are identified to the lowest possible taxon and enumerated: as nets are hauled onboard; during laboratory dissections; and/or using osteological characters for skulls and post-cranial material. The proportion of organisms found dead varied among taxa: marine mammals (100%); birds (100%); fishes (25%); and invertebrates (15%). To explore the risk to marine fauna posed by derelict gear throughout the region, we are investigating the influence of gear location, habitat type, water depth, net type, vintage, length, height, and fishing ability of derelict gillnets on the number, identity and disposition (alive or dead) of marine organisms found in recovered derelict gear. Derelict gear recovery from hotspots

for marine fauna (MPAs, haul-out sites, wildlife refugres) as well as genetic analyses of bones will refine analyses to estimate the impact of derelict gear mortality for regional marine taxa as well as species of conservation concern.

Session 5D: Dynamics of Garry Oak Plant Communities

Chair: Wayne Erickson

Origins and Sustainability of San Juan Archipelago Garry Oak Populations

Madrona Murphy, Russel Barsh, KWIAHT*

Despite the growing interest in "releasing" older Garry oaks in the San Juan Archipelago using clearing and prescribed burns, our understanding of their history and ecology has been based on assumptions from other oak populations in the western U.S. It is widely perceived that oak-dotted grasslands preceded Douglas fir forests in the San Juans, either "naturally" or as a result of fire-stick management by Coast Salish peoples, and will regenerate if "released" from the surrounding firs. Studies of regional pollen records, and our comparative studies of contemporary oak groves on Waldron, San Juan, Orcas and Samish Islands raise questions about these assumptions. Oak abundance has declined in the region for millennia; while Coast Salish people may have encouraged groves in the past, today's island populations have been influenced more by 19th century logging and planting. Releasing older oaks does not address the issue of recruitment in an archipelago lacking in most caching animals. Without a focus on recruitment recommendations have also ignored the growing abundance and diversity of oak parasites, which has attracted attention on Vancouver Island. Other important endemic trees, e.g. cedars and arbutus, historically formed a larger part of the islands' landscapes, but their decline attracts less attention.

The Role of Local Environmental Conditions and Landscape Context in Determining Plant Diversity In Garry Oak Ecosystems on Southeastern Vancouver Island

Patrick Lilley, Mark Vellend, University of British Columbia*

Throughout the Georgia Basin Puget Sound region, human land use patterns are converting natural ecosystems to fragmented networks of habitat patches. On southeastern Vancouver Island, the endangered Garry oak (*Quercus garryana*) ecosystem has been fragmented by urban development, agriculture and forestry such that less than 1-5% of the ecosystem remains in a near-natural state. Many of the remaining patches of Garry oak ecosystem exist as ëhabitat islands' in parks and protected areas. These habitat patches are crucial reservoirs for the high plant species diversity characteristic of this ecosystem. However, patches vary substantially in their local environmental conditions as well as their size and position within the surrounding landscape. Designing effective policies to conserve species can benefit from a thorough understanding of how environmental characteristics and landscape context influence species distributions and diversity.

We surveyed plant community composition and diversity in 43 Garry oak habitat patches that vary in their topography, tree cover, soil conditions, area and connectivity to assess the relative importance of these factors in influencing plant distributions and diversity patterns. The resulting analysis provides a framework to assess the value of existing protected sites, prioritize new sites for protection, and generate new hypotheses for future experimental work on factors that control plant populations and community dynamics.

Invading Geese Facilitate Invading Grasses in Canada's Gulf Islands National Park Reserve

Rebecca Best, Peter Arcese, University of British Columbia*

Non-native Canada geese have been nesting in British Columbia's Gulf Islands since the 1980s, and are altering rare island plant communities through grazing and seed dispersal. Some of the best remnants of Garry oak ecosystem, these islands currently have high abundances of native plant species but are rapidly being invaded by non-native grasses. Using open and exclosed plots at 19 sites on eight small islands, we found that geese feed selectively on these grasses, and that the grasses produce more stems under grazing. By germinating seeds from goose feces, we also found that geese can disperse the seeds of these grasses in their guts. While the non-native grasses benefit from the novel grazer, native forbs not adapted to competition under grazing are declining on these islands. Although theory suggests the grasses should be limited by a selective enemy, our results show that co-evolved grass and grazer strategies can benefit multiple non-native species and degrade native communities.

Session 5E: Toxic Loading To the Marine Environment

Chair: Scott Redman

Development of an Empirical Water Quality Model for Stormwater and Watershed Land-Use in Puget Sound

Christopher May, Jill Brandenberger, Valerie Cullinan, Battelle Pacific Northwest National Laboratory*
Robert Johnston, Puget Sound Naval Shipyard
Sally Lawrence, Washington Department of Ecology

A watershed-based assessment of stormwater pollution in the Sinclair -Dye Inlet watershed was conducted as part of the Project ENVironmental InVESTment (ENVVEST) being conducted by the Puget Sound Naval Shipyard in cooperation with the U.S. Environmental Protection Agency, Washington State Department of Ecology, the Suquamish Tribe, Kitsap County, the City of Bremerton, the City of Port Orchard, and other local stakeholders. The goal of this study was to identify stormwater pollution problems within the Sinclair-Dyes Inlet watershed and to develop and empirical model of the relationship between stormwater pollution and watershed land-use. This study quantifies stormwater pollution based on extensive monitoring and sampling program. Data from this effort is then used to develop an empirical model relating stormwater pollution to land-use and land-cover characteristics. In this manner, water-quality parameters can be estimated for the entire watershed without having to monitor all sources. As part of this study, an integrated watershed-receiving water model was developed to predict pollution levels for a wide range of land-use scenarios. This study was conducted to provide the technical information needed to continue current water quality cleanup efforts and to help implement future efforts to protect and restore beneficial uses. This approach holds great promise for use in other areas of Puget Sound.

Urban Toxics Load to Puget Sound - A First Approximation

Gary Minton, Sierra Club, Cascade Chapter*
Steve Ruden, Water Quality Consultant

The authors have used readily available information to develop an annual loading estimate of key pollutants from primary urban sources. A loading estimate was first made for the City of Seattle. The estimates were made for three primary sources: public wastewater discharges, stormwater runoff, and combined sewer overflows. The pollutants considered were fecal coliform, phosphorus, nitrogen, aggregate metals, pesticides, and petroleum hydrocarbons. The simple spreadsheet model generates loadings based on known volume discharges and concentrations (CSOs and wastewater plants), or acreages and per unit acre loadings (stormwater). A per capita loading was calculated knowing the population of Seattle. The total urban loading was estimated by multiplying the total urban population of the Puget Sound watershed times the per capita loading estimated for Seattle. The total urban population was obtained from U.S. census information updated to 2005. The authors will also discuss the weak points of the estimated loadings and recommendations on field research

to better define key elements to improve loading estimates.

Preliminary Estimates of Toxic Contaminant Loading to Puget Sound

James Maroncelli, Department of Ecology*
Scott Redman, Puget Sound Action Team

The Puget Sound Partnership and its advisors have recommended that efforts to reduce toxic contaminant loading to Puget Sound be guided by a better understanding of the major pathways by which toxic contaminants enter Puget Sound and are transfered through the Sound. In response to this recommendation, the U.S. EPA and Washington State Department of Ecology have agreed to undertake a project to develop preliminary estimates of the loading of toxic contaminants to Puget Sound. This project, to be initiated in late 2006 and completed by mid-2007, will use existing information to estimate (or identify the barriers to estimating) toxic chemical loadings from direct-to-Puget Sound discharge of industrial wastewater, effluent from sewage treatment plants, stormwater from municipal stormwater management systems, stormwater from industrial facilities. To the extent possible, this project will also attempt to characterize loadings of toxic chemicals from discharge of major rivers and streams, atmospheric deposition to the waters and tidelands of Puget Sound, non-point runoff, groundwater discharge, migration of biota, and transfer to and from bottom sediments. This presentation will describe the types of data that are available for the project, the estimation approaches used, and preliminary estimates of loadings from the various sources and pathways.

The Permitted Loading of Toxic Constituents to the Puget Sound Basin

James Maroncelli, Nancy Winters, Gary Bailey, Department of Ecology*

The Water Quality Program of the Washington Department of Ecology reviewed available information to quantify the permitted discharge of toxic constituents into the waters of the Puget Sound Basin. The reviewed information included NPDES point-source individual non-stormwater permits and the monitoring data submitted by permittees via their Discharge Monitoring Reports. The review found that a relatively small number of permits existed that identified discharge limits for toxic constituents, though more of them did require periodic monitoring for toxic constituents. The calculated permitted loadings must be considered reasonable maxima for the permittees because the design flow information in the permits and the accompanying Fact Sheets often indicated a much greater potential flow than the permittees typically reported as actual flow. Also, since Ecology permit managers have typically crafted permits to closely fit the specific operations and discharge characteristics of each facility, the extraction and aggregation of comparable data was often difficult.

Mixing Zone Contributions of Persistent Bioaccumulative Toxic Chemicals into Puget Sound

Heather Trim, People For Puget Sound*
Anna Yost, Jennifer Pengilly, Wm. Laird O'Rollins, Ada Hamilton, University of Washington

Mixing zones are currently permitted for wastewater discharges into Puget Sound and its drainages. Mixing zones are roughly spherical dilution areas in waterbodies around discharge pipes in which contamination levels are allowed to be higher than water quality standards. Mixing zones in Puget Sound range in size from a few feet to 1600 feet in diameter. Compliance with permit limitations is required at the edge of mixing zones. Persistent bioaccumulative toxic (PBT) chemicals are of concern in these areas because of their potential to adversely impact the food web and to accumulate in salmon, seals, orcas, and other species. Contaminants in permitted discharges with mixing zones in Puget Sound include arsenic, chromium, copper, zinc, PCBs, and dioxin. PBDEs are a huge unknown and are not addressed. There are over 1000 permitted discharges in Puget Sound, including over 100 sewage treatment plant outfalls – most with mixing zones allowed. The elimination of mixing zones in Puget Sound could be a strategy for reducing the harm from PBTs. An aggressive source control program is needed.

Session 5F: General Management and Planning Approaches/Tools

Chair: Scott Brewer

Projecting Buildout Conditions in the Hood Canal Watershed: Impervious Surface Estimates for Watershed Planning and Salmon Recovery

Gretchen Peterson, Peterson GIS*
Scott Brewer, Hood Canal Coordinating Council

An important indicator of watershed health is the ratio of impervious surface to land-area. In order to contribute to summer chum salmon recovery planning, research on how much impervious surface area can be expected for a given land use along with a rigorous error analysis was carried out and will be presented. A model of future land use given zoning regulations and current land uses was subsequently developed that used the impervious surface ratios as an input. From this model, estimates of future impervious surface quantity within the watersheds of the Hood Canal summer chum habitat were derived.

Data from two counties in Washington State containing more than 44,000 parcels were analyzed in conjunction with 5-meter impervious surface data and zoning delineations within a geographic information system. The impervious surface ratios in the study area ranged from 0% to 52% for the various land use groups. Watershed impervious surface estimates under buildout conditions ranged from 0% to 32%, with some watersheds increasing in impervious by more than 50% while others did not change significantly. Calculations for riparian corridors, nearshore zones, and estuaries were also computed. Maps of the analysis areas and their results will be shown.

Land Use Permit Tracking: Monitoring and Evaluation of Land Use Regulatory Programs for Salmon Recovery Planning in Hood Canal

Scott Brewer, Hood Canal Coordinating Council*
Gretchen Peterson, Peterson GIS
John Kliem, Creative Community Solutions

As part of the implementation of the Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan (Plan), HCCC, working with County and Tribal staff, is pursuing a tracking system for the regulation of land use and development. The intent of this approach is to gather information from each jurisdiction; sum up that information and those trends at the regional scale; and assess significant departures from current land use regulations. The HCCC is currently assessing the magnitude of those differences and ways to overcome them. Also, there is no current system in place that can aggregate data and assess trends at the ESU scale. This is critical because the Plan analysis of regulatory programs (build-out analysis and regulatory program review) concludes that current land use regulatory regimes are adequate to aid summer chum salmon recovery. But, this is the case only if those regimes are maintained. If significant relaxation of those current regulations takes place, then that assumption of adequacy may be undermined. To address this issue, the design and implementation of a land use and development permit querying system is in development. The following questions can then be discussed: 1) can a system be developed that tracks land use and development over time?; 2) how does the information impact Plan implementation and development?; and 3) can this information be used to update land use codes, regulatory programs, and affect implementation policy?

Ecosystem Status and Trends Assessment

Robert Rankin, Risa Smith, Environment Canada*

The Biodiversity Working Group of the Canadian Council of Resource Ministers is in the early stages of preparing a science-based assessment of Canada's ecosystems. The Ecosystem Status and Trends Assessment (ESTA) will provide an integrated assessment of current status, emerging trends and significant stressors of Canada's ecosystems. It is intended to contribute recommendations for a national system for ecosystem monitoring and status and trends reporting, to add an ecosystem component to species and protected areas assessments already completed and to provide information on Canada's contribution towards the 2010 global target to reduce the rate of biodiversity loss.

As part of the preparatory work for the ESTA we have surveyed a wide range of experts on ecosystem based indicators currently in use in Canada, the temporal and spatial extent of data to support them and critical gaps in information necessary to understand the status of our ecosystems. The results of this survey will presented along with an analysis on how these results will be used to develop the ESTA. A discussion with the audience on the survey results and their relevance to other ecosystem based assessments will be encouraged.

Use of Coast Salish Knowledge in Early Studies of Pacific Salmon Zoology, 1855-1860

Russel Barsh, KWIAHT*

Ethnoscience, or the study of indigenous, tribal and local knowledge systems, developed as a discipline within cultural anthropology and psychology in the 1950s. However, one pioneering study by American naturalists in the Salish Sea relied upon local knowledge a century earlier. In their efforts to compile a comprehensive zoology of the salmonidae of the Pacific Coast, members of the Northwest Boundary Commission's scientific teamóDr. George Suckley, Dr. C.B.R. Kennerly, and George Gibbsóassiduously compiled the views of a dozen Northwest native peoples on the taxonomy and behavior of salmonidae, including extensive vocabularies in Coast Salish languages. Native knowledge was used in many instances to resolve issues of taxonomy, as well as determining which specimens were juvenile forms of species originally known only from observations of adults. Edited transcriptions of the team's field notes and correspondence, soon to be published for the first time, offer insights into the nature and extent of Coast Salish peoples' understanding of salmonid biology and its influence on 19th century Pacific Coast zoology. They also provide a baseline for the spatial distribution and annual timing of salmonid runs 150 years ago.

Improved Decision Making with The Boater Information System

Janet Olsonbaker, David Jones, Troy Tanner, Applied Physics Laboratory, UW*

Boaters need improved weather and oceanographic tools to make informed decisions about their use of Puget Sound. Boaters, i.e., sailors, power boaters, kayakers, fishers, windsurfers, and kite boarders have to search numerous websites, TV and radio stations, and paper documents to plan a trip in the highly variable Northwest environment. Access to this information is cumbersome and the information is not always understandable or usable by boaters. The Boater Information System (BIS) is a decision-making tool designed through collaboration with boaters to meet their needs. The goal of BIS was to improve boater safety while protecting critical resources. Boaters were surveyed and have served on a citizen advisory board to help scientists, software and web engineers build this cutting-edge tool boaters are now using. Via a web portal, BIS delivers winds, tides, currents, and other critical data on an interactive map display. Oceanographic and meteorological forecast information is translated and visualized along the routes boaters select. They can designate a threshold wind value that will color code winds to meet or exceed this value. Puget Sound boaters want this tool expanded for cruising in the Georgia Basin; access to similar data in the Georgia Basin could make this a reality.

Enhancing Transportation Project Delivery Through Watershed Characterization

Richard Gersib, Washington State Department of Transportation*

Watershed characterization is a planning tool developed by Washington State Department of Transportation to identify alternative mitigation options to conventional stormwater flow control and the on-site mitigation of unavoidable natural resource impacts. This paper presents the work of an interdisciplinary technical team tasked with answering the question: Where do we restore degraded natural resources that mitigate transportation project impacts, maximize long-term environmental benefits, and reduce project cost? Guiding principles, results, and lessons learned are presented from four watershed characterization projects completed on the I-405, SR-520, and SR-167 corridors in King, Pierce, and Snohomish Counties in Washington State.

Panel 6A: Small Wood Debris and Impacts on Nearshore Habitats

Co-Chairs: Hilary S. Culverwell and Andrea MacLennan

This panel will address a number of issues including: source of wood waste in the Georgia Basin Puget Sound region, impacts to marine communities, the extent of the problem in the GBPS region, examples of impacts, remediation and restoration efforts, and lessons learned from restoration efforts.

Panel Members:

- *Joel Breems, University of Washington and Skagit Fisheries Enhancement Group*
- *Russ McMillan, Washington State Dept. of Ecology*
- *Jon Houghton*
- *Chris Picard, University of Victoria*
- *Joel Elliott, University of Puget Sound*
- *Clay Patmont, Anchor Environmental*

Sediment Wood Debris: Potential Physical Effects, Toxicity Relationships, and Implications for Restoration

Clay Patmont, Dan Hennessy, Anchor Environmental, LLC
Bill Gardiner, Weston Solutions
Joe Germano, Dave Browning, G&A
Steve Thiele, Stoel Rives

Numerous forest products facilities have historically operated in the Northwest. While changing market conditions have closed many of these facilities, and regulations have controlled ongoing discharges, historical releases of bark, wood chips, and sawdust have resulted in wood debris accumulations in regional sediments.

A wide range of focused investigations of the adverse environmental effects of wood debris in the aquatic environment have been conducted in the Northwest. The type and degree of impacts have varied widely depending on the concentration and type of wood debris and the environmental setting. In many cases, benthic succession processes have mitigated wood debris impacts.

The fibrous/flocculent physical characteristics of certain wood debris materials can render the sediment habitat less suitable for colonization by certain species. However, chemical toxicity associated with wood debris degradation chemicals has been less commonly observed. Distinctions between physical and chemical impacts associated with wood debris in sediments may determine the appropriate restoration approach and the regulatory/legal authority upon which actions are often based.

Extensive wood debris restoration actions have been completed within the region, and have included a range of source control, capping, and dredging remedies, all of which have been demonstrated to be effective in particular situations. Lessons learned for future restoration actions are summarized.

Session óß: Marine Fish Dynamics I

Chair: Wayne Palsson

Regional Variation in ICUN Redbook Listings of Marine Fish Species: Overzealous Listing Activity in the Atlantic or Too Little in the Pacific?

Doug Hay, Fisheries and Oceans Canada, Pacific Biological Station*

The ICUN (International Union for Conservation of Nature and Natural Resources) Redbook has nine categories of which six are ëconservation listings'. These describe incremental degrees of concern ranging from vulnerable or near-threatened to ëextinct' or ëextinct in the wild'. Three categories are related to instances of unwarranted concern, or insufficient information. The frequency of conservation listings of marine fish species varies significantly among the FAO marine areas and is significantly higher in all regions of the Atlantic than the Pacific. This difference is significant ($P<<0.01$) when compared (i) according to the number of listed species as a proportion of total species present or (ii) as the proportion of listed species per unit area. Specifically, for North America, there are more species listed in the north Atlantic (13) than the north Pacific (4). The lower frequency of Pacific listings could reflect geographic differences in species vulnerability. Alternately, the difference may reflect a lower profile for conservation biology of marine fish species in the Pacific. A review of the status of key smelt species (Osmeridae), which is endemic to the north Pacific, shows four instances of valid conservation concerns where Redbook listings might be considered. These include several populations of smelt species in the Georgia Basin.

Fraser River White Sturgeon: Science, Knowledge and Action in Support of a Sustainable Transboundary Population

Troy Nelson, LGL Limited Environmental Research Associates*
Bill Gazey, W.J. Gazey Research
Karl English, LGL Limited Environmental Research Associates
Rick Hansen, Rick Hansen Man In Motion Foundation

White sturgeon (*Acipenser transmontanus*) is an ancient species and the largest freshwater fish in North America, attaining lengths in excess of 6 m and weights of more than 600 kgs. Tough and resilient to environmental change, they can tolerate both fresh and salt water environments; however, white sturgeon spawn only in fresh water. In the lower Fraser River and estuary, white sturgeon sit at the apex of a complex and fragile ecosystem that is also an integral component of the greater Georgia Basin ecosystem. In November 2003, white sturgeon in Canada were designated "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Since 1999, the Fraser River Sturgeon Conservation Society has managed an intensive stock monitoring and assessment program for white sturgeon in the lower Fraser River. This significant, volunteer-driven mark-recapture program (utilizing PIT tags) has successfully coordinated partnerships and in-kind contributions from true stewards of the resource: sport fishing guides, recreational, commercial, and aboriginal fishers, test fishery and enforcement personnel, and various fishery monitors. Program results have reduced knowledge and data gaps, and provided reliable information used by resource managers for stock recovery assessment. Prioritized stock recovery actions have been identified in a Fraser River White Sturgeon Conservation Plan, and a technical/community "team" approach has been adapted to implement these actions.

Seattle Aquarium's Sixgill Shark (*Hexanchus griseus*) Conservation Ecology Project Update

Shawn Larson, Jeff Christiansen, Joel Hollander, Seattle Aquarium*

Seattle Aquarium biologists have been informally monitoring sixgill shark (*Hexanchus griseus*) sightings for the past 10 years and formally studying sixgill population ecology for the past three years. The aquarium's Sixgill Shark Population Ecology project is a long-term conservation research program to address gaps in the body of scientific knowledge on these relatively unknown local animals. Living mainly at abyssal depths (2000-5000 m) but also in shallow waters of Puget Sound, Washington, sixgills are thought to be long-lived and slow-growing, and appear to have established movement corridors and territories that remain relatively fixed over time. No information exists on how many sixgills are in Puget Sound, whether they are year-round or seasonal, local or migratory, or whether they use local water primarily for feeding or for recruitment. The Aquarium's sixgill population ecology research involves three interwoven projects to determine aspects of basic sixgill biology using the techniques of (1) genetics research, (2) visual marker tagging, and (3) acoustic tracking. The project will ultimately expand from the Aquarium to include the rest of Puget Sound and beyond, eventually including studying sixgill populations worldwide. The Aquarium had to suspend its visual and acoustic tagging portion of the project in July 2005 because of construction above and below the pier. The underwater tagging portion of the project will begin again in 2007 when the underwater protected contact research station is rebuilt. Here we update the progress of the sixgill research since the 2005 conference. Specifically we will share data on the number of tagged sharks returning to our research site, our progress with tracking acoustically tagged sharks and significant population genetics results to date.

Impacts of Disease to Wild Fish Populations with Special Reference to the Salish Sea Region

Paul Hershberger, Marrowstone Marine Field Station*
Jim Winton, Western Fisheries Research Center

Infectious and parasitic diseases are integral components of population dynamics and ecosystem function, and disease processes in wild populations are governed by a combination of natural and anthropogenic factors. In human and terrestrial animal populations, disease impacts are relatively easily observed and well documented; however, in populations of wild fishes, analogous disease events often go unobserved, and the ecological impacts of epizootic and chronic disease mortality are extremely difficult to enumerate. This observational difficulty has resulted in a general lack of understanding of disease ecology principles governing wild fish populations; consequentially, inexplicably large errors often occur in predictive population models. We will review classic examples of chronic and epizootic mortality in fish populations throughout the world and discuss population and ecosystem-level shifts that occurred as a result. We will conclude by presenting examples of infectious and parasitic disease concerns to fish populations in the Salish Sea region, and providing an empirical framework that can be used to develop management activities intended to mitigate the effects of disease on wild fish populations.

Prevalence of Ichthyophonus in Copper Rockfish (*Sebastes caurinus*) from Puget Sound, WA.

Jake Gregg, Cristy Pacheco, Paul Hershberger, Marrowstone Marine Field Station*

Ichthyophonus is a highly pathogenic protozoan parasite that has repeatedly caused severe epizootics in wild marine fishes in the North Atlantic; however, until recently it was not known to exist in fishes from the eastern North Pacific. Since the index case in the eastern North Pacific, a single Pacific staghorn sculpin collected from the coast of Oregon in 1983, the reported host range, infection prevalences, and infection intensities have expanded dramatically. For example, infection prevalence has reached 30 to 50% in some stocks of Chinook salmon, Pacific herring, Pacific Ocean perch, and yellowtail rockfish, and the prevalence of disease has reached epizootic proportions in Yukon River Chinook salmon. In the inland waters of Washington State, >10% of Puget Sound rockfish (*S. emphaeus*) are infected, and it is plausible that this host represents a significant reservoir for the parasite in the near shore rocky reef. Here, we describe the results from a recent survey of copper rockfish from north and central Puget Sound, where 5% were

infected. We conclude that the future emergence of Ichthyophonus in Puget Sound and Georgia Basin rockfishes is likely, based on currently high prevalences in rockfishes from the coast of Washington and in sympatric herring from the Salish Sea.

Panel 6C: Seagrass Distribution and Ecology in the Salish Sea: Physical and Chemical Factors

Chair: Jessie Lacy and Jeff Gaeckle

Seagrass is emerging as an indicator of ecological health for the Salish Sea. Improved understanding of the ecology, status, and trends of seagrass is critical to the management of this important resource. Scientists and resource managers are developing new technologies and analytical techniques to advance monitoring of the status and trends in seagrass distribution, as well as interpretation of these trends. The ecology and habitat provided by seagrasses are also areas of active research. This session will focus on status and trends, ecological functions and values, and natural and anthropogenic controls on the distribution of seagrass resources in Salish Sea. Innovative and alternative technologies, analyses, and modeling used in research and monitoring at local and regional scales will be featured.

Panel Members:

- *Renee Takesue, U.S. Geological Survey*
- *Zachary Hughes, University of Washington*
- *Michael Hannam, University of Washington*
- *Anja Schanz, Washington State Department of Natural Resources*
- *Jessica Lacy, U.S. Geological Survey*

Linking Long-Term Eelgrass Monitoring with Local Research and Management Projects

Helen Berry, WA Dept. of Natural Resources*
Blain Reeves, Washington State Department of Natural Resources

A major challenge that large-scale monitoring programs face is to provide long-term trends data and also address current natural resource management questions. The Washington Department of Natural Resources Nearshore Habitat Program has worked to meet both of these objectives in its eelgrass monitoring program. In addition to providing yearly updates on the status of eelgrass throughout greater Puget Sound, we have collaborated with managers and researchers to provide data on issues of local concern. This presentation reviews a series of projects that we have undertaken with local partners over the last five years. We review seven case studies and discuss three in detail: mooring buoy placement in Sucia Island State Park, county-wide eelgrass mapping and subsequent monitoring in San Juan County, and assessment of harmful green algal blooms through National Science Foundation funded research at Seattle Pacific and University of Western Washington. These case studies demonstrate the potential strengths of collaborations, along with the methodological challenges and limitations. We believe that these case studies exemplify how collaborations can improve the knowledge of seagrass resources, increase the power of data sets collected over a range of spatial scales, and save money.

Redox-Driven Bioavailability of Phosphate and Sulfide in Eelgrass (*Zostera Marina*) Root Zones

Renee Takesue, U.S. Geological Survey
Sandy Wyllie-Echeverria, Univ. Washington

Sediment reduction-oxidation (redox) conditions affect the bioavailability of nutrients and sulfides to eelgrass. We measured sediment redox potential (Eh); labile (pore water + weakly adsorbed) nutrients and metals; solid-phase phosphate bound to ferric iron oxides; and plant characteristics at four sites in the San Juan Archipelago to explore whether eelgrass health could be related to redox-driven bioavailability of phosphate or sulfides. Sediments ranged from oxygenated (Eh = +170 mV) in False Bay (<1% mud) to highly reducing (Eh < -150 mV) in Shoal and Shallow Bays (both 3% mud) and in Westcott Bay (34% mud). In False Bay, eelgrass was sparse in the troughs of sand waves, sediments were well oxygenated, and labile phosphate concentrations were very low. If oxidizing conditions were persistent in False Bay sediments, phosphate concentrations may have been suboptimal for eelgrass growth. Eelgrass grew in dense fringes in Shallow and Shoal Bays, and has been absent from the head of Westcott Bay for at least three years. Surprisingly, Westcott Bay sediments had two and five times more sulfide-buffering capacity, in the form of ferric iron, as Shoal Bay and Shallow Bay sediments, respectively. We will compare redox conditions, potentially bioavailable (labile + iron-bound) phosphate, ferric iron, and eelgrass characteristics in Shallow and Shoal Bays, and speculate whether phosphate or sulfide availability contributed to eelgrass disappearance in Westcott Bay.

Bathymetry, Bottom Mapping, and Recovery Projections of Eelgrass for Anchor Buoy Relocation Project at Echo Bay, Sucia Island, WA

Zachary Hughes, University of Washington, Environmental Science
Sandy Wyllie-Echeverria, University of Washington
Gary Greene,
Ted Smith, Washington State Parks
Blaine Reeves, Washington State Department of Natural Resources
Mike Hannam, Kevin Britton-Simons, University of Washington

As part of a regional plan to protect marine biodiversity and productivity and provide public access to remote state parks in the San Juan Archipelago, Washington State Parks (WSP) will relocate and alter existing mooring buoys within Echo Bay on Sucia Island and establish a voluntary "no anchor" zone. This action is primarily taken to avoid further disturbances to existing eelgrass (*Zostera marina*) beds. Habitat mapping using multibeam bathymetry and backscatter can guide removal and relocation efforts and provide a baseline of eelgrass abundance against which potential recovery can be compared. Statistical protocols associated with these techniques allow us to estimate the amount of eelgrass present, determine the minimum and maximum depth of plant growth, illustrate depth contours and characterize surface sediment profiles. These source data are then imported to ArcGIS for landscape-scale analysis. Our data and the fact that eelgrass is found at deeper depths (~ 10 m) within sites similar to Echo Bay in the region, suggests that areas adjacent to the existing maximum depth of eelgrass growth may support population expansion once buoys are relocated. Finally, economic value of potential eelgrass expansion will be assessed in terms of dollars per hectare per year based on ecological function and relative importance to economically valuable species.

Mapping Submerged Aquatic Vegetation in South Puget Sound

Michael Hannam, University of Washington
Joel Elliott, University of Puget Sound
Kristin Williamson, South Puget Sound Salmon Enhancement Group

Submerged aquatic vegetation (SAV) contributes to biodiversity and nearshore productivity in the Puget Sound. To guide future restoration efforts, the South Puget Sound Salmon Enhancement group undertook a project to assess the shoreline between Point Defiance and the Nisqually River Delta in Southern Puget Sound, a reach highly impacted by rip rap bulkheading associated with the Burlington Northern Santa Fe railroad. As a part of this assessment, we mapped SAV, focusing on eelgrass, *Zostera marina*, along the same reach. Mapping was initiated on foot during summer low tides with digital video and GPS receivers. We outlined the perimeter of *Z. marina* beds and recorded other dominant vegetation assemblages and substrate types. Underwater video was used to delineate the deep edge of *Z. marina* beds and estimate cover within the beds. Video and GPS data were synchronized and video was coded for *Z. marina* cover and substrate type prior to GIS analysis. Preliminary observations suggest that *Z. marina* distribution

along portions of our study area may be related to proximity to culverts that pass freshwater and sediment underneath the railway. If this is substantiated, efforts to restore more natural sediment delivery to this reach may hold restoration potential.

Do Hydrodynamics Initiate Changes in Ecosystem Function of Intertidal Seagrass Beds?

Anja Schanz, WDNR, Aquatic Resources Devision

Recent and ongoing decline of seagrasses all over the world is attributed to human impact and climatic change. In addition, the effect of hydrodynamics is important, because it interlinks and alters various processes in seagrass beds from species to ecosystem level.

Field experiments in the Wadden Sea (SE North Sea, Germany) demonstrated that water dynamics are a key factor in controlling the species composition and the trophic transfer within the food web of a seagrass community as well as the development of the seagrass bed. Drop trap catches carried out in seagrass beds with strong and weak hydrodynamics showed a distinct impact of water movement on the composition of mobile, epibenthic macrofauna. Drastic changes were observed in the trophic guild of grazers. Experiments with an in situ three-current-flume, modifying the entire current velocity, and cross transplantation experiments between sheltered and exposed seagrass beds, revealed a cascading impact of hydrodynamics on an epiphyte-grazer system in intertidal seagrass beds by directly affecting the density of grazers and indirectly leading to enhanced epiphyte growth, thereby inhibiting seagrass development. Additionally, the results show that cascading effects within the trophic web are not only triggered by biotic interdependencies but can also be caused by physical factors. Further investigations revealed that stronger hydrodynamics also directly affects seagrass beds by reducing seagrass density and shoot morphology, as well as the extent of seagrass beds.

Interaction of Eelgrass with Nearshore Tidal Currents

Jessica Lacy, U.S. Geological Survey
Sandy Wyllie-Echeverria, University of Washington
Guy Gelfenbaum, US Geological Survey

The seagrass *Zostera marina* (eelgrass) attenuates currents in the nearshore region of Puget Sound, and at the same time tidal currents continually modify seagrass habitat. We conducted field studies of seagrass-flow interactions and sediment transport in 2004 and 2005 in subtidal meadows adjacent to Shaw and Waldron Islands in the San Juan Archipelago. At both sites eelgrass attenuated near-bed tidal currents 70-80% when velocities above the meadow were less than 15 cm/s. Velocities from 15 to 30 cm/s were attenuated by 50-60%. At Waldron Island, where median bed-sediment grain size ranges from 0.12 to 0.17 mm, eelgrass reduced the near-bed tidal currents from those capable of resuspending sediment (30 – 40 cm/s) to a level below the threshold for sediment motion, based on the Shields parameter. Underwater digital video recorded the posture of the eelgrass leaves and showed deflection in response to tidal currents. Current speeds of approximately 10 cm/s decreased canopy height by more than 50%. Reduction of canopy height decreases the volume of habitat available to canopy-dwelling organisms and allows turbulence generated at the top of the canopy to descend farther down into the meadow, potentially enhancing import of nutrients into, and export of oxygen out of, the meadow. In our next deployment, at Possession Point on Whidbey Island, we will investigate the interaction of eelgrass and waves, and the role of wave energy in structuring distribution patterns.

Session 6D: Urban Landscape Restoration

Chair: Ken Brock

Bulkhead Removal Feasibility Study, Central Puget Sound, WA.

Andrea MacLennan, Jim Johannessen, Jonathan Waggoner, Coastal Geologic Services*

The objective of the study was to determine the feasibility of removing some or all of the bulkheads fronting this historic nearshore sediment source without threatening a home located atop the bluff. The site is located south of Seattle, Washington, in Central Puget Sound. Residential development and bulkheads are widespread resulting in a substantial reduction in nearshore sediment supply to drift cells. Assessments of the beach, bluff, and uplands were performed to determine baseline conditions, and how the bulkheads have altered beach and bluff processes at the site. An analysis of current and historic bluff conditions was performed to identify the dominant drivers of bluff erosion at the site, determine erosion rates and observe how bluff processes have changed since bulkheading. Assessment methods used in this study included: field surveys (habitat mapping and high accuracy topology), GIS analyses, and traditional geomorphic air photo analysis. The results of these analyses were used to determine a recommended phased plan for restoration of impounded bluff sediment. Recommendations included a number of bulkhead removal scenarios, some of which included soft shore protection designs to enhance beach sediment and moderate bluff erosion near the house.

Seattle's Central Waterfront: Opportunities and Constraints for Nearshore Habitat Restoration

Paul Schlenger, Anchor Environmental*
David Graves, Seattle Parks and Recreation
Peter Hummel, Anchor Environmental
Kevin Stoops, Seattle Parks and Recreation
Paul Korsmo, Anchor Environmental
John Owen, Makers Architecture and Design

The City of Seattle Department of Parks and Recreation funded a feasibility study and Environmental Impact Statement to develop and evaluate alternatives for the redevelopment of Seattle's Central Waterfront shoreline between Waterfront Park and Pier 62/63 in Elliott Bay. Each of the alternatives included innovative elements of nearshore habitat restoration while utilizing various pier configurations to also maintain park uses. This presentation will not be a description of each of the alternatives—rather it will discuss the constraints and opportunities related to nearshore habitat restoration that were identified through the process of alternative development. Site constraints include highly altered sediment transport and supply conditions, extensive overwater structure, a seawall, and restrictive land use designations. The opportunities are equally significant and include creating shallow water habitat waterward of the seawall, reconfiguring overwater structures to provide a shallow water "corridor of light," and adding habitat diversity along the extensive stretches of deep subtidal sand and silt habitat that comprise the downtown waterfront. This presentation is intended to shed light on the potential for meaningful habitat improvements despite significant challenges of working in an urban area.

From Capitol Lake to Deschutes Estuary: Modeling Restoration of an Impounded Estuary

Douglas George, Guy Gelfenbaum, US Geological Survey*
Giles Lesser, US Geological Survey/Delft Hydraulics
Andrew Stevens, US Geological Survey

The Deschutes Estuary Feasibility Study (DEFS) in Olympia, Washington, is examining the restoration of the Deschutes Estuary by removing a dam installed in 1951 to create Capitol Lake. The four component studies of DEFS represent an interdisciplinary approach to estuary and ecosystem restoration. As one of these studies, a sediment transport and hydrodynamic model was developed to investigate estuarine evolution under restoration scenarios and provide information to the three companion studies. The model predicts an estuary similar in morphology to the pre-dam environment will develop within five years after dam removal. The model produces salinity regimes, inundation frequencies and sediment grain size distributions used to estimate the biological communities that may colonize a restored estuary. Predicted current

velocity fields, circulation patterns and morphological change from the model will be used to analyze threats to existing infrastructure around the lake. Modeled sediment accumulation in a downstream commercial port and marina will also allow managers to estimate maintenance costs for dredging. The model results suggest that the estuary environs would be significantly different than the present lake conditions and therefore, the decision to restore the area will require extensive interaction with the community.

Net Benefit Analysis of Restoring an Estuary in an Urban Setting: The Deschutes River Basin, Washington

Michael Taylor, Cascade Economics LLC*
Katharine Wellman, Susan Burke, Northern Economics, Inc.
Matthew Wilson, Spatial Informatics Group LLC

Economists face inherent challenges where the removal of an existing dam is contemplated in order to restore an estuary. Legitimate questions are raised about particulars of the "newly created" environment, as well as anticipated (or perceived) changes in attributes and well being. The challenge is magnified in an urban setting, where the stakeholders are numerous and widely varying. How best to develop information on the full range of economic and social values that will lead to an informed decision?

In this study, a multi-step process was applied to assess the net benefits of restoring a naturally functioning Deschutes River estuary, as compared to managing man-made Capitol Lake in Olympia, Washington. A community "stakeholder process," sponsored by the lake's adaptive management steering committee, generated a set of attributes and components of importance. These were organized into categories of estuary "goods and services" modeled after the United Nations-sponsored Millennium Assessment. The assessment of goods and services were further mapped to an economic framework that included market, non-market, and non-economic (social) values. Finally, each type of value was treated quantitatively or qualitatively, with particular emphasis placed on those values that would most likely affect a decision of whether or not to remove the existing dam and restore the estuary.

Building an Action Plan for Biodiversity Conservation in the Greater Vancouver Region

Theresa Duynstee, Greater Vancouver Regional District*
Jan Kirkby, Environment Canada (Canadian Wildlife Service)*
Marcy Sangret, The Corporation of Delta*

The Biodiversity Conservation Strategy for the Greater Vancouver Region is in the final phase of the process to develop coordinated strategies and actions that guide decision makers on how to conserve biological diversity across the region. This partnership initiative under the Georgia Basin Action Plan involves Environment Canada, BC Ministry of Environment, Burrard Inlet Environmental Action Plan - Fraser River Estuary Management Plan and the Greater Vancouver Regional District who are working in conjunction with member municipalities, non-government organizations, stewardship groups and post-secondary institutions.

This is the first regional biodiversity strategy undertaken in British Columbia (a provincial biodiversity strategy is also in the process of being developed). A draft framework was developed through extensive habitat and technical assessments, case studies reviews, workshops, and analysis of existing legislation and tools. Further work is requiredunderway to identify specific actions municipalitesmunicipalities can do to conserve biodiversity in the region. A consultation process begins in fall 2007 to seek input from those who can help implement the plan, including government staff, municipal advisory committees, land managers, environmental organizations and community groups. This is an iterative process intended to build cooperation and identify avenues to participate in the plan.

Three Speakers from three different levels of government will highlight the process, key assessments, and products, benefits, challenges and lessons learned during the planning development of the strategy and action planprocess. The presentation is aimed to provide information and encouragement to inform other jurisdictions undertaking similarwho may be considering the development of regional conservation planning strategies.

Urban Watershed Restoration – Putting Plans into Action

Tanis Douglas, Capital Regional District*

The Capital Regional District used a collaborative framework for urban watershed management planning for the Bowker Creek watershed, a highly urbanized and degraded creek. The Bowker Creek initiative is active and high profile, because the plan is supported by a part-time implementation coordinator and implemented with ongoing, multi-jurisdictional steering committee meetings. This presentation will showcase various examples from the Bowker Creek watershed to demonstrate the effectiveness of integrated watershed management planning and implementation. Partners in the initiative are currently accomplishing or initiating actions described in the implementation strategy, including a watershed master drainage plan currently underway, a future planned watershed habitat assessment, restoration projects, outreach to the public and with schools, and greenways planning. Input is also given to proposed developments to promote land use in keeping with the plan. The work requires many community partners to carry out restoration as well as maintain and monitor water quality, and the community will be further aware and engaged as the work progresses.

Session 6E: Stormwater and Salmon Health

Chair: Nat Scholz

Impacts of Stormwater Runoff on Coho Salmon in Restored Urban Streams

Sarah McCarthy, NOAA/NMFS/NWFSC*
Julann Spromberg, John Incardona, Blake Feist, NOAA Fisheries
Jenifer McIntyre, University of Washington
Jana Labenia, Mark Myers, NOAA Fisheries
Laura Reed, Seattle Public Utilities
Katherine Lynch, Seattle Public Utilities
Jay Davis, US Fish and Wildlife Service
Tracy Collier, Nathaniel Scholz, NOAA Fisheries

Beginning in the late 1990s, agencies in the greater Seattle area began conducting fall surveys for spawning salmon to evaluate the effectiveness of local stream restoration efforts. These surveys detected a surprisingly high rate of mortality among migratory coho females that were in good physical condition, but had not yet spawned. In addition, adult coho from several different streams showed a similar progression of symptoms (disorientation, lethargy, loss of equilibrium, gaping, fin splaying) that rapidly led to death. In recent years, pre-spawn mortality (PSM) has been observed in many lowland urban streams, with overall rates ranging from ~25% to 90% of the fall runs. Continuous daily surveys of wild coho spawners in a forested reference stream revealed <1% PSM. Although the precise cause of PSM in urban streams is not yet known, conventional water quality parameters and disease do not appear to be causal. Rather, the weight of evidence suggests that adult coho, which enter small urban streams following fall storm events, are acutely sensitive to non-point source stormwater runoff containing pollutants that originate from highly developed landscapes. These findings have important implications for restoration and conservation efforts in urban and urbanizing watersheds. This project was supported by the NOAA Coastal Services Center, the NOAA Coastal Storms Program, the U.S. Fish and Wildlife Service's National Contaminants Program, and the City of Seattle.

Coho Pre-Spawn Mortality in Urbanized Puget Sound Watersheds: What Does the Surrounding Landscape Tell Us?

Blake Feist, NOAA/NMFS/NWFSC*
Paul Arnold, Jay Davis, U.S. Fish & Wildlife Service
Sarah McCarthy, National Marine Fisheries Service
Nat Scholz, National Marine Fisheries Service

Pre-spawn mortality (PSM) of adult coho salmon (*Oncorhynchus kisutch*) is a phenomenon that has been consistently observed over the past several years in urban Puget Sound area streams, with rates ranging from 63-89%. Although the precise cause of PSM in these streams is unknown, conventional water quality parameters (i.e., temperature and dissolved oxygen) and disease do not appear to be causal. Rather, the weight of evidence suggests that adult coho, which enter small urban streams following fall storm events, are acutely sensitive to non-point source stormwater runoff containing pollutants that typically originate from urban and residential land use activities. In order to test this hypothesis, we ran a series of spatial analyses where we looked at the correlation between land use and land cover (roads, impervious area, forested, etc.) patterns and PSM rates in 6 different streams. We found that total area of heavy use roads was most correlated with coho PSM rates. We also found that PSM events were closely linked with precipitation patterns. From this, we built a predictive spatially explicit model of coho PSM rates for the eastern Puget Sound basin. The highest PSM rates are clustered around the major metropolitan areas of eastern Puget Sound. In addition, there are large areas in the basin that are expected to experience 35 – 100% PSM rates. In the future, we will apply these findings to models that predict PSM rates under various urban expansion scenarios.

Synergistic Toxicity in Juvenile Coho Salmon Exposed to Mixtures of Organophosphate and Carbamate Insecticides

Cathy Laetz, NOAA/NMFS/NWFSC*
David Baldwin, Northwest Fisheries Science Center, NOAA Fisheries
Vincent Hebert, John Stark, Washington State University
Nathaniel Scholz, Northwest Fisheries Science Center, NOAA Fisheries

Organophosphate and carbamate insecticides are commonly detected in surface waters that provide habitat for threatened and endangered salmon (*Oncorhynchus sp.*) in the Pacific Northwest. These insecticides inhibit the activity of the enzyme acetylcholinesterase (AChE), thereby interfering with chemical signaling (neurotransmission) at nerve synapses. Mixtures of these insecticides are frequently detected in the environment, but their effects on the neurobiology and behavior of salmon and other fish are poorly understood. Previous work in our lab found that in vitro treatments with insecticide mixtures produced dose-additive toxicity, as measured by AChE inhibition. To determine if in vivo exposure also produces additive toxicity, we exposed juvenile coho salmon (*Oncorhynchus kisutch*) to sublethal concentrations of the insecticides diazinon, malathion, chlorpyrifos, carbaryl and carbofuran both individually and as binary mixtures. Single insecticide exposures produced dose-dependent inhibition of brain AChE. However, AChE inhibition was greater than expected after exposure to mixtures, indicating synergistic (i.e., greater-than-additive) toxicity for many of the binary mixtures. Moreover, several organophosphate mixtures caused mortality at concentrations that were sublethal in single insecticide exposures. These results indicate dose-additive models of toxicity may underestimate the risks that insecticide mixtures pose to salmon throughout the Pacific Northwest.

Pesticides and Pacific Salmon: Linking Exposure to Physiology, Behavior, Growth, Survival, and The Long-Term Productivity of Threatened and Endangered Populations.

Julann Spromberg, David Baldwin, Nathaniel Scholz, NOAA Fisheries, Northwest Fisheries Science Center*

Current use pesticides have been widely detected in salmon habitats throughout the Pacific Northwest. Pesticides are specifically intended to kill, repel, or otherwise control biological organisms. These chemicals therefore have the potential to limit the recovery of threatened or endangered salmon populations in lowland agricultural and urban environments where pesticides are most commonly used. Of particular concern are insecticides, many of which have been shown to specifically target the salmon nervous system. While the neurobehavioral effects of pesticide exposures have been extensively documented in salmon and other fish species, the linkages between the health of individual animals and population-scale processes are still very poorly understood. The present study focused on chinook salmon (*Oncorhynchus tshawytscha*) and common classes of insecticides that target acetylcholinesterase, an enzyme that supports neurotransmitter-mediated signaling in the salmon brain. Specifically, we developed a model to quantitatively connect pesticide-induced inhibition of brain enzyme activity in individual juvenile salmon to reductions in feeding behavior, ration, growth, size at migration, and early marine survival. This information was then fed into a chinook salmon life history population model to estimate impacts on population abundance and growth rates. Our modeling results indicate that short-term exposures to insecticides at low, environmentally realistic concentrations are likely to reduce the size of individual salmon during critical life stages, thereby increasing size-selective mortality due to predation. These effects, in turn, reduce both the intrinsic growth rate and the percent spawner abundance of the modeled population relative to an unexposed population. Based on these findings, we suggest that pesticide-induced physiological perturbations in individual salmon can propagate to higher scales of biological organization. Moreover, we identify focal areas for targeted new research to improve the predictive accuracy of our model.

Five Years of Research on the Health of Salmon in Urban Streams: Lessoned Learned and Future Directions.

Nathaniel Scholz, NOAA Fisheries, Northwest Fisheries Science Center*

As noted recently by both the U.S. Commission on Ocean Policy and the Pew Oceans Commission, coastal development and terrestrial runoff are increasingly undermining the long-term viability of at-risk aquatic species in North America. This is particularly true of Puget Sound, where urbanization is rapidly degrading the quality of aquatic habitats throughout the region. For the past five years, the Northwest Fisheries Science Center's Ecotoxicology and Environmental Fish Health Program has been investigating the cumulative impacts of urban stormwater runoff on the health and survival of salmon in urban and urbanizing watersheds. This has been a large, multi-stakeholder effort with support from the NOAA Coastal Storms Program, the NOAA Coastal Services Center, the U.S. Fish and Wildlife Service, King County, the City of Seattle, and Washington Trout. The aim has been to conduct experimental research on restored urban streams in the greater Seattle area to advance our basic understanding of how chemical contaminants in surface runoff affect the physiology and behavior of salmon at different life stages. The focus has been on pesticides, heavy metals, and hydrocarbons, as well the as-yet unidentified contaminants that cause recurrent die-offs of adult spawners as well as developmental defects in salmon embryos. This presentation will 1) review the state of the science as it pertains to stormwater and salmon health, and 2) identify priority areas for new research.

Session 6F: Modeling and Decision Support Tools: Applied Management Tools

Chair: Randal Taira

Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan: The Hood Canal Coordinating Council Approach to Salmon Recovery Planning

Scott Brewer, Jay Watson, Hood Canal Coordinating Council*
Dave Christensen, Thurston County
Richard Brocksmith, Hood Canal Coordinating Council

The Hood Canal Coordinating Council (HCCC) is a coalition of three Counties and two Indian Tribes with a dual mission of protecting the water quality of Hood Canal and providing for the restoration and recovery of threatened Hood Canal salmon stocks. The HCCC pursued salmon recovery as part of Washington State's response to the Endangered Species Act (ESA) listings of Hood Canal summer chum salmon and Puget Sound chinook. Recognizing the need to engage the land-use authorities (i.e., Counties), the HCCC developed a Plan that builds on a wealth of existing and in-progress works while focusing on specific actions in specific areas. Aspects of harvest and hatchery management have been in place in anticipation of the listing. Development of this recovery plan allowed the opportunity to focus on those aspects of land use, development and regulatory programs. County staffs were consulted regarding a review of current land use and regulatory programs. The Plan also developed a build-out analysis in an attempt to link current and projected development with important summer chum salmon habitat. The Plan further describes a land use permit tracking system intended to monitor the effectiveness of current regulatory programs to protect important habitats and allow for restoration opportunities. The Community Nearshore Restoration Program was also incorporated that focuses on salmon friendly marine nearshore habitats. The Plan is to be adopted as a Federal Recovery Plan.

Ground-Truthing the Habitat Inventory for the Fraser River Estuary: Habitat Status Report and Lessons Learned

Anna Mathewson, FREMP*
Rob Knight, British Columbia Ministry of Environment
Kathleen Moore, Environment Canada
Brad Mason, Fisheries and Oceans Canada
Gary Williams, North Fraser Port Authority

The Fraser River Estuary Management Program (FREMP) is an intergovernmental partnership program for coordinated environmental management of the Fraser River estuary, one of the most significant aquatic ecosystems in the Lower Mainland of British Columbia.

FREMP has developed a number of tools to manage the "living, working river", including a habitat classification system that assigns colour-codes to intertidal and riparian areas on the basis of the relative values of their habitat features. The classifications are based on an inventory of all habitat types in the estuary, and guides prospective developers in selecting appropriate sites and design concepts prior to seeking approval of their projects. First mapped in the 1980s, the FREMP habitat inventory was updated in 2003 using an ecological ëfeatures and functions' approach to capture information on upland linkages. A comprehensive ArcView dataset and linked Access database was developed with over 12,000 habitat polygons.

In 2006, FREMP undertook a project to ground-truth and verify the habitat polygons with the BC Conservation Corps. The presentation will provide a habitat status report (including established data confidence levels and observations of invasive species), review project methodology and challenges, and identify lessons learned that may assist other field-checking and mapping projects.

Application of a Coastal Landform Classification GIS Database to Washington State Parks in the Puget Sound

Cinde Donoghue, Thurston County Planning Department*
Andrew Perkins, Janet Rhoades, Melissa Blackburn, Central Washington University

A process-based coastal landform classification GIS database using existing data sources was developed for Washington's Puget Sound shoreline. A geo-database was used to compile a wide variety of data sources for analysis, including historical and current aerial photographs (oblique and vertical) as well as information on topography, hydrology, slope stability, drift cells, coastal dynamics, and other relevant shore zone information such as sediment type and abundance. The classification breaks the shoreline into a nested hierarchy of segments that relate to the physical processes important in determining geomorphology and shape. The resulting classification distinguish between the beachforms and upland forms, including further distinctions such as anthropogenic modifications and whether they are depositional, stable or erosional These smaller features are further nested into beachform and upland form groups, which identify larger process-based geomorphic systems. The classification is a critical basis for understanding how different shoreline types are formed and how susceptible they are to change and various impacts. A case study application of the classification to Washington State Park shorelines demonstrates its utility as a planning tool for assessing the links between geomorphic processes and land forms and the ecological functions related to the wide diversity of marine shorelines found in the Puget Sound.

Modeling Potential Effects as a Management Tool for Washington's State-owned Aquatic Lands

Carol Cloen, Washington State Department of Natural Resources*

As proprietary manager of over 2.4 million acres of state-owned aquatic lands, Washington DNR is charged with ensuring environmental protection for the habitats managed as well as supporting their use for commerce and navigation; public use and access; the production of renewable resources; and income generation. To ensure that land management actions comply with the federal Endangered Species Act (ESA), the agency is developing a Habitat Conservation Plan for fresh- and saltwater habitats utilizing a spatial database and model to predict effects on species and habitats.

This presentation will focus on the development of the Potential Effects model and its components, uncertainties associated with the model, integration of conservation strategies, and present some preliminary estimates of how DNR's activities affect aquatic habitats.

An Interdisciplinary Cyber-Infrastructure for Multi-Scaled Coastal Zone Research

Miles Logsdon, Jill Colye, Donald Averill, Jeffrey Richey, University of Washington*

Over the next decade sophisticated cyber-infrastructure tools will provide coastal zone researchers with unparalleled access to computational modeling of the complex interactions between the physical system and the impacts of human dynamics. Rapid growth of computing resources and the advances in observational networks make this an inevitable component of future interdisciplinary coastal zone research. Our research in information system architecture encompasses tools that are built on metadata services that drive integration efforts and archive strategies. These services require an FGDC-compliant metadata document to accompany each data set. The use of an XML encoding scheme can be written, edited, and queried with simple desktop or on-line tools provided to a collaborative team of investigators. These data management tools use both push (proactive) and pull (reactive) technologies for the exchange of data. They have been designed, developed, and are currently in use by a number partnership research programs at the University of Washington. We have experienced a powerful synergy between modelers and observational sciences as a result of this work. This presentation reports on the recent advances and new perspectives in cyber-infrastructure implementation in support of computational earth science modeling for coastal zone research.

ntegrated Modeling of Surface Water in WRIA 8: An Application of the Integrated Water Resource Modeling System (IWRMS)

Curtis DeGasperi, King County, Deptartment of Natural Resources and Parks, Water and Land Resources*
Randal Taira, Pacific Northwest National Laboratory
Tom Georgianna, King County Dept. of Natural Resources and Parks
Kevin Dorow, Pacific Northwest National Laboratory

The King County Department of Natural Resources and Parks (KCDNRP) and the Pacific Northwest National Laboratory (PNNL) have developed an integrated modeling and data management system called the Integrated Water Resources Modeling System (IWRMS). The IWRMS provides the KCDNRP with a new capability in which integrated modeling can be performed to provide scientific support for studies and planning and policy decisions. The IWRMS is an integrated suite of tools with components for problem conception, data harvesting, integrating disparate computational models, central data storage, distributed computing, and ports to visualization and analysis tools. In this paper we describe the process of implementing the IWRMS to perform an integrated modeling assessment of surface water in Water Resource Inventory Area 8 (WRIA 8). Components modeled include WRIA 8 watersheds, Lake Sammamish, Sammamish River, and Lake Washington. Details on how the hardware and software components were applied are provided along with a discussion on challenges encountered and potential next steps for applications and development.

Panel 7A: Ecosystem Indicators for Decision-Making on Sustainability

Chair: Gevan Mattu

The workshop session will present three recently-released reports on ecosystem indicators, from a transboundary, watershed and landscape perspective: the Puget Sound / Georgia Basin Ecosystem Indicators Report; the Fraser Basin Council's "Snapshot" reports; and the Fraser River Estuary Management Program (FREMP) Monitoring Report.

These perspectives will be brought together to illustrate differences in indicator selection, consultation, report development, outreach, and connection with decision-making in these different contexts. The workshop will allow discussion on strategic issues and common challenges relating to the development and use of ecosystem indicators to advance sustainability in our shared region, with a goal of documenting and advancing the "state of the art". Issues to be covered include:evaluating and enhancing the use of indicators; developing sustainability targets and benchmarks; and visual presentation of indicators and data.

Panel Members:

- *Steve Litke, Fraser Basin Council*
- *Zita Botelho, British Columbia Ministry of Environment*
- *Michael Rylko, Environmental Protection Agency*

Session 7B: Marine Fish Dynamics II

Chair: Ruston Sweeting

An Assessment of the Efficacy of Forage Fish Egg Surveys

Kirk Krueger, Washington State Department of Fish and Wildlife*
Dan Penttila, Washington Department of Fish and Wildlife
Timothy Quinn, Washington Department of Fish and Wildlife

Pacific sand lance (Ammodytes hexapterus) and surf smelt (Hypomesus pretiosis) are important forage for Pacific salmon, marine mammals, and marine birds. The state of Washington protects forage fish and their spawning habitat by limiting human activities on beaches where forage fish spawning (i.e., presence of eggs) has been recorded. Extensive surveys using methods developed by the Washington Department of Fish and Wildlife have sampled most of the beaches in Puget Sound. While detection of sand lance or surf smelt eggs is accepted as evidence of presence, the reliability of absence data has not been rigorously assessed. False absences, i.e., concluding the absence of eggs when in fact they are present, may result in issuing permits for activities that disturb forage fish spawning. We calculated the probabilities of detecting the eggs of Pacific sand lance, surf smelt, and either species, given their presence on the beach, using a range of sample sizes at 3 or 4 elevations above mean low low water (MLLW). Our results indicate that a relatively small number of samples are required to reliably detect forage fish spawn. However, the probability of detection for a given number of samples varies by species and by sample elevation relative to MLLW. Failure to detect forage fish spawning is likely due to true absence, but additional samples and sampling across a range of beach elevations can reduce the probability of false absences.

Biocomplexity and Metapopulation Dynamics of Pacific Herring (*Clupea pallasii*) in Puget Sound

Danielle Mitchell, University of Washington*
Pat McAllister, Kurt Stick, Washington Department of Fish and Wildlife
Lorenz Hauser, University of Washington

Although the biocomplexity concept has been used to explain the resilience of salmon metapopulations to disturbance, it is less established for marine populations which are typically difficult to identify. Nevertheless, similar metapopulation dynamics may also affect the abundance of many marine species. Here, we examined temporal and spatial variation in population structure of five spawning aggregations of Pacific herring in Puget Sound (Semiahmoo Bay, Cherry Point, Port Gamble, Quartermaster Harbor, Squaxin Pass) using 12 microsatellite loci. By examining patterns of differentiation over a six year period (1999-2005), we detected different dynamics of two spawning groups: while Cherry Point herring remained genetically differentiated, the genetic differentiation of Squaxin Pass fish in 1999 had disappeared in 2005. We confirm our previous hypothesis that the late spawn-timing of Cherry Point herring relative to other Puget Sound assemblages may act as an effective barrier to gene flow and may promote reproductive isolation of this stock. In contrast, the increase in abundance of Squaxin Pass herring, loss of their genetic differentiation, and results from genetic assignment tests suggest that this geographically isolated population may have experienced increased immigration and possibly replacement by other stocks. We conclude that Puget Sound herring are well described under a metapopulation model.

Application of Population Modeling to Identify the Eastern Pacific Decadal Oscillation as a Factor in the Decline the Cherry Point Pacific Herring (*Clupea Pallasi*) Stock

Wayne Landis, IET, 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. Landis et al attributes the decline to factors operating at large scales. 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. The analysis demonstrates that the causative agent for the decline of the CPPHS existed in the 1974-1975 timeframe with effects persisting until 2004. The results of the analysis of the criteria for causality indicates 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. The other Washington State runs of Pacific herring are

currently undergoing the same analysis.

Diets of Larval and Juvenile Pacific Hake and Walleye Pollock in The Strait of Georgia.

Chrys-Ellen Neville, Richard Beamish, Fisheries and Oceans Canada*

Zooplankton eggs are a major diet item for larval Pacific hake and walleye pollock in the Strait of Georgia at the time of exogenous feeding. Between 1997 and 2003 we sampled the guts of approximately 1500 larval hake and pollock from the Strait of Georgia. The eggs in the guts were various sizes with copepod eggs being the most abundant. Pacific hake have increased in abundance over the last 50 years to become the dominate species in the Strait of Georgia. We propose that the success of Pacific hake is a result of a close linkage of the timing of copepod production and the shift of these larval fish to exogenous feeding. In addition, we discuss how shifts in the marine climate may affect these processes.

A Remarkable Settlement of Young-of-the-Year Rockfishes in Puget Sound and the Strait of Juan de Fuca in 2006

Larry LeClair, Raymond Buckley, Wayne Palsson, Robert Pacunski, Tony Parra, Ocean Eveningsong, Jim Beam, Washington Department of Fish and Wildlife*
Matt McCallum, University of Washington

During 2006, we investigated a remarkably large settlement of post-larval rockfishes (Sebastes sp.) marine waters of Washington. Quantitative scuba transects were conducted to determine the distribution and abundance of young-of-the-year rockfishes in nearshore habitat and how these parameters changed with time and growth. Two major patterns of recruitment were observed. In Puget Sound, high densities of copper (S. caurinus) and quillback (S. maliger) rockfishes were observed in nearshore vegetated habitat including attached floating and submerged macroalgae. Lower densities were observed in eelgrass during the early summer. These post-settlement fish initially measured between 20mm and 40mm total length (TL), increasing to near 80mm TL by early fall when the fish moved toward deeper water and their habitat associations changed. The other pattern in rockfish settlement was observed in the Strait of Juan de Fuca where unusually large schools of rockfishes were observed in September at both the eastern and western ends of the strait. The species composition of these schools was different and more varied than those observed in Puget Sound and included S. melanops, S. pinniger, S. mystinus, S. entomelas, and S. flavidus. Genetic identification using microsatellite loci was used to determine the species composition of sampled juveniles.

