



2011 Salish Sea Ecosystem Conference

October 25 - 27, 2011

Vancouver Sheraton Wall Centre

Vancouver, British Columbia

ABSTRACT BOOK

MANY VOICES, ONE SEA



www.salishseaconference.org

Table of Contents

Monday, October 24, 2011	5
T1: Howe Sound SCUBA dive and REEF fish and invertebrate count	5
T3: Tour Cleveland Dam Fish Passage and Capilano Fish Hatchery	5
T4: Pacific Spirit Park Mushroom Walk	5
Tuesday, October 25, 2011	6
Data Fair – Web-based Ecosystem Tools	6
Opening Plenary Panel	12
1A: Contaminants: Sources, fates, transport and impacts I	13
1B: The conservation imperative for the marine birds and mammals of the Salish Sea I	17
1C: Mission possible: Implementing a new culture for urban watershed protection and restoration in the Salish Sea Bio-Region	21
1D: Climate change	23
1E: Estuary science to support adaptive management	26
1F: Multiple Benefits Approach: Integrating social and ecological values to recover the Salish Sea	31
2A: Contaminants: Sources, fates, transport and impacts II	36
2B: The conservation imperative for the marine birds and mammals of the Salish Sea II	41
2C: Puget Sound Watershed Framework - Using the Puget Sound Characterization Project to Guide Planning and Development	46
2D: Implications of ocean acidification for the Salish Sea	49
2E: Restoring estuaries of the Salish Sea: Case studies and social and scientific challenges I	53
2F: The Salish Sea as a coupled social-ecological system	57
3A: Contaminants: sources, fates, transport and impacts III	60
3B: Ecology of forage fish	64
3C: Future growth scenario planning	68
3D: Adapting to future climate change	73
3E: Restoring estuaries of the Salish Sea: Case studies and social and scientific challenges II	77
3F: Roundtable discussion: The role of social sciences in ecosystem recovery	80
Wednesday, October 26, 2011	81
4A: Transboundary air – Shared Canada and US issues	81
4B: Science and management of killer whales I	84
4C: Approaches to assessing the health of the Salish Sea	88

4D: PSP Action Agenda: Strategies and actions	92
4E: Shorelines I: Ecology, restoration & shore-friendly development	93
4F: Media in science outreach: Strategies and new directions	98
5A: Marine Protected Areas in the Salish Sea – A transboundary exploration	101
5B: Science and management of killer whales II	106
5C: Applying environmental indicators for ecosystem-based management	111
5D: Threat and risk assessments in the Salish Sea	115
5E: Shorelines II: Local & regional management tools and issues	119
5F: Building towards a better informed Salish Sea constituency through education and outreach I	124
Lunch and Coast Salish Plenary Panel: "Working together for the Salish Sea"	128
6A: Stormwater: Science and management I - Recent findings	129
6B: The Salish Sea food web—From description to quantification I	133
6C: Traditional foods of the Salish Sea: Connections, current status, and policy	137
6D: Knowledge translation and exchange: Improving ecosystem management through novel collaborations	141
6E: Habitat restoration in the Salish Sea: Headwaters to marine waters I	146
6F: Building towards a better informed Salish Sea constituency through education and outreach II/ Connecting citizen science to research, monitoring and management I	151
7A: Stormwater: Science and management II	156
7B: The Salish Sea food web—From description to quantification II	160
7C: Environmental challenges to safe shellfish harvest and aquaculture	163
7E: Habitat restoration in the Salish Sea: Headwaters to marine waters II	168
7F: Connecting citizen science to research, monitoring and management II	173
Thursday, October 27, 2011	177
8A: Science and management of eutrophication and hypoxia in the Salish Sea I	177
8B: Marine survival of salmon in the Salish Sea	181
8C: Non-native and invasive aquatic species in the Salish Sea: Ecosystem impacts, status, trends, monitoring and control techniques	185
8D: Hydrologic analysis, water resources, and freshwater ecosystems in the Salish Sea watersheds I	189
8E: Cutting edge science: improving ecosystem recovery in the US and Canada	192
8F: Transboundary Monitoring Partnerships	196
9A: Eutrophication and hypoxia in the Salish Sea II	202
9B: Life history and ecology of salmon: Implications for management and conservation in the Salish Sea	205

9C: Seaweeds and seagrasses in the Salish Sea I	209
9D: Hydrologic analysis, water resources, and freshwater ecosystems in the Salish Sea watersheds II	213
9E: Actualizing ecosystem services	217
9F: Transboundary Collaboration I – From Parallel Play to Integrated Play: Case Studies	221
Lunch, SeaDoc Society Salish Sea Science Prize Awards Ceremony and Keynote Address	223
10A: Monitoring and modeling of harmful algal blooms and pathogens that threaten human health in the Salish Sea	224
10B: Frameworks and case studies for ecosystem solutions	228
10C: Seaweeds and seagrasses in the Salish Sea II	232
10D: Numerical models of land and sea	235
10E: Threats to the Salish Sea ecosystem: Perception and reality	239
10F: Transboundary Collaboration II – Raising the Next Generation of Transboundary Projects	242
Closing Plenary—Regional Leaders Panel: "Which comes first? Science and decision-making for protecting the Salish Sea"	242
Poster Presentations	243
Contaminants: Sources, fates, transport and impacts	243
The conservation imperative for the marine birds and mammals of the Salish Sea	253
Climate change	255
Estuary science to support adaptive management	260
Multiple Benefits Approach: Integrating social and ecological values to recover the Salish Sea	262
Puget Sound watershed framework - Using the Puget Sound Characterization Project to guide planning and development	263
Implications of ocean acidification for the Salish Sea	264
Restoring estuaries of the Salish Sea: Case studies and social and scientific challenges	266
The Salish Sea as a coupled social-ecological system	268
Ecology of forage fish	270
Transboundary air: Shared Canada and U.S. issues	274
Science and management of killer whales	276
Shorelines: Ecology, restoration, shore-friendly development, local and regional management tools and issues	280
Marine Protected Areas in the Salish Sea - a transboundary exploration	285
Applying environmental indicators for ecosystem-based management	286

Threat and risk assessments in the Salish Sea	289
Building towards a better informed Salish Sea constituency through education and outreach	291
Stormwater: Science and management	296
The Salish Sea food web—From description to quantification	299
Knowledge translation and exchange: Improving ecosystem management through novel collaborations	302
Habitat restoration in the Salish Sea: Headwaters to marine waters	303
Connecting citizen science to research, monitoring and management	309
Environmental challenges to safe shellfish harvest and aquaculture	314
Science and management of eutrophication and hypoxia in the Salish Sea	317
Marine survival of salmon in the Salish Sea	318
Non-native and invasive aquatic species in the Salish Sea: Ecosystem impacts, status, trends, monitoring and control techniques	322
Hydrologic analysis, water resources, and freshwater ecosystems in the Salish Sea watersheds	324
Transboundary Monitoring Partnerships	327
Life history and ecology of salmon: Implications for management and conservation in the Salish Sea	328
Seaweeds and seagrasses in the Salish Sea	332
Monitoring and modeling of harmful algal blooms and pathogens that threaten human health in the Salish Sea	337
Frameworks and case studies for ecosystem solutions	341
Numerical models of land and sea	343

Monday, October 24, 2011

10:00 am - 3:00 pm

T1: Howe Sound SCUBA dive and REEF fish and invertebrate count

Join SeaDoc Society for a REEF dive with Sea Dragon Charters. You will learn how to identify common species and discover how recreational divers contribute to our environmental health by collecting data for the REEF database. Explore how scientists and agencies throughout the country use this data to monitor the health and success of our ecosystem. If you'd prefer not to count species on your dives, feel free to join us to simply learn and have fun. Please bring your SCUBA certification cards, SeaDoc Society will supply the REEF information.

1:00 pm - 4:00 pm

T3: Tour Cleveland Dam Fish Passage and Capilano Fish Hatchery

Visit Capilano River Regional Park for a tour of the Cleveland Dam and Capilano Fish Hatchery. The numerous dams in the Salish Sea region have created unique challenges for organizations to restore the ecological integrity of the aquatic ecosystems that have been altered by these river impoundments. Learn about fish passage that are currently operating or are in stages of development to improve the survival of salmon and trout in the Capilano River. Participate on a tour of the Capilano Fish Hatchery that is sustaining a sport fishery, providing research and education opportunities. Take in scenic views at Cleveland Dam and a 30 minute walk (optional) to the Capilano Fish Hatchery. Wear shoes suitable for walking and dress for the weather.

T4: Pacific Spirit Park Mushroom Walk

Join us and Terry Taylor for an informative walk through Pacific Spirit Park to learn about mushrooms! Since it is a park we will not be collecting mushrooms but we will look at what species are present as well as the fungal ecology in the park. Our tour guide, Terry Taylor, has studied the native BC flora and fungi for the past 40 years. He performs botanical identifications for environmental impact studies in various parts of the province. Terry is a member of several naturalist and botanical societies, including Nature Vancouver, Vancouver Mycological Society, Native Plant Society of BC, American Bryological and Lichenological Society, as well as the Sigma Xi Research Society. Terry received the Queen's Jubilee Medal for nature education in 2003. Wear shoes suitable for walking and dress for the weather.

Tuesday, October 25, 2011

7:30 am - 8:30 am
Registration

8:30 am - 7:00 pm

Data Fair – Web-based Ecosystem Tools

Parksville Room, Third Floor

Don't miss this special opportunity to view, test, and explore resources related to data collection, handling and sharing, mapping, modeling, and more. Drop in, see displays, interact with experts, and experiment with models or databases on screen. Governmental, academic, and nonprofit organizations are showcasing freely available resources and tools that may be helpful and relevant to your own work in the Salish Sea. Visit our Data Fair throughout the day on Tuesday. Data fair presenters will be available particularly during breaks and the evening Poster Gala.

Suzanne Shull

Island County Marine Resource Committee of the NW Straits Commission
Island County Sound IQ
Suzanne Shull, Linda Rhodes, Ann Stark

Abstract:

The Island County Marine Resource Committee (MRC) has collected a variety of nearshore, geospatially-referenced data on forage fish, feeder bluffs, eelgrass and more. These, along with data collected by natural resource agencies, reside in many separate, isolated locations, largely unknown to the public, scientists, and planners at all levels to whom they might be helpful in making decisions.

In a collaborative venture toward improving archival of and access to these data, the MRC, with support from the Northwest Straits Commission, partnered with the City of Bellingham to create Island County Sound IQ, an adaptation of the land-based Web Mapping Service City IQ. The result is a web-based Ecosystem Tool designed to consolidate disparate data, provide interactive mapping, and to produce data summaries of Island County's nearshore data.

Points of interest in the nearshore that have been identified by the MRC provide selectable query locations on the map that link to a variety of relevant information. Data layers are grouped into the following 10 map services: Human Structures and Activities; Invertebrate Distribution; Birds and Marine Mammals; Fish Distribution (Salmonids and Forage Fishes); Intertidal/Subtidal Habitat; Shoretypes and Slopes; Freshwater Bodies and Sources; Aerial Photos; Digital Terrain; and Base Map.

Sound IQ is a compilation of publicly available data layers developed by the Island County MRC, Puget Sound Nearshore Restoration Project, Washington State Department of Health, National Oceanic and Atmospheric Administration, Washington Department of Fish and Wildlife, Washington Department of Natural Resources, and the United States Agriculture Department. Assistance with data acquisition was also provided by ESA Adolphson and by the Island County Planning, Public Works, and Health Departments.

Joan Drinkwin

Northwest Straits Foundation
Washington Statewide Derelict Fishing Gear Database
Joan Drinkwin, Ginny Broadhurst, Jeff June, Kyle Antonelis, Abby Faust

Abstract:

Derelict fishing gear includes nets, lines, pots and traps that are lost or abandoned during commercial and recreational fishing activities. Much of this gear is made from plastic and never degrades in the marine environment. It continues to fish indiscriminately for decades. Derelict fishing gear in the Salish Sea has been documented to entangle and kill multiple species including mammals, birds, and fish. Derelict gear also destroys a variety of marine habitats.

The Northwest Straits Initiative manages a comprehensive program aimed at eliminating harm from derelict fishing gear in Puget Sound. The Initiative's program focuses on gear removals, research and prevention. An important tool of this program is the statewide derelict fishing gear database. This database is housed on a Structured Query Language web-based platform and is managed by the Northwest Straits Initiative. The use of this database is available to researchers, resource managers and the public by permission from the Northwest Straits Initiative. Access to non-confidential data is generally provided to whoever requests it.

The database holds data on all reported and removed derelict fishing gear in Puget Sound. It also holds all data related to habitat and species impacts observed during the removal of more than 3,900 derelict nets and 2,000 derelict crab pots in Puget Sound. This database holds a treasure trove of information on impacts of derelict fishing gear in Puget Sound. It includes locations, gear type, size and condition, habitat types, and species impacts. All data can be downloaded into spreadsheet formats or into GIS formats for mapping purposes.

This database will be showcased during the data fair at the Salish Sea conference. Access to the database will be provided to researchers and resource managers at the conference. Requests for permission to use the database after the conference will be taken.

For more information about the Northwest Straits Initiative's derelict fishing gear program, please visit www.derelictgear.org.

Jason Northcott

The Nature Trust of BC
BC Conservation NGO Lands Atlas
Jason Northcott, Dan Buffet, Kathleen Moore

Abstract:

The BC Conservation NGO Lands Atlas represents a joint initiative among environmental non-governmental organizations (ENGOS) and various levels of government. The objective is to create a GIS map layer of BC of the private lands acquired by ENGOS for conservation that is accurate and to the same level of resolution as the current map of Provincial Parks, Ecological Reserves and Wildlife Management Areas. Current Provincial maps do not include conservation lands held by ENGOS, National Parks or National Wildlife Areas, or regional and municipal parks. This project will complement the provincial parks and protected areas map by sourcing the data from common resources and providing the same level of output information in terms of parcel information with all legal/cadastral and attribute fields that are spatially accurate to this scale. The resulting provincial coverage of lands already designated for conservation (whether public or private) will assist the process currently underway to develop a Biodiversity Strategy for BC. Academia, governments and conservation organizations will use the conservation lands map for research, monitoring projects, securement initiatives, and innovative landscape-based management plans. A database has been developed to house the map layer and attribute fields to further detail properties. In addition a Map Atlas was developed with our partners at the Community Mapping Network that will allow easy browsing, querying, and producing reports and maps. This project can aid in regional planning for areas including the Salish Sea to give a complete picture of all conservation land types.

Janna Nichols

Reef Environmental Education Foundation (REEF)

The REEF Survey Project – An ongoing data collection effort in the Salish Sea
Janna Nichols, Christy Pattengill-Semmens

Abstract:

Volunteer data collection, or citizen science, provides a valuable alternative for scientists and resource agencies needing information but lacking sufficient resources to gather it. The Reef Environmental Education Foundation (REEF) Volunteer Survey Project is one such citizen science program. REEF volunteers collect distribution and abundance data on all marine fishes and a sub-set of invertebrates using a standardized visual method during diving and snorkeling activities. This citizen science program has generated one of the largest marine life databases in the world, with over 150,000 surveys conducted to date at thousands of sites throughout the coastal waters of North and Central America, Caribbean, Hawaii, and the South Pacific. The Project, which started in the Florida Keys in 1993, was launched in the Pacific Northwest in 1998. Since then, over 700 divers have conducted 12,307 surveys over 800 sites in the Salish Sea. The program has resulted in a collaborative enterprise in which the general public engages in inquiry and investigation that results in practical management solutions. Data generated through the program have been used in a variety of conservation and management applications, including in the development of the stock assessments, the assessment of marine reserve effects, and the assessment of at-risk species. REEF Survey data are available in summary reports on the REEF website (www.REEF.org) and raw data files are provided to researchers and agencies upon request. REEF surveyors become keen observers and field naturalists. Beyond providing valuable data, REEF's efforts empower volunteers to take an active role in support of effective marine resource management as well as serve an important role in educating the public about issues and threats facing marine resources. We will demonstrate how to explore the REEF dataset through the REEF website, how to generate summary reports on species distributions and geographic regions, how to submit data to the program, and REEF's online training tools.

Robert Neely, Benjamin Shorr

NOAA

NOAA's Climate Assessment and Proactive Response Initiative Puget Sound Pilot

Abstract:

The mission of NOAA's Damage Assessment, Remediation and Restoration Program (DARRP) is to protect and restore coastal and marine resources threatened or injured by oil spills and releases of hazardous substances. Hazardous waste facilities and oil infrastructure in coastal areas may be more vulnerable to releases due to climate related impacts. In response, DARRP developed the Climate Assessment and Proactive Response Initiative (CAPRI) to provide a framework and tool to evaluate potential contaminant impacts in the coastal zone related to climate change. CAPRI's flexible GIS-based framework incorporates an assessment of regionalized climate change forecasts, contaminant threats, and ecosystem and species values and sensitivities into a screening level vulnerability index. The CAPRI framework encompasses four major components: assessment of climate change impacts and related contaminant threats; development of a spatial vulnerability index; use of the web-based, open source Environmental Response Management Application (ERMA) for visualization and analysis of data layers and results; and identification of efficient prevention, response, and restoration options. Selected sites within the Puget Sound are the initial testing ground for the CAPRI framework. This pilot incorporates Puget Sound area-specific datasets. The CAPRI framework is intended to provide a national model that can be adapted to the unique data available in a particular region or coastal area. CAPRI will enable NOAA and other local, state, regional, and federal decision makers to better prepare for and adapt to climate change by improving understanding of contaminant impacts to coastal resources.

Pete Davidson

Bird Studies Canada

Bird data tools for applied biology and conservation management

Pete Davidson, Denis Lepage, Andrew Couturier, Karen Barry, Christopher Di Corrado

Abstract:

Bird Studies Canada (BSC – www.birdscanada.org) is Canada's leading non-government organization focused on bird research and monitoring with the mission of advancing the understanding, appreciation and conservation of wild birds and their habitat. One of BSC's core strengths is in data management, mapping and dissemination, through web-based platforms. BSC has built an innovative suite of web tools that make large scale bird monitoring datasets (from programs like eBird, Canadian Migration Monitoring Network, BC Coastal Waterbird Survey) freely available to the public in standard formats through the website www.naturecounts.ca, and provide trend information using graphs and interpretive maps from some of these surveys. Nature Counts combines data entry, management, download and analytical functions in one central location, and is the only current Canadian node of the Avian Knowledge Network www.avianknowledge.net. One of the best example of advanced web tools for managing and mapping biodiversity data is the BC Breeding Bird Atlas www.birdatlas.bc.ca, one of a suite of provincial scale bird atlases across Canada, that enable public data entry, peer-review and dissemination in tabular and mapped forms, in near real-time. We will present a poster and on-site computer demonstrations of these functions, and describe how these tools are being used by government agencies, environmental consultants, land and resource management interests (from land purchase groups to forestry companies), and academic institutions to advance research, conservation and management in the Salish Sea region.

Justin Longo

Centre for Global Studies, University of Victoria

Digital Fishers: Data from the deep, judgment from the crowd, wisdom from the process

Darryl Bidulock, Tim Boesenkool, Rod Dobell, Eric Guillemot, Maia Hoeberechts, Murray Leslie, Tony Lin, Justin Longo, Marjolaine Matabos, Dwight Owens, Benoit Pirenne, Ronald Schouten, Jodie Walsh

Abstract:

Digital Fishers represents a joint project of NEPTUNE Canada and the Centre for Global Studies (both at the University of Victoria, with additional support from eBriefings.ca) to use the power of crowdsourcing to help filter and annotate the large volume of video data being collected from the NEPTUNE Canada seafloor observatory. As this video data is not currently amenable to machine processing, the guiding position of the Digital Fishers project is that - in the absence of an alternative - this volume of video data will eventually overwhelm the capacities of the NEPTUNE Canada scientific community. A Digital Fishers crowdsourcing option provides the possibility of using the Internet-based volunteer efforts of a large number of non-expert participants as a first-pass alternative to machine processing or analysis by experts.

This poster will place the Digital Fishers project within a broader context of the "staircase of knowledge", a concept that takes us through seven steps, from the recording of observations and the development of data through the creation of information and the building of knowledge to the emergence of the understanding and wisdom which can offer a foundation for legitimate collective action. The ultimate objective of the Digital Fishers project is to provide a platform for web-enable science-oriented crowdsourcing which can assist scientists in managing the firehose of video-data emanating from the NEPTUNE Canada seafloor observatory.

Norma Serra

PacMARA

Marxan conservation and land/sea use planning software

Heather Coleman, Norma Serra, Dave Nicolson

Abstract:

Using Marxan software, conservation and land/sea use planners can identify an efficient system of reserves or specific use sites that include a suite of biodiversity targets at a minimal cost. Marxan provides a unique method for designing reserves that is systematic and repeatable. It is

the most utilized conservation planning tool worldwide; over 60 countries, 1100 users, and 600 organizations use Marxan to support the design of terrestrial and marine reserves. Marxan has also been used to identify marine areas of high conservation utility for British Columbia through the BC Marine Conservation Analysis (BCMCA). The tool helped the BCMCA achieve conservation objectives while minimizing impacts to marine users and coastal communities. This demonstration will give an overview of Marxan's capabilities and outputs.

PacMARA is a Victoria-based charitable organization conducting Marxan training and developing support materials. Marxan is free software hosted by the University of Queensland.

Eric Mielbrecht

EcoAdapt

The Climate Adaptation Knowledge Exchange (CAKE)

Eric Mielbrecht, Jessica Hitt, Rachel Gregg, Alex Score, Jessi Kershner, Jennie Hoffman, Lara Hansen

Abstract:

The Climate Adaptation Knowledge Exchange (CAKE), a joint project of Island Press and EcoAdapt, is aimed at building a shared knowledge base for managing natural systems in the face of rapid climate change. CAKE brings together EcoAdapt's recognized leadership in developing the concepts and practices of climate adaptation with Island Press's 27 years as the leading publisher of solutions-based environmental information to offer the most valuable, up-to-date, and authoritative materials on the subject. Just as importantly, it is intended to help build an innovative community of practice. It helps users to get beyond the limitations of their time and the unwieldy thicket of books, papers and articles by 1) vetting and clearly organizing the best information available, 2) building a community via an interactive online platform, 3) creating a directory of practitioners to share knowledge and strategies, and 4) identifying and explaining data tools and information available from other sites.

It consists principally of four interlinked components: 1) Virtual Library, 2) Case Studies, 3) Directory, and 4) Tools. It also houses community forums for the discussion of current issues in conservation in a changing climate.

CAKE will support the changes that conservation has to make to keep up with the changing planet.

Sarah Mikulak

Applied Physics Lab, University of Washington

Data and data products available via the NANOOS Visualization System (NVS)

E. Mayorga, J. Allan, R. Blair, C. Jaramillo, D.W. Jones, S. Mikulak, C. Risien, C. Seaton, T. Tanner

Abstract:

The mission of NANOOS is to coordinate and support the development, implementation, and operations of a regional coastal ocean observing system (RCOOS) for the Pacific Northwest region, as part of the U.S. Integrated Ocean Observing System (IOOS). NANOOS maintains strong cross-boundary ties with observing programs in Alaska, British Columbia, and in central and northern California through our common purpose and because of the overlap of data and products. A key objective for NANOOS is to provide data and user-defined products to a diverse group of stakeholders in a timely fashion, and at spatial and temporal scales appropriate for their needs. To this end, NANOOS has developed the NANOOS Visualization System (NVS), which aggregates, displays and serves meteorological and oceanographic data, derived from buoys, gliders, tide gages, HF Radar, meteorological stations, river gages, research cruises, seabed cabled platforms and satellites, as well as model forecast information in such a way that it presents end users with a rich, informative and user friendly experience. First released in November 2009, NVS has already undergone several significant updates. While its original focus

and continued strength is on near-real-time (NRT) observations from in-situ assets (buoys, coastal stations, etc.), NVS has evolved to include other types of observations as well as forecast information. NVS integrates data from a wide diversity of providers across the region, ranging from county agencies, private industry and regional partnerships, to core IOOS federal programs, and state agencies and academic groups that are principal partners in NANOOS' Data Management and Communication (DMAC) efforts. Regional and national feedback confirms that NVS has been well received by ocean observing and stakeholder communities alike. Presenters will demonstrate the ability of NVS to serve as a portal for one-stop access to near real-time regional data and forecast products, In addition, we will describe future development plans that include greater functionality, iteratively improving NVS based on feedback received from users and identified stakeholders.

Christianne Wilhelmson

Georgia Strait Alliance

Connecting communities to a healthy Strait: The Georgia Strait online map

Abstract:

There is an indelible connection between people and the landscapes that support the ecosystems and communities in which we live. However, though 70% of British Columbians are very concerned about the region and feel it needs more protection (April 2011 poll - Organizing for Change), many residents of the region, and the communities of which they are a part, are not connecting their own actions to the negative impacts on the Strait, and therefore cannot make changes to reduce those impacts. With an increasing population, and related economic and land use changes in the Salish Sea region, the threats to Georgia Strait are increasing – and their impacts on iconic species speak to this.

The recent fate of salmon, a keystone species in the region, illustrates the problem. The marine survival of coho salmon is declining. In 2009, we saw the crash of the Fraser River sockeye, and despite their return in record numbers in 2010, the reasons for the crash are still unknown. Up the food chain, the killer whale is also threatened. With increasing toxins and pollution finding their way into southern resident killer whales, they are one of the most contaminated marine mammals on the planet, and with only 85 individuals left, are endangered. Our northern resident killer whales are threatened, with approximately 200 individuals remaining.

Building on our years of successful outreach to communities in the region, in early 2011, Georgia Strait Alliance launched an online map (<http://www.mapping.uvic.ca/gsa/>), which visually represents the Strait of Georgia, the people who steward this inland sea, the creatures that make it their home and the many threats to its health. The map is interactive, engaging – with videos, links, and up to date information - and has the potential to increase networking and public engagement among those who care about these waters and increase awareness for those who want to learn more. As it grows, this map will become increasingly a reliable resource guide and directory for environmental issues in and related to the Georgia Strait, as well as a resource for action and solutions that individuals and communities can take to mitigate threats.

Our goal is that this map will educate residents wherever they live about the Strait, provide links to information to help them make sustainable changes in their activities and take action on issues of concern. The map will also provide links to strong science for community leaders to guide their decision making on coastal issues. By engaging communities along the shores of the Strait in understanding local threats that have a regional impact and by getting community leaders to make protection of the Georgia Strait a priority in their community planning, our online map will become an important tool that will result in communities that are more engaged stewards of Georgia Strait. The result will be increased sustainability in community development in the region and a corresponding improvement in ecological health.

8:30 am – 10:00 am

Opening Plenary Panel

Opening Film: A special thank you to PRR and Howard Rosen Productions for providing this inspirational video

Coast Salish Welcome: Tsleil-Waututh Nation Councilor Carleen Thomas

Co-host Welcome:

- Paul Kluckner, Regional Director General, Environment Canada
- Gerry O’Keefe, Executive Director, Puget Sound Partnership
- Local Government Panel

Leading in tough times—How can science keep Salish Sea protection and recovery a priority during challenging economic times?

A panel of officials from US and Canada discusses perspectives on the role of local governments in protecting and restoring the Salish Sea ecosystem, including the relationship between economic development, growth and ecosystem recovery, and the role of science and data in the decision-making process. Audience questions to be invited.

Panel Participants:

- Jay Manning, former Chief of Staff for Governor Gregoire and former Director of the Department of Ecology, Panel Facilitator
- Kitsap County Commissioner Josh W. Brown
- Dow Constantine, King County Executive
- Mayor Lois E. Jackson, The Corporation of Delta
- Mayor Pamela Goldsmith-Jones, District of West Vancouver

10:00 am - 10:30 am

Morning Break

10:30 am - 12:00 pm

1A: Contaminants: Sources, fates, transport and impacts I

This session offers a comprehensive look at our current understanding of the level of contaminants (toxics and nutrients) in various media, characterization of sources, fate and transport processes once released and biological impacts in the Salish Sea. The session focuses on the following themes:

- Contaminants—What do we know about contaminant levels in various media of the Salish Sea?
- Sources—What do we know about sources of contaminants? Examples of source categories include: primary releases, atmospheric deposition, POTWs, rivers and streams and stormwater.
- Fate -Transport - Impacts—What do we know about fate and transport processes along with impacts of contaminants? Examples of topics could include modeling, attenuation, contaminant cycling, biological impacts and biological markers.

Conveners: Dale Norton, Scott Redman, Robie MacDonald
PRR Facilitator: Kimbra Wellock

James West

Washington Department of Fish and Wildlife

Persistent bioaccumulative and toxic contaminants in Puget Sound's pelagic food web

James West, Jennifer Lanksbury, Sandie O'Neill, Gina Ylitalo

Abstract:

Previous studies on Pacific herring and Pacific salmon species, harbor seals and killer whales suggest that Puget Sound's pelagic food web is exposed to an unexpectedly high burden of persistent bioaccumulative and toxic contaminants (PBTs). The present study was designed to fill gaps in our understanding of PBTs in the lowest trophic levels of Puget Sound's pelagic food web, and to bolster our understanding of how residency in Puget Sound affects PBT exposure in mid-trophic level pelagic fish predators. We compared PBT concentrations across a wide range of Puget Sound basins and pollution gradients in phytoplankton, krill (primarily *Euphausia pacifica*), and two species of gadoid codfishes (Pacific hake [*Merluccius productus*] and walleye pollock [*Theragra chalcogramma*]) sampled in this study, along with published PBT results for Pacific herring (*Clupea pallasii*) and Pacific salmon (*Oncorhynchus* spp). Using stable isotopes of nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) in biota tissues to estimate their trophic level and the relative influence of ocean vs. estuary on their home waters, we compared biomagnification of PBTs across a gradient from Puget Sound's most estuarine (and contaminated) basins or embayments to its more oceanic (less contaminated) basins. We observed a strong gradient of $\delta^{13}\text{C}$ in krill from inland waters to oceanic waters, and an increase in $\delta^{15}\text{N}$ for species across a putative food chain defined as [phytoplankton] → [krill] → [herring/Coho salmon/juvenile hake] → [adult hake/Chinook salmon]. We explain variability in PBT concentration using these variables, along with tissue lipid concentration, to propose a model for biomagnification of two PBT classes; polychlorinated biphenyls (PCBs) and brominated flame retardants (polybrominated diphenylethers, or PBDEs). Difficulties in sampling and processing phytoplankton samples resulted in some uncertainty for interpreting PBTs in that group, however overall, location was the strongest predictor of PBT concentration in biota (measured as tissue residue in whole bodies), with greatest PBTs observed in urban embayments (krill and phytoplankton), and in Puget Sound's main basins (for the larger, wider ranging fish species). PBTs also increased with trophic level ($\delta^{15}\text{N}$) suggesting magnification of contaminants in higher-trophic-level species that serve as prey for apex predators. These results suggest that loading of PBTs to urban basins can result in far-reaching effects in the pelagic food web.

Bernadita Analacion

NOAA Fisheries Northwest Fisheries Science Center

Total mercury levels in Pacific Northwest Cetaceans

B. Analacion, D.T. Boyd, M.B. Hanson, C.K. Emmons, R.W. Baird, G.S. Schorr, G.M. Ylitalo

Abstract:

Using a simple and rapid method for analysis of total mercury, we were able to obtain baseline levels of this metal in free-ranging and stranded cetaceans from the Pacific Northwest. Analyses were conducted on Southern Resident killer whale (*Orcinus orca*) samples obtained non-lethally via live-remote biopsy and on samples from harbor porpoise (*Phocoena phocoena*) that stranded in Puget Sound, WA. Total mercury was measured in skin samples of all animals and in liver, kidney and muscle from harbor porpoise. Measurement of total mercury was conducted on a direct mercury analyzer (LECO AMA254) using combustion atomic absorption spectrometry (AAS). We were able to optimize and reliably measure total mercury in very small masses of skin tissue (< 10 mg), similar to those that are routinely available from live-remote biopsies. In addition measurement in different tissues from the harbor porpoise allowed for comparison of mercury accumulation in different compartments of the same animal. Results for the killer whale skin showed an age-dependent accumulation of total mercury with slightly higher levels overall in the L-Pod animals than J-Pod, likely due to differences in feeding strategy and/or age of animals sampled within each pod. Mercury levels in the skin of harbor porpoise showed a size-dependent accumulation (likely related to age) and among the different tissues analyzed, the rank order was generally liver > kidney > muscle > skin. These measurements provided the opportunity to obtain valuable contemporary baseline metal data for the cetaceans in this region, where few data are available. In addition, this initial data will allow us to begin to examine the utility of mercury levels in individuals as a possible ecological tracer to distinguish such characteristics as ecotypes, age class and geographic areas of residency.

Thomas Gries

Washington Department of Ecology

Characterization of toxic chemicals in Puget Sound and major tributaries, 2009-2010

Thomas Gries, David Osterberg

Abstract:

The Washington State Department of Ecology has been conducting a series of technical studies to inform source control strategies for toxic chemicals entering Puget Sound. Previous studies developed toxic chemical loading estimates and used computer models to predict outcomes of control actions. Recently-completed studies were intended to reduce uncertainties associated with loadings estimates and model predictions. This study collected seasonal water samples from seven sites in Puget Sound and ocean boundary waters, and from near the mouths of the five largest rivers flowing into the Sound. Samples were analyzed for a range of chemicals of concern.

Many organic chemicals were seldom if ever detected in marine waters, but concentrations of metals and polychlorinated biphenyls (PCBs) were similar to values previously reported. Organic carbon, copper, and PCB concentrations were higher in outgoing Puget Sound waters than in incoming ocean waters, while the opposite was true for cadmium. Ocean exchange estimates indicated most target chemicals of concern appear were exported from Puget Sound to the ocean. River waters contained concentrations of conventional parameters, nutrients, metals, and some organic compounds that were generally within ranges previously reported. Petroleum-related compounds, semivolatile organic compounds (BNAs), polycyclic aromatic hydrocarbons (PAHs), and chlorinated pesticides were seldom detected. Daily loads for many chemicals were calculated that can be compared to estimated loads from other studies and model simulations. Suspended particulate matter (SPM) samples, collected from deep marine waters and river waters, were analyzed for a suite of chemicals similar to those analyzed for water samples. Hood Canal and South Puget Sound basin sample results were used to estimate loss rates of toxic chemicals from the water column via sedimentation. Toxic chemicals such as PAHs were more

often detected in river SPM than in river water. The author will summarize study findings, emphasizing various field and analytical challenges encountered.

Heather Osachoff

Simon Fraser University and Environment Canada

Detection of estrogenic hormones in BC sewage treatment plant effluents

Heather Osachoff, Vesna Furtula, Joanne Harkness, Graham van Aggelen, Chris Kennedy

Abstract:

Natural and synthetic estrogen hormones have been documented in sewage treatment plant (STP) effluents worldwide. Estrogen hormones are found in STPs because they are excreted from humans and animals. There are three main vertebrate natural estrogen hormones: estrone (E1), 17-beta-estradiol (E2), and estriol (E3). E1 is the main estrogen in menopausal women, and it is a metabolite and environmental breakdown product of E2. E2 is the main vertebrate estrogen hormone involved in reproduction as well as many other bodily systems. E3 is the hormone associated with human pregnancy. In addition, women are prescribed synthetic estrogen hormones for birth control and hormone replacement therapies, and these estrogens also end up in sewage treatment plants. Estrogen hormones may not be completely removed by STP systems and so they can be present in STP effluents. There is great aquatic environmental concern regarding the discharge of estrogenic substances because of potential impacts on organisms' reproduction, behaviour, migration and survival.

Limited information has been gathered on the identity, presence or concentration of estrogenic hormone compounds in British Columbian STPs. This study profiled the estrogenic hormones contained in influents and effluents from six secondary or tertiary STPs. All six STPs used in this study discharge effluents to fresh water systems; three of the STPs discharge to waters in the Fraser River system, which enters the Salish Sea. Two STPs were evaluated in late fall, six STPs in early spring, and two STPs in early summer. In addition to the natural and synthetic estrogen hormones, which are sterol/steroid compounds, this study profiled plant and fecal sterol compounds.

No estrogenic hormones were detected in the influents (possibly due to the complex nature of the influents), and E1 was detected in 50% of the effluents in each sampling season. The E1 concentrations ranged from 26 to 97 ng/L. One of the tertiary STPs had E1 detected in each of the sampling seasons. No other natural or synthetic estrogen hormones were detected, which differs from studies of effluents from other parts of the world. Profiles of plant and fecal sterol compounds, which are more abundant than the estrogen hormones, were obtained and used to investigate STP processes by an evaluation of the percent reduction between the influent and effluent concentrations. Not surprisingly, tertiary STPs generally removed more plant and fecal sterol compounds than secondary STPs.

Dave Serdar

Washington State Department of Ecology

Sources, pathways, and an approach to establishing priorities for control actions

Dave Serdar, Dale Norton, Jenee Colton, Richard Jack, Deb Lester

Abstract:

The Washington State Department of Ecology and other agencies initiated the Puget Sound Toxics Loading Analysis (PSTLA) during 2006 to provide information to help guide decisions about toxic chemical control strategies for the Puget Sound basin. The main focus of PSTLA was to estimate toxicant loading to Puget Sound through various pathways including surface runoff, groundwater, publicly owned treatment works (POTWs), and direct air deposition. Other components of PSTLA included an effort to estimate the quantities of selected chemicals released from anthropogenic sources, and a hazard screening to help gauge the relative toxicity of these chemicals at typical environmental concentrations.

Surface runoff was found to deliver the largest loads to Puget Sound for most of the parameters

assessed, typically accounting for more of the total annual load than all other pathways combined. Toxicant loads delivered to Puget Sound through POTWs are generally the smallest among the pathways assessed.

Simple conceptual models were developed to link information on sources, loading, and pathways for each chemical. For most of the chemical parameters addressed, the total annual load delivered to Puget Sound through the various pathways is one-to-three orders of magnitude lower than the total quantity released from anthropogenic sources. For most of the sources assessed, the mechanism and medium of chemical release appears to play a more important role in the enrichment of a delivery pathway than can simply be explained by the quantity released from a source.

A hazard screening method was developed to evaluate the relative importance of selected chemicals by comparing environmental concentrations across the entire Puget Sound basin to effects data contained in databases or established criteria and threshold concentrations. The hazard evaluation proved to be a useful screening tool, but also contains many limiting and complicating factors due to its application on a broad geographic scale and for multiple media and chemicals.

Results of the hazard evaluation were coupled with information on sources and loading to propose priorities for source control among the chemicals assessed. Based on the conceptual models and the proposed priorities for source control, recommendations are presented to focus areas for control strategies and to fill data needs.

1B: The conservation imperative for the marine birds and mammals of the Salish Sea I

Marine birds and mammals are some of the most conspicuous users of the Salish Sea Ecosystem. We seek to evaluate the current status, trends and health of these upper trophic level predators. Known threats and stressors include contaminants (e.g., flame retardants, perfluorinated compounds, heavy metals, PAHs, petroleum and pesticides), climate change, changes in prey populations (e.g., herring and other forage fishes), habitat modification, degradation and loss (e.g., foreshore development), and mortality from gillnet fishing and derelict fishing gear. A diverse array of laws and policies from multiple levels of federal, state (provincial), municipal (county), aboriginal, and private land owners need to be acknowledged and understood. The purpose of the session is to highlight the successes and shortcomings of current approaches to conservation science and management in the Salish Sea.

Conveners: Douglas Bertram, John Elliott, Steven Jeffries, Peter S. Ross

PRR Facilitator: Kirsten Hauge

Erin Ashe

Oceans Initiative

Dolphins without borders: Conservation status of a poorly studied, transboundary marine predator

Erin Ashe, Alexandra Morton, Rob Williams, Philip S. Hammond

Abstract:

Robust information on abundance, survivorship and trends is fundamental to evaluating the conservation status and health of marine mammal populations. There is a tendency to equate commonness with favourable conservation status, but rarity does not always imply peril, and abundant species may be at risk when in decline. Pacific white-sided dolphins epitomize the difficulties involved in providing such information for highly mobile, pelagic predators. These dolphins have become conspicuous visitors to the Salish Sea only recently. Further to the north, Alexandra Morton initiated a photo-identification study in the 1980s when dolphins moved inshore to the Broughton Archipelago after a decades-long absence. The dolphins are clearly abundant, but only a relatively small proportion of the population has long-term markings that can be used reliably for individual recognition and only a small fraction of these are resighted between years. As a result, estimates of abundance, survivorship and population growth are frustratingly coarse. Robust-design mark-recapture models, which account for temporary immigration and emigration, were fitted to photo-ID encounter history data. Results revealed surprisingly high estimates of adult mortality. Notwithstanding this low survival rate, sightings as a whole continue to increase. Taken together, these findings suggest that increased abundance may be due to a distributional shift (i.e., permanent immigration), rather than true population growth. As a result, one should not assume favourable conservation status of Pacific white-sided dolphins based solely on the casual observation of increased numbers of sightings in inshore waters near urban areas. Our understanding of factors that affect movements and numbers of dolphins is hindered by a lack of basic information on demographic parameters, population stock structure, diet, prey populations, mortality and serious injury from human activities (such as bycatch in active and derelict fishing gear) and the potential impacts of transient killer whale predation on dolphin populations. A simple bioenergetics model revealed that killer whale predation could conceivably account for a large proportion of natural mortality, but there is insufficient information on predation events to support or rule out this factor. A coordinated, transboundary effort is needed to understand stock structure and population status of this species, but this will require a paradigm shift in setting priorities for research. Setting funding priorities solely on the basis of at-risk status could be counter-productive, if they never fund the basic research needed to find out whether abundant populations are in decline, and therefore need conservation status reassessment or additional management measures.

John Calambokidis

Cascadia Research

Changes in cetacean occurrence in the Salish Sea: Anomalous sightings in S. Puget Sound
John Calambokidis, Jessie Huggins, Dyanna Lambourn, Steve Jeffries, Bethany Diehl, Josh Oliver

Abstract:

In the last few years, several unexpected species have been sighted and stranded in southern Puget Sound. In 2010, two Bryde's whales and two bottlenose dolphins were sighted alive and then were documented to have died several weeks to months later. The two Bryde's whales included the January 2010 sighting and stranding of a 39' immature female, and the November-December 2010 sighting and subsequent stranding of a 34' immature male with several serious injuries from an apparent ship collision (thought to have occurred weeks or months earlier). In the eastern North Pacific, Bryde's whales have not to our knowledge been documented north of southern California and are considered a tropical species. The two bottlenose dolphins included: 1) an animal sighted early June 2010 which then is suspected to have died in mid-July when a decomposed dolphin was found stranded near Steilacoom, and 2) the December 2010 sighting of another live bottlenose dolphin seen repeatedly and then found dead on 31 January 2011 at the Nisqually Delta. Necropsies were conducted of but tissue decomposition prevented determination of cause of death of either of the bottlenose dolphins. Bottlenose dolphins have only been documented stranded twice before in Washington State prior to these two animals and typically do not occur north of central California. While any one of these occurrences would be unusual, but perhaps just a chance occurrence, the presence of four warm water species coming alive into Southern Puget Sound in a one year period suggested there was a connection between these events. Additionally, starting around 2007, numerous harbor porpoise were sighted at multiple locations throughout southern and central Puget Sound, an area where they had been common in the 1940s but had been virtually absent from for at least the last 40 years. While the return of this species may be positive, it has also resulted in the death of a number of these animals due to entanglement in nets. We explore some of the factors that may have contributed to these changes in occurrence of marine mammals in the Salish Sea.

Joseph Gaydos

SeaDoc Society, UC Davis Wildlife Health Center - Orcas Island Office

Comparing post-release movement of rehabilitated harbor seal pups to age-matched wild seals
Joseph Gaydos, Ignacio Vilchis, Monique Lance, Steven Jeffries, Austen Thomas, Penny Harner, Vanessa Greenwood

Abstract:

In the inland waters of Washington and British Columbia, the harbor seal (*Phoca vitulina*) population is considered robust and believed to be nearing carrying capacity. Females give birth in June and July and nurse for three to four weeks until weaning ends the maternal-pup bond. In areas of high human density, stranded pups often are collected and admitted to rehabilitation centers. We do not know, however, how released rehabilitated pup movement compares to that of wild weaned pups in Washington State. To help answer this question we outfitted ten rehabilitated pups and ten wild weaned pups with satellite transmitters to track and compare post-release movements between the two groups. Because of a timing disparity in the weaning of wild pups and pup release post-rehabilitation, wild seals were outfitted an average of 49 Julian days earlier than rehabilitated seals. At release, rehabilitated seals were longer and heavier than wild pups at capture, while wild pups had a larger axillary girth (all tests $P < 0.05$). After release, rehabilitated seals transmitted for shorter periods of time ($P = 0.006$), an average of 76 days compared to 135 days for wild weaned pups. Rehabilitated seals also moved a greater average daily distance ($P = .02$) and showed a greater overall movement away from the release site than wild seals ($P = .04$). Learned behavior during the brief 3-4 week nursing period when a pup is with its mother likely enables wild harbor seal pups to move less daily and remain closer to their weaning site than rehabilitated pups.

Monique Lance

Washington Department of Fish and Wildlife

Seasonal and spatial variation in harbor seal (Phoca vitulina) diet in the San Juan Islands, Washington

Monique Lance, Wan-Ying Chang, Steven J. Jeffries, Alejandro Acevedo-Gutiérrez

Abstract:

Harbor seals are abundant, ubiquitous generalist predators that are capable of shifting prey selection in response to shifts in availability seasonally, spatially, and inter-annually. We studied diet composition of harbor seals and their seasonal, regional and inter-annual variations from 1723 fecal samples collected from haul out locations throughout the San Juan Islands, Washington, from 2005 to 2008. Overall, the eight most common species or species groups of prey were clupeids, adult salmonids, Pacific sandlance, Northern anchovy, gadids, juvenile salmonids, cottids, and shiner surfperch. Diet composition showed significant seasonal and regional patterns. Adult salmonids were a dominant prey group only during summer/fall and had the highest frequency of occurrence in the western regions. Higher occurrences of adult salmon were observed in odd years, 2005 and 2007, when pink salmon were present. Clupeids (primarily Pacific herring) were common for all seasons but surpassed other groups during spring when adult salmon became less available. Higher proportions of juvenile Pacific herring were found in the diet during summer/fall compared to spring for all years except 2007, suggesting that harbor seals consumed largely spawning adults during spring and non-migrating juveniles during summer/fall. Herring had higher occurrences during spring and sand lance had higher occurrences during winter coinciding with spawning for these primary prey species. Rockfish were only present in a small percentage of samples however their dramatically reduced populations for some species could be affected by even a small amount of predation given the high abundance of harbor seals in this region. Cluster analyses illustrated that during summer/fall, adult salmonids occurred as one distinct cluster indicating that harbor seals consumed them almost exclusively whereas winter samples contained a higher number of distinct prey groups. Findings will help develop ecosystem-based recovery and management for depressed populations of fish species in this region.

Cait Nelson

University of British Columbia
Industrial contaminants in coastal river otters
Cait Nelson, John Elliott, Dan Guertin

Abstract:

The trans-boundary Georgia Basin-Puget Sound waters of southern British Columbia, Canada and northern Washington, USA is an area of international concern. Cumulative with other anthropogenic stressors, the region contains numerous sites contaminated with toxic polyhalogenated and polycyclic aromatic hydrocarbon chemicals. Top predator species in aquatic food webs are exposed to industrial and agricultural chemical contaminants, which are persistent, bioaccumulative and toxic. Evidence suggests that elevated contaminant concentrations have caused reproductive impairment, physiological effects, and immunotoxicity in several wildlife species in the region. A number of those wildlife species have been proposed as indicators of contamination; however, most species have limited application for contaminated site assessment due to their larger range, migratory behaviour, and because of the need for intrusive sampling (not supported by the public).

Although not considered true marine mammals, North American river otters (*Lontra canadensis*) are residents along the coast of the Georgia Basin-Puget Sound, and have many traits that make them a useful indicator of nearshore environmental contamination. For instance, river otters have a home range that is relatively small and seasonally constant, they neither migrate nor hibernate, and they primarily feed on intertidal and subtidal fish. Consequently, individuals can be exposed continuously to localized sources of pollution. Although there are no published studies of polyhalogenated aromatic hydrocarbon toxicity to river otters, the mink (*Mustela vison*), another aquatic mustelid that inhabits a similar ecological niche and has similar life-history traits (i.e., delayed implantation), provides a reasonable surrogate. Mink are very sensitive to the toxic

effects of dioxin-like chemicals, which adversely impact the female reproductive system and offspring survival. Several authors propose a similar sensitivity of otter to dioxin-like chemicals. It has been suggested that Polychlorinated Biphenyls (PCBs) contamination constituted a major factor in the decline of the Eurasian otter (*Lutra lutra*) in Europe during the 20th century. Monitoring the contamination status of wild otter populations is challenging due to their elusive nature and the difficulties associated with capture and sampling. As an alternative to capturing individual animals for toxicant testing, studies have shown that field-collected feces can be an efficient means of investigating contaminant exposure in mustelids. Using that approach, we show that feces collected from river otter latrines in Victoria Harbor, British Columbia had concentrations of PCBs exceeding the criteria for reproductive dysfunction developed for the Eurasian otter.

Although previous work has demonstrated that fecal DNA genotyping can be used effectively to monitor the exposure of river otters to environmental contamination and to monitor spatial and temporal trends in individual contaminant exposure, further research is required to investigate the temporal stability of both genetic and demographic population-level patterns. Continued investigation of mustelid populations at contaminated sites will contribute to a more thorough understanding of the impacts of persistent organic pollutants and other stressors on these high trophic-level indicator species.

John Elliott

Environment Canada

Bald Eagles and Chum Salmon: Lower winter survival and breeding success leads to density dependence

John Elliott, Kyle Elliott

Abstract:

During the late 20th Century, due to decreases in both contaminants and persecution, bald eagle (*Haliaeetus leucocephalus*) populations increased dramatically. Currently, mechanisms regulating eagle populations are not well understood. To examine potential regulating processes in the Pacific Northwest, where eagles are no longer primarily regulated by contaminants or direct persecution, we examined bald eagle reproduction, breeding populations, winter populations, mortality and salmon stream use. Wintering and breeding eagle populations in south-coastal British Columbia quadrupled between the early 1980s and the late 1990s, and have since stabilized. Density dependent declines in reproduction occurred during 1986-2009, but not through changes in site quality. Mid-winter survival was crucial as models showed that most mortality occurred then, and that density-dependent reductions in population growth rates were partially due to reduced survival. Wintering eagles in British Columbia fed heavily on chum (*Oncorhynchus keta*) salmon runs, and then switched to birds in late winter, when mortality was highest. The number of eagles in BC was inversely proportional to winter temperature in Alaska; eagles tended to arrive after the peak in salmon availability at streams in BC as part of a migration associated with salmon streams from Alaska to northern Washington. Eagles were most abundant in southern BC during cold Alaskan winters and in years of high chum salmon availability. We suggest that eagle populations in the Pacific Northwest are currently partially limited by density on the breeding grounds and partially by adult survival in late winter, likely due to reduced late winter salmon stocks forcing eagles to exploit more marginal prey supplies. Larger eagle populations have affected locally some prey populations.

1C: Mission possible: Implementing a new culture for urban watershed protection and restoration in the Salish Sea Bio-Region

A decade ago, the Province of British Columbia made a conscious decision to follow an educational rather than prescriptive path to change practices for the use and conservation of land and water. Practical research and new tools are now enabling engineers, planners and other disciplines to do business differently.

Released in June 2010, *Beyond the Guidebook 2010: Implementing a New Culture for Urban Watershed Protection and Restoration in British Columbia* describes how a 'convening for action' philosophy has taken root in British Columbia. Bringing together local government practitioners in neutral forums has enabled implementers to collaborate as regional teams. Their action-oriented focus has resulted in 'how to do it' examples of rainwater management and green infrastructure that help decision-makers visualize what 'design with nature' policy goals look like on the ground.

The Salish Sea Ecosystem Conference provides a timely opportunity to inform and educate planners, engineers and other professionals on both sides of the Canada-USA border. It is about turning the whole game around to design with nature as a consistent approach to development and redevelopment, urban infrastructure practices, and protection/restoration of stream and watershed health. When the land ethic changes for the better, the health of the Salish Sea will be improved.

This forum will be structured in two segments. First, we will present information that provides context and sets the scene for the town-hall segment that will follow. The objective in the first part is to inform and educate the audience so that there will be a common understanding about: shared values; how shared values lead to sharing of a vision; and how a shared vision can be a powerful motivator for action. What are the common beliefs and/or shared values? How can the common beliefs be integrated together?

This session will conclude with a 45 minute Town Hall Discussion.

Conveners: Kim Stephens, Tim Pringle, Richard Boase, Glen T. Brown
PRR Facilitator: Rita Brogan

45 minute Town Hall Discussion Moderated by:
Kim Stephens
Partnership for Water Sustainability in British Columbia

Participants:
Ted van der Gulik
Senior Engineer
BC Ministry of Agriculture

Lynn Kriwoken
Director
BC Ministry of Environment

Glen Brown
Executive Director
BC Ministry of Community, Sport & Cultural Development

Eric Bonham
Convening for Action on Vancouver Island (CAVI)

Richard Boase
Environmental Protection Officer

District of North Vancouver

Alan Lill

Program Manager

Living Rivers - Georgia Basin / Vancouver Island

**** This session will conclude with a 45 minute Town Hall Discussion.**

1D: Climate change

Climate change is the greatest challenge in the history of conservation. This session explores approaches and tools to address conservation and land management and climate change adaptation. Talks include discussions on decision frameworks that can be used for identifying areas across the landscape that are likely to be more resilient to climate change, improving an understanding of contaminant impacts to coastal resources, and addressing the uncertainties for planning and implementing ecosystem restoration. The presentations also discuss policy options for addressing sea level rise, a watershed-based approach for integrating science and policy, and an international endeavor to better link science with land and natural resource management.

Convener: Mary Mahaffy

PRR Facilitator: Jamie Strausz-Clark

Eric Mielbrecht

EcoAdapt

Anticipating the future: A climate-informed conservation blueprint for the Pacific Northwest

Eric Mielbrecht, Jessi Kershner, Marni Koopman, Jessica Leonard, Dan Ritzman

Abstract:

The natural landscapes of the Pacific Northwest exist due to the combination of unique geology and climate. The resulting iconic ecosystems are essential to the survival of the Pacific Northwest's wildlife and to the well-being of human communities. Rapid climate change is altering the conditions within this region, necessitating an adjustment of traditional approaches to conservation and land management. Building upon existing and emerging climate change research and collaborating with ongoing conservation efforts, the "blueprint" was created as a spatial framework to inform climate change adaptation in the Pacific Northwest. Available terrestrial and freshwater conservation area data, select ecosystem and species data, and modeled climate change stressor data were used as inputs for GIS-based conservation planning tools. The resulting climate-informed blueprint identifies areas across the landscape that are likely to be more resilient to climate change and opportunities to improve management efficacy.

Robert Neely

NOAA Office of Response and Restoration

NOAA's Climate Assessment and Proactive Response Initiative Puget Sound Pilot

Robert Neely, Benjamin Shorr, Marla Steinhoff, Mary Baker, Anthony Dvarkas, Amy Merten, Ann Jones et al.

Abstract:

The mission of NOAA's Damage Assessment, Remediation and Restoration Program (DARRP) is to protect and restore coastal and marine resources threatened or injured by oil spills and releases of hazardous substances. Hazardous waste facilities and oil infrastructure in coastal areas may be more vulnerable to releases due to climate related impacts. In response, DARRP developed the Climate Assessment and Proactive Response Initiative (CAPRI) to provide a framework and tool to evaluate potential contaminant impacts in the coastal zone related to climate change. CAPRI's flexible GIS-based framework incorporates an assessment of regionalized climate change forecasts, contaminant threats, and ecosystem and species values and sensitivities into a screening level vulnerability index. The CAPRI framework encompasses four major components: assessment of climate change impacts and related contaminant threats; development of a spatial vulnerability index; use of the web-based, open source Environmental Response Management Application (ERMA) for visualization and analysis of data layers and results; and identification of efficient prevention, response, and restoration options. Selected sites within the Puget Sound are the initial testing ground for the CAPRI framework. This pilot incorporates Puget Sound area-specific datasets. The CAPRI framework is intended to provide a national model that can be adapted to the unique data available in a particular region or coastal

area. CAPRI will enable NOAA and other local, state, regional, and federal decision makers to better prepare for and adapt to climate change by improving understanding of contaminant impacts to coastal resources.

Ilon Logan

ESA

Informing coastal restoration planning decisions in a changing climate

Abstract:

Climate change presents new challenges and opportunities for the protection and restoration of coastal ecosystems worldwide.

Accelerated rates of sea level rise, increases in air and water temperatures, changes in precipitation patterns, and increased frequency and severity of extreme weather events are some of the anticipated effects on coastal systems. The complexity, variability, dynamism, and diversity in the effects of climate change results in tremendous uncertainty for the planning of coastal ecosystem restoration. Furthermore, the range of social responses and adaptations to a changing climate is extensive and complex.

Principles to support restoration planning in the face of these challenges include futuristic thinking, building resilience, use of relevant and contemporary rationales, adaptive management, and a focus on opportunities. To apply these principles, I present a decision support framework for informing restoration planning and implementation. Integrating climate change effects into restoration begins with a spatially explicit assessment of vulnerabilities and opportunities across a coastal landscape. Identification of the distribution of constraints and opportunities resulting from climate change (e.g. social, economic, ecological, hydrological, geomorphological) across the landscape will lead to an ability to prioritize areas for restoration. Information regarding the vulnerability and adaptive capacity of social-ecological systems can be used to inform restoration strategies. In summary, the principles and the decision framework suggest that achieving desirable outcomes for coastal restoration will require integrative and adaptive approaches to planning and implementation that can account for complex connections between humans and nature under conditions of persistent uncertainty.

Tina Neale

BC Ministry of Environment, Climate Action Secretariat

Raising dikes and rolling back – Coping with sea level rise on the BC coast

Abstract:

The coast of the Salish Sea will be impacted by sea level rise of approximately one meter by the end of the century. Sea level rise will increase flood risk in populated areas and will force intertidal ecosystems to migrate inland. There are a range of options for adapting to sea level rise, but most of these involve tradeoffs between a variety of economic, ecological and social values. This presentation will discuss a number of policy options for addressing sea level rise both in the Salish Sea region and in other jurisdictions with a focus on examining the combination of options that could form the basis of a sea level rise adaptation plan.

Larry Wasserman

Swinomish Indian Tribal Community

Climate science and policy in the Skagit Watershed: Lessons learned

Larry Wasserman, Carol MacIlroy

Abstract:

Climate adaptation planning in local communities is prudent to pursue both in terms of mitigating negative impacts and taking advantage of positive ones. Research scientists in the Skagit watershed participating in the Skagit Science Climate Consortium (SC2) are integrating their scientific models from the Cascade glaciers to the waters of Puget Sound to understand how

changes in climate may specifically affect the Skagit River watershed and impact local communities. The downscaling of regional models to the Skagit Watershed scale is beginning to produce findings that raise the question of where Skagit County communities and businesses might want to explore potential vulnerabilities created by shifts such as changing flood frequency, size and timing to adapt transportation infrastructure, hydropower dam management, salmon habitat management, and flood management among other things.

This session will discuss the development of a watershed-based approach to integrating science and policy to assist in the development of adaptation strategies responsive to climate change effects. The session will provide a basic overview of the Skagit Climate Science Consortium: why it was formed, breadth of research organizations represented, and Consortium objectives.

The major focus of the talk however, will be on lessons learned in trying to bridge the gap between science and policy based on a workshop hosted between SC2 and elected officials in the Skagit Watershed. It will discuss what can be learned by the scientific community as decision-makers grapple to understand and make sense of new research findings; link research findings to policy processes, key issues and decisions; and determine their level trust in the scientists, models and predictions. It will also look at what scientists need to understand from their policy colleagues in order to better ensure that their research is successfully communicated to decision-makers and stakeholders, as well as adequately funded to provide the tools useful in a policy or business decision-making environment.

Mary Mahaffy

US Fish and Wildlife Service

Participating in the North Pacific Landscape Conservation Cooperative

Abstract:

Climate change is the greatest environmental and conservation challenge of the 21st Century. The impacts of climate change will exacerbate existing stressors on fish and wildlife resources. Landscape Conservation Cooperatives (LCCs) are self-directed partnerships between federal agencies, states, tribes, non-governmental organizations, universities, and other entities to collaboratively address the challenges of climate change and other stressors in an integrated fashion across broad areas. LCCs leverage resources and strategically target science to inform conservation decisions and actions. They provide a critical bridge to link science and management. They identify common science and conservation goals and priorities, develop science-based tools, and support biological planning, conservation design and adaptive management. A network of 21 LCCs exists in the U.S. and across our international borders, each operating within a specific landscape.

The North Pacific LCC extends over 2,200 miles north to south and encompasses parts of four states, one province and one territory. The common biome shared throughout the LCC is the NW temperate rainforest and coastal/nearshore ecosystems. The North Pacific LCC is in early planning stages and recently received its first direct allocation of funds. Nine science projects were selected for funding in 2011. A Steering Committee has been established and is starting to identify goals and priorities for the North Pacific LCC. We invite input from stakeholders and other interested parties on science needs, objectives and priorities and invite participation.

1E: Estuary science to support adaptive management

It is widely recognized that estuarine restoration is needed to improve the health of the Salish Sea ecosystem and recover threatened and endangered fish and wildlife that provide for human livelihood. Rigorous scientific evaluation of restoration is essential to understand and improve project performance. This is especially important in estuaries where physical, biological and socioeconomic processes interact in complex ways to create shifting baselines and where few undisturbed “reference” systems remain to use for benchmarks. This session examines several unique challenges facing science and monitoring of estuary restoration identified by experts during two recent workshops. What are the emerging interdisciplinary techniques required to assess restoration performance? Are we able to detect and forecast the cumulative impacts of land use and climate change that may occur outside of the restoration area and influence enhancement outcomes? Are we learning the right things and applying the lessons learned sufficiently to implement adaptive management to achieve enhancement objectives. The session also reviews critical information and resources that can support estuary science across the Salish Sea and discuss approaches that will minimize their costs and facilitate comparison of results in order to improve understanding of the gradients in drivers and responses that affect overall ecosystem recovery.

This session will also feature a 15 minute facilitated discussion.

Conveners: Eric Grossman, Roger Fuller

PRR Facilitator: Hadley Rodero

Introduction:

Roger Fuller (3 minutes)

The Nature Conservancy

Introduction: Solutions to enhance restoration/adaptive management success

Curtis Tanner (12 minutes)

Washington Department of Fish and Wildlife

Strategic restoration and protection of nearshore ecosystems in the southern Salish Sea

Abstract:

The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) is a collaborative effort working to advance strategic restoration and protection of nearshore ecosystems in Puget Sound, Washington, the southern reaches of the Salish Sea. Diverse partners representing governmental, non-governmental, academic, and tribal entities are supporting the U.S. Army Corps of Engineers (Corps) and the Washington Department of Fish and Wildlife who co-lead the study. Ultimately, PSNERP seeks to identify a “portfolio” of strategic actions, a subset of which will be advanced for potential funding and implementation by the Corps. As a priority of the Puget Sound Partnership’s Action Agenda, PSNERP will contribute to the recovery of Puget Sound by supporting not only the work of the Corps, but the broader community of restoration practitioners in this region.

PSNERP has completed an analysis of historic to current change in nearshore ecosystem conditions throughout the 4,000 km southern extent of the Salish Sea. Systematic evaluation of change in geomorphic shore type and assessment of co-occurrence of observed change with anthropogenic structures and stressors allowed the team to summarize anthropogenic change in Puget Sound shorelines as a set of quantitative problem statements. This definition of major problems summarizes observed changes, framing them in terms of major problems to focus nearshore protection and restoration efforts. Restoration and protection objectives were developed to address identified problems, focusing on the fundamental physiographic processes which build and sustain nearshore ecosystems. Taken together, problem statements and

restoration objectives can be viewed within an adaptive management framework perspective as hypotheses about what is impaired and how we should respond.

Potential restoration projects were screened using criteria intended to select sites which best meet objectives. Sites which appeared to address identified restoration needs were advanced for further evaluation. Conceptual restoration designs were developed for 36 sites, with a focus on maximizing restoration of degraded nearshore physiographic processes. We are currently evaluating cost-effectiveness of restoration plans, comparing implementation costs with projected ecosystem benefits of completed actions. Projects that best meet the requirements for cost-effectiveness as defined by the Corps of Engineers will advance for potential implementation by that agency. Other actions, likely smaller in spatial scale and cost but still addressing priority restoration needs, will be the focus of other programs and funding sources. The spatial distribution, diversity of project type, range in size, and ecosystem types and functions restored provide a broad sample size for testing the hypotheses defined by our problem definition, restoration objectives, and selection of actions to implement.

Annemarie De Andrade (12 minutes)

Fraser River Estuary Management Program

Achieving integrative and collaborative ecosystem management in the Fraser River Estuary

Abstract:

Established in 1985, the Fraser River Estuary Management Program (FREMP) is an inter-governmental partnership that coordinates planning and decision making in the estuary. FREMP partners are: Environment Canada, Fisheries and Oceans Canada, Transport Canada, BC Ministry of Environment, Metro Vancouver and Port Metro Vancouver.

FREMP is guided by the Estuary Management Plan (EMP), which outlines a shared vision, goals and action programs for improving the environmental, economic, and social health of the Fraser estuary. EMP updates in 2003 included a new Integration Action Program with the objective to: "Develop and implement an ecological features and functions approach (EFFA) to management and decision-making in the estuary." The task under this objective is to develop Reach Overviews for 10 reaches in the estuary.

EFFA is an ecosystem-based, collaborative and flexible approach to management, which includes estuary and upland features, while taking into account the biological, economic and social characteristics of the river. The main purpose of a Reach Overview is to develop a complete and functional compilation of information that will lead to more effective strategies and management guidelines.

Roberts and Sturgeon Banks are situated within the Fraser River Estuary, a globally significant ecosystem that support millions of migrating salmon at early and adult stages of development. Marshes and bogs of Banks provide essential resting and feeding areas for migratory birds on the Pacific Flyway. The estuary is considered one of the most significant Important Bird Areas in Canada.

From an anthropogenic perspective, the rich soils upland from the Banks has attracted urban and agricultural development, generating billions of dollars in economic growth. Management of the reach is shared amongst four orders of government, First Nations, and major private land owners, resulting in complicated decision making processes.

In 2009, FREMP completed Phase I of the Roberts and Sturgeon Banks Reach Overview (RSBRO). Phase I contains a compilation and synthesis of existing information on the physical, biological and human activities and processes for Roberts and Sturgeon Banks. This work has provided a foundation for understanding how natural processes are affected by contemporary activities in the area and is a first step towards understanding what should be considered with regards to future development in the reach.

In 2010, FREMP completed Phase II of the RSBRO. Phase II provides an analysis of and recommendations for management of water, shoreline and upland issues that transcend individual municipal and agency boundaries. The final report updates and confirms habitat classification mapping, outlines consistent guidelines and management strategies for all projects, including mitigation and compensation, and identifies research needs to improve knowledge about habitat features and functions.

Through this process, it was also concluded that working collaboratively to conduct new comprehensive mapping for Roberts and Sturgeon Banks to establish a regional baseline for key indicators is a high priority initiative. FREMP is currently conducting a habitat inventory on the Banks and efforts are being made towards collaboration with Academia to continue this project on a yearly basis.

Eric Grossman (12 minutes)

USGS Pacific Coastal and Marine Science Center and Roger Fuller, The Nature Conservancy
Incorporating cumulative watershed and climate change effects in estuary recovery in the Salish Sea

Eric Grossman, Andrew Stevens, Eric Beamer, Chris Ellings

Abstract:

Sea-level rise, climate-driven hydrologic changes, and land-use activities across watersheds can greatly influence delta ecosystems yet predicting their impacts on restoration outcomes is challenging. Few reference environments remain to use as benchmarks and 150 years of human modifications to hydrologic processes, habitat structure and ecosystem functions continue to shift targets for recovery. Restoration actions themselves can modify hydrodynamic processes, sediment transport, habitats, and food-webs outside of the restoration footprint that targeted species for recovery depend upon. An assessment of the extent of historical change in the Skagit and Nisqually Deltas of western Washington shows how cumulative impacts to hydrology and sediment transport affect the vulnerability of these estuaries. Analysis and comparison of the sediment budgets and fate of sediment delivered to these two deltas show the challenges facing restoration where much of this resource is lost offshore or trapped behind dams. There is an imminent need for improved sediment management to ensure that large-scale restoration efforts of deltas and their wetlands succeeds while minimizing additional impacts to important ecosystems offshore. In the long-term, significant changes to sediment management are required to enhance delta resilience in light of projected rates of sea-level rise ranging 2.0-3.5 mm/yr.

Initial models point to possible solutions that will likely require strategic implementation of restoration across their watersheds that are phased in the right sequence in time. A conceptual framework and initial modeling effort help to clarify the importance of understanding these processes and the interaction of sediment, vegetation, grazing animals, and sea-level rise on overall coastal resilience. This framework helps to clarify the interdisciplinary research and core science infrastructure needed to support restoration goals across the complex environmental gradients of the Salish Sea.

Sean Boyd (12 minutes)

Science & Technology Branch, Environment Canada

Why are estuarine marshes in the Salish Sea disappearing and what must be done to fix the problem?

Sean Boyd, Neil Dawe

Abstract:

Snow Geese on the Fraser River estuary and Canada Geese on the Little Qualicum River estuary on Vancouver Island are negatively impacting marsh plant communities. By definition, both goose populations have exceeded the carrying capacities of their primary, supporting ecosystems and they are now severely damaging these and other estuaries in the Salish Sea. In recent years,

good weather conditions on the Wrangel Island breeding grounds resulted in a ca. 10% increase in recruitment while sport harvest declined by ca. 10%. Together, these factors have contributed to a doubling in the number of Snow Geese overwintering on the Fraser River delta and an increase in grubbing intensity, resulting in an approximate 60% decline in bulrush (*Schoenoplectus americanus*) density. If this trend continues the bulrush zone over large parts of the delta will be functionally extinct in <20 years. After being introduced to Vancouver Island several decades ago, Canada Geese are now resident year-round. Their numbers increased gradually at first and then grew exponentially from the 1980s to the 2000s; some local populations have continued to increase. Their excessive grubbing activity has eliminated marsh vegetation from large parts of the Little Qualicum River estuary and, as a result, at least 17 tonnes of sedge (*Carex lyngbyei*) dry mass are now being lost every year from this system. What are the associated impacts on the detrital food webs and myriad of fish and wildlife species dependent on these systems? Managers have some tough decisions to make when it comes to maintaining high numbers of geese (including an introduced species) at the expense of productive coastal habitats. In some cases, as with the wild Snow Geese and the introduced Canada Geese, it may not be possible to have both. We discuss these aspects and recommend possible management solutions, including reducing Snow Goose numbers back to their early 1990s level and eliminating Canada Geese altogether from some areas of Vancouver Island.

Casimir Rice (12 minutes)

NOAA

A scientific monitoring framework for estuary restoration in the Salish Sea

Abstract:

Sound scientific information is critically important in advancing the practice of estuary restoration in the Salish Sea yet insufficient guidance is available to project planners for the development and implementation of rigorous monitoring programs. Consequently, little consistency and integration of monitoring occurs across restoration projects. Here we outline a basic but comprehensive and coherent framework for science in support of estuary restoration that focuses on the delivery of: 1) an empirically based rationale for estuary restoration, 2) clearly articulated, systematic, and prioritized metrics, sampling designs, and analytical approaches, 3) application of monitoring results in adaptive management and ecosystem contexts, and 4) field data entry and project management tools to increase efficiency, quality, availability, and security of monitoring data.

Paul Cereghino (12 minutes)

NOAA Restoration Center

A Salish Sea Learning Network: Using conceptual models, contract deliverables, and social networks

Abstract:

In 1997 Carl Walters, a consistent author of the Adaptive Management concept wrote “The critical need today is not better ammunition for rational debate, but creative thinking about how to make management experimentation an irresistible opportunity, rather than a threat to various established interests.” Tens of millions of dollars are spent every year in Puget Sound on habitat restoration actions resulting in the repeated and varied manipulation of ecosystems. What have we learned? How do we track knowledge? What are the important questions we need to pursue? Who exactly is ‘we’?

Restoration actions are complex, site specific, and may involve deferred or diffuse benefits. Many ecosystem functions are difficult to measure. Planning, funding, implementation, project development, regulation, program development, and monitoring are often completed by tenuously coordinated partners. Designing robust ecological experiments is demanding work, even for an experienced scientist. Each of a score of participating hierarchies faces political pressure to independently demonstrate “success” at a minimum of cost. The long term effectiveness of restoration is ultimately dependent on precarious protections as competition for our finite land

base increases. In the hands of many institutions, the adaptive management concept is expeditiously redefined as a kind of haphazard trial and error learning. These issues are the tip of a jagged socio-political iceberg that frequently makes the dream of robust and proactive adaptive management in Puget Sound a verbose charade, like a party on the deck of the Titanic.

If we want adaptive management, it is likely 'we' will need to design the system that is capable of supporting adaptive management. To be viable, such a design will not depend on a radical redistribution of authority or budgets, rather we must organize existing technical assets towards common goals. Regardless of hierarchical leadership, this development will require increasingly dynamic and sustained networks among technical staff. We present a systematic approach in which we have, 1) deconstructed existing restoration hierarchies, networks, and markets, 2) identified critical processes within the restoration system that impel learning, 3) develop a wiki-published framework to organize action-scale adaptive management among technical networks, and 4) incrementally revise the relationship between technical networks and policy development so that adaptive management increasingly supports decision making. We invite you to evaluate our initial efforts and to participate in a Salish Sea Learning Network.