Panel 7C: Seagrass Restoration in Salish Sea

Chair: Ron Thom

Seagrasses provide valuable ecological functions to coastal systems but are under constant threat from development and degrading environmental conditions. Although not fully documented, seagrass losses in the Salish Sea region are believed to be extensive. As a result, eelgrass restoration and mitigation has been increasing throughout the region. Because of the challenges in restoring eelgrass and anticipated future threats, a comprehensive and coordinated seagrass restoration program is required to result in a net gain in the area and quality of seagrass meadows. Future restoration projects will need to adapt based on previous data to improve seagrass transplant success, however, the results of the multitude of seagrass transplant efforts are mixed and often not readily available. It is only through open and cooperative region-wide effort that true progress toward a net improvement in seagrass systems will be made. The goal of the session is to provide an opportunity for scientists, consultants and managers to network and present methods and results of seagrass restoration projects.

Panel Members:

- *Jeffrey Gaeckle, Washington State Department of Natural Resources*
- *Pete Dowty, Washington State Department of Natural Resources*
- *Cynthia Durance, Precision Identification*
- *Matthew Boyle, Grette Associates, LLC*
- *Amy Borde, Battelle Marine Sciences Laboratory*

Eelgrass (*Zostera Marina L.*) Status and Trends in Greater Puget Sound: Local Change Within Large-Scale Stability

Jeffrey Gaeckle, Pete Dowty, Blain Reeves, Helen Berry, Washington State Department of Natural Resources
Sandy Wyllie-Echeverria, University of Washington
Tom Mumford, Washington State Department of Natural Resources

The Nearshore Habitat Program in the Washington State Department of Natural Resources (WADNR) has monitored seagrass (*Zostera marina* L.) status and trends throughout greater Puget Sound since 2000 as part of the Submerged Vegetation Monitoring Project (SVMP). The SVMP experimental design and statistical framework extrapolate sound-wide *Z. marina* area from random site-level sampling throughout the greater Puget Sound study area. In 2005, the SVMP estimated there were 20,400 ha of *Z. marina* area distributed equally between flats and fringe seagrass habitat types. There was no significant change in the 2005 sound-wide *Z. marina* area estimate relative to previous years. However, a multi-parameter assessment of site-level change, in addition to independent data, provides cause for concern in two regions of Puget Sound. Nearly 25% of the 62 matching sites sampled in 2004 and 2005 showed a significant decrease in *Z. marina* area during the change interval while only 6% of the sites showed a significant increase. A new analysis of depth distribution found that most of the *Z. marina* sampled was found between 0 to -5 m MLLW (Mean Lower Low Water) with a maximum recorded depth at -11.9 m MLLW.

Biophysical Modeling to Assess the Effect Of Changes in the Light Environment on *Zostera Marina* (Eelgrass) Production and Growth

Pete Dowty, Washington State Department of Natural Resources
Douglas Bulthuis, Washington Dept. of Ecology

In response to localized declines in *Z. marina* in Washington State, the state Department of Natural Resources initiated an effort to investigate the key stressors causing these declines. Data sondes will be deployed in *Z. marina* beds at selected sites to continuously monitor light (PAR) and other water quality parameters. A biophysical model of *Z. marina* production and growth is being developed as a way to synthesize these data streams and interpret site differences in terms of effects on seasonal and annual *Z. marina* performance. The model initially emphasizes plant response to light and builds on the work of R. Zimmerman developed in San Francisco Bay. The model was tested using continuous water quality data collected by the Washington State Department of Ecology at contrasting sites in the Padilla Bay National Estuarine Research Reserve. The results validate basic model behavior and demonstrate the importance of particular patterns in the time-varying light availability.

Eelgrass Restoration and Compensation in the British Columbia

Cynthia Durance, Precision Identification

A tremendous loss of eelgrass (*Zostera marina*) habitat has occurred in the Pacific Northwest over the last century due to filling, dredging, and industrial impacts. With the realization of the importance of these habitats, and in response to the loss and continual development pressure, Fisheries and Oceans Canada instituted a "No Net Loss of Productive Habitat" Policy. In response to this policy in British Columbia, a method was developed that has been used to successfully restore and create eelgrass habitat.

Methods to transplant eelgrass were initially developed in the 1970s and 1980s, primarily along the eastern seaboard of the United States. Initial attempts to transplant eelgrass in the Pacific Northwest

using these techniques were less successful. A transplant method was developed in the mid-1990s in British Columbia that has proven highly successful. The method considers genetic variation between populations of eelgrass, seasonality, and the hydrodynamic regime of transplant sites. The method has been employed at over 30 sites since 1994. The transplanted areas typically achieve natural density and cover within three years. The earliest transplant was 5,400 square meters in 1994 and has provided donor stock for several subsequent transplants. The factors that have contributed to successful restoration and compensation are discussed.

The Drayton Harbor Eelgrass Habitat

Matthew Boyle, Grette Associates, LLC
Mike Stoner, Port of Bellingham
Glenn Grette, Grette Associates, LLC

During the planning phases of the Port of Bellingham's Blaine Harbor Marina Expansion, Port officials identified the opportunity for a large-scale habitat project using clean dredged material from the marina basin. Instead of traditional open-water disposal, the sediment from the marina was deposited at a low spot in Drayton Harbor and resulted in the conversion of over 15 acres of subtidal area to an intertidal/shallow subtidal area that would be more accessible to juvenile salmonids. This was a voluntary action of the Port, and was not required as mitigation.

In order to assess the existing habitat and inform the site locating process, a physical characterization of sediments in existing eelgrass beds was conducted as well as macroinvertebrate surveys in Drayton Harbor. The preferred site was identified based on the relatively low existing habitat function to target species (salmon, Dungeness crab) compared to the surrounding areas, and the potential for increased function. In particular, the likelihood of eelgrass to colonize and thrive on-site was considered a significant potential benefit.

After material had been placed, eelgrass test plots were planted over a five year period. On-going monitoring, including dGPS mapping and aerial photography indicates that planted eelgrass has survived and spread, and volunteer plants have colonized over much of the site. Monitoring for salmonid prey organisms indicates the site is providing rearing habitat for juvenile fish, and Dungeness crab have been regularly observed during monitoring efforts.

The success of the Drayton Harbor site demonstrates the potential for beneficial use of dredge material at a carefully selected location to construct valuable habitat.

Eelgrass Restoration: State of the Science in the Pacific Northwest

Amy Borde, Sue Southard, Battelle Marine Sciences Laboratory

Planting of eelgrass for restoration dates back to the 1970's in the Pacific Northwest, and perhaps earlier. Dr. Ron Phillips conducted plantings in the early 1970's for research purposes. There is anecdotal information that eelgrass was planted as Brant goose feeding habitat by wildlife biologists as far back as the 1940's and 1950's on a very limited basis. A review published in 1990 indicated that a majority (57%) of the eelgrass projects conducted along the west coast (many of which were in the Northwest) were at least partially successful. Eelgrass researchers who were very knowledgeable of plant requirements carried out the most successful plantings. Since that time, eelgrass restoration has advanced in the Northwest primarily as compensatory mitigation for coastal development projects. Eelgrass restoration projects not associated with mitigation are few but growing in number. Although the prevailing view is that eelgrass restoration is generally unsuccessful, there are a number of examples where eelgrass restoration has been accomplished. Successful projects have in common the elements of careful planning, planting and performance monitoring.

Patterns of Change and Stability in Distribution of Eelgrasses and Macroalgae in Padilla Bay, Washington, 1989 to 2004

Douglas Bulthuis, Padilla Bay National Estuarine Research Reserve*
Suzanne Shull, Padilla Bay National Estuarine Research Reserve

Eelgrasses (*Zostera marina* and *Z. japonica*), macroalgal beds (primarily Ulva spp. and Enteromorpha spp.), and intertidal flats without macro-vegetation were mapped in Padilla Bay, Washington in 1989, 2000, and 2004. True color aerial photographs were taken during an extreme summer low tide event each year. Photointerpretation and ground truth investigations (at 100, 250 and 1360 sites respectively) were combined each year with different methods of digitizing and georectification to produce distribution maps of vegetation in Padilla Bay. Comparisons were made among years in the total area covered by vegetation, in the distribution of individual species, and in the gains and losses in local sub-areas of Padilla Bay. Eelgrasses consistently covered 3-4000 hectares of intertidal and subtidal flats in Padilla Bay, with inter-annual variation most pronounced on the intertidal flats above mean water.

Session 7D: Ecological Assessment Following Restoration

Chair: Scott Redman

Historical Changes in Nearshore Sedimentation and Habitat Availabilityi the Skagit River Delta

Eric Grossman, U.S. Geological Survey*
J.P. Walsh, Eastern Carolina University
Doug Bulthuis, Padilla Bay National Estuarine Research Reserve

Restoration of habitat to recover a growing number of ESA-listed taxa is active throughout Puget Sound despite limited understanding of nearshore habitat quality, habitat availability and the extent to which nearshore systems respond to land use. Using seismic reflection profiling and analyses of sediment cores, we reconstruct how nearshore habitats have evolved in response to natural variability over the past several thousand years and human land-use activities over the last 150 years across the greater Skagit River delta. High resolution CHIRP seismic reflection profiles reveal marked reflection surfaces that may be related to erosion or lithology, including Glacier Peak lahar deposits and recent sediments. Sediments from cores reveal abrupt changes in sediment grain size, with significant coarsening offshore of channelized river flow. 210Pb and 14C dating of sediment cores reveals that these abrupt changes began ca. 1850 and that sediment accumulation rates have generally increased ≥10x across extensive areas of the nearshore. These records help to quantify the regional sediment budget and extent to which eelgrass, pocket estuaries and forage fish spawning sites change due to sediment impacts related to land use. They provide key criteria for developing restoration strategies, predicting outcomes, and recovering nearshore ecosystem health.

An Integrated Ecological and Human Health Risk Model for Lake Whatcom, a Multiple-Use Water Supply in Whatcom County WA

Christina M. Maginnis, Wayne G. Landis, Western Washington University*

A screening level integrated ecological and human health risk assessment was conducted for Lake Whatcom in Whatcom County, WA. This multiple-use watershed serves as the only surface water supply for over 86,000 people and lacks a comprehensive management plan. Instead, several jurisdictions have conflicting management responsibilities in regards to land use policies, recreational uses, and data collection efforts. The integrated risk assessment found that land disturbance posed the greatest risk to the endpoints of water quality and human health. A Monte Carlo uncertainty analysis was performed using Crystal Ball software, and revealed that the risk model can

successfully predict risks despite data gaps. Additional data would reduce uncertainty, as well as more clearly identify risk reduction measures for each source. In contrast, a Washington Department of Ecology Total Maximum Daily Loading (TMDL) study focused on limiting Total Phosphorus levels in Lake Whatcom. Unlike the TMDL, the integrated risk assessment calculates risk for multiple sources and stressors, rather than for only one contaminant. An elimination of Total Phosphorus as a stressor would only reduce risk to the watershed by 20 percent. The integrated framework developed in this study is applicable to other regions managing rapid population growth and development in multiple-use watersheds.

Watershed-Scale HSPF Modeling to Evaluate the Hydrologic Effects of Floodplain Restoration and its Ability to Mitigate the Hydrologic Impacts of Highway Construction

Ed Molash, Washington State Department of Transportation*
Joe Brasher, Clear Creek Solutions

The Bear Creek watershed is a 48,000 acre, 4th order tributary to the Sammamish River in King County, Washington. The Washington State Department of Transportation initiated computer modeling investigations to determine whether floodplain restoration at the confluence of Bear and Evans Creeks could mitigate the hydrologic effects of highway expansion by reducing in-stream peak flows and the frequency of erosive and channel-forming flows. A calibrated Hydrologic Simulation Program-Fortran (HSPF) model was modified to examine 11 restoration/mitigation scenarios and the conventional flow control method - a wet vault designed to match pre-developed flow/duration statistics. The results indicate that reforestation of 0.2 percent of the total watershed reduced all peak flows between 50% of the 2 year storm to the 50 year storm by 0.2 percent. Adding backwater wetlands to the floodplain restoration scenarios reduced peak flows by 3.9% to 11.0% and reduced the frequency of significant erosive and channel-forming flows for all scenarios evaluated. The results indicate that floodplain restoration has the ability to "turn back the clock" hydrologically and may be an effective and cost-effective strategy for mitigating the hydrologic impacts of highway construction and associated development.

Session 7E: Stormwater Solutions

Chair: Bruce Wulkan

Non-Point Sources of Pollution in the Lower Fraser Valley: 1970-2006

Jennifer MacDonald, IRES/UBC & Environment Canada*
Sandra Brown, Hans Schreier, Ken Hall, Institute for Resources & Environment (IRES) UBC

How to deal with agricultural and urban non-point sources of pollution are the main water quality challenges in the tributaries of the Lower Fraser Valley. Trends in water quality have been examined over the past 30 years in a large number of watersheds by the UBC team and the results indicate that progress is being made by introducing innovative mitigation and pollution prevention measures. However, nutrient and trace metal problems in the most intensively used agricultural area are increasing. Changes in impervious areas in the urban environment coupled with the increase in transportation are contributing to increased metal and organic contamination in water and sediments. This is demonstrated in two urban, one urban-rural fringe and three agricultural watersheds, which have been studied over a 30 year period. The presentation will highlight the impacts of land use activities on stream, local groundwater and sediment quality. The effectiveness of innovative stormwater detention systems and protective buffer zone measures will be featured to show how such approaches can help in reducing the impacts.

Urban Non-Point Source Impacts on Seattle Area Stream Phosphorus Transport

Michael Brett, Sara Muller, Ben Brattebo, Micaela Ellison, George Arhonditsis, University of Washington*

We have conducted a series of studies looking at urban land cover impacts on stream nutrient transport in the King County region of Puget Sound. These stream catchments assessed are along a gradient of 73% forest to 87% urban land cover, with no major nutrient point sources. Nutrient transport in these study sites was examined at decadal, seasonal, daily and hourly increments. Overall, stream water phosphorus concentrations were moderately strongly correlated with catchment land-cover type, whereas nitrogen concentrations were only weakly correlated with land cover. Dissolved nutrients concentrations had distinct seasonal cycles, with dissolved P peaking in the summer and dissolved N peaking in the winter, but varied little at daily and hourly increments even during storm events. Particulate phosphorus had extremely dynamic concentration fluctuations which were associated with short term flow spikes. Approximately 25% of the total TP transport in these streams occurred during just 2-5% of days, but this transport was dominated by particulate P with low (i.e. 20-25%) bioavailability.

Bioretention Design, Sizing, and Flow Control Benefits

Curtis Hinman, Washington State University*

Over the past few years much attention has been directed to educating engineers, planners, and allied disciplines about low impact development and stormwater management in western Washington. For example, in January 2005, WSU Extension and the Puget Sound Action Team completed the Low Impact Development Technical Guidance Manual for Puget Sound that serves as a resource for western Washington stormwater managers. Currently, little attention has been directed toward homeowners concerning the benefits of LID and in particular design assistance for the primary LID applicationóbioretention or rain gardens. During February 2007 the first rain garden guide for western Washington homeowners will be completed by WSU and regional experts in stormwater management, hydrology, and landscape architecture. To better understand the level of flow control that can be expected from bioretention installations, extensive modeling examining different impervious surface coverage's, soil types and rainfall amounts was conducted using the Western Washington Hydrologic Model (the primary stormwater design model recommended by WA Department of Ecology). WWHM3 PRO incorporates the latest monitoring data on bioretention flow control collected by City of Seattle over the past four years. The presentation will briefly introduce the rain garden handbook and then focus on the modeling process for the project and the resulting bioretention sizing and flow control guidelines.

Stormwater Quantity Control for Highways and Subdivisions- The Case for Exempting Projects Discharging to Large Streams

David Hartley, Derek Stuart, Northwest Hydraulic Consultants, Seattle Office*
Sarah North, Northwest Hydraulic Consultants, Vancouver, B.C. Office

Prior to 2005, Washington State Department of Transportation (WSDOT) and other stormwater management agencies applied "best professional judgment" to identify river reaches "big" enough to receive stormwater runoff directly from highways and subdivisions with no stormwater quantity control facility and only water quality treatment. After the ESA listing of the Puget Sound Chinook, the Federal Services requested that the Department of Ecology (WADOE) and WSDOT provide a scientific rationale for these river exemptions. In eastern Washington, WADOE had recently determined that best available science supported quantity control facilities to protect small streams, but not streams larger than 5th order. This was the departure point for determining criteria for the contrasting climatic, physiographic, and land use conditions west of the Cascades. Since available literature

suggested a lack of precise tools relating stream instability and other impacts to land use actions or stream size, an ecologically cautious approach requiring simultaneous satisfaction of both conservative stream size and land cover change criteria was proposed. GIS tools were conceived and applied to screen all western Washington streams for these two criteria and thus identify reaches suitable for quantity control exemption. The resultant list of exempt reaches has been incorporated into both the 2005 WSDOT Highway Runoff Manual and the WADOE Stormwater Manual for Western Washington.

Using Market Forces to Implement Sustainable Stormwater Management

Jim Middaugh, Dan Vizzini, City of Portland Environmental Services*

Growth and inadequate infrastructure have impaired Portland's natural systems. Traditional responses are inadequate to meet existing or emerging demands. Portland's immediate response is to invest $1.4 billion in large tunnels that will manage about 15 percent of the development planned through 2040. To address community, economic and environmental concerns, Portland also is evaluating the feasibility of using a credit trading system to create incentives for property owners to install small-scale, performance-based stormwater systems. The study is focused on current and future infrastructure needs, the potential environmental and economic benefits from private redevelopment and retrofit opportunities, the relationship of a credit trading system to the financial structure of the City's utilities, the likely levels of public acceptance and participation, and the costs of administering the credit trading system. The project also is attempting to establish ecosystem service values of BMPs compared with traditional piped approaches, confirm valuation of future flow control and stormwater quality, conduct an assessment of the regulatory and policy implications of the program, and to evaluate economic and social equity issues that may arise from it.

Parking Lots to Creeks to Puget Sound

Melinda Fohn, Kitsap County Health District*

Kitsap County Health District (Health District) and Kitsap County Surface and Stormwater Management are taking a unique approach to reduce fecal pollution threatening shellfish beds in Dyes Inlet, Silverdale, Washington. Onsite sewage system inspections, stormwater site inspections, and education of property owners and tenants in this predominantly commercial land use area have resulted in a statistically significant reduction in fecal coliform bacteria in Clear Creek, the major fresh water tributary into Dyes Inlet. Since 2005, the Health District and Surface and Stormwater Management have performed stormwater system site inspections of over 200 targeted commercial properties. Thirty percent (30%) of the properties inspected required maintenance, predominately sediment removal. A majority (96%) of property owners have complied with maintenance deficiency correction requests. Additionally, educational surveys have been conducted with tenants of the properties. Educational surveys inform tenants on how to manage their business to produce clean stormwater runoff. Future work includes completing additional educational surveys, follow-up water quality monitoring of problem stormwater outfalls, and assessing the quality of marine water and streams in the Dyes Inlet watershed. This project educates watershed residents and property owners about their actions linking water quality, public health and stormwater system maintenance.

Low Impact Solutions to Stormwater from Small Farm Confinement Areas

Brian Stahl, Richard Geiger, Kitsap Conservation District*

Located between the Hood Canal and central Puget Sound, Kitsap county drains to both bodies of water, with 228 miles of shoreline and numerous bays and inlets ideal for shellfish growing and boating. The county is also home to approximately 2000 small farms. As development increases, management of storm water through control of impervious surfaces has become critical.

Small farms typically concentrate livestock in heavy use areas (HUAs) for feeding, housing, and other purposes to protect pastureland, prevent soil compaction, and protect natural resources. In wet weather, livestock confined in these areas create mud and impervious conditions. If HUA surfacing has been installed, it is usually considered impervious as well, due to the type of materials, such as concrete and compacted gravels, used. Kitsap County code requires any development or redevelopment which results in the creation or accumulation of five thousand or more square feet of impervious surface (including any impervious HUA areas) to meet Storm Water Drainage requirements.

Using a local model, Kitsap Conservation District will demonstrate a feasibility and engineering methodology that will offer small farm owners solutions to storm water infiltration on their property. This design provides a serviceable HUA and storm water retention, detention and controlled release all within a single area or "footprint." Typically, runoff from an HUA would need to be directed into a separate retention/detention pond with an outlet control structure. This results in several design requirements that detract from the function of a small farm. The separate land area for the pond serves no other purpose, and would probably need to be fenced to keep livestock out. To achieve the required volume, the storm water designer must balance pond surface area against pond depth and length of outlet flow conveyance for the pond to fill and meter out storm runoff with gravity flow. To take advantage of infiltration, the pond's bottom area must be as large as possible. Rather than burden the landowner with situating additional facilities inside a small parcel, all these functions can be integrated within the heavy use area.

Panel 7F: The Shared Waters Alliance: Proactively Addressing Water Quality in an International and Multi-Jurisdictional Watershed

Chair: Julia Brydon

The Shared Waters Alliance (SWA) is an international working group focused on the water quality of the Canadian-US shared waters of Boundary Bay. Boundary Bay's waters support a rich and diverse ecosystem; however, as the region's population has grown, these waters have experienced varying degrees of environmental degradation due to urbanization and agricultural intensification. The SWA was formed in 1999 and is made up of government representatives, First Nations and community groups from both countries. A primary driver for the formation of this working group was the shellfish contamination that had closed Boundary Bay for harvesting since 1962. Since then, the focus of the group has expanded to reflect emerging concerns. Watershed studies have been conducted, including a circulation study of Drayton Harbour and a survey of outfalls along the Bay, which identified the Little Campbell River (LCR) as the most significant contributor of fecal contamination into Drayton Harbour. These results led to a watershed characterization study of the LCR and a water quality monitoring program which links into a watershed forecast modeling system. The experiences of the SWA reflect how a multi-jurisdictional watershed with numerous non-point sources of pollution can be managed through a coordinated effort among different stakeholders. Presentations will be followed by a panel discussion.

Panel Members

- *Alice Cheung, Environment Canada*
- *Pamela Zevit, Adamah Consultants*
- *Christy Juteau, BC Ministry of Environment*
- *Stuart Hamilton, Environment Canada*
- *David Riley, Little Campbell Watershed Society*
- *Carrie Baron, City of Surrey*
- *Hillary Culverwell, Puget Sound Action Team*
- *Joanne Charles, Semiahmoo First Nation*

Panel 8A: Hypoxia in Estuarine and Coastal Areas of the Pacific Northwest

Chair: Jan A. Newton

This session is a panel presentation and discussion of spatial and temporal observations of hypoxia in estuarine and coastal areas of the Pacific Northwest. Invited panelists will present data from the coastal shelf, Georgia Basin, and Puget Sound including Hood Canal. Hypoxia is a complex issue because the factors driving it are diverse and can include both large-scale climate and oceanic forcings as well as local scale perturbations in the watershed or landuse. We will examine the patterns in the entire region and discuss underlying mechanisms. Panelists will present short summaries and then there will be a general discussion with the audience.

Panel Members:

- *Al Devol, University of Washington*
- *Jeff Richey, University of Washington*
- *Wayne Palsson, Washington State Department of Fish and Wildlife*
- *Pete Dowty, Washington State Department of Natural Resources*
- *Joel Elliott, University of Puget Sound*
- *Mitsuhiro Kawase, University of Washington*
- *Bohyun Bahng, University of Washington*
- *Sandy Parker-Stetter, University of Washington*

Session 8B: Juvenile Salmon Habitat

Chair: Kurt Fresh

Distribution Information from Coded-Wire Tag Recoveries of Juvenile Coho and Chinook Salmon Released into the Strait of Georgia and Puget Sound from 1997 to 2007.

Richard Beamish, Fisheries and Oceans Canada*
Ruston Sweeting, Fisheries and Oceans Canada

We report the results of an analysis of over 5000 coded-wire tag recoveries of ocean age 0 coho and chinook salmon captured in our surveys from 1997 to 2007. In the July surveys, a consistent percentage of about 10-15% of the tagged coho in the Strait of Georgia were from Puget Sound. Most (92%) of these coho were from the Nooksack and Skagit River areas (WA01 and WA02). No tagged coho released into the Strait of Georgia were found in Puget Sound and few coho from WA01 and WA02 were captured south of their release areas. Recoveries in Juan de Fuca Strait and off the west coast of Vancouver Island were virtually all from releases from Puget Sound from areas WA01 and WA02. In the September surveys, the number of tagged coho in the Strait of Georgia remained high, while recaptures in Puget Sound dropped dramatically. There were large increases in tag recaptures in Juan de Fuca Strait and off the west cost of Vancouver Island, with most of these coho originating from the southern part of Puget Sound (WA03 to WA05).

About 10% of the tagged juvenile chinook salmon recaptured in the Strait of Georgia in July were from Puget Sound and virtually all were from WA01 and WA02. Only one chinook released into the Strait of Georgia was recaptured in Puget Sound. In September, the percentage of tagged coho released in Puget Sound and recaptured in the Strait of Georgia remained unchanged except that most of these coho came from WA03, WA04 and WA05. Unlike coho, large numbers of tagged chinook salmon were captured in Puget Sound in September. About 3% of these recaptures were originally released off Canada. Catches in Juan de Fuca and off the west coast of Vancouver Island indicated that chinook salmon from Puget Sound the Strait of Georgia were moving offshore.

In general, the pattern of releases and recaptures indicated that coho released into the Strait of Georgia virtually never enter Puget Sound and only a few percent of the chinook released in the Strait of Georgia enter the sound. Virtually all the coho released into Puget Sound and captured in the Strait of Georgia were from the Skagit/Nooksack area. In fact, these coho were not common in our catches in Puget Sound south of this area. Tag recaptures showed that most coho left Puget Sound in August and the Strait of Georgia after September. Chinook remained in Puget Sound through September.

Juvenile Chinook Salmon Use of Small Non-Natal Estuaries in the Whidbey Basin

Eric Beamer, Skagit River System Cooperative*
Aundrea McBride, Skagit River System Cooperative
Kurt Fresh, NOAA - Northwest Fisheries Science Center

Skagit Bay research conducted in 2002 found that wild fry migrant Chinook salmon extensively use non-natal pocket estuaries. Non-natal pocket estuaries are small estuaries within the landscape that are not associated with salmon bearing watersheds. A large estuary like Puget Sound contains river mouth estuaries & smaller-scale estuaries along its margins. Our understanding of Chinook salmon ecology in pocket estuaries has thus far been limited to sites within Skagit Bay. We have now expanded our research to 10 sites throughout Whidbey Basin in order to better understand the potential role of pocket estuaries in the larger scale salmon ecology. Our research has shown that differences in habitat type, annual smolt population size, and landscape connectivity all influence juvenile Chinook salmon use of nearshore habitats. We generally observe higher densities of juvenile Chinook salmon at pocket estuary sites nearest natal Chinook river mouths. We also find 3 of 4 corridor pocket estuary sites (those distant from any river) have consistent juvenile Chinook salmon use, suggesting that corridor sites are also important in the nearshore landscape as salmon travel from their natal rivers to ocean environments. More study is needed to quantify how fish move within the nearshore environment, especially after they have exited natal river estuaries.

Fornsby Creek/Smokehouse Floodplain SRT Project

Steve Hinton, Skagit River System Cooperative*
Rachel Lovelford, Swinomish Tribal Community
Todd Mitchell, Swinomish Tribal Community

Funded by the Washington State Salmon Recovery Funding Board, USFWS, and NRCS this tide gate replacement project conducted by the Swinomish Tribal Community, of LaConner Washington, began baseline data collection in 2003. In 2005 an "Aberdeen style" gate design was installed and tested. In addition, the project included several floodplain and riparian elements designed to improve habitat quality in preparation for salmonid utilization. The project went fully operation during the salmonid out migration period early in 2006. This presentation provides a glimpse at initial monitoring results from data collected on fish use, groundwater effects, surface water, and salinity movement through the 2006 migration season relative to baseline information. This presentation also provides insight to the design, implementation and operation of a barn door style hydraulic design as a solution to fish passage issues.

Juvenile Salmonid Use of Off-Channel Marsh and Vegetated Distributary Channel Edge Habitats in the Snohomish River Estuary, Puget Sound

Mindy Rowse, NOAA/NMFS/NWFSC*
Andrew Haas, Snohomish County, Department of Public Works
Kurt Fresh, NOAA Fisheries, Northwest Fisheries Science Center
Anna Kagley, NOAA Fisheries, Northwest Fisheries Science Center
Joshua Chamberlin, NOAA Fisheries, Northwest Fisheries Science Center
Todd Zackey, The Tulalip Tribes, Natural Resources Department

The Snohomish River estuary/delta provides critical habitat for Chinook and other juvenile salmonids as they migrate from freshwater to ocean feeding grounds. Juvenile salmon use off-channel marsh and vegetated

distributary channel edge habitats for rearing during their transition between fresh and salt water. Although use of off-channel marsh habitat is well documented, little is known about use of distributary channel margins. In the Snohomish delta, 85% of the pre-settlement tidal marsh extent has been lost due to diking and filling. Most remaining habitat is located along the edge of four major distributary channels. Diking, clearing and LWD removal have greatly simplified these estuary habitats. We studied juvenile salmon use of off-channel marsh and vegetated channel edge habitats in spring and summer using enclosure traps. We compared blind tidal marsh channels, simple (no LWD) vegetated distributary channel edges, and complex (LWD) vegetated distributary channel edges. Preliminary results indicate channel edge habitats have increased species richness when LWD is present. Edge habitats also have similar salmonid densities compared to off-channel marsh habitats. Relative to juvenile salmon distribution and the continuity of suitable habitats, distributary channel edge habitat represents an area important for juvenile salmonids rearing in the Snohomish River estuary.

Spatial and Temporal use of the Snohomish River Estuary by Four Species of Juvenile Salmon

Kurt Fresh, Mindy Rowse, Anna Kagley, NOAA Fisheries, NWFSC*
Brian Keldar, Tulalip Indian Tribe (currently at Syracuse University)
Joshua Chamberlin, NOAA Fisheries, NWFSC
Todd Zackey, Tulalip Indian Tribe

Since 1991, we have been studying spatial and temporal patterns in use of intertidal areas of the Snohomish River Estuary by juvenile salmon using beach seining. We found that hatchery produced juvenile coho and Chinook salmon appeared to move rapidly through the system. Naturally produced juvenile Chinook salmon were typically present for the longest time period with juveniles present in some years from the beginning of sampling in February until sampling terminated in September/October. Few juvenile Chinook salmon were present in intertidal areas after water temperatures exceeded 17-18C. The shortest species residence times were generally for pink salmon (March to May) and coho salmon (May to July) although in several years, we found coho salmon juveniles in estuarine habitats into late fall. The presence of chum salmon juveniles as large as 75mm suggested some chum salmon were rearing either in lower mainstem wetlands or estuary. Although all species used all areas of the estuary, fish were generally more abundant in mainstem channel habitats than in the major distributary channels. Considerable annual variability in abundance and distribution of all species using the estuary was observed and was likely due to a combination of factors including environmental conditions and variability in escapement.

Session 8C: Invasive Species I - Spartina

Chair: Tom Therriault

Aquatic Nuisance Species in the Pacific Northwest - - Update from the 2003 Georgia Basin Puget Sound Conference

Stephen Phillips, Pacific States Marine Fisheries Commission*

In 2003, we gave a presentation at the Georgia Basin Conference on responses to aquatic nuisance species of concern. This talk will provide a PSMFC ANS program update, including past, present and future activities.

We continue to direct funds at four aquatic nuisance species: zebra mussels, Atlantic salmon, green crab and Chinese mitten crab. Other species are drawing interest as well.

We continue monitoring the abundance and distribution of the European green crab along the west coast. A pilot green crab eradication project in California was started in 2006. In Washington, we continue to fund Atlantic salmon monitoring. A predictive model for estimating the potential West Coast range and population size for Chinese mitten crabs was developed by Portland State University.

The year 2003 marked the beginning of the Bicentennial of the Lewis and Clark expedition, and the concern was that the predicted thousands of boats traveling the route could be an invasive species vector, particularly zebra mussels. A program was put in place to stop the potential introduction of zebra mussels from this event – what did we learn?

This talk will provide information on a zebra mussel economic impact study and the development of zebra mussel rapid response plan.

A collaborative approach to Spartina detection and removal in the Georgia Basin - Spartina

Kathleen Moore, Canadian Wildlife Service, Pacific Wildlife Research*
Gary Williams, GL Williams & Associates
Rob Knight, Community Mapping Network
Tom Blackbird, British Columbia Ministry of Environment
Verne Kucy, Corporation of Delta
Amber Smith, Vancouver Aquarium Marine Science Centre
Juergen Baumann, Vancouver Port Authority
Richard Wallis, Greater Vancouver Regional District
Dan Buffett, Kim Houghton, Ducks Unlimited Canada
Nikki Wright, Seagrass Conservation Working Group

In the fall of 2003, *Spartina anglica* was discovered during habitat surveys in the Fraser River Delta (Vancouver, British Columbia). Since this invasive plant can negatively impact mudflats, a multi-agency partnership was formed to monitor and remove Spartina. Since 2003 the agencies have located infestations using a rapid assessment method (i.e. hovercraft) and walking shorelines with hand held global positioning systems (GPS). The GPS data was mapped using a geographical information system (GIS) and entered on the Community Mapping Network website allowing all agencies and the general public access to the information. Control methods were restricted to manual methods, which include digging up individual plants and small clones, and mechanical "deep in situ" burial of large clones using a low ground pressure excavator. Despite limited funding and resources, the partnership have removed all identified locations from Roberts Bank, significantly reduced the distribution and amount of Spartina in Boundary Bay and expanded detection to the east coast of Vancouver Island. In addition, agencies from BC and Washington have cooperated on sharing data, a drift card survey, outreach information and technical expertise for the detection and control of Spartina demonstrating a strong cross border partnership.

Is Spartina Eradication Possible in Puget Sound?

Randy Taylor, Washington State Department of Agriculture*

Spartina , commonly known as cordgrass, is an aggressive noxious weed that seriously disrupts the ecosystem of native saltwater estuaries in Puget Sound. Spartina out competes native vegitation and converts mudflats into monotypic Spartina meadows, destroying important migratory shorebird and waterfowl habitat, and severly impacting shellfish production.

WSDA is leading a cooperative effort to eradicate Spartina from Puget Sound. Using an Integrated Pest Management approach, the effort has resulted in a reduction of Spartina from a high of approximately 1000 solid acres in 1997 to roughly 300 acres at 99 sites in Puget Sound in 2006.

The reduction of infested acreage presents new challenges to the ultimate goal of total eradication. As the infested acreage shrinks, it becomes more and more difficult to seek out remaining plants in the vast acreage of Spartina habitat. The resources are available to ensure eradication at smaller individual sites, but we must develop new methods and resources to achieve total eradication in the entire Puget Sound.

Spartina Mapping and Drift Card Tracking on the Community Mapping Network

Rob Knight, Community Mapping Network*

The Invasive Species Atlas on Community Mapping Network (CMN) is one of over 50 web-mapping projects that CMN has developed for its partners. It focuses on locating and describing the rapidly expanding suite of invasive species as accurately as possible. CMN is working on bridging the information gaps in provincial/state data by engaging citizens groups and concerned agency staff in BC and Washington.

Spartina sp. is a particularly nasty genus of intertidal invasive plants that threaten the productivity of the Pacific Flyway. They are showing up in the Georgia Basin and are well established in areas of Puget Sound. In BC "Spartina Busters" has started mapping locations of Spartina and is using those data to coordinate mechanical removal. *Spartina anglica* is the big concern right now because so aggressive but plant clusters are still small enough to be dealt with using hand shovels and backhoes.

At the same time, folks in Puget Sound and BC have started a drift card study to anticipate where Spartina may be found next. Drift cards released monthly from 6 Spartina locations are being reported by US & Canadian citizens when found, using CMN's on-line digitizing function.

The CMN is an NGO dedicated to sharing a wealth of natural resource information and maps with communities, locally and internationally. CMN integrates data from many sources and makes it accessible through a user-friendly web mapping system, providing a unique set of tools to explore and promote awareness of natural resource features. Using a network of distributed servers, CMN offers Internet access to comprehensive base mapping, aerial imagery and local information, working closely with other NGOs and local governments.

Modeling Habitat Capability for Invasive Species Using the Shorezone Mapping System

Jodi Harney, John Harper, Coastal and Ocean Resources Inc.*
Mary Morris, Archipelago Marine Research Ltd.

ShoreZone is a coastal habitat mapping and classification system in which low-altitude, georeferenced aerial imagery is collected specifically for the interpretation and integration of geological and biological features of the intertidal zone and nearshore environment. The mapping system (housed in ArcGIS and MS Access databases) provides a spatial framework for coastal habitat assessment on local and regional scales. Mapped regions now include more than 16,000 km of coastline in the Gulf of Alaska (see www.CoastAlaska.net) and 45,000 km of coastline in British Columbia and Washington state (from the Columbia River mouth to the Alaska/BC border). An additional 10,000 km of imagery was collected in Alaska in 2006.

Current research applications involve habitat capability modeling, in which physical and biological attributes mapped in the ShoreZone database are used to predict the distribution of habitats that would support a particular group or species of interest. For example, a capability model developed for the European green crab (Carcinus maenas) appraises the sensitivity of shorelines in Washington, BC, and southeast Alaska to colonization by this invasive species. Potential green crab habitat "hot spots" identified by the model could provide a spatial basis for the planning and implementation of monitoring stations for species detection.

Subtidal Marine Invasives in Marinas

Glen Jamieson, Lucie Hannah, Thomas Therriault, Fisheries and Oceans Canada*

Marinas on the east side of Vancouver Island were surveyed for subtidal invasive species in August, 2005, both to determine the abundance and spatial distribution of species and to assess whether marina features could be correlated with invasive species occurrence. Marina features considered were overall marina size, determined by total length of moorage capacity; and abundance and distribution of invasives within each marina, i.e., on the outer perimeter or more centrally located within the marina. Scrapings of about about 500 cm2 were taken from floating docks and both indigenous and invasive species presence were documented. Results are summarized, and recommendations provided as to how subtidal inventories for invasive species can be most effectively conducted.

Panel 8D: BC's Coastal Douglas-Fir Zone

Chair: Andy MacKinnon

British Columbia's Coastal Douglas-Fir (CDF) ecological zone is a small coastal rainshadow zone situated primarily on southeastern Vancouver Island and the southern Gulf Islands. This area has less remaining old-growth forest, fewer protected areas, less provincially owned (Crown) land, and more developed land than any other ecological zone in BC. The population in this zone is also increasing rapidly. Not surprisingly, this area also contains a disproportionate number of threatened and endangered plants, animals and ecosystems. This session will highlight recent inventory and conservation initiatives in BC's coastal rainshadow forests.

Panel Members:

- *Andy MacKinnon, British Columbia Ministry of Forests and Range*
- *Tara Sharma, Parks Canada*
- *Marlow Pellatt, Parks Canada*
- *Trevor Jones, University of British Columbia*
- *Todd Golumbia, Parks Canada*

Conservation Challenges in BC's Coastal Douglas-Fir Zone

Andy MacKinnon, British Columbia Ministry of Forests and Range

BC's Coastal Douglas-Fir (CDF) biogeoclimatic zone is BC's most developed, least protected ecological zone. This coastal rainshadow area, located primarily on southeastern Vancouver Island and the southern Gulf Islands, contains a disproportionate number of threatened and endangered species and ecosystems. And management options are constrained because approximately 93% of the zone is private land. This paper describes this ecological zone, reviews land ownership and status, and describes current initiatives in inventory and conservation in the CDF.

Mapping landscape changes in the Gulf Islands National Park Reserve

Tara Sharma, Parks Canada

Established in May 2003, the Gulf Islands National Park Reserve protects Dry Coastal Douglas-fir ecosystems. The park is subject to ecosystem pressure as it is in close proximity to a rapidly growing region and is a hub of tourism in the region.

The objective of this study was to identify and map the natural and anthropogenically-caused changes in the park's greater ecosystem to support park planning and management. Historical orthophotos at the scale of 1:10,000 to 1:15,000 from 1950 to 2004 were used to map different ecosystems. These maps were overlayed in a GIS to derive ecosystem change maps showing hot spots of landscape changes and to generate various change statistics. In parallel, projects on a detailed terrestrial ecosystem mapping and a LiDAR-based mapping are in progress to generate species-level information that will help enhance the landscape change detection to provide information for restoration planning and protection in the park. In this paper, results will be presented for landscape changes that have taken place in the area in past 50 years.

Using of Paleoecology and Bioclimatic Envelope Modeling to Garry Oak (Quercus Garryana) Ecosystems in the Coastal Douglas-Fir Zone of Southwest British Columbia.

Marlow Pellatt, Parks Canada
Ze'ev Gedalof, Department of Geography, University of Guelph
Karin Bodtker, Parks Canada
Marian McCoy, Department of Biological Sciences, Simon Fraser University

Alex Canon, Environment Canada

Under the Canadian Species at Risk Act (SARA) Garry oak ecosystems are listed as "at-risk" and act as an umbrella for over one hundred species that are endangered to some degree. In order to effectively recover or allow these species to persist where possible, it is critical to understand the ecological process essential for their ongoing survival. The project I will discuss is a multi-disciplinary research project that examines the paleoecology, modern ecology, ethnobotany, and fire history of selected Garry oak ecosystems. Understanding mean fire return intervals, ecosystem dynamics over time, and the role of people in this ecosystem structure is critical to the long-term survival of these communities. We develop bioclimatic envelope models to display future scenarios for Garry oak distribution in order to consider climate change in the potential persistence and recovery of Garry oak ecosystems at a spatial scale relevant to land managers. We are synthesizing the results of this project and proposing management actions to assist protected area managers, scientists, and recovery teams in the task of ecosystem management and restoration. The restoration of ecosystem processes may help in the long-term conservation of these systems and achieve ecological integrity in Garry oak ecosystems.

Integrating Advanced Spectral and Structural Remotely Sensed Data to Improve Vegetated Terrestrial Ecosystem Mapping and Monitoring

Trevor Jones, Nicholas Coops, Universtiy of British Columbia
Tara Sharma, Parks Canada: Gulf Islands National Park Reserve

The Gulf Islands National Park Reserve encompasses 35 square kilometers of lands spread over 15 islands and numerous islets in British Columbia. Rapid urbanization in the region makes this area one of the most threatened landscapes in Canada. To ensure long-term ecological integrity within the Park, accurate and up-to-date information on the various ecosystem components is required. Information yielded from conventional aerial photography-based Terrestrial Ecosystem Mapping provides some of this information, but is costly and requires significant interpretation making it poorly suited for operational monitoring. Satellite-based remotely sensed data offer a viable option for reliable and repetitive ecosystem mapping in a cost efficient manner; however, broad-band data have limited spectral and spatial resolution, making vegetative species discrimination, and changes in forest canopy structure difficult to predict. Recently, hyperspectral remotely sensed data has been shown to improve vegetative discrimination whilst airborne LIDAR data is increasingly being used to represent 3-dimensional terrain and forest canopy structure. This research investigates the integration of Landsat TM data with AISA hyperspectral imagery, and LIDAR, in conjunction with field observations, to derive structural, compositional, and distributional information related to terrestrial ecosystems within the Reserve. The initial results and future direction of this research are presented.

Baseline Inventory, Ecological Classification and Mapping the Southern Gulf Islands: A Framework for Ecosystem-based Management

Todd Golumbia, Parks Canada

Gulf Islands National Park Reserve (GINPR) was established in May 2003. It is comprised of 3500 ha of land and 2600 ha of coastal and nearshore subtidal areas on 16 islands and over 30 islets and adjacent marine areas throughout the southern Gulf Islands region of British Columbia, Canada. The key objectives for the GINPR are to ensure the long-term integrity of the ecological and cultural values within the park; and to provide opportunities for the public to learn about and appreciate values within the park in a low-impact manner.

Due to the fragmented nature of park lands, inventory initiatives have utilized regional partnerships to support well-informed decision-making in the greater ecosystem for ourselves and our neighbours. In order to ensure that ecological integrity is given appropriate consideration, numerous surveys have been undertaken over the past 3 years to establish an understanding of baseline conditions at establishment. Data acquisition includes an assessment of current conditions using high resolution ecosystem mapping of terrestrial, freshwater and coastal areas as well as historic snapshots of land use from 1933, 1950 and 1975. As these data sets are compiled, we are now able to provide meaningful data analysis in support of management decision making, ecosystem representation and landscape scale monitoring.

This talk will provide an overview of the various products and offer examples of their current and proposed applications.

Session 8E: Nearshore Restoration Planning

Chair: Curtis Tanner

Scaling Tidal Channel Geometry with Marsh Island Area: A Tool for Habitat Restoration, Linked to Channel Formation Process.

Gregory Hood, Skagit River System Cooperative*

Hydraulic geometry and related analyses are often used to investigate tidal channel geometry and evolution, and inform marsh restoration. An alternative approach is presented that avoids calculating tidal prism and allows analysis of additional channel metrics. It relies on scaling relationships between marsh island surface area and various metrics of the set of tidal channels draining each island. In the Skagit Delta marshes (Washington, USA), total channel surface area and length, and surface area of the largest channel draining an island scaled disproportionately with island area, suggesting restoration of a 100-ha site would be preferable to restoration of ten separate 10-ha sites to maximize channel length and area. A model of channel formation through random island conglomeration replicated observed scaling patterns, linking channel scaling to blind channel evolution from river distributaries. Channel size and complexity varied spatially, with significant deficits in an eroding marsh isolated from river distributaries and riverine sediments.

March Point Geomorphic Mapping and Restoration Assessment, Skagit County, WA

Jim Johannessen, Andrea MacLennan, Coastal Geologic Services*

This study of March Point, located between Fidalgo Bay and Padilla Bay in the northern Puget Sound region, was conducted for the Skagit County Marine Resources Committee. March Point contains degraded forage fish spawning areas, impacted salt marshes, and long reaches of shore protection. The project included current conditions and historic reconstruction of key bluff sediment sources and accretion shoreforms. Current conditions mapping was performed using geomorphic reconnaissance by small boat with GPS, with maps developed in a GIS. Historic reconstruction was accomplished though analysis of all relevant historic maps, charts, air and ground photos, along with historic records of landslides and related topics. Additional historic change analysis was conducted in GIS to determine erosional rates and trends at March Point cusp and Crandall Spit complex, which were identified as important nearshore habitat areas in previous studies. Specific coastal restoration recommendations were provided based on results of quantitative GIS analysis of current and historic conditions, along with past studies of the shore of March Point. Restoration options were prioritized to assure that restored sediment supply would benefit important nearshore habitats. The sustainability of restoration recommendations was also a major consideration and both short term and long term projects were outlined, along with cost estimates.

A Landscape Process Based Restoration Plan for North Fidalgo Island, Washington

Aundrea McBride, Eric Beamer, Skagit River System Cooperative*

We propose a preliminary restoration plan for the North Fidalgo Island shoreline based on restoring natural processes at the drift cell-

or geomorphic cell-scale. Working within a geomorphic framework yields more predictable and sustainable results, and maximizes the complexity and diversity of habitats restored based on the natural landscape potential. The North Fidalgo Island restoration plan is based upon historic change analysis, field reconnaissance, and application of a geomorphic model. The historic Fidalgo Island shoreline included shallow bays with eelgrass, lagoons, small tidal creeks, forage fish spawning beaches, and rocky habitats with kelp. Many of these habitats still exist but are heavily impacted. Historically, there were 11 small pocket estuaries along the north Fidalgo Island shoreline, totaling at least 150 acres. Under present conditions, there is only 1 estuary site (12 acres) with habitat accessible to fish. Physical restoration potential exists for 6 of the historic sites, for a gain of approximately 43 acres of additional habitat area. Restoration of these 6 sites will decrease the distance that fish must travel between pocket estuaries. Similar losses have occurred in other important habitats, such as eelgrass meadows and forage fish spawning beaches. This approach to restoration is being applied throughout the Whidbey Basin as well.

Multi-Scale Analysis for Shoreline Restoration Planning: Linking Science to Policy and Stewardship

Michelle McConnell, Jefferson County*
Stephen Stanley, WA Dept. of Ecology
Heida Diefenderfer, Battelle Marine Sciences Laboratory
Margaret Clancy, ESA Adolfson

How do you decide where to focus your efforts in order to maximize restoration efforts and other management approaches given limited funds and competing interests? By combining landscape analysis, watershed scoring and nearshore assessments, Jefferson County is taking a novel approach to the restoration planning component of their Shoreline Master Program (SMP) Update. This presentation links landscape-scale characterization of ecological processes, watershed-scale scoring of those processes' level of importance and level of alteration, and marine nearshore reach-scale scoring of ecological functions and stressors to develop a tool that will help prioritize restoration opportunities both in and out of the shoreline area, help guide development of the goals, policies, designations and regulations for the Jefferson County Shoreline Master Program, and is flexible enough to accommodate new data as they become available for an adaptive management approach. The results are a powerful database of GIS layers, easy-to-read color coded matrices and maps that show areas of high, medium, and low relevance. This approach is designed to meet and exceed the Washington State Guidelines for SMP Updates (WAC 173-26).

Analysis of Methodologies for Prioritizing Nearshore Restoration Areas in Puget Sound and the Northwest Straits

Kirstin Holsman, Camille Russell, Eric Stover*, Robin Clark, People For Puget Sound*

Restoration and conservation activities in Puget Sound and the Georgia Basin have increasingly focused on restoring ecological processes that support numerous aquatic species and ecosystems while addressing basin-wide ecosystem threats and consequences. These activities are increasingly supplemented by responses from local jurisdictions to shoreline management programs that require the protection and restoration of critical habitats in the nearshore regions. Consequently, there is a growing need to assess the role of multiple, interdisciplinary and site-specific nearshore restoration projects and methodologies currently of significance in the Puget Sound region. Within this context, People for Puget Sound, a non-profit advocacy group, has developed a meta-analysis of timely and significant projects, inventories, characterizations, and assessments to inform a new approach for prioritizing site-specific, habitat restoration projects. Our work synthesizes a diverse pool of studies and methodologies derived from non-profit organizations, academia, government agencies, private consulting groups, and research entities. Our approach builds upon existing methodologies based on ecological function, geomorphological and shore-form characterization, and flow and process modeling, while evaluating our current prioritization methodology, The Bays Blueprint, which relies on volunteer-based shoreline observations, aerial photography, and digital shoreline information. This paper synthesizes and examines the methodologies, and explores new strategies for filling knowledge and data gaps, prioritizing restoration projects, and conducting cost and feasibility analyses in nearshore habitat restoration.

Community Nearshore Restoration Program

Sue Texeira, Richard Brocksmith, Hood Canal Coordinating Council*

The Hood Canal Coordinating Council's Community Nearshore Restoration Program (CNRP) is a combined education and a restoration program for marine waterfront property owners. It provides education on nearshore processes and ecosystem functions in marine "edge" habitats, and how anthropogenic disturbances impact those processes and functions. The CNRP has been conducted on three small-scale segments of nearshore in Lower Hood Canal, and will continue to expand north. The CNRP is a community-initiated program where shoreline landowners advise, promote, attend, educate, host, and continue support through an ambassadorship role. The education is delivered through workshops and beach walks where attendees learn the habitat essentials that benefit salmon and water quality. At beach events, specialists discuss stewardship practices and identify potential restoration or preservation projects with landowners. The CNRP helps landowners find funding for habitat restoration projects and protection. Through the Marine Riparian Initiative landowners are provided technical assistance on planting plans, plantings, noxious weed removal, and given native shoreline plants. The results are a new group of informed property owners that will lead to more ecologically friendly methods of developing and managing their land; provides more detailed information to the regional nearshore study; greater opportunities to work with nearshore property owners on submitting project applications.

Session 8F: Ecotoxicology in the PS/GB: From Fish To People

Chair: Tracy Collier

Pacific Herring Bioassays for Testing Effluent and Marine Water Toxicity

Paul Dinnel, Western Washington University*
Randall Marshall, Washington Department of Ecology
Douglas Middaugh, U.S EPA, Retired
Karen Bergmann, James Elphick, Nautilus Environmental

Pacific herring (*Clupea pallasi*) is an important forage and commercial fishery species throughout its range on the Pacific Coast of the U.S. and Canada. The largest Washington State herring stock at Cherry Point has suffered substantial declines in the last decade. While much of this decline may be due to natural factors and excess fishing pressure, both point and non-point sources of pollution cannot be ruled out as potentially significant stressors that may be acting in concert with other factors. Ongoing concerns about possible effects of chemicals in effluents and sediments on early life stages of Pacific herring resulted in an effort by the Washington Department of Ecology to develop embryo and larval Whole Effluent Toxicity (WET) test protocols for future testing of effluents in Washington. Three early life stage test protocols have now been successfully developed (and partially validated): 1) an 18-day embryo development test with both lethal and sublethal endpoints, 2) a 4-day acute larval test using early post-hatch larvae, and 3) a 10-day survival and growth test that uses Artemia nauplii as a food source. Additionally, there is good potential for establishing a future sediment test protocol using the embryo development test.

Estrogenicity of Municipal Sewage: Toxicogenomic Studies with Chinook Salmon (Oncorhynchus tshawytscha)

Heather Osachoff, Simon Fraser University and Environment Canada*
Joy Bruno, Environment Canada
Rachel Skirrow, Environment Canada
Tom Mommsen, University of Victoria
Chris Kennedy, Simon Fraser University
Graham van Aggelen, Environment Canada

As a five year Georgia Basin Action Plan project, the Environmental Toxicology Section at the Pacific Environmental Science Centre is investigating the potential impacts on salmon of emerging chemicals of concern (in effluents such as sewage) that enter the Georgia Basin. Studies use a toxicogenomics approach - combining the fields of environmental toxicology and genomics - with a custom cDNA microarray to examine the effects of sewage on liver gene expression in chinook salmon (*Oncorhynchus tshawytscha*) exposed to environmentally relevant sewage dilutions (a 200-fold range). Data presented focus on the estrogen-responsive subset of genes contained on the microarray, including: vitellogenin (VTG; structural egg protein often used as a biomarker), vitelline envelope proteins (VEPs; three structural egg proteins), and estrogen receptor (ER; transcription activator). VTG and VEPs are female-specific egg proteins not produced by male fish unless stimulated by an exogenous estrogen-mimicking chemical. Results show the absence of VTG gene induction in sewage-exposed fish in our experiments, while other estrogen-responsive genes (VEPs, ER and others) are clearly induced, some of them very strongly. Discussion includes preliminary interpretations: 1. a hypothesis that the VEPs are early, highly sensitive indicators of estrogen-mimicking compounds, and 2. a novel concept of two different types of estrogenic response to pollutants: a response with or without VTG gene induction.

Mortality of Swans Due to Ingestion of Lead Shot in NW WA and SW B.C.

Cindy Schexnider, U.S. Fish and Wildlife Service*
Mike Smith, Washington Cooperative Fish & Wildlife Research Unit, University of Washington
Laurie Wilson, Environment Canada (Canadian Wildlife Service)
Mike Davison, Washington Dept. of Fish and Wildlife
Martha Jordan, The Trumpeter Swan Society
Jennifer Bohannon, Washington Dept. of Fish and Wildlife
Sean Boyd, Environment Canada (Canadian Wildlife Service)
Chris Grue, Washington Cooperative Fish & Wildlife Research Unit, University of Washington

At least 2,100 swans (mostly Trumpeter Swans [Cygnus buccinator]) have died in Whatcom County, Washington and Sumas Prairie, British Columbia during the past seven winters, the majority from ingestion of lead shot. In 2001, the Canadian Wildlife Service, the Washington Department of Fish and Wildlife, the US Fish and Wildlife Service, and other stakeholders jointly initiated a study to locate the sources of lead and halt the swan mortalities. Results are presented for 2001-2006. The overall area of the suspected lead source has decreased from 100,000 ha to less than 10,000 ha. Swans were trapped, blood samples collected and analyzed for lead, and trumpeter swans fitted with VHF radio or satellite transmitters. The locations of radio-tagged swans were recorded each day and night to determine forage and roost sites. Carcasses were examined and cause of death determined. Core sampling in forage fields and roost sites has revealed lead shot contamination in high swan use areas. An experimental technique of hazing a relatively high lead shot density roost site is being conducted during the 2006-2007 winter, while swan mortalities and habitat use patterns continue to be monitored.

Toxic Chemicals in Washingtonians: Findings of the Pollution in People study

Margaret Shield, Toxic-Free Legacy Coalition*

The first comprehensive body burden study of toxic chemicals in Washington residents was reported in 2006 by the Toxic-Free Legacy Coalition, a state-wide alliance of health and environmental organizations. Accredited labs analyzed levels of parent compounds or metabolites of: heavy metals, PBDEs, phthalates, perfluorinated compounds (PFCs), pesticides, and PCBs in blood, urine, or hair samples donated by ten individuals. Results confirm that exposure to these chemicals is pervasive. Individuals tested had at least 26 and as many as 39 toxic chemicals. PFCs, phthalates, PCBs, and mercury were detected in all participants, through exposures from food, products, and other sources of pollution.

Study results will be presented and their significance discussed by the lead author. Two study participants, an occupational health nurse and an environmental health advocate, will share personal and professional views on the findings. Actions to reduce chemical exposures in occupational, community and home settings will be outlined. The successes and challenges of a new initiative at Children's Hospital to reduce toxic exposures to patients and staff will be described. Washington State's policy climate for improved chemical regulation will also be discussed, including the accomplishments and challenges of the state's program on Persistent Bioaccumulative Toxins and new policy options to prevent harm to future generations from unnecessary exposures to toxic chemicals.

An Ecotoxicology Research Plan for Puget Sound

Nathaniel Scholz, Tracy Collier, NOAA Fisheries, Northwest Fisheries Science Center*

Ecotoxicologists at NOAA's Northwest Fisheries Science Center have been investigating the impacts of chemical contaminants on fish and other NOAA trust resources in Puget Sound for more than three decades. Early research was largely focused on human land use activities of the past. This included assessing the impacts of contaminated "hot spots", or localized sediments with high levels of PCBs, PAHs, and other chemicals associated with the industrial activities of the last century. In recent years, the research challenges related to toxics in Puget Sound have become more complex. The sphere of concern has expanded from contaminated sediments to the pelagic food web and, more recently, to watersheds that are increasingly undergoing development. As a consequence of regional population growth and urbanization, terrestrial runoff and other forms of non-point source pollution are now among the most important sources of chemical contamination in the Puget Sound ecosystem. In response to these challenges, this presentation will identify current NOAA research priorities in three theme areas. These include 1) mechanistic laboratory research to identify novel pathways of toxicity, to establish thresholds for adverse health effects, and to develop new tools to diagnose injury; 2) environmental monitoring and experimental manipulations to assess the status and health of flatfish, rockfish, salmon, forage fish and other species in the field; and 3) the use of GIS analyses, population modeling, risk assessment and other approaches to forecast the cumulative and long-term impacts of toxics on the Puget Sound ecosystem. Several cross cutting issues will also be discussed, including 1) the need for new research on emerging contaminants; 2) the effectiveness of source control efforts to reduce contaminant loading; 3) the efficacy of habitat restoration activities in polluted environments; 4) the need to consider multiple stressors (chemical and non-chemical); 5) the need for more ecology ("eco") in ecotoxicology; and 6) the need to connect the health of individual organisms to population-scale processes.

Session 9A: Hypoxia in Hood Canal

Chair: Jan Newton

In Situ and Remote Monitoring of Hypoxia in Hood Canal: the ORCA Time-Series at Twanoh

Wendi Ruef, Allan Devol, Jan Newton, Colin Smith, University of*

Washington

High frequency profiles of chemical, physical, and biological properties have been collected by an autonomous moored profiling system at a fixed station in southern Hood Canal since January 2005 using surface meteorological sensors and a profiling underwater instrument package consisting of a Seabird CTD, dissolved oxygen electrode, and chlorophyll fluorometer.

The water column at this station was strongly stratified through-out the seasons. Data collected during large wind storms indicate localized mixing during the event and rapid restratification after the wind forces relaxed. The bottom water (lower 5 meters) was persistently hypoxic and surface water (upper 10 meters) oxygen concentrations fluctuated between undersaturated and supersaturated seasonally. Large chlorophyll blooms were observed throughout the year with subsurface maxima during the summers. Maximum bottom water oxygen concentrations of ~90 umol/kg (~2.81 mg/L) were observed at depth in the spring and decreased through early fall. The rate of decrease was faster in 2006 and the minimum fall oxygen was also lower. Deep oxygen concentrations rebounded by November in both years. A box model was used to evaluate the roles of sedimentary oxygen consumption, water column respiration, and advective oxygen input in maintaining the persistent hypoxia in the bottom water through out the year.

Hood Canal Fish Kill of 2006

Allan Devol, Wendi Ruef, Jan Newton, University of Washington*

As part of the Hood Canal Dissolved Oxygen Program, 4 autonomous moored profiling systems (ORCAs) have been deployed in Hood Canal, Puget Sound Each system collects high frequency (bi-hourly) profiles of chemical, physical, and biological variables at fixed stations using surface meteorological sensors and a profiling underwater instrument package.

On September 19, 2006, a major fish kill occurred in southern Hood Canal. Data collected by the ORCA moorings suggest this fish kill was caused by the combination of the gradual depletion of deep water oxygen, followed by shoaling of oxygen depleted deep water to just under the pycnocline, caused by the annual intrusion of high salinity water from the Pacific Ocean, and finally a rapid, sustained upwelling favorable wind event that pushed the surface water layer northwards and resulted in outcrops of low oxygen water at the surface. Oxygen changes in the surface water occurred rapidly; within 12 hours the surface oxygen concentration decreased by ~125 umol/kg (4 mg/L) to values less than 20 umol/kg (~0.6 mg/L). The event lasted ~ 24 hours and ended abruptly, with surface oxygen concentrations increasing back to pre-fishkill levels within 2-4 hours.