1F: Multiple Benefits Approach: Integrating social and ecological values to recover the Salish Sea

Recovering the Salish Sea will take a village. Strike that. It will take three metropolitan cities, 22 mid-sized cities, over 45 sovereign tribes, and communities of farmers, foresters, and fishermen in between. Long-term success depends on connecting recovery efforts in a meaningful way to the people who live, work, and play in the Salish Sea region. The Nature Conservancy (TNC) and National Oceanic and Atmospheric Administration (NOAA) will jointly facilitate this session to highlight and discuss a growing body of regional case studies that have found success through broadening the intent of projects to incorporate human well-being goals, and thus provide social as well as ecological benefits.

Many of the low-hanging fruits for ecosystem recovery have already been picked, and yet we have a long way to go. One of the most pressing management issues is integrating multiple community and stakeholder interests to maximize ecological and social outcomes for the region. By working with local communities and designing for flexibility, inclusive large scale planning, incentive-based conservation, modeling, and on the ground restoration actions have been able to shift the recovery project paradigm to move beyond the limits of single interest efforts. This session showcases a variety of case studies where creative flexibility has advanced flood protection, recreation, economic and community goals alongside ecological recovery goals.

Conveners: Kat Morgan, Polly Hicks, Kara Nelson

PRR Facilitator: Mike Rosen

Richard Brocksmith

Hood Canal Coordinating Council

HC IWMP: A framework for assessing the relationships between ecological and socioeconomic systems

R. Brocksmith, S. Brewer, M. Holman, J. Meyer, J. White, H. Huber, J. Horowitz, K. Nelson, A.J. Morgan, D. Herrera

Abstract:

The Hood Canal Coordinating Council is a watershed-based council of governments historically focused on natural resource conservation. More recently, we have worked with a broader constituency of partners and citizens to expand our vision: Humans benefit from and coexist sustainably with a healthy Hood Canal. To meet this local vision we have launched the Integrated Watershed Management Plan utilizing a strategic planning framework that relies on the community to prioritize focal components of the vision, goals to attain long term persistence of that vision, pressures on those components, and strategies to reduce those pressures in an adaptive management process that upscale into the Puget Sound Partnership's Action Agenda. Much work through various planning efforts is already in progress and it's the Council's belief that integrating these efforts is necessary to provide a higher certainty of success.

A small set of strategically selected focal components is hypothesized to be able to conserve the majority of ecological structures, functions, and processes important to the health of the Salish Sea and its inhabitants. A larger scale hypothesis is that ecosystem function throughout the Hood Canal watershed can be protected and restored, and water pollution reduced, while at the same time accommodating expected future population growth. Both hypotheses can be tested through monitoring of indicators at multiple scales.

This presentation will explore how we define our vision with attributes and indicators; how spatial analyses of those indicators allows for assessment of past and current conditions that can be projected out for goal setting through a policy lens; how planning-scale indicators can downscale to site-specific strategies and actions to roll up to the goals; and how ecological conservation supports and/or degrades socioeconomic values. This presentation will emphasize the latter by describing overlaps in conservation priorities that provide synergy, as well as gaps or even

conflicts that require iterating new indicators, goals and strategies.

Sally Lawrence

Washington Department of Ecology

Going local with water quality improvement: The Samish Bay fecal coliform case

Sally Lawrence, Rick Haley

Abstract:

The Samish Bay watershed is the focus of a state-local partnership where state and federal funds are helping local government succeed in taking on water quality improvement responsibilities. An outbreak of illness among consumers of oysters harvested commercially from Samish Bay in Skagit County, Washington state, in 2004 led the Department of Ecology to initiate a Total Maximum Daily Load (TMDL) water quality improvement project. The watershed is largely rural, with 6,000 households using onsite septic systems, seven dairies, and both commercial and non-commercial livestock operations. The TMDL combined a year-long monitoring study to identify sources of fecal coliform bacteria with an implementation plan to help address sources of pollution. The plan outlined responsibilities of local landowners to review their land management practices and reduce their bacteria inputs to the Samish River, its tributaries and to agricultural ditches and direct drainages to Samish Bay. Even as the TMDL was being published, every heavy rainfall was accompanied by polluted runoff that loaded the Samish River and the bay with bacteria, resulting in a continuing series of temporary shellfish harvest closures in the bay. In response, state government brought together local agencies (Skagit Health District and Skagit County Public Works) and other organizations in the Clean Samish Initiative to write a successful grant proposal to EPA to monitor the water and find and eliminate sources of bacteria through house-to-house visits in parts of the watershed contributing particularly high loads of bacteria. Under the grant, Skagit County is tracking progress through monitoring and is continuing to refine its approach to working with landowners. For example, County Health developed an innovative communications tool to reinforce homeowners' willingness to have their onsite systems inspected. In early 2011, despite the County's initial work, high fecal coliform counts continued to load the river every time it rained. After a briefing by state agency directors, Governor Christine Gregoire brought more state muscle to the County work with assistance from the Puget Sound Partnership. Part of the strategy was to increase local awareness of cost-share and other incentives available for livestock owners to install Best Management Practices. County Commissioners have consistently supported the goal of protecting and restoring shellfish beds and this has increased support by residents. Initial analysis of long term trends in fecal coliform in the river suggest the numbers are coming down, but the Partnership has set an ambitious goal of just one temporary closure of the shellfish beds between fall of 2011 and June 2012. This talk will report progress through summer 2011.

G. Chad Bowe chop

Makah Tribal Council

Federal, state and tribal oil pollution prevention, preparedness and response

Abstract:

One might call this a multiple-benefits prevention project. In this case, the Makah Tribal Council, the Coast Guard and the Washington State Department of Ecology (WDOE) collaborated through a government-to-government consultation process to improve oil spill and marine emergency response capabilities at the mouth of the Strait of Juan de Fuca. As a result, all trust resources in the region including features of Olympic Coast National Marine Sanctuary, Olympic National Park and several National Wildlife Refuges are better protected against the possibility of a marine disaster.

The Makah tribe signed the 1855 Treaty of Neah Bay with representatives of the federal US government to reserve the right to harvest marine resources from the ocean. The right to access the wealth of resources connected to the marine environment was reserved for the Makah people and included the tribe ceding more than 300,000 acres of timbered property to strengthen their

claims to a prescribed ocean area. Those treaty rights have been affirmed, most notably in the 1974 US vs. Washington Boldt decision.

The Oil Pollution Act of 1990 was enacted in response to the Exxon Valdez spill, and it empowered the Coast Guard to create regulations to prevent and respond to such disasters. After the Coast Guard proposed rulemaking on oil spill and marine emergency response capabilities in 2002, the MTC requested a consultation and coordination process with the Coast Guard. Subsequently, a Presidential Executive Order (13175) provided further direction on consultation to federal agencies when their actions imposed impacts on tribal governments. The MTC received technical guidance from both the Coast Guard and WDOE to review federal and state regulations, to determine the relationship that exists between the Coast guard and the WDOE oil pollution authorities.

By working through a consultation for which there was no precedent, the Coast Guard and Makah came to a mutual understanding of their shared risks and responsibilities with regard to oil spills and other marine disasters. Because the value of the Makah's treaty rights depends so much on the health of the ocean environment, they were able to speak for the highest level of protection against maritime disasters. The Coast Guard and its parent agency, the Department of Homeland Security, responded positively and made the consultation a model for future federal-tribal interactions on resource protection.

The multiple benefits of this process accrue to the ocean environment and its habitats and species, the Makah people and the value of their rights to ocean resources, and to other tribal and non-tribal people who depend on the distant benefits of a healthy ocean to produce oxygen, food and a transportation corridor for our import/export economy.

Steve Liske

Ducks Unlimited

Nisqually Estuary Project: Combining public use and ecological benefits to ensure project support
Steve Liske, P.E., Jean Takekawa, Jesse Barham, Christopher Ellings, Isa Woo

Abstract:

Ecological restoration projects are extremely important undertakings, whose value to our world is ever-increasing. At the same time, competing uses for the dwindling availability of land has increased the scrutiny with which the public views and evaluates the need for restoration projects. To make matters worse, many people misunderstand the importance of ecological recovery projects and dismiss them as a waste of tax-payer dollars. As a result, the planning and completion of critically important restoration projects is becoming more and more difficult. In many cases, multiple uses and benefits must be taken into account if a restoration project is to garner the public support needed to allow it to move from an idea to a completed project.

In 1997 the U.S. Fish and Wildlife Service (USFWS) and Ducks Unlimited, Inc. (DU) entered into an agreement to implement the largest estuary restoration project in the Pacific Northwest - at the Nisqually National Wildlife Refuge near Olympia, WA. The goal – to remove 5 miles of the 100-year old Brown Farm Dike and restore 762 acres of the historic Nisqually Delta Estuary to its pre-1900 condition. To the restoration professionals involved, the return of the tides to the delta was worthy of years of effort and millions of dollars that would be required to accomplish the task. To others, however, it meant only the destruction of a popular hiking trail, reduced public use and money ill-spent. To address these and other concerns, the USFWS provided the public with a variety of ways for their voices to be heard. In a series of public meetings, forums and comment periods, the USFWS collected questions, comments and concerns from all interested parties. Through these efforts, the USFWS and DU were able to develop a final restoration plan that considered the ecological needs as well as the social needs of the project. The steps taken to accomplish this were necessary to ensure the successful completion of the Nisqually project, and they will be necessary for future restoration projects as well.

Jenny Baker

The Nature Conservancy

Fisher Slough Tidal Marsh Restoration: A multiple benefits project for agriculture and salmon

Abstract:

Fisher Slough freshwater tidal marsh restoration is a priority in the Skagit Chinook Recovery Plan and is a “proof of concept” project intended to demonstrate that agricultural and salmon recovery goals can be met on a single project site. The Nature Conservancy is employing a multiple benefits approach here because of its potential to form new partnerships, build community support for large-scale ecosystem restoration, and leverage funds unavailable to projects focused solely on ecosystem restoration.

Planning and implementing multiple benefits projects with numerous stakeholders has the ability to create broad community support. Fisher Slough project goals are to restore estuarine habitat for juvenile Chinook salmon, establish native vegetative communities, improve fish passage, and increase flood storage capacity for the sub-basin. These co-equal goals were developed with project partners (including Dike District 3, Drainage and Irrigation District 17 and Skagit County) and have directed decision making at each phase of the project. The inclusive and transparent process used to plan and implement the project to achieve these goals has resulted in strong relationships with a broad base of partners including agriculture-based entities. Now in the final year of construction at Fisher Slough, TNC hopes to build on these relationships to implement future projects.

Estuary restoration often requires working in a built and populated environment, where projects involve flood control, drainage and other infrastructure (e.g. highways) as well as ecological function. Restoration activities at Fisher Slough include levee setbacks, installation of self regulated floodgates and the removal of antiquated culverts and fish passage barriers. Funding for “non-fish” related infrastructure can be difficult to obtain from conservation-focused funding sources. However, broadening project goals and outcomes may also broaden potential funding sources.

Because the Fisher Slough project is located in a built environment, risk and liability associated with the construction and long-term ownership of infrastructure was negotiated with our project partners at every stage of the project. Partners agreed to long-term ownership and maintenance of the infrastructure and TNC addressed short-term construction concerns and design issues as they came up. Some of the project elements that incorporate measures to address project partner concerns are: 1) floodgate operations take both flood control and fish passage needs into account, 2) levees are set back from project boundaries, slightly reducing restored estuary area, to address farming and drainage maintenance concerns and 3) drain tile is installed, adding cost not directly related to fish benefits, in order to address drainage concerns in adjacent farm fields.

Julie Morse

The Nature Conservancy

Farming for wildlife: Integrating habitat conservation and crop production

Julie Morse, Kris Knight, Kevin Morse

Abstract:

Maintaining habitat values and key ecosystem functions in agricultural landscapes is a critical issue today given the global expansion of agriculture. A multiple benefits approach is needed to ensure that increasing agricultural yields can support a growing human population while also improving ecological functions of the landscape. One example, the concept of wetland habitat rotations seeks to merge waterbird conservation objectives with improved agricultural production. This concept involves restoring wetland habitat without taking farmland permanently out of production by temporarily flooding fields. Over the past five years, The Nature Conservancy has worked with Skagit Valley farmers in Washington to test the feasibility of integrating wetland habitat rotations into commercial crop production on working farms, in an innovative project

known as “Farming for Wildlife.” Data from a pilot project demonstrated that wetland rotations can attract a diversity of shorebird and waterfowl species and the conservation value of wetland rotations was substantially higher than traditional rotation practices of grazing or forage harvest during fall and spring migration periods. Ongoing research in collaboration with Washington State University is examining potential agronomic benefits of wetland rotations through improved soil fertility or decreased soil-borne pathogen loads. The Farming for Wildlife project is a local proof-of-concept project with a direct link to national policy, and a strategy for influencing it. Through working with NRCS and farm bill programs this project demonstrates a novel approach to achieve broad scale conservation of wetland-dependant species in agricultural landscapes.

12:00 pm - 1:00 pm
Lunch and Poster Viewing

1:00 pm - 2:30 pm

2A: Contaminants: Sources, fates, transport and impacts II

This session offers a comprehensive look at our current understanding of the level of contaminants (toxics and nutrients) in various media, characterization of sources, fate and transport processes once released and biological impacts in the Salish Sea. The session focuses on the following themes:

- Contaminants—What do we know about contaminant levels in various media of the Salish Sea?
- Sources—What do we know about sources of contaminants? Examples of source categories include: primary releases, atmospheric deposition, POTWs, rivers and streams and stormwater
- Fate -Transport - Impacts—What do we know about fate and transport processes along with impacts of contaminants? Examples of topics could include modeling, attenuation, contaminant cycling, biological impacts and biological markers.

Conveners: Dale Norton, Scott Redman, Robie MacDonald
PRR Facilitator: Kimbra Wellock

Curtis DeGasperi

King County Water and Land Resources Division

The Quartermaster Harbor Nitrogen Management Study: Project overview and preliminary nitrogen loading

Abstract:

In 2009, King County, in partnership with the University of Washington Tacoma and the Washington Department of Ecology, began a 4-year study of the role that nitrogen inputs play in critically low dissolved oxygen concentrations observed in the harbor. The study is supported by an EPA West Coast Estuaries Initiative grant. The study is planned to be conducted in phases and includes the development of a predictive hydrodynamic and water quality model of the harbor. A separate presentation on the model is planned for the Numeric Models of Land and Sea session. The objective of the study is to determine to what extent (and at what cost) management activities might be able to affect improvement in harbor dissolved oxygen levels. The primary study objective is to provide support for any suggested updates to nitrogen management policies in the 2012 update to King County's Comprehensive Plan. Preliminary estimates of nitrogen loading to the harbor have been made and follow up field studies and additional local information have resulted in refinements to the initial estimates, and a more complete picture of the relative magnitude of various sources of nitrogen to the harbor. The latest nitrogen loading estimates will be provided and a preliminary assessment of the relative role human-derived inputs play in the harbor oxygen budget will be presented.

Teizeen Mohamedali

Washington State Department of Ecology

Puget Sound nutrient loading: Sources and magnitudes

Teizeen Mohamedali, Brandon Sackmann, Mindy Roberts

Abstract:

Nutrient loads, particularly nitrogen, have been identified as a potential stressor to the Puget Sound ecosystem. One consequence of excessive nutrient loads is eutrophication, which can lead to low dissolved oxygen (DO) concentrations; field data have shown that portions of Puget Sound violate Washington State water quality standards for DO. Low DO conditions can have adverse effects on fish and other marine life, which in turn can impact the Puget Sound

ecosystem as a whole. Identifying sources of nutrients, their relative magnitudes, and their fate once they enter Puget Sound is essential to understanding the dynamics that result in low DO concentrations and to target appropriate management actions.

The Washington State Department of Ecology has initiated a study to evaluate the relative contribution of human nutrient loads and climate influences on the occurrence of low DO levels throughout the Salish Sea. The first step is to identify nutrient loads from all watersheds (which include all upstream sources) and wastewater treatment plants (WWTPs) that discharge directly into the marine waters of Puget Sound and the Straits of Georgia and Juan de Fuca. Monthly monitoring data collected from rivers and WWTPs were used to estimate continuous daily nutrient loads for the years 1999-2008 using a statistical method called multiple linear regression. This statistical approach relates concentrations to daily flow patterns and time of year to achieve a best fit to monitoring data.

These nutrient loading estimates are some of the most comprehensive estimates developed for the Puget Sound region to date. We are now able to identify the relative contributions of nutrient loads from WWTPs and rivers, recognize spatial patterns in loads being delivered to different basins of Puget Sound, and describe the seasonal nature of these loads. The next step is to couple these loading estimates with varying climate scenarios to assess circulation and DO in Puget Sound and the Straits using a hydrodynamic and water quality model. This model will be used to assess alternative management scenarios both now and into the future if human sources of nutrients significantly impact water quality. If so, the model will also inform us about how much we need to reduce human point and nonpoint sources of nutrients to protect water quality in Puget Sound and the Straits.

A primary goal of this work is to effectively communicate the results of the study to the public through creative and visual means. This presentation will share the majority of the results of nutrient loading estimates using visually appealing maps, plots and figures.

Jill M. Brandenberger

Pacific Northwest National Laboratory

Monitoring water, sediment, and biota to assess protection of beneficial uses for Sinclair Inlet

J.M. Brandenberger, R.K. Johnston, G.H. Rosen, E.W. Mollerstuen, J.M. Young, B. Beckwith

Abstract:

A network of monitoring stations was established within Sinclair and Dyes Inlets to characterize environmental conditions, assess potential impacts, identify sources of stress, and establish environmental quality trends within the Inlets. Water, sediment, and biota monitoring locations within the region were selected based on proximity to suspected sources (industrial, waste water, and stormwater outfalls; marinas, stream mouths, and others) and locations that were representative of ambient marine and nearshore conditions for seasonal sampling. Water column stations and effluents from industrial outfalls were sampled seasonally for total and dissolved metals (Al, Ag, Cd, Cr, Cu, Hg, Pb, and Zn), conventional parameters (salinity, dissolved and total organic carbon, total and suspended solids, NO₂+NO₃, NH₄, N, and P), and select stations for toxicity. Indigenous mussels (*Mytilus* spp.) were sampled semi-annually for contaminant residues of metals and toxic organic compounds (polycyclic aromatic hydrocarbons and polychlorinated biphenyls), and sediment monitoring for metals and toxic organic compounds is being conducted at three-year intervals. Effluent and water column toxicity tests included mysid shrimp (*Americamysis bahia*) 96 hr survival, sand dollar (*Dendraster excentricus*) or purple sea urchin (*Strongylocentrotus purpuratus*) 96 hr embryo development, QwikLite – dinoflagellate (*Pyrocystis lunula*) 24 hr bioluminescence response, *Mytilus* sp. 48 hr larvae survival and development, and kelp (*Macrocystis pyrifera*) 48 hr growth and germination. The integrated regional monitoring provides answers to key questions such as:

1. Are discharges from shipyard industrial outfalls and storm drains protective of beneficial uses of Sinclair Inlet?

2. Are discharges from all sources of contamination into Sinclair and Dyes Inlets impacting the overall quality of water, sediment, and biota in the Inlets?
3. What is the status and trend of water, sediment, and biota residue quality in Sinclair and Dyes Inlets with respects to historical quality and both the regional and Puget Sound water and sediment quality?

Results from five events in 2009-2011 showed some evidence of seasonality. Three events were sampled during the wet season (November through May) and two during the dry season. The average concentrations of dissolved Cu and Zn were not significantly different between seasons (wet: 1.15 ± 0.90 and dry: 1.08 ± 0.75 $\mu\text{g/L}$) and Zn (wet: 4.26 ± 3.13 and dry: 4.89 ± 7.68 $\mu\text{g/L}$) compared to dissolved Hg (wet: 0.419 ± 0.337 and dry: 0.819 ± 2.32 ng/L) and Pb (wet: 0.0152 ± 0.0103 and dry: 0.0214 ± 0.0107 $\mu\text{g/L}$) which were about twice as high during the dry season. The dissolved fraction comprised 74-80% of the total Cu, 89-97% for Zn, 39-40% for Hg, and 15-18% for Pb. Mussel tissue residues were below screening level benchmarks at most locations, and no toxicity was observed from exposure to whole effluent samples. In contrast, toxicity measured in ambient water samples was highly correlated with the abundance of *Gymnodinium splendens* algal blooms.

For more information: <http://environ.spawar.navy.mil/Projects/ENVVEST/index.html>

Richard Jack

King County Department of Natural Resources, Water and Land Resources Division
Lake Washington Watershed PCB and PBDE Loadings Study
Richard Jack, Jenee Colton

Abstract:

In 2001, King County funded University of Washington graduate studies examining the food web and bioaccumulation of PCBs, mercury, and chlorinated pesticides in Lake Washington biota. Surprising results revealed that Lake Washington biota were close to the most contaminated for PCBs statewide. Based on these results, the Washington Department of Health (WDOH) issued a fish consumption advisory for PCBs in Lake Washington which covers yellow perch, cutthroat trout, carp, and northern pikeminnow in 2003. However, in the Greater Lake Washington watershed, it is not clear where regulatory or management actions should focus to achieve sufficient pollutant loading reductions to remove these consumption advisories. The degree to which PCBs are exported from the Lake Washington watershed as a source to Puget Sound is also unknown.

To further understanding of current PCB and PBDE loadings to Lake Washington and exports of these important chemicals to Puget Sound, King County, EPA, and shoreline jurisdictions are collaborating to:

- Collect whole PCB and PBDE water samples from potential major input pathways into Lake Washington or the Ship Canal, as well as water exiting the Ship Canal to Puget Sound.
- Analyze these whole water samples at low detection limits, using standard methods to produce data of appropriate quality for use in loadings calculations, fate and transport, and bioaccumulation models.
- Measure the fractions of PCBs and PBDEs partitioned between particulate and dissolved water fractions in a subset of whole water samples. Measurements of partitioning are needed to calibrate fate and transport models.

- Analyze total organic carbon, dissolved organic carbon, and total suspended solids in all whole water samples for use in loadings calculations, fate and transport, and bioaccumulation models.
- Collect samples where flow can be measured for use in loading calculations.

PCBs have been sporadically analyzed and detected in a variety of media in the Greater Lake Washington drainage basin. In many cases older Aroclor-based analytical methods for water have low frequencies of detection coupled with higher method detection limits. Due to this, these data are of limited utility compared to modern congener methods for fate and transport, and bioaccumulation modeling. This study is one of the first to examine PCBs and PBDEs across an entire highly urbanized Puget Sound basin to fill data gaps and develop modeling tools to answer three management questions:

1. Which 5 input pathways; stormwater, CSO, stream/river, road runoff, and wet/dry deposition are the highest priorities for PCB/PBDE load reduction?
2. Will potential loading reductions from these pathways reduce fish bioaccumulation, and contribute substantially towards lifting the fish consumption advisory on Lake Washington?
3. How long might it take the system to respond to these hypothetical loading reductions?

Scientific and water quality management staff of shoreline jurisdictions identified the fish advisory among their top water quality concerns during a watershed scoping exercise for Total Daily Maximum Load-related planning. Based on measured and modeled results, an advisory board of shoreline jurisdictions will develop recommendations for regulatory or management actions to reduce PCB or PBDE loads.

Christopher St. Clair

Simon Fraser University

Heavy Metal Exposure and Accumulation in Pacific Coast Dunlin (Calidris alpina)

Christopher St. Clair, Patricia Baird, Leah Bendell

Abstract:

Declines have been noted in many North American shorebird species over the past few decades. A likely contributing factor for declines is bioaccumulation of toxins. Marine and intertidal feeding birds are often subject to high levels of heavy metal exposure and accumulation, posing health risks that can result in mortality or otherwise reduce the viability of such species' populations. We are investigating cadmium, copper, lead, and zinc levels in Dunlins (*Calidris alpina*) captured in the Fraser River Delta (FRD) of southwestern British Columbia along with their prey. Dunlins are generalist sandpipers that feed variably in intertidal and agricultural areas on biofilm, insects, worms, gastropods, and other marine invertebrates. Our research objectives are:

1. Determine if accumulated heavy metals in pacific coast Dunlins are at levels proven to have negative health or reproductive impacts on avian species;
2. Determine metal exposure to Dunlins from the FRD;
3. Investigate the contribution of metals from different habitat and prey types.

We have analyzed Dunlin kidneys, gizzard contents, and prey items from the FRD intertidal zone for the listed metals and, in addition, conducted stable isotope analyses on Dunlin tissues, gizzard contents, and diet items to indicate the origin of metals ingested and accumulated. For the listed metals, sampled kidney concentrations were not observed at levels believed to incur significant health or reproductive effects. However, our research indicates cadmium exposure and accumulation is greater for Dunlin utilizing intertidal habitat than for those feeding predominantly

in agricultural habitat. Copper and zinc kidney concentrations were not correlated with habitat preference. Mean concentrations of gizzard contents were 5ug/g Cd, 60ug/g Cu, and 150ug/g Zn. We found that pacific coast Dunlin have lower cadmium concentrations in kidney tissues than do Western Sandpipers, a species that feeds more predominantly on biofilm.

Allen Chartrand

Robinson Noble, Inc.

Applying ecotoxicology to effectively manage contaminant impacts in the Salish Sea Watershed

Abstract:

This presentation will focus on how ecotoxicology is applied in the US, with a focus on the Puget Sound and adjoining watersheds, to manage aquatic contaminants, especially in larger urban areas. It will provide an overview of how these concepts are currently applied, and offer insights concerning how we might more effectively manage our contaminants within the overarching regulatory framework of the US Endangered Species Act (ESA) and Clean Water Act (CWA). The profusion of ESA listings within the Salish Sea/Puget Sound is unique in North America, and has commanded Congressional attention and aided funding for rehabilitating the Puget Sound. However, the interests of federal oversight agencies (e.g. EPA and NOAA) are not always in harmony, and potential conflicts should be reconciled.

There are several key examples of how current ecotoxicological tools are applied to help manage stormwater, surface water and sediment issues in compliance with ESA and CWA. Research agencies have issued guidelines based on toxicological approaches not available in developing EPA's currently enforced national ambient water quality criteria (AWQC) data base. Such ecotoxicologic techniques can advance identification of contributing causal agents within complex environmental mixtures, and from this research to derive toxicity-based guidelines to help protect listed species and their critical habitats.

Washington's Sediment Management Standards (SMS) represent a key example, as they and other sediment guidelines suffer from several limitations, including: 1) they only address effects to benthic communities; 2) they do not address freshwater sediment issues, and 3) they generally overlook the issue of bioaccumulative contaminants. Current ecotoxicological tools can help us address and establish a framework for managing each of these questions using data measuring more subtle forms of toxicity such as behavioral responses and contaminant interaction. As an illustration, this presentation will discuss copper in stormwater as ubiquitous aquatic contaminant requiring a fresh look in establishing regulation, and in linking observed species responses to potential impacts on fish and wildlife.

Regarding bioaccumulative chemicals; evaluations are currently largely performed on a case-specific basis in the absence of consistent regulatory agreement and guidance, when bioaccumulation is an ecosystem-wide issue. We need to address bioaccumulation more systematically; we should fully integrate lessons learned worldwide from well-documented legacy bioaccumulatives (e.g., DDT, dioxins, PCBs, mercury). Bioaccumulatives in sediments is especially important in aquatic ecosystems especially as clean sediments are needed to replace and enhance habitat in sensitive areas such as the sediment-scoured Lower Columbia River; clean sediment placement is a critical of the habitat protection required under ESA for salmonid outmigrants and other sensitive species.

In summary, when research discloses new findings regarding toxicological responses of aquatic life to toxicants, we need to set in motion a rigorous peer-review process by which to determine which research can be used to define regulatory guidelines and policy. We need to strike a balance between practicing sound science and achieving regulatory policy goals, while not enforcing regulations so zealously that economic growth is thwarted.

2B: The conservation imperative for the marine birds and mammals of the Salish Sea II

Marine birds and mammals are some of the most conspicuous users of the Salish Sea ecosystem. We seek to evaluate the current status, trends and health of these upper trophic level predators. Known threats and stressors include contaminants (e.g., flame retardants, perfluorinated compounds, heavy metals, PAHs, petroleum and pesticides), climate change, changes in prey populations (e.g., herring and other forage fishes), habitat modification, degradation and loss (e.g., foreshore development), and mortality from gillnet fishing and derelict fishing gear. A diverse array of laws and policies from multiple levels of federal, state (provincial), municipal (county), aboriginal, and private land owners need to be acknowledged and understood. The purpose of the session is to highlight the successes and shortcomings of current approaches to conservation science and management in the Salish Sea.

Conveners: Douglas Bertram, John Elliott, Steven Jeffries, Peter S. Ross

PRR Facilitator: Kirsten Hauge

Scott Pearson

Washington Department of Fish and Wildlife

Using Rhinoceros auklet diet and reproductive success data to assess ecosystem conditions

Scott Pearson, Peter J. Hodum, Michael Schrimpf, Julia K. Parrish, Thomas P. Good, Jane Dolliver

Abstract:

Like other coastal zones around the world, the Salish Sea is threatened by a variety of human activities. The rhinoceros auklet (*Cerorhinca monocerata*) is a locally breeding, burrow-nesting seabird. It is an ideal candidate for assessing the health of this threatened ecosystem because its population trends are likely to be tied to regional factors and as a top-level piscivorous predator it is susceptible to changes in forage fish populations. From 2006-2010, we compared rhinoceros auklet diet quality, quantity and composition and reproductive metrics among three island colonies:

1. Protection Island, located at the eastern end of the Strait of Juan de Fuca where birds forage exclusively in the Salish Sea;
2. Tatoosh Island, located at the confluence of the Strait of Juan de Fuca and the Washington Coast where birds likely forage in both the Salish Sea and coast; and
3. Destruction Island, on the outer Washington coast where birds forage exclusively on the coast.

This 3-way comparison allowed us to assess differences between a healthy, upwelling system (coast/California Current) and a non-upwelling system apparently in decline (Salish Sea). To put our contemporary data in an historic context, we compared diet and reproductive variables between the 1970s and today at a coastal (Destruction Island) and a Salish Sea (Protection Island) site. This final comparison allowed us to assess whether or not our contemporary data are within the bounds of the historic sample. For these comparisons we compared chick diet quality (bill load weight and calories), diet species composition and reproductive variables (% burrows with eggs, hatching success and fledging success). We found no significant difference in burrow occupancy, hatching success, or fledging success among islands. However, the occupancy rate was consistently lower on Destruction Island (coast). Within the Salish Sea, burrow occupancy rates were marginally higher today than the 1970s. For our contemporary diet quality comparisons, we found no differences between the Salish Sea and coast and we also found no apparent differences in bill load weight between the 1970s and today within the Salish Sea. Rhinoceros Auklet chick diet contained over 30 prey species. Across all islands and years, the vast majority of auklet chick diet (> 80%) was composed of Pacific sandlance (*Ammodytes*

hexapterus), Pacific herring (*Clupea harengus pallasii*), and northern anchovy (*Engraulis mordax*). Within the Salish Sea, diet composition has not changed since the 1970s. These results coupled with our work indicating a breeding population increase on Protection Island suggest that rhinoceros auklet populations in the Salish Sea are healthy.

Louise Blight

Centre for Applied Conservation Research, UBC

*Stable isotopes and meta-analysis of reproductive traits reveal Glaucous-winged gull (*Larus glaucescens*) diet shifts and egg production declines over the last 150 years*

Louise Blight, Peter Arcese

Abstract:

Historical studies of animal ecology often compare changes in past and present distribution and abundance, or relate such population shifts to alterations in ecosystem function. Long-term changes in basic biology are more difficult to measure due to a paucity of detailed observations. The glaucous-winged gull (*Larus glaucescens*) is a conspicuous species with accessible nesting colonies, and as such has been studied and collected by naturalists and biologists for the last 150 years. A wealth of historical data and museum specimens are therefore available, and are now of interest as this common species is in decline over much of its range. We combined demographic modeling, a review of traditional biological studies, and stable isotope analysis to characterize century-long population trends and to ask (a) whether long-term changes to reproductive output were driving population declines; and (b) whether reproductive changes may have been caused by changes in forage fish availability. First, we used meta-analysis to examine long-term trends in egg (108 y) and clutch (48 y) size, using data collected from field research, published literature, and measurements of historical egg sets held in museums worldwide. Mean egg volume decreased over the study period, while modal clutch size declined from three eggs to two. As both these reproductive traits respond to food quality and availability we then used stable isotope analysis of museum specimens (1860 – present) to determine whether gulls had undergone long-term dietary shifts. Preliminary results from isotopic analyses (C and N) indicate that since 1860, glaucous-winged gull diet has become less marine, and that gulls are now feeding at a lower trophic level. As chicks hatching from smaller eggs show reduced survival, concurrent egg and clutch size reduction may play a role in observed glaucous-winged gull declines. Information gleaned from historical accounts indicates that this species may be returning to historically-depressed levels, rather than to “natural” baseline numbers.

Nacho Vilchis

SeaDoc Society

Long-term trends of wintering marine birds in Puget Sound

Nacho Vilchis, Joe Evenson, Joe Gaydos, Don Kraege, Bryan Murphy, Tom Cyra, Scott Pearson, Dave Nysewander

Abstract:

Puget Sound faces an increasing rate of local extinctions in its wildlife. Most of these extinctions will be the direct result of either fisheries or cascading effects of ecosystem deterioration in the face of human disturbance. Marine birds, because of their natural history (long-lived, migratory apex predators), can be key indicators of the health of Puget Sound and, therefore, flagship species for its conservation. Using aerial survey data of wintering marine birds collected by the Washington Department of Fish & Wildlife under the auspices of the Puget Sound Ambient Monitoring Program, we assessed long-term trends in marine birds wintering in Puget Sound. Beginning in 1994, aerial surveys have been completed annually every winter covering an average of 5,000 kilometers of shoreline and open sea. During this time-frame, over 3,000,000 individual birds have been accounted from 116 different species. Using a phylogenetically and ecologically diverse suite of species we determined temporal trends in densities for forty focal species from nine different orders and eleven families of birds. We found non-random decreases in density for 13 species belonging to a variety of bird families while, increases in density were limited to waterfowl. In addition, with a community analysis, we found that species composition of

the 40 focal species changed as a function of time; species' compositions at the beginning of the surveys were different from those in later years. We hypothesize that species that are obligate piscivores are more likely to have population decreases in Puget Sound, and that species' compositions are changing accordingly. Our research can be applied to identify management and conservation strategies that will positively impact multiple species and encourage ecosystem-level recovery in Puget Sound.

Sean Boyd

Science & Technology Branch, Environment Canada

Ever wonder where Salish Sea birds go to breed, molt, and stage? Connecting the dots...

Sean Boyd, Dan Esler

Abstract:

Hundreds of thousands of migratory birds overwinter in the Salish Sea, including several species of sea ducks and Arctic geese. To conserve populations of these species, managers need to understand migration patterns, including affiliations with breeding, molting, and staging areas and their degree of site fidelity across years. During the last decade we marked Surf Scoters, White-winged Scoters, Black Scoters, Barrows Goldeneye, and Western High Arctic (grey-belly) brant with satellite transmitters to track their movements throughout the annual cycle. All three scoter species were marked in Baynes Sound on Vancouver Island B.C. and all tagged birds migrated north along the Pacific Coast in spring. Surf and White-winged Scoters bred over a large geographic area east of the Rocky Mountains, from northern Alberta to the Northwest Territories whereas the Black Scoters bred only on the western edge of SW Alaska. Most White-winged and Black Scoters staged for several weeks during spring migration off the northeast tip of Haida Gwaii B.C., suggesting that this could be an important site for nutrient acquisition. Surf Scoters, on the other hand, used a different migration strategy, often stopping at herring spawn sites along the B.C. and SE Alaska coasts. Barrow's Goldeneye marked in Indian Arm near Vancouver B.C. bred over the southern portion of interior British Columbia, roughly from the Okanagan to Prince George but concentrating around the Kamloops area. Once females began to incubate eggs their mates migrated up to 2,000 km further north to undergo wing feather molt. Finally, brant marked on Melville Island in Nunavut during their summer molt migrated along the Arctic and Pacific Coasts to overwinter in Samish and Padilla bays in northern Puget Sound WA. These birds staged at Izembek Lagoon on the Aleutian Peninsula for up to 2 months before making a trans-Pacific migration to their Salish Sea wintering grounds. Most marked individuals for all of the above species showed a high level of site fidelity between years, returning to the same wintering area and often to the same bay or inlet. This suggests that aggregations overwintering in specific areas of the Salish Sea could be strongly affected by local conditions, e.g., numbers could be reduced if harvest levels are too high or if their habitat becomes degraded because of disturbance, oil spill, etc. The information gained during these studies provides a unique spatial-temporal perspective on the connectivity between the Salish Sea and breeding, molting, and staging areas in western North America for different species. The information is also novel and impossible to achieve with other methods, illustrating the value of satellite telemetry for conservation of migratory birds.

Eric M. Anderson

Centre for Wildlife Ecology

Western Grebes in the Salish Sea: Status update and prospectus of monitoring and research needs

Eric M. Anderson, Peter Arcese, Scott D. Wilson, Douglas F. Bertram, Joseph R. Evenson, L. Ignacio Vilchis

Abstract:

Western Grebes (*Aechmophorus occidentalis*) are Red-listed in British Columbia, and are currently being considered for legal designation in Canada and Washington State. These protection efforts are largely a result of limited analyses of population trends because long-term monitoring and research on Western Grebes are rare over most of the species' breeding and

wintering range. Accordingly, we provide an initial assessment of several key objectives likely to aid in further analyses of Western Grebes as a priority for conservation and, potentially, species recovery efforts. Our main findings include the following:

1. A review of past studies indicates that a range of human disturbances constitute the main threats to Western Grebes; on coastal habitats these include oil spills, bycatch in gill nets and derelict fishing gear, contaminant exposure, predation, and declines in small fish that are the main prey of Western Grebes.
2. We replicated historical boat- and shore-based counts of wintering Western Grebes at eight sites in the Georgia Basin, and in all but one site maximum counts had declined by >90% since the 1980s/1990s. Analyses of the more extensive BC Coastal Waterbird Survey also indicated marked declines in BC.
3. In Washington, aerial counts in the Strait of Juan de Fuca and the San Juan Islands indicate that numbers of Western Grebes declined by 95% between the periods 1978-1980 and 1992-1999. Ongoing aerial surveys by the Washington Department of Fish and Wildlife throughout the inner marine waters of Washington also indicate that Western Grebes have declined between 1992 and 2010.
4. Analyses of Christmas Bird Count (CBC) data indicated that Western Grebes wintering on the Pacific Coast of North America declined by ~27% from 1975 to 2009. However, trends differed greatly among regions with steep declines in southern BC and Washington, and increases of nearly 300% in southern California. These results, while indicating that modest declines in the total wintering population have occurred, are consistent with the hypothesis that wintering Western Grebes have shifted their centre of distribution southwards along the Pacific Coast.
5. Several findings suggest that Western Grebes are highly vagile, and thus a southward shift in their wintering distribution is perhaps plausible. For instance, banding data indicate that wintering site fidelity and migratory connectivity are not strong in this species. Genetics studies also suggest that Western Grebes frequently disperse between regions.
6. Finally, we identified priorities for monitoring and research based on results of the above analyses and of a focal workshop including federal, state, and university scientists. Key priorities include:
 - i. Identify exogenous drivers of CBC trends regionally and coast-wide;
 - ii. Evaluate whether relocation of Western Grebes to coastal areas that are not adequately surveyed (e.g., Baja Mexico, Haida Gwaii) might 'explain' their ~27% coast-wide decline indicated by CBC data and the virtual disappearance of the species from coastal BC and Washington;
 - iii. Establish degree of wintering site fidelity, and of migratory connectivity between major breeding and wintering areas;
 - iv. For breeding colonies, assess historical change in their location, size, reproductive output, and adjacent land use.

Mikaela Davis

Simon Fraser University

Dietary trends of the Glaucous-winged gull on the Canadian West Coast

Mikaela Davis, John Elliott, Tony Williams

Abstract:

The accumulation of persistent organic pollutants (POPs) in the environment is an ongoing hazard to ecological integrity. There is thus a need for monitoring programs to track contaminant levels in the environment. POPs accumulate in the tissues of high trophic level predators, making them potentially useful as biological monitors for pollutant concentrations, means of exposure, and spatial and temporal contaminant trends. As a top predator in aquatic systems, the Herring gull (*Larus argentatus*) has been used successfully by Environment Canada for more than 35 years to monitor POPs in the Great Lakes. Building on the Great Lakes experience, Environment Canada recently established a national ecosystem monitoring program with the intention of tracking legacy and emerging contaminants (such as organic flame retardants), utilizing gull species such as the Glaucous-winged Gull (*Larus glaucescens*) on the West coast of Canada. The utility of the Glaucous-winged gull as a marine monitor hinges on its consumption of a marine-based diet. However, there is a lack of recent and reliable data on the diet of this species in the Salish Sea. Using a combination of conventional diet analysis and stable isotope methods, we are studying the diet at 3 breeding colonies, two in the Salish Sea and one on the West coast of Vancouver Island, and comparing findings with data from 30 years ago. Preliminary results from conventional sampling methods suggest that current adult diet (combined pre-lay and incubation periods) varies from historical records at Salish Sea Colonies (Mandarte and Mitlenatch Islands). Compared to 1982, adult diets from 2010 included a lower prevalence of anthropogenic diet sources and elevated marine sources. In contrast, current adult diet on the West Coast (Cleland Island) appears consistent with historical data, remaining marine-based. For chick diet, conventional sampling data varies little between 1982 and present years, with fish dominating at all colonies. The occurrence of anthropogenic items in chick diet still occurs at Salish sea colonies, although appears reduced. We will present data on stable isotope analysis and compare results to conventional dietary sampling approaches.

2C: Puget Sound Watershed Framework - Using the Puget Sound Characterization Project to Guide Planning and Development

To be successful in protecting and restoring ecosystems and the processes that drive them, it is critical that local governments have the tools and information to develop effective land use designations, regulations, and development standards. The Puget Sound Characterization Project has developed a “watershed based” decision support tool for guiding local planning and development. The first half of this session will summarize the characterization project, the results of the assessments and the decision framework. The second half will focus on the application of the results by local government. King and Pierce Counties and the City of Bremerton, Snohomish County, the Cascade Land Conservancy and the Puget Sound Regional Council will share how they are using the assessment framework to help make decisions that will shape land conservation and growth management across the Puget Sound Region over the next decade. This will include presentations on the Regional Transfer of Development Rights (TDR) program to protect forest and farm lands critical to watershed health.

This session will also feature a facilitated discussion.

Convener: Stephen Stanley

PRR Facilitator: Rita Brogan

Stephen Stanley

Washington Department of Ecology

Puget Sound Watershed Framework - Using integrated watershed assessments and data to guide planning

S. Stanley, S. Grigsby, T. Hruby, P. Olson, G. Wilhere, D. Booth, R. Horner, D. Hartley, J. Thomas, P., B. Fuerstenberg, P. Bissonnette, J. Lee

Abstract:

To successfully protect and restore our lakes, rivers, wetlands, estuaries and terrestrial habitat, a hierarchical framework must be established that organizes and integrates watershed resource data and information for all watershed resources and processes. Once established and implemented, a watershed framework can guide management actions that effectively maintain or restore watershed health and thus sustain ecological integrity of watershed ecosystems. Washington Department of Ecology, Fish and Wildlife and Department of Natural Resources in conjunction with the Puget Sound Partnership and Tribes have developed a watershed framework for Puget Sound. The framework proposed for the Puget Sound Characterization is divided into four levels, with broad or watershed scale being level 1 and 2 and the reach or site scale being level 3 and 4. The assessment results for water flow, water quality and fish and wildlife at levels 1 and 2 will be summarized. Level 1 and 2 assessments can inform local planning efforts (SMP and GMA updates) and prioritization programs for selecting areas for protection and restoration actions, including in-lieu fee and TDR programs.

George Wilhere

Washington Department of Fish and Wildlife

A coarse-scale assessment of relative conservation value for terrestrial, freshwater, and marine nearshore habitats in the Puget Sound Basin

George F. Wilhere, Timothy Quinn, John Jacobson, Dale Gombert, and Dan Miller

Abstract:

We conducted a spatially-explicit, coarse-scale assessment of the relative value of places for the conservation fish and wildlife habitats in the Puget Sound Basin. Because of differences in dimensions, spatial scale, data quality, and ecosystem-level processes the assessment was broken into three separate assessments: terrestrial, freshwater, and marine nearshore. Analysis units for the terrestrial and freshwater assessments were small watersheds with median area

equal to 12 km². In the terrestrial assessment, relative value was mainly a function of ecological integrity, which was based on open-space fragmentation and land use. The freshwater assessment was confined to lotic habitats, and relative value was a function of salmonid habitats, hydro-geomorphic features, and accumulative potential downstream impacts. For the marine nearshore assessment, the analysis was done at two spatial scales: shoreline segments with median length equal to 0.23 km and drift cells with a median length of 3.1 km, and relative biological value was a function of ecological richness, which was defined as the number of species and habitat types occurring in a segment. Relative value was calculated within water resource inventory areas (WRIAs) and oceanographic subbasins for freshwater and marine nearshore assessments, respectively. In the terrestrial assessment places with highest relative value were oak woodland and prairie, open-space at the mouths of large rivers, or exceptionally large areas of forest. The freshwater assessment indicated that the majority of analysis units had a high relative value for at least one of the index's components (salmonid habitats, hydro-geomorphic features, and accumulative potential downstream impacts), and therefore, most analysis units warrant some type of conservation action. The spatial distribution of relative biological value in the marine nearshore assessment presented a diffuse pattern, and therefore, protection of habitats along marine shorelines will be challenging.

Michael Murphy

King County

Integrating watershed characterization with transfer of development rights in the Puget Sound region

Michael Murphy, Darren Greve, Ivan Miller

Abstract:

Transfer of Development Rights programs are one of the tools that can be used to protect forest and farm lands critical to watershed health. Governments and non-profits across the Puget Sound are implementing an innovative Regional Transfer of Development Rights (TDR) program and forging local and regional partnership. These partnerships will empower the TDR mechanism as a growth management policy tool to harness private sector development to steer development potential away from important ecological lands and into existing urban areas.

Regional TDR Partners are using the newly released GIS watershed characterization information from the Washington State Department of Ecology, and funded by the US EPA, to guide policy decisions that will determine where throughout the landscape development rights should come from, and where they should be moved to.

King and Pierce Counties will share how they are using newly released scientifically-driven ecological GIS information to help make decisions that will shape land conservation and growth management across the Puget Sound Region over the next decade. Presenters will explain how these decisions, informed through ecological and GIS mapping science, are enabling local governments to protect the lands and properties that have the greatest positive impact on Puget Sound water quality and watershed health.

Aaron Petersen

Pierce County, Planning and Land Services

Integrating watershed characterization with transfer of development rights in Pierce County

Abstract:

The Pierce County Transfer/Purchase of Development Rights (TDR/PDR) program was established in 2007 in response to threats to agriculture from land use conversion. Specifically, the TDR/PDR program was created in order to provide a tool to keep farmland intact while monetarily compensating the landowner. The program allows development rights to be transferred/purchased (Sending Site) from agriculture land, forest lands, habitat, and trail extensions. The development rights are then transferred (Receiving Sites) to or in some cases required in cities, urban growth areas and comprehensive plan amendments resulting in higher

densities. Working resource lands (i.e. agriculture and forestry) specially, two agricultural communities along the Puyallup River have been identified as priority sending site areas.

A geographic assessment was made to determine how and if the mapped Watershed Characterization, water flow data published by the Washington Department of Ecology, could be used as a tool with which to support the Pierce County TDR/PDR program. Specifically, it was tested as a tool for identifying where productive resources lands overlap with lands important to water flow processes within the Puyallup River watershed (WRIA 10). Three example focus areas identified as priority areas for sending site transactions were mapped and evaluated.

Staff concluded that the data was useful as a tool for defining potential focus areas within already prioritized sending site areas. In addition, the data was also useful for determining how and in what locations the TDR program can assist in restoring water process within the Puyallup River watershed.

Jennifer Grathwol

Parametrix

Developing a watershed based subarea plan for Gorst Creek

Abstract:

Under a 2010 National Estuary Program grant (EPA), the City of Bremerton is developing a subarea plan for the Gorst Creek watershed located generally west of the City. This area is relatively undeveloped, consisting of forested tracts in the northern portion of the watershed and rural residential in the southern and eastern portions. Gorst Creek watershed is a municipal water source for the City and supports valuable salmonid populations. It is crucial that future development not impact these ecosystem services. Using the methods and watershed framework developed for the Puget Sound Characterization Project, water flow processes and fish/wildlife habitat were assessed. This information was then used to identify the best areas for protection, restoration and development and to inform the final subarea plan.

2D: Implications of ocean acidification for the Salish Sea

Ocean acidification is the process by which excess anthropogenic carbon dioxide drives reductions in seawater pH and carbonate ion availability. It has been identified as the most significant near-future threat to marine ecosystems, and considerable impacts are already being felt by many species, particularly those that rely on calcified shells and skeletons. Because many of these species are socio-economically and/or ecologically important, there has been a recent push to quantify the responses of marine organisms to acidification. Although our understanding of individual-level responses is improving, management and policy relevant information regarding the responses of marine populations, communities, and ecosystems is largely absent.

The Salish Sea may be particularly vulnerable to ocean acidification due to the combination of climatic factors (e.g., the upwelling of corrosive water), ecological sensitivities, and the social and economic importance of marine-derived food and income in the region. In this session, we aim to bring together oceanographers, physiologists, and ecologists along with members of Native American/First Nations governments, aquaculture organizations, and state/provincial and federal government agencies. Talks include cutting edge research on the responses of marine organisms to ocean acidification, and what these responses will mean to key species and entire ecosystems. Input from the aquaculture industry will highlight recent pH changes in the Salish Sea, and their impacts on cultured species. Representatives from government provide context on what steps may be taken in the realm of management, and what additional scientific data will be required to aid in minimizing negative impacts on human societies. Our goal is to facilitate dialogue between researchers, stake holders and governments to help set priorities for near future research directions and management strategies.

Conveners: Christopher Harley, Jan Newton, Dr. Karen Kohfield, Paul Williams, Anne Solomon

PRR Facilitator: Jamie Strausz-Clark

Richard Feely

Pacific Marine Environmental Laboratory, NOAA

Ocean acidification in the Salish Sea

Richard A. Feely, Simone R. Alin, Christopher L. Sabine, Jan Newton, Mark Warner, and Allan Devol

Abstract:

The Salish Sea is a large estuary complex in the U.S. Pacific Northwest that is home to a diverse and economically important ecosystem threatened by anthropogenic impacts associated with climate change, urbanization, and ocean acidification. While ocean acidification has been studied in oceanic waters, little is known regarding its status in estuaries. Anthropogenically acidified coastal waters upwelling along the western North American continental margin can enter the Salish Sea through the Strait of Juan de Fuca. In order to study the combined effects of ocean acidification and other natural and anthropogenic processes on Salish Sea waters, we made the first inorganic carbon measurements in this estuary on two survey cruises in February and August of 2008, and again the summers of 2009 and 2010. Observed pH and aragonite saturation state values in surface and subsurface waters were substantially lower in parts of Salish Sea than would be expected from anthropogenic carbon dioxide (CO₂) uptake alone. We estimate that ocean acidification can account for 24–49% of the pH decrease in the deep waters of the Hood Canal sub-basin relative to estimated pre-industrial values. The remaining change in pH between when seawater enters the sound and when it reaches this deep basin results from remineralization of organic matter due to natural or anthropogenically stimulated respiration processes within the Salish Sea. Over time, however, the relative impact of ocean acidification could increase significantly, accounting for 49–82% of the pH decrease in subsurface waters for a doubling of atmospheric CO₂. These changes may have profound impacts on the Salish Sea ecosystem over the next several decades.

M. Brady Olson

Western Washington University / Shannon Point Marine Center
Microzooplankton feeding and growth in an acidified Salish Sea
M. Brady Olson, Brooke A. Love, Suzanne L. Strom, Ariel Morrison

Abstract:

Despite recognition as key members of marine food webs, microzooplankton are largely absent from the growing number of studies exploring the effects of ocean acidification on marine zooplankton. Sensitivity by microzooplankton to ocean acidification may potentially alter many important marine biogeochemical cycles, namely C, N and P transfer and regeneration. Ocean acidification may affect microzooplankton directly, or indirectly through ingestion of prey whose own biochemistry or physiology is altered by ocean acidification. To study ocean acidification effects on microzooplankton feeding ecology we developed a novel laboratory experimental system that allows air-sea gas exchange to drive our carbonate chemistry, rather than direct bubbling of CO₂ enriched air into media. Our model organisms are several species of resident Salish Sea microzooplankton, including dinoflagellates and ciliates, and calcifying (CCMP 2668) and non-calcifying (CCMP 373) strains of *Emiliana huxleyi*. Both microzooplankton and *E. huxleyi* cultures are grown in air-tight boxes supplied with either ambient, 750 or 1000 ppm CO₂-enriched air. When individual microzooplankton species are acclimated to CO₂-enriched conditions, ingestion and growth rates across CO₂ treatments are the same as ambient controls when feeding on non-acclimated prey, suggesting that they are not directly affected by acidified conditions. We have shown that both strains of *E. huxleyi* alter aspects of their physiology and biochemistry when grown under acidified conditions. Experiments are currently underway to determine whether these changes in prey state affect the feeding or growth rate of microzooplankton grazers. We will discuss the results and implications of these experiments with respect to the Salish Sea, as well as describe our experimental system.

Simone Alin

NOAA Pacific Marine Environmental Laboratory
Water chemistry and larval oyster success in Puget Sound as impacted by ocean acidification
S. Alin, B. Allen, A. Suhrbier, J. Davis, R. Feely, J. Newton, A. Devol, C. Sabine, B. Peabody, B. Hales

Abstract:

Recent observations have shown that marine waters below the surface in Puget Sound are undersaturated with respect to the biomineral aragonite throughout the year. Decreasing oyster populations and high mortality in larval stages throughout the Pacific Northwest have raised concern that ocean acidification may be changing water chemistry and causing the observed shellfish declines. To examine linkages between water chemistry and oyster settlement, we collected water and biological samples during the growing seasons of 2009 and 2010 at two index stations located in Totten Inlet (South Puget Sound) and Dabob Bay (Hood Canal). Totten Inlet is an important area for Olympia oyster (*Ostrea lurida*) production, and Dabob Bay is a key site for Pacific oyster (*Crassostrea gigas*) larval production and farming.

During the summer 2009 sampling season, partial pressures of CO₂ (pCO₂) were much higher at the Totten Inlet station than at the Dabob Bay station. Accordingly, saturation states and pH values were substantially lower in Totten Inlet, with undersaturation of aragonite observed in 80% of samples. During storm events in the fall, CO₂-rich water with low pH and saturation states was mixed to the surface at the Dabob Bay station. In 2010, pCO₂ levels were much lower at both stations, with higher values at Totten than Dabob as in 2009. Higher pH and saturation states were also observed at both sites in 2010. With the onset of stormy weather in the fall, pCO₂ levels showed abrupt increases at both sites, accompanied by decreased pH and saturation states. Comparison between the water chemistry at the two index stations suggests that the dominant control on water chemistry at Dabob Bay is upwelling and winds, whereas at Totten Inlet nearshore carbon chemistry is dominated by biological respiration.

Peak abundance and settlement of the Olympia oyster occurred between early June and mid-August at Totten Inlet in both years. Peak Pacific oyster settlement in Dabob Bay centered on August during both years. At both sites, the decrease in pH and carbonate saturation states at the end of summer or early fall corresponded with the end of settlement and the time when dominant shell mineralogy in juvenile oysters transitions from aragonite to calcite, with calcite being the more stable mineral form in lower saturation waters.

Jeff Marliave

Vancouver Aquarium

Possible biological correlations to ocean acidification and climate regimes in the Strait of Georgia

Jeff Marliave, Skip Young, Andy Lamb, Donna Gibbs, Charlie Gibbs

Abstract:

The Vancouver Aquarium has kept pH records of intake seawater since 1954 and Pacific Marine Life Surveys taxonomy records exist continuously from 1967. Ocean acidification occurred progressively from the late 1970s to the present. Peak anomalies of either high or low pH tended to be during late winter through early summer in different years. Maximum pH has only slightly decreased from 8.0 to 7.9 while variance has increased considerably, from 7.9-8.0 to 7.3-7.9. In February 2010, wolf-eel eggs being incubated at pH 7.3 were not hatching, despite very advanced embryonic development. Titrating their seawater from pH 7.3 to 7.6 caused a burst hatch. In 2011, another wolf-eel egg mass, incubating at pH 7.6, was titrated in the same way to pH 7.9 without any stimulation of hatching, and then a normal hatch took place one week later. Bull kelp disappeared from central latitudes of the Strait of Georgia in synchrony with decreasing pH, but other potentially confounding factors were also coincident. Both human and pinniped populations have increased in central latitudes of the Strait of Georgia during the period of bull kelp disappearance, and urchin barrens appear related to sewage pollution. Overall biodiversity has remained stable for shallow seabed communities through continuous acidification and several climate regime shifts.

Christopher Harley

University of British Columbia

Ecological impacts of ocean acidification in the Salish Sea

Christopher Harley, Ryan Crim, Rebecca Gooding, Sarah Nienhuis, Emily Tang

Abstract:

Rising atmospheric CO₂ concentrations and the upwelling of corrosive waters are driving rapid and potentially unprecedented reductions in pH and carbonate ion availability in the Salish Sea. This process, known as ocean acidification (OA), has far-reaching implications for the performance and survival of marine organisms, particularly those with calcified shells and skeletons. Here, I highlight the ways in which OA impacts plants and animals in a coastal benthic food web, with an emphasis on what we know and what we don't know about the ways in which the responses of individual organisms will scale up to long-term changes in community structure.

My system of interest is the rocky shore benthic community in the Salish Sea. Ecologically important species include producers (micro- and macro-algae), grazers (urchins and gastropods), filter feeders (mussels and oysters), and predators (sea stars). Although the direct effects of OA on coastal phytoplankton and kelps remain poorly understood, it appears as though elevated CO₂ may increase the doubling rate of planktonic diatoms. Small changes in food supply, however, may pale in comparison to the direct effects of OA on heavily calcified grazers and filter feeders. Sea urchin and mussel growth are both reduced by increased CO₂ in the lab, and decadal-scale reductions in pH are associated with reduced turban snail growth in the field. Although adult abalone growth appears to be unaffected by CO₂, larval development is impaired and larval survival is significantly reduced in acidified conditions. In contrast to the negative effects of OA on heavily calcified herbivores and filter feeders, lightly calcified sea stars actually grow faster when CO₂ is experimentally increased.

The acidification-induced changes described here are likely to result in substantial shifts in the benthic ecosystem. Increasing predation pressure may further reduce the abundance of grazers and filter feeders that are already suffering direct negative impacts of acidification. Declines in grazer populations may in turn allow primary producers such as kelps to become more abundant. Because kelp forests provide habitat for a wide array of species, OA may have a positive impact on some aspects of biodiversity. On the other hand, mussel beds also harbor hundreds of dependent species, and a loss of mussel beds due to reduced mussel growth rates and increased loss to predators would decrease biodiversity of this component of the benthic community.

The predictions outlined above should be viewed as preliminary due to large gaps in our understanding. For example, the effects of OA on fertilization and other sensitive life history stages and transitions remain unquantified in the vast majority of species, and any effects of such changes on population dynamics remain unknown. Furthermore, the strength of interactions among species may change in unexpected ways due to, for example, the effects of pH on organismal physiology. Finally, the effects of ocean acidification are not occurring in isolation, and critical physiological and ecological thresholds may be crossed when OA effects are combined with increases in temperature, storm disturbance, pollution, and fishing pressure.

Jan Newton

University of Washington

Integrating ocean acidification research across the Salish Sea

Abstract:

The pace of ocean acidification is increasing rapidly as recognition of the problem grows and research capacity increases. Studies of estuarine condition with respect to carbonate chemistry, biological responses of key organisms, ecological responses, and mitigation strategies all are underway. Despite advances, no overarching organization of regional research efforts now exists. Here I report on the status of ocean acidification research across the Salish Sea and propose a research framework that could inform a regional integrated assessment of the problem. Collaboration and coordination among research activities will increase the speed with which new knowledge is obtained and applied in this regional setting.

2E: Restoring estuaries of the Salish Sea: Case studies and social and scientific challenges I

Estuarine restoration is critical to recover ecosystem services, the health and productivity of diverse natural resources, and maintain a rich cultural heritage. This session will feature lessons learned and ongoing processes on the Nisqually Delta, the Nanaimo River Estuary, the urbanized and dammed Deschutes Estuary at Capitol Lake, the Skokomish, the Skagit and the Snohomish and others. Through a series of restoration case studies, we will present examples of the successes and challenges of estuarine protection, conservation, and restoration. Our goal is to facilitate knowledge transfer of fruitful interdisciplinary partnerships, applied research and monitoring efforts, as well as socio-political challenges of restorations in urban estuaries to inform restoration science, management, policy and community well-being.

Conveners: Isa Woo, Sue Patnude, Pamela Shaw, Eric Grossman, Christopher Ellings
PRR Facilitator: Hadley Rodero

Sue Patnude (30 minutes)

Deschutes Estuary Restoration Team
Visualize the Deschutes Estuary
Sue Patnude, Jeff Dickison, Doug Myers

Abstract:

On the very southern borders of the Salish Sea, in Puget Sound's Budd Inlet, the Deschutes River rushes toward its marine home, only to be trapped by a concrete dam that forms Capitol Lake. If the Deschutes Estuary was restored, what would it look like? Let's approach estuary restoration within a watershed from its marine persona as organisms and nutrients penetrate the hyper-productive zone that is the interface between the land and sea. Every piece of the habitat puzzle must function effectively to restore resource productivity to the Salish Sea. The estuary is a link, a highly productive connection, between the watershed and the vastness of the marine environment. Estuary restoration without a productive marine environment would be like adding another lane to the bridge to nowhere.

South Puget Sound is a highly productive and diverse network of waterways that generate large amounts of forage fish and other food supplies for growing piscivores, attracting juvenile salmonids from numerous river systems including some north of Tacoma Narrows. These fish occupy habitat space and consume food from multiple food trophic levels and are highly dependent on estuary habitat, including river deltas and pocket estuaries. For fish, a successful life history strategy means the maintenance of intact and contiguous marine habitat is critical.

The Squaxin Island Tribe has determined through habitat assessments of potential marine restoration sites, that single projects in a highly degraded area are not likely to offer successful habitat function. Multiple projects are necessary to achieve a critical mass of habitat function surrounding an estuarine environment. Without a functioning Deschutes Estuary, other adjacent habitat restoration projects would stand little success.

Restoring the Deschutes Estuary is scientifically feasible, but socially challenged. The river is dammed at Capitol Lake. The lake is considered an "icon" of the state, even though it is eutrophic, full of invasive species and is filling with an average of 32,000 cy (cubic yards) of sediment annually. Design alternatives for lake management were discussed through a State-sponsored process that compared keeping the lake intact or restoring the estuary. Estuary restoration was the final recommendation but was quickly challenged by lake supporters who began a public campaign that painted a visual of the restored estuary as a stinky mud flat, a swamp in downtown Olympia and balked at the assumed new costs to dredge local marinas.

What would a restored urban estuary look like? A saltwater marsh with no mudflats may not be

feasible given tidal regimes and hydrology. Future sedimentation patterns of a restored estuary will be dependent on finer scale design elements. Minimizing effects on sediment impacts to the built environment such as port, marinas, downtown flooding and stormwater treatment are all subjects of future stakeholder discussions. Moving forward with a restored estuary visualization process and contingency planning in a cooperative way with all stakeholders could realign expectations and diffuse polarizing positions and would help obtain needed funding and policy support.

Keith Dublanica (15 minutes)

Mason Conservation District

Restoration processes of the Skokomish Estuary

Abstract:

The restoration of the Skokomish estuary—at the Great Bend of Hood Canal—began in the mid-1990s with certain assessments led by the Skokomish Indian Tribe, and provided by various entities interested in rehabilitating a certain near-shore landscape back to estuarine processes. This landscape is totally encompassed by the Tribe's Reservation, on land owned by the city of Tacoma, but previously by an agricultural interest that had modified hundreds of acres of near-shore and estuarine landscapes in the middle part of the last century. The Tribe was instrumental in securing the early support and gained additional leverage of subsequent funding to gain more of a restoration footprint than previously identified by an Army Corps of Engineers summary analysis in 1995. Following over a decade of varied requests for proposals addressing the landscape issues (and project obstacles), the Tribe was successful in the implementation of two Phases of estuarine habitat restoration in 2007 and 2010 respectively, restoring over 250 acres directly with an additional 1000 acres of estuarine near shore and deltaic plain influenced by this project. A Phase 3 is anticipated in low flow of 2012 following successful funding pursuits. At this site of Hood Canal—glacially-carved fjord of the Puget Sound—the Skokomish Indian Tribe and its collaborative partners have implemented a successful estuarine restoration project that addresses both landscape and cultural restoration. This restoration project was also key in motivating the Tribe and the city of Tacoma to enter mediated discussions to resolve the longest re-licensing effort in the history of the Federal Energy Regulatory Commission (FERC). FERC Project #460—the Cushman Hydro-electric Project, has had a long history that has fostered adversarial attitudes and positions in the watershed. The FERC process will result in the implementation of multiple license conditions including transfers of the landscape property titles to the Skokomish Indian Tribe.

Restoration of salmon and shellfish habitats, sequestering of nutrients to improve dissolved oxygen levels of Hood Canal, access to greater distribution and abundance of culturally –specific vegetation, increasing habitat for migratory shorebirds under the Pacific flyway, and addressing issues of sea level rise and climate change are all paramount foci of this project. But also is the restoring and returning of the landscape back to the culture with the longest history in the area.

As the phases of the project mature along certain restoration trajectories, both project monitoring and effectiveness monitoring are being implemented. This project, led by the Skokomish Indian Tribe, administered by the Mason Conservation District, and supported by the Skokomish Watershed Action Team and numerous other entities, is comparable to other Puget Sound estuarine restorations, but with specific elements unique to this landscape at the foothills of the southeast Olympic Mountains. It is an example of restoration of both cultural and ecological landscapes.

Lora Tryon (15 minutes)

Lake Trail Environmental Consulting

An ecosystem approach to planning restoration and protection projects in the Courtenay River Estuary

Abstract:

The Courtenay River estuary (CRE) has over 2000 hectares of river channel, mudflat, saltmarsh, and riparian habitats that support a diverse array of plants, fish, birds, and mammals. The natural areas in the estuary have been altered and continue to be threatened from human activities, including hydroelectric operations, historical dredging and log storage, dike development, shoreline hardening, riparian development, recreational boat use, and pollution. With the goal of providing a foundation for future salmon habitat restoration and protection activities that will ensure a healthy thriving estuary ecosystem for salmon and other species that rely on it, the Comox Valley Project Watershed carried out a study in the estuary in 2010 with funding from the BC Hydro Fish and Wildlife Compensation Program. This study resulted in an overall ecological characterization of juvenile salmonid requirements in the estuary and the development of a comprehensive list of restoration and protection options.

Estuary characterization involved a field investigation of juvenile Chinook and Coho habitat requirements over the spring and summer of 2010. Field methods involved beach seining and minnow trapping, tagging fry, water quality monitoring, snorkel counts, and habitat mapping. Data from past studies were analyzed to identify changes in the residency period and size classes of these salmon. The development of restoration and protection options also utilized information from past strategy reports, meeting minutes from the Estuary Working Group, and input from various experts and stakeholders.

Overall, the estuary provided the necessary ecological requirements for Chinook and Coho fry to survive and benefit from their residence over the spring and summer of 2010. Chinook and Coho fry stages were more dependent on the estuary than the smolts, which moved through the estuary quickly. The mark-recapture component of the study revealed that Chinook frequently migrated between habitats while Coho had high site fidelity throughout the summer.

Chinook fry in the Courtenay River estuary would benefit from restoration projects that improve food production and habitat connectivity throughout the upper and lower estuary by naturalizing hardened shorelines, creating deep water refuge habitat adjacent to upper intertidal marsh habitats, and ensuring frequent velocity refuge opportunities along the estuarine continuum for all tide heights. Coho fry would benefit from restoration projects in the upper estuary that increase the area and quality of refuge habitat. Similarly, protection projects that ensure existing areas with these features for Chinook and Coho remain healthy will benefit both the salmon and their ecosystems.

There were 41 restoration options and 33 protection options identified for the estuary. The restoration and protection options were prepared to serve as a baseline for planning projects in the estuary that could be used by various stakeholders and adapted over time. Social realities of achieving restoration and protection options were addressed by including the knowledge and expertise of stakeholders in the development of these options, by developing maps to communicate the results with managers, and by involving the community in field data collection.

Gregory Hood (15 minutes)

Skagit River System Cooperative

Making and testing vegetation predictions for Oligohaline Tidal Marsh restoration

Abstract:

Effective planning and design of habitat restoration projects requires prediction of project outcomes. Vegetation prediction for tidal marsh restoration has become feasible with the development of GIS, RTK-GPS, and Lidar technologies, and this is now being undertaken in the Skagit Delta tidal marshes. RTK-GPS was used to collect point data on dominant vegetation and associated elevation throughout the South Fork Skagit River Delta, an oligohaline tidal marsh. Probability distributions relative to elevation were generated for the dominant plant species and applied to Lidar data to generate predictive maps of likely vegetation in a 3-acre portion of the Deepwater Slough restoration site. Vegetation colonization was impeded at the site by pre-existing (pre-restoration) non-native cattails (*Typha angustifolia*). Consequently, the 3-acre study

area was mowed repeatedly over three seasons to reduce pre-emptive competition from the cattails and facilitate colonization by native species. The transition to predicted marsh vegetation was assessed by RTK-GPS point sampling, one and four years after last mowing the site. Predicted and observed vegetation patterns were similar, with extensive colonization of the site by sedge (*Carex lyngbyei*) and spikerush (*Eleocharis palustris*); cattail remained dominant at higher elevations, as predicted. While generally successful, the vegetation model underpredicted cattail distribution and overpredicted sedge distribution, likely due to the competitive advantage held by cattail as a result of its prior establishment. Further model development will include the effects of soil salinity to generalize the model over the estuarine salinity gradient.

Ian Miller (15 minutes)

WA Sea Grant / UC Santa Cruz

The Elwha Delta: Shrinking or growing?

Ian Miller, Jon Warrick, Andrew Stevens

Abstract:

Chronic erosion on the sub-aerial shoreline fringing the Elwha River delta on the Strait of Juan de Fuca in Washington State is well documented. Shoreline setback is associated with berm overwash and the injection of coarse beach sediments into beach-backing lagoons and estuarine habitats and over time those lagoon habitats have declined in size. Mean erosion rates of 0.6 m/yr (measured between 1939-2006) are frequently attributed to the emplacement of two dams on the Elwha River in 1913 and 1925. The impending removal of the two dams, slated to begin in September 2011, is expected to provide an additional 28,000 to 80,000 m³/y of coarse sediment to the coastal zone. Here we present preliminary results of an analysis of annually-collected topography and bathymetry data set. Data was collected on the beach and in nearshore zones with RTK-DGPS systems, mounted on backpacks and on jet skis. Data are gridded and annual differences calculated. Results suggest that the Elwha River continues to deliver more sediment to the coastal zone than can be transported alongshore by waves, but that accretion is primarily sub-tidal. This finding suggests that a simple model of coastal response to dam removal (i.e. remove the dams and the sub-aerial shoreline responds) may need to be revised. This large dam-removal provides an exceptional natural laboratory in which to test models of coastal response to new additions of sediment.

2F: The Salish Sea as a coupled social-ecological system

In this session we integrate human dimensions into ecosystem management of the Salish Sea. We define the Salish Sea as a social-ecological system and use specific examples of projects and partnerships to demonstrate approaches to managing this social-ecological system. Lessons learned from different domains—the Puget Sound Partnership, the Tsawalk Partnership, and the university classroom—offer examples of the application of social science theoretical models and frameworks to regional ecosystem management and illustrate the need and rationale for integrating human dimensions into these processes.

This session will also feature a 10 minute facilitated discussion.

Conveners: Terrie Klinger, Katharine Wellman, Tom Leschine, Jennifer Knauer
PRR Facilitator: Mike Rosen

Thomas M. Leschine (20 minutes)

University of Washington

Lessons from the classroom: Teaching across the social-ecological divide

Terrie Klinger, Thomas M. Leschine

Abstract:

Management of marine systems is moving from traditional sectoral approaches to more holistic approaches that view marine ecosystems as coupled social-ecological systems (SES). The SES perspective is fundamental to the implementation of ecosystem-based management and other strategies that seek to maintain and enhance social-ecological resilience. New pedagogical methods are needed to train future practitioners to assess, evaluate, and work within SES frameworks, requiring teaching across the social-ecological divide. Here we present the results of a 2-year experiment in pedagogical innovation in which we 1) instructed graduate students in case-study methodologies, coupled-systems approaches, and resilience thinking; 2) co-developed with students case studies focused on ecosystem management in Puget Sound; and 3) developed a model for publishing the results of student research as an open-source on-line text. We found that students were able to frame questions in an SES context and were to apply SES approaches to problems in the marine environment. The model we developed is generalizable and transportable and can be modified to teach students to work effectively across established disciplines.