Response of a Hood Canal Circulation Model to a Wind Event Preceding September 2006 Fish Kill

Mitsuhiro Kawase, University of Washington*

The fish kill event of September 19, 2006 in the southern Hood Canal was preceded by a three-day period of southerly wind. This is believed to have caused upwelling of hypoxic subsurface waters that lead to the observed fish kill. To test this hypothesis, a circulation model of Hood Canal was run with the observed wind of September 15 - 19, 2006 measured at the ORCA oceanographic buoys. The model was initialized to a September of a climatological run with seasonal river discharge and external salinity boundary conditions, and forced for five days with the observed wind. Modeled response of the water column closely resembled the observation at the Hoodsport ORCA buoy before and during the event. The surface layer was pushed northward by the wind and replaced by an upwelling deep layer, which reached the surface after four days of integration. Surface salinity increased throughout the southern Hood Canal, particularly along the lower Olympic coast, where the depth of upwelling reached 20m. The resultant oxygen decrease at the surface was estimated to be up to 8mg/l along the lower Olympic coast. At the same time, the average deep inflow below 20m at the Hoodsport ORCA section increased from 434m^3/s to 1026m^3/s. Wind stress also acted as a significant source of turbulent mixing in the upper layers of the model. The model results strongly support the hypothesis of wind-driven upwelling causing fish kill events, and highlight the importance of wind in the dynamics of Hood Canal.

Predicting the Impacts of Hypoxia on Marine Fish Populations in Southern Hood Canal

Wayne Palsson, Robert Pacunski, Tony Parra, Jim Beam, Washington State Department of Fish and Wildlife*

Hypoxic conditions have had a dramatic impact on fish populations in southern Hood Canal. Using visual census surveys while on scuba, we have tracked the abundance and depth distribution rockfishes, lingcod, and other marine fishes at Sund Rocks and other sites in southern Hood Canal since 2001. By correlating ambient oxygen concentrations with fish abundance and by relating fish kills to oxygen concentrations, we are developing a model for predicting when fish will avoid or be killed by low oxygen events. Copper rockfish avoid oxygen concentrations below 2 mg/l but can tolerate concentrations to 1 mg/l. Other marine fish species show similar responses, but smaller fish and species appear to be affected more than larger ones.

Fish kill events are not consistent between years, affecting rockfish in one instance and lingcod in another. Differences in behavior and lethality during hypoxic conditions may relate to the magnitude and duration of exposure, temperature, past experience, and physiology. Recent and past fish kill events have resulted in long-term impacts reducing populations of rockfish and lingcod at Sund Rocks by one third. Continued efforts to minimize other population stressors are warranted.

Big Bacteria: The Identification and Ecology of Visible Mats of White Bacteria in Different Habitats of Puget Sound

Joel Elliott, Mark Martin, University of Puget Sound*

Visible mats of white bacteria have been observed on the surface of sediments and rocks in a variety of marine habitats in Puget Sound. The goals of this study were to 1) identify members of these microbial communities using morphological and genetic methods, 2) use underwater videography and beach surveys to map the distribution and abundance of the mats, and 3) examine the ecological factors influencing their distribution and abundance in space and time. The mats were composed of sulfide-oxidizing bacteria, and the most common member of the microbial community on sediments was Beggiatoa spp., with large filaments (up to 120 µm diameter) capable of gliding motility. Mats were observed at a variety of geographic locations (e.g., Hood Canal, Commencement Bay), where they occurred within specific depth ranges (10-25 m in Hood Canal, <10 m in Commencement Bay). They occurred where there were relatively high levels of hydrogen sulfide (typically > 1000 µM) in sediment porewater or where streams of sulfide were seeping from intertidal sediments. The type of bacterial community varied among habitats with different substrates (mud, sand, rock), and other environmental characteristics. The presence of surface mats of sulfide-oxidizing bacteria may be an indicator of eutrophication or deposits of organic material (e.g., wood waste) in the sediment.

Hypoxia in Hood Canal: An Overview of Status and Contributing Factors

Jan Newton, University of Washington*
Dan Hannafious, Hood Canal Salmon Enhancement Group

In its second year, the collective efforts of the Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling study (HCDOP-IAM) have resulted in a better understanding of the extent and dynamics of hypoxia in Hood Canal as well as on-going evaluation into its contributing factors. In this presentation, we give an overview of the current status of Hood Canal, compared with historical data, and some insights on the major findings to date.

Session 9B: Juvenile Salmon Habitat II

Chair: Grant Kirby

Salish Sea Boundary Waters and Islands as Nursery Habitats for Juvenile Pacific Salmon

Tina Wyllie-Echeverria, Wyllie-Echeverria Associates*
Russel Barsh, KWIAHT Center for Historical Ecology of the Salish Sea

Waters surrounding the San Juan and Gulf Islands form the crossroads of the Salish Sea, where Pacific salmon (*Oncorhynchus spp.*) from Puget Sound and the Fraser River cross on their outbound and inbound migrations. Until recently, surprising little attention was given to juvenile salmonid use of nearshore habitats around the islands. In 2004, using the beach seine method developed by Eric Beamer we began to investigate the seasonal distribution of juvenile salmon in the San Juan Islands, focusing on the Boundary Pass area (in the direct path of the Fraser), south San Juan and Lopez Islands (closest to Admiralty Inlet and Puget Sound) and San Juan Channel, which connects these areas. Results thus far indicate that juvenile salmon occupy select nearshore habitats from February through August. Juvenile chum (*O. keta*) and pinks (*O. gorbuscha*) appear in the nearshore in February and were unavailable to the beach seine by May and June respectively. Juvenile Chinook (*O. tshawytscha*) occur in our nets from May through July, and in August 2006 when we sampled with an offshore net. Even though there are no identified functioning spawning streams in the San Juan Archipelago for these species of salmon, they occupy the nearshore waters for several months each year.

An Assessment of Juvenile Fish Use in the Nearshore of West Whidbey Island

Micah Wait, Wild Fish Conservancy*
Thomas Buehrens, Bowdoin College
Brent Trim, Wild Fish Conservancy

Washington Trout sampled the nearshore waters of western Whidbey Island during the juvenile salmon outmigration periods of 2005 and 2006. The purpose of the sampling was to determine the location, timing, species composition, river of origin and size of juvenile salmon using nearshore habitats on Whidbey Island in Admiralty Inlet and the Strait of Juan de Fuca. The west Whidbey shoreline is not adjacent to the mouth of any large salmon producing river in Puget Sound. Fish usage data here demonstrate how nearshore sites distal from river mouths serve as secondary marine rearing habitat, used by fish migrating between primary marine habitat at nearshore sites adjacent to river mouths, and marine pelagic habitats. While it is conventionally held that nearshore habitat occupation rates for juvenile salmon decrease with increased distance from river mouths, our data show occupation rates comparable with those observed at more proximal locations. We suggest that secondary nearshore sites are important migratory corridors for juvenile salmon and are relevant conservation targets. The results of this study have supported a science-based prioritization of nearshore habitat protection and restoration projects in the Island County watershed planning process.

Landscape Structure of Intertidal Zostera Marina in Hood Canal and the Eastern Strait of Juan de Fuca: Hyperspectral Characterization of Variation in Juvenile Chum Salmon (Oncorhynchus keta) Habitat

Charles Simenstad, University of Washington*
Ralph Garono, Earth Design Consultants, Inc.
Ted Labbe, Port Gamble S'Klallam Tribe
Alan Carter-Mortimer, Aspect Consulting, Inc.
Robert Robinson, Earth Design Consultants, Inc.
Chris Weller, Steve Todd, Point No Point Treaty Council
Jason Toft, Jennifer Burke, University of Washington
David Finlayson, US Geological Survey
Miles Logsdon, University of Washington

Understanding nekton response to the spatial organization of habitats requires knowledge of landscape structure scaled to the organisms' interactions. In June-July 2000, we acquired Compact Airborne Spectrographic Imager (CASI) hyperspectral imagery from 20 km of the Hood Canal and eastern Strait of Juan de Fuca shoreline to characterize the landscape structure of intertidal eelgrass (*Zostera marina*) used by migrating juvenile chum salmon (*Oncorhynchus keta*). We subsampled imagery from 26 of the 145 flightlines, mapping 12 intertidal cover classes over 1100 ha of shoreline in seven regional 'focal areas' at 1.5-m pixels (2.25 m2) resolution. Imagery was classified and georeferenced along 4-ha sampling blocks. Dense eelgrass (203-1,298 m2 ha-1) and unvegetated beach sediments (sand, mixed sand gravel, mixed gravel-cobble) typically dominated intertidal coverage. Mean total area, and patch size, edge density and arrangement (interspersion/juxtaposition) of dense eelgrass varied across the focal areas, reflecting beach geomorphic setting, and perhaps extent and position of shoreline modifications. If important species like juvenile chum salmon respond differentially to variation in eelgrass landscapes, refined knowledge about whether/how these landscapes are self-organized, regulated by environmental factors and/or affected by anthropogenic shoreline modifications will be necessary for both resource management and restoration planning in this region.

Measuring Habitat Linkages in an Urbanized Landscape: Case Studies of Shoreline Enhancements for Fish and Invertebrates along Estuarine Shorelines of Puget Sound

Jason Toft, Jeffery Cordell, Charles Simenstad, University of Washington*

Puget Sound shorelines have been extensively modified, especially those associated with urban centers. A challenge for nearshore ecologists is to understand how anthropogenic modifications affect fish and invertebrates, and how to best restore or enhance biological functions by integrating science and management. The waterways surrounding Seattle, WA offer a compelling landscape to address such issues, due to the abundance of shoreline modifications and the use of shallow water habitats by juvenile pacific salmon (predominantly chum, chinook, and coho). Endangered populations of chinook salmon migrate and rear along the entire estuarine corridor, further complicating the understanding of habitat associations across the freshwater-saltwater gradient. Our research seeks to understand such interactions by assessing habitat linkages and restoration progress by utilizing various sampling techniques, including enclosure nets, snorkel surveys, gastric lavage, and invertebrate sampling. We will incorporate a review of recent datasets with current case studies of shoreline enhancements and restoration, as compared to more natural beaches. Results indicate that different habitat types can affect not only fish and invertebrate abundance and compositions, but also fish behavior and feeding patterns. Such linkages are just beginning to be investigated, and illustrate the need to further understand the role of habitat mosaics in urbanized estuaries in order to guide restoration efforts.

Impacts of Ferry Terminals on Juvenile Salmon Movement along Puget Sound Shorelines

Ronald Thom, Susan Southard, Battelle Pacific Northwest National Laboratory*
Gregory Williams, NOAA
Jason Toft, University of Washington
Christopher May, Geoffrey McMichael, Jessica Vucelick, Battelle Pacific Northwest National Laboratory
Jennifer Newell, University of Washington
John Southard, Battelle Pacific Northwest National Laboratory

Over-water structures (OWS) may affect juvenile salmon, especially chinook and chum, directly by disrupting migratory behavior along the shallow-water nearshore zone. To address this issue, we used 30 visual surveys at 10 terminals, light measurements at 10 terminals, 160 snorkel surveys at two terminals, and enclosure net monitoring and acoustic tagging and telemetry at one terminal to investigate variables affecting

juvenile salmon abundance and behavior.

Juvenile salmon were observed most frequently adjacent to ferry terminals (within 10 m of the edge of the OWS), but were also observed far from (10 to 50 m away) and underneath the terminals. Variations in habitat, as mediated by tidal stage (affecting current magnitude and direction, light under structures, water level) and time of day (light level, sun angle, cloud cover), likely affect these movements. Thus, shading caused from various OWS characteristics can deter or delay juvenile salmonid movement, and that this effect may be decreased at low tides when ambient light can better filter beneath the terminal structure. Acoustic tracking at Port Townsend indicated that the juvenile chinook and coho moved under and past the structures quickly during the late evening when there was a less distinct shadow boundary than during full daylight.

Analysis Of Trade-Offs Between Water Supply And Critical Habitat For Fish Species In A Drinking Water Reservoir

Ian Williamson, Simon Fraser University*

As early as 1889, the Capilano River was partially dammed to supply water for Vancouver. In 1954, construction of the Cleveland Dam creating a reservoir that currently supplies 40% of Greater Vancouver Regional District's (GVRD) water supply. The Cleveland Dam blocked the route of Coho and Steelhead travelling up the Capilano River to spawn. Greater than 95% of their spawning and approximately 75% of their rearing habitat was lost.

Capilano is a protected watershed and drinking water reservoir managed by the GVRD in accordance with British Columbia's Drinking Water Protection Act, Canadian Drinking Water Quality Guidelines, and GVRD Drinking Water Management policy. Conflicting situations may occur where significant drawdown of reservoir level could compromise critical habitat for aquatic species. The issue is the trade-off between critical habitat for aquatic species and water supply. The experience pre-2002 under the Fisheries Act will be investigated and compared to the post-2002 context under the Species at Risk Act.

Panel 9C: An Experiment in Marine Conservation: The Northwest Straits Initiative

Chair: Andrea E. Copping

After 7 years the Northwest Straits Marine Conservation Initiative has a solid record of providing guidance to local governments on marine issues, engaging volunteers on projects that protect and restore their marine resources and shorelines, and empowering large numbers of individuals to view the marine environment as key to their well being. We will demonstrate the effectiveness and cost efficiencies of the NWS Initiative as a model for marine conservation with examples of projects and activities successfully undertaken by the seven Marine Resources Committees (MRCs) who make up the NWS Initiative and the Northwest Straits Commission. The panel will include local government representatives who can discuss the role they see the MRCs can play in marine conservation, as well as agency staff and citizens who interact and benefit from the work of the Initiative.

Panel 9D: Converting Data into Decisions for the Georgia Basin-Puget Sound

Chair: Gina Bonifacino

A panel of four air quality managers and scientists will reflect on the science-policy interface in the management of GB-PS airshed. Questions to be posed to the panel will include: How do managers use the information they get from scientists? How do managers communicate their science needs to scientists? How could scientists and managers work together more effectively? At this point in time, is scientific knowledge a limiting factor in decision-making? What conflicts do you see between scientific understanding and other decision drivers such as economics or public perception? How should policy-makers react best to rapidly emerging science?

Panel Members:

- *Gina Bonifacino (panel moderator), United States Environmental Protection Agency*
- *Hu Wallis, British Columbia Ministry of Environment*
- *Peter Schwarzhoff, Environment Canada*
- *Sarah Rees, Washington Department of Ecology*

Session 9E: Shoreline Restoration

Chair: Doug Myers

Puget Sound Beach Restoration: The Role of Beach Nourishment

Hugh Shipman, Washington State Department of Ecology*

Much of Puget Sound's shoreline consists of sand and gravel beaches, characterized by active sediment transport under the influence of waves. The relationship of these beaches to the ecosystems they support is particularly complex due to the dynamic nature of sediment movement, the significant role of natural disturbance, and the large local heterogeneity in substrate, hydrology, and energy regimes. The long-term condition of Puget Sound beaches is believed to be harmed by the cumulative effect of seawalls and encroaching structures that bury the upper beach and eliminate the supply of sediment from eroding bluffs. Besides removing seawalls, which is not always feasible, beach nourishment is one of few methods that directly addresses impaired sedimentary processes on beaches. Beach nourishment is the artificial addition of sediment to a beach to restore beach profiles, to replenish key sediment sizes, or to mitigate diminished sediment supplies. In this paper, we present a conceptual model for beach processes that provides a context for evaluating nourishment at both site and drift cell scales. We examine several locations where nourishment has been employed to create, enhance, or restore beach functions, or where a nourished beach has been used to enhance other habitat types.

Longterm Monitoring of the Response of Skagit River Chinook Salmon to Estuary Restoration

Correigh Greene, NOAA/NMFS/NWFSC*
Eric Beamer, Skagit River System Cooperative

Chinook salmon depend on functional estuaries as part of their complex life history, but these habitats have undergone substantial loss and modification over the last 150 years. The Skagit River estuary is no exception, but recent efforts by a number of organizations has reversed this trend with restoration projects in the Skagit River tidal delta and nearshore. Scientifically documenting the effects of restoration on the salmon population is a challenge that needs extensive longterm monitoring. In this talk, we describe a conceptual framework for predicting the effects of restoration, and a multi-component research design that will allow us to quantify key life history types, migration rates, and population dynamics in response to multiple restoration projects planned for the next ten years.

Nisqually Delta Phase 1 Estuarine Restoration Fish Monitoring

Christopher Ellings, Nisqually NWR & Ducks Unlimited*
Sayre Hodgson, Nisqually Indian Tribe

In the Nisqually Delta, the Nisqually Indian Tribe and the Nisqually National Wildlife Refuge are restoring tidal influence to nearly 850 acres of former pasture and farmland over the next several years. The first phase (Phase 1) was implemented in 2002 and reclaimed approximately 40 acres of pasture. This paper covers the results of our Phase 1 restoration site monitoring efforts from 2003-2005.

Our objectives for the Phase 1 restoration site monitoring were to evaluate the opportunity, capacity, and realized function of the site for salmonids and other fishes and to compare and contrast these findings

with those from other sloughs within the Nisqually Delta. Opportunity was examined by fyke-trapping each slough mouth, invertebrate densities at each slough throughout the 2005 sampling season were used as measures of capacity, and the diet composition of unmarked and marked (hatchery) Chinook salmon was used to assess the realized function of the sloughs for supporting juvenile Chinook.

Results indicated that the Phase 1 restoration site provided immediate benefit to Nisqually fishes by producing large quantities of prey organisms. Blind tidal sloughs were found to be an important habitat for several fishes in the Nisqually Delta but the diversity and density of fish varied between the sloughs. Cumulatively, this monitoring data enables us to make educated hypotheses about the impact of continued estuary restoration on Nisqually Delta fish ecology.

Lone Tree Creek and Pocket Esturary Restoration Project

Todd Mitchell, Swinomish Indian Tribal Community*
Rachel LovellFord, Sarah Akin, Tiffany Hoyopatubbi, Swinomish Tribe

The Lone Tree Creek Restoration Project restored and enhanced salmon habitat in the stream and pocket estuary located on the Swinomish Reservation in Washington State. The stream and pocket estuary were blocked from tidal influence and fish passage by a series of perched and undersized culverts. An important aspect of this project is that these are culverts entirely on Tribal land. The Tribe has taken the initiative to correct fish passage problems on Reservation, including this project, even though the land base is relatively small (<12 sq. miles). The project restored tidal influence and fish passage by replacing existing impassible culverts (2 foot diameter) with a 40' bridge, a 10 foot wide arched culvert, and three 8 foot wide squashed culverts. Tidal influence in the enhanced pocket estuary will re-create estuary-type freshwater/salt water mixing zones, critical rearing habitat for juvenile salmonids. Fish usage will be monitored pre- and post- project to determine effectiveness of improvements. Planting additional estuary and native plants in the wetlands and increased buffer will enhance the newly opened estuary habitat as well as maximize filtering effects to improve water quality. Current water quality monitoring will be continued to determine water quality improvements.

Restoring Puget Sound Nearshore Ecosystem Through the Use of Emerging Shoreline Protection Technologies.

Jose Carrasquero, Tim Abbe, Herrera Environmental Consultants, Inc.*

In Puget Sound, the use of bulkheads for shoreline protection has resulted in significant impacts to the nearshore ecosystem. The greatest effect occurs in the upper-most portion of the shoreline between MHW and MHHW where the forage fish species surf smelt (Hypomesus pretiosus) and Pacific sand lance (Ammodytes hexapterus) spawn. This is particularly important given that the shoreline area between the MHW and MHHW is Critical Habitat for salmonid species protected under the Endangered Species Act (ESA). In addition, these forage fish species are an important food source for the ESA-protected salmonid species. New restorative technologies that emulate natural shoreline riparian and aquatic conditions offer an approach to protecting shoreline while restoring nearshore habitats. This new approach emulates the native shorelines of Puget Sound, provides wave energy dissipation in the upper tidal zone, and preserves forage fish spawning habitat. The approach consists of structures formed with a complex array or matrix of driftwood embedded into the beach in combination with multi strata riparian planting. Wood density increases up the beach to a maximum density at the toe of the bank or bluff. The structures do not interrupt longshore drift or reflect wave energy and visually reflect the natural accumulations of trees and driftwood found along Puget Sound shorelines. These structures can also be used in Puget Sound's lacustrine and fluvial ecosystems.

Restoring the Beaches of Puget Sound

Jon Houghton, Pentec Environmental*
David Simpson, Coast and Harbor Engineering
Jim Starkes, Derek Ormerod, Jason Stutes, Pentec Environmental

The majority of the east side of Puget Sound was hardened with riprap and bulkheads during the 20th Century, and much of this hardened shoreline is occupied by a railroad that is unlikely to move. Restoration of more natural shoreline habitats, and the natural processes that sustain them have been identified by several regional restoration planning efforts in Puget Sound as one of the elements critical to salmon recovery. This presentation describes two projects that have been completed in Everett, Washington that have sought to restore a more natural shoreline habitat in areas where existing infrastructure precludes re-establishment of natural processes. Both projects have created more natural beach profiles with beach face, storm berm, and backshore along approximately 0.5 km of hardened shoreline. Physical monitoring has shown that the pebble/sand beach constructed near Mukilteo has responded to the ambient wave environment much as predicted. Biological monitoring at this beach has shown a high level of activity by juvenile salmonids and forage fish. It is not yet certain if forage fish that previously spawned in sand at the base of the railroad bulkhead will actually spawn on the new beach, however. For the second project, clean dredged material was used to create a sloped sandy beach in front of a rock jetty to improve the nearshore migration cooridor for migrating salmon smolts. The ecological and fiscal costs and benefits of both projects will be analyzed

Session 9F: Contaminant Loading: Case Studies

Chair: Scott Redman

2003-2005 Contaminant Concentrations in Storm Water, Sinclair/Dyes Inlet Watershed a Subasin of Puget Sound, WA, USA

Jill Brandenberger, Chris May, Battelle Pacific Northwest National Laboratory*
Robert Johnston, Space and Naval Warfare Systems Center
Dwight Leisle, Bruce Beckwith, Gerald Sherrell, Puget Sound Naval Shipyard & Intermediate Maintenance Facility

Contaminant concentrations during storm events were evaluated in representative streams and outfalls discharging into the Sinclair-Dyes Inlet watershed during eighteen winter/spring storm events from 2003-2005. A combination of time-composites, flow-composites, and grab composites along with flow measurement were collected during baseflow conditions and storm events. Samples were analyzed for metal contaminants (mercury, arsenic, cadmium, chromium, copper, lead, silver, and zinc), organic contaminants (polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyl), and nutrients (total inorganic nitrogen and total phosphorus) to determine event mean concentrations (EMCs) as a function of total event rainfall and upstream land use. Samples were also analyzed for aluminum, total suspended solids, and total and dissolved organic carbon to estimate relationships with particulate matter. EMCs were evaluated during baseflow and storms classified based on total event rainfall. EMCs for outfalls were often five times higher than streams for the metals and 24 times higher for PAHs; however, calculated loadings from outfalls were lower than streams due to the higher flow rates and larger volumes of streams. EMCs for copper, lead, zinc, and mercury show a positive relationship between total metals and storm size. Generally, this was an inverse relationship for outfalls suggesting a dilution effect with larger storms.

Characterizing Wastewater Sources to a Small Puget Sound Embayment using Stable Isotopes and Chemical Indicators

Richard Dinicola, U.S. Geological Survey, Washington Water Science Center*
Theresa Liedtke, USGS Columbia River Research Laboratory
Jessica Lacy, Renee Takesue, USGS Pacific Science Center

The U.S. Geological Survey is investigating urbanization effects to

nearshore ecosystems as part of the Coastal Habitats in Puget Sound (CHIPS) project. The ultimate objective is to link specific watershed and shoreline land-use activities with impaired nearshore processes and ecosystems. Strategies for evaluating urban wastewater inputs to a small embayment in Kitsap County, Washington, were explored in a 2006 reconnaissance study. Samples were collected in partnership with the Suquamish Tribe and the Liberty Bay Foundation to analyze stable isotopes (δ15N and δ13C) in biota, wastewater-indicator chemicals and metals in marine sediments, and chlorophyll a in marine water. Multiple wastewater compounds, including detergent metabolites and human fecal indicators, were detected in nearshore sediments and showed that Liberty Bay was clearly affected by wastewater. Lead and copper concentrations in bay sediments were significantly higher than those measured at a reference outside of the bay. The δ15N values from biological tissue samples increased consistently with increased trophic level, and will be evaluated with δ13C data to establish the extent of wastewater nutrient contributions to various levels of the food web. Spatial and temporal variation in chlorophyll a concentrations indicated a high sampling intensity is needed in even a small embayment to understand the interaction between physical and biological processes.

An Investigation into the Fecal Coliform Pollution Around the Shoal Island Shellfish Sanitary Closure

Andrew McNaughton, McNaughton Environmental Consultants*
Alice Cheung, Environment Canada

The Shoal Islands is located in southeast Vancouver Island, just east of Crofton, British Columbia. The intertidal foreshore is densely populated with Manilla clams (Venerupis philippinarum) and Pacific oysters (*Crassostrea gigas*). Since the early 1970's, the area has been closed to the direct harvest of shellfish product in part due to elevated levels of fecal coliform in both marine water and biota and upland sources of pollution. Suspected pollution sources have included agricultural, wildlife, and the nearby pulp mill. As the closure has considerable implications to the Halalt First Nation (HFN), who traditionally harvest the area for food, social, and ceremonial purposes, the HFN has been actively investigating pollution sources and applying remediation strategies. In 2005, under a cooperative partnership with Environment Canada (Georgia Basin Action Plan), the HFN continued their pollution identification and mitigation efforts in the Shoal Islands. Extensive field sampling was undertaken in both the marine environment as well as the freshwater tributaries that drain into the Shoal Islands. This presentation will discuss the study results, data anomalies, and next steps in building on our understanding of this complex project area.

Modeling PCB transport in the Lower Duwamish Waterway, Seattle WA

Bruce Nairn, King County*

The Lower Duwamish Waterway Superfund site is made up of approximately 5.5 miles of the downstream portion of the Duwamish River which flows into Elliott Bay near downtown Seattle, WA. For decades much of the land adjacent to the Lower Duwamish Waterway has been industrialized. The U.S. Environmental Protection Agency (EPA) added the waterway to the Superfund list in 2001 because of contamination found in the waterway sediments, notably polychlorinated biphenyls (PCBs). To support modeling of PCB accumulation in the aquatic foodweb, a three-dimensional fate and transport model was applied to simulate PCBs using the Environmental Fluid Dynamics Code (EFDC). An analysis of model sensitivity to different choices of model configuration and resolution is given, illustrating the importance of scale on selecting a model configuration.

Current Use Pesticides in Surface Waters from an Urban and Agricultural Watershed of the Puget Sound Basin

Chris Burke, Paul Anderson, Dan Dugger, Dale Norton, Washington State Deparment of Ecology*
Jim Cowles, Washington State Deparment of Agriculture

The unintended transport of pesticides to surface waters poses a risk to aquatic organisms. In response to concerns of non-target toxicity, the Washington State Departments of Agriculture and Ecology established an intensive surface water monitoring program for pesticides in salmonid bearing streams to generate regional data to evaluate exposure. Two study watersheds in the Puget Sound basin, Thornton Creek and the Skagit-Samish Rivers, were selected to represent urban and agricultural land-use.

Thornton Creek, which discharges to Lake Washington was selected as the urban index watershed due to habitat utilization by salmonids, prespawning mortality of Coho Salmon, and historical pesticide detections. The Samish-Skagit watershed represents a diverse agricultural area, with intense production and proximity to salmonid bearing surface waters.

During 2003-2006, the program collected samples weekly between March and September. Novel procedures were employed to analyze for 120 currently registered pesticides and degradate compounds.

Progressive registration restrictions in the urban watersheds have lead to an apparent decrease in detection frequency and magnitude of organophosphorus insecticides.

Session 10A: Hood Canal and DO: Nutrient Dynamics

Chair: Duane Fagergren

On the Movement and Fate of Water and Nitrogen in the Hood Canal Watershed

Jeffrey Richey, School of Oceanography, University of Washington*
Porranee Thanapakpawin, Dept. of Chemical Engineering, University of Washington
Matthew Wiley, Dept of Civil and Environmental Engineering, University of Washington

In order to identify the potential natural and anthropogenic factors that may be contributing to Hood Canal's severely depleted oxygen levels, the Hood Canal Dissolved Oxygen Program (HCDOP) is taking a watershed approach. A dynamic mass balance is being established of the movement of water and nitrogen across the landscape into the Canal, as a function of the moisture regime and landuse attributes. This is being done through monitoring of the chemical composition of stream water discharged into the canal, evaluation of land use/land cover patterns and changes in the canal's watershed, and the implementation of an integrated hydrological/biogeochemical modeling scheme designed to simulate water and chemical fluxes through the watershed. Hydrologic conditions in the approximately 1200 square mile area that form the contributing watershed to Hood Canal are simulated using a physically based, high resolution, rainfall – runoff model (DHSVM), with GIS derived representations of elevation, soil type, soil thickness and vegetation. A model of nitrogen transformations on land and subsequent mobilization to and through streams is then coupled to the hydrology model. Results addressing overall mass flux and progress on separation of natural and anthropogenic conditions are presented.

Land Cover and Soil Effects on Freshwater Nitrogen Loading to the Hood Canal

Peter Steinberg, Michael Brett, Jeffrey Richey, Matt Wiley, Lauren McGeoch, Porranee Tanapakpawin, Suzanne Osborne, University of Washington*

The scale and duration of hypoxia in the N-limited Hood Canal, Washington have increased in recent years. Adverse effects on marine biota have motivated an interest in measuring and modeling streamwater N dynamics, particularly land cover, land use, and soil effects on total N load and N speciation. Dominant land uses/covers in the Hood Canal tributary watersheds include old growth and regrowth coniferous forest, mixed forest, deciduous lowland forest, as well as suburban and semi-rural development on shorelines and uplands.

Among 45 sampled tributaries and nearly 2 years of monthly sampling data, we have observed clear correlations between deciduous mixed forest and total dissolved N, nitrate, and dissolved organic N. We have also documented negative correlations between mature conifer forest and total dissolved N and nitrate. Dissolved organic C and N have been correlated with percentage watershed area in muck and in silty clay loam soils, both of which have high surface soil organic matter content. Correlations with watershed characteristics and comparisons with typical rainwater N concentrations both indicate that current or historic anthropogenic disturbance in tributary watersheds has influenced the timing, speciation and magnitude of watershed N loading to Hood Canal.

Nutrient Dynamics in Hood Canal

Corinne Bassin, Jan Newton, Al Devol, University of Washington*
Dan Hannafious, Hood Canal Salmon Enhancement Group

Primary production in Hood Canal is dominated by the input and transport of dissolved inorganic nitrogen (DIN) from several sources. The residence time of DIN in Hood Canal as well as the dynamics governing the movement of DIN needs to be further resolved, especially regarding its impact on stimulating hypoxia. At times, samples in Lynch Cove at the landward end of Hood Canal have shown higher levels of nitrate than samples at Admiralty Inlet, the entrance to Hood Canal, suggesting retention and recycling of nitrogen. Horizontal cross sections of nutrients collected by PRISM and WA-DOE in the 1990's and 2000's will be discussed to access this potential increase in DIN along the canal. Nutrients at discrete depths as well as CTD profiles have been collected at several stations from Admiralty Inlet to Lynch Cove on a monthly basis by a volunteer project through HCSEG and HCDOP. These data, spanning 2004-2007, will be used to map DIN temporally and spatially in Hood Canal. Of interest is if a nutrient gradient is observed with these data and how the gradient changes along Hood Canal throughout the year at discrete depths. The pycnocline depth along and across the channel will be used to discuss the movement of marine nitrate through the canal.

The Interaction of Nitrate Geochemistry and Physical Processes in Hood Canal, Washington

Anthony Paulson, U.S. Geological Survey, Washington Water Science Center*
Marlene Noble, USGS, Coastal and Marine Geology
Carol Kendall, USGS, National Research Program

An understanding nitrogen cycling is essential to understanding low dissolved oxygen conditions in Hood Canal. An anomaly of high values of δ15N and δ18O of nitrate in the nitrate-depleted waters of shallow sites in Lynch Cove, during September 2004 has been previously reported. During the period that these discrete water column samples were collected (September 21-23), a CTD mounted on a bottom tripod at the entrance to Lynch Cove documented a front of warm, salty water entering Lynch Cove on September 22. Comparison of temperature-salinity profiles from CTD casts with the sequence of the temperature-salinity data from the mounted CTD for the month prior to the CTD casts provides insight into the physical processes that affected the isotopic signature of nitrate. The temperature-salinity CTD profiles indicate that the water containing depleted nitrate concentrations and higher values of δ15N and δ18O of nitrate entered Lynch Cove the previous month. In contrast, water containing higher nitrate concentrations and lower values of δ15N and δ18O of nitrate was either at the leading edge or behind the front of salty, warmer water. Thus, the amount of time water was resident in Lynch Cove likely was responsible for the altered chemical signature of bottom water from shallow sites.

Quantifying Submarine Ground-Water Discharge and Nutrient Loading into the Lynch Cove Area of Hood Canal

William Simonds, Peter Swarzenski, Chris Reich, Jason Greenwood, Don Rosenberry, U.S. Geological Survey*

Low dissolved oxygen concentrations in the waters of Hood Canal threaten marine life in late summer and early autumn. Eutrophication in the landward reaches of the canal has been linked to phytoplankton growth, which is controlled by nutrients (primarily nitrogen) that enter the canal from various sources. Although seawater entering the canal is the largest source of nitrogen, ground-water discharge also contributes significant quantities particularly during summer months when increased nutrient availability in the canal directly effects eutrophication. The amount of nutrients entering Hood Canal from ground water is being estimated using direct and indirect measurements of ground-water discharge and analysis of nutrient concentrations. Ground-water discharge to Hood Canal is variable in space and time because of local geology, the hydraulic gradient in the ground-water system adjacent to the shoreline, and a large tidal range of 3 to 5 meters. Streaming resistivity surveys along the coastline of Lynch Cove and measurements of ground-water seepage and hydraulic-head gradients in the shallow near shore areas were used to characterize the spatial variability of submarine ground-water discharge and identify areas of enhanced ground-water discharge. In areas with confirmed ground-water discharge, shore-perpendicular resistivity profiles, continuous electromagnetic seepage-meter measurements, and continuous radon measurements were used to characterize temporal variations in ground-water discharge over several tidal cycles. The results of these investigations show that ground-water discharge into the Lynch Cove area of Hood Canal is highly dynamic and strongly affected by the large tidal range. In areas with a strong hydraulic gradient, ground-water discharge is spatially concentrated in or near the intertidal zone with increased discharge during low tide. Areas with a weak hydraulic gradient have lower discharge rates and more spatial variability. Although nutrient concentrations in ground water are small, the flux of ground-water discharge may be large in some areas of the Hood Canal coastline; therefore, understanding the relative load of nutrients entering the canal from the ground-water pathway is potentially important.

The Fate of Onsite System Nitrogen Discharges in Groundwater of the Hood Canal Basin

Julie Horowitz, C. Andrew James, Bryan Atieh, Ali Kanda, Scott Miller, Lauren McGeogh, Matt Wiley, Mark Benjamin, Michael Brett, University of Washington*

The Hood Canal basin of Puget Sound has been severely affected by low dissolved oxygen concentrations thought to be caused by excess nitrogen loading. Low dissolved oxygen impairs water quality, affecting the ecological and economic integrity of the region. Onsite wastewater treatment systems may be an important source of nitrogen to Hood Canal. This study will attempt to quantify nitrogen loads from onsite wastewater treatment system effluent to determine the relative importance of this source for the nutrient dynamics of Hood Canal. We modeled nitrogen loading to Hood Canal using rates and coefficients obtained from the primary literature and regional census data. Individual distributions were compiled for seasonal population, per capita water use, septic system effluent nitrogen concentrations, and zero order denitrification rates. These parameters were used in a Monte Carlo framework to calculate a probabilistic distribution of potential nitrogen loading to Hood Canal. Because conventional onsite wastewater treatment systems are not designed to remove nitrogen from effluent, onsite nitrogen load reaching the canal is primarily dependent on the amount of denitrification which occurs in the groundwater flowpath between onsite systems and the Canal. We are currently conducting in situ measurements of nitrogen loss rates in septic leachfields of near shore and upland homes to determine region specific denitrification rates. This information will be applied as a part of a greater assessment of nutrient dynamics in the Hood Canal system.

Panel 10B: Where is Your Plan for the Sound?

Chair: Jacques R. White

We have plans for the Puget Sound region that guide everything from commercial, housing and transportation development, protection of water quality, flows and biodiversity, to the recovery of critical habitats and species at risk. Unfortunately, we lack effective coordination among these various planning efforts to jointly identify the greatest existing stresses and future threats to public well being and our environment. Given the increasing focus on Puget Sound recovery, this panel will focus on how these different planning processes could scale, incorporate, and implement potentially conflicting goals and outcomes consistent with emerging attitudes and mandates.

Panel Members:

- *Jim Kramer, Executive Director, Shared Strategy for Puget Sound*
- *Ron Shultz, Director of Programs, Puget Sound Action Team*
- *Norman Abbott, Director of Growth Management Planning, Puget Sound Regional Council*
- *Curtis Tanner, Project Manager, Puget Sound Nearshore Partnership*
- *Molly Ingraham, Associate Director of Conservation Planning, The Nature Conservancy*
- *John Floberg, Vice President Stewardship, Cascade Land Conservancy*

Panel 10C: Sea Floor Mapping and Habitat Delineation

Chair: Wayne A. Palsson

New technology provides the ability to map undersea habitats with high precision. This session will feature papers focused on the results of multibeam sonar, side-scan sonar, and other techniques to map the sea floor in nearshore and deep enviornments. Studies that make use of these maps to identify and survey sub-tidal habitats will demonstrate the usefulness of high resolution maps that improve population surveys, identify habitat types, and improve habitat management.

Panel Members:

- *Kim Conway, Geological Survey of Canada*
- *Jeff Marliave, Vancouver Aquarium*
- *Gary Greene, Moss Landing Marine Laboratories*
- *Robert Pacunski, Washington State Department of Fish and Wildlife*

Seafloor and Habitat Mapping in the Georgia Basin, British Columbia

K. W. Conway, J. V. Barrie, K. Picard, Geological Survey of Canada, Sidney, B.C., Canada
H. G. Greene, Moss Landing Marine Laboratory, Moss Landing, CA, USA

The seabed of the Georgia Basin has been surveyed using swath multibeam bathymetry by the Canadian Hydrographic Service working in concert with the Geological Survey of Canada and Moss Landing Marine Laboratories. Geological mapping of the Strait of Georgia is being undertaken and delineation of geological units is well advanced. The mapped geologic units reflect 1) diverse rock types and geomorphology related to tectonic processes 2) subsequent glacial cycles during which extensive drumlinoid banks were created 3) terrestrial sedimentation derived mainly from the Fraser River 4) reworking of surficial sediments by oceanographic processes. In the southern strait the character of benthic habitats is controlled by the distribution of blanketing Fraser River sediments in deeper waters. Where the coarse glacial substrates and bedrock are mantled by recent muds, attached organisms requiring hard substrates are sparse or absent. Strong tidal exchange results in sorted mobile sediments in several areas such as Boundary Pass (Canada/US border). Mapping has identified several sponge reefs which represent unique habitats. Selected areas, such as the International Boundary area between the Canadian Gulf and U.S. San Juan Islands have been mapped in detail and thematic maps of seafloor geohazards and habitat are under development.

Predicting Optimal Rockfish Habitat: Comparison of Micro- and Macro-Scale Modeling Approaches.

Jeff Marliave, Vancouver Aquarium
Wendell Challenger, Simon Fraser University, Statistics & Actuarial Sciences
Donna Gibbs,Vancouver Aquarium

Any management decision is dependent on the quality of information that is available during the decision making process. Increasingly, managers are using the results of modeling projects to formally evaluate and select between competing management strategies. In 2004, Rockfish Conservation Areas (RCAs) in British Columbia were based partly on a modeling project that incorporated historical catch data and bathymetry information to predict optimal areas for designations. The macro-scale modeling approach has however generated some concerns over its degree of accuracy. These concerns stem from the observation that rockfish often have very specific, small-scale habitat requirements. If this is true, then designated areas may be missing local hotspots with prime habitat. To address these concerns we outline a different approach whereby we developed a micro-scale habitat model to predict the probability of occupancy based on direct ecological characteristics believed to be important to rockfish habitat selection. A series of randomly selected dive sites inside versus outside the RCA prediction model were monitored in 69 dives in 2006. We are using the site-occupancy model to predict the overall habitat suitability between the randomly chosen locations within designated RCAs and outside, but adjacent to, the surrounding model prediction area.

Marine Benthic Habitat Mapping in the Inland Sea of the San Juan Islands: An International Interdisciplinary Research Program

H. Gary Greene, Center for Habitat Studies, Moss Landing Marine Labs
J. Vaughn Barrie, Canadian Geological Survey
Bryan Dieter, Charlie Endris, Center for Habitat Studies, Moss Landing Marine Labs
Don Gunderson, University of Washington, School of Aquatic and Fisheries Sciences
Holly Lopez, Center for Habitat Studies, Moss Landing Marine Labs
Ron McDowell, Orcas Island
Palsson Wayne, Robert Pacunski, Washington Department of Fish and Wildlife ,

For the past five years high-resolution multibeam bathymetry and backscatter data have been collected in the inland sea of the San Juan Islands and the southern Strait of Georgia area as part of a Center for Habitat Studies (Moss Landing Marine Laboratories) and Geological Survey of Canada (Natural Resources Canada) effort to characterize potential marine benthic habitats. Emphasis was placed on rockfish (Sebastes spp.) habitats because of the declining abundances of these fishes. The deep fiord channels and straits were imaged using a Simrad 1002, 95 kHz system, whereas the shallow water areas were imaged using Simrad 3002 300 kHz system. Geological structures, including faults (some active) and folds, glaciated bedrock, and extensive sediment waves and dune fields were imaged. Geological interpretations of these images suggest that active tectonics has shaped the seafloor and islands into steep walls and cliffs that have since been modified by glaciation. In addition, strong tidal currents have winnowed most of the glacially deposited sediments into coarse-grained lag pavements and bolder/cobble/pebble fields. The past and present active physical processes are what created the desirable bottom fish habitats, such as steep, near vertical rock walls, stacked boulders (e.g., moraines and rockfalls), which have the potential of providing habitat for juvenile and adult rockfish, and sandwaves that shelter sand lances and other organisms, and may provide foraging habitat for bottom fish. This newly found information is now being used to evaluate the effectiveness of MPAs in the San Juan Islands.

Results of a Habitat-based Survey of San Juan Channel Bottomfish Using a Small Remotely-Operated Vehicle (ROV)

Robert Pacunski, Wayne Palsson, Washington State Department of Fish and Wildlife
Don Gunderson, University of Washington School of Aquatic and Fishery Science
Gary Greene, Charles Endris, Moss Landing Marine Labs

A small ROV was used to survey marine habitats in San Juan Channel (SJC) to examine differences in habitat use by benthic marine fishes and improve existing habitat maps of the region. High-resolution multibeam sonar data and coarse-scale camera data were combined to develop a mesoscale (1-10 km resolution) habitat map that served as the sampling frame.

We accomplished 58 transects to depths of 145 m covering an estimated area of 38,167 m2. Rockfishes, lingcod, and kelp greenling were highly associated with rocky, complex habitats, while juvenile gadids occurred almost exclusively on flat sand, mud, and coarse substrates. Trawl, SCUBA, and drop-camera surveys have traditionally been used to assess bottomfish populations on benthic habitats in SJC, but each has been limited in their coverage of habitats because of depth, time, and substrate type. The use of a small ROV provides one tool that overcomes these limitations and can be used to characterize fish communities at all depths and bottom types and to provide quantitative estimates of abundance and distribution.

Session 10D: Invasive Species II - Management, Risk Evaluation and Prediction Tools

Chair: Kevin Anderson, PSAT

Aquatic Invasive Species in the Strait of Georgia, British Columbia, Canada

Thomas Therriault, Fisheries and Oceans Canada
Glen Jamieson, DFO*
Claudio DiBacco, UBC
Colin Levings, DFO

Aquatic Invasive Species (AIS) by definition are not native to the ecosystem in which they are found and pose a threat to native biodiversity and economic wellbeing of ecosystems across Canada, including the Strait of Georgia (SoG). The SoG is susceptible to AIS due to relatively warm summer surface waters and lower salinity areas that create unique habitats that could enhance invasion success potentially paralleling other highly invaded systems such as San Francisco Bay. In addition a wide variety of AIS vectors are available to transport AIS into the SoG including commercial shipping, recreational boating and aquaculture, each of which has transported non-indigenous species to the area in the past. To better understand AIS and their impact in marine ecosystems Canada has two new major programs: 1) the Canadian Aquatic Invasive Species Network (CAISN); 2) the Canadian Department of Fisheries & Oceans (DFO) AIS program. The CASIN program aims to better understand AIS vectors and pathways and factors affecting AIS establishment while the DFO program is focused on Risk Assessment, Monitoring, Research and Rapid Response. An overview of each of these major programs will be provided and preliminary findings discussed. Links to similar activities in the USA will be highlighted on this transboundary issue.

Invasive Tunicates in the Strait of Georgia, British Columbia

Cathryn Clarke, Glen Jamieson, Thomas Therriault, Fisheries & Oceans Canada
Heidi Gartner, University of Victoria; Fisheries & Oceans Canada*

The economic impacts of invasive tunicate species can be severe, particularly on suspended shellfish and aquaculture equipment. These invasive species have modified benthic habitats for a variety of bottom-dwelling species and are smothering both wild and cultured sessile invertebrates. Four species of tunicates have recently been recognised as nonindigenous species in British Columbia: the solitary tunicate Styela clava (club tunicate) and the colonial tunicates Botrylloides violaceus (violet tunicate), Botryllus schlosseri (golden star tunicate), and Didemnum sp. A monitoring project to document the distribution of nonindigenous tunicates was begun in spring 2006. Two types of settlement plates were deployed at nine locations throughout the Strait of Georgia and the presence and density of native and non-native species was recorded. At least three species of potentially invasive tunicates were identified on the collectors. Their presence and abundance is much more extensive than previously thought for the region. Preliminary results of the investigations into the spatial distribution and population dynamics of nonindigenous tunicates within BC waters are presented.

Risk evaluation of invasive species transport across the U.S. – Canada border in Washington State

Laura Sellens, Amy Jewell, April Markiewicz, Wayne Landis, Western Washington University*

Impacts of non-indigenous invasive species (NIS) are a multi-million dollar cost to society every year. Incongruities exist between the Canadian and American policies that regulate the introduction and control of invasive species. Policies may ineffectively overlap across terrestrial, freshwater, and marine jurisdictions. NIS are easily overlooked at border crossings due to the small size of propagules and because immigration, customs, and security concerns take precedence. We used the Relative Risk Model to conduct a landscape scale risk assessment of human mediated transport of invasive species across the Washington State-British Columbia border. This project investigated terrestrial, freshwater and marine transport pathways of invasive plants and animal species to the major habitat types in Washington. Risks of impacts by NIS were calculated for endpoints of economic, cultural, and ecological importance. Quantitative analyses were performed spatially in a geographic information system (GIS). Uncertainty and sensitivity analyses were performed using Monte Carlo Simulation software. The results of this assessment will be used to inform policy makers and managers on both sides of the border of the most important transboundary transport pathways for NIS, as well as major data gaps and sources of uncertainty.

European Green Crabs (Carcinus Maenas) in the Northeastern Pacific: Using Genetic Tools to Assess the Introduction and Regional Expansion of an Invasive Species

John Darling, U.S. Environmental Protection Agency*
Carolyn Tepolt, Independent contractor to the US Environmental Protection Agency
Michael Blum, Mark Bagley, US Environmental Protection Agency

The European green crab Carcinus maenas is a widely successful invasive species, with established introduced populations on all continents outside of its native range except Antarctica. C. maenas was introduced to San Francisco Bay in the late 1980's, and has since spread rapidly northward as far as Vancouver Island. This expansion appears to have been mediated by current-driven larval dispersal facilitated by periodic increases in ocean temperature and nearshore currents associated with El NiÒo events. Here we report on the development and utilization of genetic tools for analyzing the spread of C. maenas in the eastern Pacific. First, we describe the results of population genetic analysis based on highly variable microsatellite markers. This analysis further supports the hypothesis that C. maenas has spread by larval dispersal from a single introduced population in San Francisco. Our genetic data show no evidence of multiple cryptic introductions to the North American Pacific coast, and are consistent with significant ongoing gene flow between established populations. We also describe the development of a DNA-based assay for the

specific and highly sensitive detection of C. maenas larvae in mixed plankton samples. Given the importance of larval dispersal and the possibility of additional introductions via ballast water transport, this assay should prove a powerful monitoring tool for researchers and managers concerned with the introduction and spread of this species.

Predicting the Potential Distribution of the Invasive Tunicate Didemnum Sp on the Canadian West Coast.

Leif-Matthias Herborg, Tom Therriault, Glen Jamieson, Fisheries and Oceans Canada*

Predicting the potential distribution of invasive species allows a focused and efficient management approach. The invasive tunicate Didemnum sp has potential negative ecological and economical impacts. Recent surveys have shown its presence in several locations within the Strait of Georgia, Puget Sound and the west coast of Vancouver Island. We applied ecological niche modelling based on its current distribution to predict suitable habitat along the Canadian West Coast. The distribution of suitable habitat was then combined with estimates of human aided transport vectors related to recreational boating and aquaculture to identify areas at the highest risk of invasion. Predictions based on seasonal ocean temperature, salinity and oxygen content forecast suitable habitat as far north as the Queen Charlotte Islands. Aquaculture facilities provided a strong transport vector for Vancouver Island and surrounding waters, whereas recreational boating could spread Didemnum sp additionally to locations along Hecate Strait. The combination of ecological niche modelling with estimates of human aided transport provide an important tool for future management of this invasive species.

Ballast Water and Aquatic Invasive Species: An Analysis of Propagule Pressure on the Atlantic and Canadian Coasts

Veronica Lo, University of British Columbia*
Colin Levings, Department of Fisheries and Oceans Canada (Pacific region)
Nathalie Simard, Department of Fisheries and Oceans Canada (Quebec region)
Kai Chan, University of British Columbia

The introduction of aquatic invasive species (AIS) to ecosystems can cause widespread and irreversible damage to ecosystems. One of the principle mechanisms for the transport of AIS is through the uptake and release of ballast waters, which also carries suspended sediments harbouring AIS. Approximately 3 to 5 billion tons of ballast water are transferred among international waters annually. Unfortunately, there are few studies that determine the extent to which propagule pressure—the frequency of introduction events and the abundance of AIS within each event—affects the successful establishment of invasive species. This knowledge gap will be addressed by developing a geographical database using shipping patterns and associated ballast water data as a surrogate for potential propagule pressure, and will additionally be used to analyze the impact of propagule pressure on the temporal dynamics of invasive species (time to establishment and to 'superabundance'). The shipping pattern analysis is an important initial step in a nation-wide research project, the Canadian Aquatic Invasive Species Network (CAISN) (http://www.uwindsor.ca/CAISN), which represents a collaboration between scientists in universities and 5 federal laboratories, the shipping and aquaculture industries, and non-government organizations. The results will allow the Network to determine appropriate ports to sample for realized propagule pressure. This research is supported through funding to CAISN from NSERC, DFO and other sponsors listed at: www.uwindsor.ca/CAISN.

Session 10E: Sediment Quality and New Cleanup Site Evaluation Methods

Chair: Maggie Dutch

Coastal Conditions in Washington State: Estuaries, Intertidal, and Offshore

Valerie Partridge, Washington State Department of Ecology*

The Coastal Component of the West Coast Environmental Monitoring and Assessment Program (EMAP) is a partnership of the U.S. EPA, NOAA, and the states of California, Oregon, and Washington to measure the condition of the estuarine and offshore waters of these three states. Coastal EMAP is an integrated, comprehensive monitoring program using spatially-balanced probabilistic designs and common sets of survey indicators for all states. Because of the compatible designs, coastal conditions can be described and compared at several levels of scale. From 1999 through 2003, the coastal waters of Washington were sampled according to stratified random designs for small outer-coast estuaries (1999), the greater Puget Sound area (2000), estuarine intertidal areas (2002), and the continental shelf (2003). In 2004, the outer-coast estuaries and Puget Sound were sampled again as part of EPA's EMAP National Coastal Assessment, to examine temporal trends. Data were collected for a suite of indicators of biotic condition (infaunal communities, fish-tissue contaminants), abiotic/pollutant exposure (sediment quality), and general habitat condition (water quality, sediments). This presentation gives the first comprehensive look at the condition of Washington's coastal areas, estuarine and offshore, in the period 1999-2003 and a comparison of the estuarine areas from 1999-2000 to 2004.

Historical Record of Trace Metals in Sediment and Natural Recovery in the Main Basin of Puget Sound

Jill Brandenberger, Eric Crecelius, Battelle Pacific Northwest National Laboratory*

This study compares trace metal profiles and sedimentation rates from sediment cores collected at the same locations in Puget Sound in 2005, 1991, and 1982 to estimate the rate of surface sediment recovery for select metals and determine the rate of burial of the historical peak in contaminants. In the 1982 core, the depths of maximum lead contamination were 21-34cm, in 1991 the depths were 43-49cm, and in 2005 the depths were 58-60cm. This indicates that cleaner sediments are burying historically contaminated sediments at a rate of approximately 1cm/yr, which is consistent with the sedimentation rate estimated using lead-210 dating techniques. The three studies provide empirical evidence that environmental regulations targeting trace metals have had a positive impact on the water quality in Puget Sound. Point-source controls enacted since the 1970s resulted in a significant reduction in the anthropogenic enrichment of lead, copper, zinc, and arsenic. However, the rate at which lead, copper, and zinc are approaching pre-industrial conditions has decreased since the late 1980s. This suggests that point-source controls significantly reduced the metal load entering the main basin of Puget Sound, but diffuse sources may impede the continued progress of recovery for some metals (i.e. lead, copper, and zinc).

Can Sediment Profile Imaging Surveys Streamline Cleanup Site Investigations?

Tom Gries, Dale Norton, Pete Adolphson, Brad Helland, Washington Department of Ecology*
Joe Germano, Dave Browning, Germano and Associates, Inc.

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.

Evaluation of Post-Dredge Monitoring Results to Assess Net Risk Reduction of Different Sediment Cleanup Options

Jeffrey Stern, King County, Deptartment of Natural Resources and Parks, Water and Land Resources*
Clay Patmont, Dan Hennessy, Anchor Environmental, LLC.

A survey of recent sediment cleanup projects, including the Diagonal/Duwamish (Washington) sediment cleanup project completed in 2004, demonstrates that post-dredge sediment residuals are present within and immediately beyond the dredge prism. The dredging-related releases of contaminants into the water column, along with releases from permanently bedded residuals can temporarily increase bioaccumulation of contaminants during and following dredging and follow-on capping actions. We examine the Diagonal/Duwamish project where concurrent sediment, water, and tissue data were collected to support detailed evaluations of contaminant exposure resulting from the cleanup project. Bounding assessments were used to identify the characteristics of dredging and capping-related contaminant exposure, and to evaluate what data may be needed to improve our understanding of contaminant exposure from sediment, water and tissue media as a result of implementation of different sediment cleanup technologies. The results from this case study are also used to demonstrate how predictive modeling can be used to assess short-term risk implications that can result from releases during proposed cleanup actions. This information can inform evaluations of risk reduction provided by different sediment cleanup alternatives and provide an assessment of net risk reduction consistent with current EPA guidance.

Session 10F: Environmental Education: Citizen Science

Chair: Greg Ambrozic

Free Fish and Invertebrate ID Classes Gets SCUBA Divers Involved in Marine Conservation

Janna Nichols, Anne Stoltz, Shaun Lane, Joseph Gaydos, SeaDoc Society, UC Davis Wildlife Health Center*

In the Georgia Basin Puget Sound, recreational SCUBA divers can help monitor marine fish and invertebrate populations by entering dive sightings into a national database (www.reef.org). Participation is a vehicle for citizen stewardship of sub-tidal resources that are not visible to the public at large, and data collected on species distribution and species abundance can help biologists working to recover species in decline or identify invasive species. Previous work suggested that offering free fish and invertebrate identification classes was the best way to increase diver participation. After training 261 citizens to identify a suite of common fish and invertebrates, participants were queried to see how many dive surveys they had conducted and to see if they felt that training had increased their capacity for marine conservation. The 261 people trained were queried and 11% (n=29) completed an on-line follow-up survey. On average, each participant reported conducting six roving dive surveys since taking the class. Assuming respondents are representative of the group at large class participants have collectively already completed 1,611 surveys since talking the course. Additionally 97% of respondents felt the course increased their appreciation for marine creatures and conservation, while 55% responded that the class inspired them to increase their marine conservation efforts in ways additional to conducting roving dive surveys. Judging the merit of marine conservation education efforts can be difficult; however, it appears that offering free fish and invertebrate identification classes increases diver participation in collecting helpful data and increases their capacity for other marine conservation activities.

HCDOP Diver Observation Program: Volunteer Diver Observations Are Used to Monitor the Depth Distribution of Fish in Relation to Low Dissolved Oxygen Conditions

Teresa Sjostrom, Dan Hannafious, Hood Canal Salmon Enhancement Group*
Janna Nichols, Mike Racine, Washington SCUBA Alliance

Hood Canal is a long, deep, narrow fjord which lies west of the greater Puget Sound basin in western Washington. This unique marine waterbody has physical characteristics and processes which make the southern portions especially prone to annual low dissolved oxygen (DO) conditions. The marine biota have shown considerable behavioral and distribution responses to changes in the low DO concentrations.

To better understand how marine life in Hood Canal responds to changes in DO, a volunteer Diver Observation Program has been developed as part of a larger Hood Canal Dissolved Oxygen Program science plan.

Recreational and volunteer diver observations are being used to examine biota nearshore movements over time and investigate how trends in abundance and depth distributions may correspond with DO concentrations.

During the 2006 low DO period and resultant fish kill event, reports from volunteer divers provided insight to the behavior and condition of many fish and invertebrate species. Observational data reflected the progression of the fish kill event by recording the shifts in depth distributions and spatial abundance of the fish populations.

The Diver Observation Program provides a mechanism for divers to share their observations and contribute to the larger effort to understand the causes and effects of low DO periods in Hood Canal.

Citizen Science Monitoring at Nisqually Reach Nature Center (NRNC)

Daniel Hull, Nisqually Reach Nature Center*

Since June 2003 NRNC implemented a highly successful Citizen Science platform that provides people a way to learn, be involved with, and take ownership of the important process of environmental monitoring, data management and reporting on issues that affect their local environment. Our platform includes; near shore monitoring through fish seining and invertebrate quadrate sampling, bird monitoring in conjunction with estuarine restoration, estuarine phytoplankton diversity and abundance, invertebrate monitoring on estuarine restoration by neuston, benthic core, and fallout sampling.

It is our intention to share our management and methodology behind our programs with others to encourage the successful use of citizen science in the future.

Seabirds, Citizens, and Conservation: The Coastal Observation and Seabird Survey Team

Julia K Parrish, Kate Litle, Jane Dolliver, University of Washington*

The US Commission on Ocean Policy and the Pew Oceans Commission have called for high quality, accessible information, increased ocean education, and an increased stewardship ethic among citizens. With effective design, implementation, and maintenance, citizen science programs can answer both of these callsócollecting high quality data while educating and informing citizens.

The Coastal Observation and Seabird Survey Team (COASST) is a citizen science project of the University of Washington in partnership with local community and environmental organizations, and state and federal agencies. More than 400 COASST volunteers survey more than 150 beaches monthly in Washington, Oregon, Alaska, and northern California using beached birds as environmental indicators. In an average year, volunteers discover and tag more than 2000 carcasses of nearly 60 species. We have designed an integrated training and data verification program that allows us to track volunteer accuracy, which is at nearly 90% every year.

What do beached birds tell us? Data collected by COASST volunteers creates the baseline, or "normal," pattern of beached bird deposition which allows for the detection of change from natural and human-induced causes. So far, COASST data have shown consistent annual patterns of post-breeding mortality and migrant winterkill which represent 50-75% of annual deposition, and alerted the scientific and management community to deviations from the normal pattern, such as the spring die-off of Brandt's Cormorants and Common Murres in 2005 during which Brandt's Cormorants were being found at rates more than four times normal. In COASST, citizens are collecting high-quality data that can directly inform natural resource management decisions, while becoming more informed and active stewards of their coastal environment.

Restoration Resource: An On-Line Restoration and Monitoring Database for Volunteers

James Selleck, III, Eliza Ghitis, People For Puget Sound*

Habitat restoration projects require a solid foundation of the most current scientific knowledge for the greatest chance at success. There is often a barrier in public access to the best-available practices from professional and experimental restoration projects. People For Puget Sound is establishing an on-line resource database of habitat restoration and monitoring literature for volunteers and other practitioners. This unrestricted website is designed to target a broad range of individuals with scientific and non-scientific backgrounds. The primary audience is the Sound Stewardship program, which utilizes community-based participation to design, implement, and maintain restoration sites in Puget Sound nearshore habitats. General topic categories will include landscape structures, environmental processes, the flora and fauna of nearshore environments, project design, and success monitoring. Initially, the database will contain 100-150 articles available for public use, from sources including state and federal agencies, non-profit organizations, and peer-reviewed literature where available. The site will be maintained, updated, and amended with the most current resources, including links to outside sources. We will include opportunities for users to provide feedback and submit relevant new material. The current timeline has the fully functional database available through the People For Puget Sound website by the spring of 2007.

Special Panel: First Nations / Tribal Panel

Panel Members:

- *Sto:lo Nation, Sonny McHalsie, Environmental Protection of the Sto:lo Nation*
- *Skagit River Cooperative System, Steve Hinton, Collabortive Environmental Projects*
- *Homalco Nation, Chief Darren Blaney, Fish Farm: Effects on the Ecosystem*
- *Tulalip Tribes, Terry Williams, Climate Change in the Salish Sea Eco Region*
- *Squamish Nation, Randall Lewis, Squamish Environmental Parnership Projects*

Session 11A: Hood Canal and DO: Biotic Response To Low DO

Chair: Duane Fagergren

Relationships between Benthic Invertebrates, Sediment Quality, and Dissolved Oxygen Levels in Hood Canal, WA

Margaret Dutch, Sandra Aasen, Edward Long, Kathy Welch, Valerie Partridge, Washington State Department of Ecology*

Relationships between sediment-dwelling invertebrates, sediment quality, and dissolved oxygen levels in Hood Canal were examined by Ecology's Puget Sound Assessment and Monitoring Program Sediment Monitoring Team to assess the effects of low dissolved oxygen on benthos in Hood Canal as part of the Hood Canal Dissolved Oxygen Program. Examination of data collected from 1932 through 2005 revealed a number of patterns. Chemical contamination and toxicity were generally low in Hood Canal, and usually confined to Port Ludlow, Port Gamble, and Dabob Bay. Unique infaunal assemblages were distinguished for nine sub-regions of the canal, based on benthic index, grain size, organic carbon, and depth values. Infaunal abundance, diversity, and dominance values 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. Noticeable changes in benthic assemblage structure were apparent when DO levels were at or below 6 and then 1 mg/L. Multivariate analyses of these data, conducted by task partner David Shull, WWU, further explores these relationships. Identification of data gaps, development of initial critical values/ thresholds, and recommendations for future work on this topic will be presented.

Reconstructing the Historical Response of Benthic Communities to Hypoxia in Hood Canal, WA

David Shull, Western Washington University*

Because benthic infauna are relatively immobile and sensitive to concentrations of bottom-water dissolved oxygen, benthic community structure is considered a useful indicator of ecological response to hypoxia. The WA Department of Ecology has been monitoring benthic communities in Hood Canal, WA since 1989, but measurements of bottom-water oxygen concentration at benthic sampling locations have only been collected since 2004. How can one reconstruct historical changes in benthic community structure in Hood Canal due to changes in bottom-water oxygen when appropriate data on bottom-water oxygen are not available over the time period of interest? This problem was addressed by application of canonical analysis to data on spatial patterns of dissolved oxygen and benthic community structure. The canonical relationships between benthic community structure, dissolved oxygen, and other environmental variables were then applied to the longer-term data set for which appropriate data on dissolved oxygen were not available. The analysis indicates little variation in community structure attributable to changes in dissolved oxygen in northern Hood Canal, but historical changes in benthic communities in southern Hood Canal are consistent with reduced levels of bottom-water oxygen.

Population-Level Impacts of Low Dissolved Oxygen on Hood Canal Demersal and Benthic Biota

Tim Essington, University of Washington*
Wayne Palsson, Washington Department of Fish and Wildlife

We used long term data on fishes, macroinvertebrates and microinvertebrates collected throughout Hood Canal to determine the species-specific responses of recent hypoxic events on population abundances. These data span the entire spatial range of Hood Canal, including the northern areas that have not been subject to recent hypoxic events. We used generalized linear models to test for significant effects of location, time, and a time x location interaction term on species biomass and / or abundances while accounting for other environmental covariates. We found some evidence for changes in population biomass by space or time but there was no consistent trend of increasing or decreasing biomass by region or time among species. Further, there was no evidence for a time x region interaction (the strongest possible indication of an effect of hypoxia). However, statistical power to detect a significant effect was low; on average, there was only a 18 % chance of detecting a 50% reduction in population biomass in the southern regions of Hood Canal. These analyses indicate highly species-specific population-level impacts of hypoxia and that more intensive monitoring is needed to reach scientifically-defensible conculsions regarding the impacts hypoxic events on Hood Canal biological populations.

Acoustic Assessment of Biotic Response to Hypoxia in Hood Canal

Sandra Parker Stetter, John Horne, University of Washington, School of Aquatic and Fishery Sciences*

Hypoxic conditions can influence the horizontal or vertical distributions of pelagic organisms. In Hood Canal (Washington), low oxygen has resulted in fish kills during late summer. Our study examined whether the distribution of biota (fish and large invertebrates) reflected decreasing oxygen levels or localized hypoxic zones. Acoustics (38 and 120 kHz) were used to quantify the water column distribution of biota along transects between the Duckabush River and Lynch Cove. We surveyed Hood Canal during both day and night before (July), during (September), and after (December) a hypoxic event in 2006. Pelagic biota vertically avoided low oxygen zones during September. However, dissolved oxygen concentrations alone did not explain vertical differences among July, September, and December. Patterns in horizontal distribution also differed between sampling periods, with larger patches and schools detected during July than either September or December. Results suggest that overall biomass reductions observed between July and September were primarily due to changes in fish biomass, possibly due to mortality or emigration from Hood Canal. Vertical and horizontal movement due to hypoxia may reduce pelagic species population fitness, and could serve as an indicator of stressful offshore oxygen conditions.

A History of Severe Hypoxia on the Outer Coasts of Oregon and Washington

Brian Grantham, Washington State Department of Ecology*

Hypoxia in coastal waters is increasing in frequency throughout the world. Hypoxia occurs when high nutrient availability and strong stratification stimulate phytoplankton growth in near-surface waters and increase the flux of organic material to the bottom. Oxygen is consumed as this material decomposes and in the absence of mixing bottom waters become oxygen depleted. Hypoxia typically develops in enclosed or semi-enclosed seas, or on open coasts with low mixing and large inputs of nutrient-laden runoff. However, it also occurs in some coastal systems where the nutrients fueling phytoplankton growth come from seasonal upwelling, rather than terrestrial runoff.

In contrast to most upwelling ecosystems, coastal waters within the California Current system have not historically experienced severe hypoxia. However, in July, 2002 severe hypoxia and an extensive die-off of fish and invertebrates occurred in shallow waters off the central Oregon coast. Hypoxic conditions have recurred each year since then and in summer 2006, particularly severe hypoxia extended up the coast from Oregon into Washington, where it caused mass mortality of fish and crabs. This talk will review the history of hypoxia on the WA and OR coasts and discuss the possible causes and implications of this recent phenomenon.

History of Hypoxia Recorded in Sediments of Hood Canal, Puget Sound

Eric Crecelius, Battelle Pacific Northwest National Laboratory*
Jill Brandenberger, Battelle Marine Sci. Lab
Patrick Louchouarn, Texas A&M University
Sherri Cooper, Bryn Athen College
Estella Leopold, Liu Gengwu, University of Washington
Kristin McDougall, US Geological Survey

Hood Canal, a fjord in Puget Sound, has experienced several hypoxic events in the last few years that resulted in fish kills. Sediment cores were collected and age dated for the purpose of reconstructing the history of hypoxia, from pre-Euro American settlement to the present using a multitracer approach based on the comparative analysis of concomitant markers of redox-sensitive and stable metals; elemental, isotopic, and biomarker signatures of organic matter; and the accumulation of microfossils. The markers recorded in three sediment cores show historical fluctuations in sedimentary redox conditions and inputs of organic matter (OM; marine vs. terrigenous). The relationship between them suggests that the more labile marine OM supports higher respiration rates in deep basins. Additionally, the redox indicators in sediments deposited prior to Euro American settlement, show that deep-water oxygen levels have historically been lower in these basins than they have been for the most part of the 20th Century. There appears to have been approximately five hypoxic events during the last 500 years that were more severe than hypoxic events during the last 50 years. Based on these historical trends, the increase in marine OM recorded in the last decade suggests that conditions conducive to low oxygen levels are now returning to the Canal. There appears to be a good correlation between the timing of the hypoxic events in the Canal and the interdecadal climate signal in the Pacific.

Session 11B: Marine Birds and Waterfowl I

Chair: Dave Nysewander

Field-Feeding Behaviour of Wintering Waterfowl on the Fraser River Delta

Kim Houghton, Ducks Unlimited Canada*

Located on the Pacific Flyway, the Fraser River Delta (FRD) contains one of the largest estuaries on the north Pacific Coast. Approximately one million migrating and wintering waterfowl use the FRD on a yearly basis. Upland agricultural crops provide important foraging habitat for dabbling and grazing waterfowl, however, urban sprawl, increased human disturbance and changing land-use policies continue to reduce the amount of waterfowl habitat. To better understand habitat preference of wintering waterfowl on agricultural lands, feeding behaviour and grubbing depths were examined using the Altmann scan sampling technique on three common crop types: potato, perennial grass and corn. Observations were conducted on a weekly basis from October 2005 through April 2006. Foraging behaviour was categorized as skimming, pecking, grubbing and non-foraging behaviour as resting, preening and locomotion. Results showed five species of waterfowl feeding on upland agricultural crops with most time spent on potato fields. However, each species displayed different behaviour while present on this crop type. American Wigeon (Anas americana) and Mallards (Anas platyrhynchos) were the only species found grubbing but they did so at varying depths. Green-winged Teal (Anas crecca) and Northern Shovelers (Anas clypeata) were observed only pecking; Northern Pintails (Anas acuta) mainly resting. This study demonstrates the importance of potato fields to migratory waterfowl and enables decision-makers to improve conservation planning and delivery to meet nutritional and other requirements of waterfowl on the FRD.

Seasonal Habitat Requirements of Surf and White-Winged Scoters

Eric Anderson, James Lovvorn, Department of Zoology and Physiology, University of Wyoming*
David Nysewander, Joseph Evenson, WDFW, PSAMP Marine Bird and Mammal Monitoring

While declines in many marine mammal and bird populations are well-documented in the Puget Sound-Georgia Basin, the role of specific habitat resources in such declines is often unknown. To guide protection efforts, we are evaluating habitat use patterns of Surf Scoters (Melanitta perspicillata) and White-winged Scoters (Melanitta fusca) in bays of alternative benthic habitats in northern Puget Sound. The ability of White-winged Scoters to consume larger prey likely enables them to continue consuming bivalves and thus maintain condition and forego costly movements when smaller bivalves preferred by both species are depleted. Alternatively, Surf Scoters appear to have multiple strategies to partially compensate for seasonal declines in their condition. For instance, Surf vs. White-winged Scoters consume a greater diversity of prey and as winter progresses often move to eelgrass (Zostera sp.) habitat where standing stocks of most epifaunal prey are typically greater relative to unvegetated habitats. Since the 1970s, White-winged Scoters have increased by 30% and Surf Scoters have declined by 45% in northern Puget Sound. However, it is unclear whether changes in coastal resources in this region vs. changes in migration and breeding areas have contributed to these unique population trends.

Estimating Black Oystercatcher Breeding Populations With New Methods In and Near the San Juan Islands, Washington State, May and June 2006

David Nysewander, Ruth Milner, Joseph Evenson, Thomas Cyra, Washington State Department of Fish and Wildlife*
Sue Thomas, U. S. Fish and Wildlife Service

The Black Oystercatcher (Haematopus bachmani) is described as a "species of high concern" in the U.S., Canadian, and Alaskan shorebird conservation plans, due to the species' small population size, threats to their habitat, and their susceptibility to human disturbance. The marine shorelines of Washington State and nearby southern portions of British Columbia host a significant resident population of this species. Although this species is relatively easy to see, few systematic surveys have been applied to all appropriate habitats within a more widespread geographic area inside a limited time frame. Boat-based surveys were conducted in and near the San Juan Islands in Washington mid-May to early June 2006 during nesting when territorial defense displays are common. The new use of playing recorded calls allowed for complete coverage of areas in less time, with more assurance of the likelihood of observation of all breeding pairs. Data generated by these surveys helps monitor other indices of population structure such as nests incubated. The total breeding population of oystercatchers for the 93 sites that were censused in 2006, using recorded calls, is estimated to be 108 breeding pairs that nested (216 breeding birds on a total of 68 of the 93 sites) with possibly up to 112 non-breeders also present, suggesting the total number of oystercatchers found in this region is likely to fall in the range of 250-300, depending upon the movement of the non-breeding component.

Importance of Coastal Field Habitats for Great Blue Heron and Associated Wildlife

Ann Eissinger, Nahkeeta Northwest Wildlife Services*

Coastal grasslands throughout the Salish Sea serve a vital habitat role for numerous wildlife species including the Great Blue Heron (Ardea herodias). Grass-dominant fields, wet meadows and fallow agricultural lands provide year-round upland habitat. Herons utilize grasslands for foraging, loafing and staging. Field habitats harbor an important preybase that include small reptiles, amphibians, birds and mammals, of which the meadow vole (Microtus townsendii) is most

notable. Habitat utilization by Great Blue Heron, in association with a major heron colony, was studied over a one-year period. The study revealed the heron's primary association with fallow field during the breeding season and regular use year-round. The study, through weekly sampling, recorded and compared the heron's use of four habitat types within a 1,200 acre study area. Data collected included: conditions, timing, location, behavior and numerical abundance. Wildlife observed during the study resulted in 124 species recorded along with associated habitat and seasonality. The study was conducted with the support of BP Cherry Point Refinery of Blaine, Washington, in association with the Birch Bay Great Blue Heron Colony Conservation Program.

Western Grebe Population Declines in the Strait of Georgia B.C. and Puget Sound WA: Patterns and Possible Reasons.

Sean Boyd, Environment Canada (Canadian Wildlife Service)*

Counts conducted by the Canadian Wildlife Service in the Strait of Georgia B.C. (eg, Baynes Sound) suggest that Western Grebe numbers have declined considerably since the early 1980s. Counts conducted over much of the Strait of Georgia and Puget Sound WA during annual Christmas Bird Counts and aerial surveys by the Washington State Dept. of Fish and Wildlife suggest that Western Grebe numbers have declined considerably since the 1970s, and especially so since the early 1990s. Prior to 1970, Christmas Bird Counts were conducted at only 4 locations in the Strait of Georgia and Puget Sound (Vancouver, Victoria, Comox, and Seattle). Data from these 4 sites indicate that Western Grebes disappeared completely from this large coastal area for about 10 years starting in 1963. This disappearance coincided with a dramatic collapse in their preferred prey species, Pacific Herring. The collapse in Herring stocks was apparently caused by an unregulated reduction fishery at the time. After a period of recovery, the abundance and distribution patterns of Pacific Herring are changing once again on both sides of the Canada-US border, and this is having a cascading effect on Western Grebes. The Strait of Georgia and Puget Sound are at the northern edge of their winter range and therefore Western Grebes are likely very sensitive to changes in the ocean environment, including abundance and distribution patterns of their preferred prey species. An analysis of more recent Christmas Bird Count data hints that Western Grebes may simply have shifted further south, towards California.

On and Off-Shore Drivers of Historic Population Trend in Marbled Murrelets

Peter Arcese, University of British Columbia*
Ryan Norris, University of Guelph
David Preikshot, University of British Columbia
Douglas Bertram, Environment Canada (Canadian Wildlife Service)
Kurt Kyser, Queens University

We used stable isotope analysis of museum specimens to reveal a 107 yr decline in trophic feeding level of Marbled Murrelets in the Georgia Basin region. In the last 40 yrs, diet quality was closely related to forage fish biomass and murrelet abundance, allowing us to validate a simple population model and back-cast population growth rate to 1889. We suggest that murrelet numbers in the Georgia Basin were once limited by the availability of forest nesting habitat, but may now be limited by feeding conditions at-sea. We describe a landscape-level experimental monitoring design to test if variation in 'eat-sea' or 'eon-shore' habitat quality has the greatest effect on population trend and suggest that conserving terrestrial and marine habitats of this highly secretive, threatened seabird will be necessary to insure its persistence in future.

Session 11C: Nearshore Habitat and Species Restoration

Chair: Doug Myers

Historical Changes to Estuaries, Spits, and Associated Tidal Wetland Habitats in the Hood Canal and Strait of Juan De Fuca Regions of Washington State

Steve Todd, Nick Fitzpatrick, Chris Weller, Point No Point Treaty Council*
Alan Carter Mortimer, Aspect Consulting

We used 19th century maps and contemporary air photos to assess changes in tidal wetland habitats associated with estuarine and spit complexes in the Strait of Juan de Fuca and Hood Canal regions. We assessed changes in surface area and connectivity of tidal wetlands associated with these complexes, and evaluated how habitat-forming processes have been altered by human intervention.

We identified 250 habitat complexes across the study area, ranging from < 1 ha to 799 ha in size. Overall changes included a 7% decrease in tidal wetland habitat (marsh and lagoon) associated with the complexes. The numbers of spit/marsh complexes that provide surface water connectivity with adjacent waters (i.e., potential accessibility to juvenile salmon) decreased from 77 to 65, and tidal wetland habitat associated with these complexes was reduced from 449 to 351 ha.

Fill resulting from transportation and residential development were the most common causes of habitat change. Delta progradation has occurred in several larger estuaries, the result of channelization and sedimentation from land use activities. Complexes were given a "relative condition" rating to indicate the level of changes in tidal wetland and habitat connectivity impairment. Findings are helping to prioritize salmon habitat conservation and local shoreline planning.

Remembering our Roots: A Possible Connection Between Loss of Ecological Memory, Alien Invasions and Ecological Restoration

Val Schaefer, University of Victoria*

When a community or ecosystem that once occupied a site is lost, some of its properties may remain, leaving behind an ecological memory. The soil properties, spores, seeds, stem fragments, mycorrhizae, species composition, populations and other remnants of the previous inhabitants may contribute to the establishment of the replacement community or ecosystem to varying degrees, depending upon the extent of the original habitat loss. This ecological memory helps a site to restore itself after a disturbance.

The loss of ecological memory where disturbance has moved previously existing conditions beyond a critical threshold may enable foreign invasive species to become established and dominate a site. Conversely, successful invasive species control may involve more than removal of invasives and the subsequently reintroduction of native species. A more holistic approach that re-establishes other biotic and abiotic factors may be necessary in some cases. There is some urgency for further research to document and conserve ecological memory for future application in ecological restoration.

Juvenile Dungeness Crab Habitat Study: Obtaining Best Available Science through Partnerships & High-Endurance Volunteer Power

Stef Frenzl, Snohomish County*
Don Velasquez, Washington Department of Fish & Wildlife

Dungeness crab is an important species ecologically and economically in the Puget Sound region. Little is known about juvenile Dungeness crab habitat preferences and duration of settlement along the nearshore environment in much of the region. The Washington Department of Fish & Wildlife (WDFW) and the Snohomish County Marine Resources

Committee investigated juvenile Dungeness crab preferences for habitat type and tide elevation at five sites along the Snohomish County nearshore environment from May through September 2006. Additionally, we investigated the duration of settlement and residence. Sampling occurred every two weeks at each site. Results indicate that juvenile Dungeness crabs prefer mixed substrates with a sand component, and secondarily, vegetated sand habitat. We found no consistent settlement preference patterns among tide elevations between the categories of habitat sampled. Juvenile Dungeness crab settlement occurred continuously throughout the study period after June 14th. WDFW will use study results to develop rules for Hydraulic Project Approval applications in Snohomish County. This ambitious effort was possible due to an extensive number of partnerships and over 70 highly-trained college students and volunteers. This study can serve as a model for those interested in developing collaborations among various agencies, organizations, and institutions to implement sound, applied science.

Location, Location, Location: Intertidal Diversity Gradients in Puget Sound

Helen Berry, Washington State Department of Natural Resources*
Megan Dethier, Jennifer Ruesink, University of Washington
Blain Reeves, WA Dept of Natural Resources
Amy Glaub Sprenger, University of Washington

Effective assessment and restoration of littoral habitats depends on an understanding of intertidal biodiversity patterns and the processes that drive them. Recent studies show a striking gradient in species richness on pebble-sand beaches along the estuarine gradient of Puget Sound. This pattern is consistent among years and exists for both epibiota and infauna. We investigated the processes behind the pattern, exploring gradients in physical conditions, growth rates, recruitment, and early post-recruitment mortality. Although richness and biomass of adult organisms are almost twice as high at the marine end of the gradient, richness and abundances of new infaunal recruits (<1 month old) show no such gradient, even when sediment grain sizes are controlled. Protecting bivalve recruits from predators had minimal effects on survival over 4 months. Our results suggest that early post-recruitment mortality of infauna drives the richness gradient.

A Conservation Strategy for Tarboo-Dabob Bay, Washington

Peter Bahls, Northwest Watershed Institute*

Tarboo-Dabob Bay is one of the largest, high quality saltmarsh estuaries remaining in Puget Sound and provides important habitat for fish, wildlife, and shellfish resources. Portions of the Bay are protected by state preserves, but the health of the estuary as a whole is threatened by increasing development pressure and associated road building, shoreline armoring, and logging along the steep slopes and shorelines. Northwest Watershed Institute is working with partners to develop a comprehensive conservation strategy for Tarboo-Dabob Bay that includes expansion of the existing Natural Area Preserve and Trust Land Transfer options to preserve the watershed processes that keep the estuary functional. In this presentation, I will discuss the scientific and political considerations and our progress to date on this conservation initiative.

Marine Nearshore Habitat Priorities in the Green-Duwamish Watershed in Central Puget Sound

John Small, Paul Schlenger, Ali Wick, Anchor Environmental*
Julie Hall, Seattle Public Utilities
Kollin Higgins, King County DNRP

This presentation describes a science-based approach for the prioritization of restoration and conservation opportunities along the marine nearshore of Central Puget Sound. The purpose of the project is to assist the salmon recovery efforts and focus resources on areas that can significantly contribute to providing habitat that meets the ecological needs of juvenile salmon.

The prioritization effort focused on nearshore processes that create and sustain habitats. To this end, habitat conditions were considered on several scales from the site specific level of tens of feet, to the drift cell scale of several miles, to the landscape scale comprising the project area's 90 miles of shoreline and beyond.

The project area is the Puget Sound shoreline of the Green-Duwamish Watershed, including Vashon and Maury Islands. The project area includes Elliott Bay a heavily urbanized shoreline. These urbanized areas presented a challenge for identifying restoration and conservation priorities in this project and in other salmon recovery focused efforts in the region. A comparison of the conditions in Seattle with those in Mason County, a less altered portion of South Puget Sound, where habitat restoration and conservation is still needed, but presents different challenges.

A completed restoration project at Seahurst Park, located south of Seattle, will be described. This restoration project is and example of the type of projects that are needed along the Puget Sound shoreline.

Panel 11D: Critical Load Modelling for Atmospheric Deposition I

Chair: Peter Schwarzhoff

A Critical Load is the highest deposition rate that will not cause chemical changes leading to long-term harmful effects in the most sensitive ecosystems. The indicators and potential endpoints for effects vary with the intent and the sensitivity of receptors. This session will present aspects of critical load and deposition modelling and effects underway in the Georgia Basin at present.

Panel Members.

- *Patrick Shaw*
- *Shaun Watmough*
- *Alyse Mongeon*
- *Elizabeth Waddell*
- *Paul Arp*

Introduction to the Critical Load Concept

Shaun Watmough, Julian Aherne, Trent University

In recent years the sensitivity of terrestrial and aquatic ecosystems to acidification and eutrophication have been described in terms of critical loads; defined as "a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on sensitive elements of the environment do not occur according to present knowledge". The concept has been widely accepted as a basis for the development of air pollution control strategies in Europe. The linking of ecosystem response to deposition level is the central principle of the critical load approach, with methods ranging from simple semi-quantative assessments to dynamic modelling (used to assess the time required to reach steady state). Recently, the critical loads methodology has been used to assess the impacts of atmospheric deposition of nitrogen and sulphur to upland forests in Eastern Canada and the Prairie Provinces. Critical loads of atmospherically deposited nitrogen and sulphur and currently being developed for Georgia Basin ecosystems. This presentation will provide an introduction to the critical load concept and the application of the approach to the Georgia Basin in British Columbia.

Weathering Rates and Steady-State Critical Loads for Forest Plots in the Georgia Basin

Alyse Mongeon, Julian Aherne, Shaun Watmough, Trent University

During June 2004, the Pacific and Yukon Region of Environment Canada initiated a research programme to determine critical loads of atmospherically deposited nitrogen and sulphur for Georgia Basin ecosystems, British Columbia. A critical load is defined as "a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on sensitive elements of the environment do not occur

according to present knowledge". Critical loads of acidity are strongly dependent on the rate of release of base cations from the soil matrix, i.e. the soil weathering rate. During summer 2006, soils from 19 forest plots were sampled for mineralogical analysis. A significant proportion of the study sites were part of the former Canadian Forest Service (CFS) Acid Rain National Early Warning System (ARNEWS) plot network (11 plots). Furthermore, a number of the plots were located in long-term study catchments (UBC research forest and Roberts Creek). As such, a wealth of historic data exists for many of the study sites. Soil mineralogy will be used in conjunction with soil physio-chemical characteristics to determine the weathering rate for each study site. These estimates will be central in determining the steady-state critical loads of acidity for the forest soils in the Georgia Basin.

Establishing Critical Loads for Nitrogen and Sulfur Deposition in NW Washington

Elizabeth Waddell, NPS

For over a decade, the critical load concept has been an important policy tool in Europe and Canada. Canada has employed combined maps of critical load values for both aquatic (lake) and terrestrial (upland forest soils) ecosystems in several assessments evaluating how acid deposition impacts Canadian ecosystems - especially in the East (Environment Canada, 2004, RMCC 1990, Environment Canada 1997).

There has been growing interest in using the critical load concept in the U. S. In 2000, the federal land managers indicated their intent to develop critical loads. In 2004, the National Academy of Science recommended that EPA consider critical loads to protect ecosystems. In 2006, EPA provided that states could use critical loads in lieu of increments. In May 2006, Rocky Mountain National Park established a critical load for eutrophication effects to alpine lakes.

In September 2006, the Northwest Clean Air Agency sponsored a nitrogen and sulfur deposition critical loads science workshop co-hosted by the National Park Service, U. S. Forest Service, and U. S. Geological Survey to assess the quality of existing data and the additional data needed for establishing critical loads in NW Washington (Puget Sound airshed). Six high priority research efforts were identified at that workshop addressing both terrestrial and aquatic ecosystem effects. This presentation will discuss the results of that meeting and the progress that has been made since that meeting.

Framework for High-Resolution Modeling and Mapping of Criticial S and Loads and Exceedance

Paul Arp, Faculty of Foresty and Env. Management

An approach will be presented for mapping critical S and N load (CL) and exceedances of forest soils within the Georgia Basin, based on an upland-wetland delineation at high resolution (10 m). This delineation is crucial for tracking differences in soil N chemistry as affected by soil drainage: upland soils are sensitive to N-induced acidification when: atmospheric N2 is fixed and nitrified (as in red alder stands), incoming NH4-N is also nitrified, and part or all of the incoming and soil-produced NO3-N is not taken up by the vegetation. In poorly to partially drained soils, part of the incoming NO3-N is de-nitrified, thereby causing an increase in critical N and S+N loads for wetland soils. The approach uses these data layers: digital elevation, atmospheric S, N, Ca, Mg, K deposition grids, climate grid for air temperature and precipitation, forest site classification, soil map, and forest inventory data. The latter is used to quantify nutrient demands in reference to primary nutrient supplies, originating from atmospheric deposition and soil weathering. Nutrient demands refer to nutrients lost due to forest harvesting and fires. These can be derived from expected mean annual forest biomass increments, by dominant species type, per map unit. This approach deals with steady-state and dynamic CL assessments, with the latter needed to deal with ascertaining base-cation depletion rates in response to actual and projected S and N emission and deposition targets.

Session 11E: Toxics in Biota I

Chair: Peter Ross

Environmental Biomarkers using Mussels.

Susan Baldwin, Paul van Poppelen, Annette Muttray, Ekaterina Vassilenko, University of British Columbia*

Biomarkers give us an easily measurable way to deduce information about complex biological processes associated with the health of an individual or the presence of a disease. In environmental monitoring, they are used as part of a collection of tests to predict environmentally-induced diseases and damage to ecosystems. As indicators of environmental quality, bivalve mollusks, such as *Mytilus spp.*, are often used as sentinel organisms. Many so called "mussel watch" programs are in place across North America to track temporal changes in contaminant body burdens and population health. Recent developments in genomics and proteomics have provided more accessible tools for including molecular biomarkers in the suite of tests used to assess the physiological conditions and health of mussels used in mussel watch programs. In this talk, we will outline our approach to the development of genetic biomarkers for environmental monitoring. We will discuss the desired attributes of an environmental biomarker and the challenges and pitfalls that need to be overcome. In our laboratory, we are developing genetic biomarkers for a leukemia-like disease (haemic neoplasia) that is a non-lethal endpoint monitored at some locations. Examples of challenges that we have faced and ways that are proposed to overcome these will be given.

Current-Use Pesticides and Salmon Neurophysiology: Implications for Salmon in British Columbia

Keith Tierney, Simon Fraser University*
Peter Ross, Fisheries and Oceans Canada
Mark Sekela, Environment Canada
Chris Kennedy, Simon Fraser University

Salmonids, including coho (*Oncorhynchus kisutch*) and sockeye (*O. nerka*) spp., utilize many areas adjacent to urban and agricultural activities for spawning and early life history stages. Recent declines in the abundance of certain stocks, and alterations in the migratory patterns of others, triggered concerns regarding the possible impacts of waterborne contaminants such as current-use pesticides on the neurological systems of these fish. In this talk we will provide pesticide concentrations in-field around the province of B.C., and then relate these to known sublethal neurophysiologic effects. For example, atrazine has been detected in urban (Scott Cr.) and rural (Nathan Cr.) streams, and has been shown to decrease olfactory neuron responses within minutes of exposure. Exposure has also been associated with decreasing olfactory-mediated attraction to the amino acid L-histidine. Similarly, the insecticide chlorpyrifos was found in the same streams, and has been shown to differentially impair both rapid acceleration and sustained swimming performance. By linking physiological and behavioural endpoints, and comparing adverse effects levels to concentrations measured in BC salmon streams, we are attempting to provide managers and regulators with a relevant risk assessment platform.

Contaminants and Associated Transcriptional Responses in Fish from Remote High Elevation Lakes of Western Washington, USA

Patrick Moran, Robert Black, US Geological Survey*
Neelakanteswar Aluru, Mathilakath Vijayan, University of Waterloo

The consistent cold temperatures and large amount of precipitation in the Olympic and Cascade ranges of Washington State are thought to increase atmospheric deposition of contaminants in these high elevation locations. Total mercury and 28 organochlorine compounds were measured in composite, whole fish samples collected from 14 remote lakes in the Olympic, Mt. Rainer, and North Cascades National Parks. Mercury was detected in fish from all lakes sampled and ranged in concentration from 17 to 262 µg/kg wet weight. Only

two organochlorines, total polychlorinated biphenyls (tPCB) and dichlorodiphenyldichloroethylene (DDE), were detected in fish tissues (concentrations <25 µg/kg wet weight). No organochlorines were detected in sediments (MRL ≈1-5 µg/kg), while median total and methyl mercury in sediments were 30.4 and 0.34 µg/kg (dry weight), respectively. Using a targeted rainbow trout cDNA microarray with known genes, we detected significant differences in liver transcriptional responses, including metabolic, endocrine, and immune-related genes, in fish collected from a contaminated lake compared to a lake with a lower contaminant load. Overall, our results suggest that local urban areas are contributing to the observed contaminant patterns, while the transcriptional changes point to a biological response associated with exposure to these contaminants in fish. Specifically, the gene expression pattern leads us to hypothesize a role for mercury in disrupting the metabolic and reproductive pathways in fish from high elevation lakes in western Washington.

Improved Flatfish Health Following Remediation of a PAH-Contaminated Site in Eagle Harbor, Washington

Mark Myers, Bernadita Anulacion, Barbara French, William Reichert, Cathy Laetz, Jon Buzitis, Sean Sol, O. Paul Olson, Tracy Collier, NOAA Fisheries, Northwest Fisheries Science Center*

Eagle Harbor in Puget Sound became a Superfund site in 1987 due to high sediment concentrations of polycyclic aromatic hydrocarbons (PAHs) released chronically from a nearby creosoting facility. Early studies with English sole from this site (1983-86) demonstrated high prevalences (up to ~80%) of toxicopathic liver lesions, including neoplasms. These lesions have been strongly and consistently associated with PAH exposure in multiple field studies, and have been induced in the laboratory injections of a PAH-rich fraction extracted from Eagle Harbor sediment. Further studies (1986-88) incorporated biochemical biomarkers of PAH exposure and effect, including hepatic CYP1A expression, biliary fluorescent aromatic compounds (FACs), and DNA adducts in liver. Prior to site remediation, hepatic lesion prevalences and biomarker values in these species from Eagle Harbor were among the highest in Puget Sound. In 1993 and 1994, a primary cap of clean sediment was placed over 54 acres of the most contaminated portions of Eagle Harbor, with a secondary cap added between November 2000 and February 2002, in order to sequester PAH-contaminated sediments. Lesion prevalences and biomarker values just before capping were reduced compared to historical data, consistent with closure of the creosoting facility closure in 1988, and subsequent shore-based source controls. Data on liver lesion risk, hepatic CYP1A, and biliary FACs from fish collected immediately after and at regular intervals up to ~2 years after primary sediment capping were highly variable relative to pre-capping values. However, over the entire monitoring period (up to 142 months) since cap initiation, but particularly after ~3 years, there was an overall, significantly decreasing trend in risk for hepatic lesions in English sole, and for biliary FACs and hepatic DNA adducts. In particular, the risk of hepatic lesion occurrence in English sole has been consistently low (> 0.20) compared to lesion risk at cap initiation (1.0), from ~4 years after sediment cap placement through April 2005. These results show that the sediment capping process has been effective in ameliorating PAH exposure and associated biological effects in resident flatfish species, and that longer term monitoring of pollutant responses in biological resources, such as resident fish, is necessary and far superior to monitoring of only sediment contaminants in order to demonstrate the efficacy of this type of contaminant remediation.

Contaminants in Pacific salmon (Oncorhynchus spp): the importance of fish biology in assessing sources from the Pacific Ocean versus regional sources from coastal waters of Puget Sound and the Georgia

Sandra O'Neill, West James, Washington State Department of Fish and Wildlife*

Gina Ylitalo, NOAA Fisheries

Contaminants levels in Pacific salmon and other fishes depend on where they live and what they eat. However, predicting contaminant levels in salmon is particularly difficult because of their complex life histories. Our ongoing monitoring and research studies have documented general accumulation patterns that are tightly linked to the fishes' biology. Although salmon may be exposed to contaminants in freshwater and estuarine habitats, we documented that most POPs are accumulated in marine habitats where most of their growth occurs. Observed contaminant levels in pink, chum and sockeye were lower than chinook and coho, reflecting differences in marine distribution and diet among species. Pink, chum, and sockeye salmon feed and grow primarily in oceanic waters, at great distances from coastal pollution sources, whereas Chinook and coho spend more time in coastal waters along the continental shelf where they are exposed to coastal pollution sources. We also observed regional variation in contaminant levels in Chinook populations that appears to be associated with differences in their marine distribution. PCBs and PBDEs levels were highest in Chinook salmon that resided in Puget Sound, followed by Puget Sound populations believed to be more ocean-reared, and were lowest in populations distant from urban areas.

Session 11F: Education Outreach and Citizen Involvement

Chair: Mary Knackstedt

Developing a Comprehensive Surface Water Education Plan for a Rural County

Pat Pearson, Washington State University Jefferson County Extension*

WSU Jefferson County Extension designed a comprehensive Surface Water Education Plan for the Jefferson County Surface Water Management Plan. Successful surface water and storm water management are critical to protecting water quality. Success of a management plan depends upon the public understanding the importance of water quality and natural processes and be willing to support activities and behaviors that protect the environment. WSU administered an initial community survey to assess community awareness and needs, designed a county-wide campaign titled "Water Matters", and developed new surface water education programs to reach targeted audiences and the general public. Watershed education newspaper inserts were distributed to 20,000 residents. A new program titled "Welcome to Your Watershed" was created to reach new home and property owners through partnerships with local realtors and county departments. We created a folder with local information on watershed processes, answers to water/on-site septic/ building related issues, and a list of "Who Can Help" contacts that we distribute through realtors and permitting departments. The "Green Gardening Nursery Project" provides garden nursery staffs and customers with up to date handouts, trainings, and workshops on fertilizer and pesticide reduction and natural lawn care.

Boating Clean and Green on Georgia Strait

Mike Richards, Georgia Strait Alliance*

With almost half a million recreational vessels plying the waters of Georgia Strait, a number that is increasing every year, there are many real and potential impacts from boating activities on this precious environment. Georgia Strait Alliance (GSA) launched the Green Boating Program in 2000 to address the issues of recreational boating in Georgia Strait through a proactive educational process. During this time, GSA has visited almost every marina around the Strait of Georgia, meeting with boaters and marina staff and carrying out education on environmentally sound boating practices. The program – centred on the popular "Guide to Green Boating" - has also provided signage and numerous presentations to marinas, boating clubs, government agencies and other organizations. We have distributed over 50,000

guides throughout this region and beyond, and it is used regularly in many boating education courses. In 2004, the program was expanded to help reduce hydrocarbons in our harbours. We have distributed over 14,000 fuel and oil absorbent pads in the Capital Regional District of Victoria, the Nanaimo area, with expansion into the Lower Mainland. With excellent educational tools, experienced staff and a collaborative approach, this national award-winning program has proven to be successful beyond expectations. This presentation focuses on the program, its goals, the qualitative and quantitative indicators of success and the ingredients that have kept it sustainable.

Nature Matters — A City's Commitment to Environmental Stewardship

Carrie Baron, Lanny Englund, City of Surrey*

As the City of Surrey has evolved over the years, so has its environmental stewardship and community awareness initiatives as demonstrated by the Nature Matters program. The Program objectives include:

Protecting and enhancing our environment
Educating and engaging residents in environmental issues
Increasing youth involvement through stewardship activities
Encouraging volunteerism in the community
Working with teachers and students to provide environmental education opportunities

To achieve these initiatives, staff has enhanced existing and developed new programs. Environmental programs such as SHaRP, SNAP, Releaf, Environmental Extravaganza, and Eco Rangers are but a few of the initiatives that have evolved in the last 10 years. Key highlights include:

Yearly environmental events, which bring more than 20,000 residents, businesses and students together.
350 students working in natural areas through the SHaRP and SNAP programs
Working with our agricultural community on environmental issues (any numbers?)
Contacting over 1600 business on pollution prevention practices
Tens of thousand of trees, shrubs and wetland plants installed to enhance habitat

The above programs demonstrate that "Nature does Matter" to the residents of Surrey. With dedicated funding, and a long-term commitment, these initiatives can make a difference in a community.

The Power of Watershed Education Networks

Robert Simmons, Emily Sanford, Washington State University Extension*

In the communities of the Puget Sound Georgia Basin there are numerous organizations providing environmental education to meet their own specific objectives. In some regions of the basin, environmental education networks have been established and are successfully increasing the effectiveness of environmental education efforts. In a 2006 survey of environmental educators, conducted by the Puget Sound Action Team, it was found that increased coordination and collaboration between organizations is strongly desired in areas where networks do not currently exist.

These formalized networks generally have participation from non-profit organizations, government agencies, school teachers and businesses. Networks have provided collaboration and coordination amongst the diverse groups providing outreach. Goals of these network goals typically include:

- Preventing duplication
- Providing consistent messages to the public
- Fostering collaborative efforts
- Ensuring that key audiences are reached
- Educating members on specific issues or education strategies
- Providing meaningful evaluation of programs
- Increasing responsiveness to emerging issues

Further development of such networks is considered crucial in efforts to best protect and manage Puget Sound. This presentation will discuss the operating models used by four of the more established networks, as well as their strengths, accomplishments and greatest challenges.

Successes of the Swinomish Environmental Education Program: Video Series

Kaia Smith, Swinomish Indian Tribal Community*

This presentation will discuss the Swinomish Indian Tribal Community's Environmental Education Program and provide examples of culturally appropriate environmental education and outreach activities enacted by the Program, both within and outside the Swinomish community. The Swinomish Environmental Educator, Ms. Smith, works with all ages, from toddlers to elders, employing Native values to inform local communities about the importance of protecting the local ecosystems. Through a series of video shorts, this presentation will highlight Ms. Smith's work with Swinomish youth in raising environmental awareness via hands-on learning projects and interactive tools such as Tox-in-a-Box and Enviroscape. The themes cover lead awareness, recycling, and environmental awareness. The short films are funded in part by U.S. EPA grants #R-829467 and PH-97099101.

Session 12A: Hypoxia Beyond Hood Canal

Chair: Skip Albertson

Interim Results from the Budd Inlet, Capitol Lake, and Deschutes River Dissolved Oxygen and Nutrient Study

Mindy Roberts, Greg Pelletier, Washington State Department of Ecology*

Budd Inlet and the Deschutes River do not meet the water quality standards for dissolved oxygen. An ongoing study included supplemental data collection and model development to simulate nutrient dynamics in the Deschutes River, Capitol Lake, and Budd Inlet. Nitrogen concentrations increase in a downstream direction within the Deschutes River, due to natural and anthropogenic sources. The shallow waters and limited circulation of Capitol Lake enhance primary productivity, and algae blooms produce supersaturated oxygen conditions while decreasing dissolved nutrient concentrations during the growing season. A three-dimensional hydrodynamic and water quality model of Budd Inlet and Capitol Lake will simulate future conditions to quantify the nutrient load reductions necessary within the Budd Inlet watershed to meet the water quality standards in both marine and freshwater.

Circulation and Residual Flow in the South Basin of Puget Sound

Skip Albertson, Julia Bos, Greg Pelletier, Mindy Roberts, Washington State Department of Ecology*

The south basin of Puget Sound is a complex and interconnected system of straits, open reaches, and fjord-like bays. All the water contained within is forced to exchange with the main basin of Puget Sound over a sill and through Tacoma Narrows. Within the south basin estuarine circulation can be normal (seaward at the surface, landward at depth), inverse (the opposite), and even sideways (in on one shore, out on the other), which is due to the interaction of its complex morphology with processes such as seasonal variations in river flows, snowmelt, and evaporation. The true overall flushing time based on the tidally-averaged residual flow is about two months rather then one week as estimated by a simple tidal prism method, which has important ramifications for water quality. Locations closer to the Tacoma Narrows flush faster and those further from the Narrows flush slower than average. Starting at Tacoma Narrows where it is greatly reduced (1,500 m3/s); the residual circulation reaches a maximum in the Nisqually Reach (around 15,000 m3/s) and then gradually attenuates along the main channel of Case Inlet. Flow in the finger inlets alternate between an "H" pattern (Ebbesmeyer, 1998) with residual flow splitting

around Hope and Hurtstene Islands and a counterclockwise "O" pattern with flow mostly out through Dana Passage. Variability in this flow pattern has affects near-bottom dissolved oxygen patterns in the basin.

Dissolved Oxygen Variability in Puget Sound, Washington, as Diagnosed from a Box Model Tracer

Amanda Babson, Mitsuhiro Kawase, Jan Newton, Al Devol, University of Washington*

Monthly dissolved oxygen (DO) profiles are used in conjunction with a box model of Puget Sound circulation to diagnose the relative importance in the seasonal DO budget of advection and mixing versus biological production and consumption, and air-sea exchange. DO is a biologically important water property with high concentrations much of the year in most of Puget Sound, but several areas (i.e. Hood Canal) are susceptible to seasonal hypoxia. Efforts to explain recent increases in the extent and duration of low oxygen events in Hood Canal highlight the importance of being able to separate changes in circulation from changes in biological productivity. This method shows large seasonal and inter-basin differences in both components. In the typical seasonal cycle, the lowest DO which is found in deep southern Hood Canal is shown to be more due to weak vertical mixing and advection of low DO water from northern Hood Canal where consumption is high in the spring, than due to especially high rate of local consumption. With its larger volume, more total consumption occurs in southern Hood Canal. An experiment on the magnitude of interannual variability in DO concentrations due to circulation accounts for at least half of the variability in the DO dataset.

Session 12B: Marine Biota: Invertebrates and Mammals

Chair: Linda Lyshall

Spatial Subsidy of Drift Kelp Sustains Deep Subtidal Red Urchins: Implications for the Management Of an Exploited Species

Kevin Britton-Simmons, Gerard Foley, Daniel Okamoto, Friday Harbor Laboratories*
Elizabeth Bloczynski, Western Washington University

The red sea urchin Strongylocentrotus franciscanus plays a key role in structuring subtidal marine communities and has substantial economic importance as a commercially harvested species. Although the vertical distribution of red urchins extends to depths of more than 100 m most of what we know about the ecology of this species comes from studies in the shallow subtidal. We carried out a comparative study to address two primary questions: 1) What is the diet of deep subtidal red urchins in the San Juan Islands?, 2) Is there a reproductive cost to using deep habitats (due to food limitation) in this region? We studied red urchins in shallow, algal dominated habitats (-5 m) and deep, invertebrate dominated habitats (-23 m) at 5 sites in the San Juan Islands for one year. Our results indicate that deep subtidal red urchins feed exclusively on drift algae, a resource that is seasonally variable. Our analysis of gonad mass, and numerous morphometric characters indicate that deep subtidal red urchins are not food-limited and do not have reduced fecundity, contrary to our expectations. Our results suggest that the deep subtidal is a high quality habitat for red urchins and that deep populations may contribute substantially to the pool of larvae that replenishes deep and shallow habitats alike. Deep subtidal habitats could be an important refugia from harvesting and may play a key role in sustaining the red urchin fishery in the long-term.

Octopuses (Enteroctopus dofleini) Need Cues for Learning

Roland Anderson, Seattle Aquarium*
Jennifer Mather, University of Lethbridge

Previous researchers (Fiorito, von Planta, & Scotto, 1990) were unable to prove that a common octopus (Octopus vulgaris) can learn to open a jar in order to obtain crustacean prey inside, although numerous public aquariums use this situation as enrichment for giant Pacific octopuses (Enteroctopus dofleini). We studied presenting food in bottles to octopuses (E. dofleini) under a assortment of conditions with a variety of cues about the live crustacean prey inside: 1) visual only (closed jar), 2) black jar (no visual cues), 3) minimal chemical cues (jar with holes), or 4) maximal cues (jar smeared on the outside with mucus from herring, a common food for captive giant Pacific octopuses). Enteroctopus dofleini seldom unscrewed the jar lid within the 60-minute time limit in the first three conditions (mean 1/10 trials in Condition One, 2.5/10 in Condition Two, 2.0 in Condition Three) but did so in 9.5/10 of Condition Three. Over the five days of presentation, octopuses in Condition Four significantly improved their latency to open the jar, from a mean of 41 minutes in Day One to 15 minutes in Day Three. Thus octopuses can learn to open jars if appropriate non-visual cues are available when the jar is out of sight under the arm web.

Diet of Harbor Seals in the San Juan Island Archipelago

Monique M. Lance, Steven J. Jeffries, Washington State Department of Fish and Wildlife*

Harbor seals are an important upper trophic level predator and the most abundant pinniped in the inland waters of Washington with nearly 15,000 animals. In the San Juan Island archipelago, harbor seals are the most commonly seen pinniped and use over 150 haulout sites. This study provides baseline data and uses percent frequency of occurrence of prey species identified in fecal samples to describe overall diet of harbor seals. Harbor seals fed mainly on pelagic fishes including Pacific herring (occurring in 57% of samples), adult salmonids (31%), Gadids (24%), Pacific sand lance (20%) and Northern anchovy (19%). Diet differed among seasons with Gadids, herring and sand lance important during spring, adult salmonids and herring during summer/fall and herring, anchovy, Gadids, sand lance and Spiny dogfish during winter. Mean number of different prey species differed among seasons with winter diet most diverse, 3.59 different prey species and summer/fall and spring less so 1.72 and 2.14, respectively. In general, species composition was comparable to fish abundance based on bottom trawl data and salmon return abundance timing. We suggest these data are an important component for assessing how predator populations, specifically harbor seals, may impact declining fish populations and overall biodiversity in the San Juan Islands.

Status of Pinnipeds in the Georgia Basin Puget Sound Region

Peter Olesiuk, Fisheries and Oceans Canada, Pacific Biological Station*
Steven Jeffries, Washington Department Fish and Wildlife

We review the status of pinnipeds in the Georgia Basin Puget Sound Region (GBPSR) based on aerial surveys conducted since the 1970s, and count and kill records dating back to the early 1900s. Harbour seals are the only pinniped that reside year-round and breed in GBPSR. Seal populations increased about 10-fold between the early-1970s and mid-1990s, but have been relatively stable for the past decade. Currently, about 52,000 harbour seals are distributed among 650 haulout sites throughout GBPSR. Steller and California sea lions utilize GBPSR seasonally during the non-breeding period. Both species were uncommon prior to the 1970s. Steller sea lions numbers have slowly increased, with recent counts ranging from 500-1,500. California sea lions have extended their non-breeding range northward, and males began appearing in GBPSR in the 1960s. Numbers increased dramatically during the 1970s, with counts fluctuating from 1,000-2,500 since the 1980s. Both species of sea lion are highly mobile, with distribution reflecting the availability of prey. Elephant seals breed off California and generally forage offshore, but the species is occasionally sighted in GBPSR, and in recent years have established small colonies at several sites in the Strait of Juan de Fuca. The recent increases in pinniped abundance in GBPSR reflect the recovery of populations along the west coast of North America, which had been depleted by hunting and predator control prior to being protected in the early 1970s.

Panel 12C: Coastal Watershed and Near Shore Systems Integration

Chair: Stephen W. Gajewski

This is a special technical session designed to look at where we have come in the science and technology community in realizing the goal of fully integrated systems models and tools that comprehend meteorology, watershed, groundwater, and estuarine/marine systems. The technical session will be led off by technical briefings on the "state-of-the-art" for a number of subjects, followed by a panel that explores the need for and the challenges of systems integration.

Panel Members:

- *Terry Williams, Tulalip Tribes*
- *Andrea Copping, Battelle Pacific Northwest National Laboratory*
- *Peter Best, City of Bainbridge*
- *Tarang Khanguankar, Battelle Pacific Northwest National Laboratory*
- *Randy Schuman, King County*
- *Tony Ingersoll, North Olympic Peninsula RCMP*

Panel 12D: Critical Load Modelling for Atmospheric Deposition II

Chair: Peter Schwarzhoff

A Critical Load is the highest deposition rate that will not cause chemical changes leading to long-term harmful effects in the most sensitive ecosystems. The indicators and potential endpoints for effects vary with the intent and the sensitivity of receptors. This session will present aspects of critical load and deposition modelling and effects underway in the Georgia Basin at present.

Panel Members:

- *Julian Aherne, Trent University*
- *Anliang Zhong, University of British Columbia*
- *Robert Hudson, British Columbia Ministry of Forests and Range*
- *Gordon Weetman, University of British Columbia*

Modelling the Impacts of Acid Deposition on Apline Lakes

Julian Aherne, Trent University

High elevation lakes situated along the coastline of British Columbia are considered to experience limited exposure to transboundary air pollution due to the predominant south-westerly or westerly airflow. However, although far from local sources of pollution, these lakes are nonetheless threatened by the atmospheric deposition of pollutants (acidity and toxic air pollutants) and by climate change. They are especially sensitive to acidification owing to the poor buffering capacities of soil and rocks in their catchments; similarly their catchments have little soil and vegetation to take up nitrogen deposition from the atmosphere; and they are predicted to experience significant climate change. Because of their sensitivity, these remote lakes are not only vulnerable to environmental change, but are also excellent sensors of change; however, few studies have been carried out on these remote coastal lakes. During 2005 and 2006, water chemistry was sampled from a number of high elevation alpine lakes in the Georgia Basin ranging in elevation between 1000 and 1400 m; soils samples were also collected during 2006 (two pits per catchment sampled by horizon). These data have been used in conjunction with the Model of Acidification of Groundwater in Catchments (MAGIC) to assess the potential future and historic impacts of acid deposition on these remote alpine lakes.

Chaining The FORECAST and MAGIC Models to Estimate Critical Loads of Nitrogen for Forest Ecosystems in the Georgia Basin

Anliang Zhong, University of British Columbia
Julian Aherne, Trent University
Hamish Kimmins, University of British Columbia

As forest ecosystems in the Georgia Basin are more diversified and complicated in structure, functions, and disturbance history than those in the east of Canada, we used both MAGIC model and FORECAST ecological model to estimate critical loads of nitrogen in this study. We examined the strengths and limitations of the two models in order to link the two models for a better simulation of nitrogen critical loads. We found that the limitations of MAGIC model can be compensated by the strengths of FORECAST, and vise verse. Three major components or processes in MAGIC model were identified for chaining MAGIC with FORECAST: (1) Cations in biomass. Plant biomass, nutrient concentrations and contents in biomass components over stand age on different sites are simulated by FORECAST, then converted to "cations in biomass". (2) Nitrogen net uptake by plant. The variable is simulated by FORECAST, and then used in MAGIC modeling. (3) organic matter decomposition. The process is well represented in FORECAST model, and its simulation results provide decomposition and mineralization data required in MAGIC modeling. Chaining the two models would increase accuracy for nitrogen critical load simulation because FORECAST modeling provides better input data for MAGIC modeling under varying natural disturbances and management scenarios, such as levels of forest harvest and forest fire hardly or implicitly represented in the MAGIC modeling.

The Extreme Response of Streamflow and Nitrate Concentrations to Partial Logging at Flume Creek, Sunshine Coast, BC.

Robert Hudson, British Columbia Ministry of Forests and Range

The effects of non-clear-cut logging on water quality and quantity were studied in small creeks at Flume Creek, Sunshine Coast, BC from 1994 – 2003. The two treatments chosen were dispersed retention (a.k.a. variable retention, or VR) and strip retention with 50% canopy removal, both applied over 50% of the catchment in stages that split the harvest over two years. Streamflow was measured by V-notch weirs and samples for water chemistry analysis were collected by automatic sampler on a storm-by-storm basis. A paired station paired event approach of treatment vs control was used to detect increases in peak streamflow and peak nitrate concentration following harvesting. Peak flows were increased up to 130% (average increase among affected events) under VR treatment. There was a linear relationship between the proportion of the canopy removed and the flow increase among affected events. On the average, peak nitrate concentrations increased by 10X and individual events as much as 61X the pre-treatment concentration for the strip retention treatment in the second and third years following logging. Under the VR treatment, despite being more intense, the nitrate increases were less than half of those observed under strip retention. These extreme responses to forest harvesting are clear indicators of a high level of watershed sensitivity. The unexpected difference in nitrate response between the two treatment watersheds is currently under investigation.

The Relevance of the Experience with Forest Nitrogen Fertilization to Critical N Loads

Gordon Weetman, University of British Columbia

At current low rates of N input (2 to 6 kg N/ha/yr) in the Georgia Strait present forested ecosystems it appears that no significant detrimental effects on ecosystem functions can be expected because of the ability of the humus and soil to absorb and immobilize added N.
At higher input rates of 100 to 300 kg N/ha, in single one time doses, used in operational forest fertilization, experience from similar temperate forest ecosystems suggests that no serious detrimental effects have been found provided guidelines about applications to lakes and water courses are respected. Operational forest fertilization has been applied to second growth stands in the Georgia Basin for over 30 years and is ongoing.

Repeated applications of N fertilizer, in experiments designed to approximate N saturation, have indicated a surprising ability of forested ecosystems to absorb added N.

European empirical critical N loads for natural and semi-natural ecosystems in 2002 are in the range of 5 to 20 kg N/ha/yr for forest and subalpine habitats. Coastal, inland surface water and bog and fen habitats are in the range of 5 to 25 kg N/ha/yr. Given the similarity of ecosystem structure and function these are reasonable values for the Georgia Basin. US values are in the same range
N fertilization has been used to test the degree of N saturation of forested ecosystems. This review suggests it be used in the Mountain Hemlock biogeoclimatic zone of the Georgia Basin where the greatest impacts of N inputs might be expected.

Session 12E: Toxics in the Marine Ecosystem

Chair: Sandie O'Neill

Thirty years of Persistent Bioaccumulative Toxics in Puget Sound: will they ever go away?

James West, Washington State Department of Fish and Wildlife*
Sandra O'Neill, Washington Dept. of Fish and Wildlife

We combined historical data on persistent bioaccumulative toxics (PBTs) such as PCBs and DDTs with long-term, ongoing monitoring results from the Puget Sound Assessment and Monitoring Program (PSAMP) to help us understand the fate and transport of these PBTs in the ecosystem's biota. PCB and DDT levels in benthic species (bottomfish) like flatfishes and sculpin from highly polluted, urbanized or industrialized habitats declined sharply from the 1970s to present, mirroring trends observed in other urbanized ecosystems worldwide. Current PCB levels in bottomfish from urbanized habitats average roughly 100 ppb (wet wt), which is roughly one-tenth of 1970s levels. PCB levels in Puget Sound bottomfish from relatively clean, or reference habitats have exhibited no decline in the past 30 years, with concentrations remaining in the 20 to 30 ppb (wet wt.) range. Over the past 15 years, levels have remained relatively constant in bottomfish from both urbanized and non-urban habitats. Historical PBT data from pelagic species like herring and salmon in the PS/GB are rare, however PCBs in coho salmon appear to have declined from the 1970s to current concentrations that are similar to non-urban bottomfish. Over the past 15 years, levels have remained relatively constant in bottomfish from both urbanized and non-urban habitats and in pelagic fish like coho salmon. We hypothesize that the lack of a declining trend in PCBs over the past 15 years is the result of biotic -recycling through

Endangered Southern Resident Killer Whales at Risk in The Georgia Basin – Puget Sound: Emerging Contaminant Concerns

Peter Ross, Fisheries and Oceans Canada*
Steven Jeffries, Washington Department of Fish and Wildlife
John Ford, Fisheries and Oceans Canada

The small and reproductively isolated population of southern resident killer whales (Orcinus orca) of British Columbia and Washington State face a daunting set of conservation pressures, including reduced prey base, noise and disturbance, and very high levels of toxic chemicals. While the ultimate recovery of this population requires multi-stakeholder, multi-agency, and inter-governmental cooperation, scientific scrutiny and mitigative efforts must focus on each of these threats individually, as well as the interactions among them. In the case of some contaminants, previously enacted regulations and source control have helped to ameliorate local killer whale habitat quality. PCB, DDT, dioxin and furan concentrations in the regional environment have declined over the past three decades. However, the notable persistence of the PCBs means that killer whales will continue to face associated health risks from ëlegacy' chemicals well into the future. In addition, the failure to enact regulatory changes will mean that the region's killer whales will face dramatic increases in the concentrations of an unregulated flame retardant chemical (PBDEs) over the coming years. As PCBs and PBDEs elicit similar toxic effects in mammals (endocrine disruption, immunotoxicity), the prospects for recovery of long-lived southern and northern resident killer whale populations during the 21st century remain open to debate.

Management of Threats to Fish and Wildlife from PBTs

Scott Redman, Puget Sound Action Team*

Persistent, bioaccumulative toxins (PBTs) including PCBs, organochlorine pesticides, PBDEs, and chlorinated dioxins have accumulated in the tissue of salmon, other fish, birds, and marine mammals in Puget Sound that individual organisms may experience suppressed immune function; cancer; impaired development, growth, and reproduction; and altered behavior. Toxic harm to individual organisms might threaten the viability of fish and wildlife populations. For instance, toxic stresses might hinder the recovery of species such as Puget Sound Chinook salmon and southern resident orcas. Although addressing PBT contamination of fish and wildlife is understood to be an important aspect of restoring the health of the Puget Sound ecosystem, State of Washington programs to implement the state and federal clean water acts and to clean up contaminated sites are poorly focused on control of PBT contamination to benefit fish and wildlife. Suggestions for improved management of PBTs include: revising the state's approach to identifying and describing Puget Sound's impairments related to PBTs in the state's water quality assessment; developing a scientific framework (e.g., via mass balance and food web modeling) to relate PBT sources and management to ecosystem receptors; and revising sediment management standards to account for harm from PBT accumulation in fish and wildlife via food web transfers.

PCBs in The Biota: The Importance of Understanding the Biotic Balance in Estimating Loadings to Puget Sound and the Georgia Basin

Sandra O'Neill, Washington State Department of Fish and Wildlife*
James West, WA Department of Fish and Wildlife

Although PCB levels in Puget Sound biota are lower now than they were in the 1970's, levels have not declined appreciably since the mid 1980's and current PCB levels are still causing adverse effects. Efforts are underway to estimate loadings of PCBs and other contaminants to the Puget Sound ecosystem so as to better target management actions to reduce inputs and accelerate the rate of decline. While moving forward with this effort, it's important to consider the biota as a source of bio-available contaminants to the Puget Sound ecosystem. Results from our PSAMP fish contaminant monitoring clearly show that forage fish like Pacific herring serve as an important nexus of persistent organic pollutants to the Puget Sound ecosystem. Thus, the relative amounts of these contaminants in biota, sediments, water and the atmosphere of Puget Sound all must be considered to determine the most appropriate management actions for source control and reduction of contaminants. We provide rough estimates of the mass of PCBs present in resident fish and some other key biota and sediments. Rough estimates of the amount of PCBs in surface sediments are also provided. The estimated flux of PCB mass into the Puget Sound via bio-transport of some key transient species is also explored.

Toxic Chemical Contaminants and Puget Sound

Tracy Collier, NOAA/NMFS/NWFSC*
Sandra O'Neill, James West, WA Dept Fish and Wildlife
Nathaniel Scholz, NOAA Fisheries

Puget Sound is unique among all of our nation's estuaries in being a deep fjord-like structure that contains many urban areas within its drainage basin. Because there are several sills that limit the entry of oceanic water into Puget Sound, it is relatively poorly flushed compared to other urbanized estuaries of North America. Thus, toxic chemicals that enter Puget Sound have longer residence times within the system, and this entrainment of toxics can result in biota being exposed to

increased levels of contaminants for a given input, compared to other large estuaries. The problems in Puget Sound are exacerbated by biological isolation. Because Puget Sound is a deep, almost oceanic habitat, the tendency of a number of species to migrate outside of Puget Sound is limited relative to similar species in other large urban estuaries. This high degree of residency for many marine species, combined with the poor flushing of Puget Sound, results in a more protracted exposure to contaminants. It is this combination of hydrologic and biologic isolation that makes the Puget Sound ecosystem highly susceptible to inputs of toxic chemicals compared to other major estuarine ecosystems. Three steps, namely source characterization and quantitation, source control and reduction, and biologically-based observation and assessment, are equally essential if we are to protect Puget Sound from the waste products of its surrounding, and growing, human population.

Session 12F: Environmental Education: Citizen Stewardship

Chair: Greg Ambrozic

Learning from the BC Coastal Environment 2006 Project, Part I: Consulting with Audiences and Experts

Lynne Bonner, Linda Gilkeson, British Columbia Ministry of Environment*

In 2004, representatives from two federal ministries, two provincial ministries and two universities began work on an ambitious project to report on the state of British Columbia's coastal environment. From the outset, this project made a major effort to understand what audiences value about the coastal environment and to ensure this was considered during consultation with the experts to develop meaningful environmental indicators. A framework for defining priority audiences helped to identify those audiences that it would be practical to engage (given limited time and resources) for their input on issues, desirable indicators and reporting formats. This was accomplished through an audience survey conducted by email and phone. An analysis of what would be required to undertake an effective consultation with First Nations provided a first step toward addressing the needs of this particular audience. Technical experts were encouraged to think beyond establishing availability of data sets and to address the questions and information needs of the broader audiences for coastal environment reporting. The primary consultation tools to get input from technical experts were teleconferences and facilitated workshops (in a variety of scales and locations).

More than Meets the Eye: Community Participation in Environmental Stewardship

Veronica Wahl, University of British Columbia*

Participation of volunteers in the work of environmental stewardship organizations brings direct benefits not only to the groups but also the ecosystems in which they work. It is argued however, that this type of volunteering is also vital to larger sustainability initiatives because of the long-term indirect benefits that may be accrued through hands on activities in support of environmental health. These indirect benefits may include a greater attachment to the work sites and the fostering of an environmental ethic among participants.