Sara Jo Breslow (20 minutes)

University of Washington

Understanding the cultural aspects of environmental conflict: Senses of place and axes of mistrust

Abstract:

Disputes surrounding salmon recovery in the Pacific Northwest are characterized by apparent disagreements over the content and intended uses of scientific concepts and technical information. However, the diverse historical legacies and cultural experiences underlying these disagreements typically remain obscure. This presentation will identify and describe several major cultural factors explaining the persistent conflict surrounding salmon habitat restoration on farmland in the Skagit River Valley of Washington State. Specifically, I will discuss the divergent embodied, symbolic, and epistemological ways in which tribal, farming, and scientific communities in the Skagit Valley make sense of the places in which they live and work; and I will show how these different senses of place deepen the mistrusts that conventionally divide these groups. My aim is to illustrate how seemingly intangible

cultural dimensions of environmental conflicts can have very real social and ecological effects, and therefore why the study of culture has an important place in environmental problem-solving.

Andrew Day (20 minutes)

West Coast Aquatic

Public engagement, social-ecological assessment and a coastal and ocean plan for the WCVI

Andrew Day, Thomas Okey, Laura Loucks, Jennifer Spencer, Kevin Head

Abstract:

A unique initiative to improve the management of human interactions with the West Coast of Vancouver Island (WCVI) natural resources and ecosystems is culminating in a new proposed Coastal and Ocean Plan for this region. This initiative has included a public engagement campaign, the Tsawalk Initiative, a Social-Ecological Assessment, which is an objectives-based and indicators-based assessment adapted from Integrated Ecosystem Assessment, and related efforts to collect ecological and socio-economic information and community preferences. The challenge of this process is the integration and synthesis of broad and disparate sets of knowledge, preferences, and management authorities into general assessments and plans that will be useful to managers, policy makers, and the general public. Adopting, and adapting, the indicators-based framework of Integrated Ecosystem Assessment allows us to distil this disparate information into a set of indicators of Social-Ecological System health that is small enough, and meaningful enough to be the foundation for many management decisions on their own and with the help of decision decision-support tools including various approaches to vulnerability assessment and spatial scenarios that highlight tradeoffs among human uses, such as Marine InVEST. These indicators can also form the basis of community-based monitoring programs that will further feed decision support in the context of outcome evaluation and adaptive management, and potentially through more formalized approaches to Management Strategy Evaluation. The resulting management plan can enable participatory, collaborative, and ecosystem-based management of WCVI by providing a framework and innovative approaches such as marine spatial planning while enabling gradual adjustment to existing approaches.

Mark Plummer (20 minutes)

NW Fisheries Science Center, NOAA Fisheries

The role of eelgrass in marine community interactions and ecosystem services: results from ecosystem-scale food web models

Mark Plummer, Chris J. Harvey, Anne D. Guerry, Mary H. Ruckelshaus

Abstract:

Eelgrass beds provide valuable refuge, foraging and spawning habitat for many marine species, including commercially valuable species such as Pacific salmon, Pacific herring, and Dungeness crab. We used a food web model of central Puget Sound to examine how the marine community responds to changes in coverage of native eelgrass, and how these responses can be assessed using an ecosystem services framework.

Increased eelgrass coverage was most associated with increases in consumptive services (e.g., recreational harvest and total value of commercial fisheries), while decreased eelgrass coverage resulted in sharp declines in consumptive services as well as some non-consumptive services (e.g., beach combing, bird watching). At high levels of aggregation for ecosystem service categories, we saw little evidence of tradeoffs among marine resources; that is, increasing eelgrass coverage was essentially either positive or neutral for all services we examined, although we did not examine terrestrial activities (e.g., land use) that affect eelgrass coverage. Within particular service categories, however, tradeoffs were present, emphasizing the care that should be taken in expressing ecosystem services at a particular level of aggregation.

2:30 pm - 3:00 pm

Afternoon Break

3:00 pm - 4:30 pm

3A: Contaminants: sources, fates, transport and impacts III

This session offers a comprehensive look at our current understanding of the level of contaminants (toxics and nutrients) in various media, characterization of sources, fate and transport processes once released and biological impacts in the Salish Sea. The session focuses on the following themes:

- Contaminants—What do we know about contaminant levels in various media of the Salish Sea?
- Sources—What do we know about sources of contaminants? Examples of source categories include: primary releases, atmospheric deposition, POTWs, rivers and streams and stormwater
- Fate -Transport - Impacts—What do we know about fate and transport processes along with impacts of contaminants? Examples of topics could include modeling, attenuation, contaminant cycling, biological impacts and biological markers.

Conveners: Dale Norton, Scott Redman, Robie MacDonald

PRR Facilitator: Kimbra Wellock

Sandra O'Neill

NOAA Fisheries, Northwest Fisheries Science Center

Options to reduce toxic threats to Chinook salmon in marine waters of the Salish Sea

Sandra O'Neill, James E. West, Gina M. Ylitalo

Abstract:

Chinook salmon, the least abundant and the largest of the five species of Pacific salmon, is an icon valued for its commercial, recreational, and aboriginal fisheries, its cultural importance to first nations, and its key role in role in the marine and freshwater food webs. Among Pacific salmon species, Chinook salmon have the most complex and diversified life history, spending considerable more time in rivers, estuaries and coastal marine waters than other salmon species. Because of their complex habitat requirements Chinook salmon are considered to be an important “umbrella” indicator species by the Puget Sound Partnership. Protection and restoration efforts to enhance the abundance of Chinook salmon populations within the Salish Sea should protect and restore many other species, including endangered resident killer whales that feed heavily on Chinook salmon in the summer and fall.

Currently, Puget Sound Chinook salmon are listed as threatened under the U.S. Endangered Species Act, and several populations in Lower Georgia Strait are in decline. Many factors have contributed to the decline of Chinook salmon including generalized urbanization that has resulted in habitat loss and modification and increased input of toxic chemicals. Efforts are underway to reduce toxic threats to Chinook salmon and other species to improve the overall health of the Salish Sea. In particular, the Washington Department of Ecology has estimated loadings of chemicals of concern to Puget Sound, including persistent organic pollutants (POPs) that are known to accumulate at higher levels in Chinook salmon originating from Puget Sound and a subset of Fraser River populations, compared to other West Coast populations.

In this paper, we quantify importance of the Salish Sea as a rearing and feeding habitat for Chinook salmon beyond their first winter in marine waters and as a source of contaminants. Approximately 30% of the Chinook salmon originating from Puget Sound rivers reside within the Salish Sea throughout their marine life history in close proximity to land-based sources of contaminants, accumulating POPs at sufficient concentrations to impact their health. For example, almost 22% of the maturing and sub-adult Chinook salmon samples we collected from

Puget Sound had PCB concentrations above an effects threshold identified for salmonids. We discuss options for reducing toxics threats to Chinook salmon and also to their predators, including humans and killer whales, based on recent loading estimates of POPs to Puget Sound.

Joseph Dietrich

NOAA Fisheries Service

Polybrominated diphenyl ethers (PBDEs) and Chinook salmon health

Joseph Dietrich, Mary Arkoosha, Gina Ylitalo, Lyndal Johnson, Sandra O'Neill

Abstract:

Chinook salmon are critical species in the Puget Sound pelagic food web. Puget Sound Chinook are accumulating polybrominated diphenyl ethers (PBDEs), contaminants of emerging concern. However, information on tissue concentrations of PBDEs associated with adverse effects in salmon and other fish is limited. These data are critical for assessing the risk associated with current and future levels of PBDEs in threatened salmon stocks. We exposed Chinook salmon to PBDEs during 40-day feeding challenges. We used existing monitoring data of PBDE congeners found in Puget Sound Chinook salmon to develop ten contaminant diets that spanned the range of concentrations for the two highest PBDE congeners (BDE-47 and BDE-99). The feeding trial targeted whole body concentrations from 28 to 5800 ng BDE/g lipid. Following the trial, the impacts of the increasing PBDE levels on the fish immune and endocrine systems were evaluated. The concentrations of thyroid hormones thyroxine (T4) and triiodothyronine (T3) were determined in fish plasma from each exposure diet to assess impacts on the endocrine system. Disease challenges and in vitro phagocytosis assays were used to assess impacts on the fish immune system. This project's output will significantly contribute to increasing the scientific understanding of the impacts of PBDE exposure by developing dose-response data of disease susceptibility, and endocrine and immune function. The collective results will provide dose-response relationships that can be used to develop tissue residue and related guidelines for PBDE exposure, which can subsequently be employed in biological monitoring at remediated and contaminated sites. Finally, this data can be incorporated into existing and developing fate and transport models of PBDEs within the Salish Sea by including an assessment of predicted levels and uncertainties within a biological impact context.

John Elliott

Environment Canada, Pacific Wildlife Research Centre

Persistent organic contaminants and an effects case in avian wildlife indicator species

John Elliott, Kyle Elliott, Robert Letcher, Lilian Cesh, Tony Williams

Abstract:

Polyhalogenated aromatic hydrocarbons are global contaminants that are often considered to be endocrine disruptors and include 1,1-dichloro-2,2-bis(4-chlorophenyl)ethylene (p,p0-DDE), polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs). This talk presents data on spatial and temporal trends in wildlife indicator species in the Salish Sea. Effects are examined in the bald eagle by comparing exposure to these compounds and their hydroxylated metabolites or analogues in relation to circulating thyroid hormones and retinols in plasma from nestling and adult bald eagles in British Columbia, Canada, and California, USA. We also compared our results with published data. Thyroxine (T4) decreased with PPCB and CB153 in nestling bald eagles, which was congruent with results from nine of 14 other published avian laboratory and field studies. Free thyroid hormone levels also decreased with CB-153 and hydroxylated PCBs (OH-PCBs). Retinol increased with CB118 and CB180 in nestling eagles, decreased with OH-PCBs in a subset of nestlings, and decreased in 7 of 12 PCB published studies. Thyroxine decreased with p,p0-DDE for nestlings and with data reported in one of five other published studies. In our samples, plasma retinol, triiodothyronine (T3), and T4 were independent of PPBDEs, whereas POH-PBDEs were weakly but significantly correlated with increases in T3 and retinol. Adult bald eagles showed no relationship between contaminants and thyroid hormones, which is consistent with other studies of long-lived birds, perhaps because adult birds have time to adjust to contaminant levels. Measurement of circulating thyroid

hormones appears to be a more useful biomarker than retinols, given the more consistent response of T4 to PCBs here and reported in the literature. We conclude that current environmental exposures to PCBs in British Columbia and in southern California are associated with significant decreases in T4, suggesting a potential negative effect on the endocrine system of nestling bald eagles.

Marie Noel

University of Victoria, School of Earth and Ocean Sciences

Contaminant-related alterations of genomics endpoints in Puget Sound harbour seals (Phoca vitulina)

Marie Noel, Steven Jeffries, Monique Lance, Nik Veldhoen, Caren C. Helbing, Peter S. Ross

Abstract:

The Salish Sea is receiving contaminants, including polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and mercury (Hg), from both local sources and long range atmospheric transport. These persistent, toxic and bioaccumulative contaminants often reach concentrations that can represent a risk for the health of those species at the top of the food web. Harbour seals (*Phoca vitulina*) are non-migratory top predators that consume a wide variety of prey, making them useful indicators of marine ecosystem health in the Salish Sea. In 2009, we collected blood, fur, and blubber/skin samples from 24 live-captured harbour seal pups from four sites in Puget Sound (Hood Canal; Whidbey Basin, Main Basin, and South Sound). We measured PCB, PBDE, Hg levels and applied newly developed genomics techniques to quantify the expression of a number of genes considered to be sensitive to contaminants using real-time polymerase chain reaction (PCR). Harbour seal pups from Hood Canal had the lowest PCB, PBDE, and Hg concentrations (1.57 ± 0.21 mg/kg lipid weight (lw), 0.25 ± 0.05 mg/kg lw, and 3.52 ± 0.32 mg/kg dry weight (dw), respectively), while pups from the Main Basin were the most contaminated (6.34 ± 1.53 mg/kg lw, 0.82 ± 0.14 mg/kg lw, and 11.11 ± 2.12 mg/kg dw, respectively). Body weight, length, and girth did not influence gene expression, and there were no differences between males and females for any endpoints. Three of the nine gene expression endpoints in inner blubber were positively associated with contaminant concentrations. The expression of estrogen receptor alpha (ER- α) and heat shock protein 70 (hsp 70) were strongly correlated with Hg concentrations ($r^2 = 0.72$, $p = 0.005$; and $r^2 = 0.73$, $p = 0.002$, respectively). The expression of peroxisome proliferator-activated receptor gamma (PPAR- γ) was positively correlated with Σ PCBs and Hg ($r^2 = 0.57$, $p = 0.035$; and $r^2 = 0.63$, $p = 0.015$, respectively). Although the population level consequences of these observations are presently unclear, our results suggest that the risk of adverse health effects increases in harbour seals exposed to PCBs and Hg in the Salish Sea.

Cathy Laetz

NOAA Fisheries, Northwest Fisheries Science Center

Low-dose pesticide mixtures produce synergistic toxicity in juvenile Coho salmon

C. Laetz D.H. Baldwin, J. Stark, N.L. Scholz

Abstract:

Pesticides are commonly detected at low concentrations in freshwater habitats that support threatened and endangered species of Pacific salmon (*Oncorhynchus* sp.) in the Pacific Northwest. These chemicals can enter salmon habitat from urban, residential, and agricultural areas, and affected streams commonly contain mixtures of multiple pesticides. Pesticide toxicity is usually considered on an individual chemical basis, but pesticide mixtures could have enhanced toxicity, thereby underestimating potential risks. The organophosphates (OPs) are commonly detected pesticides that inhibit the activity of the neurological enzyme acetylcholinesterase (AChE). Enzyme inhibition disrupts normal nerve transmission that underlies critical behaviors such as swimming and feeding. Juvenile Coho salmon (*Oncorhynchus kisutch*) exposed to binary pesticide mixtures of diazinon-malathion and ethoprop-malathion showed synergistic toxicity as measured by AChE inhibition, as well as significant reductions in spontaneous swimming and feeding behaviors. Notably, mixtures at the same relative

concentration (cumulative 0.03EC50) produced the same level of toxicity as measured by both enzyme inhibition and altered behavior. The diazinon-malathion mixture at 2.2 and 1.1 ug/l (respectively), as well as the ethoprop-malathion mixture at 1.4 and 1.1 ug/l (respectively), produced AChE inhibitions greater than 90% relative to unexposed controls. Spontaneous swimming speeds of those same fish were also significantly reduced relative to controls to less than 1 cm/s (or 0.2 body lengths/s). Food strikes decreased from an average of 10 strikes in 3 minutes of observation in control fish to less than 1 food strike in the ethoprop-malathion exposure group. We observed that juvenile salmon exposed to pesticide mixtures at surprisingly low concentrations showed both synergistic neurotoxicity and altered behavior. These results were consistent across two different OP mixtures, extend our earlier observations of OP synergism, and reveal a steep dose-response relationship across a small increase in mixture concentration.

Patrick Moran

US Geological Survey

Ecotoxicological response in streams at three scales of biological organization across Puget Sound

Patrick Moran, Robert Black, Neel Aluru, Nile Kemble, Chris Ingersoll, Matt Vijayan

Abstract:

As one component of a national study on the Effects of Urbanization on Stream Ecosystems (<http://water.usgs.gov/nawqa/urban/>), twenty-one stream reaches were recently studied around the Puget Sound region that spanned a broad urban intensity gradient. This urban gradient was defined as a composite metric of numerous underlying urban-associated measures; but was most strongly defined by population density (17-2364 persons/km²), road density (0.6-12.3 km road/km²) and percent impervious surface (1-41% at 1 km scale) within the watershed. Sampling consisted of quarterly measurement of 160 water contaminants and a one-time sampling of streambed sediments for 108 contaminants, as well as ecological measures of structure (algal and invertebrate communities), function (dissolved oxygen cycling, woody debris retention, leaf litter decomposition and hyporheic exchange) and toxicity (as midge and amphipod toxicity tests and transcriptional response in native cutthroat trout). The community response measures were somewhat similar to responses observed from the transcriptional studies in trout. However, the transcriptional responses were (in light of known mode of actions) more representative of the measured contaminant chemistry at the site. Sediment toxicity tests with the amphipod *H. azteca* showed mortality at 23 % of the sites, and were somewhat reflective of urbanization, but three other sediment endpoints (*H. azteca* growth, as length, the midge *C. dilutus* survival and growth, as weight) were inconclusive across the urban gradient. These various measures of ecological response, each reflective of various scales of biological organization (genes, individuals, communities) will be compared and contrasted to the urbanization score and to water and sediment chemistry.

3B: Ecology of forage fish

Forage fish are a driver of the food web in the inland marine waters of the Salish Sea. They are a unique group of fishes bound together not by taxonomy or habitat, but by ecological role. These abundant, small, and energy-dense fish serve as the prey base for a variety of salmon, commercial groundfish, marine mammals, and seabirds. By number, fewer than ~3% of fish species in the northeast Pacific are forage fish, thus they play a disproportionate role in the upward transfer of biomass and energy through marine food webs. Common forage fish of the Salish Sea include northern anchovy, eulachon, Pacific herring, Pacific sand lance, surf smelt, and longfin smelt. Our understanding of basic biology and abundance is better for Pacific herring and northern anchovy than it is for other species, due in large part to historic commercial harvest and the resulting support for research and management. Despite this focus, substantial ecological information is needed even for these better-studied species.

From a research perspective we are interested in the reproduction, recruitment, and habitat use for forage fish species. For environmental planners we offer recent studies of disease, pollution, habitat degradation, commercial fishing, and marine climate change impacts on forage fish. These stressors influence population size and ecological trends over time, and understanding their effects is fundamental to an ecosystem-based management approach for forage fish. This session showcases recent groundbreaking research, conservation, and management efforts targeting forage fish, many of which have transboundary ecological implications.

Conveners: Dayv Lowry, Teresa Liedtke, James Selleck, Collin Smith

PRR Facilitator: Kirsten Hauge

Douglas E. Hay

Pacific Biological Station, Fisheries and Oceans Canada

Changes in the distribution, composition and abundance of forage fish in the Salish Sea

Douglas E. Hay, Bruce McCarter, Thomas W. Therriault, Matthew Thompson, Jacob Schweigert, Jennifer L. Boldt.

Abstract:

Data on most forage fish species in the Salish Sea are limited but most species appear to have declined in abundance or changed distribution during the last decade, including herring (*Clupea pallasii*), surf smelt (*Hypomesus pretiosus*) and the anadromous eulachon (*Thaleichthys pacificus*). During the last 50 years the fall spawning capelin (*Mallotus villosus*) have disappeared, but in the last 20 years spring spawning capelin have appeared more frequently in some inlets to the north. Episodic incursions of anchovy (*Engraulis mordax*) appear less frequent during the last 50 years. There have been probable declines in the anadromous longfin smelt (*Spirinchus thaleichthys*), sand lance (*Ammodytes hexapterus*) and perhaps other forage species. A fundamental question is whether these changes have a common cause. To examine this we examined and compared information on four life stages of each species: egg, larva, juvenile and adult. In general, the timing of reproduction varies among all species and larval distributions do not overlap in time or space during the larval and juvenile stages of most species. The simplest explanation is that all species are impacted by a change in the marine environment at the adult stage.

Correigh Greene

NW Fisheries Science Center

Abundance and composition of forage fish across Puget Sound's pelagic ecosystem

Correigh Greene, Casimir Rice, Kurt Fresh

Abstract:

Despite growing concerns about the productivity of forage fish stocks, few datasets exist to evaluate long-term trends. Efforts within Puget Sound have actually gone back to the 1970s, and

recent syntheses of these data, presented at this conference previously, suggest strong differences across oceanographic basins in trends in forage fish abundance and diversity. We have followed these comparisons up with a broad survey effort using a Kodiak surface trawl, which served as the basis for previous monitoring efforts. We are sampling over 80 sites distributed across six of Puget Sound's seven sub-basins monthly during neap tidal cycles from April through October. We follow a sampling design that will allow analysis of basin-wide differences, as well as influences of land use in catchments surrounding the sound. In this talk, we will present the findings of the survey and put it in context of historical efforts across Puget Sound.

Jake Schweigert

Fisheries and Oceans Canada

Nearshore fish community dynamics in the Strait of Georgia: Information from juvenile herring survey

Jake Schweigert Thomas W. Therriault, Douglas E. Hay, Matthew Thompson, Jennifer L. Boldt

Abstract:

Purse seine surveys have assessed juvenile herring abundance in the Strait of Georgia since 1991. Ten "core" transects perpendicular to the shore with five sampling stations each are surveyed annually in late summer and early fall. Sampling sites vary between open water and more confined sites within wide channels. In addition to herring, many other nearshore species are sampled during this survey. We hypothesized that these incidental captures could be used to detect possible temporal and spatial changes in nearshore fish communities, potentially reflective of environmental change within the Salish Sea. Basic community metrics were calculated for each station in each year including species richness, Shannon-Weiner diversity index, Simpson's diversity index, evenness, and total abundance and herring abundance. Metrics were then compared among transects, habitat (open water and channel sites), and years, and in relation to environmental changes in the Salish Sea. Most metrics varied among stations and transects. The abundance of young-of-the-year herring appeared to be related to sea surface temperature and subsequent recruitment to the adult population. These juvenile herring surveys provide valuable measures community change in the Salish Sea and recruitment predictions for the commercially important Strait of Georgia herring stock.

Jan Lovy

Herring Conservation and Research Society

Pathogens of Pacific herring in the Salish Sea and the impacts of Viral Hemorrhagic Septicemia

Jan Lovy, Kyle A. Garver, Paul K. Hershberger

Abstract:

Pacific herring, *Clupea pallasii*, are affected by various diseases that are believed to cause natural mortality in the populations. Herring from the Strait of Georgia have not been previously examined for disease. A prevalent and serious disease of interest, which can lead to high mortalities in herring, is Viral Hemorrhagic Septicemia (VHS). This viral agent is believed to be carried in wild populations of fish and disease outbreaks may occur during times of stress. In this study, herring were captured from the Strait of Georgia in January 2010 and maintained within netpens at the Pacific Biological Station in Nanaimo, BC. The objectives were to 1) obtain a full disease history of the fish and 2) to experimentally expose them to VHS virus to determine their susceptibility. The findings demonstrated that this population of fish had a high prevalence of the coccidian parasite, *Goussia clupearum*, which at times caused severe infestations in the liver. Other pathogens found at low prevalence included viral erythrocytic necrosis, Ichthyophonus, epitheliocystis, and several bacteria. Subsequent to determining their disease history, fish were moved into research tanks and experimentally challenged with VHS virus. A positive control was run in parallel in specific pathogen free (SPF) herring at the Marrowstone Marine Field Station, USGS using the same experimental design and identical virus isolate. The mortality curves of virus-infected fish were compared between the Strait of Georgia herring and the SPF herring in order to better understand the susceptibility of wild BC herring to VHS.

Ramona C. de Graaf

Coastal Conservation Alliance of British Columbia

Forage fish in the Salish Sea: Surf smelt and Pacific sand lance spawning ecology in southern British Columbia

Ramona C. de Graaf, Daniel E. Penttila

Abstract:

Cited as the cornerstone of many marine food webs, forage fish connect zooplankton to a host of secondary predators, from seabirds, fish and marine mammals. Nearshore spawning forage fishes such as surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) use certain intertidal sandy-gravel beaches for spawn deposition/incubation, high on shorelines near the log line.

As a “valued ecosystem component”, the State of Washington has placed a high conservation priority to forage fish spawning beaches as important salmon habitat and have studied surf smelt and Pacific sand lance for decades. Unfortunately, British Columbia government agencies have been slow to recognize the role that surf smelt and sand lance play in the diets of 100s of marine predators and protect these habitats as required under Section 35 of the Federal Fisheries Act. The British Columbia regulatory framework to protect surf smelt and Pacific sand lance habitats is deficient and extensive areas of spawning habitat in the south coast has been degraded or destroyed.

Due to the absence of any provincial surveys, no data on the spawning ecology of surf smelt and Pacific sand lance were available for the entire Canadian west coast. The lack of these data has hindered effective coastal management planning. The British Columbia Shore Spawners Alliance (BCSSA), a citizen’s science project of the Coastal Conservation Institute of BC, and other stewardship groups have been conducting field studies to address these data gaps to inform marine nearshore conservation in British Columbia.

I will present some results of five years surf smelt and Pacific sand lance spawning ecology research in the British Columbia section of the Salish Sea. Surf smelt and Pacific sand lance are transboundary forage fish occupying a critical role in the health of the entire Salish Sea (and coastal areas throughout WA and BC). These results are important for the conservation of critical fish habitats in British Columbia and also inform Puget Sound forage fish management.

Results include the first spawning season data of both species for the Province, surf smelt embryo survivability, and spawning habitat attributes. I will also present the public information GIS atlas developed through a partnership of the BCSSA, Emerald Sea Biological, Community Mapping Network and Fisheries and Oceans Canada, Habitat Section, Pacific Biological Station. I will also present examples of surf smelt and Oolichan (*Thaleichthys pacificus*) habitat restoration projects in the Lower Mainland region of southern British Columbia.

H. Gary Greene

Tombolo-SeaDoc Society/Friday Harbor Labs, University of Washington

Where do all the sand lance go: Sub-tidal habitats of the forage fish Pacific sand lance in the Salish Sea

H. Gary Greene, T. Wyllie-Echeverria, D. Penttila, M Hampton, D. Cacchione, J. Bizzarro, V. Barrie, C. Robinson, A. Summers

Abstract:

Much is known about the intertidal habitats of the Pacific Sand Lance (PSL or *Ammodytes hexapterus*) in the Salish Sea, but their deep-water habitats are just being defined. Recent studies of PSL in the Salish Sea indicate that this forage fish takes refuge in dynamic bedforms such as sand waves where they appear to winter over and may even reproduce. These sub-tidal habitats are easily imaged using state-of-the-art multibeam echosounder (MBES) data and can

be mapped to identify and manage the forage fish resource. Sand wave fields of different morphologies, areas, and grain sizes have been targeted for extensive sampling and monitoring. Using a sediment grab sampler to obtain fish and sediments from the MBES targeted PSL sub-tidal habitats we developed a comprehensive, reproducible and accurate sampling protocol that can be applied to investigate all potential PSL sub-tidal habitats in the Salish Sea and elsewhere where sand lance are thought to reside. We found that the Van Veen grab sampler can efficiently capture PSL in sediment and is reproducible and that the significant metrics used to identify sampling targets are grain size (medium- to coarse-grain sand preferred by PSL), dynamic bedform morphology (~1 m amplitude and ~3 m periodicity of sand waves) and areas of strong bottom current flow. All life stages of PSL appear to occupy these bedforms and fish were found to occur in these features from early October 2010 to at least early April 2011, for at least a six-month period.

3C: Future growth scenario planning

How can scenarios of the future be modeled? Once modeled, how can they inform policy—and the public processes intended to shape policy and manage projected growth? This session considers these questions and features case studies from throughout Puget Sound and Georgia Basin.

This session will also feature a 25 minute facilitated discussion.

Convener: John Lombard

PRR Facilitator: Rita Brogan

William Labiosa (15 minutes)

U.S. Geological Survey

Developing integrated scenarios of climate/land-use change and ecosystem restoration for Puget Sound

William Labiosa, Marina Alberti, Amy Snover, Tim Quinn, Ken Currens

Abstract:

We describe a new Puget Sound Institute effort to coordinate the creation of spatially-explicit regional-scale scenarios integrating climate change effects and feedbacks, regional growth and development, and ecosystem restoration efforts, in support of regional ecosystem restoration planning. Ecosystem restoration planning is a notoriously “wicked” problem, defined by:

1. the inherently low predictability of interacting drivers within adaptive coupled-natural and human systems (each complex in its own right),
2. the large number of valued ecosystem services and valued ecosystem components that are linked in complicated ways,
3. the divergent and conflicting stakeholder values involved,
4. the complicated and distributed institutional arrangements for decision-making, and
5. the large data gaps and gaps in knowledge for many aspects of the coupled natural and human systems.

Nevertheless ecosystem restoration planners are expected to justify their restoration decisions with systematic approaches, which often (out of institutional necessity) results in overly confident and simplistic statements about potential restoration success. One approach to dealing with the wicked aspects of this planning problem is to use scenario planning methods. Such methods consider how restoration strategies might perform under very different assumptions about drivers of regional change, regional goals for development and sustainability, and unpredictable feedbacks that might strongly influence restoration outcomes. While scenario planning can mean many things, we use it here to mean a scenario building process synthesizing stakeholder inputs, expert judgment, and various model results within an iterative process involving expert workgroups, modeling exercises, and stakeholder sessions. The explicit goal is for the scenarios to be useful for evaluating various restoration strategies.

In this talk, we focus on scenario planning for Puget Sound restoration at the full basin scale. There are many relevant research activities currently supporting the development of useful Puget Sound restoration scenarios, including county land-use scenarios and focused transportation and regional growth scenarios, regional climate impact scenarios, and narrative regional change scenarios that integrate climate and growth. However, there is no process in place to coordinate the development of the envisioned spatially-explicit integrated climate/growth/restoration

scenarios specifically designed to support restoration planning. To address this need, the Puget Sound Institute is sponsoring a series of workshops to scope such a Puget Sound restoration scenario building effort, to create the needed network or consortium of researchers, practitioners, and stakeholders, and to develop a plan for obtaining the necessary funding to support the development of these scenarios. We will discuss the current status of this effort, providing more details on the purposes and goals of this effort, a discussion of the methods being explored, and a report-out on the results from the initial workgroups and the first full workshop.

Kellie Vache (10 minutes)

Biological & Ecological Engineering, Oregon State University

Envisioning future change in the Puget Sound – An alternative scenarios approach

John Bolte, Kellie Vache

Abstract:

Alternative future scenario development has become a preferred technique for examining trajectories of change for communities and landscapes in recent years. As the availability of spatial datasets and computational tools has increased, developing spatially rich representations of a variety of biophysical and sociocultural process and associated dynamics and interactions has become increasingly feasible. In particular, models that capture land use and land cover change processes, driven by growth and development pressures, land management actions, and related factors are becoming sophisticated enough to realistically depict effects of alternative growth management and conservation planning strategies in space and time. Further, tools for evaluating landscape performance under these alternative scenarios are becoming available, providing useful metrics by which to assess outcomes and tradeoffs associate with these alternatives.

Envision, an alternative future scenario modeling framework developed at Oregon State University, is an example of such a tool. It provides a robust, spatially-explicit landscape representation, a highly extensible set of “plug-in” models for representing change processes, a policy-centric, multiagent-based simulation capability for representing human “actors” and their management decisions on the landscape, an extensible framework for computing landscape production and evaluation metrics, and a visualization capability for 1, 2, and 3 dimensional datasets relevant to interpretation of landscape trajectories. Envision is capable of representing a diverse set of change processes at a wide variety of spatial and temporal scales, and is highly locally adaptable.

We describe Envisions basic approach to projecting future change, using examples of application developed in several study areas in the Pacific Northwest, including the Willamette River Basin, Oregon; the Puget Sound watershed; and Skagit County, Washington. We describe the process of developing alternative future trajectories in these areas, relevant data requirement, appropriate spatial scales, process descriptors, policy constructs, and evaluative landscape metrics employed, as well as challenges and lessons learned.

<http://envision.bioe.orst.edu>

Keith Folkerts (10 minutes)

Kitsap County

Alternative futures planning: Kitsap County's lessons learned

Keith Folkerts, David Nash

Abstract:

Kitsap County's experience with three Alternative Futures projects has provided it with several “lessons learned” about how to—and how not to—conduct a planning project that models alternative futures, which this presentation will review.

Project #1: Chico Watershed.

Successes: This project provided a local demonstration of the Alternative Futures concept. It produced sustained dialogue and a restoration plan that has guided \$4M in acquisitions and \$2M in restoration. Failures: There were no changes to zoning or other land use regulations resulting from this project. Lessons learned:

- Be clear about what decisions the project aims to inform and integrate the project with the established processes for making those decisions;
- Creating scenarios and managing data are large, time-consuming tasks;
- Scenarios should model the same total population to allow for direct comparisons;
- Premature public input can frustrate the public and cause more harm than good; the public should use the tool, not build it.

Project #2: Barker Watershed/North Dyes Inlet.

Successes: This project supported efforts to remove the lower mainstem of Barker Creek from the Urban Growth Area in County's Comprehensive Land Use Plan and zoning regulation. This project's integrated hydraulic model and salmonids habitat model provided insights about the importance of increasing baseflow. Failures: The hydraulic model was unable to adequately reflect anticipated changes to stormwater caused by contemplated Low Impact Development. These models were unable to be applied to other portions of the County; County staff were unable to update the models. Lessons learned:

- High-resolution stormwater hydraulic modeling is beyond what can be expected from regional Alternative Futures projects;
- Modeling tools that are too complex won't provide on-going insights; keep them simple enough for use by local staff.

Project #3: Envision Kitsap.

This on-going project uses Oregon State University's Envision software to model 50-year countywide growth scenarios. This project has developed a method of identifying Conservation Priority Areas and Development Priority Areas, which promises to inform a variety of future land use decisions. Considerable time and effort has been spent creating a detailed base layer for the Envision modeling.

Tentative successes: This project has provided direct support to 1) an on-going update of Kitsap County's shoreline regulations, 2) an on-going creation of a Transfer of Development Rights ordinance, and 3) non-regulatory conservation efforts. Failures: TBD. Lessons learned:

- OSU's Envision software significantly helps framing the project and managing the data
- Having tangible results (maps, graphs) from Skagit County's similar effort significantly helps explaining and selling the project to unfamiliar and skeptical decision-makers

Local governments contemplating modeling alternative futures should consider:

- Using the project to inform land use decisions regarding where to expand Urban Growth Areas and/or where to modify zoning;
- Integrating the project with decision-making processes;

- Using the parcel as the scale of analysis and the county as the scope of the analysis;
- Using Envision software to organize and run the analysis;
- Building the tool before asking the public to provide input about the future they desire for their region.

Kirk Johnson (10 minutes)

Skagit County Planning and Development Services
Envisioning a long-term future for the Skagit Valley
 Kirk Johnson, John Lombard

Abstract:

Envision Skagit 2060 is a locally-based, EPA-funded effort to develop a “Preferred Future” for Skagit County, anticipating a near-doubling of the county’s population to 225,000 over the next 50 years. It has included: an intensive, 10-month planning effort with a committee of 12 citizens, who developed a broad range of recommendations, some of which are very controversial; modeling five future scenarios—the Plan Trend, Ecosystem, Agriculture/Forestry, Economic Development, and the Citizen Committee’s Preferred Future; and extensive community outreach and debate, which is still underway. Final results of the project are still to be determined.

This presentation will focus on the advantages, disadvantages, and practical challenges we encountered in modeling future scenarios, as well as the relationship of our modeling to the work of the Citizen Committee and to the current public debate. We will also discuss how we incorporated research on climate change into our process.

The Skagit is the largest river system in the Puget Sound basin, producing a third of its wild salmon. Eelgrass beds in Padilla and Fidalgo bays are among the largest on the west coast. The tidelands of Skagit, Padilla, and Samish bays all support extensive shellfish stocks. Historically, the Skagit Delta was Puget Sound’s largest wetland complex. Today, it hosts western Washington’s largest concentration of agriculture, which raises an extraordinary diversity of crops on some of the world’s best soils. The Skagit Delta also currently supports the greatest number and variety of raptors in North America and the largest number of migratory birds and waterfowl in the Puget Sound basin.

Ecological restoration and agriculture have been in conflict in Skagit County for much of the past few decades, yet both are threatened by projected growth. The Envision Skagit process has striven to build on recent cooperative and collaborative projects in the Skagit Valley to develop a vision and a set of action steps that could help conserve the best of today’s landscape, improve Skagit’s contribution to a healthy Puget Sound, and make local cities and rural villages more attractive and vibrant places to live. Modeling future scenarios has helped highlight shared interests as well as examples where tradeoffs are necessary.

We used Oregon State University’s Envision software to model scenarios. Skagit County plans to continue to develop and use the modeling software for long-range planning, particularly for regional discussions concerning allocations of growth, transfers of development rights, and potential expansion of urban growth boundaries. We also plan to develop more sophisticated indicators than have been possible so far for evaluating the likely long-term consequences of different policy choices that local jurisdictions will face over coming years.

For more information, see

<http://www.skagitcounty.net/Common/ASP/Default.asp?d=envisionskagit&c=General&p=main.htm>

Terry Hoff (10 minutes)

Abstract:

Metro Vancouver is one of Canada's most populous and rapidly growing urban areas. The metro area includes 22 municipal jurisdictions, along with an Agricultural Land Reserve and substantial area of mountainous terrain that makes up one half of the 2,850 sq km regional district. In 2011 Metro's population is approximately 2.4 million, and it is anticipated the Metro will add another 1 million residents by the year 2041.

Metro Vancouver is currently in the final stages of preparing a new Regional Growth Strategy (RGS). The RGS is one of a suite of plans that Metro Vancouver has established under a Sustainability Framework. The RGS is primarily a regional land use concept intended to address regionally significant land use issues related to future urban development, how best to support efficient regional transportation and infrastructure services, and how to retain the viability of industrial, agriculture and conservation lands.

Following an evaluation of how the preceding regional strategy has fared over the past 15 years, a number of scenarios were considered for the magnitude of future growth and for the distribution of growth within subregions and strategic locations up to the year 2041. Scenarios were primarily concerned with the range and potential for growth to be strategically concentrated around a network of urban centres and potential major transit corridors. Alternative population, housing and employment forecasts were combined with an analysis of historical growth patterns, current land use plans and land development potential to determine what could be fitting aspirational, but achievable, targets for future land use and growth policy.

A unique combination of modeling, analytical techniques and data sources have been applied to the land use, population, housing, employment and other components of regional plan development. While many aspects of scenario analysis and plan development are long standing, tools such as Geographic Information Systems have become fundamental and are used extensively in combination with other modeling tools to manage, prepare and present information.

Although the RGS has not yet achieved final adoption, the strategy has found a generally acceptable balance in pursuing regionally significant growth objectives while providing flexibility and respecting the autonomy of local government jurisdictions. Presently the RGS has the support of 23 of the 24 member municipalities and regional agencies needed for adoption, and it is anticipated that negotiations for final adoption will be completed in the fall of 2011.

3D: Adapting to future climate change

This session features a roundtable discussion on climate change impacts and adaptation—panelists will offer 5-minute responses to the following two questions, followed by facilitated Q&A with the audience.

1. What do you think are the possible future impacts of climate change for Salish Sea ecosystems and communities (Puget Sound, British Columbia and Washington coastal areas)?
2. How can information flow be organized to allow research and local knowledge to inform and enable adaptation planning, and implementation of adaptation responses, within regional and local development and governance?

This session will also feature a 30 minute facilitated discussion.

Conveners: Stewart Cohen, Nathan Mantua

PRR Facilitator: Jamie Strausz-Clark

Randall M. Peterman

Simon Fraser University

Decreasing productivity of sockeye salmon and the need for coordinated research

Abstract:

Many researchers have found that in the past, increasing sea-surface temperatures (SSTs) during early-ocean life of juvenile sockeye salmon are associated with reduced productivity (adult returns per spawner) in British Columbia and Washington. High SST in this region is nowhere near the upper thermal limit of salmon, though; it is merely an indirect index of food supply (poor) and predator abundance (high). Simple projections of continued increases in summer SST suggest that productivity and abundance of sockeye salmon in this area will decrease. However, there are numerous physical and biological uncertainties associated with forecasting effects of projected trends in SST on Pacific salmon. For instance, climate-induced changes in surface and deep ocean currents and their associated shifts in temporal and spatial distribution of nutrients for the food chain could create unexpected outcomes, even in the Strait of Georgia. Given such uncertainties, we need to apply methods of risk assessment, risk communication, and risk management. To better inform decision making, salmon researchers and management agencies in Canada and the USA should also coordinate research activities through a shared working group. Coordinated plans for sampling programs, data collection, analysis, and rapid sharing of results will facilitate comparisons of data from different stocks across wide regions to help determine which factors mostly affect the Salish Sea and which are more widespread. This recommendation for prompt sharing of data and results across a wide region is prompted by our recent finding that the long-term decrease in productivity of Fraser River sockeye salmon populations has been shared by many other sockeye populations from Washington up through Southeast Alaska, which suggests that some large-scale processes that are not unique to the Salish Sea are contributing substantially to the decline of the Fraser River sockeye salmon. Such a working group's role might be critically important if global climatic change is responsible for the declines in sockeye productivity.

Richard Beamish

Department of Fisheries and Oceans

Communicating an understanding of the changes in the Strait of Georgia

Abstract:

The Strait of Georgia is warming and most likely will continue to warm. Physical changes will lead to changes in the timing and composition of plankton which will lead to changes in better known

species such as salmon and herring. As abundances of these and other species change, it will be important to have processes in place that inform the public of what we know, do not know and what we are doing to understand what we need to know to manage this changing ecosystem.

Mike Doherty

Clallam County

Adapting to future climate change

Abstract:

On October 1, 2006, the North Olympic Peninsula Resource Conservation & Development (NOP-RC&D) Council was awarded a grant from NASA to create a Solutions Network – a collaboration of local, regional, and national organizations helping watershed management teams to solve local natural resource issues. The primary goal was to introduce these organizations to NASA science and technology products, and explore ways to use NASA resources to improve environmental planning and decision-making at the watershed scale.

Project partners included Clallam County, the Pacific Northwest National Laboratory, Idaho National Laboratory, Olympic National Park, the Dungeness River Management Team, the Elwha-Morse Creek Management Team, and Peninsula College. The primary goals of the project were to: 1) improve the scientific basis for watershed management decision-making through the Solutions Network approach; 2) to extend this approach to other RC&D councils across the United States; and 3) provide an educational component that enabled students at a local college to participate in the research and development aspects of the project.

A unique feature of this project was the development of a proof-of-concept demonstration in the Dungeness River watershed that used remotely sensed data from NASA MODIS and real-time data from local weather stations to inform a hybrid hydrological streamflow forecasting model. This model, operating continuously since October 2008 on the Peninsula College web site, provides daily predictions of streamflow that fills an important data and information gap in the watershed. Because the model can also be run under various climate change scenarios (e.g., changes in ambient temperature, precipitation, snow pack) it is possible to evaluate how short- or long-term climate change could influence streamflow, snow pack release, and overall water availability. Clallam County depends on the Dungeness River for drinking water, irrigation, and habitat for aquatic life, including endangered salmon species. The use of predictive tools such as the hybrid model to guide decisions and assess the potential impact of future climate states is an important part of an adaptive resource management approach employed at local, regional, and national scales.

Ed Knight

Swinomish Indian Tribal Community

Adaptation planning in the Swinomish Indian Tribal Community

Abstract:

In adaptation planning at the Swinomish Tribe, discussion of climate change impacts in the context of adaptation planning has not been as much about specific impacts over any given time period as it has been about evaluating the potential risks to the community from a possible range of projected impacts. In that context, we found the following:

- There is a high risk of increasing impacts to coastal communities from inundation associated with climate change, from both sea level rise and storm surge, which threatens not only infrastructure, marine facilities, and community assets, but in the case of Swinomish it also threatens the vital connection to the mainland. There are also threats to coastal resources such as estuaries and shellfish habitat, which are at risk of permanent inundation; coastal shorelines are likely to be subject to increasing erosion.

- Average temperature increases will increase the frequency and intensity of severe heat events, potentially aggravating drought conditions and conditions for severe wildfire, creating more immediate risks to communities. Continued melting of glaciers will further reduce runoff and river flows over the long term, further diminishing local water supplies. Projected temperature increases will have more subtle but longer lasting impacts on species and habitat.
- Increasing moisture content in the atmosphere, caused by rising temperatures, may drive increasingly volatile storm cycles. Higher average temperatures will likely mean that increased precipitation falls more as rain than snow, contributing to overall declining snowpack. The collective risks to communities will likely be of more frequent and severe seasonal flood events, flooding rains of longer duration, and alternately more intense dry seasons.

Communities will experience varying combinations of the above, depending on more local conditions and factors. The Swinomish experience also taught that adaptation planning is not a defined methodology for extracting solutions but rather an ongoing process and dialogue within the community about how to deal with perceived risks. Each local community must attempt to find an approach that is best suited to that community. In the case of Swinomish, recommendations were organized around concepts of coastal resources, upland resources, physical health, and community infrastructure. Within tribal communities, there is also the added layer of cultural sensitivity toward approach and handling of information and communications, as well as consideration of the role of traditional ecological knowledge. Ultimately, and ideally, each community's process and plan should reflect the core values and structure of the community itself.

Christianne Wilhelmson

Georgia Strait Alliance

Adapting to future climate change: a community perspective

Abstract:

Human-caused climate change is already having an impact here in the Strait of Georgia and its watersheds, and these are likely to intensify. In the last few years we have experienced higher than average air and water temperatures, including record high temperatures in the Fraser River, and the Strait of Georgia is 1 degree warmer than it has been historically; changing patterns of precipitation; extreme or unusual weather events; and, significant decline in average snowpack.

In July 2007 the National Wildlife Federation (NWF) published a study, Sea-Level Rise and Coastal Habitats in the Pacific Northwest that predicts, by 2100: 65% loss in estuarine beaches, 61% loss of tidal swamp, 52% of brackish marsh will convert to tidal flats, transitional marsh and saltmarsh, up to 44% loss of tidal flats, 25% loss of tidal fresh marsh and 13% loss of inland fresh marsh

Another growing concern is ocean acidification. Evidence indicates that emissions of carbon dioxide from human activities over the past 200 years have already led to a reduction in the average pH of surface seawater of 0.1 units and could fall by 0.5 units by the year 2100. The result of increasing acidity is a reduction in carbonate, which is the mineral that is used to create the shells of shellfish and to create the structure of corals. With increasing acidity, shells cannot be created and will literally dissolve.

These effects will have massive impacts on the economy of our region, hitting especially hard at BC's tourism industry, shellfish aquaculture and fisheries. Many of our Strait of Georgia communities and sensitive estuaries face flooding by rising seawater. Salmon runs will perish as they encounter the warming waters of the Fraser River and countless other streams. We face significant great social and environmental change in the years to come.

Regarding how can information flow be organized in order for research and local knowledge to

inform and enable adaptation planning, and implementation of adaptation responses to climate, there are two important aspects that need to change. One is the development of a common language to talk about these issues. Polling shows that outside the research realm, people do not understand how carbon links to climate change, how greenhouse gases influence climate and what is adaptation. If researchers, those with local knowledge and those responsible for planning and implementation do not share a common understanding of the basic issue, any other systems put in place to allow information to flow more effectively will be unsuccessful.

If we are able share a common language around climate change and adaptation, then we need to remove silos that currently exist between the groups that need to be connecting. Information from research, local knowledge and planning processes, respectively, tend to stay separate with bridges between them being built on an ad hoc basis, usually for a particular process, after which they fall away. We need to create a culture of shared knowledge without creating systems that are bogged down by more process and less action.

Paul Pickett

WA Department of Ecology

WA State integrated climate change response strategy

Hedia Adelsman, Paul Pickett

Abstract:

With more than 3,000 miles of coastline, some of the most productive coastal ecosystems in the nation, and nearly 70% of the state's population, Puget Sound and coastal areas in Washington are expected to see significant physical, biological and socioeconomic impacts from changing climate conditions. Substantial impacts on coastal ecosystems and communities are expected as a result of sea level rise and increased ocean temperature and acidity. There is enough current scientific information to outline a clear path forward to better enable state and local agencies, public and private businesses, non-governmental organizations and individuals to prepare for, address, and adapt to the impacts of climate change.

The Department of Ecology, in cooperation with several other state agencies, is currently in the process of finalizing a State Integrated Climate Change Response Strategy. The Response Strategy will focus on integrating climate science into existing policies, programs and decision-making processes. It will also identify research and monitoring needs to improve our understanding of how natural and human systems in the Puget Sound and coastal areas will respond to future climate change; identify priority strategies to help human and natural systems prepare and adapt to climate impacts; and identify methods to improve public awareness of climate change and build support for meaningful action. The level of public skepticism about climate change and the ongoing budgetary crisis demand a high level of cooperation and collaboration among regional and local organizations; ready access to climate science and policies; and an information infrastructure that enable local communities and citizens to engage in the climate dialogue.

3E: Restoring estuaries of the Salish Sea: Case studies and social and scientific challenges II

Estuarine restoration is critical to recover ecosystem services, the health and productivity of diverse natural resources, and maintain a rich cultural heritage. This session will feature lessons learned and ongoing processes on the Nisqually Delta, the Nanaimo River Estuary, the urbanized and dammed Deschutes Estuary at Capitol Lake, the Skokomish, the Skagit and the Snohomish and others. Through a series of restoration case studies, we will present examples of the successes and challenges of estuarine protection, conservation, and restoration. Our goal is to facilitate knowledge transfer of fruitful interdisciplinary partnerships, applied research and monitoring efforts, as well as socio-political challenges of restorations in urban estuaries to inform restoration science, management, policy and community well-being.

This session will also feature a 15 minute facilitated discussion.

Conveners: Isa Woo, Sue Patnude, Pamela Shaw, Eric Grossman, Christopher Ellings
PRR Facilitator: Hadley Rodero

Christopher Ellings (30 minutes)

Nisqually Indian Tribe Salmon Recovery Program

Nisqually Delta restoration and research: a Salish Sea case study

C. Ellings, F. Leischner, S. Hodgson, J. Barham, I. Woo, K. Turner, K. Larsen, E. Grossman, S. Rubin, C. Curran

Abstract:

The Nisqually River Delta is home to the largest tidal delta restoration project in Puget Sound. Diked for more than 100 years, tidal flow was returned to most of the delta in the autumn of 2009, representing a significant advance towards the recovery of Puget Sound. It remains uncertain how the Nisqually Delta and its biota will respond to restoration of tidal inundation after over a century of disconnect from the Nisqually River, creating a need for an integrated monitoring and adaptive management program. In addition, hydrologic and sediment processes have been significantly altered by land use activities in the watershed and climate change is expected to modify them further in complex ways affecting restoration goals. Our integrated monitoring and adaptive management program seeks to address the need for managing natural resources in light of these uncertainties. The purpose of this presentation is to demonstrate how conservation, restoration, and monitoring activities in the Nisqually Delta provide a case study for the successful application of a strategic partnership between a Coast Salish Tribe, Federal agencies, and non-profit organizations.

A key to the delta restoration was the conservation and protection of lands and natural resources under the management of the Nisqually National Wildlife Refuge and the Nisqually Indian Tribe. The one-of-a kind partnership between the Nisqually NWR and the Tribe opened the door to a series of habitat restoration projects, starting on Tribal land in 1996 and culminating in the reconnection of ~ 760 acres of refuge habitat to Salish Sea tidal influence in 2009. This cooperation led the way for a collaborative and interdisciplinary research effort with an emphasis on linking processes (drivers) to responses of ecosystem structures and functions across the restored delta and connected nearshore. The monitoring framework integrates temporal and spatial scales of biological and physical processes such as hydrology and sediment regime, channel and marsh topography, vegetation colonization, invertebrate abundances, bird abundance and behavior, and fish use. Here we present an example of our integrated research; early results of the impact of the delta projects at restoring Chinook salmon estuary utilization, estuary habitat development, site capacity to produce food resources, and Chinook estuary feeding ecology, growth and residence times.

Joshua Chamberlin (15 minutes)

NOAA

Comprehensive monitoring of the Qwuloolt restoration in the Snohomish River Estuary
C. Rice, J. Chamberlin, P. Roni, T. Zackey, J. Hall

Abstract:

The Qwuloolt restoration site is approximately 360 acres of former estuarine wetland in the Snohomish River system that will have tidal inundation returned via levee breach in late 2012. Qwuloolt is one of several large restoration projects planned for the Snohomish River estuary in the next decade for recovery of salmon and other biota, which together could restore several thousand acres and constitute one of the most significant restoration efforts in Puget Sound. In 2008 we began development and implementation of a comprehensive monitoring plan for Qwuloolt that evaluates a broad suite of abiotic and biotic attributes (e.g., land forms, hydrology, and chemistry; taxonomic composition of plant, invertebrate, fish, bird, and mammal assemblages). Three years of pre-breach data document clear contrasts between Qwuloolt and adjacent reference sites. Qwuloolt is subsided, hydrologically isolated, and its biota composed of relatively few species and dominated by nonnative, freshwater species. These results provide an invaluable foundation for scientifically rigorous post-breach evaluation of project performance, and contribute to estuary-wide understanding of cumulative effects of restoration and basic estuarine ecology of Puget Sound.

Chris Good, Geraldine Manson, Pamela Shaw & Doug White II (15 minutes)

Snuneymuxw First Nation

The Nanaimo River Estuary: Restoration and balance

Chris Good, Geraldine Manson, Pamela Shaw, Doug White II

Abstract:

The Nanaimo River Estuary is a place of connection: where land meets the sea, freshwater meets saltwater, and where human impacts converge with a fragile ecosystem. This site is important as it was once the breadbasket of the Snuneymuxw First Nation, with an abundance of aquatic and terrestrial species that provided food and medicine to a large community. Thousands of years ago, societal impacts on the estuary would have been limited to fishing and harvesting. Over time, however, new and often competing uses have been grafted onto estuaries as their coastal location, topography, and habitat richness attracted new activities. Competing interests, power asymmetries, and isolated decision-making among the various regulatory bodies and organizations with interests in the estuary have resulted in undesirable outcomes. Major changes have brought about the current situation, and equally significant human-ecological system changes will be needed in the future to implement a more holistic, encompassing approach to bringing sustainability to the research area. The presenters will examine the most pressing scientific or management issue facing the Salish Sea and the Nanaimo River Estuary, which is the lack of an interdisciplinary approach to addressing problems or developing actions. The presenters will tell about the past, examine present day conditions, and look to the future for the Nanaimo River Estuary.

Websites: www.snuneymuxw.ca ; www.nanaimoestuary.ca

Tarang Kangaonkar (15 minutes)

Pacific Northwest National Laboratory

Hydrodynamic and sediment transport modeling of Skagit River – McGlenn Island Causeway Restoration Project

Tarang Kangaonkar, Taeyun Kim, Steve Hinton, Nora Kammer, Eric Mickelson

Abstract:

McGlenn Island Causeway restoration project is located near the mouth of the Skagit River and is part of the efforts to improve the ecological conditions of the Skagit River estuary through nearshore and estuarine habitat restoration actions. Historically, Swinomish Slough, connecting Skagit and Padilla Bays in Northern Puget Sound, was a significant migratory corridor for juvenile

Skagit River Chinook salmon seeking rearing habitat in Padilla Bay. A series of engineering activities taking place over a period of years starting in the late 1800's and culminating in 1937 that created the Swinomish Slough navigation channel have changed this waterway from a highly complex, braided deltaic distributary wetland to a simplified channel bounded by dikes. These changes resulted in loss of connectivity between habitats in the Skagit River, Swinomish channel and Padilla Bay. The proposed restoration design includes reconnecting the North Fork of Skagit River with the Swinomish Channel through alternatives such as lowering of the Goat Island jetty elevation or breaching of the McGlenn Island Causeway. A 3-D hydrodynamic model of the Skagit River estuary was developed using the Finite Volume Coastal Ocean model. The model domain extends from Padilla Bay at the north boundary to Saratoga Passage to the south. The model was calibrated using oceanographic data collected from low and high flow periods in 2005 and 2006. The model was then applied to assess the feasibility of achieving the desired outcome of providing a direct migration pathway and reducing the sharp salinity gradient between Skagit River and Swinomish Channel, a migratory barrier which exists today. An associated sediment transport model was setup using flow-sediment rating curves developed by USGS and sediment deposition estimates based on maintenance dredging records and sediment accretion measurements. The model was then applied over the period from 1988 through 2010, with and without proposed alternatives. The results were used to estimate relative change in sediment transport and deposition in Swinomish Channel resulting from the proposed reconnection to the North Fork Skagit River. This analysis seeks to determine the increase in sediment deposition within the Swinomish Channel due to proposed restoration actions. This information will be used to evaluate if such increases in sedimentation can be accommodated by current and ongoing maintenance dredging for the channel.

3F: Roundtable discussion: The role of social sciences in ecosystem recovery

This session provides an opportunity for open discussion of the role of the social sciences in ecosystem recovery. The conversation is open to all conference participants. It continues themes from the previous session, “The Salish Sea as A Coupled Social-Ecological System,” and from a 13 June 2011 workshop, “Human Dimensions of Puget Sound and Washington Coast Ecosystem-Based Management.”

The workshop, hosted by the Puget Sound Institute and Washington Sea Grant, convened social science academics and professionals to explore how research in the social sciences can inform and guide the Puget Sound Partnership other regional agencies in development and implementation of the Action Agenda to Restore Puget Sound. The workshop addressed a series of questions focusing on Values, Behavior, Risk, Indicators and Targets, Infrastructure, and other topics.

Building on the output of this workshop, we would like to continue the discussion of how social sciences can inform and guide ecosystem restoration and management, particularly emphasizing what concrete actions can be taken to apply these priorities in ongoing work.

PRR Facilitator: Mike Rosen

Moderators:

Katharine Wellman

Marine Environmental Economist
Puget Sound Partnership Science Panel
Northern Economics Inc.

Dave Ward

Stewardship Program Manager
Puget Sound Partnership

4:30 pm - 7:00 pm

Poster Gala Reception - All delegates welcome!

8:30 pm - 10:00 pm

Salish Sea Ecosystem Film Festival – Sponsored by Washington Sea Grant— All delegates welcome!

Wednesday, October 26, 2011

8:00 am - 9:30 am

4A: Transboundary air – Shared Canada and US issues

The Salish Sea encompasses a shared transboundary US/Canada airshed. The session provides an update on current science of the airshed, as well as perspectives on policies and management strategies including the Georgia Basin-Puget Sound International Airshed Strategy - a multi-agency, international co-operative effort to address shared air quality management concerns. A recent scientific assessment on this airshed has found that there is significant transboundary transport of airborne pollutants in both directions and that visibility is impaired 20% of the time in the Lower Fraser Valley. The purpose of this session is to identify i) key emerging issues in this airshed, and ii) mechanisms for collaborative management of the transboundary Salish Sea airshed. Identification of key emerging transboundary air issues in the Salish Sea, as well as mechanisms for addressing these emerging issues will be covered.

This session will also feature a 30 minute facilitated discussion.

Conveners: June Yoo Rifkin, Glen Okrainetz, Roger Quan, Bob Smith

PRR Facilitator: Kimbra Wellock

Roxanne Vingarzan

Environment Canada, Meteorological Service of Canada

Overview of the 2011 Georgia Basin / Puget Sound International Airshed Characterization Report

Roxanne Vingarzan, Robert Kotchenruther, Bill Taylor, Sarah Hanna, Rebecca Saari

Abstract:

The Georgia Basin-Puget Sound (GB-PS) is located in the western coastal region of the Canada-United States border. The GB-PS includes the large urban metropoli of Seattle and Vancouver as well as the provincial capital of British Columbia (Victoria) and the state capital of Washington (Olympia). This ecologically and socially diverse region is home to world-renowned parks and over 6 millions residents. Projected increases in population, economic activity, transportation and climate change pose threats to this international airshed.

The 2011 Georgia Basin-Puget Sound Airshed Characterization Report, co-led by Environment Canada Pacific and Yukon Region and the Environmental Protection Agency Region 10, is a state of the science document covering diverse topics in air quality including trends in emissions, ambient air quality, visibility, transboundary transport, impacts of climate change on air quality, deposition, socio-economic impacts and air quality modeling scenarios. The information is aimed at airshed planners and managers, interested stakeholders and the public who are interested the most up-to date air quality science information for this international airshed.

The report is a deliverable of the International Airshed Strategy (IAS), a multi-agency, international co-operative effort to address shared air quality management concerns and prevent future deterioration.

Julie Saxton

Metro Vancouver

Protecting views in British Columbia

Julie Saxton, Markus Kellerhals, members of the B.C. Visibility Coordinating Committee

Abstract:

Following work carried out in the 1990s investigating visibility in the Lower Fraser Valley and the announcement in 1999 of the Regional Haze Rule by the US EPA, the B.C. Visibility Coordinating

Committee (BCVCC) was formed in 2006 to address visibility issues in British Columbia. The committee, a collaborative initiative involving government agencies at all levels in British Columbia, has tasked four cross-agency workgroups with developing the different aspects of a comprehensive approach to visibility management. The work is interdisciplinary in nature with cross-cutting tools from science, economics, policy and social science fields being applied in a pilot project.

The pilot is being carried out in the Canadian portion of the Lower Fraser Valley. In the east, this airshed borders North Cascades National Park, a Class 1 haze protected area in the US. The purpose of the pilot is to develop the tools needed to build a visibility management strategy for the Lower Fraser Valley and provide a template for wider application to visibility management in other parts of British Columbia and Canada. A review of the aims and achievements of the BCVCC will be offered in this presentation.

Enhanced monitoring capabilities coupled with modeling have produced significant progress in our scientific understanding of the drivers of visibility degradation in the Lower Fraser Valley. A network of instruments including high resolution cameras, speciated particulate matter samplers, aethelometers and nephelometers measuring light scattering and absorption provides detailed information to relate air contaminants to impacts on visibility. Based on selected lines of sight and identifiable landmarks in images, analytical methods are being developed to assess visibility conditions in near-real time.

The technical nature of visibility measurements can make the information inaccessible to the general public. Work in other jurisdictions has shown that a perception based visibility index can be used to provide a non-technical interface for communicating visibility conditions to the public. A perception based visibility index to characterize visibility conditions under various air quality and meteorological conditions is being developed for the Lower Fraser Valley. The visibility index, supported by optical characteristics and air quality data, may also be applied to defining the visibility goal for the region.

Linkages between visibility and other issues are also being explored to inform policy development. A health benefits analysis is being carried out to determine the health and related economic benefits of improving visibility in the Lower Fraser Valley. An evaluation of additional economic benefits is also being carried out to help policy makers encourage stakeholders to take action in programs to improve visibility.

It is recognized that effective communications with potential partners, stakeholders and members of the public are vital. The interrelated nature of the different elements of visibility management presents challenges in ensuring information is shared effectively between the agencies and groups working on the project. Success in improving visibility depends on strong cooperation and collaboration that crosses traditional boundaries.

Dan Brown

US EPA Region 10

Cross-border movement of goods – An emerging transboundary air issue

Abstract not available

Gary Olszewski

Port Metro Vancouver

Milestone results and lessons learned of the cross border Northwest Ports Clean Air Strategy

Abstract:

The Northwest Ports Clean Air Strategy is a comprehensive, voluntary approach to reducing maritime and port related diesel and greenhouse gas emissions in the Georgia Basin-Puget Sound airshed through an unprecedented cross-border, three Port collaborative process. The

ports of Seattle, Tacoma and Port Metro Vancouver (Canada), have been working with a regional strategy that lays out a framework for achieving significant early emissions reductions that affect air quality and climate change in the Pacific Northwest. The Strategy was developed in 2007 as collaboration between the three ports and regulatory agencies including Environment Canada, the Puget Sound Clean Air Agency, the Washington State Department of Ecology, and the United States Environmental Protection Agency.

The Strategy defines specific goals through a set of performance measures for the reduction of port-related air quality impacts with a focus on six sectors of port operations. The Strategy includes two milestones; a set of near term performance measures for 2010, and a set of longer term performance measures for 2015. 2010 marks the completion of the first milestone of the Strategy, and the Ports and Strategy partners have made significant progress over the last three years. In some cases, the performance measures were met or even exceeded. Highlights of the 2008 - 2010 emission reduction initiatives include: Ocean-Going Vessels, use of low-sulfur fuel and electrical shore power connections for ships at berth.

- Cargo-Handling Equipment: Engine retrofits, equipment upgrades, use of low-sulfur fuel and alternative fuels.
- Trucks: Phasing out older truck engines through engine retrofits, and scrap-and-replace incentive programs.
- Rail: Idle-reduction and friction-reduction technologies, engine replacements, and operational efficiencies to reduce fuel consumption.
- Harbor Vessels: Use of alternative and low sulfur fuels, engine replacement, shore power, and resurfacing vessel hulls.
- Port Administration: Energy conservation, hybrid vehicle fleets, waste reduction, and sustainable employee commuting programs.

The Strategy addresses emissions reductions with shared targets, while allowing each Port to implement its own unique and appropriate emission reduction actions. In addition, the flexibility provided by the non-prescriptive, results-based approach for achieving the emissions reduction goals of the Strategy allows for change over time as new technologies and strategies surface and allows for customers, tenants, and other stakeholders to choose the most cost-effective options available.

The Ports and key stakeholders will incorporate the lessons learned from this first milestone continuing toward achieving the performance measures outlined in the Strategy. The Ports also recognize the need to review and adjust the Strategy on a regular basis in light of new standards, technology, air emissions data and evolving climate change policy frameworks. A major review of the Strategy is planned to occur in 2012 where the 2015 performance measures will become short-term goals and new 2020 performance measures will be set for port related emissions reduction in the Pacific Northwest.

An overview of the 2010 milestone, progress towards future goals, lessons learned and key issues will be presented from the perspective of one of the key stakeholders, Port Metro Vancouver.

4B: Science and management of killer whales I

The killer whales of the Salish Sea are listed as threatened or endangered in both the U.S. and Canada. As the scientific and stewardship communities continue to weigh the costs and benefits of invasive methods like satellite tagging, there is a pressing need to exchange all available information from non-invasive research techniques. There are also renewed efforts on both sides of the border to integrate the management of killer whales and the listed species, like Chinook salmon, upon which they prey. 2011 has also brought Federal regulation of orca-boat interactions in the U.S. This session will survey recent scientific results, with an emphasis on less-invasive techniques and new implications for transboundary killer whale management.

Convener: Scott Veirs

PRR Facilitator: Kirsten Hauge

John Ford

Pacific Biological Station, Fisheries and Oceans Canada

Contrasting long-term trends in occurrence and abundance of killer whale ecotypes in the Salish Sea

John Ford, Graeme M. Ellis, John W. Durban, Kenneth C. Balcomb

Abstract:

As the apex predators in the world's oceans, killer whales can have important roles in marine ecosystems. As a species, the killer whale is a generalist predator that feeds on > 150 prey species. However, regional populations tend to have highly specialized foraging strategies and diets. These ecotypes can have important top-down effects on their preferred prey species, and may also be affected by bottom-up processes related to fluctuations in prey availability. Three ecologically-specialized and genetically distinct lineages of killer whales co-exist in the coastal waters of the northeastern Pacific, including the Salish Sea: salmon-feeding 'residents', mammal-feeding 'transients', and fish-feeding 'offshores'. Here we describe changes in the patterns of occurrence and abundance trends of these ecotypes in the Salish Sea as determined from annual field studies since 1974, and examine the relationship of these changes to fluctuations in the availability of their primary prey species. Resident killer whales feed selectively on Chinook salmon, and may be dependent on this prey species for survival. Reduced availability of Chinook salmon may be limiting recovery of this Endangered population, which has shown minimal increase in abundance since first censused in the early 1970s. Transient killer whales feed on most marine mammal species found in the Salish Sea, but harbour seals are their most important prey. Harbour seal abundance in this area has increased more than 10-fold since intensive harvests and culling programs ended around 1970. Over this same period, the frequency of occurrence of transient killer whales in the Salish Sea increased dramatically, and their population abundance increased by an order of magnitude, likely in response to increased prey availability. The diet of offshore killer whales is poorly known, but recent evidence suggest sharks are important prey. Offshore killer whales were not documented in the Salish Sea until the early 1990s, almost 20 years after intensive field research effort on killer whales began. Since then, this ecotype has been observed sporadically in the area, but linkages between these occurrences and the availability of preferred prey species remain to be identified. Killer whales play different roles in the Salish Sea ecosystem according to their dietary specializations, and the future well-being of these ecotypes in the region will depend on healthy and sustainable populations of their preferred prey species.

Amalis Riera

University of Victoria

Acoustic monitoring to delineate killer whale critical habitats off southwestern Vancouver Island

Amalis Riera, John K. Ford, John A. Hildebrand, Sean M. Wiggins, N. Ross Chapman

Abstract:

Killer whales inhabiting the Salish Sea are listed as Threatened and Endangered under the Canadian Species At Risk Act. The identification of important areas for these odontocetes, as well as their year-round distribution, is necessary for the designation and protection of critical habitat, which will promote the recovery of their populations. The movement patterns of killer whales are well known in the Salish Sea, but there has been very little visual effort off South-western Vancouver Island and Washington, especially during the winter months. Since low prey availability is one of their main threats, identifying other foraging areas is essential. This study focuses on the seasonal occurrence of different killer whale lineages in transboundary waters between Canada and the US, off of the mouth of the Juan de Fuca Strait, using non-invasive acoustic methods.

Long-term acoustic data were collected with passive acoustic devices including High Frequency Acoustic Recording Packages at two different sites: Swiftsure bank and the inshore waters of Quinault canyon off the Washington coast. The recordings were analyzed using Long Term Spectral Averages, a tool that allows efficient analysis of large data sets.

Killer whale vocalizations were detected in every month of the year, and were especially frequent during the summer months, when they were heard almost daily, and for extended periods in each encounter. Southern Resident calls were detected throughout the year and Northern Residents were identified in 8 of the months. These results show a considerable overlap in habitat range between Southern and Northern Residents, as the latter use the southern parts of their range more frequently than previously thought. Transient calls were also present year-round; the West Coast population being more frequently detected at the Swiftsure site and the Californian population being more predominant off Washington. These findings suggest that the area is important for different killer whale populations, and this information will be useful for delineating critical habitats.

Samuel Wasser

Center for Conservation Biology

Non-invasive physiological monitoring of Southern Resident Killer Whales

Samuel Wasser, Katherine Ayres, Jessica Lundin

Abstract:

The Southern resident killer whale (SRKW) population experienced a near 20% decline in the late 1990's prompting their listing as endangered under the Endangered Species Act.

Three main non-exclusive hypotheses have been proposed to explain the decline and continued poor population recovery:

1. Disturbance from private and commercial whale watching vessels;
2. Decline in Chinook salmon, the whales' primary prey; and
3. Exposure to high levels of toxicants (e.g. PCB, PBDE and DDT).

Understanding the relative impacts of these three pressures is vital to directing future mitigations efforts, particularly given their associated economic and political impacts. The Center for Conservation Biology is partitioning these pressures by using longitudinal noninvasive measures of stress and nutrition hormones as well as toxicants excreted in feces. Scat samples are located by Conservation Canines (specially trained scat detection dogs) that are able to locate samples floating on the water from as far away as a nautical mile from the whales and, therefore, from distances unlikely to disturb the whales. Our hormone results show that SRKW nutritional status is highest when they arrive in the Salish Sea in the Spring, potentially indicating the importance of high-fat, early Spring Chinook migrations. The SRKW have the lowest stress hormone levels at the peak of the annual Fraser River Chinook salmon migrations, supporting the importance of Fraser River Chinook in this population's diet. Poor nutrition additionally corresponds with periods

of relatively high mortality in the population. Our results to date strongly support the prey decline hypothesis and suggest that prey abundance is a primary physiological driver that affects SRKW population trends. The association between food deprivation and toxin release from metabolized fat is currently being investigated as well as potential interaction effects with boat traffic.

Peter Ross

Fisheries and Oceans Canada

Ranking contaminant threats to the killer whales of the Salish Sea

Peter Ross, John K.B. Ford, Andrea Buckman, Marie Noel, Frank A.P.C. Gobas, Steve Jeffries

Abstract:

Hundreds of environmental contaminants have been detected in endangered southern resident killer whales (*Orcinus orca*), leading to important questions about their sources and their risks to the health of these charismatic marine mammals. Polychlorinated biphenyls (PCBs), polybrominated diphenylethers (PBDEs), dioxins, furans, and organochlorine pesticides have been documented in killer whales and their primary prey, Chinook salmon. Very high concentrations of PCBs have recently been associated with the altered expression of a number of genes in biopsies from free-ranging killer whales. Complementary studies in harbour seals (*Phoca vitulina*) suggest that thyroid hormone physiology and the immune system are perturbed by high PCB levels in Puget Sound. However, conservation strategies must consider the relative risks associated with a wide range of contaminants found in killer whales and their prey. We conducted a risk-based analysis of persistent contaminants in resident killer whales in order to prioritize persistent contaminants of concern in Salish Sea food webs. The conserved nature of toxicological processes among mammalian species enabled us to apply hazard quotients from controlled laboratory animal studies to support the ranking of risk profiles for different contaminants in killer whales. Results confirm that PCBs remain the major contaminant of concern in killer whales, despite regulations enacted to end their use in the 1970s. While PBDE concentrations are found at lower concentrations than their PCB counterparts in killer whales, their current use in domestic applications, and an observed doubling every three years in Salish Sea harbour seals provides an important context for conservation planners. Recovery and conservation planning for killer whales and other at-risk species in the Salish Sea will benefit from an improved understanding of priority contaminants, and the subsequent application of targeted mitigation measures. This insight may be of value as policymakers and stakeholders evaluate chemical regulations, industrial and municipal waste water effluent standards, ocean disposal protocols, and site-specific remediation.

Teresa Mongillo

Herrera Environmental Consultants, Inc.