This presentation examines theories and emerging studies in the literature on environmental stewardship volunteering, and related research areas, on the potential indirect benefits of stewardship volunteering. It will illustrate how different types of environmental experiences may relate to different attitudes toward the environment and draw out the potential connections between participation in environmental initiatives and other environmentally positive attitudes and behaviours by the volunteers. The presentation will show that through encouraging hands on participation by volunteers in stewardship projects in their communities, environmental practitioners can help to build a constituency of supporters for environmental initiatives in this region.

Paddling Away the Gunk

Teri King, Janis McNeal, Washington Sea Grant, University of Washington*

Nitrogen conservation is a tough subject to have community members rally behind. Using innovative outreach efforts such as a garbage grinder 'Round Up', the tried and true 'Septic Social' and paddling from dock to dock we were able to quickly educate homeowners about the troubles of excess nitrogen in Hood Canal.

Using a free micromesh kitchen sink screen as our ticket for discussion, we were able to garner involvement in our campaign from over 1,931 homes in a small section of the Hood Canal watershed. With nearly 96% of the participants reporting a long term adoption of the screen in addition to 30 % of them going out and purchasing more we found a tool that resonated with the community.

Fifty homes also participated in a more grueling task as a 'gunk collector', collecting all of the bits and pieces collected in their kitchen sink screen after every meal for one week. The 'gunk' was analyzed for both nitrogen and phosphorus and revealed a removal of nearly 1,950 g and 185 g respectfully.

Although the amount of nitrogen screened out was limited, participants recount on the daily visual reminder that the screen provides that they are on a septic system and that they need to be careful what they put down the drain.

GreenShores: A Proactive Initiative for Sustainable Coastal Development

John Harper, Coastal & Ocean Resources Inc.*
Brian Emmett, Archipelago Marine Research Ltd.
Martine Dubois, Martine Desbois and Associates
Gretchen Harlow, Environment Canada (Canadian Wildlife Service)
John Readshaw, Sandwell Engineering Inc.
Harriet Ruggenberg, Lanarc Consultants Ltd.

GreenShores is a voluntary program for encouraging coastal property owners to use sustainable approaches in coastal development. The GreenShores initiative follows the model of the LEED Green Buildings program where owners or developers accrue credits for use of sustainable components to property development. These approaches might include the removal of seawalls, use of sacrificial fill materials as alternatives to seawalls or restoration of riparian vegetation. Properties or developments that achieve a suitable number of credits are then GreenShores certified. The credit program is built around four GreenShores principals: (1) preserve the integrity or connectivity of coastal processes, (2) maintain or enhance habitat diversity and function (on a local or regional scale), (3) minimize or reduce pollutants to the marine environment and (4) reduce cumulative impacts to the coastal environment. Examples of application of criteria to three case examples include residential properties and "brown" shores restorations (i.e., decommissioned industrial sites).

Panel 13A: Community Mapping Network in the GBPS

Chair: Rob Knight

This session will feature a live demonstration of web mapping applications on the CMN (Community Mapping Network), featuring 3 interactive atlases to generate audience questions and participation: Southern Gulf Islands Atlas (with streaming shoreline videos); Georgia Basin Habitat Atlas (with oodles of GIS data from agencies and NGOs); Invasive Specie Atlas (with Spartina sp. mapping, drift card tracking & on-line data entry).

The CMN is working to bridge the information gaps in resource data by engaging citizens groups and concerned agency staff in BC and Washington. The CMN is an NGO dedicated to sharing a wealth of natural resource information and maps with communities, locally and

internationally. CMN integrates data from many sources and makes it accessible through a user-friendly web mapping system, providing a unique set of tools to explore and promote awareness of natural resource features. Using a network of distributed servers, CMN offers Internet access to comprehensive base mapping, aerial imagery and local information, working closely with other NGOs and local governments.

The panel will review and discuss community based web mapping projects in the Georgia Basin - Puget Sound region. The panelists will provide perspectives and comments on audience questions during demonstrations, drawing on their experiences and backgrounds. The CMN has several relevant applications in the GBPS region that will provide a catalyst for the discussions.

Panel Members:

- *Kathleen Moore*
- *Don Chamberlain*
- *Rob Knight, Community Mapping Network*

Session 13B: Biota: Marine Birds and Waterfowl II

Chair: Jay Davis

Impact of Waterfowl Grazing on Successive Cuts of Perennial Forage Fields

Vince VanBeelen, Ducks Unlimited Canada
Dan Buffett, Ducks Unlimited Canada*

Located on the Pacific Flyway, the Fraser River Delta (FRD) contains one of the largest estuaries on the north Pacific Coast. Approximately one million migrating and wintering waterfowl use the FRD on a yearly basis. Upland agricultural crops provide important foraging habitat for dabbling and grazing waterfowl, however, urban sprawl, increased human disturbance and changing land-use policies continue to reduce the amount of waterfowl habitat reciprocating increased pressure on existing habitat. Perennial forage grazing damage by waterfowl has been well documented at the first forage cut, but it is unknown what the impact is at successive cuts. Ducks Unlimited Canada undertook a study to determine waterfowl grazing impacts on biomass and protein at the first, second, third, and subsequent cuts. Four fields were subjectively classified as an intensively or passively managed field based on management. Twenty plots of grazed and ungrazed portions were identified and staked in each field. Results indicated grazed fields have a 70% decrease in biomass but a subsequent 20% increase in protein levels. Additionally intensively managed fields recovered quicker from the impact of grazing by the second cut while passively managed fields did not recover completely until the third cut. This study demonstrates that assessments of waterfowl damage need to include impacts at the first cut for intensive fields and the first and second cuts for passive fields.

Spring Usage Patterns of Surf Scoters in the Greater Puget Sound and Strait of Georgia 2004-2006, Documented Through VHF and Satellite Telemetry.

Joseph Evenson, David Nysewander, Bryan Murphie, Thomas Cyra, Washington State Department of Fish and Wildlife*
John Takekawa, Suzan Wainwright-De La Cruz, U.S. Geological Survey, Western Ecological Research Center
Daniel Esler, Centre for Wildlife Ecology, Simon Fraser University
Sean Boyd, Environment Canada (Canadian Wildlife Service)
David Ward, U.S. Geological Survey, Alaska Science Center
Erika Lok, Simon Fraser University
Matt Wilson, U.S. Geological Survey, Western Ecological Research Center

Wintering populations of Surf Scoters (Melanitta perspicillata) along the northeastern Pacific Coast, and adjacent inner marine waters, move from their wintering sites to various key marine areas along the Pacific Flyway during spring migration where they spend some time feeding, to accumulate additional energy reserves and body fat before flying inland for nesting. These areas include the outer coastal waters of Washington and Vancouver Island, Puget Sound/ Georgia Basin, Northern British Columbia, and Southeast Alaska. Surf scoters were implanted with both satellite and VHF transmitters from four wintering populations (Mexico, San Francisco Bay, Puget Sound, and the Strait of Georgia), offering an opportunity to evaluate usage patterns and key staging areas important to Surf Scoters within the Puget Sound/Georgia Basin. Satellite data were collected during three spring seasons (2004-6) and VHF data were collected during two seasons (2005-6). During spring, portions of all four wintering populations used the Puget Sound/Georgia Basin region, this being one of three major late spring staging areas. These data document the timing of use patterns, and percent utilization by wintering populations. In addition, key spring staging concentrations and sites within the region are determined. We evaluate whether scoters using this region during spring utilized a different portion of the nesting grounds than those scoters staging on the more northern marine spring staging area.

Biofilm Feeding in Western Sandpipers

Dieta Lund, University of British Columbia*
Bob Elner, Canadian Wildlife Service

Western Sandpipers (Calidris mauri) are Alaska-breeding shorebirds that migrate to the southern US and northern South America for winter. During this migration, large numbers of the birds (up to 500,000 estimated in a single day) stopover in the Fraser River estuary to refuel. Traditionally, they have been thought to be feeding primarily on large macrofauna such as amphipods by probing and pecking in the muddy substrate. However, recent investigations into tongue and bill morphology as well as isotope analysis of fecal samples and field observations suggest that sandpipers may be instead feeding primarily, or at least additionally, on microalgae, meiofauna, and organic detritus suspended in a thin layer of mucus on top of the mud, collectively known as biofilm. In order to investigate this hypothesis, an analysis of the stomach contents of Western Sandpipers and Dunlin was undertaken, that in contrast with previous studies, looks specifically at biofilm components, such as diatoms. Results support the idea of the Western Sandpiper as a primary consumer, especially the finding that diatomaceous sediment, indicative of biofilm-intake, accounts for the vast majority of the stomach volume-whereas identifiable prey remains make up only a small fraction. The Western Sandpiper contents are also compared with those of Dunlin collected from the same foraging flock. The final results of this study could have implications for the conservation efforts of the Western Sandpiper and the protection of its foraging habitat.

Monitoring Coastal Birds in the Georgia Basin: The BC Coastal Waterbird Survey

Peter Davidson, Bird Studies Canada*
Shannon Badzinski, Long Point Waterfowl and Wetlands Research Fund
Richard Cannings, Tasha Armenta, Bird Studies Canada
Jason Komaromi, Environment Canada (Canadian Wildlife Service)

The BC Coastal Waterbird Survey was established in 1999 to monitor the distribution and abundance of BC's coastal bird populations, and assess avian responses to natural and human-induced environmental change. Volunteer-surveyors contribute an annual average of over 1,000 person days to this citizen science program. Power analysis of standardised, monthly, high-tide counts at approximately 260 sites (chiefly within the Georgia Basin) between 1999 and 2004 generated credible population-trend predictions for nine of the 58 most commonly recorded species (Common Loon, Horned Grebe, Double-crested Cormorant, Great Blue Heron, Mallard, Bufflehead, Common Goldeneye, Harlequin Duck, and Bald Eagle). By 2010/11, credible population-trend data are predicted for many more (34) species, assuming current survey effort is maintained. Preliminary abundance

trends (1999-2004), generated for 58 species using route-regression techniques, reflected findings from other surveys for some species (e.g., declines in sea ducks), but indicated trends running contrary to conventional wisdom for others (e.g., a Bald Eagle decline and a Western Grebe increase); these are explored in more detail. This is the only survey in the Georgia Basin capturing credible trend data for a wide variety of coastal bird populations. Integrating these data into conservation and coastal land-use planning is a high priority.

Marine Bird Abundance Changes in NW Washington: How Much Decline and Why?

John Bower, Brian Cary, Caanan Cowles, Holly Donovan, Johanna Hobart-Crane, Tracy Lamont, Sandlin Preecs, Suzanne Sanborn, Marci Staub, Mark VanderVen, Western Washington University*

Concern continues to build over apparent dramatic declines in marine bird abundance in southern Strait of Georgia and adjacent waters. Here, we provide evidence to support these concerns by reporting final results for a two-year Western Washington University study of changes in marine bird abundance over the last 25 years. Our methods involve repeating key components of the marine bird section of the 1978-79 Marine Ecosystems Analysis Puget Sound Project (MESA), including census work from over 3000 point counts and 75 ferry runs. Results indicate a 27% decline in the total number of birds since the 1970's, including declines of over 20% for 16 of the 25 species that were most common in the 1970's. Species showing the greatest declines include surf scoter (-54 %; Melanitta perspicillata), western grebe (-82%; Aechmophorus occidentalis), brant (-73%; Branta bernicla), scaup (-61%; Athya sp.), common murre (-92%; Uria aalge), and red-necked grebe (-50%; Podiceps grisegena). We also report trends seen over 4 years of study for NW Washington waters, consider our data in relation to PSAMP's long-term marine bird abundance study, and we explore reasons for observed declines for several important species.

One Rare Bird: One Rare Woman: One Common Problem

Briony Penn, University of Victoria*

The black oystercatcher (Haematopus bachmani) is a species at risk in the Salish Sea. Dr. Rob Butler of the Canadian Wildlife Service this June estimated that were only 40 active nesting sites left in this region. One of those nesting sites is on a spit at Walter Bay, Saltspring Island; one of three left on the island and the only documented nest site. One woman, Nina Raginsky, has spent the last eleven years monitoring on a daily basis this nesting site, lobbying for signage to raise awareness of the nest site, notifying officials of disturbances, advocating for better legislation and personally defending the nest. Because of her efforts, there have been eleven successful fledgings of chicks–one eighth of the total population. In the course of her volunteer work, she has been harassed, physically and verbally abused and signage vandalised. The level of support from government officials has varied but constitutes a significant contribution of time and resources. The level of effort required to keep these birds from abandoning nests each year has been extraordinary. This case study explores various questions: What is the best way to keep this population viable? What lessons can we learn about the effective application of policy, law and resources? what might be learned for other populations at risk? what is the best allocation of resources for species at risk? Mapping, inventory, policy writing, enforcement or hiring custodians of critical nest sites?

Panel 13C: Marine Migration and Habitat Use of Salmon and Trout in the Salish Sea

Chair: Fred A. Goetz

You may have asked yourself, where are fishing going in such a hurry? They always seem to be moving or migrating from one place to another, from freshwater to saltwater, from Puget Sound to the Ocean. You also might ask yourself, once they get to their destination what are they going to do - have dinner or go to a party? Scientists have been interested in fish movements for decades, they may not ask questions quite in the way we might think of it, but the study of and knowledge of the movements of all manner of fish including salmon, trout and marine fishes of Puget Sound, is essential to our ability to protect and conserve these fish and their habitats. Recently new technologies have been developed that may help scientists answer some of these questions. These tools are opening an exciting new world of estuary and marine research using biotelemetry - measurement (telemetry) of biologically relevant data using transmitters and receivers - a research approach that has been evolving locally (Puget Sound), regionally (Salish Sea) and at an international scale. In this workshop we will present some of the latest biotelemetry research on the migration and habitat use of salmon and trout in the rivers, estuaries and marine waters of the Puget Sound and the Straits. This work is a result of a scientific collaboration of over 20 different organizations sharing equipment, staff, and information to make a Puget Sound-wide monitoring network.

Panel Members:

- *Fred Goetz, U.S. Army Corps of Engineers*
- *Russell Ladley, Puyallup Tribe of Indians*
- *Ed Connor, Seattle City Light*
- *Reg Reisenbichler, U.S. Geological Survey*
- *Anna Kagley, NOAA Fisheries / National Marine Fisheries Service*
- *Scott Steltzner, Squaxin Island Tribe*
- *Michael Melnychuk, University of British Columbia*

Pre and Post Spawning Migration of Adult Bull Trout (Salvelinus Confluentus) in the White River, Washington

Russ Ladley, Eric Marks, Terry Sebastian, Puyallup Tribe of Indians*

Radio telemetry was used to monitor pre and post spawning migrations of adult bull trout (*Salvelinus confluentus*) and locate spawning sites located in the upper White River, Washington. The White River is the largest tributary of the Puyallup River and originates on the glaciers of northeast Mount Rainer. Turbid summer and fall water conditions preclude visual observation of fish within the glacial mainstem reaches. Ten char received surgically implanted radio transmitters in June and early July of 2006 and nine were tracked to various tributaries located within or near Mount Rainer National Park. Tagged and untagged bull trout were observed to exit the main stem White and enter non-glacial tributaries to spawn in late August and throughout the month of September. A decline in tributary water temperature to 5-7∞ C appeared to initiate entry. Movement and holding behavior of individual fish varied: some exhibited steady upstream movement while others remained in fixed locations for several weeks followed by punctuated upstream progress. Similarly, post spawning movement ranged from continued holding in the tributary to rapid fall-back to mainstem river positions. Redd elevations ranged from 2600' to 3900 feet.

Migratory Behavior of Bull Trout in the Skagit River Watershed

Ed Connor, Seattle City Light*
Eric Jeanes, R2 Resource Consultants
Fred Goetz, Seattle District Army Corps of Engineers
Dave Pflug, Seattle City Light

We investigated the migratory behavior of bull trout in the Skagit River watershed by implanting fish with ultrasonic transmitters, and then tracking individual fish for a period of up to three years using a network of ultrasonic receivers. The receivers were deployed on a year-round basis throughout the Skagit River watershed, including the Skagit delta, lower mainstem river, upper river, and major tributaries including the Sauk and Suiattle rivers. Bull trout were also tracked by receivers deployed in the nearshore areas of the Puget Sound. Fish were captured and implanted with ultrasonic transmitters in Skagit Bay and the upper mainstem Skagit river, allowing us to track both anadromous and fluvial (river resident) life history forms within the watershed. We

identified areas of the Skagit River where anadromous bull trout were the dominant life history form, and other areas where fluvial bull trout appeared to be dominant. The results of this study indicate that the migratory behavior of bull trout in the Skagit watershed is highly variable, and appears to be influenced by flow variability, forage abundance, and water temperature regimes. The life history strategy of individual bull trout appears to be facultative, with some fish switching between anadromous and fluvial strategies over time.

Habitat Use and Timing by Bull Trout in Marine Waters of Northern Puget Sound, Washington State.

Reg Reisenbichler, Steve Rubin, Mike Hayes, U.S. Geological Survey*
Fred Goetz, U.S. Army Corps of Engineers
Mike Parsley, U.S. Geological Survey

Bull trout and their habitats are protected because the species is listed as Threatened under the U.S. Endangered Species Act; however, the scientific literature contains little information about the habitat used by anadromous bull trout during their residence in marine waters. We used stationary receivers located in the lower Skagit River and mobile tracking gear in marine waters to study the timing and habitat use for bull trout in Skagit Bay during April - August 2006. Acoustic tags were surgically implanted in 20 bull trout that were captured by beach seining in Puget Sound during April 2004 to July 2006, and in 20 bull trout that were captured by hook and line in the lower Skagit River during 13 March to 3 April 2006. The fish were x - y cm fork length at tagging. The fish moved past our receivers (approximately river mile 4) toward Skagit Bay during March-May and all but three returning fish entered the river and passed the stationary receivers during June-July. While in Skagit Bay, fish typically resided within 300 m of the shoreline and at depths < 5 m. Each fish tended to remain in a limited area, generally no more than 1.5 km in length. On each of four occasions, at least one week apart, we continuously tracked a different fish for > 20 hr. The only differences between diurnal and nocturnal habitat selection or behavior seemed to reflect changes in tidal height rather than solar position. We will report on other habitat features such as bathymetric topography, geomorphic shoreline forms, distance from shore, and distance from man-made structures or shoreline modifications.

A Summary of Acoustic Tagging Programs for Migratory and Resident Chinook Salmon in Puget Sound

Anna Kagley, NOAA/NMFS/NWFSC*
Fred Goetz, USACE
Correigh Greene, NOAA/NMFS/NWFSC
Tom Quin, University of Washington
Joshua Chamberlin, Kurt Fresh, NOAA/NMFS/NWFSC

Like many other stocks throughout the Pacific Northwest, Puget Sound Chinook salmon have now declined to the point that they are listed as Threatened under the Endangered Species Act. An increased understanding of their residence time, origins, migration pathways, predator/prey interactions, and habitat use is needed to help reverse this trend. We are currently using acoustic telemetry to help fill this information void. Currently there are over 20 organizations deploying over 900 tags and over 200 receivers in every Puget Sound basin and coincident with this is an international monitoring effort (POST project) using the same technology from Alaska to California. This presentation is a summary of the Chinook portion of this collaborative effort initiated over the last two years and an overview of the upcoming research plans. This united approach will give a clearer picture of the status of Puget Sound Chinook salmon including ocean-bound smolt and resident (blackmouth) behavior and survival in both the estuarine and nearshore environments and cotribute to a greater ecosystem level of understanding. This in turn will help direct future fisheries managment decisions surrounding recovery and help focus future protection and restoration efforts.

Results From a Regionaly Scaled Acoustic Network Used Track Multiple Species in South Puget Sound: 2004-2006.

Scott Stetlzner, Squaxin Island Tribe
Kyle Brakensiek, Stillwater Sciences
Cameron Sharpe, Washington Department of Fish and Wildlife
Sarah Hoque, Evergreen College
Sayre Hodgson, Nisqually Tribe
Fred Goetz, University of Washington

In 2004 the Squaxin Island Tribe installed a year round acoustic detection network in seven of the narrow passages that characterize South Puget Sound. Field testing showed that tagged fish passing these arrays had a probability of detection that approached 100%. The initial purpose of the array was to investigate the early marine phase of hatchery coho salmon (*Oncorhynchus kisutch*). Between 2004 and 2006 264 coho were tagged and released. Over 70% of these fish were detected in the acoustic array. In 2004 other agencies began using the year round South Puget Sound array to facilitate studies on species of interest other than coho. By 2006 the array had expanded to cover nine South Puget Sound passages and was being used to support the studies of seven different agencies. Species tagged were: hatchery and wild coho (*Oncorhynchus kisutch*), hatchery Chinook (*O. tshawytscha*), hatchery and wild steelhead (*O. mykiss*), coastal cutthroat (*O. clarki clarki*), and lingcod (*Ophiodon elongatus*). This collaborative effort has allowed the expansion of the existing year round listening line while providing each participating agency data beyond which it would have been able to collect on its own.

High Mortality or Extended Residency of Coho Smolts in the Strait Of Georgia? Confounding Factors in Estimating Early Ocean Survival with Acoustic Tagging

Michael Melnychuk, University of British Columbia*
David Welch, Kintama Research Corp.
Carl Walters, U.B.C.

We conducted a large-scale acoustic tracking study to monitor the downstream and early ocean migrations of juvenile salmonids through the Strait of Georgia system. Between 2004-2006, we implanted acoustic transmitters into coho salmon smolts from two hatchery populations that migrate through Georgia Strait and two wild populations that enter Queen Charlotte Strait from northeast Vancouver Island Rivers. We used the Pacific Ocean Shelf Tracking (POST) array to quantify migratory rates and routes. In contrast to steelhead and sockeye salmon smolts, which migrated rapidly and left the Strait of Georgia system, coho smolts were rarely detected after entry into Georgia Strait. Estimates of early ocean mortality were confounded by unknown levels of summer-winter residency in Georgia Strait in areas between lines of acoustic receivers. Mortality rates during the downstream migration, however, were surprisingly high for the Strait of Georgia populations (23-95%) compared to the northeast Vancouver Island populations (8-23%). Relatively small body sizes and long migration distances contributed to the higher mortality rates found in these Strait of Georgia coho populations than in other coho populations or other salmonid species.

Movement and Behavior of Steelhead Smolts in the Puget Sound

Fred Goetz, U.S. Army Corps of Engineers*
Bob Leland, Washington Department of Fish and Wildlife
Sayre Hodgson, Nisqually Tribe
Russ Ladley, Puyallup Tribe
Ed Connor, Seattle City Light
Eric Jeanes, R2 Resource Consultants
Thomas Quinn, University of Washington
Barry Berejikian, NOAA Fisheries
Hal Boynton, Steelhead Trout Club of Washington
Kelly Kiyohara, Pat Michaels, Washington Dept of Fish and Wildlife
Correigh Greene, NOAA Fisheries

Steelhead in Puget Sound were recently proposed for listing as a threatened species under the ESA. The abundance of steelhead in the Salish Sea has been declining over the past 20 years, from northern British Columbia to southern Puget Sound and Hood Canal. The factors explaining these declines are highly uncertain but current information suggests the estuary and marine environments may be critical areas for the survival and growth of smolts. In 2006 a Puget Sound wide acoustic telemetry effort was initiated to study the migratory behavior (timing/routes), habitat use and survival of steelhead smolts. During the spring migration a total of 569 smolts, 311 wild and 257 hatchery fish, were tagged and released in five different marine sub-basins from 11 different rivers and streams. We will report on steelhead released from the Nisqually, Puyallup, Green, and Skagit Rivers assessing differences in migration and habitat use between rivers, sub-basins, and between wild and hatchery fish, we will also provide a brief comparison to companion study work from the Hood Canal and Georgia Straits.

Panel 13D: Puget Sound Nearshore Partnership – Emerging Results

Chair: Curtis D. Tanner

The Puget Sound Nearshore Partnership (aka PSNERP) has developed methods for detecting changes in the physical structure of nearshore ecosystems. Conceptual models help us understand the human stressors that drive these changes, and how nearshore ecosystem processes have likely been altered. Results of change analysis are being used to identify restoration needs and develop projects that restore nearshore ecosystem processes. We are also employing analytical approaches to estimate future conditions of the Puget Sound nearshore with and without large-scale ecosystem restoration. Change analysis, strategic needs assessment, and future condition methods have been piloted in the central Puget Sound region (WRIA 9). As we scale up these methods to Sound-wide analysis, we are also working to inform and support on-going restoration efforts. Program technical guidance was used in evaluating and selecting projects for implementation through the $2.5M Estuary and Salmon Restoration Program. In addition to support for nine project proposals, the Nearshore Partnership funded project "enhancements" that supplement monitoring and education components to capitalize on learning opportunities inherent in the projects.

We have responded to the need for improved guidance for restoration project monitoring programs by development of monitoring principles. This session will discuss these early results of the Nearshore Partnership.

Panelists:

- *Curtis Tanner, Washington Dept. of Fish and Wildlife/USFWS*
- *Si Simenstad, University of Washington*
- *Doug Myers, Puget Sound Action Team*
- *Randy Carman, Washington Dept. of Fish and Wildlife*
- *Tom Mumford, Washington Dept. of Natural Resources*
- *Bernie Hargrave, U.S. Army Corps of Engineers*

Session 13E: Toxics in Biota II

Chair: John Elliott

Contaminate Residues in Demersal Fish, Invetebrates, and Deployed Mussels in Selected Areas Of The Puget Sound, WA

Robert Johnston, Space and Naval Warfare Systems Center, Bremerton, WA*
Dwight Leisle, Puget Sound Naval Shipyard & Intermediate Maintenance Facility, Bremeton, WA
Jill Brandenberger, Pacific Northwest National Laboratory, Sequim, WA
Scott Steinert, Computer Sciences Corporation, San Diego, CA
Michael Salazar, Sandra Salazar, Applied Biomonitoring, Kirkland, WA

The Puget Sound Ambient Monitoring Program (PSAMP) assisted the Puget Sound Naval Shipyard & Intermediate Maintenance Facility Project ENVironmental inVEStment (ENVVEST) to increase the data yield from the 2003 and 2005 trawl sampling in Sinclair Inlet and selected locations throughout Puget Sound. Samples of English sole, rock sole, sand sole, ratfish, surfperch, staghorn sculpin, graceful crab, and sea cucumber were collected and analyzed for residues of polychlorinated biphenyls (PCBs) and metals. In addition, caged mussels were deployed from June – September 2005 (84 days) at locations adjacent to the Shipyard and at reference locations within Sinclair and Dyes Inlets to assess contaminant accumulation and effects on growth. Tissues samples from English sole and mussels were also analyzed for biomarkers of sublethal stress. The tissue residue levels were compared to ecological and human health risk benchmarks. The whole body (wet weight) concentrations of PCBs, As, Ag, and Hg were highest in ratfish; crabs had the highest levels of Cd, Cu, Ni, and Zn; and sea cucumbers had the highest concentrations of Cr and Pb. In general, the urban bays (Elliott Bay, Commencement Bay, and Sinclair Inlet) had higher concentrations of contaminants than the other areas of the sound. The results from the caged mussel study showed that PCBs, PAHs, and Pb were accumulated at elevated levels in Sinclair Inlet, however, the mussels remained healthy throughout the deployment and contaminants did not appear to accumulate to harmful levels.

PCB Cycling in the Lower Duwamish Waterway

Jeffrey Stern, King County, Deptartment of Natural Resources and Parks, Water and Land Resources*

The Lower Duwamish Waterway was listed as a Superfund site in 2000. One of the principal chemicals of concern and most significant risk driver at the site are polychlorinated biphenyls (PCBs). Work conducted to assess risks and determine remedial action levels for the site included numerous studies on chemical sources, movement, fate and bioaccumulation. Models were developed for sediment erosion and transport, chemical fate, and food web transfer of bioaccumulative compounds. Data were collected on various inputs including atmospheric deposition and estimates developed for loadings of PCBs from sources, runoff, the Green River and Elliott Bay. Tissue concentrations were collected from many components of the food web. Taken together, the information and modeling analyses present a picture of how PCBs cycle through the abiotic and biotic components of the ecosystem in the Lower Duwamish. Insights into trophic relationships and feeding habits of the food web, resulting vulnerability of various organisms to bioaccumulation and risk implications, and the relative significance of sources and sinks to tissue levels can be discerned.

Current Levels of Pbdes and Other Contaminants in Juvenile Chinook Salmon From Puget Sound

Gina Ylitalo, NOAA/NMFS/NWFSC*
Lyndal Johnson, O. Paul Olson, NOAA Fisheries, Northwest Fisheries Science Center, Environmental Conservation Division
Sandra O'Neill, Washington Department of Fish and Wildlife
Gladys Yanagida, Sean Sol, Dan Lomax, Tracy Collier, NOAA Fisheries, Northwest Fisheries Science Center, Environmental Conservation Division

Populations of wild Pacific salmon in Puget Sound are declining and various natural and anthropogenic factors contribute to their decline. For example, it has been suggested that exposure to environmental contaminants may affect salmon populations by increasing susceptibility to opportunistic pathogens, or by interfering with normal growth and metabolism. Fish that migrate through contaminated estuaries and waterways are especially susceptible to these impacts. We have an ongoing program that measures contaminant levels and associated biological effects in juvenile Pacific salmon, including juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from Puget Sound. However, there are limited data on levels of polybrominated diphenyl ethers (PBDEs) in Puget Sound juvenile Chinook, an emerging contaminant of concern in the Pacific Northwest. In 2006, whole bodies and stomach contents of juvenile Chinook salmon from various estuaries in Puget Sound

were analyzed for PBDEs and other persistent organic pollutants to provide data on current levels of these compounds. Comparisons of fish contaminant levels will be made based on fish size and sampling region (north Sound vs. central Sound). These concentrations will also be compared to those measured in other populations of Pacific Northwest juvenile Chinook.

Persistent Organic Pollutants in Harbor And Dall's Porpoises From the Inland Waters of Washington and British Columbia: High Levels in Urban Porpoises

Brad Hanson, NOAA/NMFS/NWFSC*
Jennie Bolton, Gina Ylitalo, NOAA/NWFSC

The highly stressed status of the Puget Sound ecosystem has resulted from the intense urbanization that has occurred over the past 100 years. This water body and the adjacent waters of the Juan de Fuca Strait/Georgia Basin continue to experience increasing human population growth, placing additional stress on the system. Studies on marine mammals can provide early warnings about potential health risks associated with changes in the marine environment, including contaminant exposure, to both these species and humans due to their similar life history characteristics, as well as their common prey items. To provide information on contaminant levels in a top-level predator from Georgia Basin/Puget Sound (GB/PS) region, blubber of male harbor and Dalls's porpoises that stranded in GB/PS from 1996 - 2005 were analyzed for POPs, including polybrominated diphenyl ethers (PBDEs). Concentrations of PCBs in harbor porpoise and Dall's porpoise were similar to those previously reported in the same species in the early 1990s. Although the PBDE levels were, on average, 7 times lower than concentrations of PCBs in these animals, these flame retardant concentrations levels appear to have increased by 2-3 times over levels of male porpoises sampled here in the early 1990s making them some of the highest reported in marine mammals worldwide.

Body Condition and Tissue Concentrations of Butyltins and Other Metals in Surf Scoter (Melanitta perspicillata) Wintering on the South Coast of British Columbia, Canada

John Elliott, Environment Canada*
Megan Harris, Lorax Environmental
Laurie Wilson, Barry Smith, Suzanne Batchelor, Jim Maguire, Environment Canada

From 1998 to 2001 we examined temporal uptake of contaminants by surf scoters (Melanitta perspicillata) in the Georgia Basin region of the Pacific coast of Canada. Samples were collected during fall and winter, carcasses examined, and tissues collected for histology, biomarkers, and contaminant analysis. Scoters from both Vancouver and Victoria harbours had significantly higher hepatic concentrations of butyltins than birds from a reference site. In adult male surf scoters, hepatic butyltins increased over the winter at two sites ($p=0.02$, $n=26$), while mercury increased ($p=0.03$, $n=5$) and selenium decreased at one site ($p=0.001$, $n=15$). Body condition decreased over the winter at both the treatment site, Howe Sound ($p<0.0001$, $n=12$), and the reference site, Baynes Sound ($p=0.02$, $n=15$). Multi-factorial analysis using AIC showed an association between hepatic butyltin concentrations and overall body condition ($p=0.06$, $r=-0.237$).

PBDEs and HBCD Flame Retardants in Eggs of Osprey and Double-crested Cormorants from Washington and Oregon, 2002-2004

Charles Henny, James Kaiser, Robert Grove, U.S. Geological Survey, Biological Resources Division Forest & Rangeland Ecosystem Science Center*
Andrei LeZau, Soheila Shahmiri, Robert Letcher, National Wildlife Research Centre, Science and Technology Branch, Carleton University

We report on the persistent and bioaccumulative classes of brominated flame retardants (BFRs) known as polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs) in 79 eggs (1 per nest) of Osprey (Pandion haliaetus) collected in 2002-2004 from eight locations in Washington and Oregon i.e., Seattle, WA; Everett, WA; Yakima River, WA; lower Columbia River (4 segments), WA/OR, and headwater reservoirs of the Willamette River, OR. The objective of this study is to assess the linkage between sources of BFRs (e.g., local drainage inputs), and thus local food web accumulation, and the accumulation in breeding Ospreys. Ospreys are a good indicator species for monitoring the health of large rivers, bays and estuaries because they eat large fish caught within relatively short distances from their nests and are known to be sensitive to many bioaccumulative pollutants. Thus, BFR concentrations in their eggs are expected to reflect local conditions in aquatic food chains. We also determined concentrations of these BFRs in 12 eggs of Double-crested Cormorants (Phalacrocorax auritus) from Everett, WA. Therefore, we report species-specific differences in PBDE and a-HBCD (i.e., representative of total-(a)-HBCD) concentrations and BDE congener patterns (15 congeners evaluated), and compare and contrast concentrations for these two piscivorous avian species.

Session 13F: Partnerships

Chair: Gord Hanson

Partnerships in our Bear Tours and our Conservation Fee

Chief Darren Blaney, Homalco First Nations*

Exporting Successful Partnerships in the Georgia Basin Puget Sound Region to Other Coastal Areas Under Pressure

Kirsten Gilardi, Joseph Gaydos, Anne Stoltz, SeaDoc Society*

Numerous organizations in the Georgia Basin Puget Sound region have significantly advanced marine stewardship by building strategic partnerships across jurisdictional, geographic, and disciplinary boundaries. Agencies and tribal governments have developed agreements; scientists and managers have collaborated on topics of concern; and organizations have joined efforts on focused issues. The SeaDoc Society, a marine ecosystem health program of the UC Davis Wildlife Health Center, is using its collaborative experience and success in the Georgia Basin Puget Sound to assist other coastal regions under pressure. While organizationally based at a public academic institution, the SeaDoc Society has a regional focus on the Pacific Northwest that is driven by management needs for better scientific information, and supported by private donor investment. This public-private partnership has funded and conducted research on dozens of issues of concern, hosted strategic convenings to scientifically address pressing issues, and provided scientific input for decision makers. Building on its Pacific NW collaborations, the SeaDoc Society is applying lessons learned here to other coastal regions under pressure. Examples include cooperative efforts with the Northwest Straits Commission to launch a Derelict Fishing Gear Removal Program in California, and transboundary work with US and Mexican scientists to develop a marine ecosystem health program on the Baja California Pacific coast.

Learning from the BC Coastal Environment 2006 Project Part II: Information Gaps, Project Management

Linda Gilkeson, Lynne Bonner, British Columbia Ministry of Environment*

In 2004, representatives from two federal ministries, two provincial ministries and two universities began work on an ambitious project to report on the state of British Columbia's coastal environment. By the time the project was completed in 2006, over 140 people from 30 agencies and organizations had become involved. At the conclusion of the project a report was produced detailing data and knowledge gaps that were found and issues that arose in managing a reporting project with diverse partners. In general, data suitable for use in indicator reporting at the coast-wide scale was most lacking for: ecosystem function and productivity (e.g., eelgrass and kelp beds, shorelines,

sensitive ecosystems, estuaries); biodiversity (e.g., invertebrates, non-commercial marine species); impacts of human activities and risk to human health from environmental contaminants. Management issues included: overseeing a rigorous, yet timely, review process for technical papers; communication methods to minimize travel time, while retaining close contact for project decisions; accommodating differences between partners in approval processes, contract management and policies on public release of information.

Victoria Sewage: a Solution Through Science and Partnerships

Christianne Wilhelmson, Geogia Strait Alliance*

This presentation will focus on the decades long controversy regarding sewage treatment in Victoria, BC and how in recent years it revealed 2 important lessons: what happens when scientific data is not used to guide public policy decisions, and how a longstanding problem can actually bring opportunities.

For years, the effluent being discharged into Juan de Fuca Strait was monitored, but the evidence of contamination was not acknowledged, nor was there any recent independent analysis of a growing body of information showing that dilution was not a viable long-term strategy. Over the past year that has changed with the result being a call from the public for the region to finally start addressing the problem and a new willingness by policy makers to look for solutions.

Change came after years of pressure from many sources, including political agreements between Washington and BC, media attention, tourism boycotts and citizen action. But in the end, the solution has come from the use of science, the creation of partnerships (citizens, unions, environmental groups and local advocates), along with a community willing to look at its problem as an opportunity.

Communities around the world address sewage not as a matter of disposal but as resource recovery, obtaining heat, biogas and water from their sewage. Victoria now has the unique opportunity to address its sewage treatment while also finding solutions for solid waste disposal, air pollution and climate change at the same time.

Partnerships and Collaboration Don't End at Planning for Ecosystem Restoration

Tim Walls, Snohomish County*
Maria Calvi, Kurt Nelson, Tulalip Tribes of Washington

Ecosystem conservation at a landscape scale requires collaborative planning among numerous parties. Notable examples include the Yukon to Yellowstone Initiative. Few examples of successful landscape scale restoration efforts exist, with fewer still that seek to recover a species collaboratively. The Snohomish River Basin Salmon Conservation Plan (Plan) is an example of the latter. The Plan outlines harvest, hatchery and habitat actions to recover Chinook salmon. With over 85% of off-channel and tidal marsh habitats lost due to land use practices over the last century, modeling results show that restoring the estuary is of vital importance to salmonids in the basin, with targets set at restoring 1,237 acres. Once landscape scale planning was completed, partners expected restoration at the site-specific scale, where individual partners with jurisdictional authorities would take action. However, to meet the suite of site-specific and basin-wide goals, partners in the Snohomish Basin have found that successful restoration must retain these valuable partnerships through funding, design, construction and monitoring phases. This presentation will focus on the need for collaborative implementation of the Plan in the Snohomish Basin, using the estuary as a case study - highlighting partnerships for cost sharing and fundraising, the application of a hydrodynamic model to assess individual and cumulative effects of restoration projects, and cooperation on data collection and monitoring.

Squamish Perspective on Partnerships

Chief Gibby Jacob, Squamish Nation*

Indigenous traditional knowledge ~ our two banks made us very rich with strong healthy tribal clans.

Before contact we thanked the Creator for the blessings of a healthy environment that sustained us for thousands of years.

Today we pray for the health of Mother Nature and the species that are now extinct. we can not change the decisions we made yesterday and today, however, we can create healthy environmental decisions for the future.

The first tree fell in WHO! WHO!, what is known as today as Stanley Park, the resource extraction race was on, to the demise of the Squamish Nation.

In 1906 a delegation of our Chiefs went to England and were received by their Majesties King Edward VII and Queen Alexandra.

The commitments of the day were promised, the health of the lands would be protected and our treaty would be complete in five years. The honor of the Crown is still at stake, subject to the royal fiduciary obligation.

The Squamish Nation since colonization has made meaningful efforts towards collaboration on environmental issues and concerns, in the past two decades political will has shifted towards collective collaborative efforts from all federal/provincial government levels.

They are starting to understand some of our inherent ways of protecting the health of the environment, by seeing through our eyes, they see the health of their children's grand children in a safe clean environment.

The two banks of the river must be protected, this is achieved by a holistic watershed, wet land ecology approach, if the water of the land is safe and clean, then the water of your blood that runs through your vains is safe and clean.

All My Relations,
Chief Gibby Jacob
Squamish Nation
Chief and Council

Closing Plenary Session & Student Awards

The session will begin by briefly recognizing those students who presented exceptional technical papers and posters. Students will be evaluated during the course of the conference.

The closing plenary will feature rapporteurs' summaries that will seek to provide an overview of the conference and attempt to set the proceedings in a wider context relevant to the Georgia Basin Puget Sound bioregion. The session will conclude with a traditional First Nations closing.

2007 Georgia Basin Puget Sound

Research Conference

Abstracts

of

Poster Presentations

Poster Group 1: Integrated Assessment & Landscape Scale Studies

Watershed-Based Assessment, Modeling, and Clean-up of Microbial Pollution in a Puget Sound Embayment

Christopher May, Battelle Pacific Northwest National Laboratory*
Robert Johnston, Puget Sound Naval Shipyard
Valerie Cullinan, Pacific Northwest National Laboratory
Sally Lawrence, Mindy Roberts, Washington Department of Ecology

An assessment of fecal coliform (FC) bacterial pollution in the Sinclair -Dye Inlet watershed was conducted as part of the Project ENVironmental InVESTment (ENVVEST) being conducted by the Puget Sound Naval Shipyard in cooperation with the U.S. Environmental Protection Agency, Washington State Department of Ecology, the Suquamish Tribe, Kitsap County, the City of Bremerton, the City of Port Orchard, and other local stakeholders. The goal of this study was to identify microbial pollution problems within the Sinclair-Dyes Inlet watershed and to provide a comprehensive assessment of microbial contamination from all identifiable sources in the watershed. This study quantifies levels of contamination and estimated loadings from known sources within the watersheds and describes pollutant transport mechanisms found in the study area. As part of this study, an integrated watershed-receiving water model was developed to predict FC pollution levels for a wide range of land-use scenarios. In addition, the effectiveness of pollution prevention and mitigation measures currently in place within the Sinclair-Dyes Inlet watershed is discussed. This study was conducted to provide the technical information needed to continue current water quality cleanup efforts and to help implement future efforts to protect and restore beneficial uses such as shellfish harvesting and recreation.

An Assessment of Fecal Coliform Bateria in the Sinclair/ Dyes Inlet Watershed, Puget Sound, Wa, USA

Christopher May, Battelle Pacific Northwest National Laboratory*
Robert Johnston, Space and Naval Warfare Systems Center
Brian Skahill, Army Corps of Engineers
Sally Lawrence, Washington Department of Ecology
Mindy Roberts, Washington Department of Ecology
PF Wang, Space and Naval Warfare Systems Center
Gerry Sherrell, Puget Sound Naval Shipyard
Dwight Leisle, Puget Sound Naval Shipyard
John Keiss, Kitsap County Health District
Thomas Ostrom, Suquamish Tribe

An assessment of fecal coliform (FC) bacteria sources and pathways in the Sinclair/Dyes Inlet watershed was conducted as part of the Project ENVironmental InVESTment (ENVVEST) being conducted by the Puget Sound Naval Shipyard & Intermediate Maintenance Facility in cooperation with the U.S. Environmental Protection Agency, Washington State Department of Ecology, the Suquamish Tribe, Kitsap County, the City of Bremerton, and other local stakeholders. The study found numerous sources of FC pollution in the watershed and multiple modes of FC transport from sources to receiving waters and shellfish growing areas. In general, exceeding water quality standards were more likely in urbanizing streams served by stormwater infrastructure, in more developed watershed drainage areas, in areas served by older sewer infrastructure or onsite wastewater treatment (septic) systems, and were also more likely following major storm events. Elevated nearshore FC levels appeared to be localized and persist for only a short period of time after storm events or during extended periods of rainfall. The relationship between FC pollution and land-use showed that the loss of natural forest cover and the increase in impervious surfaces were associated with higher FC contamination. An integrated watershed-receiving water model developed during this project is being used to simulate critical conditions and prioritize actions that will provide the most effective water-quality benefits.

Trends in Magnitude, Distribution, and Coherence of Aerosol Concentrations Over the British Columbia Lower Mainland

Sean Fleming, Environment Canada*

We performed exploratory analyses of inhalable particulate matter (PM10) over the lower Fraser Valley, employing seven monitoring stations with record lengths greater than 10 years. We first considered spatiotemporal patterns in annual average August-September concentrations. Yearly means generally increased up-valley, showed decreasing temporal trends except for Surrey, and exhibited strong interannual correlation between stations with the partial exception of Richmond. We then performed empirical orthogonal function (EOF) analyses independently for each year using daily mean August-September data, and considered year-to-year changes in the leading EOF mode. The leading mode indicated very strong daily-scale regional coherence with the partial exception of Richmond, and showed positive long-term temporal trends both in percent variance explained, and in the loadings for all stations but Surrey. That is, regional coordination of daily PM10 variations is high, and generally increasing. The overall trend results presumably reflect changes in emissions levels and their spatiotemporal uniformity, and/or changes in mesoscale meteorology, which serves to modulate and distribute aerosols. The partial decoupling of Richmond particulate matter variability might reflect physiochemical effects associated with close proximity to the open marine environment, and anomalous long-term trends at Surrey might be associated with very large local-scale population increases.

Searching for Barn Swallow Fall Premigratory Roosts with Doppler Radar

Bruce Cousens, Georgia Basin Ecological Assessment and Restoration Society*

Doppler weather service radar (WSR-88/D or NEXRAD) images from 20 west coast weather radar stations, posted to the Internet at 5-10 min. intervals, were monitored at dawn daily between mid August and late October 2006 to search western North America west of the Rocky Mountains from southern British Columbia to the California-Mexico border for evidence of western Purple Martin, Tree and Barn Swallow late summer ñ fall premigratory roosts. These members of the swallow family are known to form very large single or mixed species roosts at the end of the breeding season that can persist for up to 8-10 weeks, may contain tens to hundreds of thousands of birds and produce a characteristic expanding ring "signature" on weather radar during pre-dawn dispersal. This search located a very large predominantly Barn Swallow roost complex (up to 6 roost sites) near Dayton, Oregon, in the Willamette River valley south of Portland that is known locally to have occurred in corn fields there each fall for the past 8 years but has not been documented previously and may contain much of the PNW population. Another large roost complex apparently also containing Barn and Tree Swallows was located near Yuma, Arizona, but not ground checked. Several other smaller roost sites probably containing swallow species were also found along this valley flyway east of the Coast Range. Possible implications for swallow species fall migration in western North America are discussed.

Marine Geohazards and Habitat in the Canada/US Transboundary Region of Georgia Basin

Vaughn Barrie, Geological Survey of Canada*
Gary Greene, Moss Landing Marine Laboratories
Kim Picard, Geological Survey of Canada

A multibeam bathymetric swath-mapping program in the transboundary region of Georgia Basin (southern Strait of Georgia, Gulf Islands and San Juan Islands) has provided a 5 m resolution map of the seabed. Numerous geological features of the basin, some of which can be considered geohazards, are clearly defined. During the Olympia interglacial period most of the basin was filled with sediment and then

subsequently excavated during the Fraser Glaciation, except for a group of isolated banks. The southern basin has been partially filled with the prograding Fraser River Delta during the Holocene. Active faults, slope stability features, gas pockmarks, and very large migrating sedimentary bedforms, in a region of significant seismicity, are hazards that exist in this region of rapidly growing population and infrastructure. The complex, rugged morphology of the seafloor, the result of the glacial history and dynamic oceanography, provides critical habitat to marine species and for the development of unique habitats, such as small sponge reefs.

Large River Habitat Assessment and Interpretation of Altered Conditions on the Braided Reach, Skykomish River, WA

Frank Leonetti, Michael Rustay, Andrew Haas, L. Ted Parker, Suzanne Brunzell, Robert Aldrich, Snohomish County*

The Skykomish River, WA has created some of the best habitat in the Snohomish River basin for ESA-listed Chinook salmon and other salmonids. As gradient decreases, valley confinement becomes less, and sediment accumulates as new bedforms, a dynamic channel known as the Braided Reach forms. For this study, we developed and implemented a physical habitat survey for large rivers supported by GPS, photo interpretation, and a LIDAR DEM all in a GIS to describe and evaluate the variability in current habitat conditions. Interpretation of these results based on a geomorphological analysis (companion study) of the Braided Reach indicates limits to channel migration (anthropogenic and natural) conforms mainstem habitat unit characteristics among reaches. Only within one reach with high active sediment storage and release from floodplain constraint do high quality side channels persist. Apparent among-reach differences in LWD abundance are actually negligible based on wood loading (#/m2). We conclude one degraded reach has become functionally more similar to areas upstream, whereas historically was likely more similar to downstream segments. Based on this hypothesis, mainstem and side channel habitat losses are large both in terms of total length lost, diversity of habitat types and habitat unit complexity. Understanding relationships between habitat conditions at the reach scale and explanatory factors is critical to assess risk and pose actions for protection and restoration

Land Use in the Canadian Portions Of Two Transboundary Watersheds, Bertrand Creek and Fishtrap Creek

Stephanie Koole, Karen Steensma, Trinity Western University*

Within the Fraser Valley, pressures resulting from continual urbanization are affecting the health of many local streams. This study examined two transboundary creeks, Bertrand (Township of Langley) and Fishtrap (City of Abbotsford), with headwaters located in areas that have experienced rapid urban development. With the help of a geographic information system, land use patterns within these two watersheds were examined, providing important information concerning past and current levels of development. Additionally, each land use category was linked with a percent effective impervious area (EIA) and the total percent EIA for each watershed was calculated. This knowledge of the overall watershed health has valuable implications as an increase in urbanization may result in more frequent flood damage downstream and degraded fish habitat. The project involved an analysis of the land use changes within the Canadian portion of these watersheds and is part of a larger project establishing a comprehensive view of the two watersheds in Canada and the United States. The results of this study will contribute to a more holistic understanding of what is occurring in these watersheds and will be considered in future development or conservation proposals.

A Nutrient Budget for a Large, Oligotrophic Lake in the Olympic National Park.

Patrick Moran, Steve Cox, US Geological Survey*
Steve Fradkin, Olympic National Park

A multi-year effort has begun by the US Geological Survey and the Olympic National Park to develop a nutrient budget for a large oligotrophic lake on the Olympic Peninsula. Lake Crescent is an 18 km long oligotrophic to ultra-oligotrophic lake covering 1,880 hectares near the northern border of the Olympic National Park. Despite its trophic status, concerns over increased algal growth, especially in the lake outlet or Lyre River, have spurred the development of a nutrient budget. Unique, cost-effective methods are being applied as precipitation, surface water, septic fields and groundwater are each being evaluated for low level nutrients (as Nitrogen and Phosphorous) with detection limits in the 1-10 ppb range. Concentrations and loads from each of these sources will be estimated; however nutrients are consistently below the detection limits in both the lake and outlet river. Two large (1.5-2 m) sediment cores from the lake bottom have been collected and are being evaluated for sedimentation rates, nutrient burial, and shifts in diatom communities. The challenges of evaluating productivity as a nutrient concentration surrogate in the presence of aquatic macrophytes will also be discussed. Such basic learning about a watershed will allow the pursuit of multiple future research questions and will provide managers with ratios and trends in anthropogenic to non-anthropogenic nutrient sources.

An Evaluation of Air Pollution Modeling Approaches to Assess Exposure to Air Pollution During Pregnancy

Elizabeth Nethery, Sara Leckie, Michael Brauer, School of Occupational and Environmental Hygiene, University of British Columbia*

Accurate assessment of exposure to air pollution at the population level is difficult and generally done using modeling. This work evaluates the modeling used for a cohort study of the relationship between exposure to traffic-based air pollutants during pregnancy and adverse birth outcomes. Modeling approaches used were (1) ambient monitoring network estimates and (2) a land-use regression (LUR) model at the geo-coded home postal codes of the women. Ambient monitoring networks reflect temporal variability in exposure but are limited for detecting spatial variability at neighborhood scales. Stations are located intermittently throughout the study region and individuals may live close to or very far from a station. LUR modeling uses geographic information to construct an exposure surface that has high spatial variability but only rough temporal variation. To evaluate these approaches, we compared measured (48-hour personal monitoring of NO, NO2) and modeled exposures for a sample of 62 pregnant women. Results suggest that either modeling method is comparable to personal monitoring with adjustment for home gas stove, for NO only. Combining model estimates from both ambient monitoring and LUR further improves predictive models. We conclude that both spatial and temporal variability are important and are captured separately in pollution modeling. These results indicate that exposure classification of this population using modeling is appropriate for NO but not NO2.

The Invertebrate Connection: Tracing the Value of Food Subsidies from Fishless Headwaters to Downstream Fish Populations.

Aya Reiss, John Richardson, University of British Columbia*

Resource flows across ecosystem boundaries form significant linkages between contributing and recipient ecosystems. In particular, spatial subsidies have often resulted in strong increases in recipient population productivity and overall changes in consumer-resource dynamics. The role of invertebrate subsidies from fishless headwater streams to downstream fish-bearing reaches was investigated in two parts. First, a large-scale survey of thirty-four streams assessed the seasonal and land-use induced changes in abundance and biomass of invertebrate drift from contributing upstream ecosystems. Secondly, we experimentally manipulated the rate of terrestrial invertebrate inputs to test whether the recipient ecosystem - cutthroat trout growth ñ could respond to such subsidies. Preliminary results show higher subsidies from alder

headwater streams in comparison to coniferous ones. Further, we see a positive response of cutthroat trout growth to increased subsidies. By determining the extent to which cutthroat trout accrue fitness benefits from experimental headwater inputs, we can link overall trout response to natural variation in drift. Fishless headwater streams have the potential to contribute a significant portion of the cutthroat trout diet. Establishing a firm connection between fish fitness and headwater subsidies will provide a foundation for management of these currently unprotected areas.

Differences in Food Web Connectivity Across Intertidal Gradients in Embayment and Fluvial Dominated Estuaries

Emily Howe, Charles (Si) Simenstad, University of Washington*

Despite suggestions that extensive mixing and large-scale transport of organic matter occurs within estuarine systems and across fluvial-estuarine-coastal ecotones (Teal 1962, Odum 1980), more recent evidence in detritus-based food web systems has shown strong gradients in the sources of organic matter assimilated by consumers across diverse fluvial-estuarine-coastal ocean scales (Peterson et al. 1985, 1986, Deegan and Garritt 1997, McMahon et al. 2005). These emerging results challenge our prior concepts of the scale of food web connections across the land margin. We propose to evaluate food web connectivity in two contrasting estuarine systems (a pulsed fluvial system and a non-fluvial embayment) by describing the spatial extent to which ecosystem-specific organic matter supports estuarine consumers across ecotones. Given that ecotones are distinguished by the strength of the interactions between adjacent ecological systems, and therefore can occur at a broad or fine spatial scale (Risser 1990), we will evaluate the strengths and lengths of food web connections across estuarine ecotones using multiple stable isotopes to trace connections between consumer organisms and primary producers. The spatial and temporal context within which we propose to quantify food web source connections will strengthen our current understanding of the relationship between scales of food web connectivity and landscape scale features.

Integrated Landscape Monitoring in the Puget Sound

Liora Llewellyn, University of Washington, College of Forest Resources*
Christian Torgersen, U.S. Geological Survey - Biological Resources
Guy Gelfenbaum, U.S. Geological Survey - Geology
Mark Munn, U.S. Geological Survey - Water Resources
Vivian Queija, U.S. Geological Survey - Geography

An interdisciplinary consortium is developing conceptual approaches for detecting, understanding, and predicting the effects of landscape change on freshwater, marine, estuarine, and terrestrial ecosystems in the Puget Sound. The implementation team led by the U.S. Geological Survey (USGS) consists of researchers and natural resource managers at city, county, State, and Federal levels in the Puget Sound. Conceptual models of the effects of landscape change on Puget Sound ecosystems will be developed that describe the components of landscape structure and relate these patterns to ecological function. Conceptual models will be used to identify monitoring needed to measure and evaluate potential indicators of landscape condition at scales necessary to inform management issues and practices. Over time, the findings of this pilot project will be applied and tested on other landscapes throughout the United States so that our ability to deliver integrated landscape monitoring across the North American landscape will be enhanced. By linking approaches to landscape monitoring employed by multiple land management agencies, this project aims to bridge the gap between local monitoring efforts and regional satellite-based mapping projects and thereby facilitate the detection and prediction of broad-scale human impacts on aquatic and terrestrial ecosystems.

Yet Another Effect of Urbanizationónutrients from Terrestrial Organic Matter in Small Streams

Mindy Roberts, Derek Booth, University of Washington, Department of Civil and Environmental Engineering*
Bob Bilby, Weyerhaeuser Co.

Urbanization affects freshwater and marine systems by altering one or more of five factors that include flow regime, water quality, habitat, energy regimes, and biotic interactions. This study evaluated the effects of urbanization on terrestrial organic matter from riparian vegetation. The study quantified changes to the timing and quantity of nutrients to small streams as well as organic matter transport and decomposition within small streams with altered physical, chemical, and biological processes. Historically the change from conifer to deciduous trees in the riparian zone altered the amount and timing of organic matter inputs, while complete removal of riparian trees depletes organic matter inputs. Urban streams in particular transport organic matter farther, limiting availability for macroinvertebrate and microbial processing that may otherwise buffer increasing nutrient levels. Finally, red alder leaves decompose faster in urban streams, although the effects of flooding and salmon redd construction in any given year can overwhelm measurable the effects of urbanization. Urbanization does alter the inputs, transport, and decomposition of organic matter in small streams, however, which likely affect long-term nutrient delivery to downstream water bodies like Puget Sound. This research was funded by a grant from the Puget Sound Action Team and EPA Region X.

Integrated Framework of Urbanization, Nearshore Ecosystem and Human Health Interactions

Daniele Spirandelli, Lisa Younglove, Marcie Demmy-Bidwell, Marina Alberti, Kelly Fay, Christina Drew, Nancy Judd, Elaine Faustman, University of Washington*

The Washington State Shoreline Management Act (2003) requires shoreline managers to consider interactions among urbanization, ocean/river/estuary systems and human health when developing shoreline management plans. Although significant progress has been made in modeling landscape change associated with urbanization, human exposures associated with risks, and near shore ecosystem processes, local and regional governments are challenged with linking these modeling efforts to answer questions relevant to shoreline management and planning. This poster presents an integrated assessment and management framework which synthesizes scientific and expert knowledge gathered through structured interviews of scientists and shoreline planners. After presenting a description of the framework and its application in the planning process, we demonstrate how the framework has been used to generate a database of data sources and three case studies to show the applicability of the framework to three shoreline problems: PCBs, harmful algal blooms and low dissolved oxygen.

Integration of Ecological Risk Assessment and the Gap Analysis Project to Assess Risk to Smolt Production in Developed Watersheds

Laurel A. Kaminski, Jessica A. Ellis, Wayne G. Landis, Western Washington University*

Historically, small streams of North Puget Sound have provided important salmonid habitat. In our study area, small watersheds have been altered by development. Effective management of salmon habitat requires methods for assessing the impacts of this development. We studied seven small watersheds in Whatcom County, Washington, each varying in size and range of anthropogenic disturbance. We combined ecological risk assessment with the USGS Gap Analysis Project (GAP) methodology to assess risks to salmonid smolt production. GAP habitat classification was used in combination with land cover data and sources of potential stressors. We used data from smolt traps to identify patterns between the rearing capacity of the stream and land cover in the watershed. Smolt data were available for each stream, however no relationship between production and landscape characteristics was found. Due to the inherent variability of salmon runs and lack of long term sampling data, it was not possible to determine if correlations exist.

This project has implications for the structure of future habitat utilization assessments. Despite data limitations, the combination of risk assessment and GAP provided insight into the risks to salmon production in the study area, and this method is applicable to other regions.

Ecological Risk Assessment of the Interior Landscape Analysis System Project Area (INLAS): A Pilot Study.

Suzanne Anderson, Sarah Christensen, April Markiewicz, Wayne Landis, Western Washington University*

An ecological risk assessment (ERA) is being conducted in partnership with the United States Forest Service in the Interior Landscape Analysis System Project (INLAS) area in the Upper Grande Ronde sub-basin of eastern Oregon. The Problem Formulation phase has just been completed in which sources of stressors, stressors, habitats and assessment endpoints were identified. A conceptual model was constructed showing the exposure and effect pathways linking the sources and stressors to the habitats and assessment endpoints. Risk regions were also identified using Hydrological Unit Code(s) (HUCs) and GIS. In the Analysis Phase the compiled data will be used to assign risk ranks to the sources, stressors, and habitats. The Relative Risk Model will then be used during the Risk Characterization Phase to calculate the relative risks for each source, stressor, habitat, and endpoint for each risk region. The overall management goal for the INLAS region is to achieve an historic range of variability (HRV) and to use the HRV to manage for other endpoints such as anadromous fish habitat, invasive species, insect outbreaks and forest resources. The results of this study should provide a model with uses throughout the Georgia Basin for forest management in areas affected by similar issues.

Poster Group 2: Invasive and Recovering Species

Update on Purple Martin Stewardship and Recovery in British Columbia, 2006

J. Charlene Lee, Bruce Cousens, Georgia Basin Ecological Assessment and Restoration Society*
Laura M. Darling, Parks and Protected Areas Branch, BC Min. of Environment
J. Cam Finlay, Thomas W. Gillespie, Independent, Victoria, BC

The western Purple Martin (*Progne subis arboricola Behle* 1968) is Blue-listed (until recently Red-listed) in British Columbia and a Species of Special Concern throughout its breeding range in Washington, Oregon and California. These designations were assigned because of severe range-wide population declines in the mid-1900s resulting from ongoing loss of cavity nesting opportunities both in the wild and in cities and severe competition for nest cavities from two introduced bird species, European Starlings and House Sparrows. The population has rebounded from 5 known breeding pairs nesting in offshore pilings at 2-3 sites within BC in 1985 to over 600 pairs in 2006, with an unprecedented tripling in the past 3 years, entirely as a result of nest boxes built, erected, monitored and maintained mainly by volunteers at ~60 marine coastal locations. This highly successful recovery program now includes 45 occupied nesting colonies and 15 unoccupied nest box sites distributed throughout the Georgia Basin, involving a total of ~1200 nest boxes, plus 100 nest boxes at 20 fresh water sites (one occupied). This program could not be maintained over this large geographic area without the ongoing dedication and support of 130+ volunteer stewards and assistants and support from many local businesses, sponsors and funding organizations. Success of this recovery effort and costs of co-ordinating and implementing the annual stewardship program are documented and discussed.