Health implications of exposure to a mixture of pollutants in Southern Resident Killer Whales

Teresa Mongillo, Gina M. Ylitalo, Sandra M. O'Neill, Linda D. Rhodes, Dawn P. Noren, M. Bradley Hanson

Abstract:

The Salish Sea contains myriad persistent and toxic contaminants found in the sediment, water column, and biota. Upper trophic-level predators can readily bioaccumulate these persistent and toxic contaminants potentially leading to numerous adverse health effects, including impaired reproduction, reduced immune function, and neurodevelopmental toxicity. It has only been in more recent years that studies have examined health effects in laboratory species from exposure to mixtures. The endangered Southern Resident (SR) killer whales (*Orcinus orca*) are a highly contaminated cetacean population that frequents the waters of the Salish Sea primarily during late spring, summer, and early fall. Contaminant-induced health effects have the potential to hinder the recovery of the SR killer whales. This review focuses on polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and dichlorodiphenyltrichloroethanes (DDTs) because exposure to a mixture of these contaminants may enhance adverse health effects in the SR killer whales. The laboratory case studies examined in this review demonstrated that exposure to a chemical mixture at a critical developmental growth period result in enhanced

toxicity. A mixture of contaminants resulted in either an additive or synergistic health effect across a wide range of doses. Moreover, some contaminants in mixtures interact at doses below individual no-observed-effect-concentrations (NOECs), producing adverse effects. Therefore, low concentrations of persistent pollutants in combination are health threats to SR killer whales. Because surviving SR killer whale calves have relatively high contaminant concentration levels, they are more susceptible to enhanced detrimental biological health effects resulting from the additive and synergistic interactions of multiple contaminants. These health effects can include a compromised immune system with increased susceptibility to disease, abnormal developmental effects such as a reduction in the learning and memory, or a change in their spontaneous behavior (hypoactivity and/or hyperactivity). Although it is not clear if contaminant levels in the SR killer whales are near a health effects threshold, it is reasonable to assume that a combination of PCB, PBDE and DDT exposure has the potential to disrupt the reproductive system, the endocrine system, and the immune system. These interaction studies suggest that health effects from exposure to persistent pollutants should not be considered in isolation. Ultimately, the reduction of exposure levels and determining potential resulting risks posed by a mixture of these persistent organic pollutants in the SR killer whales are essential for the effective protection of this endangered species.

Val Veirs

Beam Reach Marine Science and Sustainability School

Underwater noise in the critical habitat of the endangered Southern Resident Killer Whales

Val Veirs, Scott Veirs, Jason Wood

Abstract:

Acoustics likely plays a critical role in the lives of the endangered Southern Resident orcas. Orcas make many frequent tonal sounds, termed calls. These are thought to be used for communication between individuals and to facilitate group cohesion and group actions. Orcas also use echolocation clicks as a type of sonar to determine characteristics of their underwater environment ranging from navigation to foraging for their favorite prey, salmon.

Noise impacts on Southern Resident orcas will depend on the frequency content of the noise as well as the hearing ability of orcas. In humans the impact of noise on our hearing ability is measured using frequency weighted standards such as dB-C. For this study we have used the recently introduced dB-O weighting scheme (Bain, Veirs and Veirs, JASA, vol. 129, No. 4 Pt. 2, pg 2607, April 2011) to develop an orca hearing range noise budget for the Haro Strait. We have recorded the noise signatures of more than 10,000 ship transits of the Haro Strait (Veirs, Veirs and Wood, JASA, vol. 129, No. 4 Pt. 2 pg. 2368, April 2011) and we have recorded the passby of numerous speedboats and other vessels. These high-frequency (10 Hz – 100 kHz) recordings and vessel Automatic Identification System (AIS) radio reports are being archived 24 hours each day at Lime Kiln State park.

In this report we summarize the Haro Strait noise budget over the orca hearing range and through a multifactor analysis, identify the key sources of the noise in the orca-weighted frequency range (2 kHz – 25 kHz). dB-O levels are dominated by ships during the night but during summer days fast speedboats play important roles. We here report daily cycles of masking metrics for orcas that may be vocalizing socially (2 kHz – 10 kHz) and for orcas that may be using echolocation for foraging or navigating (5 kHz – 30 kHz) in the waters near the shore at our hydrophone location. These temporal metrics are developed using our observations of underwater noise over the past two summers (2010-2011) as weighted by the dB-O weighting scheme.

4C: Approaches to assessing the health of the Salish Sea

A number of complementary efforts are taking place to characterize status and trends in the health of the Salish Sea Ecosystem. These efforts differ in their scale, resources and perspectives. This session presents highlights of these approaches, challenges and key findings in order to develop a deeper and more comprehensive understanding of the health of the Salish Sea Ecosystem.

Conveners: Cecilia Wong, Ken Dzinbal, Sandie O'Neill, Michael Rylko, Ron Thom, Jennie Wang

PRR Facilitator: Rita Brogan

Ronald Thom

Marine Sciences Laboratory

Monitoring the Salish Sea ecosystem: The net ecosystem improvement (NEI) approach to assessing ecosystem health that informs restoration actions

Ronald Thom, Heida Diefenderfer

Abstract:

The purpose of this presentation is to describe an approach that efficiently and effectively assesses the health of an ecosystem and provides information useful for decisions about actions that can improve ecosystem health. Since the late 1960's environmental monitoring of marine and estuarine systems has been widespread, and generally informative. However, because of the complexity of ecosystems and the ability to define 'health' it is difficult to answer the question "Have the actions that have been taken really improved the health of the ecosystem?" Our approach uses a simple organizing model of Net Ecosystem Improvement (NEI). The approach accumulates information on the change in a set of ecosystem functions, the area over which the functions have changed, and the probability of the effect of various actions on producing the changes. To help with this, we compile a suite of information into a level of evidence framework to evaluate the cumulative effects of multiple restoration actions on the broader ecosystem. In order to drive decision about actions, we evaluate the set of stressors affecting the ecosystem and develop a simple index of which stressors are having the most effect on the ecosystem. Finally, we use an assessment of the level of damage to the landscape and the sites with the landscape to prioritize where specific types of actions are needed. This systematic approach includes an adaptive management step that allows refinement of the decision process relative to the goal of realizing a true net improvement of the ecosystem. We have utilized this approach successfully in the Columbia River estuary, regions of Puget Sound, the Gulf of Mexico and Massachusetts Bay.

Cecilia Wong

Environment Canada

Transboundary indicators of Salish Sea ecosystem health

Cecilia Wong, Sandie O'Neill, Michael Rylko, Jennie Wang

Abstract:

The US EPA Region 10 and Environment Canada's Pacific and Yukon Region are leading the refinement of a suite of transboundary indicators for the Puget Sound Georgia Basin Ecosystem, also known as the Salish Sea Ecosystem. The Transboundary Indicators project began in 1999 as a means to establish a common understanding of transboundary ecosystem priorities for action. Two transboundary indicator reports have since been published on the state of the Puget Sound Georgia Basin. In this presentation, we will introduce our updated approach to characterizing the health of the Salish Sea Ecosystem, describing our conceptual framework, ecosystem model and considerations for indicators selection. We will compare the current and previous approaches, report updated status and trends information where data permit and our path forward for indicators to support ecosystem based management.

Ian Perry

Fisheries and Oceans Canada

Assessing the health and functioning of the Strait of Georgia: A human-dominated marine ecosystem

Diane Masson, R. Ian Perry

Abstract:

The Strait of Georgia is arguably the most human-dominated marine system in Canada, with approximately 75% of the population of BC living along its shores. Given its rich and diversified ecosystem as well as the current and anticipated environmental and human pressures, the Strait of Georgia was chosen as the location for Fisheries & Oceans Canada's Pacific Ecosystem Research Initiative. The overall objective of the Initiative is to establish the bases for the management of ecosystem - human interactions in an integrative framework. Within this initiative, several projects were conducted to assess the present state of the ecosystem as well as to address the impacts of climate variability and human pressures on ecological processes in the strait. In particular, the influence of climate forcing, acting at a variety of scales, on ecological processes was examined by identifying the mechanisms leading to changes in ecosystem state or to its resilience to such changes. A variety of approaches were adopted, including process-oriented studies and modeling work, to evaluate the role of specific ecosystem functions in governing the observed and future variability of the physical-chemical environment, marine populations, and biogeochemical fluxes. This presentation summarizes and integrates the initial findings from these projects to describe the present health of the Strait of Georgia and how it may respond to future pressures.

Ken Dzinbal

Puget Sound Partnership

The Puget Sound Coordinated Ecosystem Monitoring and Assessment Program

Ken Dzinbal, Nathalie Hamel, Ken Currens

Abstract:

Many different monitoring programs currently operate throughout the Puget Sound region. While they collectively represent a significant monitoring effort, most of these programs were designed to satisfy individual agency mandates or are primarily intended to support local management decisions. Lacking coordination, the result is inefficient and fragmented regional monitoring and a non-uniform understanding of the Puget Sound ecosystem. In 2007, the Washington legislature created the Puget Sound Partnership and authorized the creation of a coordinated assessment and monitoring program to support the recovery and restoration of Puget Sound. In 2010 a Launch Committee was formed, and in February 2011 a draft monitoring program charter was approved by the Puget Sound Partnership Leadership Council. The Puget Sound Coordinated Ecosystem Monitoring and Assessment Program is primarily intended to coordinate, build upon, and integrate existing monitoring efforts (e.g. PSAMP). The goals of the program are:

1. to work in a collaborative, inclusive, and transparent fashion with monitoring partners from all levels of government, tribes, watersheds, business, academia, and citizen-volunteer organizations to better coordinate and integrate monitoring programs across the region,
2. ensure monitoring, assessment, and reporting of key indicators in Puget Sound and support adaptive management,
3. ensure data are credible, trusted, and of known quality, and
4. ensure findings are easily discoverable, available, and communicated to a broad audience.

Different from previous efforts to coordinate monitoring, the Coordinated Ecosystem Monitoring and Assessment Program comprises a set of topic-specific and cross-topic work groups directed by a 23-member, multi-stakeholder, independent Steering Committee. The Steering Committee is the primary decision-making body for the program and develops recommendations for monitoring entities and the Partnership with regard to the coordination and implementation of monitoring for the region. The Puget Sound Partnership Science Panel and the Ecosystem Coordination Board provide technical and policy advice to the Steering Committee but do not direct the Monitoring Program. Results from the monitoring program are incorporated into the Puget Sound Ecosystem Indicators, the State of the Sound Report, a wide variety of other local and regional reports, and support the Puget Sound Action Agenda.

Katherine Boyd

Puget Sound Partnership

How to write accountable actions: Lessons learned from performance reporting on the 2008 Puget Sound Action Agenda

Katherine Boyd, Alana Knaster, Alex Mitchell

Abstract:

The presentation will discuss the problems that the Puget Sound Partnership encountered while trying to report on the status of the 146 Near Term Actions in the 2008 Puget Sound Action Agenda, including: open-ended actions with no clear state of completion, multiple responsible parties for each action, and a lack of agreed-upon milestones, deliverables and outcome measures. The discussion will focus on how to write clear and accountable actions, and also describe the Partnership's efforts to craft the new actions in the upcoming 2011 Action Agenda.

Richard Brocksmith

Hood Canal Coordinating Council

A framework for adaptively managing ecological and socioeconomic conservation at the meso-scale

R. Brocksmith, S. Brewer, M. Holman, J. Meyer, J. White, H. Huber, J. Horowitz, K. Nelson, A.J. Morgan, D. Herrera

Abstract:

The Hood Canal Coordinating Council is a watershed-based council of governments historically focused on natural resource conservation, with a particular focus on salmon recovery planning since the listing of multiple salmon species in the Salish Sea in 1999. More recently, we have worked with a broader constituency of partners and citizens to expand our vision: Humans benefit from and coexist sustainably with a healthy Hood Canal. To meet this local vision we have launched the Integrated Watershed Management Plan (IWMP) utilizing a strategic planning framework that relies on the community to prioritize focal components of the vision, goals to attain long term persistence of that vision, pressures on those components, and strategies to reduce those pressures in an adaptive management process that upscale into the Puget Sound Partnership's Action Agenda. Much work through various planning efforts is already in progress and it's the Council's belief that integrating these efforts is necessary to provide a higher certainty of success.

Much has been said about the loss of opportunity when salmon recovery is juxtaposed against competing priorities in ecosystem recovery and human values, and so our approach for the IWMP is to fully integrate existing salmon recovery plans and goals into a broader ecosystem based management framework necessary to achieve our vision. We believe this will create new opportunities to context the natural capital that salmon represent and its relevance to human health and well-being, making a more compelling case for continuing or even expanding salmon recovery.

This presentation will explore how we define our salmon and their obligate habitats into focal components, attributes and indicators; how spatial analyses of those indicators allows for

assessment of past and current ecosystem conditions that can be projected out for validating existing or expanded salmon recovery goals; how planning-scale indicators can downscale to site-specific strategies and actions to roll up to the goals; and how salmon recovery supports human values.

4D: PSP Action Agenda: Strategies and actions

The Puget Sound Action Agenda presents recovery strategies for protecting and restoring terrestrial, freshwater, nearshore, marine systems and for preventing and controlling pollution. It is used by decision-makers throughout the Puget Sound region to guide investments and track recovery progress. This session presents an overview of the 2011 revisions to the Action Agenda including the major strategies, the nesting of local actions within a Sound-wide strategy, the adaptation cycle and recent update process, and approaches used to foster partners' ownership and buy in.

This session will include a facilitated discussion.

Conveners: Scott Redman

PRR Facilitator: Jamie Strausz-Clark

4E: Shorelines I: Ecology, restoration & shore-friendly development

The session explores Salish Sea shoreline management through the lens of science, policy, management, and development design. Topics include:

- Management strategies adopted by local and regional jurisdictions (i.e., cities, counties, provinces) for shoreline protection and rehabilitation. This may include the implementation of Shoreline Master Programs, the regulatory approach in British Columbia, the concept of no net loss of ecological function, and incentive programs to encourage adoption of lower impact shoreline development.
- New research on nearshore ecology, including the backshore ecotone; describing small-scale restoration and monitoring strategies; and exploring how this information might intersect with management and design alternatives in the nearshore.
- Development approaches to enhance shoreline sustainability in the Salish Sea that have been, or will be implemented along freshwater and marine shorelines. The focus is on projects at the parcel or park scale (public, private and First Nations), which conserve, restore or enhance physical and biological processes on altered shorelines through designs developed with ecosystem function in mind.

The session covers the research, policies, design solutions, and incentives relevant to shoreline ecosystems on a scale of interest to local jurisdictions. It provides a forum for discussing restoration strategies and results from recent restoration projects; identifying gaps in knowledge and industry preparedness in the implementation of traditional and innovative restoration activities; and discussing the role of backshore and nearshore protection and restoration projects in overall improvements in shoreline habitats and function. It serves as a platform for the exchange of ideas between participating coastal professionals.

Conveners: Erica Guttman, Katrina Hoffman, Andrew James, Joel Baker, Brian Emmett
PRR Facilitator: Hadley Rodero

Moderator:
Andrew James
University of Washington

Megan Dethier
Friday Harbor Labs, University of Washington
Impacts of armoring on Puget Sound beaches: Diverse effects on diverse scales
M. Dethier, J. Toft, S. Heerhartz, J. Cordell, A. Ogston, H. Berry

Abstract:
In the Salish Sea, one of the human activities hypothesized to be significantly detrimental to the health of the marine ecosystem is armoring of the shorelines. Shoreline armoring is widespread in the region, yet there are surprisingly few data documenting actual negative impacts on physical or biological features of nearshore ecosystems, and information is especially lacking along inland sea environments. Armoring of marine shorelines may alter natural processes at a variety of spatial and temporal scales; some, such as ‘starving’ the beach of sediments, may take decades to become visible. We are investigating local effects of armoring on ecosystem function using intensive observations and experiments at a few sites centered around a completed and planned restoration at a shoreline park, and a broader survey approach of paired armored and unarmored beaches on a scale covering much of central Puget Sound. Work associated with this project, and other restoration projects we have monitored in the region, provide insight into how shoreline armoring - and subsequent restoration - affect ecosystem function. Armoring clearly reduces riparian vegetation, accumulation of logs and marine and terrestrial detritus, and abundance of

amphipods along the depositional wrack line of beaches. Insects caught in traps in supratidal locations are also less abundant and diverse on armored beaches; amphipods provide food for shorebirds and small mammals, while insects can serve as key food items for fishes foraging nearshore, including juvenile salmon (see poster by S. Heerhartz et al.). Removal of armoring coupled with shoreline restoration can alleviate negative biotic responses at the elevations at which the armoring occurs, as demonstrated at a few restoration sites. Physical impacts of armoring on wave reflection and sediment transport are being studied with detailed beach profiles and deployment of wave gauges. Physical characteristics such as wave energy, sediment sources, and width of the low-tide terrace are highly variable among the selected pairs of armored/unarmored beaches. Preliminary comparisons within the pairs show slightly steeper beach foreshores and increased sediment size at armored beaches relative to their unarmored equivalent; these physical factors impact the spatial extent and habitat quality of intertidal environments. We have found fewer impacts at lower tidal elevations not directly covered by armoring. For example, abundance and diversity of juvenile clams in the mid-shore vary greatly with sediment type, but do not clearly relate to armoring higher on the shore. Ultimately we intend that our results will provide managers and policy makers with a biological and physical narrative about the impacts of armoring that is backed by hard data. This will inform decisions on how aggressively to prioritize shoreline armoring removal as a regional environmental restoration action, and how to best target restoration projects to improve shoreline conditions at the locations most negatively affected by armoring.

Hugh Shipman

Washington Department of Ecology

Armoring Puget Sound: Results of a 2009 workshop

Hugh Shipman, Megan Dethier, Guy Gelfenbaum, Kurt Fresh, Rick Dinicola

Abstract:

The construction of seawalls and bulkheads has become a significant management issue on Puget Sound as concerns have grown about their potential impacts on beaches and coastal ecology. This increase in attention parallels that in other regions, but is also influenced by unique aspects of the Salish Sea such as its sheltered, estuarine shorelines, the predominance of mixed sand and gravel beaches, and the relative importance of bluff-derived sediment sources.

Agencies and local governments charged with protecting public resources and restoring nearshore ecosystems need solid science on which to base regulatory and funding decisions. In response, we convened a workshop in 2009 to review the state of the science regarding the impacts of shoreline armoring in settings relevant to Puget Sound. The objectives of the interdisciplinary workshop were to summarize the state of the science on this topic, assess the levels of certainty associated with this information, and to identify information and data needs. More than 30 regional and national experts participated.

Speakers at the workshop reported geologic and biologic observations from a wide variety of armored shorelines, both on the Salish Sea and in other regions, and discussed emerging approaches to erosion control and beach ecosystems. Participants described numerous effects of armoring, including placement loss, impacts on ecological, sediment, and hydrodynamic processes, and passive erosion (the chronic loss of the beach in front of coastal structures as erosion progresses or sea level rises). They noted that the type and extent of impacts depends on both the geomorphic setting of the project and on the design and position of the structure. Discussions underscored the cumulative nature of impacts and the fact that accelerated sea level rise would increase pressure to armor vulnerable shorelines but will also tend to increase the impacts of that armoring.

The workshop provides a foundation on which to develop guidance regarding the design and the regulation of erosion control structures. We also expect it to inform efforts to manage shorelines and armoring in other regions with sheltered coastlines. The workshop report is available in a

USGS report, Puget Sound Shorelines and the Impacts of Armoring – Proceedings of a State of the Science Workshop, May 2009, (available at: <http://pubs.usgs.gov/sir/2010/5254/>).

Erica Guttman

WSU Extension

Vegetation characterization and restoration potential in the backshore

Abstract:

As communities develop critical areas ordinances and shoreline protection plans, planners and policy makers need information about the ecology of all components of the Salish Sea nearshore. This presentation will describe research that characterized the vegetation of the unique ecotone known as the backshore, which lies beyond the reach of regular tides but which is periodically disturbed by extreme high tides, usually in conjunction with storm events. The presentation will share a proposal for a more complete definition of the backshore that takes into account elevation, soils, vegetation, and stability vs. disturbance; findings about the role of vegetation in ecological functioning and the potential role of buried wood; a discussion of anthropogenic impacts to this zone, both historically and today; results of case studies and monitoring from restoration projects that have been successful in removing fill soils and uncovering the original backshore sediments; and a discussion of the potential for more restoration focus and protection to be directed at this zone.

Jonathan Turner

Squamish Oceanfront Development Corporation

Achieving Park Planning Objectives While Enhancing Habitat Values and Ecosystem Functions

Jonathan Turner, Trevor Dunn

Abstract:

Set at the northern tip of Howe Sound, mid-way between Vancouver and Whistler, and surrounded by dramatic Coast Range Mountains, the Squamish Oceanfront peninsula is a unique oceanfront development opportunity interfacing with the regional waters of the Salish Sea. The Squamish Oceanfront Development Corporation (SODC), a wholly owned entity of the district of Squamish, has been tasked with developing a live- work- recreate oceanfront community to showcase the spirit, cultural heritage and values of the people of Squamish.

The Oceanfront Park (the Project), is the first phase of a 20 year multi-phased development plan, which will shape the southern end of the Oceanfront Peninsula. The Project includes an oceanfront walkway, windsports beach, family beach, sailing boat launch/access ramp, and a rocky headland viewpoint. With the Project providing improved park amenities including recreational access and support facilities, it is also anticipated to result in enhanced ecological values over and above existing conditions. Current site conditions closely resemble that of an abandoned industrial site, with patchy primary vegetation communities dominated by red alder and Himalayan blackberry along the foreshore, and rip-rap, derelict docking and mooring structures dominating the intertidal and marine areas.

For the project to achieve shared goals of creating a valuable community oceanfront amenity, managing environmental risk associated with former industrial activities, and enhancing ecological form and function of the site, a set of environmental objectives and design principals were developed. These were created at the outset of the project to guide the land use planning, landscape and structural engineer designs. The environmental objectives and design principles for this project include:

1. Restrict the amount of hard shore protection to essential areas only;
2. Increase the quantity and quality of foreshore riparian vegetation;
3. Increase the amount of intertidal marsh and dune grass habitat;

4. Increase habitat value for out-migrating juvenile salmon; and
5. Increase the foreshore habitat diversity including: spawning substrate for herring and forage fish and rocky outcrops for kelp colonization and rockfish habitat.
6. Opportunities to enhance existing foreshore and upland habitat values must be complementary to the foreshore protection engineering needs, and planned recreational activities

This session will use the Project's environmental objectives and design principals, to challenge the traditional approach of measuring a project's impact by the simple measurement of net habitat gain / loss calculations. To support this challenge, the presentation will focus on describing the site's Valued Ecosystem Components in the context of their ecosystem features and functions as a comprehensive method to measure overall impact of the project on the marine environment. The presentation will conclude by demonstrating how the Project achieved its land-use, landscape, and structural engineering design requirements while optimizing functional habitat enhancement opportunities through a comprehensive and collaborative design process.

Andrea MacLennan

Coastal Geologic Services

Enhancing Resilience to SLR/CC at Vulnerable Priority Nearshore Habitats in San Juan County

Andrea MacLennan, Stephanie Williams, Jim Johannessen, Tina Whitman

Abstract:

San Juan County consists of 428 islands, and 408 miles of marine shoreline, more shoreline than any other county in the contiguous United States. These shorelines are diverse in character, and include a variety of geomorphic shore types (shoretypes). Each shoretype is associated with a suite of valuable nearshore habitat functions, structures and processes, upon which the larger marine ecosystem depends. Shoreline residential development is concentrated along these shorelines, much of which includes additional engineered structures such as shoreline armor and coastal roads. Shoreline modifications such as these can degrade nearshore ecosystem function and processes, which can result in a less resilient nearshore ecosystem. Less resilient systems have a reduced capacity to overcome large-scale perturbations such as those associated with climate change and sea level rise.

The relative resilience and vulnerability of priority nearshore habitats were recently assessed by Coastal Geologic Services for Friends of the San Juans with a grant from the Bullit Foundation. The objective of the assessment was to identify priority areas of greater and lesser risk to the many implications of climate change and sea level rise. Valuable habitats were defined as those highlighted as priority shoreforms for salmon recovery as well as those that are known to support forage fish spawning. Sediment supply, natural and anthropogenic constraints to shoreline translation, and inundation areas (potentially inundated infrastructure) were assessed to identify which nearshore habitats will be more resilient and those that are at the greatest risk of being degraded or lost as a result of climate change and sea level rise. The results will highlight where targeted restoration efforts that may increase resilience (thereby decreasing risk) and where to preserve resilient habitats for the long-term success of San Juan County nearshore ecosystems.

CGS has designed and implemented various restoration projects designed to enhance the resilience at several of the most vulnerable and top priority habitats identified in the assessment. A suite of different approaches are applied to preserve and ameliorate degraded processes that will contribute to a more sustainable nearshore ecosystem.

Several examples will be shown, including a "SLR-ready" residential project. Innovative design, foresight, and pragmatism are imperative to preserve resources and the needs of the built environment.

Jonathan Waggoner

Coastal Geologic Services

Beach nourishment for mitigation and forage fish habitat at March Point, Skagit County, WA

Jonathan Waggoner, Jim Johannessen, MS LEG, Andrea MacLennan, MS

Abstract:

March's Point has a long history of heavy industry and extensive shore modifications including extensive road revetments that have been in place for many decades. As a result, nearshore processes and habitats are heavily degraded. Surf smelt spawning has been greatly reduced since the early 1980s. The shore experienced an oil spill in the early 1990s. Previous work for the Skagit County Marine Resources Committee documented degraded conditions and prioritized the west March's Point shoreline for beach nourishment. Through a partnership with the WA DNR, the Skagit River Systems Coop, and Coastal Geologic Services, remaining funds in the oil spill mitigation fund for habitat enhancement. An extensive beach nourishment design was completed and implemented for the highest ranked section for shore. The intent of the nourishment project was to improve the forage fish, specifically surf smelt, spawning habitat through beach cleanup and recreation of a fine-grain high tide beach along the central shore of western March's Point. This beach has been substantially adversely impacted by the placement of the road immediately adjacent to the marine bank with associated rock shore protection along the upper beach and lower bank as well as by the removal of beach sediment during oil spill cleanup operations. Surf smelt spawning has been documented year-round for this section of beach, although in greatly reduced numbers in recent decades. However, due to the level of impact, mortality rates have been very high.

The nourishment design consisted of two placement areas. The first was placed at the up-drift end and totaled 5,200 cubic yards (cy) of pebbly sand spread over 1,400 ft of beach. This section included an additional 800 cy of sediment placed near the southern end as additional beach feed sediment. The second placement area was in the north-central area totaling 2,300 cy of pebbly sand. Some nourishment sediment remained after completing construction due to handling constraints, and was placed at the far northern end of the shoreline on the updrift end of Little Crandall Spit. Physical monitoring showed the nourishment sediment being distributed across the beach fairly quickly. Forage fish sampling has shown moderate and increasing utilization of the nourishment area by surf smelt during the winter of 2010-11.

4F: Media in science outreach: Strategies and new directions

In this 21st century in North America, a major part of the public's understanding of the world around them comes from media: reading books in school, watching television, subscribing to blogs, watching viral videos, or viewing public art installations. If we look for Salish Sea science in the media, we find a few exceptional portrayals of the largely invisible parts of the Salish Sea, but in general they are vastly underrepresented.

Since the public is such an immediate, though often unaware, stakeholder in the health of the Salish Sea, their support is essential for continuing research about, and informed management of this environment. The purpose of this session is to examine methods scientists can use to communicate a sense of our Salish Sea ecosystem to the public — the successes and failures of contemporary media as well as the promise of some of the new media technologies. It will bring together a few exceptional media examples and an audience who represent a myriad of media opportunities and additional media experiences. In addition to offering scientists some insight into the how's and why's of the media process, a discussion at the end will expand a list of concrete media resources available to scientists to enable them to share their insights with the public without having to become media experts themselves.

This session will conclude with a facilitated discussion.

Convener: John Williams

PRR Facilitator: Mike Rosen

John Williams

SEA-Media

Has the Salish Sea disappeared?

Abstract:

The ocean is the lion's share of our biosphere and the Salish Sea is an integral part of the Pacific Northwest. But you wouldn't know it from the media. A brief survey of popular mass media, even "nature" oriented TV shows and periodicals, shows quite clearly that Northwest waters are conspicuous in their absence from the media. Even when our waters are featured, we're seldom given a peek into the biggest portion of the marine ecosystem: beneath the surface of the water.

Who cares what's in the media?

Our ability to understand our local and global ecosystems relies on indirect observations, whether from ROVs, satellites, microscopes, or social networks. These observations and attendant analyses can no longer be delivered to the public simply through the cultural, community channels used in past millennia. We are increasingly dependent on an ever-shifting network of corporate and independent media.

So when the Salish Sea is missing from the media, it is missing from our lives.

Still Hope Productions has been increasing the presence of the Salish Sea in the media 3 different fronts. First, short documentary videos are produced that provide virtual underwater tours, explain parts of the underwater ecosystem, and show marine science in action in a way that the public can understand. Second, Still Hope Productions produces a TV series about what's in Northwest waters. The show "SEA-Inside: Pacific Northwest" is seen on more than 60 community stations around the U.S. (and one in Canada, one in Paris). The several short videos in each half-hour episode illustrate diverse points of view from science to art, and they come from a variety of sources, e.g. educators, artists, PBS, NOAA, NGOs, and recreational divers.

Of course, none of these approaches is very effective if they don't connect with the public in

significant numbers. So the third approach was to create a nonprofit organization, SEA-Media, focused entirely on creating a larger presence in the media for our local waters and to build connections between the media and the public. The first project of SEA-Media has undertaken is creating a web portal to existing and emerging media about Northwest waters, a portal with the public as its target audience.

Robi Smith

Blue Lantern Studio

When art meets science, good things happen

Abstract:

Even though I'm not a scientist, my art and my writings are informed by science and I've worked closely over years with scientists from many fields. What I've found is a happy pairing of people who are curious, who delight in detail and discovery, and want to share what they know with the world. In its various media, art can be a wonderful way of sharing science, especially with people who don't speak the language of science or feel intimidated by it.

In this presentation I will talk about specific ways that I've worked with scientists to communicate what they are doing and initiatives I've created to bring art into the scientific milieu. In the former, I will talk about a fellowship I received from the EarthWatch Institute to participate in field work in the Skagit River Watershed and then create artwork about my experience. This work was then shown at a wildlife reserve, the Society for Ecological Conservation Conference in Victoria, in an art exhibit, and is now displayed in the lobby of a sustainability consulting firm in Vancouver. More recently, I've been curating art exhibitions as part of scientific conferences where the art reflects the themes being discussed. This brings artists and scientists together who are interested in the same things and has led to growing relationships and new and exciting possibilities.

David Gordon

Washington Sea Grant

High-impact communications on a low-ball budget

Abstract:

In our attempts to share environmental information, we have become over-reliant on TV news segments, magazine features, Web pages and four-color brochures. Each of these oft-employed venues can have genuine benefits but they can also have serious drawbacks, including high costs, for individuals and organizations eager to spread the word with the public at large. In our efforts to keep pace with the latest developments in social media, we tend to overlook equally effective approaches that are often inexpensive and easy to mount. Drawing on his 25 years of experience as a professional communicator, Washington Sea Grant Science Writer David G Gordon has worked in the past on several public-awareness campaigns that, while produced on shoestring budgets, have reached thousands of people throughout the Pacific Northwest. In this context, he will describe his latest project — creating and placing water quality information on milk carton panels — and suggest strategies with which others can get more bang for their limited communication bucks.

Ron Steven

Rogest studio

The art of connection

Abstract:

As a presenter of any type, trying to convey an idea, whether it's to educate, persuade, encourage action or otherwise, it's imperative that you make a connection with your audience. Presentations, as nearly all of them exist now, consist of mostly facts, figures, and features, serving often the interest of the presenter. The information presented is sometimes quite forgettable. We've all sat through these, and most of us can't remember anything except the misery we experienced. This structure doesn't allow the presenter to make any sort of connection

with the audience, and thus the presentation is quickly forgotten. As an artist I introduce art in to all my presentations, articles and products with great success, here are some things that will help YOU reach the public more effectively.

Eric Solomon

Vancouver Aquarium Marine Science Centre

Helping the public make sense of Salish Sea science: The role of the media in creating context

Abstract:

We are bombarded daily with conflicting headlines about complex science-based issues. For the public to play informed and effective roles as stakeholders in the health and management of the Salish Sea, we must be able to see past sound bites and headlines to the context in which stories are set. Several barriers stand in the way our ability to do this effectively. Chief among them are common misperceptions of the nature of scientific study, the ways we communicate and consume science stories, and the interests of multiple stakeholders. This presentation will discuss how these three factors interact to limit public understanding and engagement, and ways that the scientific community, educators and the media each can play a role in addressing some of these issues. We will look at examples of both traditional and new media approaches, from exhibits to social media.

9:30 am - 10:00 am

Morning Break

10:00 am - 11:30 am

5A: Marine Protected Areas in the Salish Sea – A transboundary exploration

The session gathers marine resource scientists, NGOs and management professionals engaged in the development of Marine Protected Areas (MPAs) and MPA Networks in Washington State and British Columbia, with a focus on initiatives in the Salish Sea, and potential links with broader marine spatial planning for the Salish Sea.

Presenters will describe research into social aspects and implementation of MPAs, to collectively identify future research needs in the field, and share resources that can be mobilized toward this end. We will discuss the proposed Canada/BC MPA strategy and its implementation in the Salish Sea and recent MPA initiatives in Washington State spurred by successful dive-site MPAs and the Endangered Species Act listing of rockfish. In addition, we will explore the opportunity provided by the proposed Southern Strait of Georgia national marine conservation area (NMCA) and the Puget Sound Partnership for protecting tourism, ecological and recreational values in the area, the potential future management challenges, and the complex jurisdictional arrangements in this area.

Key topics to be addressed include:

- Overlapping and conflicting goals of existing MPAs and MPA networks with the intention of developing a shared sense of purpose into the future;
- Effectively engaging the fishing community and other constituencies;
- Can MPAs be an effective tool for the recovery of rockfish and In what circumstances are MPAs the correct tool?

Conveners: Pat Christie, Christianne Wilhelmsen, Sabine Jessen, David L. Fluharty, Kristin Hoelting , Clara Hard, Richard Pollnac

PRR Facilitator: Kimbra Wellock

Patrick Christie

School of Marine and Environmental Affairs - University of Washington

An introduction to Puget Sound MPAs: Social processes and impacts

Patrick Christie, David Fluharty, Richard Pollnac

Abstract:

While the US government has now declared a national MPA system with 24 sites located in Puget Sound (http://www.mpa.gov/pdf/helpful-resources/ns_mpas_june2010.pdf) little is known about how well these MPAs are managed or how to improve their effectiveness. MPA sites in Puget Sound have not been systematically evaluated even against their designation objectives although some efforts have been made to evaluate biological response. It can be argued that the lack of progress in some of the policy dimensions can be attributed in part to a lack of understanding of how MPA management is taking place and the basis for public interest and support or lack thereof of for management measures. Washington has a long history of developing MPAs (Murray and Fergusson 1998) of various definitions and with differing authorities: State Parks, Department of Natural Resources, Washington Department of Fish and Wildlife. Most recently, the declines in abundance of certain species of rockfish drove development of a new spate of no-take fisheries zones under WDFW auspices. In 2008 the Washington State legislature required the Department of Ecology to convene a Marine Protected Areas Work Group to provide recommendations on how MPAs could be developed in Puget Sound and elsewhere. The Work Group report recommended that the legislature support establishment of a MPA network. The choice of policy measures employing MPAs for rockfish is not one that can be taken lightly or without support of a solid social, economic and ecological

science based approach. A principal reason for this is the national and state commitment to the interests of the Treaty Tribes and fishing rights of Native Americans and controversies which MPAs create. As co-managers of fisheries the tribes are prepared to work to restore fisheries but would prefer methods that do not impinge on their rights to fish in their Usual and Accustomed Fishing areas, and methods that would accord full respect and support to their role as co-managers. Very importantly, we are observing a shift in viewing MPAs as primarily a fisheries protection measure to one where society is looking more broadly as use of marine space and the valuation of ecosystem services that are provided by marine ecosystems. Dive tourism appears to be increasing as a recreational pursuit. Having areas which are safe and accessible, with attractive habitats coinciding with some existing marine reserves could justifiably demand more attention. The importance of understanding how society values the marine environment both culturally and economically becomes of increased importance in policy decisions. This presentation will review the historic and contemporary social impacts and opportunities of marine protected areas in Puget Sound.

Clara Hard

University of Washington

Community awareness and influence: A case study of MPAs in Puget Sound

Clara Hard, Patrick Christie, Richard Pollnac, Kristin Hoelting

Abstract:

Marine protected areas (MPAs) are one management tool used to protect and restore the marine environment. Structured interviews with waterfront users, resource users, key informants and government officials provided insights on the establishment processes of MPAs created by Washington State agencies and local governments. This study examines the establishment process of seven Puget Sound MPAs through an examination of waterfront user demographics, general awareness of the nearby MPA and perceptions of collaboration between the government agency and the nearby community at the different sites.

While 44% of waterfront users in Puget Sound were aware of the nearby MPA, males and respondents with at least a college degree were more likely to have heard of the sites. Perceptions varied on the potential environmental impact of MPAs and whether waterfront users thought that their opinion had an impact on the MPA establishment. A dependent variable, 'perceived collaboration,' was built using resource user survey responses to measure the degree of collaboration between state agencies and the nearby community at each site. Two independent variables - a) whether resource users perceived that adequate information was used, and b) whether all views were taken into consideration – are key factors explaining variance in perceived collaboration. Both were significantly correlated with perceived collaboration with Spearman Rho rank-order correlations of 0.56 and 0.64 respectively at the $p < 0.05$ level. In addition, there was a significant difference between government official and resource user perceptions regarding the openness of the process and the degree of community influence in MPA establishment.

Kristin Hoelting

University of Washington

Legitimacy and collaborative process: Factors influencing public support of Puget Sound MPAs

Kristin Hoelting, Clara Hard, Patrick Christie, Richard Pollnac

Abstract:

Previous studies suggest that collaboration between management agencies and the public has the potential to increase the legitimacy of Marine Protected Area establishment processes, thereby leading to increased public support. A social survey was conducted in seven communities near Puget Sound MPAs to determine whether government agency-public collaboration can be empirically connected to increased process legitimacy and public support. Results show that perceptions of collaboration are significantly correlated with measures of process legitimacy and public support, while tangible measures of collaboration (meeting attendance, information

sharing, opinion solicitation) are not significantly correlated. Perceived collaboration is shown to account for 38.9% of the variance in process legitimacy and 13.8% of the variance in public support. Process legitimacy is shown to mediate the relationship between perceived collaboration and public support.

Sabine Jessen

Canadian Parks and Wilderness Society

MPA issues in the Southern Strait of Georgia: what is the potential for progress?

Sabine Jessen, Christianne Wilhelmson

Abstract:

The Southern Strait of Georgia or Salish Sea is a biologically complex and socially and economically significant marine region. Despite the important conservation values, implementation of MPAs and other conservation measures to protect them has been very slow.

The federal-provincial feasibility study for a National Marine Conservation Area in the Southern Strait of Georgia, the Heart of the Salish Sea, has been underway for almost 8 years. Establishment of a marine park or MPA was first proposed in the 1970s, but has still not been realized. The NMCA provides a model for protecting marine life in the Southern Strait while balancing human uses that could inform these discussions.. The proposed NMCA has gained broad support from a variety of stakeholders, including tourism businesses, boaters, municipalities, conservancy groups, scientists, and others. These stakeholders have worked together to support and strengthen efforts to protect the marine environment of the Southern Strait of Georgia.

The NMCA can demonstrate how protection and conservation practices can be harmonized with resource use in marine ecosystems for their long-term sustainability. However, implementation requires a combination of political, community and stakeholder support that in many places can be difficult to achieve. In this region, a variety of government and non-government interests have been involved in discussions of the NMCA and a common vision is within reach.

In addition to the NMCA, the proposed Canada/BC MPA strategy and its implementation in the Salish Sea, provides an opportunity to plan for a network of MPAs that captures the full range of conservation values in the region. With the economic, social and environmental health of the Salish Sea being impacted by a variety of threats, the NMCA, an MPA network, and a broader ecosystem-based management approach is urgently needed in this marine region. The establishment of a National Marine Conservation area in the Southern Strait, can serve as the first step and provide leverage in bringing a comprehensive marine planning approach to the region to effectively address threats and also identify scientific knowledge gaps in managing this complex bioregion.

In addition to the broad goals, the creation of an NMCA can provide the needed structure to begin the long overdue conversation on how to make changes to protect the endangered southern resident killer whales. Although the Canadian government listed the southern resident orcas as endangered in 2003, this “protection” has been a reality only on paper—meaning very little in terms of the whales’ day-to-day survival. Recent Canadian federal court rulings in cases brought forward by concerned environmental groups has chastised the government for lack of protection of the orca’s critical habitat since its listing under the Species at Risk Act. Rather than time in court, an NMCA and further marine planning in the region offers all concerned with the forum to begin taking action to make real change – from managing pollution to noise to salmon health – for the protection of these endangered species as well as other at risk species in the region.

Tony Pitcher

University of British Columbia

The sea before us: Reconstructing the Salish Sea with marine protected areas

Mimi E. Lam, Ian Perry, Douglas Harris, Andrew Martindale, Evgeny Pakhomov, Tony Pitcher

Abstract:

The relationship between humans and the sea has evolved over millennia in the Salish Sea (Georgia Basin/Puget Sound). Complex, pre-contact indigenous societies survived by adapting to and modifying their local environments for over 12,000 years. But the intricate, reciprocal connections of its indigenous inhabitants with local biota were disrupted, along with traditional ways of life, following contact with Europeans in the late 1700s. Successive waves of cultural drivers have since altered the local marine ecosystem and adjacent human communities, with developments in technology, demography, socio-political organization, law, and governance. Periods of relative stability (“stanzas”) in the European-dominated era of the Salish Sea may be defined by: canneries (late 1800s); steam-powered vessels (1920s); end of the whaling industry (1950s); herring collapse (1960s); climate shift (1970s); formalized fishing rights (1980s); salmon collapse and aquaculture (1990s); seal resurgence (2000s); and overfishing, pollution and climate change (2010).

Using paleo-ecology, archaeology and history, our conceptual ecosystem-stanza approach for the Salish Sea integrates knowledge of local natural and human history. Ecological markers from oceanography, stratigraphy, and the ecology of plankton, fish, marine mammals, and seabirds specify the baseline components of the Salish Sea ecosystem stanzas. We employ mass-balance and other models integrating narratives to encompass situations of varying data quality, especially historical sequences, where the precision needed for complex ecological simulations are rarely available. The human communities that evolved adjacent to the Salish Sea are described using archaeology, history, archives, science, and local and traditional ecological knowledge.

Reconstructing the “Sea Before Us”, the historical ecology of the Salish Sea, will identify ecologically and culturally important locations with potential for being defined as protected areas, recognizing their ecological and cultural resonance from deep time. Knowledge of precisely what was formerly present in the Salish Sea ecosystem, in what kind of amounts, where, and how it was used, can consolidate restoration and conservation decisions for today's depleted ecosystem. Knowledge of former cultures that had greater connectance between the natural and human spheres, and past examples of sustainable resource use, can inform policy decisions for “The Sea Ahead”, leading to a more sustainable transboundary community living adjacent to the Salish Sea ecosystem. The aim is to encourage greater overall human well-being for both present and future generations. This talk presents the latest research of a collaborative project at UBC and opens a dialogue on how to coordinate efforts from diverse academic, NGO, indigenous, fishing, and local communities affected by, and instrumental to, the successful establishment of MPAs in the region.

Wayne Bourque

Parks Canada -- Gulf Islands National Park Reserve of Canada

Status of the proposed National Marine Conservation Area

Bill Henwood, Wayne Bourque

Abstract:

Parks Canada is committed to creating a system of National Marine Conservation Areas (NMCA) across the country through the establishment of one NMCA in each of the 29 marine regions in Canada's three oceans and the Great Lakes, five of which are on the Pacific coast: Hecate Strait, the Queen Charlotte Islands Shelf, Queen Charlotte Sound, the Vancouver Island Shelf and the Strait of Georgia. Following the successful establishment of Gwaii Haanas National Marine Conservation Area Reserve in 2010, Canada and British Columbia continue to make progress toward completing the feasibility assessment of the proposed NMCA in the southern Strait of Georgia.

Canada and British Columbia have been jointly undertaking the feasibility assessment of a new NMCA in the southern Strait of Georgia since 2004. The objective of the study is to determine

whether or not the proposed establishment of an NMCA is a practical and desirable thing to do and has the support of all levels of government, First Nations, stakeholders and the public. The study completed most of its technical analyses by 2007 and discussions have been ongoing between Canada and British Columbia with respect to the potential social, economic and administrative implications of establishing an NMCA in this region. In addition, it is recognized that a decision on NMCA feasibility is subject to further discussion and consultations with First Nations. This paper will provide an update on the current status of this proposal.

5B: Science and management of killer whales II

The killer whales of the Salish Sea are listed as threatened or endangered in both the U.S. and Canada. As the scientific and stewardship communities continue to weigh the costs and benefits of invasive methods like satellite tagging, there is a pressing need to exchange all available information from non-invasive research techniques. There are also renewed efforts on both sides of the border to integrate the management of killer whales and the listed species, like Chinook salmon, upon which they prey. 2011 has also brought Federal regulation of orca-boat interactions in the U.S. This session will survey recent scientific results, with an emphasis on less-invasive techniques and new implications for transboundary killer whale management.

Convener: Scott Veirs

PRR Facilitator: Kirsten Hauge

Rob Williams (12 minutes)

Oceans Initiative

Inextricably linked: boats, noise, Chinook salmon and killer whale recovery in the northeast Pacific

Rob Williams, Erin Ashe, Christopher W. Clark, Philip S. Hammond, David Lusseau

Abstract:

Resident killer whales in the northeast Pacific are threatened by acoustic disturbance from boats and low abundance of their preferred prey, Chinook salmon. Though often presented as mutually exclusive hypotheses about killer whale declines, our work shows that the factors are inextricably linked. The socio-ecological system consisting of killer whales, salmon and human activities forms an unusually data-rich opportunity to evaluate cumulative impact of multiple stressors on cetaceans. In waters under Canadian jurisdiction, critical habitat includes prey and acoustics as key habitat elements. Several vessel interaction studies on both populations have revealed short- and medium-term responses of whales to boats. Control-exposure, vessel-impact experiments elicited stereotyped evasive responses in which louder received levels elicited stronger responses. But these responses were context-specific, including reductions in time spent feeding, which may carry energetic consequences. Exposure to kayaks increased the likelihood of a whale to initiate travelling activities, but did not tend to disrupt feeding activities. Killer whales were more likely to respond to boats in years when Chinook salmon density was low. Thus, the factors of boat traffic and salmon availability are strongly linked, and the potential for synergistic effects is high. New bioenergetics models were constructed (using morphometric data and feeding records of 30 captive whales, body size data and activity budgets of wild killer whales) to estimate prey requirements of southern residents. Current ecosystem conditions provide limited ability to meet nutritional requirements of resident killer whale populations, let alone to allow for energetic cost of disturbance, masking effects of boat noise on foraging efficiency, or to allow for population recovery. Our 3-year study in which 12 autonomous hydrophones were placed from Haro Strait to northern BC found that in the frequency bands used by killer whales for social calls, ambient noise levels in critical habitats for northern and southern resident killer whales were higher than at any other site. Coupling the potential scope of acoustic masking with demonstrated disruption of feeding activities via behavioural disturbance, boat traffic and salmon recovery need to be managed as inherently linked factors in killer whale recovery. We have an opportunity to reduce noise levels in critical feeding habitats quickly through vessel regulations at the location of the whale and ship-quieting technologies for large, non-whale-oriented vessels, while we aggressively manage salmon fisheries and habitat to restore Chinook stocks in the medium term. Ideally, we will be consistent across species, and use killer whale management as a precautionary precedent to inform conservation of other acoustically sensitive species. Proposed critical habitat for humpback whales is currently much quieter than that of killer whales, but that this would change if oil tanker traffic were introduced. The characteristics of shipping noise means that humpback whale vocalizations are more vulnerable to acoustic masking than those of

killer whales, but current policies protect acoustic attributes of critical habitat of killer whales more than they do for humpback whales or other cetaceans.

Jason Wood (12 minutes)

SMRU Ltd.

Shipping noise and vocal compensation by Southern Resident Killer Whales: Do some ships have a larger impact?

Jason Wood, Peggy Foreman, Val Veirs, Scott Veirs

Abstract:

Southern Resident killer whales (SRKW) use acoustic signals to navigate, forage and facilitate social dynamics. Researchers have published evidence that suggests SRKW compensate for increased background noise by increasing the source level and duration of their signals. Unpublished reports have also suggested that SRKW may compensate for background noise by repeating their signals and by preferentially using certain signal types. Most of this work has focused on noise from whale watching vessels but ignored shipping noise.

Haro Strait is both the center of the summertime critical habitat of the SRKW and an important shipping channel. From September 2009 to December 2010 almost 10,000 ships transited through Haro Strait with an average of 21 ships passing per day. Ship transits in Haro Strait can increase background noise by up to 20 dB and are detectable above background noise for up to half an hour (and longer for tug boats). In addition, ships produce noise at different frequencies (pitch) depending on the design and speed of the ship. Applying a frequency weighting to these ship recordings (much as human occupational safety standards use frequency weighted noise measurements), we can make predictions about which ships will interfere more with SRKW vocalizations. We can then use measures of vocal compensation by SRKW to test the validity of these frequency weightings.

A five hydrophone array and Automatic Identification System receiver located at the Lime Kiln Lighthouse on San Juan Island, WA, were used to record passing ships and SRKW in Haro Strait. Results will be presented on vocal compensation of SRKW due to background noise levels, predictions of which ships will have the largest impacts based on frequency weightings, and tests of these predictions.

Jeffrey Dismukes (12 minutes)

Sysstat, Inc.

Quantification of average summer season marine vessel traffic in the San Juan Islands June 12 – September 7, 2010

Jeffrey Dismukes, Jonathan Riley, Greg Crenshaw

Abstract:

Waters surrounding the San Juan Islands, off the Northwest coast of Washington State, carry high levels of marine vessel traffic during summer season. In addition to forecasts for relatively good weather and calm seas, summer traffic spikes result from: 1) a plentiful sport and commercial fishery; 2) an extremely popular yachting and pleasure cruising environment featuring several nature parks accessible only by private boat; and, 3) the return of Orca pods and other marine mammals to inland water along with numerous water-fowl rookeries, providing very appealing on-water tourist attractions. This study builds upon results and aerial surveying methods from a pilot study in 2006. In addition to updating and expanding trend data, the current survey focused on vessel activity and usage patterns in and around an area along the western shore of San Juan Island proposed for restricted seasonal access in regulations from NOAA NMFS aimed at protecting the endangered Southern Resident Killer Whales from boater harassment. Randomly selected data sampling was stratified by weekend/holidays and weekdays, collected for 6 weekdays and 13 weekend/holidays. Vessels were counted and identified by 9 types: power, sail, paddle, cargo, commercial fishing, tour, skiff, recreational fishing, and reef netting. Results indicate an average total of 1118 vessels on water at any given daylight time for weekend/holidays and 893 for weekdays. A subset of the data, comparable to results from the August – September 2006 pilot study, indicate an average increase of 73 more

boats on water during weekend/holidays and 133 more during weekdays. Approximate point locations for each vessel type were plotted in a GIS and further identified as to status (moored/anchored or underway) and activity (undefined, fishing or whale watching). These point layers were further analyzed, yielding relative concentration gradients with highest concentrations of 55 boats per kilometer, same as reported from 2006. Vessel traffic in the proposed regulatory zone represented 2-3% of total traffic on average. While traffic within the zone represented a small proportion of total traffic, kayaks within the zone accounted for 26-29% of all kayaks on average. Kayaks were also the most prevalent vessel within the zone, making up 61% of the zonal traffic on average. Finally, the study also focused on identifying less expensive (land based) data collection methods. Although observers were posted at 4 locations along the western shore of San Juan Island and 1 location along San Juan Channel, we were unable to derive any reliable predictor variables for local or total traffic from ground based observation data. We conclude vessel traffic is too variable, clustered and mobile to be accurately predicted or monitored from random ground based sightings.

Deborah A. Giles (12 minutes)

University of California, Davis. Dept. of Wildlife, Fisheries, Conservation Biology

Using non-invasive remote sensing equipment and GIS to assess potential effects of vessels on Southern Resident killer whale behavior in the Salish Sea

Deborah A. Giles, Kari Koski, Rose Cendak, Nicholas Reseburg

Abstract:

Abstract:

A genetically isolated population of whales known as the Southern Resident Killer Whales (SRKW) gained international protection status when they were listed as endangered first under Canada's Species at Risk Act in 2003 and later under the United State's Endangered Species Act in 2005. Several cumulative risk factors were identified as contributing to the continuing decline of this small population including reductions in the quality and quantity of prey (salmon), exposure to persistent toxins, and disturbance from vessel presence and associated noise. The purpose of this study was to determine habitat utilization by these whales and to assess whether SRKW group behavior state (foraging, traveling, socializing and resting) changes in response to vessel density, distance and/or vessel operator activities. We utilized a remote sensing equipment package consisting of a GPS unit with a built-in data recorder to collect geographic position and attribute data, a laser rangefinder for distance, and a compass for bearing; these units were electronically connected to generate geo-referenced offset latitude/longitude points for whales and vessels. Our remote sensing equipment allowed for data collection at distances greater than established viewing distance guidelines and farther than whale-watching and private boaters, thus minimizing potential impacts from the research vessel and maximizing the quantity and quality of geographical, spatial, and behavioral data being recorded. We placed the data in a GIS for animation that allowed us to visualize habitat utilization and preliminary analysis indicates a change in whale group behavior state and spatial structure (cohesion) in the presence of low vs. high numbers of vessels. Further, analysis shows the whales are spending significantly less time resting during daylight hours when compared to research findings from past decades; reduced prey availability and increased vessel presence are being examined as potential causes of this behavioral shift over time. One frequently used geographic area, know as Kellett Bluff, was identified as being potentially significant to the whales; pending research will determine if the whales are using the steep rocky cliff as a rubbing site, if the whales are utilizing a specialized hunting strategy by using the rocky crevasses to trap salmon, or both. Findings may illustrate the need to create a conservation area for the SRKW within their designated critical habitat in the United States.

Andrea Buckman (12 minutes)

Department of Fisheries and Oceans

Variability in Chinook salmon condition and implications for resident killer whales

Andrea H. Buckman, Nik Veldhoen, Caren C. Helbing, Kristi Miller, John K.B.

Ford, Peter S. Ross

Abstract:

Chinook salmon (*Oncorhynchus tshawytscha*) represent a vital food resource for the southern resident killer whales (*Orcinus orca*). Reduced abundance of Chinook, along with high levels of environmental contaminants, and noise and disturbance, underlie the 'Endangered' status of southern residents in both Canada and the United States. With climate driving changes to salmon productivity in the Pacific Ocean, reduced quantity and/or quality of Chinook may have significant implications for resident killer whales. We used a combination of microarray and quantitative real-time polymerase chain reaction (QPCR) techniques to characterize alterations in gene mRNA transcripts in Chinook salmon with varying levels of lipid. As the primary energy form in killer whale prey, lipids are a crucial component of the nutritional quality of Chinook salmon. Our results reveal that 21 lipid metabolism and biosynthesis genes are associated with low lipid and caloric energy content in Chinook salmon. Further analyses using QPCR found a 1 - 2 fold change in gene expression of five nutrition-related genomic endpoints including fatty acid binding protein (FABP-1), apolipoprotein A1 (Apo-A1), fatty acid desaturase 2 (FADS-2), retinol-binding protein I (RBP-1), and adipose differentiation-related protein (ADRP) with a 50 percent decrease in lipid percent in Chinook. Genomic and nutritional measurements in killer whale prey provide a non-invasive tool to explore one of the major conservation threats to this endangered population. Results of these applications may be relevant for fisheries management practices as the protection of Chinook stocks is crucial for killer whale health and maintaining a healthy Salish Sea.

Lance Barrett-Lennard (12 minutes)

Vancouver Aquarium Marine Science Centre

Saving salmon for endangered killer whales: A new paradigm in wildlife management?

Abstract:

For centuries humans have used the following methods to control or manage wildlife: culling predators to protect livestock or reduce hunting competition; culling herbivores to protect crops, orchards or wild fruit; using domesticated predators (cats and dogs) to drive off other predators or reduce populations of rodents and other small mammals; and altering habitats with fire or other means to reduce undesirable species and/or promote desirable species. Over the last few hundred years, hunting and fishing reserves, and more recently, wilderness parks and other protected areas have been established to limit human hunting pressure and conserve wildlife habitat, and breeding and stocking programs have been implemented to actively increase the abundance of economically valuable game or fish. Even more recently, attention has turned to conserving endangered species by protecting habitat, augmented on occasion by captive breeding and translocation programs. One wildlife management measure rarely if ever used has been to limit human harvests of valuable species in order to conserve rare or endangered predators. This approach is about to be tested, however, due to recent research establishing the importance of Chinook salmon for endangered southern resident killer whales in the Salish Sea. These findings put the governments of both countries in the position of having to manage Chinook salmon fisheries in a way that ensures their availability for killer whales. I argue that three new considerations now need to be explicitly addressed in fishery plans: the timing of commercial and sport fishing efforts must allow for a continuous supply of fish for killer whales; fishing intensities, locations and practices must accommodate the needs and natural abilities of killer whales to find and hunt salmon; and the distribution of fishing effort must be distributed in a manner that allows conservation of a diversity of salmon runs. No-fishing zones may need to be established to allow killer whales the opportunity to hunt salmon without competition or disturbance from the fishing fleet. Implemented properly, these changes will ensure greater salmon returns for both whales and fishers, and will establish useful precedent for the conservation of other at-risk aquatic and terrestrial predators.

Larry Rutter (12 minutes)

NOAA Fisheries, National Marine Fisheries Service

A scientific workshop process to evaluate the effects of salmon fisheries on killer whales

Abstract:

Southern Resident Killer Whales (SRKWs) are listed as an endangered species under both the U.S. Endangered Species Act (ESA) and Canada's Species at Risk Act (SARA). NOAA Fisheries and Canada's Department of Fisheries and Oceans (DFO) both have developed Recovery Plans for the SRKWs per their respective laws that identify prey availability as one of the threats to the whales. Recent studies in both Canada and the U.S. show that the preferred prey of SRKW are Chinook salmon, particularly large Chinook salmon. Studies also show strong and positive correlations between the growth rate of the SRKW population and the abundance of Chinook salmon as represented by certain indicators of annual Chinook abundance produced by the Pacific Salmon Commission. The concern exists that salmon fisheries that harvest Chinook salmon are harming the SRKW by reducing their available prey. In connection with their respective legal responsibilities for listed species and in recognition of the transboundary nature of SRKW and salmon fisheries, NOAA and DFO are collaborating to identify, develop and evaluate the science relevant to this question. We have established an independent panel of scientific experts and are sponsoring a bilateral series of three scientific workshops in 2011 and 2012 (the first workshop will have occurred in September of 2011) to evaluate the pertinent science surrounding these issues. The panel will produce a report by the end of 2012 that will be used by NOAA and DFO to inform future fishery management decisions and identify means to reduce scientific uncertainties.

5C: Applying environmental indicators for ecosystem-based management

Efforts to assess the status and trends in the health of the Salish Sea have generated environmental indicators to communicate the key characteristics of ecosystem health and to support ecosystem-based management. The challenge now is to link environmental indicators with needed policy and management actions to improve ecosystem health and the subsequent performance measures of the effectiveness of these actions. This session presents case studies at various geographic scales to illustrate how environmental indicators are currently being applied for ecosystem-based management in the Salish Sea.

Conveners: Michael Rylko, Cecilia Wong, Ken Dzinbal, Sandie O'Neill, Ron Thom, Jennie Wang

PRR Facilitator: Rita Brogan

Nick Brown

SeaDoc Society, UC Davis Wildlife Health Center - Orcas Island Office

Species of Concern within the Salish Sea: Changes from 2002 to 2011

Nick Brown, Joseph K. Gaydos

Abstract:

Species of concern are native species, sub-species or ecologically significant units that warrant special attention to ensure their conservation. The number of species of concern within an ecosystem can be used as a crude measure of ecosystem health and it illustrates where cross-jurisdiction work is needed to recover declining species. Within the Salish Sea, four jurisdictions assess which species require special initiatives to ensure protection and survival of the population: the Province of British Columbia, the State of Washington, the Canadian Federal Government, and the United States Federal Government. As of January 1, 2011, one or more of these jurisdictions listed 113 species of concern. This is almost twice the 64 species identified on September 1, 2008 when this metric was last evaluated. This represents new listings and also reflects an increase in the number of birds and mammals known to use the Salish Sea for some part of their life history. Since 2008, 23 new additions were made to the list due to a recent listing by one or more jurisdiction and not because of an expanded understanding of species using the ecosystem. Newly listed species include 5 fish species and 18 bird species. The addition of 23 newly listed species represents the greatest jump in species of concern since this list was first established in 2002. This is good news in that it signifies that declining species are getting much needed attention through the listing process, but it also reinforces a downward trend in declining species in the region. In light of projected increased population growth, on-going habitat modifications and expected climate change, the number of species of concern for this ecosystem is likely to increase if listing efforts remain consistent for all four jurisdictions. Increased and improved bi-national efforts to recover declining populations of species and recover this ecosystem are urgently needed to stop the insidious loss of species and ecosystem decay.

Christy Pattengill-Semmens

Reef Environmental Education Foundation (REEF)

Patterns of fish biodiversity in the Salish Sea

Christy Pattengill-Semmens, Janna Nichols

Abstract:

Biogeographic and temporal patterns in community assembly can provide insights regarding the processes driving rocky reef fish diversity in the Salish Sea. However, relatively few sets of broadly distributed observations on marine fish assemblages exist in Salish Sea. The Reef Environmental Education Foundation (REEF) Survey Project was launched in the Pacific Northwest in 1998. REEF participants collect distribution and abundance data on all marine fishes and a sub-set of invertebrates using a standardized, non-point visual method. To date, over 700 divers have conducted 12,307 surveys at over 800 sites in Washington and British Columbia.

Using the REEF dataset, we examine patterns of species richness, co-occurrence, and abundance of nearshore rocky reef fishes throughout the Salish Sea. We explore community patterns in observational data from an array of sites using multivariate techniques. To yield inference regarding the relative roles of time and space in community variability, we formally test explanatory factors using PERMANOVA and PERMDISP. Results demonstrate how this regional monitoring effort can be used to generate multivariate ecosystem status metrics for the Salish Sea.

Paul Chittaro

NOAA

Suitability of somatic growth of English sole as an ecosystem indicator

Paul Chittaro, Bernadita Anulacion, Rich Zabel

Abstract:

Puget Sound is a large marine ecosystem to which state and federal agencies have initiated an ecosystem-scale management strategy in order to restore and maintain Puget Sound's valuable economic, natural, and cultural resources. A first step to achieving ecosystem-scale management is to identify relevant ecosystem indicators and establish the critical benchmarks for promoting and attaining health and effective restoration to the ecosystem. Here we investigated the suitability of using somatic growth of a common flatfish (English sole, *Parophrys vetulus*) as an indicator of the physical and chemical environment of the Puget Sound marine ecosystem. Specifically, we investigated how otolith-derived estimates of somatic growth from sites throughout Puget Sound vary with regards to environment (e.g., water temperature, salinity, and dissolved oxygen) and anthropogenic (e.g., exposure to chemical contaminants) factors. To further understand how somatic growth could act as an ecosystem indicator we determined how metabolism and consumption (estimated from a bioenergetics approach) vary under current and projected contaminant loads and climate change scenarios. This bioenergetics approach allowed for the determination of a threshold range of values, for environmental and anthropogenic factors, that would elicit a detectable response in somatic growth of English sole.

Brandon Sackmann

Washington State Department of Ecology

Matryoshka-based monitoring of Puget Sound: Characterizing water quality at multiple scales

Brandon Sackmann, Christopher Krembs, Tarang Khangaonkar

Abstract:

Marine waters of Puget Sound are an important natural resource for people living in Washington State. Eutrophication, harmful algal blooms, stormwater, and an increasing population are all factors that can adversely affect marine water quality. Conventional monitoring approaches have historically been developed to collect high-resolution data in a single dimension, i.e., X/Y, time, or depth. Due to the ephemeral nature, immense scale, and complexity of estuarine processes interpreting these data can be challenging without additional contextual information collected at larger spatio-temporal scales. A Matryoshka-based approach to marine monitoring is meant to evoke the image of Russian nesting dolls. The approach seeks to develop products that nest within one another to support analyses across a range of time and space scales. To help develop these products the Washington State Department of Ecology (WaECY) deployed a Turner Designs C3 fluorometer in a seachest system onboard the Victoria Clipper IV, a passenger ferry traveling daily between Seattle, Washington and Victoria, British Columbia. Since May 2010 the C3 has provided measurements of chlorophyll fluorescence, CDOM fluorescence, turbidity, and temperature. Ferry data are used in combination with data from the European Space Agency's MERIS ocean color satellite which provides estimates of chlorophyll, CDOM, and suspended sediment concentrations, as well as other indices of algal biomass. WaECY has developed methods to use data from this unique ferry-based monitoring program to validate satellite products and to complement its other marine monitoring activities

(ftp://www.ecy.wa.gov/eap/Flight_Blog/latest_pictures/April_2011_Eyes_Over_Puget_Sound.pdf). Ferry, satellite, and in situ monitoring data are also combined with daily forecasts from Pacific

Northwest National Laboratory's operational hydrographic model of Puget Sound. This allows WaECY to both validate model forecasts and quickly convey more comprehensive information to the public about evolving patterns of water quality and transport in Puget Sound. By combining disparate datasets and leveraging existing model and satellite technologies WaECY is developing a high quality time series of integrated data products, specific to conditions in our region. These products provide a cost-effective way to extend WaECY's monitoring capabilities and improve our ability to characterize and predict marine water quality throughout Puget Sound.

Margaret Dutch

Washington State Department of Ecology

Relating sediment quality indicators between ambient monitoring and regulatory programs for ecosystem-based management

Margaret Dutch, Valerie Partridge, Sandra Weakland, Kathy Welch, Ed Long

Abstract:

Salish Sea sediment quality has been assessed independently for both ambient monitoring and regulatory programs for decades with a broad spectrum of sediment quality parameters and indicators and at multiple geographic scales.

Through the Sediment Monitoring Component of the Puget Sound Assessment and Monitoring Program (PSAMP), a multi-parameter Sediment Quality Triad Index has been developed based on underlying indicators of sediment chemistry, toxicity, and community structure. For the past two decades, these indicators have been used to characterize sediment quality and look for changes over time at multiple, nested geographic scales, including: individual stations, urban bays, geographic regions, anthropogenic-use strata, and Puget Sound-wide. These indicators are currently used as Puget Sound Partnership Dashboard Indicators and for the Washington State Government Management Accountability and Performance (GMAP) process to characterize regional and bay-wide sediment quality throughout Puget Sound.

At the Puget Sound-wide and regional geographic scales, PSAMP sediment quality indicators paint a broad-brush portrait of high quality sediments supporting healthy bottom-dwelling communities. However, indicators summarized at the bay-scale identify sediment quality problems in these smaller, but ecologically important areas. Both positive and negative changes in sediment quality indicators at the bay-scale have been measured over time, suggesting a response to both human-influenced (e.g., source control of toxic contaminants, toxics cleanup activity) and naturally-occurring changes in these study areas.

Along a parallel, yet separate path, state and federal regulatory pollution control programs have worked for over three decades focused on individual sediment cleanup sites nested within urban bays. These programs work to painstakingly identify contaminated sediment sites and focus on adequate permitting, source control, and cleanup of sediments based on application of Washington State Sediment Management Standards. Sediment monitoring studies required at these regulatory sites have given an excellent snapshot of sediment condition and the effectiveness of cleanup efforts within site boundaries.

Until recently, sediment ambient monitoring and regulatory programs worked independently, with no direct links between their funding, activities or findings. In 2007, the Washington State Department of Ecology began its Urban Waters Initiative (UWI). This program renewed and focused source control, cleanup, and effectiveness monitoring efforts at sites in both Commencement Bay and Elliott Bay, and linked this work with a PSAMP ambient sediment monitoring program focused on these bays. Bay-scale monitoring for the UWI has since been expanded to six Puget Sound urban bays. Results generated to date are summarized briefly for this talk.

Combining the efforts of the sediment regulatory and ambient monitoring programs through the UWI has set the stage for better understanding the effects of the regulatory program source

control and cleanup efforts, including both improvement and decline in specific sediment quality indices, at the larger (i.e., bay-wide) geographic scale. Thoughtful interpretation of these results, and good communication between environmental managers and scientists guiding these two programs, needs to follow for continued effective development and implementation of regulations and management actions that lead to improvement in Puget Sound sediment quality over time.

Ken Pierce

Washington Department of Fish & Wildlife

Regional high resolution change detection in Puget Sound using 1-m aerial photography

Abstract:

The state of Washington acquired state-wide 1-m aerial imagery in 2006 and 2009. We developed a remote sensing workflow using image differencing, image segmentation, supervised classification of training data and machine learning techniques to automate high resolution change detection. During 2010 we mapped change in 3 large Water Resource Inventory Areas (WRIA) totaling 2 million acres. Due to the high degree of pixel-to-pixel variability we focused our analysis on areas of major vegetative loss such as tree and shrub clearing from forestry activities or construction/site preparation. Segmentation was used to convert the 8 billion pixels into 904,930 homogenous regions for identification. About 10,000 polygons were reviewed and identified for the three statistical models (one for each WRIA). The statistical models predicted 27,729 out of the 904,930 polygons to be change polygons. Of the predicted change polygons about 2/3 were actual change. Additionally 11,684 randomly selected polygons predicted as non-change were checked for omission errors. Of those 130 were found to be omissions. By area omissions accounted for about 0.4% of the reviewed area. Omission rates were used to estimate non-mapped change in addition to the mapped change identified in the model.

Mapped high-resolution change polygons can be used for numerous analyses including estimating change in riparian buffers, shoreline buffers and proportion of change in different management districts. The change mapped here is only that due to major vegetative loss, so the primary result is a loss in ecological services. Change due to redevelopment or pasture/grassland conversion is not well captured by the current techniques.

Since the method uses high-resolution imagery instead of mid-resolution satellite data, the assessment of actual change is generally human-verifiable from the imagery alone. This allows for comparison of imagery from different sources and reduces field expense. Custom software has been developed for the accuracy assessment steps providing easy transferability and transparency.

5D: Threat and risk assessments in the Salish Sea

One of the critical needs of management efforts such as the Puget Sound Partnership and others in the Salish Sea is to develop a reliable framework for connecting stressors to effects (hazards and risks) on ecosystem services. The utility of ecological and human health risk assessments to inform management decisions have been well demonstrated for site assessments conducted for clean-up projects, pesticide regulation and use, management of invasive species, and many other applications. These tools can be used across the Salish Sea to support management actions taking place across varying geographic scales, addressing the relative risks of different stressors, assessing the cumulative impacts of stressors and cumulative improvements of actions, and linking management actions to improvements to ecosystem services across the region. Risk assessments can be focused on specific watersheds, invasive species, critical ecosystem services, and system restoration efforts. A critical need in the region is to also understand the linkage between ecological risk and impacts to human health and overall welfare. This session focuses on frameworks, technical approaches, and case studies for conducting regional and watershed scale risk assessments to aid ecosystem protection and recovery.

Conveners: Wayne Landis, Peter Chapman, Robert Johnston

PRR Facilitator: Jamie Strausz-Clark

David Batker

Earth Economics

Flood risk reduction and ecosystem services in the Chehalis Basin

David Batker, Maya Kocian, Briana Lovell, Jennifer Harrison-Cox

Abstract:

Since 1970, the Chehalis River Basin in western Washington State has experienced seven catastrophic flood events. A storm in 2007 brought floods to Lewis County that caused an estimated \$166 million in damage to personal property, agricultural land, local businesses and transportation systems, such as Interstate 5. Understanding how flood risk reduction is provided within the Chehalis Basin is vital for making good private and public investment decisions.

To better inform flood risk reduction decisions for the basin, Earth Economics completed a study for the Chehalis River Basin Flood Authority in May 2010. The study identified and estimated the economic value of natural systems in the Chehalis River Basin using a benefit transfer methodology. The results indicate that the Chehalis Basin ecosystem provides an average of \$6.5 billion in economic benefits to citizens every year. One of these critical ecosystem services is flood risk reduction.

Earth Economics worked with the Gund Institute at the University of Vermont to use the newly developed Artificial Intelligence for Ecosystem Services (ARIES) tool, a web-based tool for ecosystem service mapping and modeling. Preliminary maps were generated to show where flood risk reduction and other ecosystem services are provisioned, who benefits from these ecosystem services, and how the service of flood risk reduction is transferred to beneficiaries. Importantly, the maps also identify where flood risk reduction and other ecosystem services are being impaired. For example, impervious surfaces or a badly situated levee can actively impair flood risk reduction in the watershed.

This was the first case study in the Chehalis basin to look at both gray and green infrastructure in a flood prone area.

Rebecca Martone

Institute for Resources, Environment and Sustainability, University of British Columbia

Cumulative impacts to coastal ecosystem services in British Columbia

Rebecca Martone, Allison Thompson, Gerald G. Singh, Kai M.A. Chan

Abstract:

Worldwide, coastal ecosystems are subject to multiple activities and stressors, making them some of the most widely used and heavily degraded ecosystems worldwide. To address this degradation and provide for the well-being of coastal communities, resource management must contend with cumulative human impacts on ecosystem services, or the ecosystem processes that benefit people. Despite the increase in popularity of the ecosystem services framework, there is little information available on the impacts of multiple human activities on ecosystem service provisioning. What is missing is a transparent, transferable method to explicitly consider impacts to and trade-offs among ecosystem services to inform managers so that they can set priorities and plan human activities spatially. Using data available from the literature, we developed spatially explicit mechanistic models of how several land-based activities—agriculture, forestry practices, and coastal development—can lead to shellfish harvest closures, highlighting trade-offs among ecosystem services along the British Columbia coast, including the Salish Sea. We demonstrate the utility of a mechanistic approach, providing managers the detailed understanding necessary for making informed decisions about activities that cross ecosystem boundaries, and clarifying how human activities link to the benefits derived from marine systems.

Joey Bernhardt

The Natural Capital Project, Stanford University

Ecological risk assessment to support marine spatial planning

Joey Bernhardt, Katie Arkema, Greg Guannel, Jodie Toft, Anne Guerry, Mary Ruckelshaus

Abstract:

Coastal oceans provide a number of important benefits to people. Despite their importance, the ecosystems processes on which people rely for food, protection from storms, recreation, and other services are poorly understood, scarcely monitored, and often only appreciated after they are lost. As anthropogenic stressors continue to intensify in coastal areas, so does the need for quick, transparent and repeatable ways of assessing the risks posed by a diversity of human activities to nearshore ecosystems.

Here we present a risk assessment model, part of a new decision-support tool called Marine InVEST (Integrated Valuation of Ecosystem Services and Trade-offs). InVEST allows users to map, model and value the flow of ecosystem services under various alternative future scenarios. The risk assessment model within InVEST is used to screen threats posed by current and future human activities in order to prioritize management strategies that best mitigate risk and support the continued delivery of valuable ecosystem services. We build on previous attempts to assess human impacts on marine ecosystems by developing a framework that allows users to assess a diversity of stressors (vs. single sector fisheries approaches) using the best available peer-reviewed and grey literature (vs. expert opinion) in a flexible and repeatable way. We also include an explicit visualization of data uncertainty, which facilitates analyses in both data-rich and data-poor contexts. Risk is a function of an ecosystem's exposure to stressors (driven primarily by management) and the consequence of exposure (driven by ecosystem resistance and recovery potential). When run as part of a complete InVEST analysis, the spatially explicit risk assessment model allows users to evaluate how management strategies are likely to change the flow of a range of ecosystem services by modifying threats to nearshore ecosystems. The model can help users identify areas on the seascape that are suitable for conservation as well as expansion of human uses. We will illustrate how this type of analysis can be used to support marine spatial planning on Vancouver Island, BC and ecosystem-based management in Puget Sound.

Kyle Loring

Friends of the San Juans

Regulatory threats to marine ecosystems: Systemic pressures to elevate compensation over protection

Kyle Loring, Sandy Wyllie-Echeverria

Abstract:

Compensatory mitigation is often economically, socially, and politically more attractive than protecting shoreline resources upfront and can, therefore, receive a disproportionate amount of the effort focused on the health of important marine resources. The immediately visible economic benefits of compensation outweigh those for protection, which are often more attenuated. For example, approval of shoreline development likely to cause impacts will create jobs for both the initial construction of the project and its subsequent mitigation. Socially, there is the pressure to allow newcomers the opportunity to develop just as earlier landowners had. Applicants state that it would be inequitable to prevent them the same opportunity as that enjoyed by similarly situated precursors, and the use of mitigation to compensate for new impacts offers the appearance of responding to those concerns while at the same time permitting impacts. Lastly, the political climate strongly encourages selection of compensation over protection.

Regulators may find it difficult to deny an application submitted by a “client,” when the natural resource clients themselves (i.e., the resource impacted) have no voice. In addition, decades of permitting inertia and a permissive system may lead regulators to believe that they do not have the authority to deny an application, regardless of its potential impact on public resources. Thus, compensatory mitigation offers the ostensible misconception that we can have our cake and eat it too. Given the seductive call of compensation, how do we implement real resource protection in Washington, and throughout the Salish Sea?

Jeffrey Stern

King County Dept. Natural Resources and Parks

Sediment cleanup – Basin-scale risk assessment used to assess effectiveness of the current process

Abstract:

The current process for large scale sediment cleanup, the type needed to achieve any significant reduction of ecological and human health risks from this stressor, typically takes over 10 years per site, creates large impacts to the ecosystem that affect our overall welfare, and provides marginal human health risk reduction. Taking results from individual site assessments and evaluations of remedy impacts and effectiveness, and applying that to a Puget Sound-wide geographic scale risk assessment, the timing and magnitude of risk reduction can be demonstrated and the improvement to ecosystem services can be quantified. The relative reduction of risks from these stressors can then be prioritized against other management actions to address other stressors to improve our ability to maximize improvements to ecosystem services across the region in the timeliest manner. They can also be used at this scale to assess sustainability and regional impacts of remedial choices. The information is used to identify other innovative approaches to sediment cleanup process that could improve on the timing and magnitude of risk reductions at the broader geographic scale. By accepting the tenet that there will always be uncertainty in the level of understanding how remedies will respond in these complex systems, a fundamentally different approach to sediment remediation that is significantly faster becomes possible. The difference in effectiveness can be demonstrated by basin scale risk assessment. Under this new approach, other large scale remedy possibilities that could improve timing or magnitude of risk reduction, while having less impact on overall welfare are explored.

April Markiewicz

Western Washington University

Assessing ecological threats/risks at a basin scale to Puget Sound using the relative risk method
April Markiewicz, Wayne G. Landis

Abstract:

One of the long-standing issues with the management of Puget Sound and the Salish Sea basins is the lack of a comprehensive estimate of the risks or threats to the valued ecosystem services they provide. Assessments are typically based on only a few endpoints and stressors at limited spatial/temporal scales. Contaminants, habitat loss, disease, landscape change, climatic events

all potentially affect valued ecosystem services. These services are represented by the Targets and Dashboard indicators being adopted by the Puget Sound Partnership in association with stakeholder and agency input for the Puget Sound region. At smaller regional scales the ecological services are represented by specific management goals such as those recently established for the Cherry Point Marine Reserve by the Department of Natural Resources. A comprehensive approach is required to connect cause-effect relationships and such an approach is the relative risk model (RRM). The RRM has been used within the North Sound region and across the globe to examine the risks to watersheds and marine environments. The Cherry Point reach in Whatcom County has been examined for risks due to industrial activity, shipping, contaminants and invasive species. A current development of the RRM has been the application of Bayesian networks (BNs) to describe the cause-effect pathways of mercury contamination in a large riverine watershed. BNs have several characteristics that are advantageous in estimating risk in these types of assessments. They are able to integrate quantitative data and expert judgment describing the inherent uncertainty of each input. The output is a set of distributions, innately demonstrating the range of outcomes and the probability of each. It is also possible with a completed model to set management goals and back-calculate the necessary inputs to reach those goals. We have found this approach successful in calculating the threat to an eastern Oregon forest and to cutthroat trout from whirling disease in the Southwestern United States. We will demonstrate the RRM and the use of BNs in calculating risk using the Cherry Point reach and the North Sound management area as examples. The approach should be applicable across the Salish Sea region.

5E: Shorelines II: Local & regional management tools and issues

The session explores Salish Sea shoreline management through the lens of science, policy, management, and development design. Topics include:

- Management strategies adopted by local and regional jurisdictions (i.e., cities, counties, provinces) for shoreline protection and rehabilitation. This may include the implementation of Shoreline Master Programs, the regulatory approach in British Columbia, the concept of no net loss of ecological function, and incentive programs to encourage adoption of lower impact shoreline development.
- New research on nearshore ecology, including the backshore ecotone; describing small-scale restoration and monitoring strategies; and exploring how this information might intersect with management and design alternatives in the nearshore.
- Development approaches to enhance shoreline sustainability in the Salish Sea that have been, or will be implemented along freshwater and marine shorelines. The focus is on projects at the parcel or park scale (public, private and First Nations), which conserve, restore or enhance physical and biological processes on altered shorelines through designs developed with ecosystem function in mind.

The session covers the research, policies, design solutions, and incentives relevant to shoreline ecosystems on a scale of interest to local jurisdictions. It provides a forum for discussing restoration strategies and results from recent restoration projects; identifying gaps in knowledge and industry preparedness in the implementation of traditional and innovative restoration activities; and discussing the role of backshore and nearshore protection and restoration projects in overall improvements in shoreline habitats and function. It serves as a platform for the exchange of ideas between participating coastal professionals.

Conveners: Erica Guttman, Katrina Hoffman, Andrew James, Joel Baker, Brian Emmett
PRR Facilitator: Hadley Rodero

Moderator:
Katrina Hoffman
University of Washington

Kathy Taylor
Washington State Department of Ecology
Informing shoreline and marine planning and management through the Washington Coastal Atlas
Kathy Taylor, Darby Veeck, Liz O'Dea, Deborah Purce, Tammy Pelletier

Abstract:

The Washington Coastal Atlas¹ provides geographically explicit information to support informed management of Puget Sound and the coast of Washington, including coastal and marine spatial planning. This web-based atlas is currently used by local and Tribal governments, state and federal planners and resource managers, researchers, consultants, and interested citizens. Newly redeveloped to meet additional user needs, it features an improved user interface designed to be easily accessible by a diverse audience and the addition of important new data sets including 1) places the public can access beaches in Washington State where much of this land is privately owned, 2) new digital FEMA flood maps, and 3) beach closure and water quality information. These new improvements add to the information that has been historically available on the atlas such as: habitat features (e.g. wetlands and eelgrass), physical features (e.g. drift cells and slope stability), regulated features (e.g. flood zones), shoreline modifications (e.g. piers and docks) and jurisdictional delineations (e.g. cities and watersheds). The atlas also includes decades of oblique aerial photos which can be used to view current and historic shoreline

features such as level of development and presence of any shoreline modifications. In addition, the Atlas provides information on land cover changes over time using NOAA Coastal Change Analysis Program data. Furthermore, the work on the Washington Coastal Atlas includes coordination with other coastal atlas applications on the west coast², and participating in the International Coastal Atlas Network (ICAN) to collaborate and share data.

http://www.ecy.wa.gov/programs/sea/sma/atlas_home.html

<http://ican.science.oregonstate.edu/westcoast/>

Michelle Gaudry

BIEAP-FREMP

Burrard Inlet Habitat Inventory

Abstract:

Established in 1991, the Burrard Inlet Environmental Action Program (BIEAP) is an intergovernmental partnership that coordinates the environmental management of Burrard Inlet. BIEAP partners include: Environment Canada, Fisheries and Oceans Canada, Transport Canada, BC Ministry of Environment, Metro Vancouver and Port Metro Vancouver.

BIEAP focuses the resources of all partners on a management framework that coordinates activities intended to protect and improve the environmental quality of the present-day Burrard Inlet, within the context of sustainability.

The Burrard Inlet ecosystem is home to an abundance of fish and wildlife. The mountain streams feeding the inlet provide essential nursery habitat for juvenile salmon and the watershed as a whole acts as a significant fish migration corridor annually for millions of Pacific salmon returning to the Capilano, Seymour and Indian Rivers.

Along the muddy or rocky shorelines, numerous species of resident waterfowl are often sighted feeding and roosting. The Burrard Inlet is internationally recognized as an Important Bird Area, attracting tens of thousands of migratory birds along the Pacific Flyway each year.

To measure status and trends in marine habitat, BIEAP has recently developed a new environmental indicator Shoreline Change Over Time. Measuring shoreline change can help determine the impacts of development on fish and wildlife habitat. This information will support the implementation of policies and mitigation measures to prevent further loss of intertidal habitat and improve overall ecosystem health.

In 2009, BIEAP surveyed the entire foreshore of the inlet from Point Atkinson to Point Grey (excluding Indian Arm) by foot and/or boat to establish a baseline for future monitoring. Areas displaying characteristics that may inhibit or encourage development of fish or wildlife habitat were also identified and included.

Using this data, a comprehensive Geographic Information System (GIS) was developed classifying intertidal vegetation and substrate. The entire shoreline was also recorded by video and can be viewed by clicking on GPS points in the online GIS.

http://www.cmNBC.ca/atlas_gallery/bieap-frempe-atlas

A final report summarizing findings and their implications for fish and wildlife habitat is now available to the public and provides important information regarding environmental quality and trends in the inlet.

The GIS portion of this project is only the beginning of a community based mapping system. BIEAP's vision is to foster continued growth and improvement of the central database through collaboration with stewardship groups and partnerships dedicated to protecting the environmental

quality of Burrard Inlet.

Tina Whitman

Friends of the San Juans

Shoreline restoration in the San Juan Archipelago: Addressing cumulative impacts

Tina Whitman, James Slocomb

Abstract:

With over 400 miles of shoreline located at the confluence of Puget Sound, Georgia Strait and the Strait of Juan de Fuca, the nearshore marine habitats of San Juan County play a critical role in the regional ecosystem of the Salish Sea. Shore modifications, almost without exception, impact the ecological functioning of nearshore coastal systems and the proliferation of these structures has been viewed as one of the greatest threats. The majority of shoreline development activity in San Juan County occurs through incremental single-family development and individual shoreline alterations. The magnitude of these impacts may only become evident cumulatively over time. Without a complete inventory of existing shoreline modifications, it is not possible to understand the extent of the problem, evaluate cumulative impacts, identify priority restoration projects, or reduce future impacts.

In 2009, Friends of the San Juans conducted a boat-based inventory of shoreline modifications for all 400+ miles of marine shoreline within San Juan County. Modifications mapped included: Armoring; Docks; Marinas/Jetties/Breakwaters; Improved Boat Ramps; Marine Railways; Groins; Moorings and Floats; Pilings and Other. Data collected included: location, georeferenced digital photos; and information on modification type, material, size, condition, design and tidal elevation. Nearly 4,000 modifications were mapped. Results show that the vast majority of impacts are associated with residential shoreline development.

Key findings:

1. Current shoreline impact level in San Juan County is greater than previously believed, and comparable with other rural Puget Sound Counties;
2. Impacts are concentrated on non rocky 'soft' shorelines, which comprise just 20% of the county's shorelines
3. Significant restoration opportunities exist, with many degraded, outdated or unnecessary shoreline structures; and
4. Significant protection challenges lie ahead. Despite the fact that approximately half of the shoreline tax parcels within San Juan County have not yet been developed with a residence, 40% of shoreline parcels already have a shoreline modification.

Modification inventory results are being applied to landscape scale planning processes including the Critical Areas Ordinance, Shoreline Master Program, and Salmon Recovery strategic planning efforts. In addition, shoreline modifications were ranked for restoration based on a combination of physical feasibility of removal and habitat benefit factors. Feasibility factors included structure condition, distance to a primary structure, fetch, aspect, condition of adjacent shores and location in a drift cell. Habitat benefit of removal was ranked using a combination of structure size and toe elevation as well as proximity to priority habitats and species such as forage fish spawning beaches, feeder bluffs, submerged aquatic vegetation, wetlands, stream and documented juvenile salmon presence.

Modification removal restoration ranking results were then applied to a targeted awareness campaign with landowners of top priority sites. Landowners received personal letters with site specific information, maps and photographs, as well an invitation for free technical site consultations. In addition, all owners of degraded structures received information on priority

habitats and species, structure impact information and best practices to consider when planning to repair or replace their particular type structure. Friends of the San Juans has secured a small amount of funding for follow-up site visits, feasibility studies and preliminary designs at priority sites with interested landowners. Project presentation will highlight lessons learned and application of results from inventory, restoration ranking, and landowner cultivation project components.

Brian Emmett

Archipelago Marine Research Ltd.

Green Shores for Homes – Incentivizing low impact shoreline development

Brian Emmett, Margaret Glowacki, Katrina Hoffman

Abstract:

Ecosystem service values of freshwater and marine shorelines are higher than most other property types¹. Despite increased regulatory initiatives in British Columbia and Washington, the cumulative effects of shore development continues to affect ecosystem function through impacts to water quality, coastal processes, and fish habitat. Local governments have significant responsibility for permitting shoreline development yet often lack the critical resources required to address sustainable approaches to shore development.

In 2010, the U.S. Environmental Protection Agency awarded the City of Seattle a four year grant to research incentives for removing bulkheads and improving the ecological function of residential shorelines along Lake Washington. The Green Shores for Homes program will build on Seattle's existing Green Shorelines guidelines

http://www.seattle.gov/dpd/Planning/Green_Shorelines/Overview/ by developing and testing incentives to protect and improve ecosystem function along shorelines of single-family waterfront homes. Key elements of the program are (A) development of a biophysical framework to describe shoreline characteristics and identify local case examples; (B) development of a Green Shores for Homes credit system based on the existing Green Shores for Coastal Development Rating System (CDRS) developed by the Stewardship Centre of British Columbia (www.greenshores.ca and www.stewardshipcentre.bc.ca)²; (C) assessment of local incentives for property owners targeted to meet specific credit thresholds and (D) development of a training program for local Green Shores for Homes credit assessors, who will conduct property assessments to determine credit whether a property meets a specific credit threshold.

The Green Shores for Homes program will be pilot tested on Lake Washington, in San Juan County and the BC Gulf Islands. Implementing Green Shores for Homes simultaneously in British Columbia and Washington as well as in urban freshwater and rural marine shorelines will provide models for other jurisdictions within the Salish Sea to protect shoreline ecological function from future impacts of growth.

This presentation will review the objectives and framework for the Green Shores for Homes program and provide a status report on progress to date.

James Redford & Brian Chatwin

Chatwin Engineering Ltd.

Nanoose First Nation Green Shore Project

Abstract:

The Nanoose First Nation Green Shore Project restored 300m of eroding shoreline in Nanoose BC. The project site fronts the Snaw'naw'as First Nation campground in Nanoose BC. In December 2005, large storm events and high tides resulted in a greater than normal rate of erosion exposing a newly installed sanitary outfall pipe on the shore. Historical records showed that approximately 13m of shoreline had eroded since the original survey in 1878. Reconstruction of the shoreline included reclaiming the 1878 high tide line, placement of beach gravels at a 10:1 slope, construction of a 300m long coastal berm vegetated with salt tolerant vegetation and installation of a 5m wide, 300m long vegetated buffer behind the berm. The project won the

Nanaimo Chamber of Commerce Sterling Award for Environmental Sustainability and was one of three projects in BC nominated by APEG BC for Environmental Design. The PowerPoint presentation will show the site before construction, during construction and one and two years post construction. A brief discussion of the success of the project concludes the presentation. A detailed description of the project can be found on the following Green Shores website link.

http://files.greenshores.ca/example_gallery/NANOOSE_SHORELINE_PROTECTION_PROJECT_BE.pdf

Ginger Shoemaker

Washington DNR

Managing ecosystems, not leases

Carol Cloen, Ginger Shoemaker

Abstract:

The Washington Department of Natural Resources manages over 94 percent of the marine and estuarine waters in Washington State, with the agency mandated to balance environmental stewardship with commerce and public use. Until recently, agency staff had very little common understanding of what that balance looked like, how it was to be achieved, or what factors should drive decisions related to the appropriateness of a use. As a result, decisions related to siting and the construction of new uses of state-land were frequently deferred to regulatory entities and the project's proponent. Research undertaken as part of the development of the Aquatic Lands Habitat Conservation Plan has begun moving the agency toward more active stewardship of aquatic habitats, providing guidance for site-specific criteria, measures for avoidance and minimization of impacts to submerged habitats, and focusing the state's efforts to protect sensitive nearshore habitats.

This presentation will focus on implementation of stewardship efforts, strategic elements of the work, and the evolving cultural elements of the shift from managing leases to managing ecosystems.

5F: Building towards a better informed Salish Sea constituency through education and outreach I

Public awareness of the Salish Sea occurs through many paths, including both formal and informal educational settings. The purpose of this session is to provide a venue for all who have conducted, or wish to learn about, successful engagement and public education programs. These could be formal educational approaches that range from elementary to graduate school, or through informal education settings such as place-based hands-on learning experiences in the field, at informal science education (ISE) facilities (e.g., aquarium or science center), or at a public policy forum (e.g., presentations to legislators and/or committees). A recent trend toward place-based education in both formal and informal settings underscores the importance of developing Salish Sea-based approaches to teaching and communicating science. Strategies that are novel or unique are especially encouraged, as are discussions of techniques for evaluating the effectiveness of outreach and educational programs. It is our vision that session participants will gain a renewed appreciation for the value of communicating Salish Sea science, policy, conservation, and restoration to many audiences among multiple venues – and will leave with ideas and tools for planning, implementing and evaluating effective approaches for doing so.

Conveners: Jude Apple, Fritz Stahr, Rick Searle

PRR Facilitator: Mike Rosen

Penelope Dalton

Washington Sea Grant

Use of outreach and education programs in Salish Sea conservation

Penelope Dalton, Pete Granger, Raechel Waters

Abstract:

Outreach and education programs can offer innovative and effective approaches for reaching conservation goals. Using specific examples from Washington Sea Grant, the presentation will examine diverse outreach and education approaches used in:

- Building support for scientific research to guide environmental management;
- Reducing impacts of human activities on the marine environment;
- Encouraging sustainable marine uses and reduce conflicts;
- Engaging the public in marine conservation and restoration; and
- Strengthening ocean literacy and workforce capability.

Based at the University of Washington, Washington Sea Grant (WSG) supports research, provides technical assistance, marine education and outreach, and translates university science to serve those who manage and use the Salish Sea. WSG field staff work with the public on practical ways to reduce toxic pollution, restore habitat, promote eco-friendly businesses and reduce impacts on Puget Sound. The presentation will highlight the role of scientific and technical expertise in building successful programs, as well as development of partnerships and engagement of stakeholders. Programs covered will include Sound Science, Bivalves for Clean Water, NOAA Science Camp, and the Boater Pumpout Campaign.

Sarah Bernstein

University of Washington Friday Harbor Laboratories

Environmental outreach in the San Juan Islands

Abstract:

The Puget Sound Partnership's Action Agenda calls for the restoration of the Greater Puget Sound by the year 2020. In order for restoration attempts to succeed, the public needs to be involved and invested in the change. Educational outreach should be the first step in creating an educated, concerned and understanding public. This presentation will focus on an assortment of outreach programs designed by a team from the University of Washington Friday Harbor Laboratories, with support from the Puget Sound Partnership. Underwater videos, data simulation, graphic novels and storyboards are some of the ways in which this team has attempted to increase public awareness on issues relevant to the local marine environment. For example, Washington State Ferries showcased a series of educational video clips which presented underwater images to the public, and a survey was administered asking residents what they believed to be threats to the health of the Puget Sound. The survey offered a clearer understanding of public perception in regards to local environmental issues. This presentation will discuss various methods of public outreach and environmental education pertaining to the San Juan Archipelago.

Raechel Waters

Washington Sea Grant

Building capacity in effective outreach and education: The Communicating Ocean Sciences Program

Raechel Waters, Tansy Clay, Jude Apple, Shawn Rowe

Abstract:

Engaging scientists with K-12 and public audiences is essential for broadening ocean literacy, yet experience in effective outreach and education strategies is frequently missing from the training of undergraduate and graduate students studying the sciences. The Communicating Ocean Sciences (COS) and Communicating Ocean Sciences to Informal Audiences (COSIA) programs, developed by Center of Ocean Sciences Education Excellence – California (COSEE CA), Lawrence Hall of Science, and UC Berkeley, focus on two target audiences engaged in outreach and public education: university undergraduate and graduate students majoring in environmental, earth, marine and life sciences and educators working in both formal and informal science settings. For graduate and undergraduate students, the program structure includes weekly seminars where university students gain background in current education theory and practice, and a practicum where they present hands-on lessons in an elementary school classroom or “on the floor” at a local informal science education institute (ISEI). Program goals are to introduce scientists to the importance of public outreach and how their research can have “broader impacts” in their community; to introduce diverse university science students to possible careers in formal and informal science education; and to provide significant ocean sciences instruction and college-age role-models for K-12 students and ISEI visitors. The COS and COSIA programs have also been modified for use outside of the university course format, including disseminating content in short workshops for university faculty, informal educators, pre-service teachers, and citizen scientists. This program serves as a model for how universities and formal and informal educational institutions can partner to enhance environmental education. We will present an overview of program implementation at the University of Washington, Western Washington University and Oregon State University, including details of partnership development strategies, mechanisms for promoting future partnerships, our dissemination models, and results from preliminary research on program effectiveness. Findings from local evaluations will be put into the context of an evaluation of COSIA and COS impacts for undergraduate and graduate students nationwide. Findings indicate that COSIA and COS experiences impact future scientists’ perspectives on outreach, influence university scientists’ undergraduate teaching practices, and impact educators’ understanding of inquiry-based science teaching practices in both formal and informal contexts.

Carrie Tzou & Blakely Tsurusaki

University of Washington Bothell

My place in Puget Sound: Connecting ocean science and everyday expertise in a high school curriculum

Carrie Tzou, Amanda Bruner, Tansy Clay, Blakely Tsurusaki

Abstract:

Education research has shown that K-12 students have difficulty processing and will “shut down” in response to overwhelming news about the environment. Educators who relate education to students’ sense of place advocate for helping students form personal connections to the environment that will inspire and empower them towards environmental conservation. In this session, SoundCitizen, COSEE-OLC, and the University of Washington’s Institute for Science and Math Education will present findings on My Place in Puget Sound, a curriculum that engages students with contemporary environmental science research to understand how human land-use and personal practices affect the presence of pollutants in local waters. This curriculum uses culturally responsive strategies to connect to students’ sense of place, encourage students’ sense of empowerment, and motivate students to take community action. Many existing environmental education programs prescribe specific actions and emphasize overwhelming environmental messages. In contrast, the goal of My Place in Puget Sound is to develop strategies to empower students to critically assess available information to make decisions that are informed by science but also take into consideration their cultural practices and values. My Place in Puget Sound leverages SoundCitizen research, which focuses on a series of natural and man-made chemicals that are in common use in or around households. By focusing on these chemicals, students can interact with authentic scientific data, connect their daily practices with the chemistry of Puget Sound, and identify with the scientific enterprise through discovery of the unknown in complex systems.

My Place in Puget Sound connects environmental science to students’ everyday practices through several pedagogical strategies. For example, students think critically about how pollutants are travelling into Puget Sound by interpreting local maps with visual representations of scientific data, and by generating maps of watersheds in their neighborhoods that include personally relevant locations and activities. Another strategy we use to connect the science students are learning to places and practices that are relevant to their culture and identities is to ask students to self-document their practices through journaling or photographs. The culmination of the curriculum is a community action project carried out by students and shared with scientists, students and educators at a poster session at the University of Washington. Our curriculum supports students in being critical thinkers rather than promoting specific behaviors.

This curriculum has been enacted over two years by four teachers in a large urban school district in the Pacific Northwest and has reached approximately 500 students, over 50% of whom are from groups historically underrepresented in STEM fields. Initial results indicate that through participation in this curriculum students gained a better understanding of the connection between their actions and the health of Puget Sound and strongly demonstrated a sense of personal relevance of the curriculum to their lives. There was also a significant increase in students’ sense of responsibility to work for the health of the oceans and coastal areas.

Natasha Ewing

Ocean Networks Canada Centre for Enterprise & Engagement
Using real-time data from the Salish Sea for ocean education
Natasha Ewing, Krista Zala, Rick Searle

Abstract:

Ocean Networks Canada Observatory, comprised of VENUS and NEPTUNE Canada undersea cabled networks, supports transformative science in coastal and deep sea ecosystems. For the purpose of this conference we will be focusing on VENUS (www.venus.uvic.ca), the coastal network in the Salish Sea, specifically in the Strait of Georgia and Saanich Inlet.

VENUS enables real-time interactive experiments focused on ocean health, natural hazards, and marine conservation. Saanich Inlet is a naturally hypoxic estuary that undergoes an annual oxygen renewal, offering excellent conditions to research the effect of low oxygen on ocean

health and marine species. Extensive natural hazard research is ongoing at the Fraser River Delta, specifically with regards to sediment dynamics and slope stability. VENUS also enables marine mammal communication and conservation research through hydrophone technology amid the heavy marine traffic in the Strait of Georgia.

Undersea data is collected in real-time, including continuous temperature, salinity, oxygen, density, pressure, and carbon dioxide data, video footage and acoustic clips. Data is considered real-time as it is streamed online within seconds of being collected and is available 24/7. Real-time data provides a unique opportunity for the education system, allowing students to increase ocean literacy in an engaging and authentic way.

Ocean Networks Canada (ONC) conducted an online survey last fall to determine the quantity and quality of marine science content within BC curriculum and the feasibility of incorporating real-time data into lesson plans. Our results clearly indicated that educators believe that marine science education is a realistic and worthy pursuit, but request additional resources and training to do so. It was also apparent that educating students about the ocean became less important the further away from the ocean students and teachers lived.

To overcome the challenges of teaching marine science, ONC has partnered with local and national organizations and institutes to develop resources, coordinate educator workshops and increase students interest in marine science. Our main strategy to achieve this is by providing marine science content, resources and expertise to organizations and front-line educators that have the means to distribute information to students and the general public. ONC has partnered with Let's Talk Science, providing content for their CurioCity website, contributing marine science activities to their classroom kits and coordinating an Ocean Science Symposium for high school students at the University of Victoria. ONC has also supported and educated Pearson College students in collecting oceanographic data in the field during a 1200km kayak expedition along BC's Coast.

ONC's undersea networks offer teachers and students an exceptional educational opportunity: authentic data, engaging science and a dynamic learning experience.

Jude Apple

Shannon Point Marine Center (WWU) / Northwest Indian College

Sense of place and perspective: Native and western approaches to marine science education

Jude Apple, Joel Green, Steve Pavlik; Northwest Indian College

Abstract:

Indigenous understanding of the natural world (i.e. Native science) and European-based approaches to science and technology (i.e. Western science) provide valuable means of making sense – through observation and deduction – of natural phenomena and patterns. These different approaches and perspectives frequently complement one another in advancing our understanding of the natural world (e.g. impacts of climate change on natural systems, environmental degradation), yet there are also critical areas in which these perspectives on interpreting and understanding natural phenomena differ. It is critical for students, educators, and scientists alike to recognize and accommodate these distinctions as they engage in marine science education and research. This is particularly important for Western-identified scientists collaborating with Native communities and/or Tribal Colleges. As part an NSF-funded marine geoscience project and ongoing research collaboration between Western Washington University and Northwest Indian College, we have been exploring strategies for bringing together Native and Western science for a more effective integration of these into coursework and research objectives. Our presentation will offer examples of integrating these perspectives in marine science courses and provide insight for enhancing the cultural competency of scientists engaged in research and education with Native communities and Tribal colleges.

11:30 am - 2:00 pm

Lunch and Coast Salish Plenary Panel: "Working together for the Salish Sea"

The Coast Salish Western Washington Tribes and British Columbia First Nations will share insights into aspects of decision-making by aboriginal governments and the relationship between culture and decision-making as it pertains to science, policy, and social issues connected to the Salish Sea biome. Panelists will explore the significance of working together and embracing the elements of knowledge, culture, and respect as tools to support our collective work.

Coast Salish Gathering Steering Committee Leadership:

- Chief Ian Campbell, Squamish Nation
- Chief Bill Williams, Squamish Nation
- Ray Harris, Co Chair, First Nations Summit, Chemainus First Nation
- Councillor Jeffery Point, Skowkale First Nation
- Chief Dalton Silver, Sumas Nation
- Chairman Brian Cladoosby, Swinomish Indian Tribal Community
- Patti Gobin, Chairman's Office, Tulalip Tribes

2:30 pm - 4:00 pm

6A: Stormwater: Science and management I - Recent findings

Stormwater has center stage in the Salish Sea region. This session explores efforts underway to understand and address pollution and flow impacts, retrofit large untreated areas of nonpoint source runoff and engage the public in site-scale solutions. Talks will also cover the newest stormwater research, especially toxic loading studies; and new coordinated regional monitoring and other efforts to engage expertise across the region to accelerate progress towards solutions.

Conveners: Joan Lee, Erica Guttman, Bob Simmons, Heather Trim

PRR Facilitator: Kimbra Wellock

John Lenth

Herrera Environmental Consultants

Toxics chemical loadings in surface runoff to Puget Sound

John Lenth, Dylan Ahearn, Mindy Roberts

Abstract:

Since 2006, the Washington Department of Ecology (Ecology) has been conducting a series of studies to quantify the amount and to identify the primary sources of toxic chemicals in the Puget Sound ecosystem. One component of this evaluation was to estimate toxic chemical loads in surface runoff from a variety of land uses. Final loading estimates were based on actual monitoring that occurred in the Snohomish and Puyallup watersheds between August 2009 and July 2010. Surface-runoff samples were collected from eight streams in the Snohomish River watershed, and eight streams in the Puyallup River watershed. Two streams within each watershed were selected to characterize runoff from one of the following land uses: commercial/industrial, residential, agricultural, and forest/field/other (forest). Each stream was sampled six times during storm events and twice during baseflow periods. The study also recorded continuous flows in each stream over the 12-month monitoring period. Samples were analyzed for a broad range of toxic chemicals, using methods that yielded significantly lower detection limits than have been typically reported in previous studies.

The study confirmed several land use- and event-based patterns in the concentration data and load estimates for toxic chemicals in surface runoff to Puget Sound:

- Toxic chemicals were detected more frequently and at higher levels during storm events compared with baseflow (between storms).
- Contaminants were generally detected more frequently and at higher concentrations in the commercial/industrial basins compared to the other land uses.
- Agricultural and residential stormwater also contained higher concentrations of many toxic chemicals than stormwater from forested lands.
- Developed lands have highest loading rate, but forested lands produce the highest total load because they cover 83% of the Puget Sound watershed.

Ecology and its partners will use the information from the surface runoff and larger study of toxic chemicals in the Puget Sound ecosystem to help hone strategies for controlling toxic chemicals in the Puget Sound ecosystem. These strategies will be refined over time to reflect new information and new approaches for toxics reduction in Puget Sound.

Jennifer McIntyre

Washington State University

Linking sublethal copper neurotoxicity to survival in juvenile Coho salmon

Jennifer McIntyre, Nathaniel L. Scholz, David H. Baldwin, Julann S. Spromberg,
David A. Beauchamp

Abstract:

Juvenile Coho salmon (*Oncorhynchus kisutch*) rearing in lowland streams receiving agricultural, industrial, or urban runoff may be exposed to dissolved copper at concentrations that are neurotoxic to the peripheral sensory system of fishes. One sensory system affected by dissolved copper in the low parts-per-billion range is olfaction. Olfactory sensory neuron inhibition caused by acute, environmentally relevant exposure to copper results in reduced response to multiple olfactory cues of predation risk. Juvenile Coho salmon showed significant loss of antipredation behavior cued by conspecific skin extract after exposure to 5-20 ppb dissolved copper for 3 h. This loss of behavioral response persisted in the presence of predatory cutthroat trout (*O. clarki*), affecting predator-prey dynamics, and ultimately reducing survival of juvenile salmon. Reduced survival for juvenile salmon exposed to copper was also observed when predators were concurrently exposed to copper. Simplified population models suggest copper exposure from stormwater runoff may affect Coho population resilience in Puget Sound.

Jill M. Brandenberger

Pacific Northwest National Marine Science Laboratory

Copper leach rates from brake dust: Implications to riverine and estuarine stormwater management

J. M. Brandenberger, E.A. Crecelius, V.M. Everett, E. A. Fowler

Abstract:

Recent legislation was passed to limit the amount of copper (Cu) used in semi-metallic brake pads from the current 12-22% to less than 0.5% in order to reduce Cu in roadway runoff. The dust released from brake pads includes elemental Cu (metallic) dust that deposits on roadways and may be transported to streams via road runoff. The drivers behind these reductions are two-fold: 1) published laboratory studies report olfactory impairment (loss of smell) in juvenile salmon following brief exposures (minutes to 4 hr) to dissolved copper (dCu) concentrations at or below 2 µg/L and 2) documented pre-spawn mortality (PSM) of (Coho) salmon returning to small urban streams to spawn. Dissolved copper is known to affect a variety of biological endpoints in fish (e.g., survival, growth, behavior, osmoregulation, sensory function, and others), but Cu released from pads is solid elemental copper (Cu₀) with limited bioavailable. Therefore, the leaching of Cu from brake dust transported through tidally influenced rivers must be understood in order to predict the bioavailability of Cu (e.g. Biotic Ligand Model) and identify critical areas within rivers to focus road dust removal efforts. Brake dust was leached for 1, 4, and 24 hours in Dungeness River water, Sequim Bay seawater and 2, 4, and 8 ppt salinities. The exposed waters were filtered through a 0.45µm filter to express the data as the “functionally” defined dissolved fraction. The time zero brake dust contained 4.4% Cu, 1.9% Zn, 5.1% Ba, 193 ppm Pb, and 6.2 ppm Cd. Higher rates of leaching were both a function of exposure time and increasing salinity. After 24 hours, dCu concentrations in Dungeness River water (0 ppt) were 1.6 µg/L and increased with salinity of the solute to 32 µg/L in Sequim Bay Seawater (29 ppt). The time required to exceed the dCu threshold of 2 µg/L decreased with increasing salinity. It took 24 hours in 2 ppt waters, while only 4 hours in 4 ppt, and 1 hour in higher salinities. These rates provide a means to estimate changes in the bioavailability of Cu by providing the dCu concentration for usage in the Biotic Ligand Model as a function of both river mile and proximity to potential roadway runoff sources. Areas within streams supporting salmon can then be classified as sensitive to exceeding the dCu threshold and sub-basins draining into sensitive areas targeted for management actions, such as increased street sweeping and wider riparian corridors. This allows resource managers to directly link potential water quality impairments and a more feasible, localized management action.

Kate Macneale

NOAA Fisheries - Northwest Fisheries Science Center

Contaminated stormwater runoff: Effects on invertebrate drift and survival and implications for endangered salmonids

K.H. Macneale, J.A. Spromberg, S. Damm, J. Davis, N.L. Scholz

Abstract:

Numerous studies have documented declines in the diversity and abundance of macroinvertebrate communities in urban watersheds. However, the extent to which these declines are caused by non-point source pollution as opposed to physical habitat factors remains unclear. We examined the effects of contaminants in urban stormwater on macroinvertebrate communities, specifically whether exposure to contaminants alters invertebrate drift behavior and survival. Using a custom built filtration system and experimental stream channels on a stream in Seattle, WA, we exposed diverse macroinvertebrate communities to either filtered (“clean”) or unfiltered (ambient) stream water for several three-week experiments. Analysis of chemistry samples indicated there were differences between treatments (e.g. reduction of polycyclic aromatic hydrocarbons and metals in filtered treatments relative to unfiltered treatments), and we observed differences in the drift behavior and survival for some sensitive macroinvertebrate taxa. Such reductions in sensitive invertebrates may help explain why communities in chronically-exposed urban watersheds are depauperate, and why species that rely on invertebrate production, such as endangered salmonids may be at risk as well.

Bruce Nairn

King County WTD

Impact of combined sewer overflow treatment on sediment deposition and contamination potential

Bruce Nairn, Jeff Stern, Kevin Schock

Abstract:

A Combined Sewer Overflow (CSO) is a discharge of untreated sewer water and storm water released into water bodies when the capacity of sewer pipes reach to limits during storm events. CSOs often contain environmental pollutants such as polychlorinated biphenyls (PCBs), and these pollutants may distribute through water flow and accumulate in sediments near the outfall. As a component of King County’s CSO Control Plan, treatment facilities are planned to intercept CSO discharges and provide treatment before discharge. We used an EFDC (Environmental Fluid Dynamics Computer Code) model to estimate the potential for sediment contamination after CSO treatment.

Sensitivities of these three parameters, settling velocity, partition coefficient, and organic content, are analyzed, and the amount of near-field PCB deposition from the CSO is estimated. Model results suggest that deposition of sediments discharged from the CSO is highly localized due to the significant effect of particle settling velocity and CSO treatment significantly reduces deposition. The sensitivity and computation effort of the model is discussed in relation to modeling sediment contamination around existing CSO and storm water discharges.

Will Hafner

NewFields

Evaluating methods for source tracing of contaminants on the Lower Duwamish Waterway

Will Hafner, Dan Cargill, John Nakayama, Jon Nuwer, Glen Vedera

Abstract:

Various methods exist for sampling stormwater runoff and the associated sediment loads. Included among these are whole water samples, filtered suspended solids, sediment traps, bed load samplers, and catch basin grab samples. Each of these methodologies were employed during the 2011 wet season to sample stormwater flows in two sub-basins draining to the Lower Duwamish Waterway. Four locations following a downstream gradient were selected in each sub-basin to facilitate source tracing. The locations represent a range of conditions ranging from steeply angled drains with fast flows to intertidal areas. The results of this study are used to evaluate two primary objectives. The first is to determine whether it is feasible to trace and identify sources of dioxins, PCBs, metals, and other contaminants by sampling adjacent locations

along a tidally influenced storm drain line. The second objective is to compare and contrast each of the different sampling methods by evaluating their chemical and physical results. This comparison will help to determine which method offers the most representative results under given conditions and which is most cost effective.

6B: The Salish Sea food web—From description to quantification I

Food webs are an important framework in which to assess the importance of trophic connections to the transfer of energy and matter in ecosystems. We know that marine populations of the Salish Sea are changing rapidly in response to a variety of stressors, but we currently cannot predict what the ecological consequences of these changes will be. A striking example of this is the disappearance of large-lipid rich copepods, which are thought to be an important source of diet for higher trophic levels, and their replacement with smaller, lipid poor species. Understanding how organisms interact with each other in the Salish Sea food web is a fundamental first step towards understanding their role in this ecosystem. This session includes presentations characterizing different aspects of the Salish Sea food web from the benthos and the pelagic zone, and from plankton to apex predators. Presentations cover the role of plankton in the Salish Sea food web, other aspects of trophic interactions in the region, including spatial and temporal variability in trophic dynamics and dietary availability and comparisons of food web dynamics from different basins of the Salish Sea (e.g. Georgia Basin vs. Puget Sound).

Conveners: Rana El-Sabaawi, Brady Olson

PRR Facilitator: Kirsten Hauge

Lingbo Li

Fisheries Centre, the University of British Columbia

What matters in a food web? A case study in the Salish Sea using a marine ecosystem model

Lingbo Li, Tony Pitcher, Robert Devlin

Abstract:

The Salish Sea has recently experienced many changes from tiny phytoplankton, less nutritious zooplankton and increases in large marine mammals. Some stressors have been identified such as fishing, pollution and environmental changes. Here we use an ecosystem model to investigate the effects of a potential invasion of transgenic Coho salmon as a thought experiment tool to explore the resilience of the Salish Sea food web. Transgenic salmonids can grow two- to three-fold faster than non-transgenic fish, mature earlier, have higher fecundity, possess increased appetite and markedly enhanced feeding behaviour. Transgenic fish are currently legally restricted to the laboratory, but there is significant concern about their potential ecological impacts should such fish ever enter nature. Ecosystem modeling is therefore one of the few ways of examining how transgenic salmon might influence the whole food web in the context of environmental variability and fishing. We consider each potential factor within a reasonable range, discuss the worst case situation, and assess the uncertainty of our ecosystem model. The results contribute to better understanding of the Salish Sea ecosystem food web and functioning.

Emily Howe

School of Aquatic and Fishery Sciences, University of Washington

Differences in food web connectivity across intertidal gradients in embayment and fluvial dominated estuaries

Emily Howe, Charles A. Simenstad

Abstract:

Recent studies in estuarine detritus-based food webs have documented strong gradients in the sources of organic matter assimilated by consumers across diverse landscape scales. These results challenge prior concepts (i.e., estuarine outwelling paradigm) regarding the scale of food web connections across estuarine ecotones, as they infer greater compartmentalization of food webs in relation to landscape setting. However, these recent studies were conducted in microtidal environments and/or estuaries receiving little riverine input, both of which may minimize detrital transport. Given how little attention has been paid to distinguishing the scale of food web connections in relation to landscape setting and river flow regimes, the goal of this project is to quantify the strength, temporal, and spatial scales of food web connectivity among adjacent

ecosystems and across different gradients of fluvial forcing.

We use multiple stable isotopes in combination with multiple source mixing models to trace primary producer contributions to consumers transplanted to specific locations across estuarine ecotones, including emergent marsh, mudflat, Japanese eelgrass, and native eelgrass. The study is being conducted in five Pacific Northwest estuaries (Skagit, Stilliguamish, Samish, Padilla, Mud Bay) representing a gradient of fluvial forcing. By tracing the lengths and strengths of ecosystem connectivity, it is possible to determine the spatial extent of trophic linkages required to adequately capture functional food web processes. The comparison among estuaries provides insight into the role that river flow plays in connecting the food webs of adjacent ecosystems. Contrary to expectations, emerging data suggest food webs of more strongly fluvial estuaries are more compartmentalized than those of embayment type estuaries.

Evgeny Pakhomov

University of British Columbia

Between year (2006 and 2007) differences in Strait of Georgia lower trophic levels

Brian Hunt, Evgeny Pakhomov, John Dower

Abstract:

Zooplankton are key components of the pelagic food-web, providing the critical link between primary production and upper trophic levels. Seasonal and inter-annual variation in both zooplankton quality (community structure) and quantity (biomass) are therefore expected to have significant ecosystem level impacts. During the periods 23-27 May 2006 and 25-29 April 2007 we conducted two large scale surveys in the Strait of Georgia to investigate the spatial and inter-annual variation of the mesozooplankton community. Sampling was conducted from the CCGS Vector using a 1 m² Tucker Trawl fitted with a 335 µm mesh and towed obliquely between ~ 42-55 m and the surface. Multivariate statistics showed a clear separation between the 2006 and 2007 mesozooplankton communities. No substantial within year variation was observed between stations in 2007, however, in 2006 the stations in the south-west (2006A) differed from those in the rest of the survey area (2006B). These differences were driven by abundance levels of certain taxa that contributed to average levels of 798.36 ind.m⁻³ in 2007, 422.40 ind.m⁻³ in 2006B, and 109.03 ind.m⁻³ in 2006A stations. High densities of the copepods *Pseudocalanus minutus* and *Eucalanus bungii*, the appendicularians *Oikopleura* spp., and Bryozoan cyphonautes were particular to 2007. The other major contributors to mesozooplankton abundance in 2007 (the copepods Centropagidae, *Metridia pacifica*, Euphausiid larvae, the pteropod *Limacina helicina*, and barnacle larvae) were also responsible for the enhanced densities in 2006B stations, though with the exception of Euphausiid larvae levels at the latter stations were below those in 2007. Our data demonstrated significant inter-annual variation in the mesozooplankton of the Strait of Georgia, which included the degree of within year spatial homogeneity of community structure. Higher and more evenly distributed abundance level in 2007 coincided with the spring bloom occurring one month earlier in that year (early March) than in 2006 (early April), suggesting that an early bloom provides more favorable conditions for zooplankton growth. This observation has important implications for the growth and survival of upper trophic level, including salmon smolt.

Robin Elahi

University of Washington

Mesoscale oceanographic variation, grazer-prey interactions, and missing trophic links in subtidal benthic communities

Robin Elahi, Kenneth P. Sebens

Abstract:

Understanding the relative importance of ecological processes at different spatial scales is an issue central to both ecological theory and conservation efforts. In this study, we quantified the role of mesoscale oceanographic variation and small-scale predation on the structure of subtidal (~15 m depth) rock wall communities. These communities are often dominated by filter-feeding epifauna, which serve as an important trophic link between pelagic plankton and the benthos. We

used a hierarchical sampling design to survey 18 sites, nested within four distinct oceanographic “localities” in the Georgia Basin (Haro Strait, San Juan Channel, Lopez Sound, and Rosario Strait), and one locality in Puget Sound (Hood Canal). The most striking variation in community richness and composition was observed between the five localities. Namely, sites nested within the Haro Strait, San Juan Channel, and Rosario Strait localities exhibited similarly high species richness (~12 species per 0.12 m² quadrat). However, sites within Lopez Sound harbored significantly lower numbers of species (~6 per quadrat) than the three other localities within the Georgia basin, and sites in Hood Canal harbored even fewer species (~4 per quadrat). In addition, we did not observe any red urchins (*Strongylocentrotus franciscanus*) and few chitons (*Tonicella* spp.) in Hood Canal and Lopez Sound. Gut content analysis and manipulative experiments at three sites in San Juan Channel suggest that the absence of these two grazers should favor increased epifaunal richness, in contrast to our observations in Hood Canal and Lopez Sound. Instead, we hypothesize that decreased water flow and increased sedimentation in these latter two zones depress species richness. Our results highlight the potential for oceanographic context to mask the consequences of grazer-prey interactions, and offer quantitative information on poorly understood trophic interactions in the subtidal Salish Sea.

Julie E. Keister

University of Washington

Zooplankton community variability in the Strait of Juan de Fuca and Puget Sound

Julie E. Keister, Jan A. Newton, Julia K. Bos, Loren B. Tuttle

Abstract:

Changing environmental conditions have the potential to affect fish populations through changes in the species composition and lipid content of zooplankton communities. In the California Current, large, lipid-rich zooplankton are associated with cold conditions whereas small, lipid-poor taxa are associated with warmer conditions. However, how those relationships are manifested in the Salish Sea is not yet well understood, particularly in Puget Sound where very few zooplankton studies have been conducted.

Zooplankton and hydrographic data are being collected at a station in the eastern Strait of Juan de Fuca as part of the Joint Effort to Monitor the Strait (JEMS) sponsored by the University of Washington’s Puget Sound Regional Synthesis Model (PRISM) program and the Washington Department of Ecology. The purpose of the JEMS sampling is to characterize the estuary-to-ocean exchange of water, nutrients, and plankton in an effort to understand the influence of ocean conditions on Puget Sound. Sampling began in 1999 for the hydrography, chlorophyll, and nutrients; in 2003 zooplankton net tows were added. Cruises are approximately monthly through spring and summer and opportunistically in winter as weather allows. CTD casts and Niskin bottle samples collect hydrographic data, chlorophyll, and nutrients. Zooplankton are collected with a 150-µm mesh, 1-m diameter plankton net.

Eight years of sampling at monthly resolution allows comparison of seasonal and annual variability in zooplankton communities during a period of variable climate conditions which included moderate El Niño events and strong La Niñas. Preliminary analysis reveals strong seasonal shifts in species composition and evidence of interannual anomalies that may be relevant to trophic dynamics. We will present the JEMS time series data as well as shorter time series collected throughout Puget Sound with an emphasis on understanding the variability that is important to upper trophic level production in the Salish Sea.

Kevin Turner

University of Washington / Friday Harbor Laboratories

Impacts of lingcod and rockfish on benthic community structure

Kevin Turner, Kenneth Sebens

Abstract:

Commercial and recreational fishing can dramatically alter fish populations and thus marine ecosystems. Management decisions affect not just the species targeted by management, but also unharvested species related to those target species through ecological networks. Removal of top predators from subtidal communities releases prey species from predation, allowing prey populations to increase. Examples from around the world have shown that impacts from predator removals can cascade to harvestable species at lower trophic levels. Predator removals can also significantly change the composition of the entire marine community. We are studying the effects of large carnivorous fishes (lingcod, *Ophiodon elongatus*, and rockfishes, *Sebastes* spp.) on the rocky subtidal communities of San Juan Channel. Predatory fish abundance is variable within San Juan Channel, in part due to marine protected areas, which allows us to study community structure across a range of predator abundance. We use surveys of all trophic levels in this system, combined with exclusion cages designed to restrict fish access from large swaths of the benthos, to determine the community-wide impacts of predatory bottom fishes. Our preliminary results show that predator abundance does vary across San Juan Channel sites, as do species at lower trophic levels. However, correlations between predators and other trophic levels are not consistent at all sites. We have also examined the diets of two species of rockfishes to aid in the construction of a food web for this subtidal community. Our non-lethal analyses of the diets of copper and Puget Sound rockfish (*S. caurinus* and *S. emphaeus*) demonstrate close agreement with the findings from previous studies, although the copper rockfish in our study were less reliant on fish prey. The results from this research may be used to support ecosystem-based management goals by informing fisheries managers about the potential community-wide impacts of recovering bottomfish populations.

6C: Traditional foods of the Salish Sea: Connections, current status, and policy

The traditional foods of the Salish Sea area--aquatic, avian, riparian, and upland natural resources--retain deep connections to those people who have harvested and prepared them for many generations. The current status of many of these natural resources is reduced, threatened and/or contaminated, and thus no longer harvestable. This session looks at how people across the Salish Sea are connected to these traditional foods, and how policy can be created to protect and enhance what remains on behalf of all people living on both sides of the border. Examples may include: Washington State's work to bolster fish consumption rates in policy in order to better protect the health of the aquatic natural resources and all Washingtonians who harvest and consume them, as well as how implementing complimentary measures in British Columbia would be mutually beneficial on both sides of the border; and, efforts to establish climate change impact protocols such as sharing knowledge and resources regarding potential migration of culturally and medicinally important plant species across the international border.

This session will also feature a 20 minute facilitated discussion.

Convener: Jamie Donatuto
PRR Facilitator: Rita Brogan

Larry Dunn (10 minutes)
Lower Elwha Klallam Tribe
Traditional foods, tribal health & importance of establishing representative fish consumption rates

Abstract:

Over the past several decades and more specifically in the past 20 years, significant health problems have emerged in the Lower Elwha Klallam Tribe as the members have been unable to acquire sufficient salmon and shellfish to maintain their traditional diet high in fish-sourced protein and omega-3-laden fats. The inability to maintain a more traditional diet and the resulting shift to a Westernized commodity-based diet high in refined carbohydrates as well as sugars and unfamiliar fats appears to have led to the increase in health related issues. We focused specifically on the traditional fish consumption in an attempt to answer the following question: Is the increased incidence of disease in the Lower Elwha Klallam Tribe related to the decrease in fish consumption, specifically decreased consumption of salmon and shellfish?

Data were collected from a 2006 survey of the Lower Elwha Klallam Tribe conducted by the Centers for Disease Control and Prevention, from interviews with tribal members and records maintained by the tribal clinic and fisheries staff. The data were compiled and compared to national rates of disorders related to obesity and omega-3 fatty acids. The health data were also compared to the Tribe's salmon harvest rates from 1990 to 2008.

The results though not surprising were enlightening. The study highlights an inverse correlation between health indices and the sharp reduction in the Tribe's harvest of salmon, in the same period.

If this situation continues, tribal members will likely continue to experience increased risks of heart disease, Type 2 diabetes, and hypertension, as well as other weight-related disorders. In addition, the significant reduction in omega-3 fatty acids in the Tribe's diet will likely increase the incidence of depression and other diseases which have been linked to inadequate intake of omega-3 fatty acids.

The study's findings have impacted how fish consumption rates are discussed, and potentially employed in policy, in Washington State.

Fran Wilshusen & Ann Seitar (10 minutes)

Northwest Indian Fisheries Commission
Fish consumption rates and state water quality standards
Fran Wilshusen, Ann Seitar

Abstract:

The Washington State Department of Ecology is embarking on a triennial review of the state's water quality standards as part of their management of the state's surface waters promulgated through the Clean Water Act (CWA). As part of this triennial review Ecology is considering revising fish consumption rates. Currently, Washington State defaults to the national standard of 6.5 grams per day (g/d). Oregon is in the process of "resetting" their fish consumption rate to 175 g/d.

The fish consumption rate is a human health criteria and an important driver to establishing permit rates and regulating the discharge of toxics in the aquatic environment.

Tribes have been aware and active on this issue for many years, and have been requesting this criteria review and revision for over a decade. A number of the tribes in western Washington have conducted fish consumption surveys to more accurately determine and document the amount (rate) of fish that their people consume. The issue is one of both public health and environmental protection.

Nationally, the Pacific Northwest is a recognized leader on this issue with tribal treaty rights, Alaska Native subsistence rights, Pacific Islanders and Asian communities creating a human health concern that is undeniable. The opportunity to increase water quality protection by updating inaccurate and antiquated regulation is present now in this current triennial review process being conducted by Ecology.

Kathleen Feehan, Cedar Consulting, and Fran Wilshusen, NW Indian Fisheries Commission, will provide background and current status of the issue, work and importance of increasing the human health criteria / fish consumption rate.

Madrona Murphy (10 minutes)

Kwiaht: Center for the Historical Ecology of the Salish Sea
Traditional food plants may benefit from managed climate adaptation
Madrona Murphy, Brook Brouwer, Russel Barsh

Abstract:

Traditional Coast Salish food plants are currently found in habitat types that are likely to be strongly affected by projected climate change such as seaside meadows, estuaries and vernal wetlands. Ethnography suggests that traditional agricultural practices not only enhanced productivity in these habitats, but also introduced these food plants into additional habitat types, increasing their resiliency. While the cultural significance of traditional food plants has been explored in depth, much of their basic ecology is still unexplored. Our research on traditional food plants and their pollinators on small islands in the San Juan archipelago suggests that changes in climate, and the accompanying changes in storm patterns, and herbivore and pollinator behavior may mean that important plant species' survival depends on the adoption of managed climate adaptation strategies by land managers and communities. For example coastal camas (*Camassia liechtlinii*) meadows on low-lying islands are threatened by increased wave heights as well as by the increase in nesting by non-migratory Canada geese. At the same time, the ecology of many of these species, including tolerance to drought and salinity, make them particularly suited to managed sustainable food systems in a time of changing weather.

Thiago Gomes (10 minutes)

University of Victoria
Restoring the Gardens at Tl'chés, Chatham Islands, British Columbia

Abstract:

Chatham Islands, territory of the Songhees First Nation, is part of a small archipelago between Juan de Fuca and Haro Straits, in the Salish Sea, off southeastern Vancouver Island. Chatham and adjacent islands comprise nationally endangered Garry oak ecosystems, supporting a wide diversity of habitats for plant and wildlife communities. Chatham Islands, K'djis, is the birthplace and was home for Songhees elder Joan Morris [Sellemah], raised there until the age of 10 by her grandparents and other elders. The islands have been uninhabited for over 50 years now, showing signs of drastic environmental change. Sellemah longs to see the traditional gardens and orchards restored, as well as her people's relationship with their environment, for healthier and more sustainable ways of life. My research honours this vision by combining qualitative, quantitative and participatory approaches to generate baselines for ethnoecological restoration for garden- and orchard-associated ecosystems in Chatham Islands. I will investigate cultural and ecological aspects associated with the garden and orchard ecosystems and restoration practice, involving

1. the generation of ecological and cultural profile of garden and orchards remnants, through conventional ecological surveys and documentation of traditional knowledge associated with the use and cultural significance of plants and practices,
2. the generation of a historical reference for restoration through archival and historical research on socioeconomic and ecological aspects of the islands,
3. the investigation of community perceptions and relationships with K'djis and pathways for ethnoecological restoration.

Ultimately, this research aims to provide assistance in the restoration of ecological and cultural features in Chatham Islands and within the Songhees First Nation, revitalizing traditional ecological knowledge on the landscape and reversing trends of biodiversity and cultural loss.

Amy Groesbeck (10 minutes)

REM, Simon Fraser University

Ancient clam mariculture on British Columbia's coastline: An experimental examination

A.S. Groesbeck, A.K. Salomon, D.S. Lepofsky, K. Rowell

Abstract:

Our project brings together archaeological, ecological, and traditional ecological knowledge to provide evidence for the historical ecological role of clam gardens, which offer insights for contemporary shoreline conservation strategies in the Pacific Northwest. The re-discovery and documentation of ancient clam gardens in British Columbia has prompted many questions about this ancient mariculture technique. It is widely assumed that clam gardens served to increase secondary production of clam beaches managed by coastal First Nations. In this study we empirically test this assumption through contemporary surveys and ecological experiments. We survey and compare natural beaches to clam garden beaches, to understand the physical and ecological characteristics of clam gardens; and we experimentally test if clam gardens have higher secondary productivity than beaches without clam gardens. Our experiments take advantage of the comparable replicates of "classic" clam gardens that the First Nations' people built on Quadra Island, BC. We have out-planted native little neck clams (*Prototheca staminea*) in clam gardens and natural beaches during their growing season and will compare growth rates between the two types of habitats. Other factors such as temperature, submergence time, and larval recruitment success will be measured in tandem with out-planted clams for each site and compared between clam gardens and natural beaches. Preliminary surveys of these beaches indicate that clam gardens have distinct physical and ecological characteristics, such as extending clam habitat far beyond the natural slope of these modified beaches. Flattened slopes of clam gardens appear to be optimum habitat for staple foods of native little neck clams and butter clams. Results from a reciprocal out-plant of native little neck clams (*P. staminea*) in clam gardens and non-clam gardens beaches during 2011 summer will give us insights about the

influence of this engineered habitat on clam growth rates. Ultimately, we will compare contemporary growth rates to ancient growth rates of *P. staminea* collected from adjacent middens. We ground truth our data with the use of oxygen stable isotopes, which validate seasonal temperatures during time of growth.

Randall Lewis (10 minutes)

Squamish Nation

Restoring the Squamish Estuary and the return of whales

Abstract:

In the last two years whales have returned to the Salish Sea (Howe Sound, and Squamish Estuary) in the Skwxwu7mesh-ulh Temixw (Squamish traditional territory). The whales are following the herring that have just begun spawning in the estuary four years ago. From the oral history of the Elders, the whales were killed and chased away in 1890. This is the first time that whales are returning to this part of the Salish Sea. Before contact, whales were abundant in our corner of the Salish Sea. The language and knowledge that surrounded the whale for hunting, spiritual, and cultural use was known to the Squamish people. The whale was hunted away from the territory for so long that the stories, language, and knowledge were lost for four generations. In addition, due to the high level of toxins in Howe Sound, the herring, a primary food source for the whales, had deteriorated over time to a point where herring were almost extinct. Because of extensive restoration work in the estuary, the herring habitat has been revitalized to a level where herring are once again starting to flourish. Through traditional knowledge, the red cedar boughs are once again put in water for the herring eggs to gather and spawn on, laying their eggs for the Squamish to gather and leave to enrich the estuary. With this abundant return of the food source, the whales and other species are also returning.

Bill Williams (10 minutes)

Squamish Nation

XAY TEMIXW: Sacred land

Bill Williams, Chief Ian Campbell, Lisa Wilcox

Abstract:

The purpose of any Land Use Management Plan is not for it to sit on a shelf but for the Plan to become a living document of “who we are, and where we come from” as Skwxwu7mesh (Squamish Nation) people. It is to create awareness that we are not invisible on our own lands but are a thriving vibrant people that are connected to the land through our spiritual, cultural, and traditional knowledge since time immemorial. By understanding where we have come from we protect and hold sacred our lands for generations to come.

The traditional territory of the Squamish Nation comprises 6,732 square kilometers and ranges from the western boundary of Stelkaya (Robert's Creek, on the Sunshine Coast), north along the height of land to Teltiwet Shewalh (Western Door, Raccoon Pass, Upper Elaho headwaters) including all waters draining into Howe Sound, then south east to Titemtsen (Port Moody), and then south to Elksen (Point Grey, Vancouver).

Our land use plan, XAY TEMIXW, is unique in relation to other land use plans that are not developed by First Nations because it comprises key elements of our language, stories, history, traditional materials, harvesting areas, and village sites. Through the Plan, we have successfully identified different tracts of land as wild spirit places, sensitive areas and/ or restoration areas. This presentation will provide an overview of XAY TEMIXW, and how the Plan identifies and addresses the priority issues of: protected areas and Wild Spirit places; protected areas management; coordinated access management; river and stream management; energy; forestry planning; tourism and recreation; Crown development lands; and, wildlife. This presentation will also discuss the importance of government-to-government consultation in any planning process with First Nations in order to achieve successful outcomes.

6D: Knowledge translation and exchange: Improving ecosystem management through novel collaborations

Cross-disciplinary collaboration is essential to improve both our scientific understanding and management of the Salish Sea. Although ecosystems are complex open systems, researchers and managers alike often focus on specific problems due to expertise and jurisdiction. Partnerships between researchers of disparate backgrounds allows for greater exploration of questions that cannot be answered well in the isolation of a single specialty. Similarly, effective ecosystem management requires knowledge that crosses disciplines, sectors and government agencies. This session brings together practitioners with experience in transferring knowledge across disciplinary, cultural, or political boundaries as well as examples of working in collaboration across these boundaries to create new knowledge. Speakers will provide examples from their own work, discuss the challenges and rewards of the collaborative process, and highlight further opportunities for collaboration within and across their fields. The intended purpose of this session is to share lessons from both successful and unsuccessful attempts of working across boundaries. Participants will leave with a better understanding of the range of social arrangements and tools that can be used to facilitate the translation and application of knowledge.

Conveners: Angeline Tillmanns, Sarah Morley, Martin Liermann, Celine Davis, Jennifer Maxwell

PRR Facilitator: Jamie Strausz-Clark

Blake Feist

National Oceanic and Atmospheric Administration (NOAA)

The challenge of solving complex environmental problems in urbanized systems: the case of Coho spawner mortality syndrome in Puget Sound

Blake Feist, Eric Buhle, Paul Arnold, Jay Davis, David Baldwin, Julann Spromberg, Nathaniel Scholz

Abstract:

Environmental problems are inherently complicated and require a diversity of disciplines to resolve. This is especially the case in urbanized systems where understanding natural processes is further complicated by highly altered conditions. In this presentation I will provide an overview of a project that has spanned more than a decade and attempts to identify the causes of Coho salmon (*Oncorhynchus kisutch*) spawner mortality that occurs in numerous urbanized streams within the Puget Sound lowlands.

Stream surveys since the late 1990s on several Puget Sound urban streams have shown that returning Coho salmon spawners are dying at high rates (e.g., 40-90% of a total run) before they can spawn. The weight of evidence from an extensive forensic investigation suggests that toxic urban runoff is the likely cause of the recurring fish kills. Spawner die-offs at these high rates pose a potential threat to wild Coho populations, particularly in watersheds undergoing land use changes related to human population growth and development. We conducted a spatial analysis of the landscape conditions in the associated basins for surveyed streams in the greater Seattle metropolitan area. We found that the proportions of impervious surface, roads, and commercial zoned property types correlated most closely with the severity of Coho mortality across basins with varying land cover. Moreover, these relationships were strengthened when rainfall patterns were incorporated into the analysis. Our results are consistent with a role for urban runoff in the Coho spawner mortality syndrome, and suggest that motor vehicles may be sources of the causal contaminants. In addition, we used land cover attributes identified in the spatial analyses to predict possible hotspots for Coho mortality in unmonitored catchments throughout four central Puget Sound counties.

In order to reach this conclusion, we utilized a multidisciplinary team of quantitative ecologists,

landscape ecologists, spatial analysts, toxicologists, microbiologists, pathologists, chemists, and climatologists. If we had relied on traditional single discipline approaches, we would likely made far less progress in unraveling the mystery of this phenomenon.

Caroline Gibson

Northwest Straits Commission

Northwest Straits Initiative: A model for conservation through collaboration

Abstract:

The Northwest Straits Marine Conservation Initiative (Initiative) is a citizen-based organization, working to protect and restore marine waters and living resources in the Northwest Straits region of Puget Sound. The Northwest Straits Commission provides funding and technical support to seven Marine Resources Committees (MRC) of the Northwest Straits region. MRC members are volunteers, appointed by county government officials, and each MRC is unique in its approach to addressing local marine environmental issues. The non-profit arm of the Initiative, the Northwest Straits Foundation, raises additional project funding through public and private grants and donations.

A high level of collaboration is fundamental to the success of the Initiative, which holds an impressive track record for carrying out projects of local import through partnership with natural resources agencies, tribes, academic institutions, and non-governmental organizations. Authorized by the United States Congress in 1998, the organization now includes 130 committed individuals representing diverse disciplines and cultural perspectives. It is the only organization of its kind in the country.

This presentation will showcase three examples of successful collaboration in support for ecosystem management at local and regional levels, which may have implications for work in British Columbia waters.

- Eelgrass/Subtidal Habitat: "Anchor Out for Eelgrass" is a project of the Jefferson County MRC, and now in its 8th year. Through extensive outreach, and partnership with five agencies, a local dive shop, and the East Jefferson Fire and Rescue Department, the MRC has catalyzed this endeavor to protect eelgrass beds from the anchorage damage previously created by visiting boaters along the busy City of Port Townsend waterfront. Incredibly, they achieve 90% compliance from boaters!

- Forage Fish/Intertidal Habitat: The Initiative has been instrumental in helping to identify and protect beaches throughout the Northwest Straits region, by mapping spawning habitat for sand lance and surf smelt. Since 1998, the seven MRCs have conducted beach seine surveys for forage fish, in partnership with Washington Department of Fish and Wildlife, Washington State University Beach Watchers, academic institutions, and non-profit organizations. GIS maps created from these data are provided to researchers and decision-makers at other agencies and local governments.

- Marine Stewardship: The Port Susan Marine Stewardship Area is an ongoing effort to protect a beautiful and biologically-rich bay, through a coordinated process involving educational outreach, citizen science, and enforcement of existing regulation. The Snohomish and Island County MRCs and Northwest Straits Commission are working with the Tulalip and Stillaguamish Tribes, The Nature Conservancy and several other entities on this project.

Mark Scheuerell

NOAA Fisheries

Great minds do not think alike: A diversity of collaborators aids in the development and application

Mark Scheuerell, Eli Holmes, Stephanie Hampton, Steve Katz, Eric Ward, Brice Semmens, Lindsay Scheef, Dan Pendleton

Abstract:

Ecosystem-based management of marine resources requires an understanding of the interactions among members of the community (e.g., predators, prey, competitors) as well as the effects of external drivers (e.g., human disturbance, climate variability). Given time series of abundance for various species (or functional groups) in a community, multivariate autoregressive (MAR) models allow for the estimation of parameters governing intra-species (density-dependence), inter-species interactions (predator-prey), and effects of external drivers. In addition, several indices of community stability are easily computed. However, nearly all of the applications have been in freshwater systems, and therefore we set out to refine the methods for use in marine and other systems as well. To do so effectively, we recognized from the outset the need to include individuals with a variety of research backgrounds from oceanography, limnology, ecology and statistics — our group includes principal investigators, post-docs, and graduate students. I will discuss a diversity of projects that have stemmed from this collaboration, including freely available software, instructional workshops at international conferences, and dissemination of our results. Our collective insights have allowed us to answer many questions directly related to conservation and management of our coastal waters.

Weston Brinkley

Cascade Land Conservancy

Increasing ecosystem knowledge and application through a collaborative research alliance

Weston Brinkley, Lisa Ciecko

Abstract:

Research has traditionally been conducted in the realm of academia and professional research institutions. However, building a collaborative research group that includes multiple disciplines and agencies can provide unique research questions and analysis of results for both conceptual and practical application. Such a framework builds efficacy within the community around research outcomes not usually possible with a siloed approach.

The Green Cities Research Alliance (GCRA) is a collaborative effort among federal, regional, and local government agencies as well as universities and non-profit organizations, aimed at achieving these synergies. Organized by the USDA Forest Service Pacific Northwest Research Station, GCRA includes projects that explore topics such as rapid forest assessment, volunteer steward engagement, ecosystem service benefits of urban forests, suburban residential location choice, and urban foraging. Broader GCRA goals include not only increased conceptual understanding, but improved programmatic effectiveness, and a magnified public awareness of the benefits and necessity of urban ecosystem restoration.

To formalize this work as a case study in collaborative research, the GCRA has completed a self-reflection activity. Initial results suggest that the group has succeeded in connecting immediate practitioner needs with researchers to develop appropriate and interesting questions for data collection and analysis. As an example, very little research exists to describe the needs and impact of volunteer environmental stewards, even though they are potentially a major source and catalyst for ecosystem restoration. The GCRA includes organizations supporting these volunteers, which provided researchers with direct input on important questions to ask, as well as access to event information, and other logistics needed to effectively reach these stewards. The resulting research has helped identify and quantify the massive volunteer restoration effort in the Seattle region, and has provided the supporting organizations with valuable data on their volunteers, leading to improved recruitment, retention, and branding.

Another exciting value from this partnership includes the immediate implementation of research results by practitioners. The Forest Landscape Assessment Tool (FLAT) was developed by GCRA partners and is being piloted at King County parks. This research offers the Parks Department an opportunity to gather important baseline forest data never before collected. Research results have already contributed to park-scale management plans, providing

information about forest characteristics that will help identify restoration needs and build backing for future funding.

This collaborative model being implemented by the GCRA can serve as a resource for other partnerships across the Salish Sea region looking to increase their effectiveness through the connection of science and practice.

Tyson Atleo

Rain City Strategies Inc.

Tsawalk: Connecting the Nuu-chah-nulth world view to new directions in management of the Salish Sea

Tyson Atleo, Colin Doyle

Abstract:

At Raincity Strategies we understand the necessity to bring indigenous concepts forward as foundational means to re-develop contemporary economic and environmental management models. Rooted in the worldviews of British Columbia's coastal first nations lay what we believe are answers to the problems currently facing the Salish Sea ecosystem. In following lessons from the Nuu-chah-nulth of Western Vancouver Island we can draw on the successful experience of managing with respect, a process designed to ensure harmony in all relationships. From time immemorial to recent history the Nuu-chah-nulth had lived in accordance with the understanding of a constitutional worldview. Heshook-ish tsawalk as defined by Dr. Umeek Richard Atleo, hereditary Chief of the Ahousaht First Nation and chair of the former Clayoquot Sound Science Panel, is translated to pose the theoretical proposition that everything is one. In this abstract we will purposely acknowledge the connectivity of the ecosystem and the traditions of the region's indigenous peoples to help further our collective understanding of the unique and precious ecosystem that is the Salish Sea.

The worldview heshook-ish tsawalk meaning everything is one - an ontology drawn from the Nuu-chah-nulth origin stories - views the nature of existence as an integrated and orderly whole, and thereby recognizes the intrinsic relationship between the physical and spiritual. We will take these lessons from the Nuu-chah-nulth and translation from Umeek, great-grandson of Kiista, father of A-in-chut, grandfather to Cha-kwas-sik-meek and offer the application of how heshook-ish tsawalk, or the theory of tsawalk, may provide a viable theoretical alternative that both compliments and expands the view of reality presented by Western science. In the spirit of novel collaborations a simple request is proposed; we ask you to allow both Western and indigenous views be combined in order to advance our understanding of this world - asking you to walk with us among two worlds so that we may accept teachings from both.