Where's the Point – Details of a Large-Scale Inter-Agency Salmon Hatchery Release Mapping Project in the Pacific Northwest

Andrew Albaugh, Jeffrey Cowen, Northwest Fisheries Science Center, NMFS*

To aid in the recovery of Threatened and Endangered Pacific Northwest salmon populations, we at NMFS Northwest Fisheries Science Center have developed a geo-spatial database to house a wide array of salmon related data. One key component of the database, developed in cooperation with several state, federal, and tribal agencies, is a module to capture and display agency data on artificial propagation operations (hatcheries). One challenge of this endeavor was standardizing the agencies' diverse methods of documenting hatchery release locations. There were roughly 40,000 records submitted with about 8,500 unique locations provided as narrative text or a stream name. Mapping these locations from this limited information required the development of tools for the ArcGIS software environment. The result is a comparatively accurate and highly useful display of hatchery release points and spawning events presented in a spatially rigorous form. In turn, this spatial data can be coupled with other salmon data within the database, such as natural abundance. A major benefit from our approach is that it will grant all agencies access to a central location, through a web-based interface, where they can download salmon related data. We foresee this mapping effort, coordinated with our database development as a whole, becoming a vital tool for policy and decision makers with regards to Endangered Species Act status updates for these salmon populations.

Chinese Mitten Crabs (*Eriochier Sinensis*) and Puget Sound; Developing Early Detection and Rapid Response Tools for an Unwanted Aquatic Nuisance Species.

Robyn Draheim, Steven Wells, Portland State University*

Puget Sound Georgia Basin is at risk for introduction and establishment of Chinese mitten crabs (Eriocheir sinensis). Recent discoveries in St. Lawrence Seaway and Chesapeake Bay have again raised concerns about this aquatic invader and its risk to the Pacific Northwest. Work at Portland State University suggests that large stable estuaries, such as Puget Sound, face the greatest risk. If mitten crabs become established, they are expected to proliferate in Puget Sound due to optimal temperature and salinity regimes for larval survival and flushing times of sufficient duration for larval development within the estuary. With a well-established population in the San Francisco Bay and the potential for introductions from California, the East Coast, Asia and Europe, the potential for introduction of mitten crabs into Puget Sound is significant. While many introduction pathways have been addressed, the risk of a mitten crab introduction has not been eliminated. Early detection and rapid response remain the best management tools available to reduce the risk of economic and ecological impacts of mitten crabs in the Pacific Northwest. Given the size of Puget Sound Georgia Basin, the development of effective outreach tools and a network of volunteer monitors are crucial to the success of any early detection rapid response project. As mitten crabs are only one of many nuisance species of concern these efforts must be developed so that they integrate seamlessly with existing projects.

Species of Concern within the Georgia Basin Puget Sound Marine Ecosystem: Changes from 2002 to 2006

Nicholas Brown, Joseph Gaydos, SeaDoc Society, UC Davis Wildlife Health Center*

Species of concern are native species, sub-species or ecologically significant units that warrant special attention to ensure their conservation. Within the Georgia Basin Puget Sound marine ecosystem, the Province of British Columbia, the State of Washington, the Canadian Federal Government, and the United States Federal Government each assess which species require special initiatives to ensure protection and survival of the population. As of September 1, 2006, 64 species of concern were listed by one or more jurisdiction in the Georgia Basin Puget Sound marine ecosystem. Each jurisdiction underestimated the total number of species of concern within the entire marine ecosystem. Since 2002 when an ecosystem-based list of species of concern

was first compiled, the number of species of concern has slowly advanced from 60 species in 2002, to 63 in 2004 to 64 species but the percentage of total species listed by each jurisdiction has not altered significantly. Using unpublished data on species richness for the ecosystem, approximately 0.1% of invertebrates (3/3000), 12% of fishes (27/219), 19% of birds (24/128) and 45% (9/20) of mammals that utilize the Georgia Basin Puget Sound marine waters are listed by one or more jurisdiction as species of concern. This is concerning and suggestive of ecosystem decay. In light of projected human population growth in the region, efforts need to be enhanced to more rapidly address regional species declines and to institute multi-species ecosystem-based solutions where possible.

Characterizing Zooplankton Communities in the Ballast Water of Ships Frequenting Vancouver Harbour, British Columbia

Donald Humphrey, Claudio DiBacco, University of British Columbia*
Colin Levings, Fisheries and Oceans Canada

The Canadian Aquatic Invasive Species Network (CAISN) has been established to assess vectors of dispersal for aquatic invasive species (AIS), factors facilitating successful invasions and associated risks to native communities. Ballast water has been identified as a principal transport vector for AIS introductions and potential threat to the indigenous communities of the Strait of Georgia (SoG) due to the high concentration of commercial ships that frequent the area. This study examines ballast water as a transport vector for AIS into Vancouver Harbour. While management strategies such as mid-ocean exchange (MOE) have been implemented to prevent such introductions, the exemption of some intra-coastal ships may still pose a significant vector of AIS introductions. This presentation will discuss the early results of ship board studies examining the zooplankton community composition in ships entering Vancouver Harbour. Comparisons of zooplankton communities aboard ships carrying exchanged and unexchanged ballast water will provide an assessment of MOE protocols for BC. Future research will investigate zooplankton survivorship during transit and discriminate between actual and effective propagule pressure by examining the ability of species to tolerate physico-chemical conditions of receiving waters. Ultimately, we hope to gain a better understanding of which life history traits of organisms characterize and facilitate the successful establishment of AIS in the SoG.

Non Native Bivalves in the Strait of Georgia

Tina Lum, Monica A. Bravo, University of British Columbia*
Thomas W. Therriault, Glen Jamieson, Department of Fisheries and Oceans Canada, Pacific Biological Station Nanaimo, BC, Canada
Claudio DiBacco, University of British Columbia, Earth & Ocean Sciences

Aquatic invasive species (AIS) can affect native environments by altering ecological relationships among native species, disturbing ecosystem functions, and possibly changing the value of the economy within these ecosystems. The Straight of Georgia (SoG) is a rich and productive ecosystem, that is economically important because of its seafood production, maritime industries, and recreational opportunities. However, these economic and recreational activities represent potential vectors for AIS transport that make the SoG vulnerable to invasions. The SoG is currently inhabited by numerous non native species, but because very few ecological surveys have been conducted an accurate number of established species has not been determined. During the summer of 2006 a large scale intertidal survey was conducted on the east coast of Vancouver Island (from Victoria to Campbell River) to determine the distribution and abundance of non native bivalves. Sampling sites were selected to include a wide variety of environments (e.g., hard & soft bottoms, exposed & sheltered) as well as areas thought to represent a gradient of human impacts (e.g., nutrient loading, fresh water runoff). Factors influencing the establishment and distribution of these bivalves will be discussed. Understanding the environmental and anthropogenic factors associated with habitats characterized by established non native species may prove useful in identifying other locations susceptible to biological invasions.

Westcoast Domestic Ballast Water Regulations: Is 50 Miles Enough?

Nissa Ferm, Jeffery Cordell, Terrie Klinger, University of Washington*

The spread of non-indigenous aquatic organisms has become a serious domestic issue. It is known that ballast water is a major vector for the transport of these organisms. The west coast of the continental United States has the most invaded aquatic environment, San Francisco bay. In order to mitigate the risk of non-indigenous organisms transported through ballast water, regulations have been enacted in the states of Washington, Oregon and California requiring domestic vessels transiting from one state to another performs an open ocean exchange 50 miles off shore. Is fifty miles oceanic enough for exchange? It has been debated whether this distance is appropriate; due to the complex micro scale oceanic processes and coastal mesozooplankton dispersal patterns that occur within the fifty mile zone. The study is conducting transects from Long Beach, CA to the Straights of Juan de Fuca,WA that go from zero to eighty nautical miles offshore. Taking fine (80um) and coarse (303um) zooplankton tows at even intervals. Mesozooplankton will be enumerated and identified to species when possible and categorized as oceanic, coastal, or cosmopolitan. It is hoped that this will elucidate whether domestic ballast water regulations on the west coast of the continental United States do enough to reduce the spread of non-indigenous and coastal mesozooplankton with in it.

Non-Indigenous Zooplankton in Ships Entering Puget Sound: Does Mid-Ocean Exchange Reduce Risk?

Jeffery Cordell, Nissa Ferm, Russel Herwig, University of Washington*

To evaluate potential risk posed by ballast water introduced non-indigenous species (NIS), we sampled zooplankton in 246 ships in Puget Sound. Taxa were classified into a potentially high risk group of known NIS plus coastal organisms in ballast from regions other than the NE Pacific, and a low risk group of oceanic species. Most of the ships reported a mid-ocean ballast water exchange (MOE). However, despite apparent compliance with regulations requiring MOE, we found high densities and percentages of NIS and coastal species in sampled ships. Exchange efficiency models and controlled experiments with before-and-after MOE sampling have shown that MOE is effective for zooplankton, but we found that MOE as practiced probably does little to reduce the introduction of planktonic NIS to Puget Sound. Possible reasons are that MOE was reported but not conducted, or conducted incompletely, or that it is ineffective for some ship types or ballast tank configurations. In our results, both NIS and coastal taxa were consistently and significantly more abundant from domestic trips dominated by tank ships carrying ballast from California, and lower from container ships and bulk carriers with ballast from Asia. High NIS abundance also occurred in a few samples from other sources on the west coast of North America. These findings are probably a result of dense and diverse NIS assemblages present in California and other west coast estuaries and shorter transit times on coastal routes.

Assessing Phytoplankton Survival after Ballast Water Treatment

David Lawrence, Russell Herwig, University of Washington*

Ballast water discharge is a recognized pathway for the introduction of potentially harmful, non-indigenous species of phytoplankton to coastal waters. International, federal, and state standards of allowable numbers of phytoplankton in discharge water have not been finalized. However, the International Maritime Organization (IMO), State of California, and US legislation have pending regulations based on an allowable number of "viable" organisms in a volume of ballast water. A variety of technologies are being developed that treat ballast water to meet these proposed standards, including electrolytic chlorine generation,

ozone, filtration, and UV light treatments. No standard method is accepted for assessing phytoplankton survival after ballast water treatment. Here we present some of the methods available to determine the response of phytoplankton to ballast water treatment, emphasizing whether these methods can provide an endpoint to satisfy ballast water management standards. Methods include size fractionated chlorophyll a determination, flow and solid state cytometry, direct counts, and a novel method we developed based on the Most Probable Number (MPN) technique. Each method has intrinsic advantages and disadvantages in relation to their applicability for regulatory enforcement and monitoring. Treatment experiments utilizing filtration, UV light, and chlorine were conducted to compare the usefulness of the assessment methods.

Acoustic Tagging of Transplanted Black Rockfish

Jeff Marliave, Vancouver Aquarium*
Carolyn Huston, Simon Fraser University
David Welch, Kintama Research

Using fishing closure areas to conserve rockfish broodstock depends upon long-term residency by rockfish in those closures. Among inshore species, black rockfish in particular tend to occupy the water column, and their residency in association with rocky reefs is not firmly documented. In late 2004, VEMCO receivers were deployed near Pt. Atkinson and acoustically-tagged black rockfish were released there. Novel graphical methods aid the interpretation of acoustic signal detection data. The tagged black rockfish exhibit high site fidelity and relatively small ëhome ranges.' At this release site, black rockfish viewed in the same high relief area on different dates are likely the same fish. Presence and absence on different receivers tend to co-occur for some tagged rockfish, indicating the presence of social groupings. Underwater site topography and detection data have suggested where rockfish might preferentially be residing near the release site, enabling design of future studies of black rockfish behavior. This work could in turn enable site selection for future closure areas.

Is it Possible to Eradicate Invasive Species?

Jesse Schultz, Washington State Department of Fish and Wildlife*

Is it possible to eradicate invasive species? The Department of Fish and Wildlife is engaged in an effort to eradicate invasive marine tunicates in Puget Sound that may answer this question. This project will describe techniques used to control invasive tunicates and their success, and will evaluate the likelihood of successfully eradicating invasive tunicates in Puget Sound. The club tunicate (Styela clava), native to Asia, was discovered in the state of Washington in 1998. It is an invasive solitary ascidain. It has no known natural predators in Washington; as a result club tunicate populations are growing rapidly, out competing native species for space and food. This could create a serious problem for shellfish aquaculture. In April 2006, The Governor and the legislature gave the Department of Fish and Wildlife emergency funding for the purpose of surveying to determine the extent of the club tunicate infestation in Puget Sound, to stop the population from spreading, and to determine the potential costs of eradication efforts. Four marinas in two harbors were found to have club tunicates. Due to the low population at one of the marinas, the majority of that marina was cleaned of club tunicate, leaving only three marinas in Washington infested with the tunicates. To slow down the spread of club tunicates, WDFW cleaned 96% of infested vessels at the marinas. With the work that has already been done and only a couple known populations, the agency has made a great start but is eradication possible? Eradication would have to be done within a small time period to not allow the tunicates to repopulate themselves. Over time eradication of this animal may be possible, but the forecast for the immediate future is less rosy given the current level of effort and available funding.

Biological Responses to Offshore Artificial Habitats Constructed in Puget Sound

Tony Parra, Wayne Palsson, Washington Department of Fish & Wildlife*

We examined how well artificial habitats designed to attract juvenile rockfishes functioned at an offshore shoal in southern Puget Sound. In 2004, WDFW deployed four artificial habitats consisting of small quarry rock on and near an existing artificial habitat at Toliva Shoal that was originally intended to attract adult rockfishes and lingcod. Biologists conducted scuba transects using the visual census technique before and after habitat construction at four matched impact and control sites. Sites were stratified by depth and location on or away from existing artificial substrates. While adult and sub-adult rockfish densities were higher at seven out of eight transects after construction, modified artificial habitats had higher rockfish densities than their respective controls. The highest densities of rockfish were observed at the deep sites where existing adult rockfish habitats exist. Only three young-of-the-year rockfish were observed over a two-year period among all of the offshore sites, while nearshore habitats in Puget Sound supported a high settlement of copper and quillback rockfishes in 2006. Our results to date suggest that offshore nursery habitats for rockfish do not function as primary settlement sites but may attract sub-adults to small rock habitats. How these fish become integrated into adult artificial habitats and the implications for rockfish recovery efforts will be examined in future years.

Restoration of Native Oysters in Fidalgo Bay, Washington

Paul Dinnel, Western Washington University*
Betsy Peabody, Tristan Peter-Contesse, Puget Sound Restoration Fund

The native or Olympia oyster, Ostrea conchaphila, once common in Puget Sound, is struggling for survival in many locations due to past over harvest and pollution. Skagit County Marine Resources Committee (Skagit MRC), working in cooperation with Puget Sound Restoration Fund and various community, business and tribal partners, initiated a project to establish several native oyster reefs in Fidalgo Bay near Anacortes, Washington. The primary restoration site, under a railroad trestle in south Fidalgo Bay, has proven to be an excellent site. This location has several areas of standing or flowing seawater at extreme low tides, is fairly remote from public disturbance and has been enhanced by the addition of Pacific oyster shells. Seed on cultch planted several times over the last four years have shown excellent survival and growth, and there are signs of larval production. In addition, in 2006, we found clear signs that larval native oysters were setting on oyster shells, wood and metal debris near the trestle site. Future challenges include establishment of additional oyster reefs (multiple source populations) and monitoring for the extent of larval settlement within and beyond Fidalgo Bay.

Spatial and Temporal Variability of Groundfish Populations in Proposed Marine Reserves of Skagit County, Washington

J. Henry Valz, Paul A. Dinnel, Shannon Point Marine Center, Western Washington University*

Among groundfishes, rockfishes (genus Sebastes) are some of the most over-fished species in the United States. Populations in Puget Sound have declined rapidly over the last century; some rockfish species have only ten percent of their historical reproductive output. To address this problem, the Skagit County Marine Resources Committee has proposed establishing no-take marine reserves to protect groundfishes. The majority of studies of groundfish populations in the northeast Pacific have focused on summer distributions. The goal of this study was to relate intra-annual dynamics of groundfish, especially rockfishes, to physical and biological factors. Twenty-four dives were performed over one year at six sites under consideration as Skagit County Marine Reserves. Each dive consisted of eight 25-m transects where fish number and size, plus bottom composition were measured. Initial results show that changes in season were a-sociated with changes in densities of the most abundant groundfishes (copper rockfish, kelp greenling, and lingcod). Also, several physical and biological habitat conditions were strongly correlated to groundfish densities. Because of the large

seasonal trends and effects of physical factors, more diverse sampling regimes should be used and larger reserves should be considered to compensate for the seasonal migration of groundfishes.

Pcod Meets Acod: Population Structure of Pacific Cod and Implications for Biocomplexity

Lorenz Hauser, Kathryn Cunningham, University of Washington*
Ingrid Spies, Mike Canino, Alaska Fisheries Science Center

The extent of population structure in marine species is not only relevant for the management of dependent fisheries but may also be central to the ability of exploited species to withstand environmental fluctuations. Extensive research on Atlantic cod demonstrated fine scale population structure, as well as differential survival among genotypes and extreme levels of differentiation at selected loci suggesting local adaptation. Genetic data on Pacific cod, on the other hand, are limited. Here, we present data from microsatellites and the selected Pant locus of Pacific cod across almost the entire geographic range in comparison with results from Atlantic cod. Results showed large genetic divergence between Asian and American populations (FST=0.042, P<0.001), suggesting secondary contact and reproductive isolation between two major phylogeographic groups within the species. Levels of differentiation along the North America coast were limited (FST=0.0027, P<0.001), but followed an isolation-by-distance pattern suggesting limited mean dispersal distances. An exception was a sample from the Gulf of Georgia, which showed relatively high genetic differentiation from all other samples, indicating the existence of isolated cod stocks in coastal waters of Washington and British Columbia. Further research is needed to resolve boundaries between east and west Pacific populations, and to further investigate number and distribution of localized stocks within both regions.

Volunteer Divers Monitor Invasive Tunicates And Stressed Marine Life in Washington

Janna Nichols, Washington Scuba Alliance, Reef Environmental Education Foundation*

Recreational divers in Washington State are being trained to identify invasive tunicates. When found, the divers report their presence to the Puget Sound Action Team. A specially trained group of divers are then able to confirm some of the sightings, and help remove the unwanted species under a special permit through WDFW. Volunteer divers are also contributing by doing monthly monitoring in Hood Canal at 8 different sites. Marine life is surveyed for presence/abundance/condition in 4 different depth zones year round. Divers also survey for the presence of invasive tunicates. During these surveys divers are able to visually note which species are stressed, and which are found outside their normal depth zones. Notes and photographs are taken to document their condition. The data is made available online to any agency or researcher. By using volunteer divers to help gather data and observe marine life, the number of surveyors and amount of area covered is increased, and more invasive tunicate removal can take place. The volunteer divers are members of Washington Scuba Alliance (WSA) and Reef Environmental Education Foundation (REEF).

Poster Group 3: Decision-Making and Modeling Tools

Develop with Care: Implementing Environmental Protection during Urban and Rural Land Development in British Columbia through Guidelines

Bob Cox, Marlene Caskey, British Columbia Ministry of Environment*

The Ministry of Environment (MoE) is concerned with helping communities around the Georgia Basin maintain natural environmental features as they develop and grow. These features help people stay healthy through provision of Greenspace and outdoor recreational opportunities, provide capacity for meeting natural disasters (such as avoiding developments in floodplains and wildfire-prone areas) and can lower overall infrastructure and maintenance costs. Sustainable communities need to incorporate environmental concepts into their design. In response to the need for alternative stewardship processes, MoE has created Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia (DWC document). The DWC document incorporates the best available science and legislated authority to define environmental objectives and performance targets which users of the guide are expected to achieve. It recommends critical items to include in planning and bylaws, and best practices which may be followed to achieve these targets. It also provides case studies of sustainable initiatives in communities throughout the province. The purpose of this presentation is to examine the environmental aspects of sustainable communities through an introduction to the DWC. It will highlight why having the development community use the DWC document has the potential to provide better environmental protection than ever achieved before.

Assessment of a Three-Dimensional Models Prediction of Near-Field Suspended Sediment Concentrations

Kevin Schock, Bruce Nairn, King County*
Stephen Breithaupt, Cheegwan Lee, Battelle (PNNL)

In the Duwamish Estuary in Seattle Washington, King County investigated the application of a three-dimensional computer model for near-field sediment deposition at a Combined Sewer Outfall (CSO). In cooperation with Battelle (Pacific Northwest National Laboratory) we applied the computer model to determine relevant settling velocities and effect of grid size on initial dilution and distribution of suspended sediment concentrations near a CSO. Fine-grid model results indicate good correlation between observed and simulated sediment distributions near the CSO; these results define the relevant settling velocity. Against these results, we compared two simple models: a scaling model that determines relevant settling velocities and dilution model that describe effects of grid size on suspended sediment concentration and distribution; we present these solutions in non-dimensional terms. These simple relations provide a promising method for defining the relevant sediment mass discharged from a CSO and effect of grid size on suspended sediment concentrations at the CSO.

An Assessment of Error in State Shoreline Designation for Lakes of Washington

Peter Bahls, Northwest Watershed Institute*
Cary Kindberg, Micah Wait, Jamie Glasgow, Washington Trout

Lakes that are 20 acres or larger in size meet the criteria for designation and protection under the jurisdiction of Washington's Shoreline Management Act. However, since the original list of designated lakes was established in 1972, biologists have found some lakes that meet the size criteria but were erroneously not designated as Shorelines. The objectives of this project were to estimate the error rate in current lake designation in the state and develop a reliable and cost-effective method that could be used by local governments to identify lakes that meet the Shoreline criteria. We used GIS data to classify 8,888 lakes in Washington based on their size and potential to meet Shoreline criteria, with additional aerial photo analysis and field verification for lakes selected through random stratified sampling. Our analysis indicates that 253 lakes, or approximately 25 percent of the total number of lakes that meet Shoreline criteria in Washington State, are not designated or protected under the Shoreline Management Act. We recommend that the GIS shapefiles and lake classification data available on Washington Trout's website be used to identify lakes in each local jurisdiction that have a moderate to high probability of meeting Shoreline criteria. For each lake identified, a biologist trained in Ordinary High Water Mark determination by Washington Department of Ecology should conduct field verification.

Alternative Futures Analysis for Bainbridge Island, Washington

John Bolte, Oregon State University*
Dana Woodruff, Pacific Northwest National Labs

There has been considerable interest by planners, community groups, and researchers in developing and exploring alternative future scenarios for community growth, development and protection of ecosystems and ecosystem services. In response to this need, a software tool, Evoland was developed to allow a policy-oriented approach to creating and exploring a broad range of alternative future scenarios ranging from conservation- to development-oriented strategies. Evoland is a spatially explicit, multiagent-based modeling framework for anticipatory modeling of landscape change under alternative future scenarios. Evoland explicitly models landscape dynamics in response to coupled processes of actor-based human decision-making, landscape service provision, and autonomous landscape change, using a policy-centric approach to represent and constrain decision-making. We are working with the City of Bainbridge Island to adapt Evoland to meeting the needs of the City for exploring alternative strategies for growth management and assessing impact of these alternative strategies on ecological and social concerns on the island. Of primary concern is impact of alternative trajectories of change on terrestrial and nearshore habitat.

Managing, Storing and Sharing Natural Resource Project Information & Water Quality Data

Tracy Bosen, Paladin Data Systems*

The collection, storage & sharing of natural resource information is one of the most important issues facing resource managers today. Monitoring data, project task management, project locations (including landowner information), funding income & expenses, & the files & information associated with individual projects can be cumbersome to store & share with partners. Effective landscape/mapping information management tools are needed to provide resource managers the ability to view resource information from very small sub-watershed to very large and complex regional scales.

Effective tools include:

- A system that is relatively simple & intuitive
- The ability to securely share information via web technology
- Ability to integrate with existing systems & information
- Ability to search & view information/projects by individual watershed, monitoring station or regional planning unit
- Ability to use aerial and topographical maps & GIS layers
- Reporting capability to illustrate results and effectiveness
- Ability to spatially evaluate various watershed factors
- Ability to review historical efforts when planning for future projects & funding requirements

Using current web technology natural resource managers can effectively manage time, staff, funding, data, partnerships, and share information spatially, securely and quickly.

Habitat Models and Land Use Management: Got Wetlands?

Anna Kopitov, Pierce County Planning and Land Services*

Puget Sound critical areas are subject to greater land use pressures from growing populations, Growth Management Act (GMA) population targets and developers seeking to capitalize on rural land use conversions. Information regarding critical area locations, such as wetland habitats, is often incomplete or nonexistent. Predictive methods to identify and protect critical areas are essential but missing components of land use management. Landscape-level analyses, or habitat models, offer rapid quantitative methods for identifying potential wetland habitat areas. However, many rural areas do not have the capacity to develop and implement these tools. Habitat models facilitate interagency collaboration to enhance information relating to wetlands occurrence. In an effort to minimize negative environmental impacts to critical areas, Pierce County, WA is combining the use of landscape science and geographic information systems to assist jurisdictions in identifying potential critical areas. Classification and regression trees (CART) were used to predict the occurrence of potential wetland areas in three Pierce County jurisdictions. Results were then mapped using geographic information systems (GIS). Suspect wetland areas were verified using orthophotograph comparisons and field reconnaissance. Initial results show promise for predicting the occurrence of wetlands on varying rural landscapes.

A Hydrodynamic Simulation of a Conservative Tracer to Evaluate Dispersion of Out-Migrating Salmon in Sinclair Inlet, WA

Robert Johnston, U.S. Navy Space and Naval Warfare Systems Center*
PF Wang, US Navy Space and Naval Warfare Systems Center, San Diego, CA
Doris Small, Washington Department of Fish and Wildlife, Port Orchard, WA
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A high resolution curvilinear 3-dimensional hydrodynamic model (CH3D) for Sinclair and Dyes Inlets, Puget Sound, Washington was set up to simulate the hydrological and tidal conditions present during the release of hatchery-reared, juvenile Chinook salmon from the Gorst Creek Hatchery (May 19 - Jun 30, 2002). The model was used to simulate the salinity distribution and currents that occurred during a catch and release out-migration sampling study conducted by the Washington State Department of Fish and Wildlife (WDFW) in Sinclair Inlet. The model simulated the release of a conservative "tracer" that corresponded to when the majority of the marked fish were released into Gorst Creek. The model simulated dispersal of the "tracer" plume as a function of tide and wind-driven currents and fresh water inflow without any biological interactions. The model produced a time series of tracer concentrations in areas of the Inlet that were sampled during WDFW' s out-migration study. The model results were compared to fish recapture rates to evaluate differences between fish density and the tracer concentrations predicted by the model. The comparison indicated that the out-migrating juvenile salmon remained in the Inlet about 3 to 7 days longer than expected from dispersion due to mixing alone.

Adapting Decision Making to Uncertainty and Complexity when Addressing Sea Level Rise Response in Puget Sound

Alexander Petersen, University of Washington*
Edward Miles, Universtiy of Washington (Thesis Chair/Advisor)
Thomas Leschine, University of Washington (Committee member)
Douglas Canning, UW Climate Impacts Group (Committee member)

It is difficult for decision makers to deal with scientific uncertainty when making public policy choices. These difficulties become particularly apparent as local jurisdictions begin to address climate change and its related impacts. Preparation and incorporation of climate predictions is hampered by the complex non-linear nature of the climate system and the variability of future climate scenarios. Additionally, the surrounding institutional, legal and policy system is primarily linear. This difference in structure increases the complexity of addressing climate change impacts. Sea level rise provides a relevant current forum with which to address these issues. This study will focus on the local institutional, legal, and regulatory structure of Washington State, King County and the City of Seattle in order to identify the key impediments to incorporating sea level rise science and its associated uncertainty into decision making. Building on this assessment, the study will determine the institutional and regulatory context required to adequately address the issue. Finally, by using a risk-based management approach within the local context, this study will identify ways in which the impediments can be overcome, and lead to the creation of a more robust framework capable of adapting to and incorporating the uncertainty associated with sea level rise.

Seasonal Variability of Circulation in Hood Canal, Washington Due to Changing River Discharge and Outside Salinity: A Model Study

Mitsuhiro Kawase, University of Washington*

Seasonal variability of the exchange circulation in Hood Canal, Washington is studied using a three-dimensional hydrodynamic model of the circulation forced with climatological seasonal river discharge and salinity outside the mouth of the canal. River discharge and salinity are varied both individually as well as together to study their relative importance in generating variability. Deep inflow into the canal has a maximum transport in July and a minimum in January. With only the river varying, the maximum transport occurs in February ñ March, and the minimum in October; while with the external salinity varying, the peak is in August ñ September and the minimum is in January. Both forcings generate seasonal variabilities of a comparable magnitude. There are significant seasonal changes in the vertical structure of the inflow. The peak inflow during August ñ September is concentrated at the bottom, coinciding with the dense water intrusion. In November the inflow core rises to mid-depth and stays there until the next August, while a weak outward flow develops near the bottom. This switch between two- and three-layer circulation agrees with the observed rising of the sequestered oxygen minimum layer to just below the pycnocline in September, and the subsequent mid-depth ventilation of the canal in winter and the spring.

Detecting the Pattern of the "Red Edge" of Absorption in Puget Sound from Satellite Measured Water-Leaving Radiance

Rachel Halfhill, Miles Logsdon, Leon Delwiche, University of Washington*

The normalized difference vegetative index (NDVI) has successfully utilized the difference between red and infrared reflectance of plants to map vegetation on land; however, remote sensing of primary production in the open ocean has been limited to chlorophyll-a estimates using shorter wavelengths at a 1 km resolution. This spatial resolution is insufficient for the inland waters of Puget Sound. Using satellite measured reflectance of normalized red and near infrared wavelengths at a finer resolution (250m), we compared in situ reflectance and florescence measurements. We investigate the link between spatial and temporal variation of the Red Edge Ratio (RER) to primary production in Puget Sound where current remote sensing techniques are limited. The spatial and temporal resolution of the MODIS Aqua sensor in the red and near infrared wavelengths can resolve patterns in the water-leaving radiance in Puget Sound using RER as a normalized difference of the two wavelengths. In situ measurements of RER show a negative correlation with satellite derived RER at high values and a positive correlation at lower values. There is a negative relationship between florescence and satellite derived RER. Satellite derived RER may prove useful as a remote sensing technique of algal blooms as better atmospheric correction algorithms are developed.

Numerical Simulation of Hypoxia in Hood Canal, Washington, USA

Bohyun Bahng, Mitsuhiro Kawase, Jan Newton, Allan Devol, Wendi Ruef, University of Washington*

Circulation and biogeochemical variables in Hood Canal, Washington, were simulated, using Regional Ocean Modeling System (ROMS). The purpose was to hindcast the space-time variation of dissolved oxygen along with a nutrient-phytoplankton-zooplankton subsystem (NPZO), forced by river discharge, tide and salinity at the open boundary, solar radiation and wind at the surface of the Canal. Historical observation data were used to prepare seasonal climatology of the boundary and forcing conditions. The model was initially spun up for 270 days with the physical forcing conditions. Afterwards, the NPZO system was spun up for 125 days, and integrated further for 365 days. The simulation results compare well with observed data from ship cruises and moorings. The results indicate:

1. The surface outcropping of hypoxic water may occur at some locations, due to circulation change that is driven by a change in the salinity gradient and wind stress during the fall-to-winter season.
2. The magnitude of hypoxic condition at depth is likely controlled by three mechanisms: nitrification of organic nitrogen; sediment oxygen demand; open boundary condition, in the order of decreasing importance.
3. The onset of the yearly phytoplankton bloom occurs first around the flow entrainment regions, which may cause a DO-minimum layer at subsurface downstream, due to advection, sinking and re-mineralization.
4. The addition of riverine nutrients results in more oxygen demand at depth due to enhanced production and sinking near the surface.

Change in the Duwamish River Estuary: An Historic Perspective

Nicolas Arcos, University of Washington, College of Architecture and Urban Planning
Katrina Hoffman, University of Washington, School of Marine Affairs*
Scott Stolnack, University of Washington, School of Aquatic and Fishery Sciences

Landscape features and ecosystem processes in the Duwamish River estuary have been significantly altered by human activities that took place between the mid-19th century and the present. Transformations in the Duwamish estuary are explored using GIS, land use data, historic photographs, and inquiries into public policy. Patterns of change are investigated in space and time to discover correlations between public policy, economic development, and land use.

Design Considerations for a Participatory Decision Support Web Portal to Enhance Puget Sound Nearshore Improvement

Timothy Nyerges, University of Washington*

Protection and improvement of the Georgia Basin Puget Sound involve large numbers of organizations and community groups at multiple spatial and temporal scales - from international to local. Developments of web-based information systems have shown little progress to support broad-based analytic-deliberative decision processes as part of coalition building. However, recent information technology developments, particularly those involving geospatial web portals, are pointing in productive directions. A conceptual framework for characterizing four pervasive decision processes - strategic planning, improvement programming, project implementation, and emergency management - and their associated spatial and temporal scales provides a guideline for understanding the decision complexity that must be addressed. Examples of participatory geospatial web portal capabilities developed for regional transportation decision making (www.pgist.org) are presented to demonstrate analytic-deliberative decision support capabilities that could be useful to the Puget Sound nearshore improvement effort. Design considerations for redeveloping the web portal capabilities based upon the conclusions drawn from the conceptual framework for characterizing the four pervasive decision situations are presented and discussed.

Effects of Inverse Estuarine Circulation in Marginal Bays in Greater Puget Sound

Skip Albertson, Washington State Department of Ecology*
Jan Newton, UW Applied Physics Lab

Most estuaries have fresher water at the head and saltier water at the mouth, which drives a residual estuarine circulation. However, large expulsions of buoyant freshwater down the main longitudinal axis of a basin (e.g., Main, Whidbey, or Strait of Georgia) can effectively pinch off marginal embayments, inside which salinity and density remain higher than at the mouth. This inversion in the density gradient causes

the net tidally-averaged residual flow pattern to become inverse and increases the residence time of the bay. Factors leading to the creation of an inverse salinity gradient are the magnitude and timing of riverine input from unfrozen precipitation and warming that causes snowmelt. If the timing of a freshet coincides with the kinetic energy of a storm, instead of lagging after it, the flushing potential of the storm could be nullified by inversion. Could this be happening more frequently with global warming since mid-winter precipitation is not stored in the mountains as snowpack but instead released immediately as runoff? Examples are given from Hood Canal, Sequim Bay, Discovery Bay and elsewhere within the inland waters of Washington State. This effect could play a role in stimulating hypoxia or other water quality issues related to flushing.

Low Cost Data Collection and Management

Darcy Wildermuth, Kris Costello, WDFW*

In an era of decreasing budgets and staff, detailed data sets and management of those data are often the first effort to be sacrificed. Technological advancements, such as electronic measuring boards and data loggers are designed to alleviate these problems, but are costly, compounding budgetary issues. Washington Department of Fish and Wildlife has developed several systems designed to allow for the collection of large volumes of detailed data at relatively low cost. These systems are easy to operate, rugged enough to withstand the field environment and require only a small amount of lab time to manipulate into a standardized database. These systems include: 1) a lab system that electronically records length and weight using calipers and scale which maintains that information in an Excel spreadsheet for the cost of the calipers and scale; 2) a PDA based system for collecting a variety of field data maintained in Excel or Access for about $100, with an optional geocoding feature for an additional $250; and 3) an Intelligent Character Recognition (ICR) scanner based system that compiles hand written data into an Access database, for about $500. These systems decrease errors associated with data entry and total staff time without the increased cost and time loss of using professional data entry staff. In addition the ICR based system allows for the inclusion of data by non-staff members including the public. All of these systems are easily modified to fit most dataset.

Habitat Conservation Planning for Washington's State-Owned Aquatic Lands

David Palazzi, Carol Piening, Linda Wagoner, Carol Cloen, Washington State Dept. of Natural Resources*

The Washington State Department of Natural Resources (DNR)is completing an ecosystem-based multiple species Habitat Conservation Plan (HCP)for the state's aquatic lands under the Endangered Species Act. In support of the HCP, DNR has developed scientific information that characterized the potential impacts of its management activities on 108 species of plants and animals that use state-owned aquatic lands for breeding, foraging, and rearing and identified the location of certain habitats, species use of habitats, and interactions between aquatic habitat that occur on state-owned aquatic lands. This information along with a coarse synopsis of the location of DNR authorized activities and state aquatic land ownership was integrated into a potential effects model to estimate where and to what extent DNR's authorized activities are effecting birds, fish, marine mammals and amphibians and their associated habitat. The model guided DNR to propose 21 species and seven aquatic land use activities for coverage under the HCP. Specific conservation and stewardship actions will be developed and adopted to offset the impacts of DNR's authorized activities. DNR's HCP has been identified by the Governor's Puget Sound Partnership as one of seven "key immediate priority actions" for protecting existing habitat and preventing further habitat losses in Washington.

Poster Group 4: Ecosystem Indicators and Restoration

Dam and Culvert Removal in the PNW: American Rivers' Experience

Ross Freeman, American Rivers*

Our nation's rivers are plugged with 80,000+ dams over 6ft tall and many thousands of smaller structures. Many are old and obsolete, some are abandoned, others no longer serve their intended purpose. In the PNW, undersized or malfunctioning culverts are one of the most common fish passage barrier problems. American Rivers is deeply involved in river restoration and protection nationwide to benefit fish, wildlife and people; in the Northwest, we organize this work around salmon recovery. For 10 years we have promoted the benefits of dam removal, and many communities now employ the approach to restore healthy function, and implement fish passage, on their local rivers. Whereas large-scale dam removal can be contentious, highly complex, and even involve litigation, small removals typically generate minimal opposition and can be accomplished in months, not years. Since 2001, we have partnered with NOAA' s Community-based Restoration Program to remove dams, culverts, and obstructions in streams and rivers that block salmon, steelhead, alewife, American shad, and other migratory species. To date, we have awarded $2Million nationwide to help remove dozens of unwanted structures and complete feasibility studies on many more. In 2005, we extended the partnership to the PNW, providing funding, technical assistance, and permitting support. This presentation will explore several PNW case studies from the past two years, and address monitoring efforts and local stewardship.

Current and Historic Geomorphic Mapping of Central Puget Sound Marine Shores with Conservation and Restoration Recommendations

Jim Johannessen, Andrea MacLennan, Coastal Geologic Services*
Aundrea McBride, Skagit River Systems Cooperative

This study initiated by King County Department of Natural Resources and Parks as part of a larger salmon conservation planning effort. It focused on 120 lineal miles of the largely urbanized marine environment of King County and southern Snohomish County. Current geomorphic conditions were mapped in the field, followed by research into the historic condition of all currently modified shores. a. Comparison of current conditions with historic conditions mapping revealed that widespread and far reaching changes to coastal processes have occurred the nearshore in the study area. For example, historically, sediment source bluffs accounted for at least 50.3% of the study area, compared to 18.4% of the study area under current conditions. Following the completion of current and historic conditions mapping a study area wide prioritization of all potential restoration and conservation sites was performed at landscape and drift cell scales. These results can be used to characterize ecosystem processes (which is required for current shoreline master program updates), quantitatively prioritize restoration and conservation projects, and further understanding of the impacts that development has had on coastal geomorphic processes in this largely urbanized marine environment.

Long-Term Trends in Biotic Conditions Around the Iona Outfall in the Context of the Greater BC Coast

Brenda Burd, Ecostat Research Ltd*
Stan Bertold, Greater Vancouver Regional District

Following the revision of the Iona outfall monitoring program based on external consultant' s review in 1999, a detailed, extensive and consistent 7-year database of benthic infauna and related sediment physical, geochemical and contaminant information is available. Trends in biotic responses to the outfall, primarily based on organic enrichment, will be examined. Localized changes related to the outfall will be described, along with observed effects from external influences

unrelated to the outfall. The general benthic biotic condition of the Iona receiving environment region will then be placed in context with other areas within the Strait of Georgia, and the rest of BC, using an extensive coast-wide database for which common biotic thresholds have been assessed.

An Ecological Risk Assessment of POP Exposure and Toxicity in Free-Ranging Harbour Seals

Lizzy Mos, Marc Cameron, Hemmera*
Donna Cullon, Institute of Ocean Sciences
Ben Koop, University of Victoria
Peter Ross, Institute of Ocean Sciences

Marine mammals are exposed to elevated concentrations of persistent organic pollutants (POPs) that have been associated with reproductive failure, endocrine disruption and immunotoxicity. The complex mixtures in which these contaminants circulate the environment, and therefore expose wildlife species, often impede the evaluation of health risks. For this ecological risk assessment, free-ranging harbour seal (Phoca vitulina) pups (n=43) were sampled along a gradient of contaminant concentrations in the coastal waters of British Columbia, Canada and Washington State, USA, and evaluated as sentinels of marine mammal health. Prioritization of the POPs using hazard quotients indicated that polychlorinated biphenyls (PCBs) represented the largest toxicological risk. Estimated dietary intakes of PCBs by seals, and in nursing seal pups in particular, exceeded many regulatory guidelines for the protection of fish-eating wildlife, suggesting that these contaminants may adversely affect their health. A biomarker approach, documenting significant correlations between PCB concentrations and measures of immune and endocrine function further supported this notion. Based on a statistical approach integrating biomarker data, we derived a guideline for the protection of marine mammal health, including its nursing life stage with greatly increased exposure and high sensitivity to PCB-associated developmental effects. This novel reference value underscores the vulnerability of many marine mammal populations inhabiting contaminated coastal regions to increased incidence of disease and reduced reproduction.

Removing Creosote Wood Debris on Beaches in the Northwest Straits

Ginny Broadhurst, Northwest Straits Commission*
Lisa Kaufman, Washington Dept of Natural Resources

The Northwest Straits Commission (NWSC) and Washington Department of Natural Resources (DNR) are working to remove creosote and other treated wood debris from beaches throughout the Northwest Straits. Wood debris naturally occurs on beaches throughout the Northwest Straits region. A significant portion of this debris however, comes from derelict piers, docks and other structures and is heavily laden with creosote. Whether freshly washed up or buried in sand for decades, this wood leaches creosote continually. Creosote contains several hundred chemicals, many of which are known to be hazardous. Initial field surveys showed approximately 20-30% of accumulated wood debris at some sites was treated with creosote. Further surveys and removal operations have produced data on actual tonnage of creosote and other treated wood debris at levels above initial estimates. Maps are being produced that illustrate different accumulations at different sites. Since 2002, this partnership has removed over 600 tons of contaminated materials from shorelines in a highly cost effective manner. Surveys have utilized trained volunteers and collected data on GPS units. Removal operations employ work crews and either barges or helicopters to transport wood to disposal containers. DNR is also removing creosote pilings throughout Puget Sound in order to eliminate a major source of this problematic marine debris.

Managing Ecosystem Services for Puget Sound Restoration - Multi-resource Credit Trading and Stacking

Jan Cassin, Kevin Halsey, Kenna Halsey, Mark Vlahakis, Kevin Benck, Parametrix*

Puget Sound restoration faces significant challenges - increased competition for money, limited sites, consistent regional prioritization, and multiple sometimes conflicting restoration initiatives. Alternative mitigation strategies including mitigation banking, regional watershed mitigation, and natural resource offsets or trading have great potential for Puget Sound. The global success of environmental trading systems suggests the potential of market approaches, but to achieve ecosystem restoration, trading systems must accommodate multiple resources. We discuss innovative new tools for multi-resource banking, and associated policy challenges: "double-dipping" of credits,regulatory compliance, guaranteeing increased environmental benefits. We focus on the development of tools and databases for implementing mitigation of multiple resource impacts (salmon, water quality, storm water, wetlands) at regional banks in Puget Sound using an innovative accounting system based on an index of habitat integrity. This allows watershed-specific, systematic evaluation of: mitigation and restoration needs, existing functional condition, functional restoration needs, and where restoration will have the greatest benefit. These tools can support the development of private entrepreneurial banks and facilitate innovative public-private partnerships for conservation and restoration planning in Puget Sound.

Using Large Woody Debris to Restore Geomorphic Process and Floodplain Connectivity in a Regulated River System

Abigail Hook, Tulalip Tribes
Elizabeth Ablow, Seattle City Light*
Tim Abbe, Herrera Environmental Consultants
Scott Powell, Seattle City Light
David Chapin, Seattle Public Utilities

The presence of large woody debris in Pacific Northwest streams and rivers has been shown to create and maintain habitat processes through providing storage for gravels, promoting lateral recruitment of sediment and riparian wood, and providing instream structure and complexity. As a result of regulated flows and depressed riparian recruitment potential, current instream limiting factors for many species can be linked directly to a paucity of instream wood. We used engineered log jams (ELJ) and strategic placement of individual "key member" logs in a high energy gravel-bedded regulated river in western Washington to increase the frequency of gravel patches for salmonid spawning, activate historic channels used for juvenile rearing, and augment older natural jams with high levels of decay. This system had been altered by the interruption of sediment routing from the upstream dam as well as logging that resulted in the removal of instream wood and decreased recruitment potential. Wood placement focused on sites where ELJs could create sufficient hydraulic head to reconnect floodplain channels and where individual logs would remain stable and trap sediment and organic debris. Results after one water year indicate that 498 m and 298 m of lateral channel has been activated at each of the respective ELJ sites. In 2006, facies around each of the installations have been mapped in order to create a baseline for monitoring future gravel retention. This technique shows great restoration potential, particularly in dam regulated systems as it requires neither additional flow nor any costly gravel augmentation effort.

Milltown Island Levee Removal

Steve Hinton, Greg Hood, Jeff Parr, Mike Olis, Skagit River System Cooperative*

This presentation focus on the planning, implementation and monitoring of an estuarine restoration project involving the removal of a relic levee system using explosives. The project is located on Milltown Island , South fork of the Skagit River. Where over 30,000 lbs of explosives were used to demolish just under a mile of historic levee abandoned after 1976 flooding breached the levee system. Owned by the Washington Department of Fish & Wildlife the 375 acre island has been left follow but has shown limited progression toward natural estuarine marsh conditions. Relic levees and drainage channels are belived to

impeed hydraulic processes that should drive the development of tidal channel networks and native vegetation. The presentation highlights actions taken to restore hydrology and results from first year monitoring efforts.

Fornsby Creek Restoration Project: Self-Regulating Tidegates and Estuary Restoration

Todd Mitchell, Karen Mitchell, Rachel LovellFord, Sarah Akin, Swinomish Water Resources*
Steve Hinton, Skagit River System Cooperative

The Fornsby Creek Self-Regulating Tidegate (SRT) project is a fish passage and habitat restoration project located on the Swinomish Reservation along the Swinomish Channel of the Skagit River delta in Washington State. This project seeks to strike a balance with current and future agricultural land use by promoting hydraulic connectivity and exchange coupled with restoration plantings to stimulate riparian recovery. The political will to use tribal land and funds provided an excellent opportunity to test SRT' s in the Skagit Valley. Given the controversial nature of installing and using SRTs and possibly effecting adjacent agricultural production, this project has implemented a very robust water quality monitoring program to evaluate the effects, if any, to farmland and effectiveness of fish passage and riparian recovery. This project will reopen and allow access to more than five miles of channel to juvenile salmonids by replacing existing impassible tidegates with fish passable SRT' s. Restoration on 2 of the 5 miles of channelized ditches will increase water storage and exchange. Steady chloride concentrations in groundwater and surface water sampling sites have been reported since monitoring began in December 2003. Average maximum surface water levels have risen approximately 1 ft in elevation over the pre-project elevation since the installation of the barn door SRT.

Strategies for Developing a Fish Friendly Shoreline on Lake Washington

Ruth Howell, Gregg Casad, School of Marine Affairs, University of Washington*
Bryan Russo, Kelli Roberts, Material Science Engineering, UW
Dave Fries, Master Program in Arts and Policy, UW

Located within a major urban area, Lake Washington is the second largest natural lake in the state of Washington at approximately 21,500 acres. Ecologically, the lake serves an important role for several runs of salmon species, most notably the run of the endangered Chinook salmon on the Cedar River. However, as a highly urbanized lake with an estimated 82% of the >80-miles of shoreline hardened and an additional 2,500 docks and piers, the current shoreline conditions create a non-functional riparian habitat detrimental to migrating salmon populations and particularly rearing juvenile Chinook. In the fall of 2006, a team of University of Washington graduate students joined representatives from NOAA' s Sand Point facility to assess the social barriers to fish-friendly restoration projects along Lake Washington' s shoreline. The team created a spatial socio-economic characterization of Lake Washington, inventoried the regulatory framework governing shoreline restoration, and interviewed private property owners to assess potential barriers to conducting fish-friendly restoration. These interviews focused on identifying potential barriers such as regulatory and permitting obstacles, information asymmetry, perceived risks to property (including property value), and life-cycle costs of shoreline projects. This research serves as an initial step towards designing and implementing an outreach program intended to educate and encourage soft shoreline restoration in Lake Washington.

Developing a Strategic Framework to Guide Shoreline Enhancement and Restoration Along the Seattle-to-Everett Railroad Grade

Hugh Shipman, Washington Department of Ecology*

The railroad grade between Seattle and Everett represents a unique opportunity for nearshore restoration – within the limited constraints of railroad ownership and expanding operations. The railroad, built around 1900, modified the geomorphic landscape and continues to impact geomorphic processes. Railroad construction buried the upper beach, altered stream mouths and barrier estuaries, and reduced erosion of the coastal bluffs, removing the primary sediment source for this reach of shoreline. Discussions of nearshore restoration often involve suggestions of using beach nourishment seaward of the tracks to replace lost sediment supply and to restore upper beach functions. Isolated examples of such approaches already exist. We examine factors influencing sediment delivery and transport along the railroad, including historic erosion, longshore drift, shoreline configuration, and sediment size, and how they inform decisions about where and how to potentially place sediment in the future. We outline a conceptual framework for restoration planning along this reach of shoreline. Projects will continue to be brought forward by property owners, local communities, restoration organizations, and by the railroad itself. What is needed is a strategic, reach-scale framework for guiding and evaluating these proposals.

The Estuary and Salmon Restoration Program for Puget Sound

Randy Carman, Washington Department of Fish & Wildlife*
Doug Myers, Puget Sound Action Team

A total of $2.5 million was provided to the Washington Department of Fish and Wildlife (WDFW) in 2006 by the Washington State Legislature to fund shoreline restoration projects in Puget Sound. Established under the Estuary and Salmon Restoration Program (ESRP), this funding was part of Governor Christine Gregoire' s Puget Sound Initiative. The focus of this funding was to support local efforts to restore Puget Sound estuaries and preserve natural shorelines to benefit salmon. To determine best use of funds, select members of the Puget Sound Nearshore Partnership (PSNP) Implementation Team developed ranking criteria that adhere to guiding restoration principles developed under the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP). Award recommendations developed by the Implementation Team members were reviewed by select members of the PSNP Science Team and presented to the PSNP Steering and Executive Committees for approval. PSNP is a cooperative effort co-chaired by WDFW and the U.S. Army Corps of Engineers with a membership that includes seven federal agencies, tribes, local governments, state agencies and non-governmental organizations. Unique to this program is the acknowledgement that all the phases leading to ultimate on-the-ground restoration, such as feasibility studies, hydrodynamic modeling, and development of design alternatives, are necessary investments that improve the effectiveness of projects. In addition, several projects that received funds through ESRP were improved beyond their initial scope with incremental supplemental investments for development of monitoring plans or inclusion of education and outreach programs. Funds were used to match other local, state and federal funding to implement nine estuary and shoreline conservation and restoration projects with a total value of more than $20 million from Bellingham to Olympia. Projects awarded funding represented a broad spectrum of restoration activities including dike breaching, dike removal, and marsh restoration, as well as restoration design, feasibility studies, acquisition, and monitoring plan development. The range of activities funded through the ESRP provides an opportunity to complete several important restoration projects while advancing our knowledge of the Sound through strong monitoring plans that track project performance and will inform future decisions.

Urban Greenspaces: Mapping Protected Status and Indicators of Function to Identify Opportunities and Risk

Frank Leonetti, Craig Young, Laura Audette, Darla Boyer, Suzanne Brunzell, Snohomish County*

Urban greenspaces in North Creek, Snohomish County, WA including Native Growth Protection Areas (NGPAs), designated Open Space,

parks, conservation easements, and other pertinent land use codes, were identified and mapped using county-wide datasets in ArcGIS. Greenspaces located on unprotected private property were also mapped based on simple decision criteria. Data included the Snohomish County Assessor' s parcel layer, Planning and Development Services (PDS) Department plat database and shapefiles back to 1995, and the Snohomish County Auditor' s publicly recorded documents relating to plats, easements, and critical area site plans. Based on these data sources many greenspaces not encumbered in individual tracts were heads-up digitized. The final accumulation of protected parcels or boundaries was clipped in GIS for general comparison to unprotected parcels and North Creek as a whole. We documented 2036 greenspace parcels or boundaries totaling 4061 acres or approximately 22% of the watershed area. The average greenspace area was 2.8 acres. Based on these mapping outputs, we will highlight additional results related to mapping land cover in urban greenspaces as one indicator of functions and values present, evaluate corridor continuity or gaps in protection, and estimate future risk to mapped urban greenspaces. We will offer ideas for future management of urban greenspaces that support salmon recovery, NPDES and TMDL compliance and quality of life for a variety of end users.

Poster Group 5: Monitoring and Evaluation

An Evaluation of Shoreline Stabilization and Erosion Control Alternatives, Puget Sound, Washington

Wendy Gerstel, Applied Research - private company*
Jennifer Brown, JFB Environmental, LLC

Adverse impacts of shoreline armoring, exceeding 75% in some counties of Washington State' s Puget Sound, has lead to increased bulkhead permit application scrutiny by regulating agencies, and increased interest in alternative slope stabilization and beach restoration techniques. This study, investigating more than 17 sites around Puget Sound, is the first to systematically evaluate these alternatives. Alternative techniques included anchoring wood, importing beach sediment, restoring beach width and gradient, customized slope engineering, and planting vegetation. We investigated the geology, geomorphic processes, and vegetation at each site. We interviewed landowners and contractors on the permitting hurdles, design and construction complexities, and project objectives and performance. Landowners were generally pleased to have implemented alternatives, although many felt poorly informed on how and why to use them. Contractors believed they would benefit from better guidance on material resources and design specifications. Project installations were generally in good condition; however, where we noted inadequate site characterization we found potentially unnecessary shoreline modification. Observed slope instability at these sites might have been better mitigated, and at less cost, with improved upland groundwater and vegetation management. We recommend permits be conditioned with existing state and county guidelines addressing these issue.

Physical Beach Monitoring of Urbanized Puget Sound Beach Nourishment Sites

Jim Johannessen, Jonathan Waggoner, Coastal Geologic Services*

Soft shore protection through beach nourishment is of great interest in the Puget Sound area with coastal property managers and regulators. Beach nourishment projects have been installed as environmentally acceptable erosion control projects since the negative impacts of "hard" bulkheading have become more clear. Despite the gaining popularity of beach nourishment little physical monitoring data exists and ecological monitoring data is near non-existent. This poster summarizes the results of quantitative physical beach monitoring at five Puget Sound beach nourishment projects. Projects outlined include public beach parks, road protection, and beneficial re-use of dredge sediment, and are located from Seahurst Park in Burien, to Birch Bay Drive in Whatcom County, WA. These beach nourishment projects typically rebuilt the high-tide beach to protect property and homes. These projects have also benefited nearshore habitats through the introduction of littoral sediment, woody debris, revegetation, shade, and increased shoreline complexity. Physical monitoring results have documented relatively stability at some sites and the need for maintenance at other sites. Beach nourishment offers one approach for management of urbanized shores in the context of rising sea levels.

Performance of Benthic Cautions, Warnings and Triggers for the GVRD Marine Outfall Receiving Environments

Brenda Burd, Ecostat Research Ltd*
Albert van Roodselaar, Stan Bertold, Greater Vancouver Regional District

The submission of the extensive Cautions, Warnings and Triggers program for the GVRD outfalls in January of 2004 provided a framework for managing the outfall discharges to ensure that no adverse changes occurred in the receiving environment. However, this framework was based on monitoring data and research reports available to that point, with the understanding that it was an adaptive process, to be assessed and updated as new information became available. Since then, the monitoring programs for the marine outfalls have continued. An update on the performance of the cautions, warnings and triggers for detecting change in the receiving environments of the marine outfalls will be described. This will include a re-evaluation of indicators, levels, and how the indicators track the extent of known effects related to the outfalls, and any regional shifts unrelated to the outfalls.

High-Frequency Real-Time Water Quality Data Collection in Elliott Bay

Bob Kruger, Angela Grout, King County*

A Multiparameter sonde was installed along the eastern shore of Elliott Bay (Central Puget Sound) for a period of one year (November 27, 2005 to November 27, 2006) to measure real-time water quality. The sonde was interfaced with a Data Acquisition System which allowed for real-time data acquisition, storage and review via the internet. The parameters analyzed were temperature, conductivity, salinity, depth, dissolved oxygen, chlorophyll and turbidity. The data were reviewed weekly. Sondes were calibrated when required and physical water quality control samples were collected on an intermittent basis. The major goals of this project were to test the hardware and software of the system by evaluating the following: Ease of setup, robustness of the physical hardware (datalogger, solar panels, cabling and sonde in a marine environment), power management, calibration frequency requirements, and data management quality (telemetry system, web interface, database reliability). Aside from the major testing goals, the data collected allowed us to evaluate influences of the Duwamish River, seasonal water quality trends in Elliott Bay and helped the Seattle Aquarium with their water quality monitoring program.

Avian Response to Estuarine Restoration Via Dike Removal

Daniel Hull, Nisqually Reach Nature Center
Karen Myers, USFWS Biologist*

In 2003, the Nisqually Reach Nature Center began a citizen science bird monitoring program to investigate how avian populations would respond to estuarine restoration accomplished as part of a dike removal project. As part of a phased restoration process, the Nisqually Tribe has reconnected a total of 40 acres of former pastureland to Red Salmon Slough in the Nisqually River Delta since 2002, with an additional 100 acres reconnected in September of 2006. The bird monitoring survey data was collected by Nisqually Reach Nature Center volunteers, and spanned from July 2003 to August 2006. Over 16 individuals, many of them professional or amateur birders, collectively volunteered over 730 hours for this task, making consistent monthly visits to the site throughout the 2-year survey period. Over 97 species of birds have been observed to date using the restored estuarine habitat, including waterfowl,

shorebirds, raptors, and passerines.

A Discrete Simulation Model of the Impact on the Sustainable Level of Simon Fraser University Parking Service at Burnaby Campus

Tim Li, Simon Fraser University*

Simon Fraser University (SFU) Burnaby Mountain campus has been thought of running out of parking availability with constantly increasing commuter population growth and campus extension in near future. This report will address this issue with a discrete simulation model to maintain acceptable utility/level of SFU parking service at Burnaby campus in response to the increasing demand driven from campus commuter parking during the impact of campus construction in 20 years by implementing two management alternatives: First scenario increase in number of residents on campus, and secondly annual increase in size of permanent parking lot. The baseline model revealed that in 20 years the campus could achieve sustainable level of 25%. The entire model also illustrated that the level of parking service was somewhat sensitive to change in growth of resident population on campus as well as in stall population. The model overall indicated that to avoid hitting below the minimum level 25% of parking service in long run, increase in resident population will not ultimately help in terms of maintaining above the acceptable level. In other words, the result of the model suggests that someday after 20 years the parking service will drop below that level. Therefore, for the long term sustainability of parking service, the model with some degree of modifications could be operated with finding out more other alternatives.

A Vertical Geologic Strip Map and Landslide Inventory of the Tulalip Tribes Reservation Shoreline of Puget Sound, Tulalip, Washington

Todd Zackey, Tulalip Tribes*
Wendy Gerstel

This poster presents the methods and results of our attempt to map both the geology and location of landslides along the shoreline of the Tulalip Tribes Reservation in Washington State. Our objectives were to identify and characterize sediment input sources and processes along approximately 25km of coastal bluffs. Given the nature of the near-vertical bluffs, which commonly exceed 100 m in height, accurate mapping had to be carried out at large scales with detailed topography. We first used LiDAR data to generate profiles of the bluffs at exposed areas. We then used a GPS linked to a laser rangefinder to locate geologic contacts and landslides. The final product was a vertical "strip map" linked to landslide inventory data, photographs, geologic cross sections, and previously-interpreted well logs. This project was part of a larger, federally-funded project to inventory and assess nearshore marine habitat and water quality. The information is being used by tribal planners and regulators in the development of land-use and habitat management strategies on the reservation.

Modelling and Mapping Critical S and N Depostion Loads for Forest Soils in the Georgia Basin, BC

Paul Arp, Jae Ogilvie, Mark Castonguay, UNB*

This poster illustrates the approach taken to model and map critical S and N load (CL) and exceedances of forest soils within the Georgia Basin, based on an upland-wetland delineation at high resolution (10 m). This poster outlines the basic modeling steps, and shows the composition of the various datalayers use for synthesizing the critical load map, and likely exceedances incurred. Included is the process that allows for a sharp and systematic delineation of soils that are generally well drained from soils that are not. Critical N loads are much affected by soil drainage status: poorly drained soils tend to denitrify while adding dissolved organic nitrogen (DON) to stream water; upland soils on steep terrain tend not to denitrify, and may deliver DON to streams, but only during periods of surface run off. The approach is based on estimating nutrient supply and demand of the growing forest, in equivalents per hectare per year. This approach also deals with steady-state and dynamic CL assessments, with the latter used to ascertain base-cation depletion rates in response to actual and projected S and N emission and deposition targets.

Assessing Climate-Induced Threats on Alpine Biodiversity in Southwestern British Columbia: Establishing the First Canadian Sites of the Global Observation Research Initiative in Alpine Environments (GLORIA)

Kristina Swerhun, University of Victoria*

The aim of this project is to assess climate-induced threats on alpine biodiversity on southern Vancouver Island (Mount Arrowsmith Biosphere Reserve) and in the Whistler area (Garibaldi Park). The research methods used will include the Georgia Basin in an international project know as the Global Observation Research Initiative in Alpine environments (GLORIA). The GLORIA project was established in Europe to standardize alpine monitoring in order for it to be comparable around the world for the first time. By contributing to a strong global network of long-term alpine monitoring sites (designed to exist in perpetuity), this project helps develop a powerful tool for evaluating the implications of climate-induced threats on high-mountain ecosystems. Of the 47 active research sites globally, these are the first within Canada. The study in the Georgia Basin is part of a masters of science thesis and included compiling historical climate, geological and biodiversity data, establishing permanent study plots on four summits in each study area, creating baseline vascular plant inventories, documenting cover types, setting up photo monitoring, and also installing temperature loggers aiming to document micro-climates. Data analysis reveals what factors might be controlling biodiversity in these alpine areas and also give insight to the type of plant communities found.