We would like to discuss why;

1. the sustainability of resources has never been more important;

And how;

2. the world's dominate culture has screwed things up royally;

And what;

3. indigenous concepts can do to help.

These thoughts are interconnected as described by Dr. Fred Bunnell, former co-chair of the Clayoquot Sound Scientific Panel. Dr. Bunnell made it abundantly clear in a letter addressed to the intimate crowd at the recent Clayoquot Sound Science Symposium that our current economic models do not work and that it has become evident how important our natural resources are, how critical the idea of sustainability is.

What we harvest from the earth are natural gifts. The Nuu-chah-nulth, or people residing all along the mountains and sea, were challenged by the creator to manage these gifts with respect. Adhering to heshook-ish tsawalk they prevailed for millennia. Contemporary society now faces a similar challenge, one in accepting these gifts gently and ensuring renewal.

Dr. Bunnell goes on further in his letter to explain how the pursuit of perpetual growth on a finite planet is the basis of current economic models and that this practice is to engage the societies of this world in a slow collective suicide. If we all shed the veil of fear we can clearly see the costs of violating the earth's natural systems and how it will affect our children for generations to come. We are faced with an immediate and disturbing reality. Our economic models must become circles, rather than upward ramps and arrows. To correct this we must learn from Son of Raven and from Bear as the Nuu-chah-nulth had learnt.

This submission, like the conference itself, emphasizes the importance of collaboration among indigenous cultures, scientists and policymakers to solve complex environmental issues that cross political and cultural borders. By understanding the teachings from the Nuu-chah-nulth, by sharing and analyzing the origin stories of Son of Raven and Son of Mucus, we hope to share additional insight on recent management actions and best practices to protect and restore the Salish Sea Ecosystem.

Angeline Tillmanns

Adelaide Consulting and University of Victoria

The knowledge to practice gap: What prevents the application of water science and indigenous water knowledge in water policy and decision-making?

Angeline Tillmanns, Celine Davis

Abstract:

Knowledge gained through research and experience is a vital part of creating policy and aiding decision-making in watersheds. Studies of knowledge translation, or bridging the knowledge to action gap, have been mostly conducted in health sciences however water practitioners also recognize the need to improve accessibility to water science and to involve indigenous knowledge holders to help create sustainable water policies and water decisions at all levels of governments and within communities. In August 2010 the BC Government together with three BC universities hosted the BC Water Science Symposium to explore ways to overcome the knowledge to action gap. Discussions at the Symposium looked at the barriers to communication and communication methods both within and among scientists, policy-makers, stakeholders, end-users (operations), and First Nations. In most cases, no formal communication channels existed among these groups and the primary communication modes within each group were quite different. To follow up on these findings we interviewed individuals from different levels of government and from the community to create a series of case studies of both successful and unsuccessful attempts to have knowledge implemented or to engage researchers to study specific questions. Some of the main challenges identified include difficulty in bridging institutional cultures and insufficient time to develop relationships necessary for co-learning. The talk will conclude with some general principles to help improve knowledge translation across groups.

6E: Habitat restoration in the Salish Sea: Headwaters to marine waters I

The session provides examples of successful habitat restoration projects throughout the Salish Sea, from headwater and freshwater river restoration, to estuarine and near shore restoration, and marine habitat restoration. Presenters include tribal biologists and other restoration professionals who will share project details and discuss lessons learned from project implementation, including data on species and habitat affected by the projects. The purpose of this session is to highlight the latest understanding of how to successfully restore habitat in the Salish Sea and to highlight the work being done in a variety of habitats, including freshwater and marine systems.

As we face an ever-expanding human footprint in the Salish Sea watershed, much emphasis has been placed on habitat restoration. This session will help broaden the understanding of what restoration can look like in different Salish Sea habitats. Examples of habitat restoration projects may include: fish passage in freshwater systems, tribal restoration activities, habitats restored by removing creosote pilings and debris, and removal of derelict fishing gear in the Salish Sea, and others.

Highlighting these and other successful restoration projects and sharing lessons learned will help make sure restoration projects are appropriately designed and implemented.

Conveners: Joan Drinkwin, Derek Bonin, Fran Wilshusen

PRR Facilitator: Hadley Rodero

Peter Arcese

Centre for Applied Conservation Research

*Restoration genetics in maritime meadows: natural selection and the maintenance of phenotypic variation in seablush (*Plectritis congesta*)*

Abstract:

Despite rapid advances in the study of genetic variation in free-living species, relatively little is known about the mechanisms that maintain spatial variation in polymorphisms that affect plant phenotype and fitness. As a consequence, many restoration ecologists assume that phenotypic differences among populations of many plant species in the Salish Sea reflect evolutionarily important differences that could be lost via gene swamping if translocation sources outside of a 3km radius of the target population are used. This advice has, in turn, made the large-scale production of native seed in the Salish Sea prohibitively expensive. Here, I test two alternate hypotheses that A) phenotypic variation in island plant populations is largely the result of local variation in natural selection and B) that regular gene flow among populations leads to large genetically effective population sizes in at least some iconic but highly variable species potentially suitable for large-scale restoration projects. Specifically, I show that the maintenance of genetic variation at the fruit wing locus in *Plectritis congesta* (Valerianaceae) is a consequence of intense natural selection by mammalian herbivores despite regular gene flow among populations subject to alternate selection pressures. For example, surveys of 29 island populations showed that the frequency of wingless, homozygous recessives in populations varied from 0 to 100%, but averaged 94% on islands with resident herbivores versus only 10% where herbivores were absent ($r^2 = .81$). Furthermore, comparisons of 2781 progeny from 30 populations grown in a common garden showed that where herbivores were absent plants were taller, narrower, bloomed earlier and had more inflorescences than in populations with herbivores, but had fewer inflorescences relative to height. Because herbivory varies temporally across populations and spatially within them, and gene flow among adjacent populations is common, large poly-crossed populations of *Plectritis* bred from collections made across the Salish Sea should provide a highly adaptable seed source for the restoration of maritime meadow and shallow soil habitats that could be produced at a cost that is attractive to government organizations and private citizens. Similar results suggest that *Sedum spathulifolium* is a second candidate species for large-scale

production, potentially contributing with others to a 'Salish Sea' seed mix that could help reduce the use of exotic species in re-vegetation projects and speed the restoration of degraded parks and reserves.

Derek Bonin

Metro Vancouver

Fish passage on the Capilano River

Abstract:

The development of dams and reservoirs for drinking water supply and future power generation on the Capilano and Seymour rivers have altered the natural cycles in these river ecosystems. The dams created a barrier to anadromous fish, regulated downstream flows, affected water temperatures, and prevented the downstream passage of gravels and woody debris.

Engineers created the Capilano Reservoir for a growing urban region when the Cleveland Dam opened in 1954. Metro Vancouver is currently collaborating with senior governments, First Nations and other organizations to develop solutions for fisheries issues in conjunction with managing the watersheds for drinking water.

Annually adult Coho salmon and steelhead trout are transported above Cleveland Dam where they are released to spawn in the high quality habitat of the upper Capilano River. After hatching, young fish remain in the upper Capilano River from 1 to 3 years and then as smolts attempt to migrate to the ocean. Studies have estimated that 77 percent of Coho salmon and 38 of percent steelhead trout die after going over Cleveland Dam's spillway. During high flows up to 90 percent of the fish do not survive the long drop to the rocky pool at the base of the dam.

The primary issue is that summer and winter run steelhead populations are identified as an Extreme Conservation Concern. As a result a collaborative program was initiated in 2008 to trap young smolts and transport them downstream past the Cleveland Dam in an attempt to increase their rate of survival. This program has resulted in 37 percent of the salmonid yield from the upper Capilano Watershed to be captured and released in the lower Capilano River.

A range of options are being investigated for a long-term cost-effective smolt passage system at the Cleveland Dam to maximize the rate of survival for smolts migrating from the reservoir to the lower Capilano River. Consistent with the advice from agencies, the short-term initiative to reduce smolt mortality through trap and transport operations is being combined with a parallel effort to collect information on fish patterns to use in determining a long-term strategy. Habitat assessments on the Capilano river system will help determine the Capilano Watershed projected carrying capacity for the salmonids and will be used in the design of a long-term fish passage system. The habitat assessment will also provide the necessary information to identify restoration opportunities in the river system. Restoration of fish habitat in Metro Vancouver watersheds will demonstrate long-term watershed sustainability while providing a safe, reliable source of drinking water.

Keith Dublanica

Mason Conservation District - Skokomish Watershed Action Team

Upstream collaborations / Downstream processes

Abstract:

Landscape management with multiple jurisdictions is difficult at best in a simple watershed. A basin such as the Skokomish on the Olympic Peninsula, has three major sub-basins, a hydro-electric facility, a federally recognized American Indian Reservation, a major timber company with a Habitat Conservation Plan (HCP), and federally -designated forest and National Park lands in the upper sub-basins.

This watershed is a complex microcosm of both ecological and cultural issues of the Pacific

Northwest.

This case study addresses five (5) entities that have independently produced significant restoration, predominantly based in four jurisdictions. These are the Skokomish Indian Tribe and their initiatives in the lower flood plain and the estuary, the mid – Skokomish valley with agricultural lands including landowners with innovative ideas through the Mason Conservation District, Green Diamond Resource Company properties, and National Forest and National Park lands in the South and North Fork Skokomish landscapes, respectively. In addition, the City of Tacoma has signed an agreement with the Skokomish Indian Tribe--regarding restoration of North Fork Skokomish River flows--along with other re-license conditions of the Federal Energy Regulatory Commission's (FERC) Cushman Hydroelectric project, #460. Final FERC approval is expected this year following publication in the Federal Register.

This case study will be presented in a methodical fashion going upstream/ downstream. Collaborators, ongoing and proposed projects, investigative studies, along with certain success and obstacles will be offered as a 'snapshot' of the Skokomish watershed. While not exhaustive, a summary of specific celebrated projects within the upper, mid and lower watershed, along with the processes, goals, and objectives addressed through collaborative efforts, will be offered.

An ad hoc consortium identified as the Skokomish Watershed Action Team (SWAT) has been facilitated by the Wilderness Society for many of the basin's objectives in the recent past--since 2007-- with significant Congressional support for legacy road issues, but SWAT has no regulatory or enforcing capability. SWAT is a forum for healthy dialogue, discourse, and transparent communication, focusing on collaborative stewardship and resource conservation opportunities in the Skokomish watershed.

The Laird Norton Foundation may be assisting both SWAT and the Mason Conservation District, by supporting the continuing dialogue of watershed stewardship in the Skokomish watershed and drainage basin of Hood Canal a glacially-carved arm of Puget Sound. As the majority of the Hood Canal is also identified in the 1855 Treaty of Point No Point as the usual and accustomed area of the Skokomish Indian Tribe, treaty resource protective mechanisms are also emphasized in the presentation.

These mechanisms are examples where cultural and landscape restorations are not mutually exclusive.

Josh Meidav

National Oceanic and Atmospheric Administration Fisheries Service, Northwest Fisheries Science Center, Watershed Program and University of Washington School of Forest Resources
Evaluating salmonid habitat response after wood replenishment in an Olympic Peninsula watershed

Josh Meidav, Mike McHenry, Phil Roni, George Pess, Tim Beechie

Abstract:

Wood replenishment to streams previously subjected to industrial logging and channel wood removal has become a common technique for rehabilitation of salmonid habitat throughout Salish Sea watersheds. Recent reviews of the effectiveness of stream restoration methods by Whiteway et al. (2010) and Roni et al. (2008) have demonstrated that, on balance, in-stream wood placement improves the quantity and quality of salmonid habitat. Within this context and in order to support the Lower Elwha Klallam Tribe's habitat restoration objectives and efforts, we analyzed stream habitat and wood data collected over the past two decades in the Deep Creek Watershed. We investigated time series patterns from the Deep Creek Watershed since the start of restoration activities (in 1997), and contrast these with regionally relevant data from comparable watersheds. Preliminary results after the onset of wood replenishment show an improvement in physical habitat variables for bankfull width, bankfull depth ratios, pool depths, and the quantity and quality of wood in debris jams. These initial findings suggest a positive linkage of wood

placement on salmonid habitat in Deep Creek. Next steps would seek to link physical habitat improvement to responses in natal salmonid populations.

Jenna Scholz

Cardno-ENTRIX, Restoration, Engineering, and Geomorphology

River restoration within the Puyallup River Watershed: Mt. Tahoma to City of Tacoma

Jenna Scholz, Shawn Higgins, Jack Bjork, Tim Abbe, Lorin Reinelt

Abstract:

The Puyallup River flows from glaciers on Mt. Rainier to the industrial shorelines of Commencement Bay. Historic channel modifications have transformed a dynamic river that once provided a diversity of floodplain habitats into a channelized river confined by a system of levees and revetments. Occurring over many decades, this management strategy has eliminated a variety of native fish and wildlife habitat as well as reduced flood water conveyance capacity. In addition to human-induced changes to the river system, the river has undergone continuous streambed aggradation from glacial sources of sediment on Mt. Rainier.

Local government agencies, tribes, and other stakeholders have been working to help restore and improve this riverine system through the Flood Hazard Management planning process and design and implementation projects along the river's length. Each site has proven challenging and has prompted unique solutions in this watershed that supports a population of nearly 200,000. Restoration examples include a two-year, multidisciplinary planning process to address over 250 flooding and channel migration problems identified within the Puyallup River Basin and the resulting land management and engineering solutions being implemented to solve them.

This presentation provides examples of habitat restoration planning, design, and project implementation from the headwaters of the Puyallup River near Mt. Rainier to its discharge into Puget Sound near the City of Tacoma. Many of these projects incorporate recent advances in habitat assessment, design innovation, and restoration technology and span a variety of habitats in this dynamic and variable basin. We include descriptions of complex problems such as flooding and associated damage to public and private infrastructure (e.g., homes and business), channel migration and associated risks, and degraded habitat for threatened and endangered species, as well as the new assessment tools and technologies used to solve these problems. Site-specific areas include the Sunshine Point Campground at Mount Rainier National Park along the Nisqually River where levee damage and a severe potential of channel migration threaten access to the park and local communities; the Upper Puyallup River near the Town of Orting, where the river has damaged the levee in many locations and is threatening agricultural land, local schools, and several miles of road and private property; and the Lower Puyallup River where localized erosion created serious concern regarding the integrity of the North Levee, which protects residential, industrial, and agricultural areas in and around the City of Fife. In each of these cases, solutions deemed "self-mitigating" by the Puyallup Tribe of Indians and natural resource agencies were proposed or implemented, meeting the needs of multiple stakeholders.

Cyndy Holtz

Seattle Public Utilities

Collaborative riparian restoration on the Lower Cedar River

Cyndy Holtz, Jodie Salz

Abstract:

The Cedar River Watershed contains much of the best remaining aquatic habitat in the Lake Washington ecosystem and significant efforts have been undertaken to protect and restore it. Salmonid populations, (Chinook, Coho) show encouraging signs of resiliency, but long-term viability is at risk partly from widespread habitat degradation. It is imperative to improve ecological processes and riparian conditions essential to salmonid spawning and rearing. While the upper two-thirds of the river are protected within the City of Seattle's municipal watershed, which is closed to the public and managed as an ecological reserve, the lower one-third of the river is

largely in private ownership in unincorporated King County and the Cities of Maple Valley and Renton.

For over a decade King County and the City of Seattle have been acquiring and restoring river-front properties on the lower Cedar River. While this work proceeds at a steady pace, land is expensive so only a small percentage of properties have been protected to-date. During this time, the appearance of the invasive plant known as knotweed along the banks of the lower Cedar River has necessitated a new strategy for riparian restoration. Able to reproduce from tiny root fragments and occasionally from seed, knotweed takes over habitats near water, completely displacing native species, degrading habitat of salmon and other species, and potentially degrading water quality by destabilizing streambanks and causing increased sediment in the streams. Knotweed is an aggressive, invasive plant that spreads rapidly downstream by flowing water and is extremely difficult and expensive to control.

Recognizing the need to develop a new strategy to quickly address the knotweed problem, in 2010 a partnership was formed between Seattle Public Utilities, King County, Cascade Land Conservancy, Friends of the Cedar River Watershed and the watershed community to restore riparian ecosystems in the lower Cedar River on both public and private property. Efforts focus on encouraging landowner participation in activities that will contribute to riparian restoration, invasive plant eradication and native vegetation planting. This presentation will provide an overview of the partnership's progress in eradicating knotweed and other invasive plants; reestablishing native trees and shrubs; installing watershed best practices such as rain gardens and hedgerows; and building positive relationships between public and private landowners along the lower Cedar River.

2:30 pm - 3:15 pm

6F: Building towards a better informed Salish Sea constituency through education and outreach II/ Connecting citizen science to research, monitoring and management I

Building towards a better informed Salish Sea constituency through education and outreach II:

Public awareness of the Salish Sea occurs through many paths, including both formal and informal educational settings. The purpose of this session is to provide a venue for all who have conducted, or wish to learn about, successful engagement and public education programs. These could be formal educational approaches that range from elementary to graduate school, or through informal education settings such as place-based hands-on learning experiences in the field, at informal science education (ISE) facilities (e.g., aquarium or science center), or at a public policy forum (e.g., presentations to legislators and/or committees). A recent trend toward place-based education in both formal and informal settings underscores the importance of developing Salish Sea-based approaches to teaching and communicating science. Strategies that are novel or unique are especially encouraged, as are discussions of techniques for evaluating the effectiveness of outreach and educational programs. It is our vision that session participants will gain a renewed appreciation for the value of communicating Salish Sea science, policy, conservation, and restoration to many audiences among multiple venues – and will leave with ideas and tools for planning, implementing and evaluating effective approaches for doing so.

Conveners: Jude Apple, Fritz Stahr, Rick Searle

PRR Facilitator: Mike Rosen

Stephanie Williams

Coastal Geologic Services, Inc.

Outreach to coastal property owners in Whatcom County-A targeted approach

Stephanie Williams, Andrea MacLennan, Tracie Johannessen

Abstract:

The goal of this project was to identify coastal property owners who are interested in conducting restoration or conservation on their coastal property. Coastal Geologic Services, Inc. (CGS) was contracted by the Whatcom County Marine Resources Committee (MRC) to conduct a targeted outreach program that would function as the first step toward this goal. Outreach entailed surveys of targeted property owners in Whatcom County, followed by educational workshops focused on best management practices, what nearshore restoration entails, and why restoration and conservation is critical to the health of marine resources.

The target audience included shoreline property owners whose property encompassed forage fish spawning habitat or feeder bluffs. Forage fish spawn in the upper intertidal of many beaches in Whatcom County, and are central to the nearshore food web. Feeder bluffs are nearshore sediment sources, which supply and maintain beach structure and habitat. A database of private parcels that meet target criteria was developed by cross referencing parcel data and marine resource data in GIS.

A post-card mailer was sent to each of the parcels identified in GIS analysis. This mailer included information about the MRC, a survey to measure interest in learning about coastal issues, and an invitation to an educational workshop.

A total of 1,239 mailers were sent to coastal property owners. Fifty nine people responded to the survey representing 5% of those that received the mailer.

Ninety percent of respondents referenced aesthetic and cultural values using the words quiet, beauty, view and privacy. Recreational values, such as walking, were also cited. Cultural values are important to this group of coastal landowners. Ecosystem values are present but are viewed

through a cultural-value perspective. When asked what concerned coastal property owners 38 respondents (64%) indicated that bluff management and/or armoring were their greatest concerns. Concerns regarding property rights and shoreline regulations represented 20%, 15% cited current events including overdevelopment, coal trains and ferry issues.

The "Living with the Coast" workshop was designed to provide coastal property owners with a better understanding of marine resources. A morning presentation, entitled "Healthy Beach Habitats", was presented by Dan Penttila and an afternoon presentation focused on "Bluff Erosion Management" presented by Jim Johannessen. Presentations were followed by a beach walk which covered content from both presentations. Twenty post-workshop evaluations were returned. Fourteen of 20 evaluation respondents said they would be interested in attending future workshops, 4 expressed interest in Green Shores for Homes, 4 expressed interest in conservation on their property, and 4 expressed interest in potential restoration on their property. Information learned from the various feedback provided by coastal property owners can be utilized in future outreach efforts. Follow up actions to this outreach project include contacting those indicating an interest in restoration or conservation on their coastal property.

Julie Pavey

City of Port Moody

What swims beneath, Port Moody B.C

Julie Pavey, Ashley Graham, Ruth Foster, Rod MacVicar, Sandy Hollick Kenyon, Brian Naito, Murray Manson, et al.

Abstract:

The City of Port Moody, in collaboration with Burke Mountain Naturalists, Burrard Inlet Environmental Action Program, Burrard Inlet Marine Enhancement Society, Fisheries and Oceans Canada, Pacific Wildlife Foundation, Port Metro Vancouver, Port Moody Ecological Society, and the Vancouver Aquarium recently completed a fish inventory of the Port Moody Arm. The project entitled 'What Swims Beneath' (WSB) was funded by Environment Canada's Environmental Damages Fund. Project partners transformed what could have been a typical baseline study into an opportunity to educate and engage residents of Port Moody on the species of fish that make use of Port Moody Arm.

Fish sampling took place during the summer months of 2010 at local beaches within the Port Moody Arm which allowed for local residents to join the field crew in order to determine What Swims Beneath. Ultimately, the results of the fish inventory will help monitor future changes to the local ecosystem and residents were encouraged through community outreach to help conserve fish habitat. Packages were delivered to shoreline homes and businesses providing information on the species of fish that rely on the shore of Port Moody Arm. In addition, children were targeted with a colouring contest in which they had to identify species of fish that live in their backyard and commit to changing one aspect of their daily lives to help protect fish habitat. Furthermore, a community outreach event was held on the pier at Rocky Point Park, the geographic centre of the city. This event attracted over 1,000 residents and park users who were provided with the opportunity to learn of the many natural assets that exist within Port Moody.

Although the fish inventory which was continued into the fall, winter and spring months by the enthusiastic project partners is now complete, 'What Swims Beneath' lives on. A website describing the project results was created; a legacy package including fish sampling equipment was created for the community for future use and the project partners continue to share the knowledge acquired from this project. All in all, the 'What Swims Beneath' accomplished its major goals which consisted of completing a fish inventory and educating the public on the species of fish that live in their backyard. The project has also gone above and beyond accomplishing its primary goals and the success of the program has been recognized by the B.C. Recreation and Parks Association and has recently been awarded the Association's 'Program Excellence' award.

Bonnie J. Becker

University of Washington Tacoma

Surveying benthic invertebrates in Commencement Bay to engage students in conservation biology

Abstract:

Long-term ecological monitoring by undergraduate students provides an opportunity to collect useful data while providing highly-relevant training for future professionals. Environmental Studies is a major within Interdisciplinary Arts and Sciences at University of Washington Tacoma that attracts students who are interested in looking at environmental problems from a number of perspectives. These students are not science majors, but need to be able to understand, evaluate, and communicate scientific information including detailed technical reports.

Conservation Biology in Practice (TESC 332) is a required core course taken mostly by juniors, and for some "Studies" majors is their only required upper division biology class. The course was designed around a large class project, repeating part of a Department of Ecology monitoring effort in Commencement Bay (Tacoma WA), the Urban Waters Initiative (UWI). During the first part of the quarter, students delved into the UWI report, completing a number of assignments to learn the required statistical, taxonomic, and writing skills necessary to implement their project. A number of guest speakers who are actively engaged in the restoration of Commencement Bay, including a member of the UWI team, came into the classroom to lecture on their experiences. Students then collected benthic samples and associated environmental data from Commencement Bay sorted and identified all of the organisms, calculated a number of indices using their data, interpreted their results compared to past years, wrote a technical report and presented their data to community partners. Self-assessment of student confidence with associated skills was conducted at the beginning and end of the course, as was a test of student attitudes about environmental issues. Qualitative data were also collected on student perception of the relevance of the material to their career goals. Student motivation and engagement were greatly enhanced by the project-based nature of the course. The protocols and assignments created for this class has formed the basis of a long-term monitoring program associated with this course and a number of independent student capstone projects.

<http://courses.washington.edu/commbay/>

Connecting citizen science to research, monitoring and management I:

Through citizen science - engaging the public in activities ranging from making observations and collecting data to identifying research needs, designing programs, and analyzing data - we have the opportunity to provide credible, cost-effective information essential to fulfill research, monitoring and management priorities in the Salish Sea. In addition, citizen science opportunities enhance public stewardship of the Salish Sea. Current recovery and restoration efforts require an accurate characterization of the status of, and threats to, the Salish Sea, and monitoring progress toward restoration. While natural resource managers and scientists face these increasing demands, state and federal budgets are stagnant or shrinking.

In this session, we explore how rigorous science can be conducted by skilled volunteers and how citizen science projects can enhance the recovery of our waters. We highlight citizen science projects that have successfully contributed to research, monitoring, and management in the Salish Sea. Presentations provide examples of how proper design, volunteer recruitment and training, and analysis can produce quality results and demonstrate how such programs can have far greater capacity than the traditional agency approach. Following the presentations, a facilitated discussion will look at where such programs can be utilized to fill critical needs and how such programs can be structured to produce the most sound and meaningful results.

Conveners: Kate Litle, Caitlin Birdsall, Jerry Joyce

PRR Facilitator: Mike Rosen

Leah Thorpe

Cetus Research & Conservation Society (Cetus)
Engaging professional mariners in citizen science and conservation

Abstract:

Every day professional mariners spend time off the Pacific coast of Canada, often in remote areas and during times of the year where there are few other ships present. Thus, in the course of their regular duties, the crews of these ships often have opportunities to observe marine mammals (whales, dolphins, porpoises, seals, sea lions and otters) in rarely visited regions and seasons. These mariners have a unique opportunity to provide support to a variety of marine mammal conservation programs along the Pacific coast, including responding to incidents such as entanglements and strandings, and collecting sightings information. Information from and support for incidents can contribute significantly to recovery efforts.

The objective of this project has been to assess the current participation level of personnel within one specific organization of professional mariners (the Canadian Coast Guard) in existing marine mammal conservation programs along the coast of British Columbia and also to assess barriers to participation. The results of this analysis phase of the project have been used to develop a workshop aimed at increasing professional mariners' knowledge of and participation in these citizen science and conservation programs.

Development of the workshop was accomplished using the ADDIE (Analysis Design Development Implementation Evaluation) process of program design. The workshop was developed specifically to improve participation within programs from four organizations: the Vancouver Aquarium's BC Cetacean Sightings Network (BCCSN), Fisheries and Oceans Canada's Marine Mammal Response Network (MMRN), Marine Education and Research Society (MERS) and the Be Whale Wise program, spearheaded in Canada by the Straitwatch Program of Cetus Research and Conservation Society (Cetus). Through this project, insights were gained about barriers that inhibit current participation within the conservation programs and ways in which these barriers can be overcome to allow for effective citizen science and conservation from the professional mariner community.

Barbara Bennett

WSU Island County Extension Beach Watchers
Community volunteers and scientific research - The many wins of citizen science

Abstract:

Partnerships for citizen science in which community volunteers in the WSU Island County Beach Watchers program and scientists researching marine life and ecosystems on the shores of Island County work together are becoming more frequent. These partnerships advance the body of knowledge through formal research, provide hands-on educational opportunities that increase individual and community knowledge and awareness of marine ecosystems and dynamics, and inform community decisions related to the marine environment. This presentation will review the history, current models, and emerging opportunities and challenges of these partnerships in Island County. As the initial WSU Beach Watchers program, and the largest, it is hoped this summary report will support expansion of citizen science projects to foster the future health of the Salish Sea.

Tansy Clay

University of Washington School of Oceanography
Supporting collaboration among boat-based programs and scientists, a model for citizen science
Tansy Clay, Amy Sprenger, Kate Litle, Amanda Bruner

Abstract:

Boat-based education programs in the Puget Sound region are interested in both educating about current local marine research and supporting local scientific research through data collection. These programs, with their regular access to marine waters and focus on the marine

environment, are unique platforms for both data collection and marine science learning. In response to requests from boat-based programs, Washington Sea Grant and the Centers for Ocean Sciences Education Excellence – Ocean Learning Communities (COSEE-OLC) convened a workshop to connect these programs with research scientists. With an interest in expanding its sampling network in marine waters, SoundCitizen was a logical research program for boat-based educators to engage with during this initial workshop. The workshop was designed to engage boat-based educators as long-term design partners for SoundCitizen research projects. A public participatory rubric was considered in workshop design with the goal of expanding the potential of citizen science. SoundCitizen is using this same model in their program development to shift more participants from contributor to co-creator roles. This workshop successfully increased capacity for citizen science among boat-based educators. Evaluation demonstrates that partner attitudes and behaviors were impacted, and that use of the public participatory rubric supported workshop goals. Future workshops are being planned to expand to include additional scientists, research projects, and citizen groups in citizen science collaborations.

4:00 pm - 4:30 pm
Afternoon Break

4:30 pm - 6:00 pm

7A: Stormwater: Science and management II

Stormwater has center stage in the Salish Sea region. This session explores efforts underway to understand and address pollution and flow impacts, retrofit large untreated areas of nonpoint source runoff and engage the public in site-scale solutions. Talks also cover the newest stormwater research, especially toxic loading studies; and new coordinated regional monitoring and other efforts to engage expertise across the region to accelerate progress towards solutions.

Conveners: Joan Lee, Erica Guttman, Bob Simmons, Heather Trim

PRR Facilitator: Kimbra Wellock

Jim Simmonds

King County Department of Natural Resources and Parks

Development of a coordinated stormwater monitoring program in the Puget Sound Region

Jim Simmonds, Karen Dinicola

Abstract:

The Stormwater Work Group (SWG) is a coalition of federal, tribal, state and local government, business, environmental, agriculture and research interests working to develop a Stormwater Monitoring and Assessment Strategy for Puget Sound at the request of the Puget Sound Partnership and Department of Ecology. The strategy is intended to provide a coordinated, integrated approach to quantifying the stormwater problem in Puget Sound and to help us efficiently and effectively manage stormwater to reduce harm to the ecosystem. In June 2010 the SWG issued its recommendations for a prioritized, coordinated stormwater monitoring program for the Puget Sound region. In October 2010 the SWG released additional recommendations to Ecology regarding monitoring requirements for future municipal National Pollution Discharge Elimination System stormwater permits. More information on the SWG may be found here: <http://www.ecy.wa.gov/programs/wq/psmonitoring/swworkgroup.html>.

The SWG's recommendations for permit required monitoring are in the process of being adopted by the Ecology for future permits. These requirements include the pooling of resources from all permitted municipalities to conduct small stream and marine nearshore status and trend monitoring, stormwater management effectiveness monitoring, and pollution source identification information sharing. The pooled resources will be developed using interagency agreements between each municipality and Ecology, will be managed by Ecology, and overseen by a SWG subcommittee.

The SWG represents a successful multi-stakeholder committee that has reached consensus recommendations on improving stormwater monitoring programs in the Puget Sound region. It is anticipated that future work of the SWG will include overseeing implementation of the existing recommendations, and expansion of the stormwater monitoring program to include other agencies, water bodies, land uses, and permit types.

Sarah Morley

Northwest Fisheries Science Center, NOAA

Evaluating the effectiveness of new stormwater management approaches for urban stream restoration

Sarah Morley, Phil Roni, Karrie Hanson, Roger Peters, Alicia Godersky, Michele Koehler

Abstract:

Relatively little scientific research or monitoring has occurred in the Salish Sea region or elsewhere on the biological effectiveness of restoration efforts in heavily urbanized watersheds. With the overarching goal of the health of its urban creeks, the City of Seattle is testing innovative approaches to stormwater management. We report on four years of pre-project monitoring data

collected for one such technique: Natural Drainage Systems (NDS). This low-impact development approach is designed to modify the quantity, quality, and timing of stormwater delivery to creeks and other water bodies. The city has proposed a large-scale NDS within North Seattle that will treat approximately 60% of a small urban watershed. The focus of NOAA's research effort has been on the development of appropriate monitoring parameters and the collection of baseline data to evaluate the effectiveness of this major restoration action. We found that the pre-treatment biological health of the stream is poor compared to forested streams in the region, but comparable to other urban streams in the City of Seattle. The fish community is dominated by cutthroat trout (*Oncorhynchus clarki*); scores for the Benthic Index of Biological Integrity (B-IBI) range from very poor to poor; and diatom assemblages are composed of a relatively high proportion of species tolerant of high nutrient levels, organic enrichment, and sedimentation. Zinc concentrations in soil, black fly larvae, and mayfly nymphs collected from our study reaches were significantly higher than for forested streams. We did not detect any differences in copper concentrations between urban and non-urban streams. We hypothesize that in-stream biological health will improve relative to current baseline conditions following NDS implementation, with treated reaches beginning to more closely resemble forested conditions. Based on statistical power analyses, we recommend that post-project monitoring focus on rate and taxonomic composition metrics rather than simple density measurements.

Sarah Howie

The Corporation of Delta

Managing stormwater with green infrastructure: A case study in the Fraser River Delta

Abstract:

Stormwater control and treatment is critical to managing nonpoint source pollution in the Salish Sea region. The Corporation of Delta, a municipality that lies within the Fraser River delta of British Columbia, has responded to this concern by making "green infrastructure" a standard practice. Since 2005, Delta's Engineering Department has become a regional leader in green infrastructure by installing porous parking lots, swales, infiltration galleries, a daylighted ditch, rain gardens, and thousands of street trees. Taking advantage of the timing of major utility upgrades, Delta has retrofitted entire streets with porous parking strips, bike lanes, larger green spaces, gardens and street trees. Developers in the municipality are encouraged to enhance stormwater treatment on site. To engage the community, Delta has developed a rain garden program with local elementary schools, whereby city employees design and construct rain gardens at schools and then coordinate a community planting day with local streamkeepers, school children, and neighbourhood volunteers. A "Rain Gardeners" education program accompanies the rain garden construction, allowing students to take care of and learn about their rain garden throughout the school year. The benefits of the school rain garden program are already evident, as students entering secondary school who have "owned" rain gardens at their old elementary schools continue to be involved in rain garden activities in their local community. Local residents often inquire how they might obtain their own rain garden, and are provided with instructions and assistance from municipal staff and streamkeepers. The partnership between local streamkeepers, the municipality, and the school board has developed strong linkages in the community, and has paved the way for award-winning green infrastructure in the region. Delta also participates in the region's Stormwater Interagency Liaison Group, where local municipalities share successes and learning opportunities to collectively improve stormwater management in the region.

Teresa Brooks

Kitsap Conservation District

Protecting the Salish Sea one rain garden at a time

Abstract:

Kitsap County has experienced a rush of citizens who are investing time and money to help save Puget Sound. These citizens have been encouraged through a brilliant incentive program sponsored by the Kitsap County Surface and Storm Water Management Program (SSWM). The

Rain Garden element of this productive program, administered by the Kitsap Conservation District, has been successful because it offers cost share to help homeowners solve stormwater runoff issues using low impact approaches such as rain gardens and cisterns. The Kitsap County SSWM Rain Garden Program is unique in that it provides for a broader approach than just targeting new development solutions to storm water management. The program is reaching the existing homeowners and providing technical assistance and incentive funds to make it possible for them to successfully retrofit the systems used to collect and transfer the runoff their parcel generates.

In the first year (2010) of the program's outreach, 100 rain garden cost share applications were received from Kitsap County citizens. With this large influx of applicants in the beginning phase of the program, it became clear there would be an increasing number of applications, installations, and payments in the program. In 2011, the Rain Garden Program is continuing to experience a boom of involvement. Within its first quarter, 42 people signed up for cost share and twenty rain gardens were scheduled for installation. Clearly, the rapidly growing number of participants required a methodology to track the data and, most importantly, measure the success of the Rain Garden Program.

A data management system was developed by the Kitsap Conservation District to evaluate the program's effect on each watershed in the county. The management system included pertinent information about each watershed, aquifer, stream and Puget Sound bay that the program affected. Numerous scenarios can be drawn from the data such as total impervious area treated and volume of water detained. This data can then be aligned with data gathered by other agencies to evaluate whether the program is successfully providing solutions to the impact of contaminants on marine water including excessive nutrients, pathogens, heavy metals, organic pollutants, hydrocarbons and pharmaceuticals.

This workshop will provide an approach for others to save Salish Sea... one rain garden at a time. The use of an objective prioritization process and technique will be explained including how to get participant contacts, evaluate sites, use a matrix to rank project value, contract, manage data, and how to facilitate installations. By sharing the details and the methodology of the Kitsap County SSWM Rain Garden Program, a systematic approach to improving the Salish Sea becomes possible.

Adam Lorio

Samish Indian Nation, Department of Natural Resources

From monitoring to outreach in Fidalgo Bay: Addressing stormwater challenges one watershed at a time

Abstract:

Stormwater and non-point source pollution are recognized as one of the primary threats to the health of the Salish Sea by our scientific community. Yet, recent polls demonstrate that public awareness of the issue is very low. Building on over five years of stormwater monitoring data in Fidalgo Bay, we are working to use public outreach and education as the primary tool to address current challenges and prevent future degradation of the watershed. Working with tribal, city, county, state and federal government agencies and community organizations, we are creating a model for watershed scale outreach programs. This session will outline our techniques and approaches including continued watershed characterization and monitoring, integration of traditional ecological knowledge, landowner consultations and K-12 curriculum development. We will share challenges, successes and next steps.

Bob Simmons

Washington State University Mason County Extension

Creating stormwater solutions through peer-to-peer programs

Bob Simmons, Erica Guttman

Abstract:

The challenge of shifting to low-impact development practices throughout our region can seem overwhelming, in new construction as well as existing development. Retrofitting existing developments will require many thousands of small actions at the site-scale to bring about significant improvements to smaller watersheds and the Salish Sea. With a focus on site-scale LID retrofits, WSU Extension has created user-friendly tools and offered community workshops aimed at LID do-it-yourselfers for the past four years. The large response to these efforts has led to the development of new programs that will significantly expand our capacity for wider-spread education and technical guidance that can be scaled up throughout the region.

WSU is now testing the potential to achieve significant on-the-ground results through two peer-to-peer programs focused on LID education and site-based technical assistance. One program trains volunteers to provide stormwater and LID education to community groups. A second program trains highly capable volunteers to provide residents, businesses, and schools with on-site evaluations of LID options and guidance for carrying out projects. The training programs are accompanied by a suite of peer-reviewed tools that allow volunteers to step into the role of stormwater educators and advisors. In this presentation, these programs will be fully described, challenges will be discussed, and early evaluation results shared.

7B: The Salish Sea food web—From description to quantification II

Food webs are an important framework in which to assess the importance of trophic connections to the transfer of energy and matter in ecosystems. We know that marine populations of the Salish Sea are changing rapidly in response to a variety of stressors, but we currently cannot predict what the ecological consequences of these changes will be. A striking example of this is the disappearance of large-lipid rich copepods, which are thought to be an important source of diet for higher trophic levels, and their replacement with smaller, lipid poor species. Understanding how organisms interact with each other in the Salish Sea food web is a fundamental first step towards understanding their role in this ecosystem. This session includes presentations characterizing different aspects of the Salish Sea food web from the benthos and the pelagic zone, and from plankton to apex predators. Presentations cover the role of plankton in the Salish Sea food web, other aspects of trophic interactions in the region, including spatial and temporal variability in trophic dynamics and dietary availability and comparisons of food web dynamics from different basins of the Salish Sea (e.g. Georgia Basin vs. Puget Sound).

Conveners: Rana El-Sabaawi, Brady Olson

PRR Facilitator: Kirsten Hauge

Austen Thomas

University of British Columbia, Marine Mammal Research Unit

Harbor seal foraging response to the seasonal prey pulse of spawning Pacific herring

Austen Thomas, Monique M. Lance, Steven J. Jeffries, Benjamin G. Miner, Alejandro Acevedo-Gutierrez

Abstract:

Ecologists increasingly recognize the importance of resource pulses – dramatic, short-term increases in resource availability that are often extremely important for consumers. Pacific herring spawning aggregations are an excellent example of a marine resource pulse, moving seasonally into shallow inshore waters where they become prey for many marine predators. Despite abundant suggestive evidence that harbor seals are likely to utilize spawning herring pulses, they are absent from the list of predators that exhibit an aggregational response to spawning herring. To better understand the response of harbor seals to pulsed prey resources, we deployed satellite-linked GPS/Time Depth Recorders on harbor seals at Protection Island, WA, USA, and collected harbor seal scats in two contrasting herring-related seasons (spawn, post-spawn). We predicted that

1. harbor seal consumption of adult herring would peak during the spawning season,
2. harbor seal use of documented herring areas would increase during the spawning season, and
3. harbor seal diving behavior would reflect the vertical distribution of herring during the spawning season.

Contrary to predictions, herring in harbor seal diet was comprised of 77% juveniles and 23% adults in the spawning season, versus 33% juveniles and 67% adults in the post-spawn season. For all seals, use of documented herring areas was highest during the season when herring did not spawn, and seal diving behavior did not reflect the vertical distribution of herring. The lack of response by harbor seals to spawning herring pulses is likely explained by the low energy density of adult herring during the spawn season, and the availability of profitable alternative prey such as juvenile herring. This study highlights the influence of relative prey profitability on the foraging behavior of harbor seals, and may help to explain why predators do not always respond as predicted to resource pulses.

Peter Olesiuk

Fisheries and Oceans Canada

Predator-prey interactions between harbour seals and hake and herring in the Strait of Georgia

Peter Olesiuk, Jacob F. Schweigert, Jaclyn S. Cleary

Abstract:

Harbour seal populations in the Salish Sea have increased 10-fold since being protected in the early 1970s, renewing concern over their impact on local fish stocks. However, predator-prey interactions are often complex and difficult to predict. In the Strait of Georgia, harbour seals prey mainly on hake and herring. Stock assessments indicate that herring survival rates declined as seal predation levels increased. The declines in herring survival were most evident in older age-classes, indicating that seals selectively foraged on older (larger) herring. The mean weight-at-age of herring, especially within older age-classes, has declined in recent decades, and these declines may be attributable to seals selectively preying on larger herring. Stock assessments are not as extensive for hake, but seals also appear to target larger fish, and there has also been a decline in the size-at-age in older age-classes of hake in recent decades. These declines have reduced the number of large, piscivorous hake in the stock, such that juvenile fish are now less prevalent and invertebrates more prevalent in the diet of hake. It thus appears that seals have displaced piscivorous hake as the predominant fish predator in the Strait of Georgia. Despite the dramatic increase in seal abundance, overall consumption of herring does not appear to have changed appreciably, but merely shifted from large hake feeding on juvenile herring to seals feeding on adult herring. Despite the reduced abundance of larger, fecund herring and hake, both stocks appear to have experienced good recruitment in recent years due to reduced predation on juvenile herring and hake by large, piscivorous hake. Contrary to expectations, there is actually a positive correlation between seal predation levels and the recruitment of young herring.

Rana El-Sabaawi

University of Victoria

How do trophic dynamics of juvenile salmon from the Salish Sea compare to other coastal regions in the Pacific Northeast?

Rana El-Sabaawi, Marc Trudel, Asit Mazumder

Abstract:

Survival during early marine life is a crucial component of the overall survival of Pacific salmon. However, factors that contribute to early marine survival are not well known. Variability in the availability and quality in the diets of juvenile salmon is one candidate that can influence salmon survival. Here we characterize trophic dynamics of juvenile salmon from the Salish Sea and other coastal ecosystems in the region (west coast of Vancouver Island, northern Vancouver Island, Haida Gwaii, and Southeast Alaska). Our goal was to characterize whether salmon diets in the Salish Sea were different than other regions, and whether salmon diets correlated with growth and survival. We conducted a series of surveys in June and October of 2010. In each survey we collected variables such as chlorophyll, sea surface temperature, sea surface salinity, nutrient concentrations, zooplankton biomass, zooplankton quality and mixed layer stability to help us characterize different oceanic regions. We also conducted trawls and sampled individuals from three species of salmon: Chinook, Coho and Sockeye. From each individual fish we analyzed two trophic markers (stable isotopes and fatty acids) to characterize juvenile salmon diets. In the summer the Georgia Basin of the Salish Sea is warmer and fresher, more nutrient rich, and slightly more productive than other coastal regions we sampled. Zooplankton quality was slightly higher in the Georgia Basin, but zooplankton biomass was not significantly different between regions. We predict that salmon growing in the Georgia Basin will have access to a higher quality diet than in the adjacent regions. We will discuss these findings in terms of our understanding of trophic interactions in the Salish Sea food web, and their role in mitigating the survival of salmon from the region.

Gregory Williams

NOAA Fisheries / NWFSC

Using stable isotopes to clarify food web interactions of sixgill sharks (Hexanchus griseus)
G. Williams, C.J. Harvey, J. Reum, K.S. Andrews, T. Good, P.S. Levin

Abstract:

The sixgill shark (*Hexanchus griseus*) is a large predator and scavenger thought to forage across the entire marine food web, making it a good candidate as an indicator species for the overall health of the Salish Sea aquatic ecosystem. However, persistent questions remain about sixgill shark diets that are needed to clarify patterns of energy flow within the region. We compared stable isotope ratios (^{15}N and ^{13}C) of white muscle tissue collected from over 70 subadult sixgill sharks to describe their trophic interactions within the aquatic food web. Nitrogen stable isotope ratios were enriched relative to most other aquatic species, confirming that sixgill sharks represent one of the top trophic levels in the food web. Carbon stable isotope ratios, which clarify the source of primary production, were highly enriched and suggest heavy dependence on benthically-derived, nearshore production within the Sound. Stable isotope mixing models, used to estimate the relative contributions of 15 potential prey sources, consistently demonstrated over multiple iterations that pelagic species (e.g., salmon, dogfish, herring, and squid) contribute less than 5% of sixgill shark diet. However, assumptions associated with the number of broader prey groupings (clustered by isotopic similarity) and shark muscle discrimination factors do have a large effect on model output, yielding vastly different conclusions about the relative contribution of specific benthic prey sources.

Joseph Evenson

Washington Department of Fish & Wildlife

*Prey selection and its relationship to habitat and foraging strategy of remigial molting white-winged (*Melanitta fusca*) and surf scoters (*M. Perspicillata*) in Puget Sound, Washington and the Strait of Georgia, British Columbia*

Joseph Evenson, Heather J. Tschaekofske, Eric M. Anderson, Thomas A. Cyra, Bryan L. Murphie, Alison Styring

Abstract:

This study provides an initial examination of the diet of remigial molting scoters in the Puget Sound, Washington, and the southern Strait of Georgia, British Columbia region. Prey species consumption preferences may indicate specific benefits and foraging strategies sought by molting scoters. We examined fecal samples from 47 White-winged (*Melanitta fusca*) and 96 Surf Scoters (*M. perspicillata*) at both estuarine and non-estuarine sites within the Salish Sea. Diets differed by location and major taxonomic prey category. The dominant prey in most prior scoter dietary studies were bivalves, yet this study found that molting Surf Scoters consumed a significant amount of non-bivalve prey. Additionally, prey size was an important factor relating to habitat, and feeding technique, and small prey (< 5.0mm) were preferentially consumed by Surf Scoters, likely in accordance with scoter body size. Molting White-winged Scoters selected a diet of bivalves almost exclusively regardless of habitat; primarily mussels (*Mytilus trossulus*) and Varnish clams (*Nuttallia obscurata*). Molting Surf Scoters consumed bivalves primarily at the non-estuarine sites, while selecting for more gastropods, crustaceans, and polychaetes at the estuary sites dominated by eelgrass habitat. In conclusion, Surf Scoters consumed a more diverse diet than White-winged Scoters during the molt, and prey consumption was likely related to habitat and scoter body size.

7C: Environmental challenges to safe shellfish harvest and aquaculture

Traditional foods for Coast Salish Peoples have always included a variety of shellfish like clams, mussels and oysters and their more recent commercial production is an important economic engine for many local communities.

In spite of environmental initiatives on both sides of the border, environmental challenges continue to diminish harvest opportunities throughout the Salish Sea. The objective of this session is to showcase the latest research on environmental drivers of shellfish harvest downgrades to help shape future research agendas.

Since clean water and sediment are essential requirements for safe shellfish, this session will focus on factors that influence those prerequisites, including:

- Fate and transport of indicator bacteria, and their relationship to pathogens
- Sediment quality and its influence on shellfish contamination
- Influence of ocean acidification on shellfish reproduction
- Climate change and the emergence of *Vibrio*, PSP, and domoic acid outbreaks
- Benefits of shellfish harvest for clean water

This session will also feature a 15 minute facilitated discussion.

Conveners: John Konovsky, Nuri Mathieu, Brian Kingzett

PRR Facilitator: Rita Brogan

Letitia Conway-Cranos

Northwest Fisheries Science Center

Shellfish beds and the land-sea interface: Predictions and consequences of exposure to marine and terrestrially derived nutrients and pathogens in Puget Sound

Letitia Conway-Cranos, Peter Kiffney, Neil Banas, Mark Plummer, Sean Naman, Krista Bartz, Mary Ruckelshaus, Mark Strom, Rohinee Paranjpye, Parker MacCready, John Bucci

Abstract:

Shellfish are a key component of the nearshore ecosystem in Puget Sound and are affected by a suite of natural and anthropogenic processes that originate from both freshwater and marine sources. In particular, delivery of nutrients and pathogens to shellfish beds is driven by a combination of climatic variables such as precipitation, water temperature and ocean circulation as well as land use in watersheds adjacent to nearshore habitats. Here we develop and test an approach to assess how climate change, land use, and restoration strategies are likely to affect levels of marine and terrestrially-derived indicators of water quality and how changes in water quality will impact shellfish populations (e.g., shellfish closures). First, we compile and map the spatial distribution of sources of nutrients (e.g., nitrates) and pathogens (e.g., *Vibrio* spp and fecal coliforms) for three shellfish growing areas in Puget Sound: the Dosewallips, the Hamma Hamma and Samish Bay. Each of these locations supports large, commercially-harvested shellfish populations, and displays variation both in land use (e.g., forested, agriculture) and near-shore productivity and water temperature. Second, we examine the likely transport of marine and terrestrially derived nutrients and pathogens to each growing area by using a fine-scale three dimensional oceanographic circulation model (MoSSea) and validate model predictions using stable isotopes. Third, we apply predictions of nutrient export and freshwater flows from each watershed for a range of alternative climate change and land use scenarios to determine the relative future risk to shellfish populations from exposure to marine and watershed generated pathogens. Likely economic and ecological consequences of these scenarios on shellfish populations will also be assessed. Ecologically and economically viable shellfish populations

depend upon the delivery of uncontaminated water. As such, determining current and future vulnerability of shellfish beds to nutrients and pathogens is a critical aspect of sustainably managing watersheds and near-shore ecosystems.

Sarah Hu

Northwest Fisheries Science Center, NOAA

Selective distribution of potentially pathogenic Vibrio parahaemolyticus strains in oysters and water from shellfish growing areas in the Pacific Northwest

Sarah Hu, Asta Stojanowski, Rohinee Paranjpye

Abstract:

Vibrio parahaemolyticus is a Gram-negative bacterium that occurs naturally in the marine environment. Since its identification in 1950, awareness and interest has grown because it can cause gastroenteritis in humans from the consumption of raw or contaminated shellfish such as oysters. Currently outbreaks due to *V. parahaemolyticus* associated gastroenteritis occur globally. Present risk assessment models in the U.S. are based on the presence and concentration of the gene for thermostable direct hemolysin (tdh) in oysters. However, in the Pacific Northwest (PNW) there has been little correlation between illnesses related to the consumption of raw oysters and the presence or concentration of tdh+ *V. parahaemolyticus* strains in oysters harvested from the implicated growing areas, suggesting that additional markers in *V. parahaemolyticus* strains may be responsible for these illnesses.

The purpose of this project is to compare the distribution of total (tl+) and potentially pathogenic (tdh+) strains of *V. parahaemolyticus* in oysters and water from the select growing areas in Hood Canal and Willapa Bay in the PNW. A second objective was to analyze and compare the genetic profiles of environmental isolates with clinical strains from the PNW, using genetic analysis such as Repetitive-Extragenic Palindromic analysis (REP-PCR). The comparison of environmental strains with the clinical isolates from the same geographic areas will assist in understanding the population structure of PNW environmental and clinical *V. parahaemolyticus* strains and the distribution of potentially pathogenic *V. parahaemolyticus* strains.

Joy Michaud

Herrera

Population dynamics of indicator bacteria on sediment causing shellfish harvest closures

John Konovsky, Nuri Mathieu, Rob Zisette, Joy Michaud

Abstract:

Oakland Bay (South Puget Sound, Mason County, Washington) has a critical summer period for bacteria concentrations indicative of potential pathogen contamination in the marine water column. This has diminished harvest opportunities in a bay that hosts shellfish resources of North American and Coast Salish significance. The lack of typical stormwater transport mechanisms during the summer months led to an investigation of fecal coliform (FC) concentrations on both freshwater and marine sediment as potential secondary sources of water pollution. Both sediment types serve as a reservoir of bacteria which re-suspend into the water column with sufficient shear stress from wind, wave or current action.

Our data suggests that marine inter-tidal sediments are a more hospitable environment for summer FC survival than freshwater sediments. In 2010, freshwater sediment concentrations were fairly consistent between May and September ranging between 150-570 MPN/100 g DW with no discernable seasonal trend. In marine sediments, concentrations ranged from 25-21,000 MPN/100 g DW with a clear upward trend as the summer progressed. Overall, monthly mean marine sediment concentrations from 2007-10 show a steady increase from 215 MPN/100 g DW in June to 846 MPN/100 g DW in October. Somewhat elevated concentrations lingered thru the end of some years, but declined by the end of winter.

A central question necessary to develop remediation strategies is whether FC bacteria are replicating or simply accumulating on sediment surfaces. Unlike some other studies, both a microcosm simulation of Oakland Bay and analysis of biofilm samples suggest the bacteria accumulate, but do not replicate. If true, other explanatory mechanisms are necessary to account for the large increase in bacteria concentrations in marine sediment over the summer months.

If circulation patterns are consistent across seasons, summer tributary loading alone cannot account for the increase. While freshwater concentrations do increase, flows and thus loading, are significantly reduced in late summer-early fall. An alternative explanation to tributary loading would be increased deposition of fecal matter by waterfowl, shorebirds and marine mammals on marine inter-tidal sediments during late summer.

Another mechanism to explain the observed increase is that FC survival is somehow enhanced in the summer. A number of factors could contribute:

- Late summer-early fall cooling trends
- Late summer-early fall decreases in sunlight exposure
- Late summer-early fall nutrient increases
- Better pre-conditioning of FC in late summer-early fall for survival outside bird and mammalian digestive tracts (FEMS Microbiology Reviews 25:513-29)

One other potential factor is the cohesive strength of the marine sediment surface and the relative ease of bacteria re-suspension. Research elsewhere suggests that settled sediment is more easily erodible in the summer than the winter, which might also contribute to elevated marine water column FC concentrations in the summer (Hydrobiologia 540:181-95).

All these explanations and factors will become the focus of future research.

Lawrence Sullivan

Washington State Department of Health

The reclassification of Samish Bay: Managing harvest in a shellfish growing area based on river flow

Abstract:

The Washington State Department of Health (DOH) would like to give a presentation on the reclassification of Samish Bay. The DOH is responsible for evaluating all commercially harvested shellfish growing areas in Washington State to determine their suitability for harvest. Molluscan shellfish are filter feeders, so the quality of the water they grow in is a key factor in determining whether they're safe to eat. DOH recently downgraded a portion of the Samish Bay commercial shellfish growing area from Approved to Conditionally Approved due to high levels bacterial pollution during storm events.

In April 2008, extremely high fecal coliform levels were discovered in the Samish River. After the discovery of high bacteria counts, sampling in the Samish River has shown continued high fecal coliform loading during rain events. While bacteria loading to Samish Bay during storm events was very high, ambient sampling of the marine waters in the growing area did not indicate high levels of bacterial contamination. Due to the shallow nature of Samish Bay, marine samples have historically been collected within an hour of either side of high slack (the period of highest dilution) to allow boat access to the growing area. While sampling under these conditions allows for easier navigation, the sampling did not show the true impact that the Samish River has on the Approved portion of the growing area. Under low tide conditions, the Samish River discharges directly into the Approved growing area. Marine water sampling during storm events and at lower tides

indicated that the Samish Bay growing area exceeds the National Shellfish Sanitation Program (NSSP) water quality standards when bacteria loads in the Samish River are high.

The NSSP allows for a growing area to be classified as Conditionally Approved if the pollution events that impact the area are predictable. This allows for shellfish harvest during times that growing area is clean and closes the area when harvest is not safe. Beginning in May 2008, there was an extensive effort to monitor water quality in the Samish River during storm events to determine if pollution events in the Samish Bay could be predicted. An analysis of the data led to a conditional management plan based on increases in flow in the Samish River. This the first time that a shellfish growing area in Washington State has been managed based on river flow. During the months of October through December and the month of March, the Conditionally Approved portion of the Samish Bay growing area is closed for five days following a 24-hour increase in flow of 200 cfs in the Samish River. During the months of January and February, the Conditionally Approved portion of Samish Bay growing area will be closed for five days following a 24-hour increase in flow of 300 cfs in the Samish River. During the months of April through September, the Conditionally Approved portion of the growing area will be closed for five days following a 24-hour increase in flow of 100 cfs in the Samish River.

Hansi Hals

Jamestown S'Klallam Tribe

Good news for a change: Dungeness Bay shellfish status upgraded

Hansi Hals, Shawn Hines, Ann Seiter

Abstract:

Case Study Presentation:

In 1997-1998, water quality monitoring stations in Dungeness Bay on the Olympic Peninsula of Washington State reported levels of fecal coliform contamination above acceptable standards for the commercial harvest of shellfish. Areas classified as prohibited for shellfish harvest expanded in the bay from 2001 to 2004. After 13 years of focused sampling, research, analysis, waste management projects, and public education programs by watershed partners, approximately 500 acres of the bay were reclassified as “conditionally approved” by the Washington Department of Health in April, 2011.

Tracking the Sources:

Health sanitation surveys of the watershed by state agencies indicated that the sources of potential pollution were dispersed and complex. In addition to the usual suspects of septic systems and livestock, Dungeness Bay is the site of a National Wildlife Refuge, protecting hundreds of species of shorebirds and marine mammals. The lower watershed also houses the Olympic Game Farm—formerly a training ground for Disney movie animals, which maintains small groups of grizzly bears, cougars, yak, bison, and other exotic species for public viewing. Studies to document the sources included typical sampling regimes and more advanced techniques including circulation studies of Dungeness Bay and a Microbial Source Tracking analysis by the Battelle Pacific Northwest Lab to identify the sources of animal waste via genetic analysis. A “pile count” of dog feces along the shoreline was also undertaken by dedicated volunteers. The end result of the studies determined that the source of pollution was, to no one’s surprise, all of the above. Contaminant sources in the samples included humans, pets, and livestock, as well as wild mammals and avian species.

Implementing the “Fix”:

The Dungeness Watershed has a 20 year history of collaboration between the Jamestown S'Klallam Tribe, Clallam County, Conservation District, state and federal agencies, and watershed stakeholders. Major projects for remediation have included farm stewardship and irrigation improvements by the Conservation District, septic system tracking and improvements by

Clallam County, a Septics 101 class for 1,234 homeowners in the watershed, and a pet waste information program and station. The US EPA funded a study of an innovative management practice to use myco-remediation (fungi) to treat runoff. Effectiveness monitoring studies were completed by both Battelle and the WA Department of Ecology. Funds from salmon recovery programs were used to complement water quality objectives, through the purchase of property near the river mouth and the removal or decommissioning of houses and septic systems.

The “fix” for Dungeness Bay has been expensive and cumulatively amounts to at least \$2 million. The Tribe obtained major funding from the US EPA for many scientific studies and educational programs which were implemented by Clallam County, the Conservation District, and Dungeness Audubon Center. State agencies provided substantial staff time and funding for sampling, analysis, public education, and assistance to homeowners. Although the recent upgrade is evidence that the solutions have been working, continued vigilance will be necessary to expand and maintain the upgrade.

7E: Habitat restoration in the Salish Sea: Headwaters to marine waters II

The session provides examples of successful habitat restoration projects throughout the Salish Sea, from headwater and freshwater river restoration, to estuarine and near shore restoration, and marine habitat restoration. Presenters include tribal biologists and other restoration professionals who will share project details and discuss lessons learned from project implementation, including data on species and habitat affected by the projects. The purpose of this session is to highlight the latest understanding of how to successfully restore habitat in the Salish Sea and to highlight the work being done in a variety of habitats, including freshwater and marine systems.

As we face an ever-expanding human footprint in the Salish Sea watershed, much emphasis has been placed on habitat restoration. This session will help broaden the understanding of what restoration can look like in different Salish Sea habitats. Examples of habitat restoration projects may include: fish passage in freshwater systems, tribal restoration activities, habitats restored by removing creosote pilings and debris, and removal of derelict fishing gear in the Salish Sea, and others.

Highlighting these and other successful restoration projects and sharing lessons learned will help make sure restoration projects are appropriately designed and implemented.

Conveners: Joan Drinkwin, Derek Bonin, Fran Wilshusen

PRR Facilitator: Hadley Rodero

Todd Mitchell

Swinomish Indian Tribal Community

Using self-regulating tidegates to restore estuarine function and fish passage: Results from the Swinomish Fornsbys Creek restoration

Todd Mitchell, Karen Rittenhouse Mitchell

Abstract:

Tidegates regulate the flow of water between fresh- and saltwater bodies, generally to preserve upland land uses including agriculture. Conventional tidegates permit freshwater drainage and discharge to adjacent saltwater bodies only at low tide, preventing saltwater from inundating upland areas and restricting fish passage. Self-regulating tidegates (SRTs) permit a portion of the tidal prism to pass landward through the dikes, restoring fish passage and enhancing estuarine function while protecting the uplands from full tidal inundation. Use of SRTs has been controversial due to concerns that increased tidal flux may raise water tables behind the dikes, increase saltwater influence, and negatively impact land use.

The Fornsbys Creek restoration project was initiated in 2003 to replace poorly-functioning and failed conventional tidegates with technology that supports the agricultural need for drainage while permitting fish passage and enhancing estuarine habitat. Two conventional tidegates were replaced and an additional SRT was installed at a third site to replace plugged and abandoned tidegate tubes. More than five miles of channel and 70 acres of associated habitat were improved to enhance estuary function. Sixteen monitoring wells were installed at eight stations along channels behind the dike on the west bank of the Swinomish Channel. Surface water levels were monitored in the channels adjacent to each monitoring station as well as on both sides of the dike at tidegates. Fish use on either side of the tidegates as well as in the Swinomish channel in the vicinity of the tidegates was assessed pre- and post-SRT installation using small net beach seine methods.

Installation and operation of SRTs at the study site has increased water levels within the channels as designed, however the adjacent local groundwater table has not risen significantly in response to the increased tidal flux. Some monitoring wells adjacent to the channels show a sympathetic

but damped response with wells located closest to the surface water channels (~50ft) and closest to the tidegate showing the greatest changes. Salinity has increased in wells sited in restored areas and in areas where there was no previous surface water flow, however impacts to water quality have been laterally limited to about 50 feet from inundated areas. Conductivity and chloride concentrations within surface water channels and in the Swinomish channel are approximately equal both before and after SRT installation. Salinities decreased in most areas, possibly due to increased flow and drainage of water in the project area through the SRTs. Fish use monitoring results show that juvenile Chinook use of the estuarine area behind the tidegates has significantly increased post-restoration.

Jim Johannessen

Coastal Geologic Services

Nearshore restoration in Bellingham Bay: Keys to project success by local governments

Jim Johannessen, Renee LaCroix, Andrea MacLennan, Jonathan Waggoner

Abstract:

Bellingham Bay has experienced a high degree of nearshore habitat degradation, and also a large amount of effort towards restoration. The bay is typical for urban bays in the Salish Sea, with its rich industrial and cultural history, and extensive filling and conversion of nearshore habitats to accommodate past marine-dependant industrial uses. With the long-foreseen closure of the paper mill and extensive coastal brown fields, the area was long overdue for restoration or enhancement. One unique approach to accomplishing this was the creation of a multi-stakeholder Bellingham Bay Action Team (BBAT), also called the Bellingham Bay Habitat Restoration Pilot, in 1999. This group was comprised of local stakeholders for the nearshore, including local, state, and tribal representatives, along with resource managers, scientists, and activist groups. A series of restoration projects has been funded bulkhead BBAT. One recently completed estuary creation design will be outlined, along with the partnership with the City and dove tailing with an EPA cleanup project than enabled it to be completed.

The Bellingham Pubic Works Department has led several other nearshore restoration projects through a variety of funding sources. The goals, design overview, and on-the-ground outcomes of a recent salt marsh enhancement project will be covered. This project was a cooperative partnership with the local wastewater treatment plant. Another nearby beach enhancement project that involved removal of a failing rock revetment and installation of a gravel beach at a park will also be covered. This project was managed by the Port of Bellingham and received a national award in 2009. Results of quantitative beach monitoring will be presented.

A fourth project, which was yet another partnership and funding arrangement will also be briefly discussed. This project was one of the highest scored projects in a nearshore restoration prioritization funded by the Whatcom Marine Resource Committee. The project received several different types of funding and was also the subject of a public outreach effort by the City. A small saltmarsh was opened up to use by juvenile fish through the removal of a culvert and installation of an open channel. Year one fish surveys have demonstrated greatly increased use.

All of these projects show different examples of affordable and valuable nearshore restoration efforts that were typically completed within only a few years. The partnerships behind these projects and the important role of the BBAT and long-time local resource managers have played crucial roles in moving these projects along. The level of existing habitat degradation and the identification of critical habitat functions in the nearshore have enabled efficient and timely designs to be completed. Critical steps for project success will be outlined in the presentation.

Chris Fairbanks

Fairbanks Environmental Services

Chuckanut Salt Marsh reconnection: Healing from a thousand cuts

Abstract:

We have often heard the phrase 'death by a thousand cuts' to describe the incremental degradation of the Salish Sea ecosystem. A strategy for healing from these cuts is to incrementally restore ecological services with small-scale projects that provide high ecological benefits at a low-cost by leveraging partnerships of municipalities, tribes, citizen scientists and nongovernment organizations. The Chuckanut Salt Marsh project is an example of this strategy. Through a partnership between the City of Bellingham, Whatcom County Marine Resources Committee (MRC), Whatcom County, Lummi Nation, the Northwest Straits Initiative, ReSource's Beach Naturalists and WSU Extension Beach Watchers, a fish passage barrier linking Chuckanut Bay and a salt marsh was removed. Prior to removal of the undersized culvert, salmon were prevented from utilizing valuable rearing habitat in this salt marsh. Over a period of five months with eight monitoring events, only one Coho fry was observed upstream of the culvert. Over the same sampling period one year later and after the barrier culvert was replaced with a box culvert, 4 Chinook and 95 Coho were observed in the salt marsh. This project also removed vehicle parking from the beach and restored the riparian buffer along the beach berm and salt marsh with native plants. This project was identified as a priority project in the Bellingham Bay Action Team's Final Habitat Restoration Documentation Report and the MRC's Whatcom County Nearshore Habitat Restoration Prioritization. Design, permitting and construction were coordinated by the City of Bellingham. Monitoring of fish use was coordinated by the MRC with assistance from Whatcom County and the Lummi Nation. Funding was provided by the Department of Ecology, the City of Bellingham and the Northwest Straits Initiative through NOAA. Volunteers from the MRC, ReSource's Beach Naturalists and WSU Extension Beach Watchers programs assisted with public outreach and monitoring fish use before and after construction of the new culvert. The enthusiasm of these volunteer citizen scientists provided the energy to make this project a success.

Christine Woodward

Samish Indian Nation

Fidalgo Bay soft shore bank stabilization and forage fish habitat restoration

Abstract:

In 2009, the Samish Indian Nation located in Anacortes Washington networked with a variety of local, state and federal agencies to restore 550 feet of eroding shoreline along Weaverling Spit with an engineered soft shore stabilization project to protect an archeological site that was in danger of eroding onto the beach. This project also provided habitat for forage fish spawning along with shade vegetation; and helped stabilize the shoreline along the popular Tommy Thompson pedestrian trail that was currently being impacted by erosion and in danger of being lost in certain portions.

The success of the project has been measured by the following:

- Archeological site stabilized
- Erosion of the current shore stabilized
- Forage fish spawning habitat has been improved along the 550 feet of shoreline

Addition of native plants and grasses along with several large trees are providing overhanging shade which was non-existent this stretch of beach.

This project is being used as an educational opportunity on bank stabilization and beach nourishment and focuses on the value of networking a wide variety of partners working together towards the same goal.

Phase Two, The Central Weaverling Spit project that is beginning in the spring of 2011 and is located on tribal property, will replenish the lost sediment by rebuilding a natural sloping beach from the edge of the past projects and stretching an additional 500 feet east. The beach replenishment will consist of placing a wedge of sediment starting from the existing distinct cobble

zone at elevation between 5 and 6 feet above the mean lower low water (MLLW) line on the beach to the extreme high tide line at about 11 feet above MLLW on the bank. . The width of the wedge will vary from about 30 to 50 feet. The wedge will consist of two layers: a bottom layer of cobble and coarse gravel (particle sizes roughly 1" to 3" in diameter) and a top layer of ¼" to ¾" gravel. The top layer is intended to be suitable substrate for forage fish spawning.

In addition to the gravel replenishment, the proposed design also includes the following:

- Removing non-native debris from the beach,
- Moving the large pieces of remnant rip rap from the beach
- Installing approximately two drift sills made of large root wads or large logs that stick out perpendicular from the bank. The sills which will be mostly buried under the gravel wedge, will serve to interrupt along-shore transport of the new gravel, so that the gravel will stay in place for as long as possible;
- Planting native shrubs and trees along the finished bank.

James Slogan

EBA Engineering Consultants Ltd., UBC Fisheries Centre

Marine community dynamics on engineered fish compensation habitat in Burrard Inlet, BC

Abstract:

Extensive development of waterfront rocky shores for residential, commercial and recreational activities has made it increasingly necessary to understand how engineered fish compensation areas mature in urban waterways. The process of marine habitat restoration relies on predicting colonization, recruitment and succession in order to produce ecologically productive communities (as required by the Department of Fisheries and Oceans, prior to them issuing a successful compensation project authorization). In order to maximize the success of colonization, recruitment, and the overall productive capacity of fish compensation features, it has been suggested that ecological features based on local natural conditions be incorporated within compensation structures. Little work has been completed in the past to assess the impacts of engineered microhabitat features on fish habitat compensation structures.

This presentation summarizes some initial three-year results from a study to document marine assemblages at the recently-installed as part of the Vancouver Convention Centre – West's (VCC-W) compensation features. As part of the study, colonization success is being compared to a ten year old reference site adjacent to VCC-W, and a 13 year old reference area approximately five kilometres east, in Vancouver Inner harbour. One of the features at VCC-W, the marine habitat skirt, consists of an engineered five-tier concrete intertidal habitat incorporating tide pools and other micro features to improve colonization.

Results to-date show that the processes of colonization, recruitment and succession on these compensation habitats are underway. Data are being interpreted using multivariate statistics (ANOSIM, PERMANOVA) to help explain succession trajectories and effects of environment including aspect, tidal height, shading, and water quality. Marine assemblages, following three years of establishment, can be interpreted in relation to biodiversity, life history patterns, habitat preferences, predation, and potentially biological invasions.

Joan Drinkwin

Northwest Straits Foundation

Marine habitat restoration through derelict fishing net removal in the Salish Sea

Joan Drinkwin, Ginny Broadhurst, Jeff June, Kyle Antonelis

Abstract:

Derelict fishing nets include gillnets and purse seine nets lost or abandoned during commercial fishing activities. Derelict fishing nets in Puget Sound and British Columbia degrade and destroy a variety of marine habitats. Derelict fishing nets trap fine sediments that inundate marine habitat, and suffocate sessile animals. "Strumming" of nets and leadlines wears encrusting animal and plant growth off hard and soft habitat surfaces. Nets suspended in the water column ensnare mammals, fish and diving birds.

Removing nets allows these degraded habitats to recover almost immediately without further action. The Northwest Straits Initiative has restored more than 541 acres of marine habitat in Puget Sound and 3 acres in British Columbia by removing more than 3,900 derelict nets. Entangled and killed in these nets were more than 220,000 animals representing 223 unique Salish Sea species, including mammals, birds, and federally protected fish. Using a published catch rate model developed by UC Davis researchers using Puget Sound data, we estimate these 3,860 nets were entangling 1,200 mammals, 21,000 birds, 67,000 fish, and 2.2 million invertebrates annually, every year they remained derelict. The average size of fishing nets removed is about 1000 square feet.

In 2008, the Northwest Straits Foundation completed a study of marine habitat impacts of derelict fishing gear and marine habitat recovery rates after removal of derelict fishing gear. Four net removals sites and one crab pot removal site were monitored for a year after derelict fishing gear was removed. Adjacent control sites were also monitored. The study documented a 41% difference in species abundance between the gear impacted sites and the control sites immediately after gear removal. The study showed a 94% recovery of species abundance in kelp/seaweed/hydroid assemblages at the net impacted sites after one growing season without further management action. Eelgrass recovery was slower.

The Northwest Straits Initiative manages a comprehensive program aimed at eliminating harm from derelict fishing gear in Puget Sound. The Initiative's program focuses on gear removals, research and prevention. In February, 2011, the Initiative completed the first Canadian derelict fishing net removal at Pender Island, British Columbia, removing part of a purse seine that had been derelict for more than 20 years and was degrading more than three acres of rocky reef habitat. The Northwest Straits Initiative estimates approximately 1,000 nets remain throughout Puget Sound degrading approximately 100 acres of marine habitat.

For more information about the Northwest Straits Initiative's derelict fishing gear program, please visit www.derelictgear.org

7F: Connecting citizen science to research, monitoring and management II

Through citizen science - engaging the public in activities ranging from making observations and collecting data to identifying research needs, designing programs, and analyzing data - we have the opportunity to provide credible, cost-effective information essential to fulfill research, monitoring and management priorities in the Salish Sea. In addition, citizen science opportunities enhance public stewardship of the Salish Sea. Current recovery and restoration efforts require an accurate characterization of the status of, and threats to, the Salish Sea, and monitoring progress toward restoration. While natural resource managers and scientists face these increasing demands, state and federal budgets are stagnant or shrinking.

In this session, we explore how rigorous science can be conducted by skilled volunteers and how citizen science projects can enhance the recovery of our waters. We highlight citizen science projects that have successfully contributed to research, monitoring, and management in the Salish Sea. Presentations provide examples of how proper design, volunteer recruitment and training, and analysis can produce quality results and demonstrate how such programs can have far greater capacity than the traditional agency approach. Following the presentations, a facilitated discussion will look at where such programs can be utilized to fill critical needs and how such programs can be structured to produce the most sound and meaningful results.

This session will conclude with a facilitated discussion.

Conveners: Kate Litle, Caitlin Birdsall, Jerry Joyce

PRR Facilitator: Mike Rosen

Caitlin Birdsall

Vancouver Aquarium

Utilizing opportunistic citizen science: Lessons from the BC Cetacean Sightings Network

Caitlin Birdsall, Lance Barrett-Lennard, Heather Lord

Abstract:

Obtaining reliable data on wildlife distribution from large and remote coastal areas is a challenge. Regular surveys can be financially and logistically impossible. For the past eleven years, the BC Cetacean Sightings Network has created a network of observers that record and report their opportunistic sightings of wild cetaceans and sea turtles. The Network recruits participants through multimedia lectures in coastal communities, a regularly updated website (www.wildwhales.org), magazine articles, and print materials on the biology and behavior of these species and their principle anthropogenic threats. The Network allows anyone to participate, includes members engaged in a wide variety of activities, and enables data collection from a large geographic area. To date, the program has garnered 60,000 sighting reports from over 3000 observers. However, using opportunistic data has its challenges. Recruiting, training, and retaining of observers, ensuring accurate data collection, and accounting for observer effort are all issues faced by this type of citizen science. This session will look at how the BC Cetacean Sightings Network has tackled these challenges and the lessons we have learned along the way to creating a large, reliable data set used for conservation projects such as recovery planning and critical habitat identification, and a coastal population with greater environmental awareness.

Eleanor Hines

Surfrider Foundation

Recreational users test water quality at popular beaches throughout Puget Sound and tackle barriers to incorporate citizen science into monitoring and education programs

Eleanor Hines, Abigail McCarthy

Abstract:

The Blue Water Task Force (BWTF), a hands-on, citizen science, volunteer program, is driven by the desire of recreational users to test water quality throughout the Puget Sound. Coordinated by three chapters of the Surfrider Foundation within Washington state, the program not only provides important laboratory experience opportunities for high-school and college students, but also aides in Puget Sound recovery by helping to identify, raise awareness, and address pollution within the sound. At more than a dozen sites, volunteers collect and analyze samples for indicators of pathogen-causing bacteria in fresh and marine waters, including total coliforms, *Escherichia coli*, and *Enterococcus*. Results are used to alert citizens and officials about water quality problems and take actions as necessary. To overcome challenges of scientific credibility

with local and state government programs and in order to become integrated into the regional effort to restore Puget Sound, chapters have gained strong volunteer leadership and created partnerships with accredited water quality labs and local health departments in Bellingham, Seattle, and Tacoma. An example of success is Larabee State Park in Bellingham Bay, where volunteers sample for *Enterococcus* in partnership with the WA State BEACH Program. By using state accredited labs, results are able to be integrated into the regional monitoring program and ensure that investigatory action is taken to reduce sources of harmful bacterial pollution in recreational waters. Currently, Surfrider and the BEACH program are working with volunteer interns and several partners at Larabee on ground-breaking realizations about the impacts beach wrack and crabbing practices may have on water quality. An intensive summer education and outreach program through BWTF is educating park visitors and recreational crabbers about water quality issues. Results are distributed via websites and social networking tools to inform recreational users and others who utilize these popular beaches to reduce outbreaks of water-related illnesses.

Leanna Boyer

Mayne Island Conservancy Society

A citizen science approach to monitoring nearshore ecosystems

Leanna Boyer, Nikki Wright, Michele Deakin

Abstract:

The BC Community Eelgrass Network began in 2002, where 12 groups up and down the coast were trained to map and monitor eelgrass habitat. Now there are over twenty groups coordinating eelgrass mapping, monitoring, restoration or education. The network structure gives the program it's strength, drawing on a myriad of experiences and expertise of coordinators and volunteers. The work has expanded to include forage fish and kelp monitoring, and shoreland stewardship as a move towards an ecosystem based approach. Citizen Scientists play a critical role in the sustainability of monitoring projects. In this presentation we share the techniques (and lessons learned) of project design, volunteer recruitment and training that have emerged from this program. We also show how mapping and monitoring by Citizen Scientists leads to concrete changes with respect to destructive activities in nearshore ecosystems and heightened awareness of the importance of these habitats.

Paul Dorn

Suquamish Tribe

Citizen science role in West Puget Sound Nearshore Fish Utilization Studies

Paul Dorn, Peter Namtvedt Best, Doris Small

Abstract:

The BC Community Eelgrass Network began in 2002, where 12 groups up and down the coast were trained to map and monitor eelgrass habitat. Now there are over twenty groups coordinating eelgrass mapping, monitoring, restoration or education. The network structure gives the program its strength, drawing on a myriad of experiences and expertise of coordinators and volunteers. The work has expanded to include forage fish and kelp monitoring, and shoreland stewardship as a move towards an ecosystem based approach. Citizen Scientists play a critical role in the sustainability of monitoring projects. In this presentation we share the techniques (and lessons

learned) of project design, volunteer recruitment and training that have emerged from this program. We also show how mapping and monitoring by Citizen Scientists leads to concrete changes with respect to destructive activities in nearshore ecosystems and heightened awareness of the importance of these habitats.

Adam Sedgley

Seattle Audubon

Puget Sound Seabird Survey: Science by citizens

Adam Sedgley, Jerry Joyce, Eric Ward, Peter Hodum, Scott Pearson

Abstract:

The Puget Sound Seabird Survey (PSSS) leverages the expertise of birdwatchers to provide valuable - and unique - data on wintering waterfowl, loons, grebes, cormorants, gulls/terns and alcids in Puget Sound. Current and previous areal and shore-based surveys show nearly all species have declined but methodologies and differences in protocols make quantitative evaluations difficult or impossible.

The goal of the Puget Sound Seabird Survey (PSSS) is to develop density estimates for seabirds in Puget Sound during the fall and winter and subsequently detect trends over time. To accomplish this, a large sample size is developed by conducting simultaneous or near-simultaneous observations monthly at over 60 shore-based sites in six coastal counties. Nearly eighty skilled volunteers have been trained to use a sophisticated and consistent protocol based on distance-sampling methodology. Unlike simpler point count surveys, distance sampling addresses issues of detectability and allows inference to be made about species' abundances. Data are input online and monthly summaries are prepared for volunteers. After the survey season, individual records are scrutinized to assure that the measurements and species recorded are plausible and that the survey protocol was followed. Due to the documented protocol and other procedures, the survey is fully scalable and can be expanded to other areas if adequate resources are available for the recruitment and training of volunteers.

The robustness of the data set also enables ancillary uses of the data. Mainly through partnerships with agencies and universities, the PSSS data can be utilized to identify areas of stress and avian response to those stressors, as well as the potential for identifying their responses when stressors are reduced. PSSS data on individual seabird species attendance by survey site by month are already being used in developing oil-spill response plans. A feasibility study in 2009 examined the potential risk an oil spill would have on seabirds by modeling a 5,000 gallon oil spill using real-world tide, wind, and PSSS-based density estimates. The study concluded that the PSSS data can be used to examine potential oiling of birds from an oil spill and which species are the most vulnerable. A study was initiated in 2011 to quantitatively evaluate the degree of variation between observers in the PSSS program in species identification, counts of abundance of observed species, and distance estimates. Once completed, Seattle Audubon will better understand the strengths and limitations of the PSSS dataset, a prudent step before sharing with agencies and individuals or further expanding the study area.

6:30 pm - 9:00 pm

Vancouver Aquarium Reception

Buses leave at 6:30 pm - Welcome at 7:00 pm

Come visit one of Vancouver's premiere attractions! Experience the 4-D theatre, experience First Nations cultural activities learn about Vancouver Aquarium research and programs with Dr. John Nightingale, mix and mingle with other conference delegates, and enjoy a wide selection of Ocean Wise hors d'oeuvres and canapés. Sponsored in part by the Vancouver Aquarium, this great event is not to be missed!

Date: October 26, 2011

Time: 6:30 p.m.

Cost: \$50

Register through the conference website or contact us at 1-866-814-8317 or email registration@verney.ca

Thursday, October 27, 2011

8:30 am - 10:00 am

8A: Science and management of eutrophication and hypoxia in the Salish Sea I

Coastal eutrophication is a growing environmental problem impacting coastal waters. Anthropogenic nutrient inputs lead to increased incidents of hypoxia. Critically low concentrations of dissolved oxygen have been identified in the Salish Sea (e.g., Saanich Inlet, Hood Canal, Budd Inlet) and hypoxia appears to be an emerging feature of many smaller embayments and bottom waters. Despite eutrophication and hypoxia being important environmental stressors and indicators of anthropogenic and climatic impacts on coastal systems, many questions remain, including:

What is the spatial and temporal extent of hypoxia in Salish Sea waters? What are the primary sources of nutrients to the Salish Sea and how do they vary across space and time? What are in situ, climatological, and watershed-scale drivers of hypoxia? What capacity exists to model both short- and long-term changes in bottom-water hypoxia? What are long-term consequences of hypoxia on the Salish Sea ecosystem? What management and policy responses are available to reduce the likelihood of eutrophication and chronic hypoxia?

This session provides an improved, transboundary picture of hypoxia and eutrophication across the Salish Sea; provides valuable insight into the response to climate change; allows sharing of innovative management approaches, and fosters discussion across the scientific and management communities to help direct and organize current and future efforts.

**Conveners: Jan Newton, Jude Apple, Andrew James,
Joel Baker, Ken Denman, Duane Fagergren, Julie Horowitz, Christopher Krembs**
PRR Facilitator: Kimbra Wellock

Christopher Krembs

Environmental Assessment Program, Washington State Department of Ecology
Are eutrophication and dissolved oxygen trends in Puget Sound always coupled?
Christopher Krembs, Julia Bos, Skip Albertson, Brandon Sackmann, Mya Keyzers, Laura Friedenberg, Carol Maloy

Abstract:

Low dissolved oxygen (DO) conditions are an important indicator of the health of the Salish Sea marine ecosystem and are thought to be aggravated by eutrophication. Oxygen conditions are a result of the interplay of biological processes, temperatures, vertical mixing, tidal exchange, and distant coastal upwelling. While great spatial and temporal variability exists in natural conditions, human nutrient pressures have been steadily increasing along populated corridors thereby providing a unique environmental signal that should be traceable in the DO deficit in space and time.

We present regional and large-scale anomalies in the marine oxygen deficit in relation to nutrient and physical conditions of the southern Salish Sea. We specifically report on the coupling between eutrophication and the DO deficit in contrasting regions of Puget Sound with different sensitivities and exposures to human, oceanic, and climatic influences. Ecology's long historical monitoring record and large spatial coverage allows us to examine this coupling as well as explore the spatial and temporal mismatches between eutrophication and the DO deficit in the context of material cycling and transport in Puget Sound.

Linda Rhodes

NOAA Fisheries
Profiling microbial features in a Whidbey Basin Bay with low dissolved oxygen

Linda Rhodes, Anne E. Baxter

Abstract:

Penn Cove is a marine bay in the Whidbey Basin of Puget Sound that experiences low dissolved oxygen (DO), a factor contributing to its designation as a 303d (impaired) water body. The bay is within the influence of the Skagit River outflow as well as anthropogenic effectors such as sewage treatment plant outfalls and terrestrial runoff. We found that DO correlated with salinity and depth, suggesting stratification by freshwater inputs and/or tides. Seasonal comparisons revealed steep DO gradients and low DO values in late summer and fall and shallow gradients with high DO values in winter. In order to understand the relationship of heterotrophic microbes to DO, we are examining the structure and function of pelagic bacterial and archeal communities in relation to nutrients, phytoplankton, and physical conditions. Distinct bacterial community profiles appeared on a seasonal basis, and within a season, community structure exhibited site-specific similarity. Heterotrophic production was more consistently correlated with DO than temperature regardless of season, although at temperatures lower than 11 °C, production was low (< 0.5 µg carbon L⁻¹ hour⁻¹). Dissolved nitrate and phosphate concentrations were consistently higher in fall and winter, and there was a strong positive correlation between these two nutrients across the seasons, possibly due to a common source or input method. Dissolved nitrite was detectable in all samples in fall and winter, and nitrite concentrations were negatively correlated with DO, suggesting that nitrification was occurring even during periods of low heterotrophic production. Chlorophyll a concentration was weakly correlated with heterotrophic production in summer, but more strongly correlated in fall and winter, demonstrating a disconnect between nutrient levels, abundance of phytoplankton, and low DO. Our observations suggest that the low DO in Penn Cove may not fit the eutrophication-hypoxia mechanistic paradigm defined for other areas of the Salish Sea.

Kenneth Denman

VENUS Coastal Network

Tracking dissolved oxygen changes at three deep sites in the northern Salish Sea

Kenneth Denman, Richard Dewey, Verena Tunnicliffe

Abstract:

We have been observing dissolved oxygen at three sites in the southern Strait of Georgia (2) and in Saanich Inlet (1) for several years from the VENUS Coastal Network (<http://www.venus.uvic.ca>). The southern Strait of Georgia is influenced near the surface by the freshwater outflow from the Fraser River, and the resulting estuarine circulation. Saanich Inlet on Vancouver Island has a shallow sill (~75m deep) at its mouth and communicates with the Salish Sea via a wide channel. An anoxic layer forms around a depth of 100m due to the utilization of oxygen by bacteria for respiration/remineralization of sinking organic matter created from near surface photosynthesis by phytoplankton. Periodically 'renewal' events transport oxygenated waters (from the Pacific Ocean flowing in through Juan de Fuca Strait) over the sill where they sink and spread below the anoxic layer, eventually mixing oxygen upwards into the previously anoxic layer. For Saanich Inlet, oxygen concentration observations exist from 1930 for the low oxygen region between depths of 90 and 110 m, showing a long decline in maximum values of oxygen and an increase in temperature. For the last 5 years, continuous, high resolution (sampled every minute) observations from VENUS extend this time series and show variability from sub-tidal to interannual timescales. Observations of oxygen from two VENUS sites near a depth of 300m in the Strait of Georgia show similar variability at all timescales and evidence of intrusions of offshore waters. We compare the nature of oxygen variability over many timescales between sites and with standard oceanographic variables, to elucidate the processes regulating changes in oxygen concentration.

David Mora

Washington State Department of Ecology

Admiralty Reach as conduit for low oxygen water intrusions into Puget Sound

David Mora, Ashley Carle, Skip Albertson, Christopher Krembs, Brian Polagye,

Jim Thomson

Abstract:

We report on the conditions and timing of oceanic low oxygen intrusions into the Central Basin of Puget Sound using a moored sensor package deployed at a key water exchange site, the Admiralty Inlet sill of the southern Salish Sea. From the perspective of mooring observations we examine oceanic influences on Puget Sound's oxygen budget. Observations are from 2009 to present, at a depth of 65m between Port Townsend and Fort Casey (Whidbey Island) and include the exchange of near bottom water masses, solutes and oxygen between the Straits and Puget Sound. The observations (mooring deployment) are in conjunction with the study of a tidal energy project (Snohomish PUD) and a cooperative effort between the Department of Ecology and the University Washington's Applied Physics Lab. Results are placed in the context of previous studies from Thompson et al (2007) and Mackas (1997), which describe fortnightly and seasonally modulated flow and mixing regimes that should affect the inter-basin solute transport. We present results on 1) the timing, magnitude, and frequency of oceanic intrusions, 2) the influence of the fortnight cycle on tidal mixing and exchange, 3) the occurrence of seasonal transition points, and 4) differences in oxygen, salinity and temperature between ebb and flood tides.

Cheryl Greengrove

University of Washington Tacoma

Water quality in Quartermaster Harbor, Puget Sound, WA

Cheryl Greengrove, Julianne Ruffner, John Pelerine, Nannette Huber, Julie Masura

Abstract:

Quartermaster Harbor (QMH), in central Puget Sound, WA, has historically had elevated levels of nitrate and low dissolved oxygen in the water column. University of Washington Tacoma has been monitoring the marine environmental conditions in the bay since October 2006 along a seven station transect consisting of CTD profiles and water samples for dissolved oxygen, nutrients, chlorophyll and phytoplankton. In addition, a mooring is located in the outer harbor to record near surface and near bottom temperature and salinity. Starting in 2009, UWT and WADOE have teamed up with King County to do an EPA funded watershed wide study of QMH nitrogen loading and dissolved oxygen concentrations, with the goal of developing, recommending and incorporating Best Management Practices (BMPs) for improving water quality in the bay into the King County Comprehensive Management Plan for this watershed. Initial results indicate that flushing of the bay may be slow due to its geographic configuration relative to physical forcing conditions and a hydrodynamic model is being developed to estimate flushing rates for the bay. Results of this study to date will be presented.

Jan Newton

University of Washington

Hypoxia in Hood Canal: Lessons learned from HCDOP

Jan Newton, Allan Devol, Jeff Richey, Mitsuhiro Kawase, Mark Warner, Sandy Parker-Stetter, Dan Hannafious

Abstract:

The Hood Canal Dissolved Oxygen Program's "Integrated Assessment and Modeling Study" (HCDOP-IAM) was conducted to scientifically understand the factors controlling oxygen in Hood Canal. Both field measurements and numerical modeling were used to assess the status and underlying mechanisms affecting watershed, marine, and biotic factors influencing oxygen. Hood Canal has long been known to exhibit hypoxic conditions and natural variation in oxygen content is quite high. Whether human contributions of nitrogen were tipping the balance in causing higher risk of hypoxia was the root of the study. Conducted as a broad partnership of scientists, local stakeholders, and citizen volunteers, the research has yielded a wealth of scientific information on the dynamics of Hood Canal, as well as highlighted the difficulties and idiosyncrasies of this kind

of research as applied to management questions. We explore the highlights of both in this presentation.

See the HCDOP website at:

<http://www.hoodcanal.washington.edu>

8B: Marine survival of salmon in the Salish Sea

Scientists, managers, and stakeholders from the Salish Sea region, U.S. and Canada, are concerned about the level of uncertainty surrounding the impact of changing environmental conditions on the survival of salmon (wild and hatchery) while they reside in estuarine and marine environments of the Salish Sea. Marine survival for Coho and Chinook, which enter the Salish Sea from mid-spring through early summer and can utilize the Salish Sea for a significant period of time, has declined, in some cases to less than one tenth of the levels experienced in the 1970's and 80's. Puget Sound steelhead have also declined significantly, with evidence that marine survival may be an issue. Conversely, many pink and chum populations, which enter the Salish Sea in late winter to early spring, are thriving. Productivity of Fraser River sockeye salmon was declining since the mid-1990s also, until the extraordinary change in production that we witnessed in 2010 (juveniles to sea in 2008).

The interaction between salmon and the Salish Sea is complex, requiring a detailed understanding of how salmon are affected by the physical, chemical, and biological characteristics of the marine environment. Several research activities assess the salmon/Salish Sea dynamic and some recent studies suggest factors influencing survival of juvenile salmon in the Sea. However, significant information gaps remain and collaboration and information sharing among scientists could be improved.

The purpose of this session is to present the current state of knowledge regarding the factors affecting survival and productivity of salmon in the Salish Sea marine environment, including the estuary and nearshore. The presentations focus on recent findings and identified information gaps/research needs, covering topics such as climate variability, food web dynamics (predator/prey interactions, competition), habitat loss, diseases and toxics, and hatchery-wild interactions. The session presentations and associated discussions provide baseline information for a broader, transboundary initiative proposed by Long Live the Kings (US) and the Pacific Salmon Foundation (Canada) to increase research, collaboration, and outreach pertaining to the marine survival of salmon in the Salish Sea.

Conveners: Michael Schmidt, Brian Riddell

PRR Facilitator: Kirsten Hauge

Richard Beamish (30 minutes)

Pacific Biological Station

The changing Strait of Georgia ecosystem

Abstract:

The Strait of Georgia warmed about 1 degree C over the past 40 years, although there has been a cooling trend since the early 2000s. Despite the recent cooling, the Strait of Georgia remains about 2 degrees warmer than Puget Sound. Over these 40 years, there have been dramatic changes in Pacific salmon production. Marine survivals of Coho and Chinook salmon declined with hatchery fish declining more than wild fish. The early marine survival of Coho salmon declined from about 15% in the late 1990s to about 2% in recent years. In the early 1990s Coho salmon changed their behaviour and virtually all left the Strait of Georgia late in their first marine year. At the same time sockeye salmon productivity started a declining trend. Chinook salmon marine survival is now well below 1%, but an aggregate of late ocean entry populations are surviving much better than most other populations. Pink salmon abundances have been increasing with the possibility of a record high return this year. The period from about 2002 until 2007 appears to have been associated with generally poor productivity. In 2007, there was exceptionally poor survival of all juvenile salmon and herring in the surface waters in the spring resulting in record low returns of adults. Productivity of fishes improved abruptly in 2008 resulting in a large return of pink salmon in 2009 and an historic high return of sockeye salmon in 2010. A five year study of the Strait of Georgia ecosystem was completed in 2011. Investigators are

currently preparing reports, but preliminary results identify more changes such as a decline in copepod production early in the 2000s. The linkages between these changes and climate need to be identified to provide a focus for management and stability for industries that are associated with the Strait of Georgia.

Dave Beauchamp (30 minutes)

U.S. Geological Survey, Washington Cooperative Fish & Wildlife Research Unit School of Aquatic and Fisheries Sciences, University of Washington

Marine survival of salmon and steelhead in Puget Sound

Abstract:

Anadromous salmonids rely on a network of freshwater, estuarine, and marine habitats, and growth and survival are affected by numerous processes at each of these life stages. Growth performance at earlier life stages can significantly affect survival at subsequent life stages. Therefore, measuring stage-specific growth and survival associated with key habitats, and understanding the underlying processes that affect them will be important for advancing restoration of Puget Sound salmon and steelhead. For Puget Sound stocks, Smolt-to-Adult Returns (SARS) of hatchery Chinook salmon have varied at least 5-fold over the past 20+ years, declined about 2-fold for hatchery and wild Coho, and declined by about 10-fold for steelhead. Consequently, the magnitude of this recent variability/decline highlights the need to identify factors affecting marine survival and the habitats and life stages when/where these processes occur.

For example, a critical marine growth period was identified for age-0 Chinook salmon in south, central, and Whidbey basins of Puget Sound. SARS were strongly positively correlated with juvenile weight in July, after offshore feeding increased weight by 2-3-fold over weights acquired in nearshore habitats. Inter-annual and regional differences in growth were primarily attributed to different feeding rates rather than metabolic responses to differences in temperature regime or prey quality. The high, but variable feeding rate, coupled with strong size-selective mortality, suggests that seasonal availability of key zooplankton (especially crab larvae and amphipods) and competition for these prey limit growth, and thus reduce marine survival. Therefore, localized density-dependent effects and the relative importance of competition between hatchery and wild Chinook, or among other species become important questions. Bioenergetics modeling indicated that consumption demand by the herring population was at least 10-fold greater than by juvenile Chinook salmon or by other salmonids for key epi-pelagic zooplankton in Whidbey Basin through South Sound. This analysis was necessarily focused on hatchery Chinook (samples were 70-80% hatchery fish). Different factors could limit wild Chinook, especially in the Skagit Basin where higher abundance, greater life history diversity strategies, availability, and use of estuarine-marine habitats offer different ecological constraints and opportunities. A methodical examination of stage-specific growth performance and survival offers a promising approach for mechanistically diagnosing the factors that limit production of specific species or stocks of salmon and steelhead. Data for the other species will be briefly summarized to highlight the current state of knowledge and critical information gaps.

Isolating growth or survival rates for specific life stages and habitats will be challenging, but important. Many marine survival estimates use SARS, but can include freshwater smolt passage and rearing. Losses during these life stages could be mistakenly lumped into marine mortality and potentially mislead management and restoration priorities. Alternative approaches such as acoustic telemetry offer spatially-explicit short term estimates of freshwater and marine survival. Each approach has strengths and weaknesses, but could be complementary. With any approach, the associated limitations and life history context must be considered to ensure we estimate what we think we are estimating and appropriately attribute responses to the correct processes.

Brian Riddell (15 minutes)

Pacific Salmon Foundation

Coho and Chinook salmon restoration within the Salish Sea: A proposal developed by the PSF

Abstract:

Abundance of Coho and Chinook salmon in the Canadian portions of the Salish Sea are presently less than one tenth of past peak levels, resulting in a ban on retention of wild Coho salmon and historically low Chinook catches. Surprisingly, the causes of these declines in salmon abundance remain poorly investigated. The Pacific Salmon Foundation has developed a proposal to investigate how to restore Chinook and Coho production and fishing opportunities, and natural ecosystems in the Strait of Georgia by significantly improving our understanding of what currently limits their production.

Given the limitations of past work, the authors of this proposal recommended that to design an effective restoration plan for these species it is essential to identify the primary mechanisms controlling production. Therefore, the proposed activities simultaneously investigate two extremes: (i) "Bottom-up" control: productivity of the marine food chain and how it is affected by changes in climate, and (ii) "Top-down" control: competition, predation, and disease acting directly on juvenile salmon. Experimental treatments include studies of hatchery production efficiency and interactions with salmon farming within lower Johnstone Strait. It was also recommended that restoration be initiated within an adaptive management framework in collaboration with local community groups around the Sea. The proposal describes an ecosystem-based, interdisciplinary plan involving government, universities, private consultants, and community and not-for-profit groups. Fourteen research and community activities are presented involving some of the newest technologies available and building on significant in-kind contributions and linkages with other research projects.

The Pacific Salmon Foundation is currently initiating a campaign to privately fund the proposal and is seeking to begin the studies over the next year. We are confident that higher levels of production are achievable, but their extent is uncertain until causation is better understood.

Michael Schmidt (15 minutes)

Long Live the Kings

A transboundary research approach to understanding the marine survival of salmon in the Salish Sea

Abstract:

Salmon and steelhead are a fundamental component of the Salish Sea ecosystem—as an indicator species; a key contributor to the food web; and a vital food, cultural, recreational, and economic resource to the region. Many stocks of Chinook, Coho and steelhead, wild and hatchery, have experienced significant declines, whereas stocks of pink and chum are stable or increasing. Effective salmon and steelhead management requires a thorough understanding of specific life stages that appear to be most critical to their survival, including the period when salmon are in the Salish Sea as juveniles. Current management and recovery efforts rely on a reasonable understanding of issues affecting freshwater productivity but are hampered by an inadequate and fragmented understanding of issues affecting productivity in the marine and estuarine environments of the Salish Sea, a period of equal importance to the survival of salmon.

Long Live the Kings and the Pacific Salmon Foundation are initiating a United States and Canada research effort, utilizing resources from both countries to evaluate salmon and steelhead marine survival from an ecosystem context. The objective of this effort is to identify the most significant issues affecting the survival of salmon and steelhead in the Salish Sea marine environment. The project includes three phases:

1. comprehensive research planning;
2. coordinated, systematic research; and
3. dissemination and application of the research results to management.

Through the Pacific Salmon Foundation, Canadian participants have developed a relevant research plan for Chinook and Coho in the Strait of Georgia. Participants from the United States are in the research planning phase for the greater Puget Sound region. Large-scale, interdisciplinary programs such as GLOBEC and the NOAA Fisheries estuarine and ocean salmon research program proposed by Brodeur et al. (2000) could provide a rough analog for the research program design, including four concurrent activities: data synthesis and retrospective analysis, coordinated monitoring, process studies and controlled experiments, and modeling and integration. Joint US and Canada workshops to discuss, compare, and coordinate research plans and coordinated US/Canada research activities will provide opportunities to collaborate, develop Salish Sea-wide sets of simultaneously collected ecological data, compare and contrast results, etc. Project facilitation and coordination will play a vital role in this multiparty, multidisciplinary effort, with scientists from various resource management agencies, academia, treaty tribes, first nations, and nonprofits involved. Communications and outreach are also important for engaging and informing the public about the salmon/Salish Sea dynamic.

Research results could ultimately be used to: identify or help prioritize management actions to increase the survival of Salish Sea wild and hatchery salmon; improve the management of hatchery-wild interactions (and interactions with farmed salmon); and improve adult salmon return forecasting and, thusly, natural spawning, harvest, and hatchery management. Ultimately, the research results and subsequent management actions may also benefit other Salish Sea marine life, such as ESA-listed southern resident orcas.

8C: Non-native and invasive aquatic species in the Salish Sea: Ecosystem impacts, status, trends, monitoring and control techniques

This session examines the important issue of aquatic non-native species in the Salish Sea. Non-native species continue to become established and to impact native species and habitats, creating a need for research, monitoring and control. Topics include the status and trends and ecosystem impacts of non-natives, including all non-native species in the Salish Sea, but concentrating on two non-native plants: *Spartina* spp. (cordgrass) and *Zostera japonica* (Japanese eelgrass).

The session describes the current state of *Spartina* infestation and control efforts in Puget Sound and British Columbia. We discuss survey methods, control techniques, and the contributions of citizen science to *Spartina* eradication. Presentation topics include the use of sea kayakers to conduct surveys, on-line tools for tracking *Spartina*, volunteer based control efforts in BC, and more.

Currently, resource agencies differ widely in their management approach toward *Z. japonica*, from requiring mitigation to a proposal to list this species as a noxious weed. There is increasing need to determine the ecosystem role of this species and set a more consistent policy response. This session will bring together students, scientists and resource managers to present recent findings and discuss the management implications of their work.

Aquatic non-native species continue to present a serious threat to the health of marine ecosystems on both sides of the border as these invaders and their seed drift in the swift currents of the Salish Sea.

Conveners: Douglas Bulthuis, Sandy Wyllie-Echeverria, Rachel Benbrook, Megan Mach, Rob Knight, Michael Hannam

PRR Facilitator: Rita Brogan

Megan Mach

University of British Columbia

Considering science in species management: A case study of the non-native seagrass, Zostera japonica

Megan Mach, Sandy Wyllie-Echeverria

Abstract:

Management of non-native species can be difficult as the relevant science needed to inform policy decisions often lags behind the occurrence and expansion of species introductions. As efforts to control or regulate non-native species transitions from a single-species focus to an ecosystem-based approach, research on the new community interactions is necessary to inform management decisions. This approach also requires resource managers to have the appropriate access to research on the species they manage. As a case study we examined some of the barriers to effectively manage a non-native species through a comprehensive bibliometric analysis of research on the Japanese seagrass, *Zostera japonica*. This species was introduced to the Northeast Pacific more than 60 years ago and currently resource agencies in Washington State, USA differ widely in management approach toward *Z. japonica*. Programs range from requiring mitigation to proposing to list *Z. japonica* as a noxious invasive weed, a decision whose outcome may entail considerable economic costs. The majority (52%) of studies on *Z. japonica* in its introduced range were executed in only two estuaries in Washington and a quarter of papers (19 of 74) were reviews of other studies. Our meta-analysis of those papers to test the impact of *Z. japonica* on species in the native community (8 studies), revealed that while the majority of its interaction effects were negative, species that were studied were primarily infaunal invertebrates, a factor that most likely biased our results. No studies have investigated the influence of *Z. japonica* expansion on migrating finfish populations or epifaunal invertebrates that are now found

within the canopy, which might be positively affected by the presence of *Z. japonica*. We suggest, therefore, that science on *Z. japonica* in its introduced range is extremely limited and management of this species should consider the paucity and bias current research when managing this species. There is an increasing need to determine the ecosystem role of introduced species to inform management. We suggest that our approach be considered in other locations where the scientific investigation of non-native species impacts, or lack thereof, has not been adequately factored into resource management programs.

Michael Hannam

University of Washington

Microtopography mediates competition between native eelgrass and non-native dwarf eelgrass

Michael Hannam, Sandy Wyllie-Echeverria

Abstract:

The Asian seagrass *Zostera japonica* was likely introduced to the Pacific Coast of North America near the beginning of the 20th century, and now ranges from British Columbia to Humboldt Bay, California. In its introduced range, *Z. japonica* sometimes co-occurs with native *Z. marina* in a patch mosaic in conjunction with intertidal microtopography. At such sites, *Z. marina* often inhabits depressions that retain water through a low tide, and *Z. japonica* often inhabits mounds that are fully exposed during low tides. Elevational surveys indicated that an index of topographic position is a significant predictor of species presence at one such in Padilla Bay, WA. To elucidate the roles of abiotic limitations and biotic interactions in this pattern, we experimentally transplanted each species, in monospecific and mixed patches, to intertidal mounds and pools. In the first year of transplantation, *Z. japonica* shoot densities were depressed in the presence of *Z. marina*, regardless of topographic position and *Z. marina* shoot densities were depressed on mounds regardless of *Z. japonica* presence. Shoot growth and morphological responses were less consistent than shoot density in the first year. These results suggest that *Z. japonica* is competitively excluded from pools and *Z. marina* is physiologically restricted from mounds. Further experiments are under way to assess the possible density dependence of *Z. japonica*'s effect on *Z. marina*.

Douglas Bulthuis

Padilla Bay National Estuarine Research Reserve

Seasonal growth of non-native and native eelgrasses on an intertidal flat in the Salish Sea

Douglas Bulthuis, Heath Bohlmann, Nicole Burnett, Monte Richardson, Suzanne Shull, Annie Walser

Abstract:

The native eelgrass, *Zostera marina*, grows on extensive intertidal and subtidal flats in Padilla Bay, Washington covering more than 3000 hectares. The non-native eelgrass, *Zostera japonica*, was accidentally introduced to the Pacific Northwest in the mid-1900's. *Z. japonica* initially became established in Padilla Bay on high intertidal flats that had been bare of macro-vegetation. Increasingly, *Z. japonica* is growing intermixed with *Z. marina*. The seasonal pattern of growth (percent cover, density, and canopy height) was measured in fixed plots in areas of single species cover of each species and in mixed meadows.

Kayi Chan

Simon Fraser University

*The effects of an invasive bivalve, *Nuttallia obscurata*, on biogeochemical cycling in the intertidal*

Kayi Chan, Leah Bendell

Abstract:

The varnish clam, *Nuttallia obscurata*, is an invasive clam species that was first reported in British Columbia (BC), Canada in the early 1990's. It is believed to have been deposited with ballast waters into Vancouver Harbour from its native habitat in Asia. It has since spread rapidly with densities reported as high as 800 individuals/m². We applied a 3-tiered approach to determine the

effects of the varnish clam on the nitrogen cycle and sediment properties. A field survey was conducted to examine the relationship between the benthic bivalve community and sediment properties (Tier 1). The effects of this invasive species on sediment characteristics were determined using mesocosms, which were seeded with varying densities of varnish clams (Tier 2). Finally, we conducted a microcosm experiment to examine how varnish clams affect ammonium flux (Tier 3). Sediment cores from Tier 1 and 2 were spliced every 3 cm to create a sediment depth profile. Each section was examined for organic matter and ammonium content. Sediment and overlying water samples from Tier 3 were examined for ammonium content. We hypothesized that we would see an increase in organic matter content due to the excretion of biodeposits by varnish clams. Subsequently we expected to see increases in ammonium content from the breakdown of biodeposits, releasing inorganic nitrogen, as well as direct release of ammonium by varnish clams as part of their excretory processes. From Tier 1, we found that there tends to be a positive linear relationship between sediment organic matter content and bivalve densities. We found that there are significantly higher levels of organic matter and ammonium content in mesocosms seeded with high densities (800/m²) of varnish clams. We confirmed that the increases in ammonium were due to the excretory processes of the varnish clams. Given that nitrogen is a limiting nutrient in marine systems and the high densities that have been reported for the varnish clam, the increases in ammonium levels seen here are of concern as they may potentially have ecosystem level impacts.

Rachel Benbrook

People for Puget Sound

Citizen science contributions to Spartina eradication in the Salish Sea

Rachel Benbrook, Rob Knight

Abstract:

This joint presentation will cover the activities of citizen science programs to control invasive *Spartina* species on both sides of the border. These salt tolerant cordgrasses have been spreading throughout the region since the 1960s, and are now found throughout the Salish Sea from Boundary Bay to Comox on Vancouver Island and south to Tacoma as well as out to Neah Bay. Citizen science and community engagement has been an important part of the nearly complete eradication of *Spartina* in Washington State, and is a major part of growing control efforts in B.C.

Janine Bond

Ducks Unlimited Canada

The BC collaborative approach to Spartina eradication – Status, challenges and next steps

Dan Buffett, Kathleen Moore, Rob Knight, Becky Brown, Kim Houghton, Janine Bond

Abstract:

Spartina anglica was discovered on the Fraser River Delta (Vancouver, British Columbia) in 2003. This invasive plant is known to have significant negative impacts on mudflats and estuaries and has been a multi-million dollar problem in Washington. There was no single agency willing to lead eradication activities for *Spartina* in BC so a multi-organizational partnership, BC *Spartina* Working Group (BCSWG), was formed to map and remove *Spartina* plants. Since 2003 the partnership has expanded in membership and geographical scope to carry out activities. Using in-kind staff time of the partnership and available but opportunistic pots of funding, the partnership has been able to prevent significant increases in the *Spartina* population. However one year of lowered program funding during 2008 to 2009, resulted in the corresponding increase in *Spartina* in subsequent years. After successive years of mapping, three species of *Spartina* (*S. anglica*, *S. densiflora*, *S. patens*) have been detected in Fraser River delta and east coast Vancouver Island with the corresponding spatial data displayed on the www.spartina.ca website. With the data mapped, the partnership has used manual removal methods using crews and equipment to dig out the plant along with various outreach activities. Along the way, several small scale pilots such as geotextile covering, volunteer based mapping and removals, and kayak monitoring has been implemented and evaluated to determine effectiveness. Building on the partnership with US

agencies in recent years, the completion of a drift card study and a BC Spartina Response plan along with the commitment of the Province of BC have also influenced the direction of the Spartina program. While funding challenges persist and restrict the success of this program, the partnerships and diverse pilot projects have fine-tuned the Spartina program with the expectation that these efforts will support the eradication of non-native Spartina by 2018 that has been set as a target by the States of California, Oregon, Washington and Province of British Columbia.

8D: Hydrologic analysis, water resources, and freshwater ecosystems in the Salish Sea watersheds I

The purpose of the session is to provide a state-of-the-science review of the water resource within the watersheds draining into the Salish Sea. This session covers topics discussing all aspects of hydrology and water resources, including analysis of flow regimes, low flow conditions, stormwater flow, flood flows, atmospheric rivers, and drought. This session also includes presentations on the effects of climate change, land cover change, development and urbanization and subsequent impacts to freshwater and estuarine ecosystems. Analytical tools can include GIS, modeling, statistical analysis, and watershed assessments.

Conveners: Paul Pickett, Markus Schnorbus, Curtis

DeGasperi, Alan Hamlet, Chris Conrad, Rajesh Shrestha
PRR Facilitator: Jamie Strausz-Clark

Markus Schnorbus

Pacific Climate Impacts Consortium
Hydro-climatic change in the Campbell River Watershed
Markus Schnorbus, Arelia Werner, Katrina Bennett

Abstract:

This study assessed potential hydrologic effects of climate change in the Campbell River watershed, a 1,200 km² basin located on eastern Vancouver Island that drains into the Strait of Georgia. This region exhibits a typical maritime climate, with cool wet winters and warm dry summers. With an elevation range that straddles the rain-snow transition zone, the Campbell River watershed currently has a hybrid rainfall-snowmelt runoff regime (wherein runoff peaks in both the fall/winter and spring), which is typical of many of the coastal watersheds draining into the Salish Sea.

Historical and future hydrology were simulated with a hydrologic model driven by climate forcings obtained from an ensemble of 23 statistically downscaled global climate projections based on eight global climate models and three emissions scenarios (A1B, A2 and B1) from the Intergovernmental Panel on Climate Change Fourth Assessment Report. Hydrologic impacts were assessed by comparing hydro-climatic variables between 30-year historical (1961 to 1990; the 1970s) and future (2041 to 2070; the 2050s) periods.

Projected changes in temperature and precipitation over south coastal British Columbia for the 2050s include higher temperatures in all seasons, a moderately wetter winter, spring and fall and drier summers. These changes will drive the regime of the Campbell River from the current hybrid state to one almost completely dominated by rainfall runoff in the 2050s. This is evidenced by a robust signal of increased runoff in the winter (more rain and less snow) and decreased runoff in the summer (less rain and reduced snow storage). Consequently, future water management in this basin will potentially require adaptation to a substantial shift in the seasonal distribution of runoff by mid-century.

Rajesh Shrestha

Pacific Climate Impacts Consortium
Hydrologic impacts of climate change in the Fraser Watershed, British Columbia
Rajesh Shrestha, Markus A. Schnorbus, Arelia T. Werner, Anne J. Berland

Abstract:

The hydrologic regime of Fraser River watershed is dominated by spring snowmelt runoff, which could be affected by changes in climate variables, especially precipitation and temperature. This study analyzed potential changes in the spatial and temporal hydrologic response in the watershed based on global climate model (GCM) downscaled and hydrologic model simulated

results. The macro-scale hydrologic model, Variable Infiltration Capacity (VIC) was employed to simulate 30-year baseline (1970s) and future (2050s) hydrologic regimes with future climate forcings derived from an ensemble of eight GCMs and three SRES emissions scenarios (B1, A1B and A2). The Bias Corrected Spatial Disaggregation (BCSD) was used to statistically downscale low resolution GCM outputs to the resolution of the VIC model (1/16° grid-scale). The resulting projections show potential change in the future hydrologic response, specifically in the snowmelt and runoff regimes. The most significant changes include higher winter and spring runoffs, lower summer runoff and shift to earlier spring freshet. Such climate-induced changes could affect the Salish Sea region with implications on fisheries, recreation and flood control. Therefore, results of this study provide stakeholders with hydro-climatic projections that can be used for adaptation in this important water resource system in the Salish Sea ecosystem.

Alan Hamlet

University of Washington

Effects of climate change on natural and regulated flood risks in the Skagit River Basin and prospects for adaptation

Alan Hamlet, Se-Yeun Lee

Abstract:

Based on GCM scenarios from the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) and subsequent hydrologic modeling studies for the Pacific Northwest (<http://www.hydro.washington.edu/2860/>), the impacts of climate change on flooding in Western WA are likely to be substantial. Many rivers draining to Puget Sound show increases in the simulated natural 100-year flood (Q100) of 20-30% by the mid-21st century. In particular, the Skagit River at Mt. Vernon, WA is projected to experience increases in natural Q100 of 30% by the 2040s, and 40% by the 2080s for the A1B emissions scenario. Although these projections clearly signal increased flood risks in the basin, water management effects will play an important role in determining actual flood risks. Under current operations, flood control storage at Ross Dam and Upper Baker dam partly mitigate the impacts of natural floods by storing a portion of the natural discharge from the headwaters during high flow events.

To assess the combined effects of increasing natural flood risks and dam operations that determine impacts to regulated floods, we have built a new integrated daily time step reservoir operations model for the Skagit basin. By running the model for historical flow conditions, and then for projected flow for the 2040s and 2080s associated with GCM scenarios, estimates of regulated flood risks for the future can be compared to a 20th-century base line. By simulating alternative reservoir operating policies that provide increased flood storage, prospects for adaptation are considered. The study examines regulated floods at Concrete and Mt. Vernon WA. Preliminary results for the ECHAM5 GCM for the 2040s and 2080s, show strongly increased natural and regulated flood risks at these river checkpoints, with regulated daily flows associated with major flood damage shifting from roughly a 10% probability of exceedance (historical conditions), to nearly 40% probability of exceedance (2040s) at Mt. Vernon. Model simulations show that alternative management strategies which would increase flood storage and/or move flood evacuation earlier in the year are unlikely to be effective at mitigating these increased flood risks in the lower basin, because A) inflow to the system from the headwaters regulated by the dams constitutes a relatively small portion of the total flow at the downstream checkpoints, and B) existing flood storage is sufficient to contain future flood flows in the headwaters. These results suggest that climate change adaptation efforts will need to focus on improved management of the floodplain to reduce vulnerability to increasing flood risk and sea level rise, rather than on reservoir operating policies intended to reduce floods.

Curtis DeGasperi

King County Water and Land Resources Division

Trends in summer low flows in King County rivers and streams: How low will they go?

Abstract:

As part of various water resource investigations and planning efforts, we have evaluated historic trends in river and stream flow. The focus of this presentation will be on the evaluation of trends in summer low flows in King County streams and rivers. There appears to be a general downward trend in summer flows in the Skykomish and Snoqualmie rivers – two relatively unregulated rivers that drain parts of the county. These trends appear to be driven primarily by decadal climate variability. This effect of this decadal climate variability can also be seen in trends in summer low flow in county creeks. A technique will be described that attempts to isolate the effect of decadal climate variability to identify more recent monotonic downward trends in summer stream flow. At least two county creeks appears to have downward trends in summer low flow since the late 1970s that appear to be the result of basin water management activities that have resulted in a net consumption and/or export of water from the basin. The same technique also indicated an upward shift in summer low flow in one county stream that appears to be the result of water management activities that resulted in a net import of into the basin. These analyses suggest that summer low flows in watersheds can be influenced either positively or negatively by water management activities. Changes in water management have the potential to improve summer low flows in those basins where declining flows have been detected.

Christopher Konrad

US Geological Survey

Network analysis of streamflow gauging in the Puget Sound Basin for monitoring stormwater quantity impacts on small streams

Abstract:

Stormwater is a significant stressor for the Salish Sea. It transports contaminants, nutrients, and sediment from the land surface to streams, wetlands, and estuaries, but also alters streamflow patterns that impact aquatic communities in these systems. US Geological Survey (USGS) in cooperation with US Environmental Protection Agency is analyzing the network of 900 streamflow gages operated by city, county, state, tribal, and federal agencies in the Puget Sound Basin to support regional coordination of stormwater monitoring as requested by the Puget Sound Partnership and the Washington State Department of Ecology. Streamflow gaging supports three distinct approaches for monitoring stormwater impacts : 1) direct and continuous measurement of impacts at a site; 2) establishment of index gages that can be used with periodic measurements at other locations to assess impacts at those locations; and 3) development of regional streamflow models to assess impacts broadly across the region. The analysis characterizes how the current network of gages functions for each of these approaches. In particular, the analysis focuses on the spatial and temporal coverage of streamflow gages and the precision and uncertainty of information developed from the current network. USGS will be working with the Puget Sound Stormwater Work Group to identify how regional coordination on streamflow gaging could improve the monitoring of stormwater impacts on small streams.

8E: Cutting edge science: improving ecosystem recovery in the US and Canada

The incorporation of scientific underpinning into management, policy and restoration strategies is an important issue facing transboundary efforts to shape a healthy Salish Sea. But what does scientific underpinning really mean? How can science guide and inform restoration, management and educational activities and influence public policy to help ecosystem recovery? This session highlights important examples of good science improving management and policy. It also discusses important ecosystem efforts underway in Washington and British Columbia and is designed to inform scientists and policy makers in Washington and British Columbia about what management practices worked or didn't work.

Conveners: Joseph Gaydos, Usha Varanasi, Jan Newton, John Stein

PRR Facilitator: Hadley Rodero

Usha Varanasi

College of the Environment, University of Washington

Bridging science and policy: Challenges and successes in Puget Sound

Usha Varanasi, John Stein, Tom Hom

Abstract:

Biological and chemical research plays a vital role in shaping management decisions that protects the health of the Nation's marine resources. This research provides the science underpinning that is necessary to make informed decisions on the management of fishery resources and the ecosystems that support them. For example, early research findings on the fate, biotransformation and effects of polycyclic aromatic hydrocarbons (PAHs) in marine fish led to development of novel methods that were used to inform managers over seafood safety concerns in the aftermath of environmental catastrophes such as Exxon Valdez and Hurricane Katrina. Research on sub-lethal effects (i.e., liver lesions) of PAHs on fish was used to gauge bioremediation efforts of the sediment capping of creosote-contaminated areas in Eagle Harbor in Puget Sound. In addition, feeding ecology studies on ESA-listed Orca whales in Puget Sound revealed that Chinook salmon, also a threatened species, is their food of choice, providing much needed information to resource managers responsible for their recovery. These case studies are successful examples of the use and application of basic research results to policy, planning, and management efforts aimed at conserving protected species.

Kathleen Wolf

University of Washington

Social science, economics and making science relevant

Kathleen Wolf, Katharine Wellman

Abstract:

The Pacific Northwest region faces urgent and large scale socio-ecological challenges – such as declining forest and Puget Sound health. Such concerns were once addressed primarily as biophysical conditions and dynamics. Yet the urbanized condition of much of the region demands co-implementation of human dimensions and social science knowledge to address ecosystem health, conservation, and recovery. The various disciplines of the biophysical sciences aid our understanding of ecological health and function at different scales, ranging from the individual organism, to populations, to inter-species interactions, then to biome based associations of species. The social sciences likewise include an array of disciplines that address human and social systems at different scales. Psychology, sociology, anthropology, economics, and political science are but a few of the social science disciplines that offer insight about human systems ranging in scale from the individual, to small groups, to organizations, to entire cultural societies, and the interactions and interdependencies across these entities. Within programs of ecosystem recovery social science is often cast as offering one of two functions, to translate biophysical science findings to educational materials for the public or to convert those findings to policy

guidelines. Yet social science offers much more to the cause, and its disciplines include long traditions of research and theory that are both directly and indirectly associated with environment and natural systems. Three general topics will be shared in this presentation:

1. It is important to clarify two major contributions of social science in ecosystem recovery. Social science can be applied as a set of indicators in order to monitor the human consequences of an ecosystem. A system of measures can be used to periodically assess the health and well being of a certain human population. Social science can also address the social change that is needed to address human effects on ecosystems. Altering the current trajectories of human behaviors and systems are often necessary for substantial ecosystem change, and social science can contribute to this large scale process.
2. There are key theories and knowledge sets that can be applied to achieve social change for ecosystem recovery. Evidence-based principles have been derived from experimental, case study, and other analytic assessments. A review of strategic applications will be provided.
3. Finally, a discussion of the theory and applications of social change for the environment will be reviewed across the scales of human systems. How might social science be applied for ecosystem recovery in ways that range across the social scales of household behaviors to institutional policy making?

The three topics will be presented with a focus on the context of Puget Sound recovery, but in a way that can be generalized to other ecosystem situations.

Robert Johnston

Puget Sound Partnership Science Panel

Indicators, targets, and monitoring: Developing a dashboard of vital signs for ecosystem recovery

R. Johnston, J. Newton, J. Gaydos, B. Labiosa, P. Levin, S. Redman, J. Becker, N. Hamel, K. Dzinbal, R. Duff

Abstract:

The Puget Sound Partnership is a coalition of elected officials, state and federal agencies, Tribes, local jurisdictions, nongovernmental organizations, academic institutions, and the private sector that are working together to design a healthy Puget Sound. In response to a legislative mandate and the need to monitor progress they have identified ecosystem recovery goals, selected indicators, defined targets, and are implementing an Action Agenda to achieve recovery by 2020. Six ecosystem recovery goals include a robust food web with sustaining populations of native species; restored and protected upland, freshwater, estuarine, near shore, and marine habitats; water resources to sustain people, fish, wildlife, and natural functions; water and sediment quality safe for drinking, swimming, seafood harvesting, and protective of mammals, fish, birds, and shellfish of the region; healthy human populations; and a quality of life that is sustained by a functioning Puget Sound ecosystem. Dashboard indicators were selected for important ecosystem attributes from measures of ecosystem status, ecosystem stress (drivers, pressures, and impacts), and each were assigned ecosystem recovery targets. Based on current knowledge of the natural and social science about the Sound, the indicators selected are regularly updated measures that are sensitive enough to provide an early warning of negative trends. The indicators also reveal the status of key attributes of the ecosystem's natural and human dimensions that provide snapshots of the overall health of the Sound, evaluate new and ongoing management strategies, and resonate with the public as the most relevant measures of Sound-wide success. The selected dashboard indicators include natural system indicators of marine and fresh water quality, water availability, toxics in sediment and biota, dissolved oxygen in marine waters, and the status of eelgrass, Chinook Salmon, southern resident killer whales, Pacific Herring, upland birds, and benthic invertebrates in small streams; and human well-being indicators of acres of shellfish beds reopened, water quality at swimming beaches, and recreational fishing license

sales. Additionally pressure indicators were established, including shoreline armoring, land development, land-use and -cover, restoration and development along estuaries and flood plains, and discharges from waste water and on site treatment systems; and program indicators for funding and progress on the Action Agenda. Indicator champions lead the development of ecosystem recovery targets for the indicators by involving experts and stakeholders in a consensus building process to define the expected conditions needed to provide a functioning, resilient ecosystem. The final targets are policy statements reflecting the commitment and expectation of achieving the desired recovery goals. Concurrently, ecosystem monitoring goals and objectives needed to assess data gaps, advance scientific understanding, and inform adaptive management were developed to guide implementation strategies. Accurate, timely, and comprehensive monitoring and assessment data are absolutely critical for implementing an adaptive management program for Puget Sound protection and recovery as required by the enabling legislation. Remaining challenges include identifying the priority and sequence of recovery actions, building capacities and allocating resources effectively, coordinating and aligning local and regional initiatives, and providing effective outreach to engage concerned citizens and the general public.

Rod Dobell

Centre for Global Studies, University of Victoria

Web-enabled platforms in integrated coastal and marine spatial planning around the Salish Sea

Rod Dobell, Justin Longo, Jodie Walsh

Abstract:

Ocean observatories such as NEPTUNE Canada (www.neptunecanada.ca) are now generating a firehose of observations from the ocean floor. Social media are generating a torrent of text around public policy decisions-- for example, in marine spatial planning-- that must be informed by evidence drawn from the data flowing from such observatories. But there are not enough scientists or graduate students in the world to extract the relevant information from the accumulating database. Software agents must do most of the initial work. Nevertheless, in some tasks, such as pattern recognition in visual images, humans can still perform better than computers. This presentation will survey briefly some of the tools and techniques that will be used in a Web2.0 and Web3.0 world to respond to the challenge of making sense of an accelerating accumulation of data and a rising torrent of text for purposes of integrated marine spatial planning to promote marine ecosystem integrity. Specifically, it outlines the deployment of Digital Fishers (www.digitalfishers.net), a web interface to recruit volunteers to tag images from video clips for purposes of enriching the massive DMAS database serving VENUS and NEPTUNE Canada. But also, like comparable initiatives within the Zooniverse platform (www.zooniverse.org), Digital Fishers reaches out to engage those outside the research community in scientific undertakings. The conclusion is that deployment of Digital Fishers, perhaps through Zooniverse as well as within Oceans 2 (www.neptunecanada.ca/o2), can bring oceans issues and the challenges of managing human activity for reduced degradation of marine ecosystems to a broader public, and can also offer, through supporting tutorial activities, new learning opportunities leading to more informed public involvement in marine spatial planning, particularly in cross-border settings.

The Salish Sea is a semi-enclosed international sea, a transborder region in which economic relations and cultural ties (especially for the First Nations and tribes who make up the Coast and Straits Salish peoples) reach across jurisdictional boundaries in all kinds of ways. For at least a couple of decades people have recognized this cross-border bioregion as a natural ecosystem crying out for integrated management and collaborative coordination of human activities having continuing impact on habitat degradation and ecosystem function. It can be seen as an illustration of the increasing pressures arising out of the twin needs to deal with the above-mentioned growing firehose of observations and torrents of text in the development of public policy generally and the stewardship of marine resources in particular.

Nat Scholtz

NOAA Fisheries - Northwest Fisheries Science Center

Science to identify stormwater impacts on salmon: A long-term research strategy for copper
David Baldwin, Jen K. McIntyre, David A. Beauchamp, Nathaniel L. Scholz

Abstract:

Non-point source pollution in the form of stormwater runoff is becoming an increasingly difficult challenge for resource managers working to maintain and restore the health of Salish Sea watersheds. Everyday human activities release toxic chemical contaminants across landscapes, which are then mobilized by rainfall and transported to river networks and other aquatic habitats. One facet of the challenge is the large number of chemicals in runoff; motor vehicles alone emit dozens of different metals and petroleum hydrocarbons. Another facet is the diversity of aquatic species potentially at risk. Yet another facet is the problem of biological scale. Whereas toxics alter biological processes at the suborganismal molecular and cellular levels, resource decision making is commonly at the scales of populations, species, communities, and ecosystems.

Limited scientific resources and the factorial complexity of the stressor-response relationship reinforce the need for strategic, targeted research on stormwater impacts. This includes a focus on 1) priority contaminants that are representative of broad categories of land cover and human land use; 2) species that are particularly good sentinels for ecological function and integrity in aquatic habitats; and 3) linkages across biological scales, from the molecular to the population and beyond.

This presentation will review a decade of NOAA research on copper. Copper is a ubiquitous contaminant in urban runoff, in part due to use of the metal in building materials and vehicle friction materials such as brake pads. We have shown that salmon are vulnerable to the toxic effects of copper at low, environmentally relevant concentrations. Copper interferes with the responsiveness of olfactory receptor neurons in the salmon nose, thereby disrupting olfaction and olfactory-mediated behaviors such as predator detection and avoidance. This, in turn, increases mortality when juvenile salmon encounter predators. Finally, recent modeling indicates that juvenile losses can limit the productivity of wild salmon populations. These collective findings will be discussed in the context of science communication, recent toxic source reduction strategies, and new research on the effectiveness of low impact development strategies.

Michael Ford

Northwest Fisheries Science Center, National Marine Fisheries Service
Science in support of conservation: Killer whale research in the Pacific Northwest

Abstract:

The Salish Sea waters host several populations of killer whales (*Orcinus orca*), including the endangered Southern Residents. These killer whales are an important top predator in the marine ecosystem, contribute to its biodiversity and bring socioeconomic benefits to the region. Their presence in a populated urban area and their cultural importance has generated substantial public interest in their well being. Starting in 2003, the Northwest Fisheries Science Center (NWFSC) received funding to conduct research to aid the conservation and recovery of the Southern Resident killer whale population. Between 2003 and 2006, the NWFSC, Washington Department of Fish and Wildlife and the Canadian Department of Fisheries and Oceans jointly sponsored a series of workshops and symposia to help determine priorities for research on the Southern Residents. This talk discusses how NMFS funded research has been used to influence recovery actions for this endangered population.

8F: Transboundary Monitoring Partnerships

The environmental assessment for the Boundary Bay watershed has historically been undertaken by government agencies, First Nations and non-government organizations working individually on specific monitoring initiatives. Beginning in 2009, the Boundary Bay Assessment and Monitoring Partnership was developed in consultation with the Puget Sound Partnership. The purpose was to create a collaborative partnership approach to environmental monitoring that would strengthen the coordinated and cooperative approach on the Canadian side and also would have regard for the transboundary nature of this watershed.

Since the formation of this collaborative partnership approach, the various government agencies in Washington State and British Columbia have worked closely in establishing comprehensive integrated water quality monitoring programs that are coordinated within the context of the agencies mandates; in consultation with First Nations and using the volunteer contributions of the non-governmental environmental agencies.

The intent of this working session is to discuss our monitoring programs, means of improving our collaboration, and facilitating the transfer of the knowledge to all partners, including First Nations and NGO's. This will be accomplished through the participation at the session of the partnership members.

Conveners: Jim Armstrong, Ken Dzinbal
PRR Facilitator: Mike Rosen

Julie Hirsch

Hirsch Consulting Services and Nooksack Indian Tribe
Drayton Harbor TMDL Support Project: Drayton Harbor Mouth and Semiahmoo Bay
Julie Hirsch, Llyn Doremus, Geoff Menzies

Abstract:

To augment the Washington Department of Ecology's Drayton Harbor Total Maximum Daily Load study, the Nooksack Indian Tribe funded the collection of additional data from the waters surrounding the mouth of Drayton Harbor between June and December 2009. Potential bacteria sources were evaluated using data collected in the vicinity of the mouth of the Drayton Harbor and along the shoreline of Semiahmoo Bay northward to the Canadian border. The study was conducted in three components:

1. Six shoreline surveys along the Semiahmoo Bay shoreline from the Canadian border South to Blaine Harbor and along Semiahmoo Spit. Freshwater inputs were sampled including Cain Creek, storm drains and other small freshwater discharges.
2. Near shore marine sampling was conducted during five flood tides starting at the border monument to the mouth of Drayton Harbor. Samples were collected for analyses intermittently along the drogue paths.
3. Marine sampling was conducted during five ebb tides and followed drogues deployed at the mouth of Cain Creek. All samples were analyzed for fecal coliform bacteria content.

A subset of samples was analyzed for *Bacteroides* biomarkers using host specific polymerase chain reaction (HSPCR) analysis by the EPA Region 10 (Manchester) Laboratory. Presence of human and ruminant markers was widespread in fresh and marine waters and marked by significantly higher occurrence than observed in phase 1 and 2 of MST study completed in the Drayton Harbor and the upper watershed in 2006 and 2008. From a total of 12 sites, human biomarkers were identified at 11 locations with multiple detections at 10 sites. Ruminant biomarkers were found at 11 sites with multiple detections at 9 locations. Fecal sources present

were correctly identified in 3 blind positive control samples by the EPA laboratory. Maps show site locations and illustrate drogue tracks, fecal coliform bacteria densities and Bacteriodes identifications. Ebb tide drogue studies indicated that high bacteria loading from Cain Creek is likely to impact water quality in the eastern near-shore of Semiahmoo Bay and that Department of Health Station 15, which is used for shellfish growing area classification in Drayton Harbor, could be negatively impacted by the Cain Creek outflow. Flood tide results, demonstrated movement of drogues and floats south and east from the Canadian border toward the mouth of Drayton Harbor. Although drogues and floats did not enter Drayton Harbor, under certain wind and high tidal exchanges, high loads from the Little Campbell River are likely to impact Drayton Harbor consistent with Hay Study findings.

Project results were presented to a technical work group of agencies, including representatives from Canada, as a focal point to generate ideas for corrective actions to improve water quality in shared waters. These recommendations are presented including a prioritization based upon study results to assist in guiding corrective actions. Study data are used in the TMDL and recommendations will be reviewed by the Drayton Harbor Shellfish Protection District (DHSPD) advisory committee for incorporation into their Drayton Harbor Status Report and Water Recovery Plan.

Jim Armstrong

Metro Vancouver

Boundary Bay Assessment and Monitoring Program - "A Model for transboundary monitoring partnerships"

Jim Armstrong, Erin Riddell, Liz Freyman, Dennis Barlow, Lauren Petersen, Carrie Baron

Abstract:

Historically, environmental monitoring of receiving waters has been undertaken exclusively by various government agencies for the purpose of determining the effects of pollutants from various discharge sources. Each agency would design their specific monitoring program in isolation from other agencies and without collaboration with either affected First Nations or community environmental non-government organizations. These monitoring programs could continue on an annual basis for many decades without the knowledge being shared and discussed with the other involved parties.

This approach has also been prevalent in the monitoring of shared waters between the United States and Canada; each country has undertaken distinct environmental monitoring program within the confines of their territorial waters. A change to this approach was initiated in 2008 through the development of a partnership that involved all levels of government, First Nations and involved environmental non-government community organizations. As a second step in the development of the partnership, the Puget Sound Partnership (PSP) was approached to develop a collaborative partnership between the USA and Canada as a means of assessing the transboundary area of the Boundary Bay watershed.

The Boundary Bay Assessment and Monitoring Program (BBAMP) was formalized in 2009 using a multi-level partnership approach with one level consisting of the various Canadian government agencies responsible for conducting environmental management within Boundary Bay. This partnership is comprised of federal, provincial, regional and local levels of government who had previously undertaken water quality and upland environmental monitoring strictly related to their individual mandate. The PSP and BBAMP have worked collaboratively to develop the goals and objectives for the Boundary Bay Partnership as a means of ensuring that the monitoring standards are representative of the watershed, and are usable by all partners.

The majority of the government agencies have been working collaboratively with First Nations on specific environmental issues that have affected their historic and cultural well-being. Through the BBAMP, the cultural knowledge that First Nations is recognized as an important value in the assessment of the ecosystem and brings additional technical knowledge through the

transboundary association between the First Nations within the Salish Sea. The issues surrounding water quality are critical to the cultural shellfish harvesting that the various first Nations groups are exploring.

Further partnering has been undertaken by the BBAMP through the Shared Waters Alliance, which is a transboundary collaborative of government agencies, First Nations, environmental non-government community organizations and specific user groups. Each of the NGOs which participate in the Shared Waters Alliance participate in the overall Boundary Bay partnership; bring considerable technical and community knowledge and provide additional resources to the Partnership.

Joanne Charles

Semiahmoo First Nation

Aboriginal rights, food security and water quality - A call for a rational international policy

Joanne Charles, Mark J. Duiven

Abstract:

Semiahmoo First Nation enjoys inherent aboriginal rights as provided for in the Canadian Constitution (s.35.1). Semiahmoo First Nation interprets these rights to include the right to food security and the ability to practice their traditional economic activity.

Despite these rights, the Nation cannot harvest bivalves for food from the foreshore of their territory in Boundary Bay because of fecal coliform contamination. No Canadian or US jurisdiction has meaningfully applied controls or standards to remediate this situation, even though Semiahmoo sits literally on the 49th parallel and their territorial waters extend into both countries. This situation has been acute and on-going for more than 20 years.

The paper explores that nature of the contamination and considers that legislative and policy gaps that inhibit the remediation of the water quality in Boundary Bay. In so doing, Semiahmoo calls for a rationalization of local, provincial, federal and international policy and legislation to facilitate the clean up and allow the Nation to exercise its right to food security.

Erin Riddell

Corporation of Delta

Boundary Bay Assessment and Monitoring Program - Monitoring programs

Erin Riddell, Jim Armstrong, Metro Vancouver; Liz Freyman, BC Ministry of Environment

Abstract:

In the past, the United States and Canada has undertaken distinct environmental monitoring programs within the confines of their territorial waters. A change to this approach was initiated in 2008 by Metro Vancouver as a means of meeting its obligations under its Liquid Waste Management Plan (2002) that “requires monitoring of relevant receiving waters” through the development of a partnership, under the Sustainable Regional Initiative’s guidance to be collaborative, that involves all levels of government within Canada, First Nations and environmental non-government community organizations. The Puget Sound Partnership (PSP) was approached to develop a collaborative process of sharing environmental monitoring data for the Boundary Bay watershed between the USA and Canada. This partnership provides a means of co-ordinating individual environmental monitoring under a single comprehensive multifaceted program and allows for the comparison between individual monitoring efforts in the upland freshwater and the marine water environments providing a larger comprehensive watershed overview.

The purpose of the BBAMP is to establish baseline measures, assess the current water quality status of the watershed and identify any seasonal or temporal trends in any of the variables measured that might affect environmental quality. A 5 –yr monitoring plan comprised of fresh and marine water column sampling biannually, sediment sampling biennially, and one session of

marine biota sampling was developed and is being carried out by the working group partners. The smaller working group consists of Metro Vancouver, BC Ministry of Environment, the City of Surrey, the Corporation of Delta, the Corporation of the City of White Rock, and BC Hydro.

Using applicable sampling protocols over 800 water column samples were taken from 42 strategically chosen monitoring sites throughout the watershed during the dry and wet weather monitoring periods over 2009 and 2010. Each water column monitoring period consisted of one sample taken per week for five weeks. One sediment sample was taken at each marine monitoring site and in the three tributaries to the bay (1 at the mouth and 1 further upstream) in 2010. Data analysis focused on temporal trends per site while looking at a downstream migration of contaminants.

Preliminary analysis of the data indicate that most of the parameters monitored in the marine environment were measured either below the detection limit or predominantly met the applicable guidelines. In several instances, concentrations of some metals and most bacteriology parameters in the freshwater environment were elevated above the applicable guidelines.

By working in a collaborative partnership, the program has benefited from the range of expertise provided by each agency which is used to support the individual monitoring programs. Partners have also been able to develop internal expertise through their experience of working on the program. The results obtained through BBAMP provide a focus on areas of concern where partners can direct follow-up actions or ancillary monitoring programs in efforts to address or pinpoint the concerns.

Michael George

Tsleil-Waututh Nation, Treaty, Lands and Resources Department
Tsleil-Waututh Nation Marine Stewardship Program of the Territorial Waters
Ernie George, Jay Forsyth, Evan Stewart, Bridget Doyle

Abstract:

The Tsleil-Waututh, meaning “People of the Inlet”, have occupied their traditional territory since time out of mind, encompassing the lands and waters of the Salish Sea, Burrard Inlet, and Indian Arm. Many origin stories and legends are set along the shores of the Inlet. Historically, the Tsleil-Waututh people were sustained entirely on the plentiful natural resources of the Inlet and surrounding watersheds. However, Tsleil-Waututh community members can no longer eat from or bathe in the traditional waterways due to environmental degradation. A key goal of the Tsleil-Waututh Nation (TWN), through monitoring partnerships, is to gain a better understanding of what is causing the decline in marine health and forge a path for restoration and revitalization of the Inlet.

To achieve this goal, Tsleil-Waututh completed a comprehensive Marine Stewardship Program and began implementation in 2006. A key component of this successful implementation was the establishment of a number of positive, collaborative relationships with private and government agencies based on common goals. Specific partnerships include Environment Canada (EC), Health Canada, and Indian and Northern Affairs Canada (INAC). These partnerships have facilitated monitoring programs that include marine water quality sampling (TWN in association with EC), bi-valve tissue and sediment sampling (TWN in partnership with Health Canada), and surface water quality monitoring (TWN and INAC).

Tsleil-Waututh strives to nourish these important relationships while exploring new partnerships that will expand and strengthen the Nation’s presence and leadership in marine stewardship and restoration in the territory.

Looking to the future, Tsleil-Waututh plans to build on the current Marine Stewardship Program and ongoing monitoring and sampling programs. More progressive and creative approaches to monitoring and restoring Burrard Inlet will be initiated by TWN in association with a variety of

partners. Additional goals of the Tseil-Waututh Marine Stewardship Program include the establishment, sharing, and continued monitoring of important baseline information, engaging community members in restoration projects, re-establishing healthy marine populations to harvest for consumption and cultural purposes, and securing environmental mitigation projects or compensation from those responsible for the immediate and gradual degradation of the Inlet.

To assist with gathering support and awareness for this ambitious program, Tseil-Waututh will be releasing a Marine Bioregional Atlas in the fall of 2011. The Marine Atlas will provide a comprehensive display of biophysical and cultural components of Tseil-Waututh territorial waters.

Valerie Partridge

Washington State Department of Ecology

Status and trends in sediment quality in the southern Strait of Georgia

Valerie Partridge, Ed Long, Sandra Weakland, Kathy Welch, Margaret Dutch

Abstract:

A survey of sediment quality in the embayments adjoining the southern Strait of Georgia was conducted in 2006 by the Washington State Department of Ecology as part of the Puget Sound Assessment and Monitoring Program (PSAMP). Sediment quality was intermediate to high throughout the region. Chemical contamination and toxicity tended to be low. Benthic invertebrates, however, were adversely affected in almost half of the study area. Compared to a decade earlier, contamination and toxicity trends were mixed. In contrast, the proportion of study area with adversely affected benthos increased significantly. Conditions in Bellingham Bay and Boundary Bay dominated the region.

The primary objectives of this 2006 study were to determine sediment quality:

1. Degradation: geographic patterns, incidence, and spatial extent.
2. Changes that occurred between 1997 and 2006.

Samples of the surficial sediments were collected at 40 locations selected randomly according to a statistical design that enables the estimation of spatial extent of degraded environmental conditions. Analyses were performed on all samples to determine the concentrations of potentially toxic chemicals, the degree of response in three laboratory toxicity tests, and the composition of benthic invertebrates. These results were combined into the Sediment Quality Triad Index, which characterizes sediments on a 4-level scale from high quality to degraded.

The results of the 2006 survey indicated that of the 40 stations:

- No sediments were classified as contaminated (i.e., no samples had chemical contaminant concentrations higher than the Washington Sediment Quality Standards).
- Seven had toxic responses in at least one of three laboratory toxicity tests. The "toxic" samples were from Boundary Bay and Bellingham Bay.
- Nineteen had adversely affected benthos: 15 in Bellingham Bay, three in Boundary Bay, and one in Birch Bay. The benthos were considered to be adversely affected if they were judged to have a combination of reduced total abundance, reduced species diversity, decreased abundance of stress-sensitive species, and increased abundance of stress-tolerant species.
- Sediment Quality Triad Index results:
 - Sediment quality was classified as high (no contamination, toxicity, or adversely affected benthos) at 19 stations.

-None of the area had degraded quality sediments (all three triad elements indicating degradation).