Shoreline Impact from Residential Development on Vashon-Maury Island

Justin Boevers, Katrina Lassiter, Mary Ramirez, University of Washington*

Vashon-Maury Island (VMI) is an unincorporated rural community in central Puget Sound that is included in a shoreline change analysis conducted through the Puget Sound Nearshore Ecosystem Restoration Project. VMI contains almost 50% of King County's shoreline, with a lower population density and a slower population growth rate than the county averages. The residential development on VMI has remained mostly rural and is a defining characteristic of the island. Constraints such as water availability, difficulty of travel to and from the island, and a desire to retain a rural identity has limited growth. However, as ferry transportation enables more convenient commuting, technology allows for more telecommuting opportunities, and property values relative to neighboring Seattle are reasonable, this once somewhat isolated community is becoming more desirable and faces development issues that already exist among many other coastal communities. This analysis concludes that residential development is the primary driver of shoreline change on VMI. Furthermore, the size and shape of shoreline parcels, resembling a configuration of 'piano keys,' is correlated to the frequency of shoreline armoring. With an increasing demand to live on VMI, residential shoreline development and shoreline armoring should expand, resulting in increasing negative impacts on nearshore ecosystem processes.

Changes and Trends in Puget Sound Sediments: Results of the Puget Sound Assessment and Monitoring Program, 1989-2005

Valerie Partridge, Sandra Aasen, Margaret Dutch, Washington State Department of Ecology*

As part of the Puget Sound Assessment and Monitoring Program, the Washington State Department of Ecology sampled sediments at ten

fixed monitoring stations in Puget Sound each spring from 1989-2006 to assess sediment quality and characterize benthic macroinvertebrate communities. One goal of the program is to determine changes and trends in levels of chemical contaminants at 5-year intervals. Between 1989-1996 and 2000, human-driven changes in contaminants included decreases in metals concentrations and increases in polycyclic aromatic hydrocarbons (PAHs). Preliminary updates of condition and analyses of trends based on the 2005 sampling for chemical contaminants will be presented.

Washington State's Mooring-Based Marine Water Quality Monitoring Program

Brian Grantham, Stephanie Jaeger, WA State Dept of Ecology*

The Washington State Department of Ecology monitors marine water quality using monthly float plane-based sampling. However, although these data are useful for examining seasonal or longer trends, they cannot resolve high frequency fluctuations in parameters such as dissolved oxygen which can have important consequences for marine ecosystems. Recognizing the need for greater temporal resolution, Ecology began development of a mooring-based monitoring program in 1997 with the installation of four stations in Willapa Bay. Ecology currently has 2 efforts underway to develop and expand its mooring-based monitoring program - a NANOOS Pilot Project and an Ecology Urban Harbors Monitoring Project. The NANOOS Pilot brings together existing Oregon and Washington monitoring systems to develop the Pacific Northwest components of a national integrated ocean observing system (IOOS). The Urban Harbors Monitoring project is designed to demonstrate the feasibility and utility of providing real-time monitoring of water quality in Hood Canal and South Puget Sound locations experiencing, or at risk for, severe hypoxia. Both projects take advantage of the expertise and IT infrastructure provided by the Oregon Health and Sciences University (OHSU) monitoring network for the lower Columbia River. This poster describes progress on both these projects, as well as the current status and future plans for Ecology's complete mooring-based monitoring system.

Comparison of Marine Bird Population Estimates Using More Detailed Stratification, Applied to PSAMP Winter Aerial Surveys Conducted in Washington and British Columbia 1992-2006.

Joseph Evenson, David Nysewander, Washington State Department of Fish and Wildlife*
Glenn Ford, R.G.Ford Consulting Company
Bryan Murphie, Thomas Cyra, WA Dept of Fish & Wildlife
André Breault, Environment Canada (Canadian Wildlife Service)

Geo-referenced aerial surveys of marine birds are annually conducted in both the inner marine waters of Washington State and nearby portions of British Columbia. The output of these surveys is primarily expressed as marine bird densities. Survey data are currently stratified into two-depth zones (<=20 meters, and > 20 meters) using 1978-79 habitat polygons. While this method has worked well in estimating relative population density indices, the level of stratification has not worked well in estimating populations, and provides larger estimate of variance than desired because birds are associated with depth zones related to feeding strategies. The two- levels of stratification used do not represent actual distribution across depth zones that are encountered for most species. To rectify these problems so more accurate population estimates and variance could be estimated, we re-stratified the stratification used for Washington' s inner marine waters into habitat polygons based on six-depth zones (0-10m, 10-20m, 20-40m, 40-60m, 60-100m, and >100m). In addition, we split the 100m strip transect into two separate 50m strips and positioned them to be more reflective of each strips' depth location. A computer application was developed to calculate population and variance using the six-zone depth strata. We compare the previous method of calculating population indices with the newer method for selected species.

Status and Trends in Fecal Pollution in Shellfish Growing Areas of Puget Sound through 2005

Timothy Determan, Washington State Department of Health*

The Washington State Department of Health (DOH) uses a systematic random sampling strategy to monitor fecal coliform bacteria in shellfish growing areas in Washington's marine waters. Statistics (geometric means and ninetieth percentiles) are used to classify the growing areas to protect shellfish consumers. To support the Puget Sound Ambient Monitoring Program (PSAMP), the statistics were also used to determine status and trends within and among 97 shellfish growing areas in Puget Sound from 2001 through 2005. A "Fecal Pollution Index" (FPI) was used to rank the growing areas according to fecal pollution impact in 2005 and to track temporal trend in several growing areas from 1998 through 2005. The relationship of trends in selected shellfish growing areas with remedial activities in upland watersheds are addressed.

Survey of Breeding Pigeon Guillemots on Whidbey Island

Frances Wood, Whidbey Audubon Society*
Phyllis Kind, Island County Marine Resources Committee

This study documents the breeding colonies of Pigeon Guillemots (PIGUs) in the bluffs of Whidbey Island and records guillemot behavior to assess breeding success. Jointly supported by Whidbey Audubon, Washington Audubon and the Island County Marine Resources Committee, this citizen science project trained 30 volunteers who visited 23 active guillemot colonies at least six times during the breeding seasons of 2004, 2005 and 2006. The colonies varied in size from 15 to 134 birds. There were a total of over 900 PIGUs in the colonies during 2006 but only 150 active burrows, so roughly 1/3 of the birds attempted to breed this year. In late May and June the birds visited the burrows frequently and some were incubating eggs. By the end of June we began to see activities associated with young in the burrows; i.e., adults delivering fish to the burrows. Since the young fledge at night in late July and August and disperse beyond binocular range quickly after fledging, we saw very few juvenile birds from the shore in 2004 and 2005. In 2006 we surveyed by boat in August and September and observed 34 juvenile PIGIs. They were usually several hundred yards offshore at water depths of 40 to 100 feet.

Poster Group 6: Nearshore

San Juan County Soft Shore Restoration Blueprint

Jim Johannessen, Andrea MacLennan, Tina Whitman, Coastal Geologic Services*

The objective of this study was to prioritize beaches with documented or potential forage fish (surf smelt and sand lance) spawning habitat for bulkhead removal and soft shore protection in San Juan County, Washington. To reach this goal, the results of physical, biological and landowner willingness assessments were integrated into a GIS and analyzed to determine the best projects to seek funding for beach enhancement. A three-step process was employed to eliminate sites based on characteristics that influence the success and sustainability of a beach nourishment project. Initially a coarse filter eliminated sites based on existing qualitative data, followed by a secondary filter that utilized data collected during field visits. The final step in the prioritization applied a point system that weighed the quantity of spawning habitat to be enhanced with the likelihood of project success. Sites with the highest scores were of the highest priority for beach enhancement. Specific recommendations for beach restoration and enhancement were made for the top ranked sites. This study was conducted by Coastal Geologic Services and Friends of the San Juans, and funded by a grant from the Russell Family Foundation and the US Fish and Wildlife Service.

Classifying Agricultural Land in an Urban Landscape with Application to Waterfowl Conservation

Dan Buffett, Ducks Unlimited Canada*

Agricultural areas provide key habitats for migratory birds and mapping of these areas provide important information for agriculture and conservation planning. This project evaluates the technical considerations, human resource requirements and application of remote sensing of agricultural land within an urban agricultural landscape. The approach used a hierarchical tree classifier and an 84 layer dataset that consisted of 6 individual satellite bands and 4 image transforms for each of the four Landsat 7 image dates as well as 36 change vector transforms. Using a 2, 4 and 8 agricultural classification scheme the Tasseled Cap transform (TC) had significantly higher overall accuracies than other transforms. For the 8 class agricultural classification scheme, the TC transform had a higher accuracy (75.1% ± 1.6) than the normalized difference vegetation index (60.6 ± 1.8), second modified soil adjusted vegetation index (60.6 ± 1.8), or arctangent to the simple ratio (59.4 ± 1.8), and had comparable accuracy to the dataset using all 84 data layers (77.6 ± 1.5). The decision tree classification replaced the requirement of raster based classification software and reduced the financial cost of classification by 25%.

San Juan Archipelago Shoreline Protection Campaign: an Integrated Approach

Tina Whitman, Shannon Davis, Jim Slocomb, Stephanie Buffum Field, Friends of the San Juans*

With over 400 miles of marine shorelines, San Juan County provides significant feeding, breeding, refuge and migratory habitat for fish, seabirds, marine mammals and their prey. As development in San Juan County intensifies, sensitive nearshore ecosystems are increasingly at risk. Protection of nearshore marine habitat has been identified as the most important salmon recovery strategy for San Juan County. Friends of the San Juans utilizes a multi-pronged approach to improve the protection and restoration of critical nearshore marine habitat and aid ecosystem recovery efforts in the San Juan archipelago. Fundamental strategies of Friends' nearshore habitat programs include the interweaving of science and policy, public and private partnerships and regulatory and volunteer approaches. Methods and results of the following projects will be summarized: 1) Shoreline Permit Database Analysis, 2) County Nearshore Impact Assessment, 3) Soft Shore Restoration Blueprint, 4) Salmon Easements and 5) Eelgrass Restoration Assessment. Challenges and successes of the shoreline protection campaign' s integrated approach will be highlighted and provide insight for others working to ensure long term protection of nearshore marine habitat in Puget Sound

Nearshore Land Use Density Correlates with Reduced Probability of Herring Spawning

Raymond Watts, U.S. Geological Survey*
Vivian Queija, USGS

Over the past thirty years, the Puget Sound Basin has experienced intense urban growth that has resulted in the degradation of natural habitat for aquatic species. Because of increased toxic levels in Puget Sound and decreased riparian habitat, several salmon species are now listed as endangered and the resident orca population as threatened. Integral to the diets of both salmon and orcas are several forage fish species, such as herring, that spawn in the nearshore zone of Puget Sound. Although upland areas, rivers and streams, and their riparian areas have been investigated for mitigation efforts and restoration projects, greater understanding of the nearshore environment and processes are needed to connect terrestrial and aquatic mitigation efforts. This paper describes an initial effort in a long-range interdisciplinary study by the U.S. Geological Survey and its partners to explore the effects of urbanization on nearshore processes and ecosystems. We examine land use patterns along the near shore of an embayment of Puget Sound to determine anthropogenic indicators of stresses to forage fish spawning. We use a spatial analysis of parcel counts along the shoreline to show that increased urban density near the shore is positively correlated with reduced probability of herring spawning. Scientists in the USGS Coastal Habitats in Puget Sound (CHIPS) Project use results from this analysis of associations between urban and ecological status, and other similar analyses, to focus process-based investigations of causes and effects.

Oil Spill Extent and Impacts Along the South Coast of Vancouver Island: A Simulation Approach

Sean Hollands, Costa Maycira, University of Victoria*
Lyle Fairley, Canadian Forces Base - Esquimalt

Oil spills around the British Columbia coast are regular occurrences despite all precautions and rules in effect. These oil spills have dramatic detrimental effects on the aquatic and ashore environment. Therefore there is a need for the development of scientifically based procedures to minimize oil impacts on the environment. To do so, it is vital to be able to simulate the spatial and temporal dispersion of oil at the time of the crisis and estimate the trajectory of the oil to allow interception before the spill hits the shoreline. This early interception will significantly decrease the incidental damage, clean up cost, and public relation issues. In this light, the goal of this project is to describe a potential system for forecasting oil spill trajectories and possible impacts on the British Columbia coastal zone. Specifically, we performed simulations of oil spills with magnitudes of 3500 tons and 7000 tons of oil, at four different locations around Vancouver Island. The simulations were performed with the oil spill trajectory software, Crisis Management System Map (CMSMAP). Given certain conditions of the environment and oil viscosity, the results show no significant difference on the area of shoreline habitat impacted by the different amount of oil in the water. This is because of the strong currents, tide effects, and wind conditions of our coast. These results have great implications for the need of defining fast interception of oil spills even at reduced amount.

Thatcher Bay Nearshore Restoration Design: Developing a Methodology

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Joel Elliott, University of Puget Sound
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Bob Warinner, WDFW

The Puget Sound Georgia basin has a history rich in the harvest and processing of timber resources. The legacy of this history is the common occurrence of wood waste in marine environments. Thatcher Bay, located on Blakely Island in the San Juan Islands, is one such impacted area. In researching potential restoration alternatives for the site it became clear that little work has been done in developing methodologies for restoring sites contaminated by wood waste. The Thatcher Bay plan is an interdisciplinary approach to restoration. It incorporates local history and contemporary field data into the science which develops an appropriate restoration strategy for the Bay. This approach takes into account the historical and current conditions of the impacted area to determine a restoration plan. Our objective is to develop an assessment methodology for Thatcher Bay leading to a restoration plan that can be used as a template for similar restoration efforts throughout the Puget Sound Georgia basin region.

Changes in Pacific Herring (*Clupea pallasii*) Spawning Ground Use by the Cherry Point, Washington Stock, 1973-2006.

Kurt Stick, Adam Lindquist, WDFW*

The Cherry Point, Washington herring stock has experienced a dramatic decline in abundance since quantitative sampling began in 1973. Once the largest in Washington state waters, the Cherry Point stock decreased from a high of 15,000 tons in 1973 to a low of 800 tons in 2000, followed by a gradual annual increase to 2,200 tons in 2006. With the decrease in abundance, a greater proportion of spawning activity has occurred in the Cherry Point sub-area (between south Birch Bay and Sandy Point) of the stock' s documented spawning grounds. This section of shoreline has been the subject of plans for increased industrial development as a deepwater port facility. These plans prompted these analyses to quantify observed changes in spawning ground use by the Cherry Point herring stock. Analyses made use of the database of herring spawn deposition survey data collected since 1973. Spawn deposition and estimated spawning escapement results were stratified into 500 meter sections of shoreline of the Cherry Point stock' s spawning grounds. These data were then mapped. Both general and specific changes of spawning ground use over time are easily identified by this technique.

Monitoring Shoreline Habitat Restoration Sites for Forage Fish Use in Sinclair & Dyes Inlet, Washington

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Richard Bazzell, Tyson Livesey, Jon Pavy, Ty Snyder, Western Washington University
Chris Waldbillig, Washington Department of Fish and Wildlife

An important function of the upper beach in many locations in Puget Sound is spawning substrate for two species of forage fish, surf smelt (Hypomesus pretiosus) and Pacific sand lance (Ammodytes hexapterus). Many of the former high intertidal areas of Sinclair and Dyes Inlets have been lost due to filling and armoring. Yet, forage fish spawning sites persist in nearly all pockets of beach with intact upper beach profiles. Restoration of nearshore habitats suitable for forage fish spawning is proposed in many locations in Puget Sound. Monitoring and documentation of existing sites is useful to promote successful strategies and avoid potential problems in habitat restoration design. Urbanized settings pose particular challenges, in that beach forming processes are often compromised. We monitored forage fish use and physical parameters associated with two beach restoration sites built in 2000 and 2002 (Jackson Park, Charleston Beach) and a nearby natural site (Ross Point). Beach profiles steepened in the upper beach, most noticeably at one section of Charleston Beach which lost nearly all of the supplemental beach material. Forage fish spawning density, mortality and frequency varied by location, with greatest mortality at the restoration sites even when densities were similar. Lessons learned through monitoring existing restoration sites will help guide future restoration project design.

Protection, Restoration and Enhancement of Aquatic Lands: Washington Department of Natural Resources Aquatic Reserves Program

Kyle Murphy, David Palazzi, Washington Department of Natural Resources*

The Aquatic Reserves Program is part of the Washington Department of Naturals Resource' s (DNR) efforts to protect important environmental resources on state-owned aquatic lands through preservation, restoration, and enhancement. Aquatic Reserves protect sensitive habitats for a wide range of aquatic organisms. The objective of the program is to protect and support these aquatic systems and their functions above other uses. There are currently two established Aquatic Reserves in Puget Sound, and two additional sites have been recommended for Reserve status by the Commissioner of Public Lands and are in various stages of the review and establishment. The Aquatic Reserve Program provides research opportunities for scientists interested in studying the Puget Sound ecosystem. Areas of research needs include natural resource inventories, water quality impacts and mitigation, habitat restoration and enhancement. At the Puget Sound Research Conference, DNR will be soliciting applications for Aquatic Reserves for 2007/2008. DNR will be looking for applications that capture sites that exhibit high ecological quality and can enhance management of aquatic resources. Applications should be for aquatic lands of special educational or scientific interest, or special environmental importance. Applicants are encouraged to consult Priority Marine Sites for Conservation in Puget Sound developed by DNR, and similar documents that identify high quality habitats and ecosystems for potential protection, conservation and restoration.

Temperature and Shading Effects on Surf Smelt , Hypomesus Pretiosus, Egg Survival

Linda Rossell, Cedar Crest College, PA*
Paul Dinnel, Western Washington University

Much of the vegetative shading on Puget Sound surf smelt (Hypomesus pretiosus) spawning beaches has been lost to shoreline development. As a result, sand-gravel beaches experience higher summer substrate temperatures and light intensity. Field and laboratory experiments were used to determine if shade and temperature have an effect on surf smelt egg survival. Eggs were incubated at various temperatures in the laboratory for eight hours to determine their temperature tolerance. A field experiment used two shaded (screen mesh and opaque plastic) and unshaded treatments to determine how shading and temperature affects egg survivorship. A parallel laboratory tank experiment was set up to compare shaded and unshaded egg survivorship under controlled laboratory conditions. Our results showed that there is a strong relationship between shade and temperature and the survival of summer-spawned surf smelt eggs. Egg survival was significantly reduced following 8-hour laboratory exposures to temperatures over 20 ∫C and was virtually zero at temperatures over 30 ∫C. In an 8-day field experiment, egg survival was good in the shaded treatment, but zero in the shaded and partially shaded treatments. Sediment temperatures reached 40, 35 and 30 ∫C in the unshaded, partially shaded and full shade treatments, respectively. Egg survival in the 8-day laboratory exposure tanks was uniformly low due to design flows that allowed temperatures to exceed 30 ∫C in both the shaded and unshaded treatments.

Making the Link: Visualizing Nearshore Habitat Needs from Juvenile Salmon Diet Studies

Michelle Licari, Western Washington University*

Making the Link: Visualizing Nearshore Habitat Needs from Juvenile Salmon Diet Studies Utilization of nearshore environments by juvenile Chinook salmon (*Oncorhynchus tshawytscha*) was the focus of an in-depth study conducted by the Washington Department of Fish and Wildlife in 2001 and 2002. It was found that juvenile salmonids occupying Puget Sound shorelines enjoy a diverse diet, including prey from terrestrial sources, water column, and substrate. Shoreline and nearshore areas are additionally used as refuge and migration corridors. The need to protect foraging habitat of this Puget Sound species, listed as Threatened under the Endangered Species Act, and the challenge of conveying this information to the layperson is the foundation of this presentation. To demonstrate diet diversity of juvenile fish to a variety of audiences we offer a prototype display unit using individual samples to illustrate temporal and spatial models of forage usage in nearshore habitats during this critical life-stage. Bridging gaps in comprehension and understanding complex scientific studies and results is of concern when trying to make clear the importance of protection of nearshore habitat. It is our intent to expand this prototype model to further the viewer' s understanding of prey habitats, life histories, ecological structure and function, thus making the link to

broaden the scope of "nearshore" environments.

Resource Protection in the Olympic Coast National Marine Sanctuary: A Pilot Project to Address Derelict Fishing Gear

Katrina Hoffman, University of Washington, School of Marine Affairs*

In 2004, the Olympic Coast National Marine Sanctuary (OCNMS) successfully applied for funding from NOAA' s Office of Response and Restoration to initiate a derelict fishing gear pilot project in locations of geographic importance to the Sanctuary. The project was initiated to assess the scope of the problem, adapt derelict gear techniques used elsewhere, and train divers to perform removal operations. Scope of the problem and success of the pilot will be evaluated to determine whether derelict gear removal should be a programmatic focus of the Sanctuary. Diver surveys and side scan sonar were used to locate derelict gear. Maps indicate the location of nets and crab pots removed through this effort. Biological specimens entangled in recovered nets and pots were identified and quantified and results are presented in this poster.

Poster Group 7: Seagrass & Other Aquatic Vegetation

Assessment of Eelgrass (*Zostera marina*) loss in the San Juan Archipelago

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Sandy Wyllie-Echeverria, University of Washington
Eric Grossman, Renee Takesue, United States Geological Survey
Tom Mumford, Helen Berry, WA Department of Natural Resources
Maggie Dutch, WA Department of Ecology
Jan Newton, University of Washington
Victoria Wyllie-Echeverria, Friday Harbor Labs, University of Victoria
Anne Boettcher, University of South Alabama
Jim Slocomb, Friends of the San Juans
Ginger Tennant, University of Washington

We can now verify that between 1995 and 2003/04 more than 30 ha of the seagrass *Zostera marina* (eelgrass) disappeared within small embayments in the San Juan Archipelago. A program to assess putative causes of this loss began in 2004; however, because no obvious cause(s) was identified we initiated an interdisciplinary program to investigate several possibilities. Our effort involves collaboration of scientists from state and federal agencies, universities and NGO's. The first phase included development of an appropriate sampling design, selection of field sites and evaluation of suitable assessment techniques. At a variety of embayment and open water sites we initiated a survey program to (1) assess environmental variability that includes water column properties (temperature, salinity, turbidity, chlorophyll concentration, dissolved oxygen, submarine PAR) and sedimentation rates, sediment grain size, redox and sedimentary contaminants and (2) monitor changes in *Z. marina* shoot density, flowering occurrence, internode spacing and disease presence. In addition, we are reviewing Puget Sound Assessment and Monitoring Program archives such as long-term sediment monitoring, submerged aquatic vegetation monitoring, and water quality measurements. We describe the geographic distribution of our research sites, summarize assessment results and discuss implications of this work to guide eelgrass restoration and protection planning.

Community Eelgrass Restoration in British Columbia

Cynthia Durance, Precision Identification*
Nikki Wright, SeaChange Marine Conservation Society

The successful eelgrass (*Zostera marina*) transplant projects that were completed in British Columbia prior to 2000 were in response to development pressure and to ensure No Net Loss of these critical habitats. SeaChange Marine Conservation Society contacted Precision Identification Biological Consultants in 1998 for assistance restoring eelgrass in a site heavily impacted by a cement factory on the Saanich Peninsula. Since then this restoration team has developed tools to assist communities in selecting sites for transplanting and provided training and guidance to communities throughout British Columbia to enable re-establishment of historic beds. In addition to creating valuable habitat, the transplants have fostered respect for eelgrass amongst volunteers from five to eighty-five years of age. The tools and methods are described, and several of the community transplant projects are profiled with lessons that we have learned along the way.

Mapping Eelgrass Distribution Using Hyperspectral Imagery, Gulf Islands National Park Reserve, British Columbia

Jennifer O'Neill, Maycira Costa, University of Victoria*
Tara Sharma, Parks Canada
Nicholas Komick, Waterloo Pereira Filho, University of Victoria

Eelgrass, an important component of inter- and sub-tidal ecosystems, has exhibited worldwide community decline in hypothesized response to light attenuation imposed by eutrophication and sedimentation. Therefore, to assess coastal ecosystem status, there is a growing need to cost and time-effectively monitor eelgrass and associated substrata. This study seeks to remotely map eelgrass distribution around Sidney Island, BC. Using remote and in situ data, two objectives were explored. The first was to determine the optimal combination of spectral and spatial resolution for accurately resolving bed location and size. The second was to determine a water depth range within which eelgrass spectral signatures could be sufficiently distinguished from surrounding water and substrata. Two-metre resolution hyperspectral imagery was acquired over Sidney Island with airborne sensor AISA. Concurrently, in situ above-water hyperspectral remote sensing reflectance, underwater videography, and water samples for optical constituent analysis were collected. Various spatial and spectral resolutions were simulated from the dataset, and the mapping accuracy of each product was determined using a spectral mixture analysis of eelgrass and other substrates. The desired product is a resolution and tidal range combination offering the most accurate and cost-beneficial eelgrass location map, and will result in recommendations for remote ecosystem integrity monitoring and park management.

CIR Aerial Photomapping of Intertidal Eelgrass in PNW Estuaries

David Young, Patrick Clinton, David Specht, Henry Lee II, U.S. Environmental Protection Agency*

The objective of this study was to develop and test a rapid, cost-effective method of mapping the intertidal (and surface-visible subtidal) distribution of eelgrass (*Zostera marina* L.) meadows and patches in the turbid coastal estuaries of the Pacific Northwest (PNW). Initial comparisons between true color and false-color near-infrared (color infrared, CIR) film indicated the clear advantage of CIR film in aerial photomapping surveys of this region. The photosurveys must be conducted in clear (or uniform high overcast) weather during daylight low tides, when substantial portions of eelgrass distributions in coastal estuaries are tidally exposed. The most reliable surveys are obtained in late spring before the summer blooms of benthic macroalgae that can interfere with accurate classification of intertidal eelgrass and bare substrate habitats. The technique reported here incorporates a hybrid approach toward digital classification of CIR photomap images, with a minimum mapping unit of 2.5 m x 2.5 m. Comparison of results with those from ground surveys in four Oregon estuaries yielded overall accuracies ranging from 83 to 100 percent. Best results were obtained when training surveys included GPS ground mapping of the upper margin of selected eelgrass meadows. Application of this technique should assist in the delineation and assessment of intertidal eelgrass distributions in the PNW, and factors that may stress this important estuarine habitat.

Eelgrass decline and (delta)15N ratios in the Hood Canal

Elizabeth Wheat, University of Washington*
Peter Dowty, Washington State Department of Natural Resources
Jennifer Ruesink, University of Washington

Seasonal hypoxia causes localized "dead zones", closures of major fisheries, and large scale fish kills. It is a problem of growing national and international concern. Hypoxia can be driven by many factors or combinations of factors including long residence time, changes in oceanic conditions, deforestation, or eutrophication from anthropogenic nutrient sources. Increasing nitrogen levels have been shown to initiate seasonal hypoxia in many estuaries and may thus ultimately be responsible for fish-kills and eelgrass decline documented in the Hood Canal, Washington. Stable isotope ratios, particularly for carbon and nitrogen, can be used to distinguish between marine, terrestrial, and anthropogenic nitrogen sources. This study uses a paired sample design to examine spatiotemporal variation in stable isotope ratios (particularly δ15N) at sites of eelgrass decline and stability in the Hood Canal. Nitrogen is of central concern because eutrophication can cause shifts in primary producers and concomitant changes in the structure of estuarine food webs. This study analyses oyster, eelgrass, POM, and green algal tissues to assess the source of nitrogen entering Hood Canal food webs. Additionally pore water samples were gathered to assess inter-site variation in nitrogen concentrations. These data will help us understand if differences between sites in eelgrass growth rates, density, and reproductive effort are driven by nitrogen source and availability.

Estimating Sufficient Sample Sizes to Detect Changes in Eelgrass Density

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Sandy Wyllie-Echeverria, Friday Harbor Laboratories and UW Botanic Gardens
Tina Wyllie-Echeverria, Wyllie-Echeverria and Associates
Kurt Fresh, NOAA Fisheries
Brian Williams, Washington Department of Fish and Wildlife

Eelgrass (*Zostera marina*) provides important ecological services in the nearshore, has been designated as critical habitat, and is protected by a no-net-loss policy in Washington State. When projects are proposed that may impact eelgrass, such as installing docks or underwater cables, the state of Washington may require surveys to monitor changes in eelgrass density. The guidelines for surveys required by the Washington Department of Fish and Wildlife are sufficiently general to allow rigorous monitoring. However, specific guidance describing sufficient sample sizes and analytical methods has not yet been developed. We use data from a previous study to estimate the number of samples required to reliably detect a range of declines in shoot density using a before-after-control-impact (BACI) survey design. Sufficient sample sizes vary with choice of critical value and statistical power, but are most affected by the magnitude of density decline that we wish to detect. Our approach demonstrates the necessity of developing sampling designs specific to each study to ensure results that meet the legal requirements of resource management. Our results have implications for most monitoring project.

SeagrassNet: A Worldwide Seagrass Monitoring Program

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Miguel Fortes, Marine Science Institute, University of the Philippines
Evamaria Koch, Horn Point Laboratory, University of Maryland Center for Environmental Studies

SeagrassNet, a global seagrass monitoring program, is now established in 20 countries with 52 monitoring sites around the world. Standardized protocols for scientific monitoring have been developed and are successfully implemented by trained teams of in-country scientists and managers. Quarterly fixed-transect sampling is carried out at all sites for seagrass species composition, cover, density, biomass, canopy height, and depth distribution, as well as temperature, salinity, light and sediment type. A monitoring team at each site sends data via the internet to an online database and archive at www.SeagrassNet.org. Initial results from the tropical Pacific include new findings on species distributions, seasonal changes in species cover, and evidence of species succession. SeagrassNet sites as close to the Equator as the Philippines (13∞N), Malaysia (8∞N), Brazil (8∞S) and Micronesia (5∞N) show seasonality in biomass and percent cover. Across the Americas, SeagrassNet is documenting new species distributions (in Belize) but, disturbingly, also documenting widespread seagrass declines. Now in year 6, the program is yielding a data stream that affirms dynamic change in seagrass habitat. Long term and large scale assessment of seagrass resources elevates the visibility of this important coastal habitat and provides a barometer of direct anthropogenic and global climate change impacts.

A Spatial Model of the Effects of Sea Level Rise on Eelgrass Habitat in Padilla Bay, WA

Peter Kairis, John Rybczyk, Western Washington University*

Subsidence, eustatic sea level rise (ESLR), and accretion control the elevation of the estuarine sediment surface relative to sea level. Predicted increases in the rate of ESLR threaten the sustainability of estuarine systems and would impact both the plant communities and the organisms for which they provide habitat. Subsidence and ESLR must be balanced by accretion if relative elevation is to be maintained. Padilla Bay, Washington, is home to one of the largest eelgrass meadows in the Pacific Northwest. The volume of sediment delivered to the bay is significantly less than historical levels, potentially making the eelgrass at risk to submergence by ESLR. We used sediment elevation tables and Pb-210 dating of sediment cores to determine rates of accretion and shallow subsidence in Padilla Bay. These data, in conjunction with eelgrass productivity and decomposition data, are being used to initialize, calibrate and run a spatial relative elevation computer model for the bay. The model uses a sediment cohort approach to calculate changes in sediment elevation over time. Using a GIS bathymetry grid as input, the model will be run to project changes in surface elevations and eelgrass standing crop across Padilla Bay as a function of sea level rise.

Poster Group 8: Partnerships, Outreach, and Governance Approaches

The BC Coastal Environment 2006 Project

Linda Gilkeson, Lynne Banner, British Columbia Ministry of Environment*

In 2004, representatives from two federal ministries, two provincial ministries and two universities began working on a report on the state of British Columbia' s coastal environment. At the outset of the project, the list of desired indicators was developed through extensive consultation with scientific experts as well as representatives of target audiences. The final report was comprised of six technical papers: Population and Economic Activity, Climate Change, Industrial Contaminants, Ecosystem Protection, Biodiversity, and Fisheries. Each paper provides an overview of the issues and a set of indicators, including data and methods of analysis (including caveats and assumptions). The papers also describe what is currently being done to address the issues as well as what individuals can do. Other project deliverables include a web site, which presents summarized results as well as the full text of papers and data at www.eng.gov.bc.ca/soe/bcce/. A striking poster-brochure was produced as a means of interesting the public in going to the web site to learn more about the issues. Posters and CDs containing the complete reports and data sets were sent to BC schools and public libraries. To guide future collaborative projects, a report documenting data gaps and others issues was also produced.

BC School Bus Emissions Reduction Project

Bahareh Taghiani Rizi, Leigh Greenius, Environment Canada*

Environment Canada, in partnership with various BC School Districts, supported the reduction of diesel emissions through three phases of the BC School Bus Emissions Reduction Project. The objective of the project was to improve local air quality in and around school buses, which would reduce the impact of diesel emissions, including particulate matter (PM), on children' s health. We intend to present a poster summarizing the project. Twenty-nine School Districts and one private school participated in the BC School Bus Emissions Reduction Project, which was completed in March 2006. Over 550 mechanical retrofit devices were installed consisting of diesel oxidation catalysts (DOC) and crankcase emission reduction systems (CER). The last phase of the project also consisted of an on-going idle reduction campaign with the School Districts that included the distribution of over 1500 anti-idling signs.

The Strait of Georgia Ambient Monitoring Program: Results of a Multi-partner Collaborative Investigation

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Sophia C. Johannessen, Robie W. Macdonald, Fisheries and Oceans Canada, Institute of Ocean Sciences
Brenda Burd, Ecostat Ltd.
Stan Bertold, Albert Van Roodselaar, Greater Vancouver Regional District
Philip R. Hill, Natural Resources Canada, Pacific Geoscience Centre

Since 2003, scientists from Fisheries & Oceans Canada and Natural Resources Canada have collaborated with the Greater Vancouver Regional District in an ambient monitoring program designed to investigate environmental conditions in the Strait of Georgia. The program has encompassed studies of sediment accumulation rates, contaminant distribution, biology and tidal/current conditions that contribute to particle dynamics. Seven sediment cores have been analyzed for Pb-210 and Ra-226 (for sediment accumulation calculations), metals, PCBs, PAHs, PBDEs, AVS, nonylphenols, organic carbon, nitrogen and stable isotopes of carbon and nitrogen. In the summer of 2004, moorings containing ADCPs and sediment traps were placed in the study area to investigate current dynamics and particle flux to the sediments. This poster illustrates our approach and protocols, and highlights the success of the collaborative approach. Results of the carbon, nitrogen, contaminant and isotopic measurements are shown. Biological interactions and metadata are also presented. The results will be used to provide a context for the influence of the Iona Island sewage outfall on a variety of physical, chemical and biological parameters in the southern Strait of Georgia.

HCDOP Citizens' Monitoring Program: Integrating a Volunteer Monitoring Effort with the Needs of a Partnership-Based Research Program

Renee Rose, Dan Hannafious, Hood Canal Salmon Enhancement Group*
Jan Newton, University of Washington
Lalena Amiotte, Skokomish Natural Resources
Mark Warner, University of Washington

The condition and factors influencing the water quality and biota of Hood Canal is currently under increased scrutiny by researchers, politicians, and citizens. The multi-stakeholder Hood Canal Dissolved Oxygen Program (HCDOP) was implemented in March 2005 to determine the sources, processes and impacts of low dissolved oxygen (DO) events in Hood Canal. Prior to the HCDOP program becoming fully established, there became a need to supplement existing marine data in order to provide a more comprehensive assessment of the seasonal and annual fluxes of the low DO processes. In August 2003, a citizen monitoring effort was initiated and has become an important element of the larger science plan. In the summer of 2004, the sampling routine was integrated with the Skokomish Tribe Natural Resource Department. More recently, a monthly sampling routine was added for locations used to calculate an inventory value which compares the current DO trend to historical data. The Hood Canal Salmon Enhancement Group (HCSEG) continues to coordinate the weekly collection of oxygen samples and CTD casts in seven transects within Hood Canal. Engaging local citizens and aiding in their understanding of these local issues, begins to make connections between watershed health and their individual role as long-term stewards to the watershed.

Shoreline Master Programs and Marine Resource Committees: Opportunities for Partnerships and Collaboration

Gabrielle LaRoche, Judy Surber, Jefferson County Marine Resource Committee*

Shoreline Master Programs (SMP) and Marine Resource Committees (MRC) are natural partners for protecting nearshore resources. As the local government arm of a state-wide program, SMPs contribute a planning framework and regulatory tools. As the local government arm of the Northwest Straits Initiative, the MRCs bring experience with restoration projects and voluntary approaches. The study compares goals and benchmarks of the two programs and explores opportunities for partnerships in shoreline planning and implementation. Examples of how the SMPs and the MRCs compliment each others strengths and weaknesses are given. SMPs are particularly adept at developing long range plans, while the MRCs have funding and non-regulatory tools necessary to effectively work toward "no net loss" and nearshore restoration. The authors share their recent experiences with updates to the City of Port Townsend SMP and the Jefferson County SMP and their work with the Jefferson County MRC. Conclusions will be directly applicable to the six other counties of northern Puget Sound that are part of the Northwest Straits Initiative and will suggest a model for governance for southern Puget Sound and Georgia Basin.

The Harmful Algal Bloom Rapid Response Network

Amy Glaub Sprenger, Fritz Stahr, Christian Sarason, Ocean Inquiry Project*

Ocean Inquiry Project, a marine science education non-profit, is coordinating the creation of a HAB rapid response network, a proposed collaborative effort between citizens and scientists that will have the capacity to gather data on harmful algal blooms (HAB) as they are progressing in Puget Sound. The network aims to have an organized group of volunteers and scientists able to quickly mobilize and get on the water to monitor a harmful algal bloom as soon as it is detected. Using a fast moving boat provided by Seattle Maritime Academy, scientists and volunteers will be able to sample a large spatial area in a short amount of time through an evolving bloom. The HAB rapid response network sampling scheme will complement current HAB research sampling schemes and provide data at new spatial and temporal scales.

Puget Sound Main Basin Stratification, a Time-Series Comparison

Fritz Stahr, Ocean Inquiry Project*
Mitsuhiro Kawase, University of Washington
Christian Sarason, Amy Sprenger, Ocean Inquiry Project

As a partner in the Puget Sound Marine Environment Modeling group, Ocean Inquiry Project (OIP), a marine science education non-profit, collects time-series data for model comparison and other research. One location in Puget Sound main basin (PRISM-28) is sampled on almost every OIP cruise, as well as during June and December cruises of the PRISM program. This study compares the measured stratification during 2004 to the Puget Sound numerical model output for the same year. Further, trends in deep water temperature and salinity for that station will be examined over the past 6 years to show interannual trends.

Community Based Restoration Projects in Squamish A Case Study

Edith Tobe, Squamish River Watershed Society*
Matt Foy, Fisheries and Oceans Canada
Francesca Knight, District of Squamish
Randall Lewis, Squamish Nation

For over a decade the town of Squamish has discussed reopening a portion of waterway that was dyked back in 1921 to reconnect an important salmon spawning channel from the Mamquam River through to the Mamquam Blind Channel. In 2005 approval and funding were received to initiate this project with support from the District of Squamish, Fisheries and Oceans Canada, Squamish First Nation, Ministry of Environment and numerous community groups spearheaded by the Squamish River Watershed Society. This poster presentation highlights the processes involved and the spectacular outcomes that can be achieved. Only one year later the salmon are returning in record numbers, a flood control route has been reestablished to help reduce high water events, and an education program has been developed within the local schools. This project highlights the inroads that can be made through collaboration and the need to have patience as this project took well over 10 years of discussions to become a reality!

The Next Step in Planning the Future for San Juan Islands and Protection Island National Wildlife Refuges

Pamela Sanguinetti, U. S. Fish and Wildlife Service*

The U. S. Fish and Wildlife Service is developing a Comprehensive Management Plan that will serve as a guideline for the future of the San Juan and Protection Island National Wildlife Refuges. These 84 islands, rocks, and reefs support more than 75% of the breeding seabird population of Puget Sound. The planning process provides an opportunity to look at the current management from fresh perspectives over the next two years. U. S. Fish and Wildlife Service's planning team has established preliminary conservation targets, goals, and objectives for managing these marine Refuges. Integrating scientific and local knowledge from Puget Sound/Georgia Basin stakeholders is crucial to the success of this effort to protect critical areas for marine wildlife.

State Growth Management and the Effectiveness of Coastal Management Programs: A Comparison of Connecticut and Washington State Experiences

Nathaniel Trumbull, University of Connecticut*

This research provides a comparative focus in evaluating the effectiveness of state coastal management programs in protecting estuaries and coastal wetlands in Connecticut and Washington State. The latter has become a national leader in implementing its Growth Management Act (GMA) since 1990. The GMA has played a role in strengthening Washington State's pre-existing Shoreline Management Act. Connecticut has proceeded in its state coastal management largely in the absence of state-wide growth management legislation. Connecticut has relied on its Coastal Management Program, led by the Office of Long Island Sound Programs within the Department of Environmental Protection, to manage its coasts. The Connecticut Coastal Management Act of 1980 provides the primary authority for the state's comprehensive Coastal Management Program. The author poses the question of the relative value of state-level growth management legislation as an essential and integral legislative instrument for effective coastal management based on the Connecticut and Washington State experiences. Applying the evaluative analysis of Good, Weber, and Charland (1999), Connecticut and Washington State coastal management programs are assessed by means of an indicator-based approach.

Learning Through Collaboration: The Role of Communities of Practice in Natural Resource Management

Jillayne Peers, Department of Rural Planning and Development*

Watershed planning provides an integrated means by which the sustainable resource management process can be facilitated. Within watershed planning, governance structures are evolving from agency-based management towards local-level management. Voluntary stewardship groups are an important part of this shift. As with other organizations, stewardship groups rely on learning processes in practical situations in order to be productive and achieve goals. Communities of practice theory offers a perspective through which stewardship groups can be analyzed and strive for improvement. Communities of practice are centred on three core concepts: Domain refers to its focal issues and the sense of members' identity with the topic; Community includes its member relationships and the nature of their interactionsólevels of trust, belonging, and reciprocity; Practice consists of a repertoire of tools, methods, and skillsóas well as members' learning and innovation activities. The goal of this research is to determine how communities of practice theory applies to stewardship organizations and activities. This research focuses on several Streamkeepers groups in the Greater Vancouver area. Research will be conducted (during the fall/winter of 2006) using semi-structured interviews. This research will contribute to understanding the social functioning and learning processes that occur within Streamkeepers organizations.

On-Site Septic System Repair and Replacement Financial Assistance Program

Patricia Brommer, Washington State Department of Ecology*
Terry Hull, Puget Sound Action Team

Poorly functioning on-site septic systems are known to contribute fecal coliform bacteria and excessive nutrient loads to the marine environment. In addition to the human health hazard, eutrophic waters promote algal blooms and subsequent plant deterioration, which lead to low dissolved oxygen conditions. With $7.5M in appropriations from Governor Christine Gregoire' s 2005-07 Capital Budget and 2006 Supplemental Budget for the repair and replacement of failing on-site septic systems, the Department of Ecology (Ecology), collaborated with Puget Sound Action Team (PSAT), Department of Health (DOH), and county and tribal governments, to develop and implement an On-Site Septic System Financial Assistance Program (OSS). The OSS program provides loan and grant money to Puget Sound county and tribal governments to assist with funding options for homeowners' on-site septic system repairs. In addition to developing the region-wide program, Ecology worked with PSAT, DOH, and Hood Canal Coordinating Council to conceptualize and develop a Hood Canal Pilot Program. This innovative partnership will be based on an inter-local agreement between Jefferson, Mason, and Kitsap counties and Port Gamble S' Klallam and Skokomish tribes and utilize a private non-profit community development lending institution to provide a "one stop" financing program to homeowners for on-site septic system repairs.

Educating Real Estate Professionals about Water Resource Issues

Karen Janowitz, Washington State University Thurston County Extension*

Puget Sound' s water resources are critically affected by land development and individual land-use practices. Real estate professionals influence these land-use practices, yet tend to have poor knowledge of environmental issues. In 1998, a needs assessment of local environmental educators identified this audience as a high priority for water resource education. As a result, Washington State University Thurston County Extension developed and implemented a Water Resource Education Program for Real Estate Professionals. The program' s objective is to educate real estate professionals so they can make environmentally suitable decisions, as well as educate their clientele about land stewardship, water quality, and aquatic habitat. Courses cover research findings, policy and regulations of water resource related issues such as shorelines, onsites, salmon & streams and low-impact development. Hands-on learning through field trips complement

classroom presentations. Attendees receive continuing education credit toward their biennial professional license recertification. Over a period of eight years, over 840 individuals attended at least one of 67 classes, representing over 1760 attendances. The vast majority are from Puget Sound counties. Follow-up evaluations demonstrate that over 90% of program participants regularly share information they learn with clientele and colleagues, such as the value of native plants, reasons for setbacks, slope stabilization, septic maintenance, and stormwater pollution prevention.

Hood Canal Watershed Pledge

Emily Sanford, Robert Simmons, WSU Mason Extension*

To reduce anthropogenic nutrient loading to Hood Canal, Washington State University Extension implemented a social marketing based campaign in 2004 to educate and instill behavior changes among watershed residents. The "Hood Canal Watershed Pledge Program" continues today strengthened by continued partnerships and the efforts of volunteers. The Watershed Pledge program developed and distributed a booklet that highlighted natural histories of Hood Canal, and helped residents identify and commit to taking actions to help maintain Hood Canal' s health. The booklets were distributed through personal contacts in a variety of settings. Participants were provided a recycled glass suncatcher. Contact information is collected in order to provide participants with additional assistance and for program evaluation.

The social marketing elements and strategies of these programs include:

- Identification of target audiences/issues
- Development of desired behavior objectives
- Development of products to promote program objectives
- Making personal contacts and obtaining commitments
- Measurement of program outcomes; changes in awareness and behavior

Telephone surveys of representative samples of program participants were conducted to measure the effectiveness of these programs in encouraging behavior changes. This poster provides an overview of the program, conclusions derived from the most recent evaluation, and future program direct

Killer Whales and Trans-Border Whale Watching

Anna Hall, Chris Hall, Whale Watch Operators Association NW*

Our search for whales has evolved from centuries of lethal whaling to the present-day pursuit of simply watching whales. Contemporary whale watchers aim with cameras and binoculars, rather than harpoons. Though whale watching is non-consumptive, it is widely recognized that operating guidelines and minimum viewing distances are key to reducing human impact. Our goal was to provide a synopsis of the first international cooperative effort between resource managers, scientists and the whale watchers that operate in the inland waters of British Columbia and Washington. The southern resident killer whale (Orcinus orca) population frequents these trans-border waters and is the basis of a seasonal whale watching industry. This closed population is small (n<100) and considered Endangered in Canada and the US. More than 60 commercial and countless recreational vessels operate within core killer whale habitat. The unique trans-boundary aspect of the region inspired the formation of the Whale Watch Operators Association Northwest (WWOANW) in 1994 by commercial whale watch operators. Based upon on a principle of open exchange, the WWOANW provided a communicative platform for government managers, research scientists, enforcement agencies and commercial operators. This integrative approach resulted in significant conflict reduction amongst competing interests (e.g. researchers, commercial operators etc) and improved organization of commercial vessels. Further achievements include increased rigor of whale watch guidelines specifying spatial, behavioural and species-specific operating procedures and voluntary exclusion zones contributed to vessel-free areas. The WWOANW framework also provides an avenue for financial and in-kind contributions to trans-boundary scientific research. From this, we conclude that the collaborative process supplied the incentive for significant industry modifications, which resulted in noteworthy conservation actions. The WWOANW framework is dynamic and iterative, and it is hoped to provide a reference for other whale watch communities, and the managers responsible for the conservation of coastal cetaceans.

Poster Group 9: Status and Distribution of Plants, Animals and Invertebrates

Wigeon and Pintail Distribution at Multiple Scales in the Georgia Basin – North Puget Sound.

Dan Buffett, Ducks Unlimited Canada*
Mark Petrie, Ducks Unlimited Inc.
Stuart Slattery, Institute for Wetland and Waterfowl Research

The Fraser River Delta and the North Puget Sound form one biological unit for migrating and wintering waterfowl. Ducks Unlimited Canada and Ducks Unlimited Inc. initiated a research program in 2003 to better understand waterfowl foraging at multiple scales of the Fraser Delta and at the scale of the Georgia Basin Puget Sound. From the fall of 2003 to 2005, 73 American wigeon and 172 northern pintail were fitted with radio backpacks in the Fraser River Delta. Individual birds were tracked from December to April using aerial and ground telemetry at the scale of the Fraser Delta and at the scale of Georgia Basin ñ Puget Sound. Over all 3 years, the majority of wigeon and pintail were defined as wintering birds (55% - 100%) and present within the study area in January or Februrary. The remainder of birds were migrating birds (not detected in the study area during January or Feburary but detected in March or April), or unknown. In all three years, the majority of wigeon remained in the Fraser River Delta, while the majority of pintail used both the Fraser River Delta and North Puget Sound. Consideration of scale is an important component for conservation planning of waterfowl.

Snow Geese Wintering on the Fraser and Skagit River Deltas: Long-Term Population Dynamics and Grubbing Impacts on Scirpus Marshes.

Sean Boyd, Environment Canada (Canadian Wildlife Service)*

Wrangel Island (Siberia) supports the last remaining breeding population of Lesser Snow Geese (Anser c. caerulescens) in Russia. This population over-winters in two distinct areas of North America: the Fraser River (B.C.) and Skagit River (WA) deltas (northern area) and the central valley of California (southern area). Since the early 1970s, the proportion of Wrangel geese wintering in this northern area has gradually increased to the point where the Fraser and Skagit deltas now support 60-65% of the entire population. Consequently, management agencies on both sides of the B.C. - WA border have an increasingly important (international) responsibility to maintain this population, and its natural habitats, at healthy levels. Measurements of Scirpus stem densities in the late 1980s - early 1990s suggested that a low-level steady-state equilibrium existed between goose grubbing and plant re-growth rates; i.e. plant biomass was relatively low but constant across years. However, food subsidization on the winter grounds combined with unusually good weather conditions on Wrangel Island in recent years have resulted in a 2-fold increase in goose abundance. This population increase has coincided with a 50% decline in Scirpus stem density on the Fraser River delta. If this situation continues, Scirpus may be impacted to such an extent in some areas that it may not recover. This could put some Snow Geese at risk as they are still highly dependent on the marshes for food during freezing spells. It will be important to continue to monitor this interaction while responsible agencies discuss ways to alleviate the problem.

Upper Skagit Watershed Native Char: Status and Distribution of a Fragile, Transboundary Species in the Greater Georgia Basin Ecosystem

Troy Nelson, LGL Limited environmental research associates*

A biotelemetry-based field project to collect stock status, life history, and distribution information for native char in the upper Skagit River watershed across the Canada-US border commenced in the fall of 2001 and was completed in the winter of 2004. The four-year, jointly prescribed, Canadian-United States project included stock age/abundance estimates and habitat utilization assessments. A total of 67 individual char were captured in the BC Skagit River and fitted with surgically implanted radio tags prior to release. In addition, a total of 29 char were radio-tagged on the Washington side of the border. Confirmed survival (from telemetry detections) following release was 100%. Tag life span and reliability were very high, with some tags operating for over three years. The majority of Upper Skagit char that frequent the Skagit River in BC utilize both sides of the border on an annual basis; virtually all tagged char resided in Ross Reservoir (Washington) during winter months. Char abundance surveys suggest that the population of char in the BC Skagit is low (likely less than 300 sub-adults and adults). Distribution information suggests the Sumallo River (BC) is both key and critical to the integrity of the overall BC Skagit River char population. Program studies in British Columbia were conducted by LGL Limited (Sidney, BC), and administered/supported by the Ministry of Water, Land and Air Protection, with significant contributions from Seattle City Light.

Status and Trends of Puget Sound Great Blue Heron Breeding Colonies

Ann Eissinger, Nahkeeta Northwest Wildlife Services*

The Great Blue Heron (Ardea herodias) is a large familiar wader that resides year-round throughout the coastal lowlands of the Salish Sea. As an environmental indicator species linking marine, freshwater and terrestrial habitats, the Great Blue Heron was selected by the Puget Sound Nearshore Restoration Partnership as a Valued Ecosystem Component. As a result, a synthesis of existing information was prepared including, the status and trends of Puget Sound' s Great Blue Heron breeding population. Data over a ten year period, 1995-2004 provided a profile of the known heron colonies within the Puget Sound region. During this period, the heron breeding population appeared to increase slightly, while colonies shifted significantly into larger consolidated breeding concentrations. This shift has resulted in 80 percent of the breeding population coalescing into eleven colony sites. The consolidation of the heron breeding population poses new questions regarding this species' response to a rapidly changing landscape, predation and possible shifts in prey availability. Vulnerability of the breeding population has also increased with consolidation, requiring a reexamination of management guidelines and the conservation of colony sites and their supporting habitats.

Great Blue Herons of the Salish Sea: Status and Conservation.

Ann Eissinger, Nahkeeta Northwest Wildlife Services*

The Salish Sea represents the greater ecosystems of Puget Sound, Strait of Georgia and Strait of Juan de Fuca. This biologically rich coastal region is represented by few species as completely as the Great Blue Heron (Ardea herodias fannini). Although Great Blue Herons range throughout North America, the Salish Sea harbors a distinct resident population and the highest concentration of breeding herons on the west coast. Research and conservation of this important population is ongoing in both Washington and British Columbia. The current status and conservation of the Salish Sea Great Blue Herons will be presented by the transboundary Heron Working Group. The Heron Working Group is dedicated to the cooperative scientific study, conservation and stewardship of the Great Blue Heron. Biologists and conservationists are working together to collect and share both technical and biological information to guide the protection and perpetuation of this unique population.

Effectiveness of a Commercially Available Dog and Cat Repellent in Reducing River Otter Defecation On Docks

Robert Rorabaugh, Eric Eisenhardt, Joseph Gaydos, SeaDoc Society, UC Davis Wildlife Health Center*

River otters (Lontra canadensis) are widely distributed throughout the marine waters of the Georgia Basin Puget Sound where they primarily feed on numerous species of marine fish and invertebrates. They have a high metabolic rate and defecate at latrine sites on shorelines, playing an important role in the transfer of nitrogen and phosphorus from marine to terrestrial ecosystems. Otters also use docks and boats as latrine sites and offended private citizens have resorted to illegal trapping or shooting of otters in some areas. A commercially available granular dog and cat repellent was tested for its effectiveness in reducing or eliminating river otter defecation on docks. Three docks that contained river otter scat were treated with the repellent and three proximal docks that contained river otter scat were used as controls. River otter scat deposition was measured immediately before and weekly for four weeks following application and differences between treated and untreated docks were compared. Deposition on treated docks was significantly lower than on non-treated control docks, however treatment did not eliminate river otter defecation on docks. Treatment with this commercially available repellent could be suggested as an option to private dock owners frustrated by river otter defecation on docks.

Red Octopus Drills Clams

Roland Anderson, Seattle Aquarium*
David Sinn, University of Tasmania
Jennifer Mather, University of Lethbridge

Since the clarification of its species name (Berry, 1953) there have been a number of behavioral studies on the red octopus (Octopus rubescens), but few studies on its prey or predators in spite of being the most common octopus on the American west coast. There are a few casual studies on it food in the wild and one study that suggested red octopuses keep their middens inside their dens found a variety of food items, including clams. Informal observations of its food in captivity showed it able to open and eat the commercially-available Manila clam (Venerupis philippinarum). Such observations spawned this current study on how red octopuses open clams. Live Manila clams were obtained from a local fish market and fed ad libitum to 10 red octopuses (mean weight 73 g). The opened clams were examined for method of entry. Most clams were drilled by the octopus' s radula in combination with a salivary papilla that dissolves shell material like a moon snail drills. Octopuses drill their bivalve prey in order to inject a venom that paralyzes a clam' s muscles. The drill holes were primarily located over a clam' s adductor muscles (66%; n = 171) that hold clam shells together, and the majority (52%) of the drill holes were drilled over the anterior adductor muscle. It is likely the octopuses were targeting the adductor muscles to drill and inject venom into these major muscles that hold a clam together. It is not known yet whether an octopus learns to drill a clam over the adductor muscles or whether this knowledge is inborn; studies on other octopus species suggest it is a learned behavior.

The Relationship Between Oceanographic Conditions and Terrestrial Habitat for Marine Use, Nest Site Selection and Breeding Success of Marbled Murrelets: Implications for Reserve Design and Management

Jennifer Barrett, Dr. Kristina Rothley, School of Resource and Environmental Managment, Simon Fraser University*

Reserve design, in any system, must relate to the ecology, natural behavior and life history of the target species, as well as the variability of their habitat. In designing reserves however, planners often aim to optimize conservation either on land or at sea, without considering the

relationships that may exist between the two landscapes. This can be particularly detrimental for species with lifecycles that are tied to both ecosystems. The Marbled Murrelet (Brachyramphus marmoratus), a small seabird that depends on both terrestrial old-growth habitat and coastal marine areas for survival and reproduction, is an example of such a species. While huge advances have been made in our understanding of murrelets over the past decade, significant data gaps still remain. In particular, there appears to be a lack of data addressing the role of marine factors in maintaining a healthy murrelet population, and how these factors interact with the terrestrial landscape to produce "good nesting habitat". The aim of my research is to relate oceanographic conditions to the marine distribution and breeding success of Marbled Murrelets, and, by integrating my findings with terrestrial landscape models, to identify critical areas that should be considered in the management and recovery of this species. My poster will present this work in progress.

Swinomish Review of EMAP Methods for First Order Non-Fish Bearing Streams in the Puget Sound Lowland Region

Sarah Akin, Todd Mitchell, Rachel LovellFord, Swinomish Indian Tribal Community*

The Swinomish Stream Bioassessment survey was initiated to characterize and track changes in the physical and biological condition of the three perennial first-order, non-fish bearing steams located on the Swinomish Reservation, Washington State. To assess the ecological state, this project is using methods derived from EMAP Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams (Peck et al., 2003). The streams on the Reservation present unique geomorphological and ecological challenges for the application of EMAP methods as well as the development of a Swinomish Biological Index. The streams are small, wetland drainages (wetted widths less than one meter) supported by groundwater inputs and rain events, with low summer flow and flashy winter events. The three watersheds are forested and sparsely developed, with little indication of persistent anthropogenic disturbances. Recommended data analysis methods (Kaufmann et al., 1999) suggest that the streams exhibit high quality riparian habitat, low quality in-stream habitat, and low invertebrate abundance (Wisseman, 2005). Current indices for comparing the biological and physical integrity of Puget Sound Lowland streams have proven to be inadequate rulers for streams of this scale. Prominent features of small first order streams were given little weight. With further refinement, a small stream index can be derived to create numeric biological criteria for the Swinomish Water Quality Standards.

The Pacific Coast Ecosystem Information System (PCEIS): Creating a Baseline for the Future

Deborah Reusser, U. S. Geological Survey*
Henry Lee II, U. S. Environmental Protection Agency

Coastal researchers and managers have a growing need for ready access to a diversity of data types, including estuarine-specific lists of native and nonindigenous species and estuarine/landscape characteristics. These data are key components in ecological risk assessments in general and in early detection ñ rapid response strategies for invasive species in particular. However, this information is scattered in the peer-reviewed and gray literature as well as State and Federal databases. To address this problem, the U.S. EPA and USGS have developed a database, Pacific Coast Ecosystem Information System (PCEIS), synthesizing biological and landscape characteristics for the estuaries of Oregon, Washington, and California. Currently, PCEIS contains georeferenced information on 219 estuaries and more than 600 sub-estuaries and tributaries. Occurrences of native and nonindigenous species of benthos, fishes, and seagrasses for each estuary along with physical information on the associated watershed such as percent intertidal area, wetland, an land use patterns are summarized and can be displayed or exported for modeling or other research needs. Presently PCEIS contains over 7800 species of native and nonindigenous species that provides the ability to rank estuaries by relative percent invasion or generating baselines of native species to evaluate impacts of invasive species on indigenous fauna. This information will be distributed in a stand-alone ACCESS database.

Diel otolith increment validation in larval lingcod (*Ophiodon elongatus*)

Jake Gregg, Marrowstone Marine Field Station, USGS, Biological Resource Discipline*
Kenneth Massee, Rod Campbell, Neil Ashton, Manchester Research Station, Northwest Fisheries Science Center, NOAA Fisheries

Lingcod early life history characteristics, including large active larvae, long pelagic phase, and separation of juvenile and adult habitats, could easily confound spatial management schemes (i.e. MPA' s). Otolith increments, as a proxy measure of time, would be a valuable tool for estimating the duration of the larval phase and potentially the magnitude of dispersal in this species. A validation study was conducted to determine whether growth rings in lingcod are deposited with diel periodicity. Lingcod larvae from a single egg mass (synchronous hatch) were reared in six 9300 L floating mesocosms at the Manchester Field Station in central Puget Sound. Three feeding regimes (once every other day, once daily, and twice daily) were utilized to control for the potential effect of feeding periodicity on diel rhythms. Larvae were sampled from all treatments on day-0, day-1, day-2, and every even day through day-24. Weekly samples were taken through day-67. Otoliths were removed, mounted, and examined using standard bright field microscopy. Sagittal growth increments were easily distinguishable and spaced well above the resolution limits of light microscopy. Otoliths from larvae older than 45 days became too thick to read without grinding and were therefore not included in further analysis. Rate of increment formation was 0.964 day-1 for sagittae combined from all treatments. Sagitta increment counts are a good predictor of age in larval lingcod.

Genetic Biomarkers of a Leukemia-Like Disease in Mussels.

Ekaterina Vassilenko, Annette Muttray, Susan Baldwin, University of British Columbia*

The mussel *Mytilus* ssp. develops haemic neoplasia, underlying causes of which are still under investigation. It has been shown that the protein p53, an important tumor suppressor, is involved in the disease. The wild type protein p53 responds to DNA damage in cells by regulating the normal cell cycle leading to cell cycle arrest and DNA repair, or to programmed cell death. We previously isolated several isoforms of the p53 family in *Mytilus* which are structurally very similar to p53 in other taxa. Some of the isoforms are not able to perform the tumour suppressor function. We are currently quantifying expression of p53 isoforms. Preliminary data suggest that p53 is expressed at higher levels in leukemic haemocytes of diseased mussels. The increased expression of p53 in leukemic haemocytes leads us to investigate whether this p53 is functional. Therefore we have initialized sequencing experiments of p53 in normal and leukemic mussels. Preliminary data show that leukemic mussels have more frequent mutations in p53 than normal mussels. One of the mutations observed codes for truncated and non-functional p53 protein. Further mechanistic studies are required to verify that p53 gene mutation and expression level analysis can be used as early-warning biomarkers of the disease.

Assessing the Role of Microhabitat Associations in Producing Among-Taxon Congruence

Shannon Turvey, University of British Columbia*
Melissa Hogg, Simon Fraser University
John Richardson, University of British Columbia

Observational studies have demonstrated significant weak correlations in diversity across multiple taxa, but have generally failed to find evidence of strong across-taxa congruence. However, examples of experimental studies testing for across-taxa congruence as a result of an

underlying ecological mechanism are largely lacking. One mechanism that may produce congruence is use of a common habitat element by several taxa. Downed wood (DW) is abundant in the Pacific Northwest and is utilized by small mammals, amphibians, and invertebrates for a variety of ecological functions. We have used experimental additions of downed wood to riparian areas in a BACI (before-after, control-impact) design to test for congruence in diversity across sites between small mammals, amphibians, and ground beetles due to their common use of downed wood as a habitat resource. The relationship between these taxa and downed wood volumes will be assessed, and the presence or absence of cross-taxa congruence will be evaluated. The results of this study will be relevant to riparian management and to an evaluation of the effectiveness of biodiversity monitoring programs that utilize species-level indicators or indicators of habitat quality.

Infaunal Invertebrate Assemblage Structure in Hood Canal, WA (1989 – 2005)

Margaret Dutch, Sandra Aasen, Edward Long, Kathy Welch, Washington State Department of Ecology*

The structure of invertebrate assemblages in Hood Canal sediments was 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 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.

Northern Anchovy Spawn Observations in the Puget Sound Basin

Kurt Perry, Dan Penttila, Washington Department of Fish and Wildlife*

Northern anchovy (Engraulis mordax) are a small, pelagic, schooling fish ranging from Baja California to central British Columbia, Canada. Three distinct stocks (northern, central, southern) exist with the northern population ranging from northern California to central British Columbia. This species is an important prey for many species of seabirds, marine mammals and fishes. Northern anchovy eggs are pelagic and typically drift in the upper 10m of the ocean current for 2-4 days before hatching. Although well documented in California and Oregon, data pertaining to northern anchovy spawning behavior within the Puget Sound Basin is scarce. In order to better document the distribution of northern anchovy spawning activity within the Puget Sound Basin, we collected 73 plankton samples from 53 distinct locations ranging from Blaine, WA (north) to Olympia, WA (south) between 6/21/06 and 8/21/06. Of these samples, 54 (74 %) contained northern anchovy eggs. Additionally, Washington Department of Fisheries plankton data collected from 1971 to 1987 was analyzed for presence of northern anchovy eggs. Sampling sites depicting presence or absence of northern anchovy eggs are presented. Results indicate a wide distribution of previously undocumented northern anchovy spawning activity throughout the Puget Sound Basin.

Blood Analysis and Disease Screening on Free Ranging Steller Sea Lions (*Eumetopias jubatus*)

Dyanna Lambourn, Steven Jeffries, Monique Lance, Washington State Department of Fish and Wildlife*
Peter Olesiuk, Department of Fisheries and Oceans
Stephan Raverty, Animal Health Centre
Andrew Trites, University of British Columbia

Steller sea lions (Eumetopias jubatus) disperse from breeding rookeries in southern Oregon, British Columbia and Alaska, and begin to arrive in the inshore waters of southern Vancouver Island and Washington during August-October. All age classes of Steller sea lions appear to undertake movements associated with the availability of prey while on the wintering grounds, until animals begin to depart in April-May. These inland waters are fairly protected from adverse weather, are easily accessible and provide an ideal opportunity to develop and test new field techniques for capturing and handling healthy, free ranging Steller sea lions and conduct detailed studies on foraging ecology. It also allows for blood and tissue collections from these Steller sea lions. Sea lions were captured, using a floating trap anchored off of Norris Rock, British Columbia as part of a collaborative study between Washington Department of Fish and Wildlife, Department of Fisheries and Oceans, Canada, and the University of British Columbia. In the past, Steller sea lions have also been occasionally captured on a similar floating trap at Shilshole, Washington. Captured sea lions were moved into a squeeze cage, where they were physically immobilized and general population characteristic data collected. Sea lions receiving telemetry instruments (ARGOS satellite transmitters, time depth recorders and stomach sensor pills) were sedated with valium and then were anesthetized using isoflorane gas anesthesia and closely monitored. We were able to capture, handle, collect tissue and blood samples and attach a variety of instruments all classes ranging from yearlings to adult-sized animals weighing up to 580 kg. Basic serum chemistry and hematology were conducted to establish baseline and provide a general indicator of the condition and health of animals. Blood for General Diagnostic Panel (Complete Blood Count [CBC] and serum chemistries) was completed for 33 Steller sea lions. Serum was screened for the presence of antibodies to Brucella abortus antigens using traditional methods (BAPA, Card and Rivanol tests). No sea lions had positive titers for Brucella, but 9% had suspect titers. Leptospirosis screening included testing with L. pomona, L. hardjo, L. grippotyphosa, L. icterohemorrhagiae and L. canicola using MAT (Microscopic Agglutination Test), and fourteen percent had suspect (2/28) or positive (2/28) titers to Leptospira pomona.

Using Diagnostic Genetic Markers to Identify Hybrid Sebastes in Puget Sound

Piper Schwenke, Lorenz Hauser, University of Washington, SAFS*
Linda Park, Northwest Fisheries Science Center

Hybridization is a major conservation and management issue in many freshwater and terrestrial species, but has so far received little attention in marine species. Nevertheless, the implications for species of concern may be considerable, in particular where anthropogenic influences may affect the frequency of hybridization. The purpose of this project is to expand our knowledge of hybridization between copper rockfish (Sebastes caurinus), quillback rockfish (S. maliger), and brown rockfish (S. auriculatus) in Puget Sound. Although these species are found in sympatry along the Pacific Coast and in Puget Sound, there has only been evidence of hybridization within Puget Sound, (documented by L. Seeb, V. Buonaccorsi, and others). This project will use several species-specific genetic markers to determine the geographic extent of hybridization plus the direction of hybridization in Puget Sound. Our sample collection contains approximately 400 samples of copper, quillback, and brown rockfish from Puget Sound (WDFW and AFSC) and 90 reference samples from coastal populations (SWFSC). Our initial results confirm that hybridization is in fact present in many of

our Puget Sound samples. These genetic markers are fixed for each species, are easy to assay, and are independent tests for hybridization; therefore, we have implemented a strong capability to evaluate the level and incidence of hybridization in these Puget Sound rockfish.

Garry Oak (*Quercus garryana*) Plant Communities in British Columbia: A Guide to Identification

Wayne Erickson, Del Meidinger, BC Ministry of Forests and Range*

This field guide covers the native plant communities with a component of Garry oak (*Quercus garryana*) in British Columbia. It is to be released in March 2007 as BC Minstry of Forests and Range Technical Report 040. The purpose of this guide is to standardize the use of plant communities in conservation and recovery of the Garry oak habitat, and thus to move toward an ecosystem approach. Standardized communities can provide a basis for mapping and inventory. The guide is also intended to provide targets for Garry oak habitat restoration, and could help identify reference communities, which are then monitored to detect long-term ecological trends. Compared with previous work, this guide introduces the plant association as a new, simplified level. The seven plant associations (see below) are subdivided into 16 plant community types and 6 subcommunities. Most are similar to those in Erickson (1996, 1998), with changes mainly in the level of classification. Categories are maintained for bedrock outcrop and colluvial, early and late season (phenological), grassy, and shrub thicket communities. Native communities from each of these categories are included in one-page descriptions. Sections include a general description of sites, soils, stands, and vegetative composition; a chart with geographic area against site moisture regime; comments including equivalent communities and succession to native or invasive alien communities; a chart with the relative importance value of the major understorey plant species; and a chart with management rankings. It is hoped that this guide will be updated and refined over time through use and testing, together with the incorporation of local knowledge on plant communities.

Poster Group 10: Migration, Behavior, and Physiology

Impacts and Adaptation Responses of Salmon on East Coast Vancouver Island of Climate

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Climate variation and change is one the larger prevailing issues strongly linked to the success and condition of salmon populations, habitats and watersheds in British Columbia. Planning and implementation at the stream and watershed level, should incorporate an understanding of present and future climate issues and recognize present and future vulnerabilities and on salmon populations and habitats. We examine the habitat use of adult spawning chum, chinook and coho salmon and subsequent post spawning carcass deposition in small east coast Vancouver Island stream in association with seasonal rainfall and changes in the hydrograph and water and air temperatures. We also present a series of case studies to highlight the historic and recent patterns of change in watersheds and the condition of habitat which has led to recovery planning for salmon populations. We use these examples to explore approaches for understanding a climate context for salmon populations and habitats and how to reconstruct flow and temperature patterns and build projections into future plans. The considerable annual variation and changing impacts of climate on salmon and habitats, suggests that our plans and restoration implementation we will need to be responsive to change and adjust our practices and processes to reflect the level of risk and vulnerability to climate.

Urban Predators: Patterns of Movement of Sixgill Sharks Hexanchus Griseus in Puget Sound.

Kelly Andrews, Phillip Levin, Stephen Katz, NOAA Fisheries*
Debbie Farrer, Greg Bargmann, Washington Department of Fish & Wildlife
Greg Williams, NOAA Fisheries

Understanding life histories of apex predators is crucial for understanding how marine ecosystems respond to human perturbations as well as for effectively conducting ecosystem-based management. Even so, we lack basic knowledge of many large predatory fishes. In Puget Sound, we are investigating movement patterns and habitat use of sixgill sharks, a large, abundant predator in the region. We acoustically tagged 25 sixgill sharks with pressure sensor transmitters and monitored their movement patterns via passive and active acoustic receivers along a 70 km stretch of Puget Sound. Movement patterns and habitat use differed by shark size and among sites. However, sharks clearly occupy relatively small areas for weeks at a time, indicating the potential for strong, localized top-down effects. Sharks showed some diel differences in behavior, but these differences were complicated by site, gender and size related effects. These data form the basis of empirically-based movement and bioenergetic models.

Coho Salmon Movements in the Lower Elwha River: Implications for Recolonization Following Dam Removal

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Brian Burke, Northwest Fisheries Science Center, NOAA Fisheries Service
Raymond Moses, Lower Elwha Klallam Tribe

Pacific salmonid (*Oncorhynchus spp.*) populations in the Elwha River are currently depressed. These historically strong runs of salmon are either extinct or supported primarily by hatcheries, partly due to the existence of two dams that have blocked access to large portions of the river since the early 1900s. These dams are scheduled to be removed, providing salmon access to 79 km of pristine spawning habitat in the Olympic National Park. Using radiotelemetry, we monitored migration and behavior of coho salmon in the lower Elwha River in relation to environmental cues. We tagged, released, and tracked 14 adult coho salmon in 2005 and 45 in 2006 using a combination of fixed receiver sites and mobile tracking. We followed fish movements and identified essential habitat types used. Fish movements varied from almost none to several kilometers up- and downstream as fish searched for suitable spawning locations. In 2005, many fish settled in the tagging area, which was saturated with large woody debris and gravel, known to be high quality habitat for coho salmon spawning. In 2006, we tagged closer to the river mouth where fish were actively migrating to better assess movement to other potential spawning locations in the river.

Orcinus Orca: No Parallel Outside Humans

Howard Garrett, Orca Network*

Recent theoretical studies of culture in whales and dolphins have reviewed experimental research on captive animals and patterns of behavioral variation found in wild populations. Captive studies of cognitive processes in dolphins have provided indications of the capacity for culture in dolphins. The ethnographic approach, based on evolutionary ecology, has found evidence that the vocal and behavioral traditions of killer whales (Orcinus orca) appear to have no parallel outside humans. To date, however, no published theory has provided a synthesis that accommodates both the experimental findings and the ethnographic evidence and clarifies the form of social learning that underlies both. The theory of symbolic interactionism, borrowed and adapted from sociology, provides a conceptual framework for integrating the experimental "process-oriented" and the ethnographic "product-oriented" perspectives. Symbolic interactionism may help account for the divergent and complex cultural traditions found in sympatric orca populations. Prevailing theoretical paradigms (behaviorism, evolutionary ecology, cognitive ethology) do not discuss the possibility that any non-human animal uses symbols extensively in normal everyday communication, or that the use of symbols substantially

affects behavior. The theory of symbolic interactionism synthesises the experimental and the ethnographic observations that indicate that there is good evidence for cultural transmission in several cetacean species.

Reproductive and Stress Hormone Levels in Captive Giant Pacific Octopus (*Enteroctopus Dofleini*)

Shawn Larson, Roland Anderson, Seattle Aquarium*

Giant Pacific octopuses (Enteroctopus dofleini) are held in many aquaria worldwide. The Seattle Aquarium has held them on exhibit since opening in 1977. Captive husbandry of this species is well understood but the endocrine mechanisms regulating reproduction and stress are not well documented. The major reproductive hormones found within female vertebrates (progesterone and estrogen) and male vertebrates (testosterone) and the stress related hormone (corticosterone) are relatively well known. It is thought that the endocrine system controlling reproduction and the stress response within vertebrates evolved first within invertebrates. However, very few studies have been done to date on invertebrate reproductive and stress related endocrine variables. Here we report longitudinal data on non-invasively collected fecal reproductive and stress hormone metabolite levels within five captive female and four male giant pacific octopuses held at The Seattle Aquarium. Reproductive and stress hormones were measured within octopus fecal sample extracts using standard immunoassay techniques. Longitudinal samples were examined indicating seasonal reproductive cycling within both male and female octopus with one observed mating. The data documented changes in relative fecal reproductive hormone metabolites similar to that found within reproductively active vertebrates. In addition to changes in reproductive hormones, the octopuses also exhibited a vertebrate like endocrine stress response (elevated corticosterone) to a stressor. These results suggest that hormones found in octopus feces can be used to determine octopus life stages and stress levels in captive animals.

Poster Group 11: Water Quality and Quantity

Contaminant Concentrations in Storm Water Entering the Sinclair/Dyes Inlet Subasin of the Puget Sound, USA During Storm Event and Baseflow Conditions

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David Mettalo, Ryan Pingree, Brian Rupert, The Environmental Company

Contaminant concentrations in representative streams and outfalls discharging into Sinclair and Dyes Inlets were evaluated during 18 storm events and wet/dry baseflow conditions between Nov. 2002 and May 2005. A combination of time-composites, flow-composites, and grab composites along with flow measurement were collected and samples were analyzed for metal contaminants (mercury, arsenic, cadmium, chromium, copper, lead, silver, and zinc), organic contaminants (polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls), and nutrients (total inorganic nitrogen and total phosphorus) to determine event mean concentrations (EMCs) as a function of total event rainfall and upstream land use. Samples were also analyzed for aluminum, total suspended solids, and total and dissolved organic carbon to examine relationships with particulate matter and organic carbon. The results showed that EMCs for outfalls were often five times higher than streams for the metals and 24 times higher for PAHs; however, calculated loadings from outfalls were lower than streams due to the greater volumes discharged from streams. EMCs for total copper, lead, zinc, and mercury in streams were positively correlated with storm size, but an inverse relationship for outfalls was found suggesting a dilution effect with larger storms. The data were used to develop statistical estimates of contaminant levels in streams and outfalls as a function of upstream landuse and storm intensity.

Sediment Redox Tracers and Metals in Strait of Georgia Sediments – Can They Inform Us of The Loadings of Organic Carbon from Municipal Wastewater?

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Sophia Johannessen, Department of Fisheries and Oceans
Charles Gobeil, INRS, Quebec
Cynthia Wright, Contractor
Albert van Roodselaar, Greater Vancouver Regional District

Seven box cores have been collected from the Strait of Georgia from regions near the Iona municipal outfall (off the Fraser River) and from basin and distal locations. Sediments have been dated using 210Pb and analyzed for organic carbon, redox elements and tracers (Re, Mo, Mn, Cd, AVS) and selected heavy metals (Zn, Pb, Cu, Hg and Ag). The data will be examined for evidence of the source and strength of organic carbon loading and burn-down in each core based on redox tracer distributions, and the source of contaminants based on the other metals.

Toxigenic *Pseudo-Nitzschia* Species in Puget Sound and the Outer Washington Coast

Keri Baugh, Shelly Nance, Shuk Tsui, Brian Bill, Nicolaus Adams, Vera Trainer, Northwest Fisheries Science Center*

The Ecology and Oceanography of Harmful Algal Blooms in the Pacific Northwest (ECOHAB-PNW) project was designed to study the physiology, toxicology, ecology, and oceanography of the pennate diatom genus Pseudo-nitzschia, several species of which produce the toxin, domoic acid (DA). Determining the environmental conditions under which Pseudo-nitzschia produce and release DA is important in assessing the species that pose the greatest threat to the safe harvest of coastal shellfish populations. To gain an understanding of the species of Pseudo-nitzschia that are the major toxin producers in the Pacific Northwest coastal waters, representative isolates from the ECOHAB-PNW study site were grown as clonal cultures. Both particulate and dissolved DA were measured at various stages of growth using an enzyme-linked immunosorbent assay. By comparing the relative toxin levels in cultured isolates with toxin measured in seawater samples collected during ECOHAB cruises and in beach samples from Puget Sound, we were able to estimate relative toxicities of Pseudo-nitzschia from Washington State coastal waters.

Genetic Differentiation of *Pseudo-Nitzschia Pungens* from the Pacific Northwest and the North Sea

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Russell Herwig, Lorenz Hauser, Gabrielle Rocap, University of Washington
Vera Trainer, NOAA-Fisheries

Using microsatellite data, the population genetic structure of Pseudo-nitzschia pungens in the Pacific Northwest and the North Sea was compared. The Pacific Northwest samples showed significant deviations from Hardy-Weinberg and linkage equilibrium whereas the North Sea sample had none. The Pacific Northwest samples were significantly differentiated from the North Sea sample both when considered individually and as a pooled sample, but the individual Pacific Northwest samples were not significantly different from each other. However, clustering algorithms were able to separate the Pacific Northwest samples into two separate populations that exhibited few deviations from Hardy-Weinberg expectations and no deviation from linkage equilibrium. The degree of differentiation between the subpopulations in the Pacific Northwest indicated that there may be cryptic speciation of P. pungens as these subpopulations were more divergent than either was from the North Sea sample. This approach will be used in the future to compare oceanic strains of Pseudo-nitzschia species to those responsible for domoic acid events in Puget Sound.

Depleted Oxygen Levels in the Nearshore Waters of Northern Washington

Mary Sue Brancato, Lindsey Milonas, David Kirner, Olympic Coast National Marine Sanctuary*

In 2004 the Olympic Coast National Marine Sanctuary (OCNMS) initiated dissolved oxygen (DO) monitoring to determine the timing, severity, and extent of depleted oxygen levels along the Olympic Coast. In 2004 and 2005, CTD-DO casts were taken off the RV Tatoosh biweekly between June and early October along three cross-shelf transects at Cape Alava, Teahwhit Head and Cape Elizabeth. In 2006, OCNMS deployed moorings with continuous CT-DO recorders approximately 1 meter off the sea floor along two of these transects and continued casts along the third. No measured oxygen levels recorded in 2004 or 2005 could be characterized as hypoxic (<2mg/L). However, in 2004, near hypoxic conditions (<3mg/L) were routinely measured. In 2005, a few "near hypoxic" events were measured at >50m depths off Cape Elizabeth in May-July. In 2006, hypoxic conditions occurred in May and June as far north as Cape Alava and as far south as Cape Elizabeth. Hypoxic conditions were more extensive at Cape Elizabeth, extending into shallower and deeper waters and for longer durations. Data co-occurring with the reported fish and crab mortality events in late July near Cape Elizabeth are supported by dissolved oxygen concentrations that got as low as 0.02 mg/L between 16 and 30 July 2006. No observations of invertebrate or fish mortalities were reported during the May, June, or August hypoxic events, which could be due to a variety of reasons, e.g., the events were short in duration or limited in extent, no observers were on the beach at the time, etc.

Development of Non-invasive Methods to Monitor Environmental Pollutants in Coastal River Otters of the Puget Sound/Georgia Basin

Daniel Guertin, Alton Harestad, Simon Fraser University*
John Elliott, Environment Canada (Canadian Wildlife Service)

Pollution of aquatic ecosystems is a major threat to river otter (Lontra canadensis) populations, yet little effort has been made to monitor environmental contaminant levels in wild otters. Due to their elusive nature, river otters are difficult to study in their natural surroundings, however, advances in non-invasive sampling has opened opportunities for gathering information on the species. In a pilot project, scat samples obtained from marine-foraging river otters near Victoria, BC in the Puget Sound/Georgia Basin (PSGB) had elevated levels of industry produced polychlorinated biphenyls (PCBs). Based on these results, we have undertaken a novel approach to examine the significance of PCBs on the region' s river otter population. We identified 180 river otter latrine sites spanning 86.5 km of coastline on southern Vancouver Island, BC. A total of 893 fresh scats were collected from Dec 13 - 18, 2005 and June 1 - Aug 22, 2006. Fecal DNA genotyping will be used to determine the abundance and distribution of river otters in the study area. River otters in which genetic profiles are obtained will have their scat analyzed for toxin levels and prey remains. Results are pending. Due to their top predator status in the nearshore environment, high site fidelity, and long life, river otters are an ideal species to monitor localized environmental contaminants in marine ecosystems such as the Pacific Northwest.

Trace Elements as Tracers of Physical Processes

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Trace elements are naturally occurring, although potentially toxic to living organisms at high concentrations, and can be used as tracers of physical and biological processes. A trace element' s usefulness as a tracer does not depend on whether the element originates from natural or anthropogenic sources. Nickel and cobalt data are used to distinguish among water masses in the Lower New York-Raritan Bays originating from the Arthur Kill, the Raritan River and the Hudson River. Likewise, cadmium data are interpreted to examine mixing of Fraser River water with oceanic water in North Puget Sound.

Yard Trimmings Compost as an Environmental Buffer in the Over-Winter Field Storage of Poultry Litter

Erica Milligan, Art Bomke, Wayne Temple, University of British Columbia*

One major non-point source of freshwater pollution is livestock manure used as a fertilizer or soil amendment on agricultural fields. In British Columbia' s Fraser Valley intensification of poultry farming has led to an over-abundance of poultry manure in the region. The solution has been to move excess manure to more manure-poor areas, such as the Fraser delta, to be used as a soil amendment. However, there are significant ecological and food safety concerns associated with the importation of a high nutrient material into a region subject to intensive winter leaching. The objective of this research was to examine the ability of the City of Vancouver yard trimmings compost (YTC) to act as a buffer in the over-winter field storage of poultry litter. Over the winter of 2005-06 four experimental manure storage piles were constructed in farmers' fields in Delta, BC to assess the affects of a YTC covering, base pad, and combination of the two on the leaching of salts, nutrients and heavy metals from the poultry litter. Results indicate that both the YTC base pad and covering have a positive impact on regulating the leachate and run-off quality emanating from the stored manure.

Sill Dynamics and Deep Water Renewal – Idealized Numerical Experiment

Dmitri Leonov, Mitsuhiro Kawase, University of Washington*

Sensitivities and time scales of adjustment of fjord-type estuary circulation to different forcing mechanisms are examined within an idealized numerical experiment. The model domain is chosen as an idealization of Puget Sound's Main basin, a channel with a double-sill entrance profile taken from a thalweg cross-section through Admiralty inlet. The experiments are set up on a z-level grid with partially filled cells using MITgcm. The model is first run with constant external conditions (river discharge and oceanic salinity) and no wind forcing until a steady fortnightly cycle has been reached. The phasing of fortnightly cycle and its properties are consistent with observations (Geyer and Cannon, 1982; Bretschneider et al., 1985). The model then undergoes several abrupt changes in external conditions separated by long (several fortnightly cycles) time intervals, during which adjustment is monitored. Adjustment to changes in salinity shows strong asymmetry with respect to the sign of salinity change, adjustment to a decrease in salinity being a 2-stage process. Adjustments to river discharge are more symmetric, produce moderate changes in total salt content and have overall shorter adjustment time scales. Increase in river discharge enhances the reversed circulation signal that peaks around spring tide and weakens the dense water intrusions.

Hydrologic Effects of 120 Years of Land Cover and Climate Change in the Puget Sound

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Marina Alberti, UW Department of Urban Design and Planning
Dennis Lettenmaier, UW Department of Civil and Environmental Engineering
Jeffrey Richey, UW School of Oceanography

Land cover has changed dramatically in the Puget Sound region since the first European settlement in the mid-19th Century. These changes have consisted largely of urban growth in the lowland areas, and removal of old growth timber and replacement with forests having a range of maturity over most of the upland area, along with construction of forest roads. We use the Distributed Hydrology-Soil-Vegetation Model (DHSVM) run over an 88-year period with current land cover, and reconstructed land cover representative of conditions early in the post-European settlement era, to assess the effects of land cover

change on the timing, and magnitude of freshwater fluxes to Puget Sound. Reconstructed land cover is based on early 1880' s settlement extent, and 1883 Density of Forest ñ Washington Territory Map from Department of Interior. To assess the effects of climate change over the period of the climate record (88 years) we first adjust the entire record to have temperatures similar to those of the most recent two decades, and then adjust the entire record to have temperatures similar to those of the early instrumental record. Through comparison of 88 years of hydrologic predictions for combinations of historic and current land cover and climate, we are able to assess their relative contributions to long-term changes in freshwater fluxes to Puget Sound.

Overview of the South Puget Sound Dissolved Oxygen Study

Mindy Roberts, Julia Bos, Greg Pelletier, Storrs "Skip" Albertson, Karol Erickson, Carol Maloy, Washington State Department of Ecology*

South Puget Sound, including Budd, Carr, and Case Inlets, has low levels of dissolved oxygen that do not meet state water quality standards and impair marine life. Excess nitrogen enhances primary productivity and causes algae growth. As the algae die, microorganisms that decompose the algae deplete oxygen levels in the near-bottom waters, creating zones of low dissolved oxygen that may be harmful to fish and other aquatic organisms. The first phase of the study indicated that both point sources from wastewater treatment plants and nonpoint sources from watersheds and rivers contribute significant nitrogen loads. The current project further refines those loads. Data collected from 80 marine stations will enhance understanding of how nitrogen moves around South Puget Sound and the relationship with dissolved oxygen levels. Three-dimensional circulation and water quality models will simulate present conditions in South Puget Sound, based on the extensive data collection programs. The calibrated models will be applied to a variety of management actions to determine how much point and nonpoint source nitrogen loads must be reduced to meet water quality standards. The South Puget Sound dissolved oxygen study is part of Governor Chris Gregoire' s long-term effort to help restore and preserve Puget Sound.

Status and Trends in Parlytic Shellfish Poisoning (PSP) in Puget Sound through 2005

Timothy Determan, Washington State Department of Health*

The Washington State Department of Health (DOH) monitors levels of paralytic shellfish poisoning toxin (PSPT) in mussels taken every two weeks from sentinal sites located throughout Washington State marine waters. Results from thirty two sites in Puget Sound were examined to determine spatial patterns and temporal trends as part of the Puget Sound Ambient Monitoring Program (PSAMP). Results of the analysis through December 2005 are presented.

Long-term Monitoring of Puget Sound, Gray's Harbor and Willapa Bay: Status and Trends in Water Quality from 2001-2005

Carol Maloy, Brian Grantham, Skip Albertson, Julia Bos, Adrienne Stutes, Washington State Department of Ecology*

The Washington State Department of Ecology has been monitoring the water quality of Washington's estuaries for 35 years, more recently as part of the Puget Sound Assessment and Monitoring Program. As human populations in the Puget Sound region continue to increase, water quality will be affected. Atmospheric conditions and climate changes also affect water quality. Ecology scientists have developed indices as a way of systematically assessing the conditions and trends in marine water quality. The Index of Sensitivity to Eutrophication includes the variables of dissolved oxygen (DO), dissolved inorganic nitrogen (DIN), and the degree and duration of stratification. Areas showing the highest sensitivity to eutrophication have very low DO, low DIN, and strong and persistent stratification. The Water Quality Concern Index includes the additional variables of fecal coliform bacteria (FCB) and ammonium (NH4), where high FCB and high NH4 would cause the most concern. We present 5-year trends in these variables at 40 long-term monitoring stations, as well as results of the indices. Areas showing the highest sensitivity to eutrophication are Saratoga Passage, Possession Sound, Penn Cove and Hood Canal. Areas of highest water quality concern include Possession Sound, Penn Cove, Budd Inlet, Hood Canal, and Grays Harbor. This analysis was recently published in the 2007 Puget Sound Update, by the Puget Sound Action Team.

Poster Group 12: Toxic Contaminants

Water-Borne Loading of PCBs and PBDEs to the Strait of Georgia: Rivers and Wastewaters.

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A legacy of historical polychlorinated biphenyl (PCB) and, more recently, polybrominated diphenyl ether (PBDE) contamination is evident in tissues of aquatic organisms in the Strait of Georgia ecosystem. An effort is underway to characterize loading of these contaminants by potential sources. To this end, we have conducted sampling to understand the contribution of water-borne sources to the Strait, both from rivers and from the major municipal wastewater effluents. Measurements have been collected over 2004-2006. PCBs and PBDEs in the Fraser River were sampled quarterly at three sites using a discharge-weighted compositing scheme and pre-concentrated using XAD-2 resin before analysis. Large-volume samples (40-120L) were collected quarterly from three additional river sites in the basin using an Infiltrex II submersible pump fitted with an XAD-2 resin column. Effluent samples were collected quarterly at discharges in both Greater Vancouver and Victoria. Four-litre 24 hour composites samples were collected and extracted in total. All samples were analyzed for PCB and PBDE congeners by high-resolution gas chromatography-mass spectrometry. Total PCB and PBDE loadings and congener patterns, seasonally and between sites will be presented and related to other similar samples on the west coast and elsewhere.

Fonofos Poisons Raptors and Waterfowl Several Months After Granular Application

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Pierre Mineau, Suzanne Trudeau, John Elliott, Environment Canada

Fraser Delta farmland supports intensive agriculture and provides important habitat for birds. Potato production requires management of wireworm (Agriotes spp.), an introduced pest; in 1994, fonofos became the recommended insecticidal option. Over the ensuing five years, we confirmed 15 raptors, including 12 bald eagles (Haliaeetus leucocephalus), found dead or debilitated in the Delta had severely inhibited cholinesterase activity and fonofos residues in ingesta. Fourteen raptors contained duck remains. Another seven bald eagles had severe cholinesterase inhibition, but without evidence of fonofos residues. During the 2 winters of 1996-98, 420 ha of potato fields, half treated the previous spring with fonofos, and the remainder untreated, were searched weekly for wildlife remains. Waterfowl outnumbered other species in field-use counts and birds found dead. Of the 211 wildlife remains observed, most had been scavenged. Thirty-five intact carcasses were suitable for post-mortem examination and/or toxicology analyses; of those, 30 brains were assayed for cholinesterase levels, with 5 of 18 waterfowl being severely depressed. The ingesta of a mallard found in a fonofos-treated field contained 49 µg/g fonofos residues, linking waterfowl mortality with labelled use of the product. The findings demonstrate the risk of poisoning by anti-cholinesterase where non-target wildlife forage intensively in farmed fields.

Current Use Pesticides in Fraser River Salmon Habitat

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Million Woudneh, AXYS Analytical Services
Tom G. Brown, Pacific Biological Station
Chris Kennedy, Simon Fraser University
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The use of current use pesticides (CUPs) represents a growing conservation concern to Fraser River salmon habitat. We carried out a study of CUPs in two salmon-bearing tributaries of the Fraser River, and one reference site on British Columbia' s central coast, comprising urban (Musqueam Creek), agricultural (Nathan Creek), and remote (Koeye River) areas. Water, sediment, air, and coho salmon (*Oncorhynchus kisutch*) smolt samples were collected from each site. Total pesticide concentrations in three of the four matrices were highest at the agricultural site (water: 162 ng L-1, sediment: 1475 ng L-1, air: 1285 ng L-1), while concentrations detected in biota were highest at the urban site (54.5 ng L-1). Correlations between log Kow and observed water:sediment ratios (agricultural r2 = 0.36, urban r2 = 0.64) and between Henry' s Law coefficients and air:water ratios (agricultural r2 = 0.55, urban r2 = 0.09) revealed the importance of physicochemical properties in determining the fate of different pesticides in aquatic environments. Inter-site differences likely reflect the heavy agricultural use of CUPs near Nathan Creek, a legacy of organochlorine contamination in Musqueam Creek, and atmospheric delivery of pesticides to the Koeye River. Differences in concentrations and patterns of CUPs in different environmental compartments underscore the complex nature of defining ëexposure' and ultimately of assessing risk of adverse health effects in sensitive salmonids.

PCBs and PBDEs in the Georgia Basin Water Column

Neil Dangerfield, Norman Crewe, Robie Macdonald, Fisheries and Oceans Canada*
Pat Shaw, Environment Canada
Peter Ross, Fisheries and Oceans Canada

We collected water samples at two stations in the southern Strait of Georgia aboard the CCGS Vector to measure concentrations of PCBs and PBDEs and to estimate exchange. Samples were collected at both near surface (-10m) and near bottom (variable depths) seasonally over a one year period. In an effort to capture movement in and out of the system, a minimum of one tidal cycle was sampled with InfiltrexTM in-situ samplers. Current speed and direction, conductivity, temperature and salinity were recorded at timed intervals during sampler deployment. PBDEs were analyzed at the Institute of Ocean Sciences two fractions, representing dissolved (XAD) and particle-bound (0.7 um GF/F). PBDEs partitioned preferentially into the dissolved phase, which comprised 63 +/- 10% in shallow water and 54 +/- 2.1 % in deep water. This partitioning was in part related to chemical properties of the PBDEs, with the ëheavier' decaBDE more readily associating itself with particles. Principal components analysis (PCA) further revealed a congener-related pattern difference between the dissolved and the particle-bound fractions, highlighting the importance of both particles in the water column and sampling methodology. Given the increasing presence of unregulated PBDEs in the environment, partitioning in the water column represents an important prelude to food web accumulation of these endocrine disrupting chemicals.

Effects of Six Airborne Short-Chain Aldehydes on Alveolar Macrophages

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Aldehydes are ubiquitous airborne contaminants originating from anthropogenic and natural sources, and photo-oxidation of hydrocarbons. Use of oxygenated fuels and biofuels also contributed contribute to increased levels and changing patterns of aldehydes. Formaldehyde and acetaldehyde are the most abundant short-chain aldehydes followed by acrolein, and crotonaldehyde. Recently, glyoxal and methylglyoxal have also been detected. While data on aldehyde levels and exposure is are available, there is are significant data gaps on the adverse effects of many aldehydes. These data gaps hamper the comprehensive risk assessment/management of aldehydes. We studied the cytotoxicity of 6 short-chain aldehydes on alveolar macrophages - lung cells in direct and early contact with airborne contaminants. Rat alveolar macrophages were incubated in 96-well plates for up to 4 hours in culture medium containing aldehydes and then assayed for cytotoxic indicators: cell viability (LDH leakage), cellular function (secretion of TNF- α), and glutathione depletion. Acrolein was the most cytotoxic, depleting cellular GSH at 5 μM, and causing cell death and suppression of TNF- α secretion at 50 μM . Crotonaldehyde suppressed TNF- α secretion at 50 μM and cell death at 500 μM. At 500 μM, methylglyoxal, formaldehyde and acetaldehyde also suppressed TNF- α secretion. Aldehyde effects on zymosan-induced chemiluminescence (phagocytic activity) in blood leukocytes was also examined. Acrolein and crotonaldehyde suppressed chemiluminescence at 5 and 50 μM, respectively. These results indicated indicate that the relative cellular toxicity is: acrolein>>crotonaldehyde >methylglyoxal, formaldehyde, acetaldehyde>glyoxal; and the experimental design may be applied to the comprehensive toxicity/risk assessment of all airborne aldehydes.

The Effects of Diesel Exposure on Survival and Gene Expression in Rainbow Trout

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Each day, nearly 3 billion gallons of oil are used in the world, of which 17.000 tonnes were spilled in 2005 alone. Many of the events consisted of inland diesel spills, which may have impacted freshwater ecosystems. In this study, a diesel spike test with juvenile rainbow trout (*Oncorhynchus mykiss*) was carried out to simulate exposure during spills. Chemical analysis was used to identify individual components, and survival was monitored over 7-14 day exposures to establish lethal concentrations. Subsequently, trout livers were used in micro-array experiments to screen for molecular changes that could indicate subtle toxic effects and identify mechanisms of action. Trout survival was affected at diesel exposures of 40-100 mg/L (33-100% mortality). Gene expression was altered at all doses tested (0.8-40 mg/L), but only at the highest dose clusters of genes were up- and down-regulated. Down-regulated gene clusters included those involved in oxygen binding and transport, as well as other carrier proteins. Immune system and detoxification (metabolising enzymes and electron carriers) genes were among the most abundant up-regulated genes. Furthermore, indications that diesel may serve as an endocrine disruptor were documented. Since relatively little is known about the toxic effects of diesel, this study provided an important first step in identifying the short- and long-term risks associated with diesel spills in freshwater ecosystems.

Molecular Approaches for Understanding Oil Spill Impacts on Nearshore Spawning Fish

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Coastal oil spills can have severe ecological effects on intertidal and shallow subtidal zones, which provide critical spawning and nursery habitat for numerous species. Several important northeast Pacific forage fish species deposit demersal, adherent eggs in these zones including Pacific herring (*Clupea pallasi*), sand lance (Ammodytes hexapterus), and surf smelt (Hypomesus pretiosus). The sensitivity of teleost embryos to crude oil was demonstrated by the Exxon Valdez oil spill, which coincided with the spawning of Pacific herring in Prince William Sound.

Studies following the spill showed that embryonic exposure to polycyclic aromatic hydrocarbons (PAHs) in crude oil induces a common suite of developmental defects including pericardial and yolk sac edema, craniofacial and body axis defects. Moreover, significant sublethal effects result in the absence of obvious malformations. Our basic studies of PAH toxicity in the zebrafish model identified the developing heart as the primary target of the tricyclic compounds most abundant in crude oil. Using the sophisticated genetic and molecular tools associated with the zebrafish model, such as gene knockdown techniques and DNA microarrays, we are working to identify potential candidate genes expressed in the developing heart that are misregulated in response to PAH exposure. Toward the ultimate goal of developing physiologically relevant biomarkers for PAH exposure, we are groundtruthing these findings in Pacific herring embryos.

Environmental Partitioning of *Phthalate Mono Esters*

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Environmental Partitioning of Phthalate Mono Esters Phthalate di-esters (PDEs) are synthetic chemicals produced worldwide in large volumes (5 M tones/yr) for use in medical and consumer products. PDEs are rapidly hydrolyzed to form phthalate mono-esters (PMEs), which are thought to be the more toxic form. The behavior and fate of these PMEs in the environment is largely unknown. This paper reports on laboratory and field studies to determine the sediment-water partitioning (Koc) characteristics of PMEs. Sorption coefficients for 8 different PME congeners in saltwater and freshwater at neutral pH levels were measured in sterilized marine and fresh water sediments in the laboratory and in natural sediments in field studies. Sorption coefficients ranged between 47 and 75 L/Kg, while sorption coefficients in field sediments ranged between 1027 and 2568 L/Kg. The sorption coefficients from laboratory studies were lower than expected from their Kow values and also lower than those measured at marine field locations. We conclude that PMEs partition rapidly between water and sediments with equilibration less than 24 hrs and that at neutral pH partition coefficients are much lower than expected from their reported Kow.

Post-Harvest Aluminum Toxicity in Podzolic Soils of the Sunshine Coast, B.C.

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Most forest soils in the Georgia Basin – Puget Sound area are acidic and naturally high in available aluminum. Aluminum is toxic to most terrestrial biota, and after leaching into drainage waters, to aquatic biota. This study investigates the changes in aluminum geochemistry following forest harvesting. We collected soil samples from undisturbed plots, and compared them to samples from neighbouring plots that were clear-cut 1 to 15 years ago. Geochemical analyses revealed that the soils are very acidic and at risk for aluminum toxicity. There is no change in pH following logging. The soils are podzolic and exhibit a thick (up to 15cm) Ae horizon. Imogolite-type material (ITM) is widespread in the sub-soil horizons. ITM is a very reactive, amorphous mineral rich in aluminum. If dissolved it may release toxic aluminum ions to soil and drainage water. Forested plots of this study contain up to 40g ITM/kg soil. In logged plots the soil ITM content decreases to a low of 12g/kg in the 5 years harvested plot. We observe only weak signs of ITM pool recovery at 15 years post disturbance. Forest harvesting seems to cause a lasting disruption of ITM. In logged plots we also observe a slight increase in exchangeable aluminum. However, exchangeable calcium levels also increase after harvesting and may help alleviate aluminum toxicity in these soils. The Ca/Al molar ratio, a useful predictor of aluminum toxicity in soils, is remarkably constant (around 1.1) in all plots.

Environmental Contaminants in the Marine Foods of Vancouver Island First Nations; a Community-Oriented Risk Evaluation

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Peter Ross, Institute of Ocean Science

Traditional marine foods play a crucial role in the food security and culture of coastal First Nations in British Columbia. Growing concerns regarding the continued safety of these foods has arisen from reports of high contaminant levels in salmon, crab, and harbour seals. Currently, there is little quantitative information available on dietary preferences and consumption patterns of coastal First Nations, making it impossible to assess the risk posed by these contaminants. Our study has two elements: 1) dietary surveys of up to 60 respondents at each of five partnering First Nations communities on Vancouver Island (Quatsino, Ahousaht, Campbell River, Snuneymuxw, and Pacheedaht First Nations); and 2) Contaminant analysis of four sentinel food species collected from each of the five communities (harbour seals, sockeye salmon, Dungeness crab, and butter clams). Preliminary dietary survey results indicate a heavy reliance on traditional seafoods, including salmon and crab. Analyses for polychlorinated biphenyls (PCBs), polybrominated diphenylethers (PBDEs) and organochlorine pesticides of 78 samples are currently underway. Through participatory research, our goal is to increase understanding of the integrity of coastal traditional food systems, and of the health benefits and risks associated with the consumption of traditional food resources.

Levels of Chemical Contamination and Toxicity in Sediments from Hood Canal, WA (1952 – 2005)

Sandra Aasen, Margaret Dutch, Edward Long, Washington State Department of Ecology*

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.

Polybrominated Diphenyl Ethers (PBDEs) In Puget Sound Sediments – A Baseline Update

Margaret Dutch, Sandra Aasen, Washington State Department of Ecology*

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.

Inorganic Arsenic Concentrations in Seafood Species from the Lower Duwamish Waterway (Seattle, WA) and Puget Sound Background Areas

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Doug Hotchkiss, Port of Seattle
Jeff Stern, King County
Skip Fox, The Boeing Company
Jennie Goldberg, City of Seattle

The Lower Duwamish Waterway (LDW) in Seattle, WA was designated by EPA as a Superfund site in 2001. In support of the human health risk assessment, fish and shellfish species potentially eaten by people were collected and analyzed for inorganic arsenic. Arsenic naturally occurs in the earth' s crust and is also found at elevated concentrations in soil from central Puget Sound, including areas near the LDW, as a result of industrial activity at the former Asarco smelter in Ruston, WA. Consequently, background samples of fish (English sole and shiner surfperch), crab (Dungeness and slender), and clams (Eastern softshell and Macoma) were collected for use in an incremental risk assessment. Inorganic arsenic concentrations in perch, English sole, and crab were similar between LDW and background areas. Inorganic arsenic concentrations in LDW clams, however, were many times higher than inorganic arsenic concentrations in clams from background areas. Concentrations of inorganic arsenic in softshell clams from the LDW ranged from 0.132 to 3.27 mg/kg wet weight, compared to inorganic arsenic concentrations in clams from two background areas, which ranged from 0.047 to 0.227 mg/kg wet weight. The LDW concentrations are much higher than inorganic arsenic concentrations reported in the scientific literature for other northwest shellfish. Hypotheses to explain the unusual results are evaluated.

Atmospheric Transport of Persistent Organic Pollutants (Pops) in Southern British Columbia: Implications for Coastal Food Webs

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Environmental contaminants come from many sources and can enter the marine environment in a variety of ways. The high concentrations of persistent organic pollutants (POPs) reported in marine mammals inhabiting ëpristine' areas support the notion that atmospheric transport processes can readily deliver contaminants of concern to remote food webs. However, the propensity of a given contaminant to undergo long range atmospheric transport depends on the interaction between its physicochemical properties and numerous environmental features. We investigated the levels of various POPs (including polychlorinated biphenyls (PCBs), polybraminated diphenyl ethers (PBDEs), and organochlorine pesticides) in air samples collected from southern British Columbia. Samples were collected weekly and pooled into seasonal samples for analyses during a 12-month period in 2004. Two sampling stations were used, comprising 1) Georgia Basin (Saturna Island), in close proximity to local industries and urban centers, and 2) the west coast of Vancouver Island (Ucluelet), a remote location which receives air masses from Asian sources. Some of our previous work has suggested that a combination of ëlocal' and ëglobal' contaminants is contributing to the heavy contamination of marine mammals, including harbour seals (Phoca vitulina) and killer whales (Orcinus orca). The present study sheds some light on the important role that atmospherically-delivered contaminants plays in contaminating coastal food webs.

Feeding Rates of Benthic Suspension-Feeding Macroinvertebrates in Washington State on the Toxin-Producing *Phytoplankton Pseudo-Nitzschia*

Eva Dusek, Charles Simenstad, Micaela Parker, Andre Punt, Megan Dethier, University of Washington*

In Washington state, blooms of the toxin-producing phytoplankton Pseudo-nitzschia have caused numerous beach closures for shellfish collection. Several species of Pseudo-nitzschia produce the neurotoxin domoic acid, which bio-accumulates in the soft tissues of suspension-feeding shellfish and can cause death in vertebrate predators. Since 1991, beach closures for razor clam collection have occurred regularly along the Washington coast. In Puget Sound, however, beach closures for domoic acid have been less frequent, and only first occurred in 2003. One hypothesized reason for the higher frequency of beach closures along the Washington coast relates to differences between suspension-feeding assemblages on sand/cobble beaches in the two locations: specifically, Puget Sound has a more complex assemblage of suspension-feeders that consume Pseudo-nitzschia, whereas along the Washington coast, consumption of Pseudo-nitzschia is concentrated in fewer and more harvestable species. To test this hypothesis, feeding capacity on Pseudo-nitzschia was assessed in 13 species of shellfish found in Washington. Generally, oysters and mussels consumed Pseudo-nitzschia at substantially higher rates than clams, and bivalves found in Puget Sound consumed Pseudo-nitzschia faster than razor clams found on the Washington coast. These data will be presented with a generalized model to assess the capacity of Washington's nearshore assemblages to filter Pseudo-nitzschia from the water column.

2007 Georgia Basin Puget Sound

Research Conference

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Jamie Alley is a geographer by training with degrees in natural resource management from Simon Fraser University and the University of Victoria. Jamie began his career with the BC provincial Government in 1977 and has held a variety of positions in natural resource ministries as well as the Intergovernmental Relations Secretariat and the Cabinet Office. He is currently the Director of the new Oceans and Marine Fisheries Branch of the Ministry of Environment and has responsibility for marine fisheries management, seafood industry development and oceans resource management.

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Amanda Babson hails from Gloucester, Massachusetts. She majored in physics at Carleton College in Northfield, Minnesota. She received her M.S. from the University of Washington School of Oceanography in 2002 and will receive her Ph.D. from the same institution in December 2006. Her research has focused on questions of circulation variability in Puget Sound using simplified and idealized modeling tools.

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Peter Bahls is Director of Northwest Watershed Institute, a non-profit organization based in Port Townsend, WA. He earned an M.S. in Fisheries Science and Aquatic Ecology from Oregon State University and has worked on watershed assessment, protection, and restoration in Oregon and Washington for over 12 years.

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Leslie Banigan is a Registered Sanitarian with the National Environmental Health Association and a certified On-Site Wastewater Inspector with Washington State Department of Licensing. She is the Pollution Identification and Correction (PIC) Program Coordinator at the Bremerton-Kitsap County Health District and has been with the Health District's Water Quality Program since 1996. Since 1996, Leslie has worked on various pollution identification and correction projects throughout Kitsap County including Port Gamble Bay, Gorst, Tracyton, Long Lake, Burley Lagoon and the Upper Hood Canal. Her efforts in Port Gamble Bay and Burley Lagoon were key in the identification and correction of sources of fecal coliform pollution that eventually led to the upgrade of commercial shellfish growing areas. She is co-founder of the PIC Protocol and Priority List. In addition, Leslie developed extensive experience in water quality monitoring techniques while assisting with the Health District's Stream and Marine Water Trend Monitoring Program.

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Carrie Baron is the Drainage & Environment Manager for the City of Surrey. She is a Water Resources Engineer with over 21 years of experience in this field from both a municipal and consulting perspective. Her section's responsibilities include overseeing the function of the natural and manmade drainage systems within Surrey and the Engineering component of the Nature Matters Program.

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Russel Barsh studied human ecology and law at Harvard, then taught at the University of Washington (1974-84), University of Lethbridge (1993-99) and New York University (2000-2002), and advised on Indigenous peoples and environmental issues at the United Nations (1984-2000). He now directs KWIAHT, a nonprofit conservation laboratory in the San Juan Islands with a focus on human and climate forcing of long term ecosystem change.

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After two years in the Danish Ministry for Foreign Affairs, Henriette Bastrup-Birk worked for more than ten years in the EU Commission (Brussels) on community development and collaborative ecosystem management in cross-border regions. Between 1998 and 2005, she undertook ten study tours to the PS/GB region in order to gain better understanding of land use planning and ecosystem restoration in this region, meeting a variety of actors north and south of the border. In 1999, 2000 and 2003, she spoke at seminars and conferences in the region. She is currently research associate at the Department for Educational Science and Learning, Catholic University of Leuven, Belgium. She will be a visiting scholar at UBC in spring 2007.

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Eric Beamer has worked as a scientist for the Skagit River System Cooperative since 1984. He is the principle investigator on several Skagit watershed projects, including monitoring Chinook salmon in the tidal delta & nearshore, studies of the use of non-natal estuaries by juvenile Chinook salmon, and recent research that directly links estuarine & nearshore habitat to recovery of wild Skagit River Chinook salmon populations.

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Rebecca Best is completing her M.Sc. at the Centre for Applied Conservation Research at UBC. In September, she plans to begin Ph.D. research on the ecology of invasive species in Pacific Northwest eelgrass beds.

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Chief Darren Blaney is serving his 2nd 3 year term as Chief of Homalco First Nations and has also served 6 years as the Council President of Bute Inlet Development Corporation. He received a Bachelors in First Nations Studies in 1998 from Malaspina.

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Gina Bonifacino (panel moderator) is an Air Quality Planner with the US EPA Region 10 Office which has jurisdiction in the Pacific Northwest states of Washington, Oregon, Idaho, and Alaska. Prior to coming to EPA, Gina was a fisheries volunteer with the US Peace Corps in the Philippines. She holds a B.S. in Environmental Resource Management from Penn State University and an M.S.E.S. and a Master of Public Affairs (M.P.A) from Indiana University.

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Lynne Bonner has been working in the British Columbia Ministry of Environment's State of Environment Reporting unit for the past 4 years. Over the past 18 years with the provincial government in Victoria, BC, she has worked in habitat enhancement, monitoring and inventory programs and was instrumental in developing standards for wildlife habitat ratings applied to terrestrial ecosystem mapping. Currently, Lynne is working on updating the Environmental Trends in British Columbia report for projected release in late 2007.

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John teaches field biology, natural history, evolution, environmental issues, and folk music performance at Fairhaven College of Interdisciplinary Studies at Western Washington University. His current research centers on changes in NW Washington marine bird abundance. His past research includes studies on bowhead whales and acoustic communication in songbirds. Most recently, John and his family lived 500 miles off the coast of Chile on Isla Robinson Crusoe for five months while studying endangered hummingbirds and seabirds.

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Ms. Jill Brandenberger is a marine chemistry research scientist. She manages programs focusing on the biogeochemical cycling of trace metals in marine and freshwater environments. Recent research programs focus on correlations between storm water loading of contaminants and land use classifications, watershed scale contaminant mass balances, evaluating historical trends in hypoxia in the Puget Sound, biotic uptake and depuration of uranium, and the dissolution of barite and release of associated trace metals in the marine environment.

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Scott Brewer is currently the Salmon Recovery Program Manager with the Hood Canal Coordinating Council. Scott has a BA degree in Urban and Metropolitan Studies/Policy Analysis from Michigan State University and Master of Science from the UW School of Fisheries. Scott also worked as a Senior Ecologist for King County on salmon recovery planning for the Lake Washington/Cedar River watershed. Scott has also served as the Director of the Port Gamble S'Klallam Tribe's Natural Resources Department; an Ecologist with American Rivers; and Fisheries Manager with the Skokomish Tribe.

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Ginny Broadhurst is the Marine Program Coordinator for the Northwest Straits Commission. She manages regional marine conservation and restoration projects and provides technical support to seven Marine Resources Committees. Ginny has a BS in environmental conservation from University of New Hampshire and an MMA in marine affairs from University of Washington.

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Irene B. Brooks was appointed as Commissioner to the U.S. Section, International Joint Commission, by President George W. Bush and assumed office on December 3, 2002.

In an era of unique challenges, Irene Brooks has carefully and thoughtfully tread an impressive path as administrator, negotiator and leader. She was appointed by Governor Tom Ridge to represent Pennsylvania on all interstate river basin commissions of which the Commonwealth is a member. Ms. Brooks served as Pennsylvania Commissioner and Executive Director, Pennsylvania Department of Environmental Protection, Office for River Basin Cooperation from 1995-2002. She coordinated with the Secretary of the Department and the Governor's Office on a variety of interstate issues, including the development of long-range plans and adoption of policies, as well as regulations affecting the water of millions of citizens within fifteen states and two Canadian Provinces. She served as Chair of the Great Lakes Commission from 1998-2000 and Vice Chair from 1996-1998.

In 1989 she was appointed by President George Bush to serve as the United States Commissioner to the Delaware River Basin Commission, a five-member regulatory and quasi-judicial agency managing the water resources within the 13,000-square-mile Delaware River Basin. She helped formulate federal policy, coordinating a consensus among all federal agencies and working with Congressional committees, individual Congressmen and staff members plus state and federal representatives.

Previously, Ms. Brooks was appointed by unanimous vote of the Court of Common Pleas to complete a term as Chester County Commissioner and was subsequently elected to that position. She developed and implemented a comprehensive countywide plan to help protect and preserve the environment, farmland and open spaces, the first of its kind in Pennsylvania. The Chester County Open Space Program has been adopted by other counties across the country and has won several Presidential Awards.

Ms. Brooks graduated cum laude with a Bachelor's degree in political science/public administration from West Chester University. She has received the Mary H. Marsh Medal from the American Water Resources Association, the Stewardship Award from the Delaware River Basin Commission, recognition for her outstanding service from the Great Lakes Commission, the Leadership Award from the Interstate Council on Water Policy and the Outstanding Service to Conservation Award from The Nature Conservancy, among others. She enjoys fly fishing, tennis and exploring the ebbs and flows of notable American tributaries.

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Darren Brown is an Environmental Coordinator with the City of Abbotsford. Previous to his position with the City, he worked in the private sector both nationally and internationally covering a wide variety of environmental issues and disciplines.

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Dr. Burd's Benthic work has taken two directions; 1) development of sampling designs for aquatic habitats, as well as analysis of benthic community response and recovery patterns as they relate to the environment. These projects are numerous, and cover a variety of temperate and tropical marine habitats from 1980 to present. Some projects are outlined in the attached curriculum vita, and include relatively untouched areas as well those potentially affected by metal mines, pulp mills, fish farms and multiple discharges (sewage, stormwater, industrial, ocean dumping); 2) development of sampling and analytical protocols and theory for benthic research and monitoring programs.

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Jeff dissertation focused on eelgrass (*Zostera marina*) ecology and restoration. Jeff has worked on numerous eelgrass restoration and monitoring projects throughout the northeastern US and has traveled the world monitoring seagrass distribution and status for SeagrassNet, a global seagrass monitoring project. Jeff joined the Washington State Department of Natural Resources in 2006 as a seagrass ecologist for the Submerged Vegetation Monitoring Project.

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Chief Leah George-Wilson is a member of the Tsleil-Waututh Nation, located in North Vancouver, BC, Canada. Chief George-Wilson was the first female to be elected Chief by the Tsleil-Waututh First Nation (2001-2003), and is currently serving her second term (2005-2007). Chief George-Wilson has held various positions prior to her election. Most notable include: the Director of the Tsleil-Waututh Nation Treaty, Lands and Resources Department, a key member of the Tsleil-Waututh First Nation's negotiating team in the BC Treaty Process, Self-Government Co-ordinator and community advocate. Chief George-Wilson frequently speaks on issues related to First Nations governance to various school groups, ranging from elementary to post secondary. She possesses a degree in anthropology from Simon Fraser University and is the recipient of the Outstanding Graduate Award by Leadership Vancouver. She is a board member for the Legal Services Society, the Chief Dan George Centre, Fraser Basin Council, Georgia Basin Council, as well as Ecotrust Canada. In 2004, she was elected to serve as Co-Chair of the First Nations Summit, which is the organization that represents First Nations in the BC Treaty Process. Chief George-Wilson has been happily married for 13 years, and has a beautiful daughter.

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Todd has worked at several National Parks across western Canada as an ecologist and a park warden since 1982. The range of work as a park ecologist is multi-faceted, ranging across disciplines of both natural and social sciences and across a range of freshwater, marine and terrestrial ecosystems. Todd is currently working as the ecologist for Gulf Islands National Park Reserve. He has been involved in this venture since park establishment in 2003. This move to Canada's Mediterranean follows 10 years in another paradise, working on the Haida Gwaii Archipelago (Queen Charlotte Islands) as the ecologist for Gwaii Haanas National Park Reserve and Haida Heritage Site.

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Chief Gibby Jacob, whose ancestral name is Kákeltn siyám, carries the title of hereditary Chief and is a member of the Squamish Nation located in North Vancouver, British Columbia, Canada. Chief Jacob has been an elected Councilor, since December 1981 serving seven consecutive four-year terms. Chief Jacob is the Executive Operating Officer of Intergovernmental Relations, Natural Resources, and Revenue for the Squamish Nation and is responsible for overseeing four departments: Project Negotiation & Development; Business Revenue & Services; Environmental & Natural Resources; and Land Management.
Chief Jacob plays an instrumental role within the Squamish Nation as:

- Chief Negotiator – this is a process to produce modern day treaties between First Nations and the Province of British Columbia, the Squamish Nation treaty negotiation process was initiated in September 1992.
- Political spokesperson – communicating with and addressing the local media, and informing the 3,700 members of the Squamish Nation.
- Chairperson for the Land & Resource Sub-committee – this is a subcommittee of the Squamish Nation Main Treaty Committee with a mandate including environmental issues, renewable and non-renewable resources, assertion of rights and title within the Squamish Nation traditional territories, and land development opportunities.
- Chairperson of Land Issues & Environmental Committee – with a mandate that includes the Capilano Master Plan, BC Rail properties, Squamish Estuary, and Porteau Cove lands, forestry, and "Run of the River" micro-hydro project to name just a few of their ongoing projects and initiatives.
- Intergovernmental relations – liaising and relationship building with all levels of government including Municipal, Regional, Provincial, Federal, and First Nation's and First Nation organizations.

Other organizational involvement includes:

- Founding Director of EAGLE (Environmental Aboriginal Guardianship through Law and Education);
- Board of Directors for the Vancouver 2010 Olympic and Paralympic Winter Games for both the Squamish Nation and the Lil'wat Nation;
- Co-chair of the British Columbia Aboriginal Fisheries Commission – Coastal Region for four years;
- Former Representative of Canada for the Pacific Salmon Commission for a two year term; and
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My research involves laboratory and field projects involving juvenile salmon. Most of my time is devoted helping to understand salmon habitat use through field monitoring and telemetry. Laboratory techniques include surgical tagging and necropsy of salmonids. Often my responsibilities often include animal husbandry tasks such as feeding and caring for salmonids, and disease prevention and identification. My field experience includes various fishing techniques, boat handling skills, and fish and invertebrate collection and identification.

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Dr. Daniel Pauly is a French citizen, born in May 1946 in Paris, France. He grew up in the French-speaking part of Switzerland, but completed high school and university studies in the Federal Republic of Germany, where he acquired a "Diplom" (= MSc) in 1974 and a Doctorate degree in Fisheries Biology in 1979 at the University of Kiel.
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Anja Schanz is currently leading the Eelgrass Stressor-Response Project, which focus on identifying the causes of eelgrass losses in Puget Sound with the Washington State Department of Natural Resources. As a post-doctoral researcher she worked on the development and intercalibration of a Trilateral Seagrass Monitoring and Assessment Program (TMAP) in the Wadden Sea (North Sea), and was involved in projects dealing with the habitat destruction and species lost along the European Coasts (ELME) at the Alfred Wegener Institute for Polar and Marine Research. Her previous research focused on seagrass ecology, hydrodynamics and ecological functions of seagrass systems (PhD). She graduated as a marine biologist (Diploma) at the University of Bremen, Germany.

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Dr. S. Wyllie-Echeverria is a Research Scientist, UW Botanic Gardens and Friday Harbor Laboratories, University of Washington. His expertise lies in the field of seagrass ecology and ethnobotany, primarily with temperate species in the Northeast Pacific.

Tina Wyllie-Echeverria
Wyllie-Echeverria Associates/ Samish Indian Nation
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Tina Wyllie-Echeverria is a fisheries oceanographer who has worked on the life history and habitat of Pacific coast rockfishes, environmental impacts on juvenile walleye pollock and habitat preference of juvenile salmonids. She is currently working in San Juan County, Washington on basic salmonid life history requirements and habitat restoration actions.

Zhaoqing Yang
Senior Research Scientist
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Dr. Yang is a senior scientist in the coastal and water resources modeling group. He has more than 20 years of experience in numerical modeling of estuarine and coastal hydrodynamics and transport processes, as well as general physical oceanography and ocean engineering. He has conducted many studies related to estuarine hydrodynamics, coastal ocean circulation, estuarine and wetland restoration, and sediment and fate transport using 3-D numerical models. Dr. Yang also has extensive experience in Computational Fluid Dynamics (CFD) modeling, groundwater modeling, river flood and magangement analysis.

Gina M. Ylitalo
Supervisory Research Chemist
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Gina Ylitalo is a supervisory research chemist at the Environmental Conservation Division, Northwest Fisheries Science Center in Seattle, WA. Her research interests include assessing links between exposure to chemical contaminants and potential health effects to marine mammals and fish as well as developing methods to analyze for new contaminants of interest in marine sediments and biota.

Anliang A. Zhong
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I am a research associate at the University of British Columbia. My research interests include nutrient cycling in forests, forest nutrition and fertilization, biosolids land application as an organizer fertilizer or soil amendment, and forest health and productivity related to acid rain