-The remaining stations were intermediate in quality: 16 intermediate/high (one triad element degraded) and five intermediate/degraded (two triad elements degraded).

Sampling and analytical methods were similar or identical to those used previously by a joint Ecology-NOAA survey conducted in this region in 1997, allowing comparisons to the 1997 results:

- The percentage of area exceeding Sediment Quality Standards (SQS) decreased from 10% in 1997 to 0% in 2006, whereas the mean ratio of contaminant concentrations to SQS increased slightly.
- The percentage of area that was toxic in one test increased from 1997 to 2006, whereas it decreased in another kind of test.
- The proportion of area with adversely affected benthos increased from 15% in 1997 to 44% in 2006.
- High quality sediments decreased from 76% to 56% of the study area; intermediate quality sediments increased from 24% to 44% of area.

10:00 am - 10:30 am
Morning Break

10:30 am - 12:00 pm

9A: Eutrophication and hypoxia in the Salish Sea II

Coastal eutrophication is a growing environmental problem impacting coastal waters. Anthropogenic nutrient inputs lead to increased incidents of hypoxia. Critically low concentrations of dissolved oxygen have been identified in the Salish Sea (e.g., Saanich Inlet, Hood Canal, Budd Inlet) and hypoxia appears to be an emerging feature of many smaller embayments and bottom waters. Despite eutrophication and hypoxia being important environmental stressors and indicators of anthropogenic and climatic impacts on coastal systems, many questions remain, including:

What is the spatial and temporal extent of hypoxia in Salish Sea waters? What are the primary sources of nutrients to the Salish Sea and how do they vary across space and time? What are in situ, climatological, and watershed-scale drivers of hypoxia? What capacity exists to model both short- and long-term changes in bottom-water hypoxia? What are long-term consequences of hypoxia on the Salish Sea ecosystem? What management and policy responses are available to reduce the likelihood of eutrophication and chronic hypoxia?

This session provides an improved, transboundary picture of hypoxia and eutrophication across the Salish Sea; provides valuable insight into the response to climate change; allows sharing of innovative management approaches, and fosters discussion across the scientific and management communities to help direct and organize current and future efforts.

Conveners: Jan Newton, Jude Apple, Andrew James, Joel Baker, Ken Denman, Duane Fagergren, Julie Horowitz, Christopher Krembs

PRR Facilitator: Kimbra Wellock

Jude Apple

Shannon Point Marine Center (WWU) / Northwest Indian College

Oxygen and nutrient dynamics in Bellingham Bay: Spatial and temporal patterns in seasonal hypoxia

Jude Apple, Joel Green, Charlotte Clausing, Northwest Indian College

Abstract:

Hypoxia is an emerging feature of critical concern in many coastal and marine ecosystems, including fjords and embayments of the Salish Sea. Several years ago, evidence of hypoxic bottom waters in Bellingham Bay (Bellingham, WA) prompted a collaborative effort between Northwest Indian College (NWIC) and Western Washington University (WWU) to monitor dissolved oxygen concentrations and investigate potential drivers of hypoxia in this system. A primary objective of this project was to create a research-platform for providing students with an inquiry-based, hands-on experience in marine science and water quality research. Since 2008, this project has served over a dozen students from a range of research-oriented educational programs, including NSF and USDA funded REU programs at NWIC and the NSF-funded REU and MIMSUP (Multicultural Initiative in Marine Science Undergraduate Participation) programs at Shannon Point Marine Center. Collectively, these students and their research have provided valuable insight into oxygen and nutrient dynamics in Bellingham Bay. Their work has revealed an area of low dissolved oxygen in central Bellingham Bay that returns predictably each summer and identified that marine inputs of inorganic nutrients make a much larger contribution to the nutrient budget than originally thought. Historical data indicate that bottom water hypoxia may be a natural feature of this ecosystem, although more recent data indicate that the intensity and frequency may be increasing. The Bellingham Bay hypoxia and water quality study provides a model for engaging Native students in relevant, place-based research and has become an important part of Native Environmental Science program at Northwest Indian College.

Tarang Khangaonkar

Pacific Northwest National Laboratory

Development of a biogeochemical model of Salish Sea, simulations of nutrient balance, algae, and DO

Tarang Khangaonkar, Taeyun Kim, Zhaoqing Yang, Brandon Sackmann, Mindy Roberts, Ben Cope

Abstract:

Puget Sound, a fjordal estuary located in the Pacific Northwest of U.S., receives substantial loading from rivers, nonpoint source runoff, and discharges from nearly one hundred wastewater and industrial outfalls. Nutrient pollution is considered a potential threat to the ecological health of Puget Sound causing hypoxia in some basins and there is considerable interest in understanding the effect of nutrient loads entering Puget Sound. The Puget Sound water quality model developed to address this concern uses the unstructured grid Finite Volume Coastal Ocean Model (FVCOM) framework and the CE-QUAL-ICM model biogeochemical water quality kinetics. A total of 19 state variables, including two species of algae, dissolved and particulate carbon, and nutrients, are included to calculate primary production and the impact on dissolved oxygen (DO). Results based on calibration to 2006 data showed that the model generally captures observed patterns phytoplankton growth and die-off, succession between two species of algae, nutrient dynamics, and surface water DO in Puget Sound. Nutrient and DO concentrations in the Puget Sound water column below the pycnocline reflect Pacific Ocean water, which enters Puget Sound at depth over the Admiralty Inlet sill. The concentrations in the mixed outflow layer occupying approximately 5-20 m of the upper water column correspond to the exchange flow diluted/mixed with the freshwater discharges from the rivers and show effects of primary production and algal dynamics. The model parameterization was able to simulate important system features such as two peaks in phytoplankton growth including the spring bloom of diatoms and larger summer bloom of dinoflagellates observed in 2006. In many shallow areas, surface algal production was shown to deplete nutrients but contributed to DO levels that exceed 10 mg/L. The bottom layer of Puget Sound however showed a steady reduction of DO through most of the year reflecting nutrient rich low DO up-welled water entering the Puget Sound from the Pacific Ocean and the Strait of Juan de Fuca. By November and December, the low DO waters at the bottom, along with other water column constituents of interest, were flushed out and renewed with wintertime Pacific Ocean water that contained higher DO. While the initial model results are encouraging, model error analysis, uncertainty, and evaluation of potential areas of improvement are in progress.

Mindy Roberts

Washington State Department of Ecology

Are human contributions decreasing dissolved oxygen in the Salish Sea?

Mindy Roberts, Andrew Kolosseus, Brandon Sackmann, Greg Pelletier

Abstract:

Under the Clean Water Act, the Washington State Department of Ecology manages water quality throughout Puget Sound and the Straits of Georgia and Juan de Fuca. Scientists have measured low levels of dissolved oxygen in many parts of Puget Sound. Low oxygen levels can stress aquatic life. Since natural processes also induce low oxygen levels, our challenge is to distinguish the human contribution. Human nutrient loads from treated wastewater discharges or through nonpoint source pollution can spur algae growth beyond natural levels. Because organic matter decomposition takes up oxygen, human nutrient sources may be responsible for some oxygen depletion. The Washington State water quality standards establish stringent limits on human influences in particularly sensitive areas such as Budd Inlet and South Puget Sound.

Ecology manages three different projects addressing sources of low dissolved oxygen levels at nested spatial scales.

1. Budd Inlet, near Olympia, has the lowest levels of dissolved oxygen outside of Hood Canal. Ecology is in the final stages of developing a computer model of the processes affecting dissolved oxygen in Budd Inlet, including naturally low circulation and human

nutrient sources. The results will be used to establish reduction targets for both point and nonpoint sources of nitrogen. The targets will be used in future wastewater and stormwater permits.

2. South Puget Sound, west of the Tacoma Narrows, also experiences low dissolved oxygen levels. No large population centers or treated wastewaters discharge to Carr and Case Inlets, where low levels occur. A primary question is the extent to which human sources further away influence oxygen levels in these and other areas of South Puget Sound. The first step is to identify areas of influence of the different sources and whether those sources cause violations of the water quality standards. If nutrient reductions are needed, then the next step is to identify load reduction targets by source.

3. Other areas of Puget Sound, including Whidbey Basin, Hood Canal, and other small bays, also experience low levels of oxygen. We are working with the Pacific Northwest National Laboratories to develop a circulation and water quality model of the Salish Sea. This tool will be used to understand the relative contributions of human and climate influences on dissolved oxygen levels now and into the future. A fundamental question is whether low oxygen measurements indicate discrete problem areas or whether there are Salish-Sea wide processes that can be addressed.

We will provide an overview of the science and tools we use to assess whether and how much human nutrient source cause violations of the water quality standards. We will also describe how we manage human point and nonpoint nutrient sources in the Puget Sound ecosystem.

45 min Facilitated Panel Discussion
Moderated by: Julie Horowitz

Panelists:

Tom Eaton

Director, EPA Washington Office

David Herrera

Fish and Policy Director, Skokomish Indian Tribe

Kenneth Denman

Venus Coastal Network

9B: Life history and ecology of salmon: Implications for management and conservation in the Salish Sea

Management and conservation of salmon populations in the Salish Sea will require detailed information about how salmon interact with their environment at local, regional, and coast-wide scales. This session's talks are ordered along a range of increasing spatial scales to provide examples of current research. The studies assess the influence of climate change on salmon in freshwater systems, effects of early life history variation on marine survival, variation in spatial distribution and habitat use, the importance of neritic food webs, and factors affecting productivity along the entire west coast of North America.

Convener: Sandie O'Neill

PRR Facilitator: Kirsten Hauge

Randall M. Peterman

Simon Fraser University

A widespread decrease in productivity of sockeye salmon on the west coast of North America

Randall M. Peterman, Brigitte Dorner

Abstract:

To set the context for learning more about possible causes of the reduced abundance and productivity of Fraser River sockeye salmon over the last decade, we obtained long-term data sets on abundance of spawners and their resulting adult recruits for 64 populations of sockeye salmon from Washington state, Alaska, and British Columbia, including 19 from the Fraser River. We then estimated time trends in productivity for each stock to determine whether the Fraser River's situation is unique, or whether other sockeye populations have suffered the same fate. We also obtained freshwater time-series data on fry or smolt abundances for 24 sockeye populations to help determine whether the long-term decline productivity arose from causes mainly in fresh water or the ocean. We used three measures of productivity: 1) number of adult returns per spawner, 2) residuals from the best-fit spawner-recruit relationship to reflect effects of environmental factors, and 3) an extension of the second index that uses a Kalman filter to remove high-frequency year-to-year variation in productivity to clarify long-term productivity trends. We compared time trends for these three productivity measures across all Fraser River and non-Fraser sockeye stocks using correlation analysis, Principal Components Analysis, and clustering.

We found that most Fraser (with a notable exception being the Harrison River sockeye stock) and many non-Fraser sockeye stocks, both in Canada and the U.S.A., show a decrease in productivity, especially over the last decade, and often also over a period of decline starting in the late 1980s or early 1990s. Thus, declines have occurred over a much larger area than just the Fraser River system and are not unique to it. Specifically, a downward trend in productivity that started in the late 1990s for most Fraser River sockeye stocks is similar to trends shown by sockeye stocks from Puget Sound (Lake Washington), Barkley Sound on the west coast of Vancouver Island, the B.C. Central and North Coasts, Southeast Alaska, and the adjacent Yakutat peninsula in Alaska. Analyses of juvenile data indicated that declines occurred primarily in the post-juvenile stage. The observation that productivity has followed shared trends over a much larger area than just the Fraser River system is an important new finding. In contrast, productivities of western Alaskan sockeye populations have generally increased, not decreased, over the same period.

These results suggest that there may be shared causal mechanisms for declines across the west coast, not just in the Salish Sea. Mechanisms that operate on this larger, regional spatial scale, and/or in places where a large number of correlated sockeye stocks overlap, should be seriously examined by researchers. Examples of such large-scale phenomena include (but are not limited to) increases in predation by marine mammals and fishes, climate-driven increases in pathogen-

induced mortality, or reduced food availability due to oceanographic changes. Further research is required to draw definitive conclusions about the relative influence of such processes, but such research must be strongly coordinated across jurisdictions and agencies along the entire west coast.

Dave Beauchamp

USGS-UW: Washington Cooperative Fish & Wildlife Research Unit, University of Washington, School of Aquatic and Fisheries Sciences

Pelagic food web ecology in Puget Sound: Competition and predation effects on growth and survival of juvenile chinook salmon

Dave Beauchamp, Elisabeth J. Duffy, and Iris Kemp

Abstract:

Recent evidence for strong size-selective marine survival in relation to variable feeding and growth of ESA-listed Chinook salmon highlight the importance of the critical early juvenile rearing period in the pelagic zone of Puget Sound. Over the last decade, inter-annual, seasonal, and regional differences in growth were primarily attributed to differences in feeding rate (a surrogate for food supply or access to food). Much of the variability in pelagic feeding rate corresponded directly to the variable contribution of crab larvae, insects, and amphipods in the energy budget of juvenile Chinook. The observed high, but variable feeding rate, coupled with strong size-selective mortality, suggests that competition could affect growth during pelagic rearing, and thus reduce overall marine survival, as measured by smolt-to-adult returns (SARs). We examine the potential importance of competition within and among Chinook, other species of salmon, and herring. During the critical summer growing season, herring dominated the biomass of the shallow pelagic planktivorous fish community, and exhibited extensive diet and spatial overlap with juvenile Chinook and other salmon. A bioenergetic analysis indicated that herring consumed 10-47 times more biomass of the key prey resources than were eaten by Chinook salmon during the critical early marine growth period. These results suggest that any assessment of marine carrying capacity will need to account for the population and feeding dynamics of all major daylight planktivores, especially herring. Bioenergetics simulations suggested that population-level consumption by ages 1 and older resident Chinook salmon could potentially account for 50-60% mortality of the hatchery and wild Chinook smolts entering the marine environment each year. Determining factors that affect growth performance during this critical period and the consequent influences on mortality during subsequent life stages will inform managers and researchers about the role of the Puget Sound food web in supporting production and survival of Chinook and associated pelagic species.

Russel Barsh

KWIAHT, Center for the Historical Ecology of the Salish Sea

Rethinking salmon habitat requirements: Neritic food webs

Russel Barsh, Madrona Murphy, Audrey Thompson, Ann Harmann

Abstract:

Freshwater and estuarine ecosystems have been the focus of Salish Sea salmon recovery efforts. Until recently, little was known about juvenile salmon behavior in the shallow marine waters of the Salish Sea, between river deltas and the ocean. At the 2007 conference we shared evidence that juvenile Chinook and other juvenile Pacific salmon forage each summer in nearshore areas of the San Juan Islands. Beamer, Fresh and Teel subsequently documented extensive seasonal use of the islands by juvenile Chinook from throughout the Salish Sea. After four more years of fieldwork, we can report the diet of juvenile Chinook in the islands consists mainly of sand lance, crab larvae and insects, terrestrials comprising as much as one-third of prey biomass in mid- to late-summer. We also report evidence of individual- and stock-level diversity in prey choice that suggest a combination of sub-regional adaptations and learned behavior. The dominant variable in prey utilization in the islands appears to be the availability (size and abundance) of sand lance, a species with poorly understood ecology. New evidence is presented on the life history of the islands' sand lance, and the factors influencing some juvenile

Chinook to remain resident in the islands as “Blackmouth”.

Todd Zackey

Tulalip Tribes Natural and Cultural Resources Department

Juvenile Chinook salmon in non-natal coastal streams of Puget Sound's Whidbey Basin

Todd Zackey, Derek Marks, Eric Beamer, David Kuligowski, David Teel

Abstract:

The use of shallow, non-natal estuarine and freshwater habitats by juvenile Chinook and other salmon in Puget Sound is not well understood. Recent work has documented extensive use of small, pocket estuaries by juvenile Chinook salmon. We explored whether small coastal streams are also used by juvenile Chinook and other salmonids. We electrofished the lower reaches of 17 different small coastal streams in the Whidbey Basin biweekly between January and June in 2009 and 2010. We encountered a total of ten fish species including five salmonids. Juvenile Chinook were present in 16 of the 17 streams. Genetic stock identification allowed us to estimate the region of origin of each Chinook as well as track individual juvenile Chinook residence times and growth rates. Our results confirm that juvenile Chinook use small non-natal coastal streams, sometimes for extended periods, suggesting that these streams may provide important rearing habitat for fry migrant Chinook.

Edward Connor

Environmental Affairs Division, Seattle City Light

Predicting the effects of climate change on Bull trout, Steelhead and Chinook salmon in the Skagit River

Edward Connor, Ron Tresser

Abstract:

Climate modeling by the UW Climate Impacts Group (CIG) has predicted an increasing frequency of major flood events as a result of climate in the Skagit River Basin change over the next 50 years. The results of CIG's modeling indicate that summer low flow events will also become more frequent, and summer water temperatures will become warmer in the mainstem Skagit River and many tributaries. We are now analyzing the impacts of increasing hydrological variability and warmer water temperatures on steelhead, bull trout and Chinook salmon populations in the Skagit River watershed. This analysis involves linking the results of the CIG's hydrology and temperature models to life-cycle and habitat preference models we have developed for these three fish species, which are all listed as 'threatened' under the U.S. Endangered Species Act. We are determining temperature preferences of bull trout, a species dependent upon cold water, in the upper Skagit River using acoustic tags that are surgically implanted in fish. The tags transmit the temperature and depths that are being used by bull trout to receivers that have been deployed throughout the drainage, allowing us to determine the temperatures and habitats used by this species in Ross Lake and upper Skagit tributaries in Washington and British Columbia. The temperature preference information obtained through this study will be used in conjunction with CIG's stream temperature modeling to assess the impacts of climate change on bull trout. We have also developed a model that predicts the impacts of increasing hydrological variability on steelhead and Chinook salmon using empirical relationships that we been developed between hydrology and fish survival in the Skagit. Finally, we are examining how reservoir operations at Seattle City Light's Skagit Hydroelectric Project might be used to reduce climate impacts to these three fish species in the future. Linking hydrology, reservoir operation, and fish habitat and life cycle models will allow us to better the understand the long-term effects of climate change on bull trout, steelhead, and Chinook salmon in the Skagit, and develop adaptive approaches to reduce climate impacts on these species.

Paul Schlenger

Friends of the San Juans

Salmon recovery planning at the landscape scale: Integrating fish use and shore form condition

Tina Whitman, Jim Slocomb, Paul Schlenger, John Small, Andrea MacLennan

Abstract:

Located at the confluence of Puget Sound, Georgia Strait and the Strait of Juan de Fuca, the 400 lineal miles (650 Km) of nearshore marine habitats of San Juan County play an important role in regional salmon recovery efforts, providing feeding, refuge and migration corridors for outmigrating juvenile salmon. In order to develop comprehensive recovery plans for Puget Sound salmon has been limited by a lack of information on the origin of juvenile Chinook salmon and their habitat use in non natal mixing areas, such as the San Juan Archipelago, where salmon populations from multiple major Canadian and north Puget Sound sources coningle.

Until now, comprehensive identification and prioritization of restoration and protection actions in the county and elsewhere in the region have been limited by a lack of data on salmon habitat utilization of nearshore habitat as well as the location and extent of shoreline modifications. Rapid population growth rates and increasing demand for shoreline development in San Juan County demands a strategic and process-based approach to the identification of priority conservation and restoration actions. To fully understand the current level of degradation to nearshore processes across all geomorphic shoretypes, and focus habitat protection and restoration efforts, degradation to eight nearshore processes were assessed within each of the ten shoretypes identified in the study area. This assessment of process degradation was based on the presence of stressors known to impact the subject process. The processes assessed included: Coastal Sediment Dynamics, Wind and Waves, Fluvial Sediment Dynamics, Freshwater Hydrology, Tidal Hydrology, Detritus Import and Export and Solar Radiation. Stressors used to assess process degradation included: shoreline armor, tidal barriers, breakwaters and jetties, roads, marinas, overwater structures, culverts, groins, boat ramps, dams, impervious surfaces and artificial shoreforms.

The shoreform was the fundamental unit of analysis of this study, which enabled integration of recently completed nearshore habitat fish utilization research in WRIA 2 (Fresh et al and Beamer et al). This approach also applied key conceptual approaches from Puget Sound Nearshore Ecosystem Restoration Project's (PSNERP) strategic needs assessment and the Puget Sound Recovery Implementation Technical Team's (RITT) shore form and key ecological attribute-based adaptive management framework. New data collected to support the analysis included an inventory of riparian vegetation, pocket beach mapping and current and historic geomorphic mapping.

Methods and results of the broad scale restoration and protection prioritization will be presented including: Countywide geographic prioritization of priority habitat based on juvenile Chinook salmon presence probability, rearing forage fish presence probability and forage fish spawning habitat utilization, and Process-based countywide evaluation of degradation by shore form to identify restoration and conservation priorities.

9C: Seaweeds and seagrasses in the Salish Sea I

Benthic marine aquatic vegetation provides complex structure, buffering against water motion, carbon sequestration, and primary production in the Salish Sea ecosystem, yet the value of these services and responses of aquatic vegetation to multiple stressors remain poorly quantified. Current research seeks to address these gaps in understanding and contribute to sound decision-making. Topics related to the services provided by aquatic vegetation include: productivity rates and transport of materials among habitats and through food webs; their habitat functions for many important fish and invertebrates; and responses in terms of geomorphological processes. Topics related to threats include: responses to eutrophication and other types of water quality issues; harvest for biomass or biofuels; and invasive species impacts, including those of a non-native seagrass. Recent advances in subtidal surveys have made it possible to begin to expand existing intertidal knowledge and explore the full biodiversity and distribution of seaweeds and seagrasses. Continued research concurrent with technological progress provides the best available science to manage the restoration, mitigation, conservation and protection of marine benthic vegetation in the Salish Sea. This session will explore the current scientific research on marine benthic vegetation in British Columbia and Washington State. It will also provide an overview and comparison of the policies that manage these habitats and the activities that affect them under the laws set by both governments. Presenters and participants will be encouraged through an organized panel discussion to develop strategies to promote transboundary research and monitoring projects and policy change that will further protect marine benthic vegetation in the Salish Sea.

Conveners: Tom Mumford, Cynthia Durance

PRR Facilitator: Rita Brogan

Mary O'Connor

University of British Columbia

Salish Sea eelgrass communities in the context of a global eelgrass experimental network

Mary O'Connor, Emmett Duffy

Abstract:

Eelgrass beds are an important habitat for birds, fish and invertebrates in the Salish Sea. Eelgrass communities are changing worldwide, and eelgrass is declining in many places. Eutrophication and overfishing are the two primary factors blamed for the decline, though disease and habitat destruction are also important causes. Surprisingly, the relative importance of eutrophication and overfishing as stressors for eelgrass community structure and function are poorly understood. Even when they are understood in a particular region, it is not clear whether or how eelgrass community responses to these stressors vary throughout the world.

To begin to address this problem, we are conducting experimental studies in eelgrass beds in southern British Columbia. We are manipulating predator abundance, grazer abundance and nutrient levels in the field, and measuring the abundance and diversity of eelgrass (*Zostera japonica*), macroalgae and benthic invertebrates. These experiments are underway in summer 2011, and will provide insight into the trophic relationships in these important communities, and how they might respond to perturbations such as predator removal and nutrient augmentation. We will present experimental results that include invertebrate abundance and diversity, eelgrass density, epiphyte density, and trophic relationship among these groups.

This work is not only important to managing B.C. marine resources, but also to understanding global patterns of eelgrass community health. Our B.C. site is part of the *Zostera* Experimental Network (ZEN), and the same experimental procedure was carried out simultaneously at 15 other sites dominated by *Zostera marina* in the Northern Hemisphere in 2011. Comparison of results reveals fascinating biogeographic patterns in *Zostera* growth rates, grazers biodiversity, grazer impacts and the strength of predation. We will present some results from this global experimental

network, highlighting interesting comparisons among sites and illustrating how BC eelgrass beds stand out as being highly diverse and valuable resources among the world's eelgrass beds. Though only in its early stages, the experimental network is providing an exciting new perspective on eelgrass community ecology.

Kate Buenau

Pacific Northwest National Laboratory

Analysis of eelgrass stressors in Puget Sound

Kate Buenau, Ronald Thom, Chaeli Judd, Valerie Cullinan

Abstract:

Recent studies have shown that seagrasses are declining globally. There is widespread concern that eelgrass is significantly less abundant than historically in Puget Sound. It is assumed that stressors caused by human activity have caused most of the loss, though the contribution of natural variation to eelgrass declines is unknown. The intensity and type of disturbances affecting eelgrass are changing over time as population growth, land use, climate change, and regulatory actions change in the Puget Sound region and affect eelgrass habitat. Decisions regarding the most effective and efficient management actions to take suffer from critical uncertainties about the intensity, extent, and reversibility of stressors affecting eelgrass. Understanding the relative importance of various stressors, their interactions, and anticipating their future impacts will help drive research and management actions to restore eelgrass. The objective of our work was to provide a technical summary of stressors to inform target setting for eelgrass area and health and to help prioritize eelgrass management and research activities. We combine information from global seagrass assessments, local eelgrass case studies, spatial quantification of stressors, analysis of natural eelgrass variability and expert opinion to classify and rank stressors according to their expected impacts and level of uncertainty. Our analysis showed that increases in sea level and temperature, turbidity, and algal blooms are estimated to have both the greatest anticipated threat and highest levels of uncertainty. Additional stressors of high concern with moderate uncertainty include freshwater input, sulfides, construction, and shoreline armoring.

Jeffrey Gaeckle

Nearshore Habitat Program, Aquatic Resources Division, WA State Department of Natural Resources

Eelgrass (Zostera marina L.) monitoring in greater Puget Sound (Washington, USA): Project development and results

J. Gaeckle, P. Dowty, H. Berry, L. Ferrier, T. Mumford

Abstract:

Yearly monitoring of eelgrass (*Zostera marina* L.) beds provides valuable information on ecosystem health. Since 2000, the Submerged Vegetation Monitoring Project (SVMP) has monitored status and trends in eelgrass area and depth distribution throughout greater Puget Sound (Washington, USA) using underwater videography and a high resolution echosounder. The SVMP experimental design and statistical framework provide estimates of eelgrass area and maximum and minimum bed depth at multiple spatial and temporal scales from random samples. Monitoring results are based on extensive sampling: 108 sites were sampled over 55 days in 2010. In addition to annual soundwide monitoring, one of five regions in the study area is sampled with greater intensity each year. The results show that there has been a pattern of losses throughout Puget Sound at sites that typically support eelgrass, but these losses have not affected the overall soundwide eelgrass area estimate. Areas with declines in eelgrass abundance suggest a changing system, likely the result of localized anthropogenic activities or broader climatic influences, and need to be further investigated to identify specific factors that affect this important habitat. Our well-established monitoring project has worked closely with citizen groups, local governments, and state agencies to assist in tracking eelgrass in locations specific to their interests. Consequently, the data from the annual eelgrass monitoring is directly connected to the establishment of indicators and targets for eelgrass and developing strategies for nearshore management throughout Puget Sound. With an increased focus to assess the

condition of Puget Sound, the project has developed techniques to monitor other important marine vegetation and is designing a geospatial database and web-based atlas that will facilitate data management and dissemination.

http://www.dnr.wa.gov/ResearchScience/Topics/AquaticHabitats/Pages/aqr_nrsh_eelgrass_monitoring.aspx

Cynthia Durance

Precision Identification

*Inter-annual variation in eelgrass (*Zostera marina*) productivity at Roberts Bank, British Columbia*

Abstract:

Eelgrass (*Zostera marina*) surveys of the inter-causeway meadow at Roberts Bank, B.C. were conducted annually between 2007 and 2010 as part of the Vancouver Fraser Port Authorities Adaptive Management Strategy. The surveys were designed to determine whether the construction and operation of a new container facility resulted in any unforeseen impacts to the eelgrass habitat. The surveys included four study sites in the inter-causeway, two reference sites west of the DeltaPort causeway, and three reference sites in Boundary Bay.

The development and operation of the new facility did not impact the productivity of the eelgrass meadow however large inter-annual variation in productivity was documented at all of the sites.

Research has shown that eelgrass productivity may be influenced by many large scale environmental factors and near shore oceanic conditions. The inter-annual variation in productivity at the study sites was compared with the Pacific Decadal Oscillation (PDO), sea surface temperature, and the onset of daytime spring low tides.

The Pacific Decadal Oscillation index correlated well with the Leaf Area Index (LAI) data from all years except for 2010. The local winter sea surface temperature was greatest in 2009/2010 and may have contributed to the enhanced productivity that year. The timing of daytime spring low tides varies between years, and was shown to correlate well with the LAI data. Productivity was higher in years where the onset of low daytime tides was earlier.

The relationship between eelgrass productivity and these large scale physical influences will be presented.

The results demonstrate that studies designed to assess site specific changes to eelgrass productivity over time should include off site reference stations to enable one to differentiate between changes caused by site specific impacts as opposed to large scale environmental factors and near shore oceanic conditions.

Sandy Wyllie-Echeverria

Friday Harbor Laboratories, University of Washington

*The role of disease in San Juan Archipelago *Zostera marina* decline: An untested but potentially serious problem*

S. Wyllie-Echeverria, J. Gaydos, D. Martin, A. Boettcher, A. Jarrell, C. Curtin

Abstract:

In 2003 and 2004, relatively rapid decline of *Z. marina* meadows was observed at several sites in the San Juan Archipelago, a prominent feature of the Salish Sea sub-region of the Pacific Northwest. Cause for these declines is still the subject of investigation, however, even though the pathogen known to bring about a disease epidemic exists in the San Juan Archipelago, the possibility that acute loss was the result of a disease event has not been thoroughly tested.

Microorganisms of the genus *Labyrinthula* are the most notable disease agents. Once infected a leaf can spread disease to other leaves, lethally infecting a large area. Past studies suggest two or three species are present on leaves but only one "pathogenic" form (*L. zosterae*) has been

described. The description of this form was based on cell size, shape and re-infection assays. In contrast, subsequent investigation suggests at least five strains/species of *Labyrinthula* are present on *Z. marina* leaves, several of which may lead to an infectious disease outbreak.

Overall estimates of maximum diversity for *Labyrinthula* have not yet been attempted. Therefore, we designed a project to investigate two geographically adjacent sites with varying *Z. marina* genetic diversity and population stability, followed by four additional sites sampled less intensively, providing much-needed information on the diversity and distribution of this opportunistic pathogen. We will present results of our investigation and put forth a program to assist natural resource agencies to monitor disease presence and the potential spread of infection.

James Norris

Marine Resources Consultants

Submerged aquatic vegetation of the Elwha and comparative shorelines

Ian Fraser, James Norris

Abstract:

To measure the response of nearshore submerged aquatic vegetation to dam removals on the Elwha River (scheduled to begin in September 2011) we conducted a series of baseline surveys between 2006 and 2010 to determine the pre-dam removal vegetation characteristics of nearshore habitats between Crescent Bay and Dungeness Spit. Macroalgae dominates the entire region—over 98% of the seabed out to a depth of –15 m has some type of macroalgae growing on it at a density of at least one plant per square meter. Eelgrass beds (*Zostera marina*) are located in Crescent and Freshwater Bays, along the outside and inside edges of Ediz Hook and Dungeness Spit, Dungeness Bay, and in the Dungeness Bluffs region. Eelgrass beds fell into three distinct categories:

1. those growing over a large depth range from –2 ft Mean Lower Low Water (MLLW) to –22 ft (e.g., the protected western sections of Crescent and Freshwater Bays);
2. those growing over a narrow, deep depth range from –14 ft to –23 ft (e.g., eastern sections of Crescent and Freshwater Bays and the outer edges of Ediz Hook and Dungeness Spit); and
3. those growing over a narrow, shallow depth range from –1 ft to –8 ft (e.g., inside edge of Ediz Hook).

Our methods were consistent with Washington State Department of Natural Resources Submerged Vegetation Monitoring Project protocols and our results will provide the foundation for measuring any submerged aquatic vegetation responses to dam removals

9D: Hydrologic analysis, water resources, and freshwater ecosystems in the Salish Sea watersheds II

The purpose of the session is to provide a state-of-the-science review of the water resource within the watersheds draining into the Salish Sea. This session covers topics discussing all aspects of hydrology and water resources, including analysis of flow regimes, low flow conditions, stormwater flow, flood flows, atmospheric rivers, and drought. This session also includes presentations on the effects of climate change, land cover change, development and urbanization and subsequent impacts to freshwater and estuarine ecosystems. Analytical tools can include GIS, modeling, statistical analysis, and watershed assessments.

Conveners: Paul Pickett, Markus Schnorbus, DeGasperi, Alan Hamlet, Chris Conrad, Rajesh Shrestha

PRR Facilitator: Jamie Strausz-Clark

Paul Pickett

Washington Department of Ecology

An environmental indicator based on trends in low flow

Abstract:

An environmental indicator was developed to show changes in low flow conditions in rivers and streams draining to Puget Sound. Thirteen rivers and streams were selected based on the availability of long-term flow records from USGS gaging stations, their representativeness of major river basins or significant urban streams, and their overlap with past indicators and with climate modeling sites. The total watershed area above these thirteen gages represents about 70% of the Puget Sound watershed.

The trend in the annual minimum summer 30-day average flow was selected because of its significance to salmon habitat needs. Water Year 1975 was selected as the first year in the trend in order to capture as long a record as possible for all rivers and streams, and to minimize long term climactic effects like Pacific Decadal Oscillation, without mixing data from pre- and post-dam construction.

Trends are determined both with a linear regression of annual low flow against time, and with a Mann-Kendall non-parametric test. If either test shows significance with probability less than 0.5 the trend is considered “weakly significant” (more likely than not the trend exists), and if the probability is less than 0.1 the trend is considered “strongly significant” (highly likely the trend exists).

The analysis of the indicator through Water Year 2010 shows that the Cedar River had a strongly significant increasing trend, while the Nisqually and Skokomish Rivers had weakly significant increasing trends. Six rivers had no significant trends: the Dungeness, Elwha, Green, Nooksack, Puyallup, and Skagit Rivers. The Snohomish River had a weakly significant decreasing trend. Strongly significant decreasing trends were found in the Deschutes River, Issaquah Creek, and the North Fork Stillaguamish River.

Determining the factors influencing the trends requires additional analysis. However, a review of the major dams regulating flows in these streams shows that all rivers with dams regulating flow from over 45% of their watershed had no trend or an increasing trend. The three rivers and the creek with decreasing trends are all effectively unregulated and in regions with relatively high population growth.

The Washington State Governor’s Office has selected this indicator as a Government Management Accountability and Performance (GMAP) performance measure

<http://performance.wa.gov/NaturalResources/NR040611/Habitat/instreamflows/Pages/Default.as>

[px](#)). This indicator will also likely be adopted for the Puget Sound partnership's Dashboard of Ecosystem Indicators (http://www.psp.wa.gov/pm_dashboard.php).

Patrick Lilley

Raincoast Applied Ecology

Monitoring low impact development measures: Stream flow, water quality, and benthic community change

Patrick Lilley, Nick Page, Carrie Baron

Abstract:

Cities are increasing using innovative storm water management strategies, such as the use of low impact development (LID) standards, to mitigate the impacts of urban development on stream hydrology and water quality. However, few streams are intensively monitored during development to determine if these strategies have been successful. The project examined the changes in stream flow, water quality, and the benthic invertebrate community in North Creek, a small stream draining the developing East Clayton Neighbourhood in the City of Surrey, BC, Canada, from 1999–2009.

The study period spanned a time when the area transitioned from a rural residential community to a more dense urban community which is still undergoing development. Through this period, stream flows, water quality, and the benthic invertebrate community changed substantially as a result of development. While some of the changes were negative changes to stream condition typically associated with increasing urbanization, other positive changes occurred linked to the use of LID measures on lots and some community facilities.

Some key findings included:

- Stream flow as a proportion of precipitation increased significantly, suggesting exfiltration galleries and other strategies to infiltrate precipitation into the shallow subsurface drainage system has been effective
- Maximum annual storm flow (a measure of peak flow) decreased
- Water temperature increased significantly, likely due to the installation of a large storm water detention pond,
- Specific conductivity increased, indicating that urbanization has substantial effects on chemical processes in small catchments.
- Turbidity increased during the initial clearing and development phase, although the overall change was not statistically significant. The data suggest that, even with erosion and sediment control measures, increased turbidity is unavoidable during site clearing and initial development.
- The benthic invertebrate community became more similar to other urban streams in the region because of the loss of sensitive taxa, and the establishment of new tolerant taxa. Changes in the Benthic Index of Biological Integrity scores were driven by changes in only four of the ten component metrics.

Overall, the results of the analysis suggest that storm water strategies applied to the developing community have been effective from a flow management perspective, but have not eliminated the effects of urban development on water quality.

E. Ashley Steel

PNW Research Station, USDA Forest Service

Human impacts to riverine thermal regimes and biological consequences

E. Ashley Steel, Brian Beckman, Aimee F. Fullerton, Don Larson, Abby Tillotson, Keith Denton

Abstract:

Water temperature is a key regulator of aquatic communities. Human activities, such as dams, land-use, and climate change, impact the variability and complexity of water temperature regimes; yet, biological responses to these altered thermal regimes are just beginning to be understood. Alterations in thermal regimes may include not only increases or decreases to means, minimums, and maximums but reductions or increases in variability at multiple temporal scales. Understanding the impacts of altered thermal regimes requires a range of expertise from statistics, to river ecology, to fish physiology. This interdisciplinary work is essential for effective management of freshwater habitats and will require attention to the complexities of natural thermal regimes, a better understanding of how humans impact thermal regimes, and research on the biological and physiological implications of human alterations to natural thermal regimes. Looking across landscapes, we summarize natural temporal and spatial variation in water temperature regimes in a relatively undisturbed floodplain, demonstrate how dams can reduce temporal variability at multiple temporal scales, and investigate the impacts of large-scale land-use patterns on variability in water temperature and flow regimes. The experiment we designed in response explored the behavioral and physiological consequences of these landscape-scale patterns. We exposed Chinook salmon eggs to eight thermal regimes that varied with respect to daily and seasonal temperature patterns and compared emergence timing as well as developmental stage and condition at emergence. We present evidence that variability in thermal patterns, for example diel temperature fluctuations, alters emergence timing and suggest that there may be genetic drivers of these differences.

KathiJo Jankowski

University of Washington

Assessing non-point source N loading and N fixation in lakes in the Salish Sea watershed

KathiJo Jankowski, Daniel E Schindler, Gordon W Holtgrieve

Abstract:

Eutrophication remains a widespread problem for aquatic ecosystems in urban areas. Runoff from human-dominated watersheds in the Salish Sea region has greatly altered nitrogen (N) and phosphorus (P) cycling in local lakes. Nutrients from human sources are distinct from those from undisturbed ecosystems in several ways including lower N: P ratios, which can drive ecosystems to N limited conditions, and unique stable N isotope characteristics. In this study, we used these distinct characteristics to estimate shifts in N sources to 27 lakes across a human density gradient in the Puget Sound region of western Washington, U.S.A. We compared a stable N isotope mixing model with a mixing model that coupled N stable isotopes to N: P stoichiometry and found that a two-source mixing model (human and watershed sources) performed poorly in explaining observed variation in $\delta^{15}\text{N}$ of POM and primary consumers ($R^2 = 0.55$). However, when we included a third N source (N fixation) that was facultatively added to the ecosystem below a critical N: P ratio, the mixing model described the observed variation in POM and primary consumer $\delta^{15}\text{N}$ among lakes extremely well ($R^2 = 0.73$). In lakes with P concentrations $> 20 \mu\text{g L}^{-1}$ (N: P mass ratio < 18), N-fixation became an increasingly important component of the N cycle, accounting for $> 50\%$ of lake N budgets. This model provides a novel way to estimate the contribution of non-point N sources and N fixation to aquatic systems in urbanized watersheds.

Dan Buffett

Ducks Unlimited Canada

An analysis of loss and conservation prioritization of Fraser Lowland Wetlands 1989-2009

Dan Buffett, Kathleen Moore, David Major

Abstract:

Freshwater ecosystems of the Salish Sea provide important habitat for wildlife species and are important for the continuing functioning of estuaries. While recognition of the importance of freshwater wetlands continues to rise, the loss of these limited habitats also continues. In 1989,

Environment Canada created an inventory of wetlands in the Fraser Lowland of British Columbia, using aerial photos and digitizing wetland boundaries as polygons. It was updated in 1999 to document the amount and causes of wetland loss. In 2010, Metro Vancouver used 2009 orthophotos to monitor the same 320 wetland units. Results showed that one in five wetlands was affected to some degree. Small, cumulative conversions were common, primarily to agricultural and urban development. While the rate of loss was less during the 1999 to 2009 period, the number of wetlands affected was nearly identical in both periods. Importantly, one-third of all wetlands in the study area monitored over the 20-year period were affected to some degree by human encroachment. Upon completion of the updated wetland assessment, Metro Vancouver, Ducks Unlimited Canada and Environment Canada identified a need to develop an up to date list of priority wetlands for conservation action. Looking at only the remaining wetlands, each site was assessed based on size class and degree of surrounding natural area (determined from land cover information). The result is a consistent preliminary ranking of each wetland. Each partner can combine the rankings with other criteria to develop a customized and flexible list to meet each organization's mandate. By quantifying the sources and degree of wetland loss in combination with an explicit assessment of conservation priority, the conservation partners can be assured that scarce resource dollars will collectively acquire the most important wetlands, and can consistently target the sources of chronic wetland loss.

Dan Siemann

National Wildlife Federation, Pacific Region

Floodplains: A key to salmon restoration, Puget Sound recovery and public safety

Abstract:

Floodplain restoration is emerging as an essential component of efforts to restore Puget Sound and to recover ESA-listed orca and salmon runs. Well-functioning floodplains slow floodwaters, filter impurities from runoff, and provide critical salmon and riparian habitat. However, the Puget Sound basin has lost more than 90% of its wetlands and floodplains over the past 200 years—largely due to development, levees, dikes, and dams. Current land use policies continue to allow development that harms these sensitive areas. Increasingly severe storms due to climate change will likely exacerbate existing problems.

Development in U.S. floodplains is largely determined by standards established under FEMA's National Flood Insurance Program (NFIP). Following NWF's successful lawsuit, the National Marine Fisheries Service recently concluded that the NFIP promotes development in critical floodplain habitat and jeopardizes the continued existence of ESA-listed salmon and orca. As a result, FEMA must strengthen its NFIP minimum criteria for Puget Sound communities in order to comply with the Endangered Species Act. Communities are required to adopt these changes by September 2011 to qualify for NFIP coverage. These changes will transform protection of river, lake and marine shorelines and will create opportunities to begin restoring damaged floodplain habitat. Similar lawsuits are likely to require similar changes in Oregon, Florida and throughout the US, making Puget Sound a pilot and a model for the nation.

This presentation will describe the ecological and functional value of floodplains, how they have been harmed by human activities, and the implications for water quality, fish and wildlife and human communities. It will also describe how climate change may exacerbate existing problems. It will provide background on the NFIP lawsuit and the scientific analysis that is requiring FEMA to incorporate habitat and species protections into its floodplain standards. It will describe the major changes that FEMA is implementing and it will describe opportunities and efforts to fix existing floodplain management problems from a scientific, legal, and policy perspective. Finally, the presentation will assess the current status of similar lawsuits around the United States and the implications for the Puget Sound approach to be implemented elsewhere. This presentation will provide new information on a timely and ecologically significant issue.

9E: Actualizing ecosystem services

Good decisions require good information. Herman Daly, Robert Costanza and many others have for decades pointed to the need for an economic model that reflects physical reality, one that understands the economy as a subsystem of nature. Numerous organizations, including the United Nations and World Bank, have been grappling with how to advance these concepts. Through the Millennium Ecosystem Assessment and other work, ecosystem services have emerged as a vehicle to describe the value that our home – Earth – provides us and the cost of losing these services. However, despite the power of these concepts to change the use and management of our 'natural capital', the field is still relatively new and we have yet to see significant changes on the ground that are driven by application of these concepts. This session explores the topic of ecosystem services, its current applications and – importantly – explores with you how to break through the barriers to wider policy and decision-making acceptance.

The session begins with an introduction to the science and evolution of ecosystem services, with an eye toward where we stand now. Following this, presenters will explore a few current applications including indicators/measures of capital, advancing a “whole” economy within a government structure, why and how the private sector is incorporating ecosystem services into business practices and how funding agencies can drive the innovation in ecosystem services and their application. From there, the session organizers will facilitate a conversation with participants regarding two key questions:

1. What are the barriers to using ecosystem services, and how might we overcome them?
2. What course should we set for the application of ecosystem services in the Salish Sea?

This session will also feature a 25-35 minute facilitated discussion.

Conveners: Tim Walls, David Batker, Jan Cassin

PRR Facilitator: Hadley Rodero

David Batker (10 minutes)

Earth Economics

Watershed economics for the 21st Century: Revealing our best investments

Abstract:

Since 1998, Earth Economics has been providing science-based economic analysis for sound action in watershed project and infrastructure planning efforts. Much of this work involves applying ecosystem service identification, valuation, mapping and modeling to complex, multi-jurisdictional problems. Results have been used to create accounting and funding mechanisms that shift investments towards sustainability. Earth Economics now has a solid track record of developing case studies and piloting tools using ecosystem services. Past successes of this work will be presented to demonstrate how ecosystem services can be used at various geographic and jurisdictional scales, including:

- Using ecosystem service analysis to unite stakeholders and justify a \$5 million levee setback project in Western Washington.
- Using ecosystem service valuation along with updated jobs analysis to help an Eastern Washington community college win a \$3 million Economic Development Administration federal grant to expand their water and environment center.

Current projects utilizing ecosystem services will also be highlighted, including:

- Working alongside six major water utilities to identify funding mechanisms for preserving the watersheds that filter their drinking water. This includes options to update national accounting rules to allow governments to include natural capital (such as watersheds) as an asset on their books.
- Helping an urban watershed in Western Washington to develop a 21st century natural capital institution, called a Watershed Investment District. The institution will be designed to coordinate investments in ecosystem services throughout their watershed, at the watershed scale, and ensure dependable funding mechanisms for natural capital.
- Advising federal agencies such as the Federal Emergency Management Agency (FEMA) on how to include ecosystem services in their cost/benefit analysis, and potentially shifting billions of dollars towards sustainable projects.

Tim Walls (10 minutes)

Snohomish County Public Works

Using ecosystem services within local governments

Abstract:

Local governments in the Salish Sea are responding to many natural resource issues, including water pollution, stormwater, climate change, and species recovery. Responses to these demands require that local governments act across areas of their jurisdictional authority, whether through governing development, recreation or through public works. The ultimate goal of many of these activities is achieving a level of sustainability, balancing community prosperity and health with ecosystem health.

Ecosystem services may be one framework in which these themes can come together. Local governments can use ecosystem services in developing measures, targets for viability, and as a communication tool within governmental departments and with the public.

This talk will look at how local governments can use the ecosystem services framework for valuation of ecosystem services, the impacts and benefits of projects (such as public works projects), and in funding for activities. Each of these elements will be in the context of the role that local governments can play in using ecosystem services and raising questions about how to make their use more practical and useful.

Lisa Ciecko (10 minutes)

Cascade Land Conservancy

Urban forest ecosystem services: Existing tools, model limitations, and policy applications

Abstract:

Trees in cities, whether along streets, in backyards, or in neighborhood greenbelts, provide social and ecological benefits. Urban forests have been shown to positively affect public health and environmental conditions, including reducing the heat island effect, decreasing stormwater and subsequent sediment runoff, and intercepting air pollution. Preserving ecosystem services in urban areas is critical to making cities healthy, desirable places to live and work, which has a lasting effect on the conservation of natural resources and working lands throughout the Salish Sea region. Unfortunately, the Seattle area alone has lost over 22% percent of its canopy cover in the last 35 years. But recent efforts by municipalities to establish urban forest management plans and canopy goals suggest a growing recognition of the importance of ecosystem services.

In order to fund urban forest restoration, local agencies are commonly looking to quantify and communicate the structure, function, and monetary value of urban trees. Research was initiated in the City of Seattle and in King County in 2010 using the i-Tree Eco model. Developed by the US Department of Agriculture Forest Service, I-Tree Eco (formally known as the Urban Forest Effects Model) includes plot-based data collection to estimate vegetation and ground cover

characteristics to model pollution interception, carbon sequestration and storage, residential energy reduction benefits, and compensatory values.

This research provides an important example of both the opportunities available for integrating ecosystem service values in advocacy and policy, as well as the barriers that exist to quantifying these services. Even with a history of work to create municipal funding for tree planting and maintenance activities based on ecosystem service values, economic conditions, available data, and extensive political support may limit application. Other concerns represented in this research include the ability to accurately estimate ecosystem services using models like i-Tree Eco, as well as questions about the cost and complexity of data collection. Recognizing and responding to these implementation concerns is an important step towards increasing ecosystem service valuation in the Salish Sea region.

Michelle Molnar & Maya Kocian (10 minutes)

David Suzuki Foundation

Valuing marine ecosystem services of the northern Salish Sea

Michelle Molnar, Maya Kocian, Hugh Stimson

Abstract:

Marine and coastal ecosystems provide vital goods and services to our quality of life. Such services include carbon storage, flood protection, habitat and recreation. The Northern Salish Sea ecosystems are under increasing pressure from multiple threats such as overfishing, unsustainable aquaculture, storm water runoff and other anthropocentric factors. However, as we do not pay directly for these services, they are undervalued in our market economy. They are worth billions of dollars per year, but need to be valued more accurately because their loss has massive economic impacts, threatening health, food production, climate stability, and basic needs such as clean air and water.

Last fall (2010), the David Suzuki Foundation released a report valuing terrestrial ecosystem services of the British Columbia Lower Mainland (Natural Capital in BC's Lower Mainland: Valuing the benefits of nature). In conjunction with that report, we aim now to look closely at the marine ecosystems of the region and provide the first valuation of marine-centric services of the Northern Salish Sea.

To inform decisions on the ecosystem services provided by the marine systems, the David Suzuki Foundation, with support from Earth Economics and Hugh Stimson Environmental Informatics, conducted a study of Northern Salish marine systems. The resulting study identifies and values non-market ecosystem services using primary valuations undertaken with a benefit transfer method. The spatial scope of the study transcends the national boundary, valuing services based on ecosystem rather than political divisions. This project represents the first multiregional scale valuation to focus on Marine benefits.

Jodie Toft (10 minutes)

The Natural Capital Project

From Douglas fir to Dungeness crab: Land use change and ecosystem services in Hood Canal, WA

J. Toft M. Marsik, G. Spiridonov, D. Sutherland, A. Guerry, P. Levin, M. Plummer, M. Ruckelshaus

Abstract:

Marine ecosystems produce a wide range of ecosystem services, including the provision of seafood from natural populations, beautiful places for tourism and recreation, water filtration, climate regulation, and cultural benefits. As these ecosystems suffer stress, so do the benefits we derive from them. Many scientific diagnoses of declining marine species and habitats, and recreational use patterns along U.S. coasts point to upland and freshwater sources of imperilment. A growing number of scientists argue that the best hope for protecting marine

resources for multiple uses is to consider larger-scale processes when designing management strategies. Yet scientific understanding is poor regarding how including land- and water-use practices in strategies to sustain marine resources affects management outcomes. We have undertaken research to estimate and compare the nature of the influence of watershed practices on a suite of key marine and coastal ecosystem services and ask under what conditions including upland activities increases the likely effectiveness of management strategies. We will present this work for Hood Canal in the Puget Sound region of Washington State. We have built a linked watershed-marine model with a diverse suite of ecosystem service outputs (e.g., food from shellfish and crab harvest, aesthetic quality, recreation fishing for crab, filtration by shellfish) that are derived from nearshore marine habitats in Hood Canal. This model is used to evaluate how land cover changes in the terrestrial system are likely to affect the timing and quantity of freshwater flow and nutrient discharge, which then affect the delivery of these ecosystem services in the nearshore and coastal marine system. A key modeling step has been to quantify the relations between watershed processes and coastal and marine ecosystem structure and function. We will also describe how we will mirror the Hood Canal work in other locations in Puget Sound, Chesapeake Bay on the US East Coast, and Galveston Bay, Texas.

9F: Transboundary Collaboration I – From Parallel Play to Integrated Play: Case Studies

The Salish Sea lies in a common ecosystem and culture, yet with notable exceptions many ecological initiatives in the Puget Sound and Georgia Basin remain limited in scope by the international border, rather than transboundary. A 2009 conference session sought to identify key elements of effective transboundary ecosystem-based management, and how to move from, as one panelist put it, “parallel play” among these efforts, to “integrated play.” The goal of this session is to examine case studies of ecosystem protection initiatives or projects that successfully demonstrate “integrated play” – that is, where participants on both sides of the border are equally engaged and invested in the success and outcomes of the project. Panelists will briefly describe examples of successful recent transboundary projects in three categories: site-specific implementation projects; development of regional policies; and monitoring. Potential example projects include: derelict gear removal in Boundary Bay and Pender Island; Northwest Ports Clean Air Strategy; and the Tribal Journey Water Quality Project. A facilitator will then lead the panelists and audience in a discussion to identify key elements of these projects’ success, such as clarity of mandate, leadership, supporting relationships, and funding. In addition, the panelists will explore the role that existing transboundary coordination mechanisms and forums such as the International Airshed Strategy (IAS), Statement of Cooperation (SoC), and Environmental Coordinating Committee (ECC) played (or did not play) in facilitating these transboundary projects. Common themes for successfully moving into joint activities will be explored.

This session will also feature a 45 minute facilitated discussion.

Conveners: Lisa Chang, Geoff Reid

PRR Facilitator: Mike Rosen

Ginny Broadhurst

Northwest Straits Commission

Case Study: Derelict fishing gear removal in Washington and British Columbia waters

Ginny Broadhurst, Jeff June, Kyle Antonelis, Joan Drinkwin

Abstract:

The Northwest Straits Marine Conservation Initiative (NWSI) is the lead organization finding and removing derelict fishing gear in Puget Sound. Beginning in 2002, the NWSI worked with WA State agencies, tribes and partner organizations to create this program which includes standardized methodologies, a reporting system, a database and on-going removal operations. Tremendous progress has been made in Puget Sound to remove derelict fishing gear, particularly nets. Over 3800 nets, or approximately 80% of “legacy” nets have been removed to date. These nets had a devastating impact on marine species and habitat. Over 200,000 individual animals representing 223 species were removed from the nets, many hundreds of thousands more died in the nets over the years and decades that they were underwater. Over 550 acres of marine habitat was restored through these removals.

In 2008, the NWSI held a workshop about the derelict fishing gear removal program to provide updates on our work and share information and methods. We hoped to inform more of our own state managers but also to encourage replication of the project in the northern portion of the Salish Sea (Canadian waters). This workshop included a field trip to see a net removal project occurring near Lummi Island in Whatcom County. Several Canadians attended the workshop and field trip.

NWSI encouraged Canadian counterparts to utilize our expertise and capacity to do some removals in Canadian waters in order to demonstrate the potential successes of the project. In 2011, this effort came to fruition with the removal of 218 derelict crab pots and a purse seine net at Boundary Bay and Pender Island, respectively. Funding came from British Columbia’s Ministry of the Environment and Parks Canada, divers, boats, biologists and project management were

provided through the NWSI.

There are tremendous opportunities to continue the integration of this project both in terms of removals and assessment of ecological impacts to the Salish Sea ecosystem. This presentation will provide more in depth information on the program and potential for integrating into larger transboundary efforts.

Eric Grossman

USGS Pacific Coastal and Marine Science Center

Case Study: Tribal Journey Water Quality Project: Characterizing coastal ecosystem conditions and change along Coast Salish ancestral highways

Eric Grossman, Sarah Grossman, Charles O'Hara, Eric Day, Debra Lekanoff, Darren Blaney

Abstract:

Improving water quality and understanding how it will be impacted by climate change are viewed as essential strategies by Western Washington Tribes, British Columbia First Nations, federal, state, and local agencies to recover the Salish Sea ecosystem (Puget Sound Partnership, 2010). The North Pacific landscape and its biophysical processes are diverse and undergoing rapid and dramatic change (Mote et al. 2008; Salathe et al, 2010) and coastal and marine ecosystems are integrators of climate and land use impacts. Unfortunately, the rich marine resources that sustained Coast Salish peoples for millennia are increasingly impacted by a growing number of stressors including habitat destruction, harmful algal blooms, anoxic conditions, and ocean acidification. These threaten once vibrant wild salmon and shellfish populations. Integrated models and tools for understanding and predicting coastal change are urgently needed that transcend culture, science, policy, and economics to serve a rapidly expanding population while preserving unique traditions and heritages of the Pacific Northwest.

Since 2008, the Tribal Journey Water Quality Project, a partnership between Coast Salish Nations and the US Geological Survey, has conducted comprehensive mapping of surface water quality in the Salish Sea during summer when high air temperature, declining river flow and changes in upwelling lead to marked changes in productivity and shifts in water quality (www.usgs.gov/coastsalish). The project relies on close partnerships among scientists, canoe families and skippers, and cultural leaders to synthesize indigenous and cultural knowledge with scientific data. It generates quantitative data and models of coastal ecosystem variability using multi-parameter water quality sondes towed behind canoes to examine broad spatial patterns, moored instruments to gather time-series data, profiling instruments to examine variations with depth, and analyses of water for dissolved nutrients, plankton community composition and biomass. The goals of the project are to improve understanding of the variability of coastal waters and to forecast future changes by linking our measurements and models of coastal water responses to downscaled climate models, as well as, hydrologic and circulation models. Analyses, reports, presentations, workshops, and communications are shared and partnerships continue to be developed to implement a framework for international collaboration on Salish Sea ecosystem recovery and resource management.

Kari Koski

The Whale Museum

Case Study: Be Whale Wise Transboundary Case Study

Abstract:

Annually over 500,000 people engage in marine wildlife viewing activities in the transboundary region of Washington State and Southern British Columbia, Canada. The Southern Resident population of Killer Whales are the star attraction and are listed as Endangered in the U.S. and in Washington State and as a Species at Risk in Canada. Potential threats are identified as prey availability, toxins, and vessel disturbance.

The Whale Museum's Soundwatch Program minimizes vessel disturbance to Southern Resident killer whales by providing education to boaters on viewing guidelines and regulations; monitoring vessel activities around whales; and reporting trends to regional managers and stakeholders. Soundwatch helped to develop a transboundary set of marine wildlife viewing guidelines known as Be Whale Wise in 2002. The Be Whale Wise Guidelines for Watching Marine Wildlife are now the regional best practice guidelines used by both NOAA Fisheries and Fisheries and Oceans Canada to prevent vessel disturbance to whales and other marine wildlife by commercial and recreational boaters. Both the US and Canadian governments have prioritized public outreach on the Be Whale Wise Guidelines a part of larger killer whale recovery efforts and work with a host of government, non-profit and business partners to promote the Be Whale Wise message .

Ron Stuart

Port of Tacoma

Case Study: Northwest Ports Clean Air Strategy

Abstract:

The Northwest Ports Clean Air Strategy is a proactive and voluntary effort of the Port of Seattle, Port of Tacoma, and Port Metro Vancouver to reduce greenhouse gas and diesel particulate emissions from maritime operations in advance of regulation. Developed in 2007 in collaboration with U.S. and Canadian regulatory agencies, the Strategy is the first and only tri-port, bilateral agreement to voluntarily reduce maritime emissions. The Strategy established short-term (2010) and long-term (2015) targets for ocean-going vessels, cargo-handling equipment, rail, trucking, and harbour vessels in ways that encourage innovation and take in to account differing business needs.

12:00 pm - 1:30 pm

Lunch, SeaDoc Society Salish Sea Science Prize Awards Ceremony and Keynote Address

Dr. Faisal Moola

Director, Terrestrial Conservation and Science Program, David Suzuki Foundation

Recognizing the true \$value of nature

Abstract:

As biological creatures, we depend on natural capital to sustain the health and well-being of our communities: trees clean our air; wetlands filter our water; and green urban spaces cool our cities and protect us from storms. And this doesn't even account for the health, psychological, and for some—spiritual—benefits people receive from time spent outdoors. Research by the David Suzuki Foundation and others has shown that the benefits we receive from nature are extremely valuable in monetary terms, and in some cases are truly priceless. For example, land cover analyses of the Lower Mainland reveal that Vancouver and the suburbs are sitting on a Fort Knox of natural assets worth a staggering \$5.4 billion a year, or \$2,462 per person, in ecological benefits. It's time we started looking at the true value of our forests, fields, farmland and other natural capital in the Salish Sea Region. They are worth so much more than just the resources we take from them.

1:30 pm - 3:00 pm

10A: Monitoring and modeling of harmful algal blooms and pathogens that threaten human health in the Salish Sea

Numerous efforts are underway in the Salish Sea to monitor and model harmful algal blooms (HABs) and pathogens that threaten human health. Some HAB species that commonly occur in the Salish Sea include *Alexandrium catenella* and more recently *Pseudo-nitzschia* spp. These HABs produce biotoxins that accumulate in shellfish and cause illness or death in humans if consumed. Another HAB species, *Heterosigma akashiwo*, causes significant fish kills particularly of captive salmon that cannot escape bloom waters. Noxious blooms of macroalgae can attain high biomass and cause damage to the environment. Outbreaks of marine pathogens such as *Vibrio parahaemolyticus* cause severe gastroenteritis from the consumption of raw oysters. The capacity to forecast these marine biological outbreaks would significantly improve efforts to protect human health by providing management agencies with tools to make good decisions ahead of time, and would also significantly reduce economic losses suffered by commercial shellfish and finfish growers. This session will highlight the monitoring and modeling efforts for harmful algal blooms and pathogens that are currently being conducted by various academic, state, and federal agencies in the Salish Sea. These efforts range from coordinated volunteer-based monitoring to large-scale multidisciplinary research programs. The intended purposes of this session are to bring together and engage the monitoring and modeling community, share data and observed trends, and identify the potential for transboundary future collaboration.

Conveners: Juli Dyble, Stephanie Moore

PRR Facilitator: Kimbra Wellock

Rohinee Paranjpye

NOAA, Northwest Fisheries Science Center

*The ecology and distinctive population structure of *Vibrio parahaemolyticus* in the Pacific Northwest*

Rohinee Paranjpye, William B. Nilsson, Mark S. Strom

Abstract:

Over the past decade, there has been a significant increase in *Vibrio parahaemolyticus*-related gastroenteritis from the consumption of raw oysters harvested in Washington State, partly attributed to increases in water temperatures. Such illnesses/outbreaks pose a threat to public health and result in severe economic losses to the shellfish growers. Increases in *Vibrio* populations due to changes in environmental conditions have been previously reported but the ecology of these bacteria and their interactions with the aquatic environment are not clearly understood. Extensive monitoring and analyses of oysters by the Washington State Department of Health (WDOH) have shown little or no correlation between water temperature at harvest, concentrations of potentially pathogenic (tdh+) *V. parahaemolyticus*, and illnesses. The increase in *V. parahaemolyticus* gastroenteritis has prompted public health officials and the oyster industry in Washington State to implement stricter post-harvest handling protocols to prevent the increase in concentrations of *V. parahaemolyticus* in oysters after harvest. However sporadic illnesses have continued to occur in spite of diligent efforts to monitor concentrations of *V. parahaemolyticus* in oysters and control the post-harvest storage temperature.

We are investigating the influence of environmental variables on concentrations of potentially pathogenic and avirulent strains of *V. parahaemolyticus* in oysters and in water, focusing on harvest areas with historically higher prevalence of the species. In addition we are examining the association of *V. parahaemolyticus* with co-isolated phytoplankton species. We are also comparing the genetic diversity of environmental and illness-associated *V. parahaemolyticus* strains from the Pacific Northwest to strains isolated from clinical cases elsewhere in the world. Through this work, we hope to gain a better understanding of the spatial, temporal and environmental factors that influence the selection of strains responsible for clinical *V.*

parahaemolyticus infections in the Pacific Northwest. These efforts may assist in the improvement of risk assessment strategies and in developing and enhancing forecasting abilities to prevent *V. parahaemolyticus*-related illnesses.

Nicky Haigh

Vancouver Island University

The harmful algae monitoring program: The first dozen years and outlook for the future

Abstract:

British Columbia's Harmful Algae Monitoring Program (HAMP) was initiated in 1999 to aid the salmon aquaculture industry with issues of harmful algal blooms (HABs). In the past 12 years HAMP has accumulated a database of algal species and abundances, including harmful algae species concentrations, from weekly samples taken at 12 – 28 sites around BC. During this period a total of 62 different sites were monitored, with eight sites monitored for eight years or more. In the Salish Sea significant HAMP monitoring sites are Departure Bay, Nanaimo (7 years data), Kunechin Point, Sechelt Inlet (10 years data), and Raza Island (10 years data). HAMP has also increased the knowledge of fish-killing species of phytoplankton in BC; we can now identify at least eleven different harmful species. The future directions of HAMP include isolation and culturing of algae species from fish-killing blooms, an increase in monitoring to assess the impact of HABs on wild salmon populations, and greater involvement with the shellfish aquaculture industry in BC.

William Cochlan

Romberg Tiburon Center for Environmental Studies

Heterosigma ECOHAB activities in Puget Sound: Defining growth and toxicity leading to fish kills

William Cochlan, Vera Trainer, Charles G. Trick, Mark L. Wells

Abstract:

Fish farms in the Salish Sea are exposed to the menace of fish-killing phytoflagellates. Recurring blooms of the raphidophyte, *Heterosigma akashiwo* Hada (Sournia) have caused extensive damage (\$2-6 million per episode) to wild and net-penned fish of Puget Sound, Washington, and are believed to be increasing in scope and magnitude in this region and elsewhere in the world over the past two decades.

The mechanism of *H. akashiwo* toxicity is not well understood. The toxic activity of *H. akashiwo* has been attributed to the production of a combination of reactive oxygen species, neurotoxic organic molecules, excessive mucus, or hemolytic activity, however these mechanisms are not confirmed consistently in all fish-killing events or cultured strains. There is also very little definitive information of the physical and nutrient conditions that will result in a toxic bloom.

The difficulty of conducting research with active, toxin-producing field populations of *H. akashiwo* have resulted in conflicting findings from those obtained in lab culture studies, thereby limiting the ability of fish farmers to respond to these episodic blooms. The overall goal of this project is to identify the primary toxic element and the specific environmental factors that stimulate fish-killing *H. akashiwo* blooms, and thereby provide managers with the fundamental tools needed to help reduce the frequency and toxic magnitude of these harmful algal events.

We provide interpretations of finding from laboratory, field and in situ growth experiments with regards to the project objectives: 1) identifying the element(s) of toxic activity (inorganic, organic, or synergistic) associated with blooms of *H. akashiwo* and the various cellular morphologies of this alga, and 2) determining the environmental parameters that stimulate the growth success and expression of cell toxicity in the *H. akashiwo* populations of Puget Sound.

Robin Kodner

UW Friday Harbor Labs and Beam Reach Marine Science and Sustainability School

Comparative community dynamics and toxin production over the course of domoic acid producing Pseudo-nitzschia blooms in East Sound, WA
Robin Kodner, Michelle Jakaitis, Kelsey Gaessner, Matthew Knight, Micaela Parker

Abstract:

Two domoic acid producing *Pseudo-nitzschia* blooms were observed in consecutive years in East Sound, a fjord within the San Juan Islands, in 2009 and 2010. Phytoplankton community diversity in this region was characterized weekly leading up to the bloom and daily during the bloom. Automated Ribosomal Intergenic Spacer Analysis (ARISA) was used to determine *Pseudo-nitzschia* species composition and relative abundance. The results from quantitative cell counts, ARISA, toxin and nutrient analyses are considered together to assess the bloom dynamics in each year and describe the difference between them. In 2009, DA production was normally distributed and followed a similar pattern to the distribution of *Pseudo-nitzschia* abundance data measured by cell counts and the non- *Pseudo-nitzschia* community was relatively diverse. In 2010 however, we observed a sharp rise and DA concentration that declined asymptotically, as well as a similar, less clear pattern of *Pseudo-nitzschia* abundance though time with low diversity in the non-*Pseudo-nitzschia* populations. Though DA was produced in both years, the general patterns of toxin production, genus diversity within the bloom and leading up to the bloom, and the dynamics of *Pseudo-nitzschia* species were quite different.

Neil Banas

University of Washington Applied Physics Lab

Ocean, atmosphere, and watershed impacts on Alexandrium in Puget Sound: Observations and modeling

N. Banas, S.K. Moore, J.E. Stein, B.D. Bill, V.L. Trainer, D.M. Anderson, E.P. Salathe, C.L. Greengrove, N.J. Mantua

Abstract:

The PS-AHAB (Puget Sound Alexandrium Harmful Algal Blooms) program, part of NOAA ECOHAB, seeks to understand environmental controls on the benthic (i.e., cyst) and planktonic life stages of the toxic dinoflagellate *Alexandrium catenella*, and evaluate the effects of climate change on blooms. This includes mapping the distribution of overwintering cysts, determining environmental and endogenous controls on cyst germination, and assessing the effect of summer transport patterns on connectivity between cyst “seed beds” and shellfish-growing areas. A spatially detailed map of Puget Sound winter cyst distributions from Jan 2011, the first of three such annual mapping projects planned, found the highest cyst concentrations in Bellingham Bay, Birch Bay and Semiahmoo Bay in the north, Port Madison, Liberty Bay and Port Orchard on the west side of the Main Basin and Quartermaster Harbor in central Puget Sound. The cyst maps provide input for climate-timescale modeling. A 40-year atmospheric climate projection downscaled using WRF (Weather Research and Forecasting Model) from the CCSM3 global model was coupled to a high-resolution hydrodynamic simulation of the Salish Sea and Northwest coastal ocean (MoSSea: Modeling the Salish Sea: <http://faculty.washington.edu/pmacc/MoSSea/>). A comparison between present-day and circa-2050 conditions lets us disentangle the effects of three climate pathways on transport patterns and conditions affecting cyst germination and *A. catenella* growth. These three pathways are 1) changing ocean inputs (in the CCSM3 scenario, associated with stronger summer upwelling winds), 2) changing streamflow magnitude and timing, and 3) increased direct insolation. Running the hydrodynamic model in hindcast mode for selected years from 2005-present lets us examine the same pathways on the interannual scale.

Tom Leschine

School of Marine Affairs, University of Washington

An institutional perspective on partnerships in harmful algal blooms monitoring and research

Tom Leschine, Andy Gregory, Meggen Chadsey, Vera Trainer

Abstract:

Harmful algal blooms are typically geographically widespread and recurrent phenomena that, by their nature engage a diverse set of local, state, tribal and federal authorities in response. In two cases we examined in Washington State, partnerships consisting of state, federal, tribal and local governments, together with a variety of non-governmental stakeholder groups, formed to develop programs of research and monitoring in response to HABs outbreaks affecting shellfish populations of economic and cultural importance. In the case of domoic acid affecting razor clams on the state's outer coast, the Olympic Region Harmful Algal Blooms Partnership (ORHAB), an ad hoc voluntary partnership, proved instrumental both in advancing research and monitoring and in securing state funding to replace seed monies provided through the national HABs monitoring and event response program MERHAB. Demonstrable improvements in management capacity emerged. In the case of SoundToxins however, a program organized to address a variety of HABs-related problems within Puget Sound, efforts to replicate the ORHAB partnership's success have proved more difficult. Among other things, shellfish growers have not contributed monitoring data to an emerging Puget Sound wide HABs monitoring network to the extent hoped for by the program's originators. These differences in outcome are explainable through institutional analysis that elucidates the conditions under which voluntary partnerships are likely to emerge to undertake and sustain attention to HABs, their associated societal impacts, and the research and monitoring needed to minimize social and economic as well as human health consequences.

10B: Frameworks and case studies for ecosystem solutions

In today's uncertain world of complex decision-making, limited fiscal resources, and densely populated landscapes, protecting ecosystems and the services they provide is increasingly challenging. This session provides policy makers and ecosystem practitioners with some useful frameworks, case studies, and other tools to help strategically navigate the realm of ecosystem asset management. During this interdisciplinary session, presenters will explore a healthy mix of topics, including assigning value to ecosystem services, working collaboratively across multidisciplinary teams, and engaging the local human population in watershed stewardship. Real world initiatives and lessons learned will be featured.

This session will also feature a 15 minute facilitated discussion

Convener & PRR Facilitator: Jamie Strausz-Clark

John Richardson

University of British Columbia

Balancing the conservation of freshwater ecosystems and human needs in an uncertain world

Abstract:

Water is an essential resource to all organisms, including humans, and can become limiting to the survival of many organisms at some times. We engage in many actions to meet policies to protect freshwater ecosystems and the ecosystem services they provide, but many of these are reactive rather than strategic. Moreover, the future presents many uncertainties that should encourage us to have a strategic approach to water management to accommodate an uncertain future. As an example, reserving water for "environmental flows" has developed around reservoir management, and primarily for salmonids. However, water management could be more strategic in its geographic and temporal scope, rather than a site-by-site approach. Short-term bottlenecks in available habitat, such as regional, annual low-flow periods (or extreme floods) may be sufficient to lead to local extinction of species populations. Experiments conducted in the past decade have demonstrated some of the short-term and persistent effects of low flows, and we have examples of large-scale loss of biodiversity and ecosystem services from reduced flows. The concept of "environmental flows" does not take into account this broader spatial scaling or the need for safety factors, or the impacts if low flows are accompanied by other stressors, such as warm temperatures. Freshwater ecosystems are receiving environments of most land-use changes and local alterations to the land are easily seen in aquatic systems. The cumulative effects of small alterations in freshwater ecosystems can result in unintended, and largely unmonitored, changes in downstream environments. In particular, cumulative effects are difficult to demonstrate in flowing water as effects are diluted downstream, but that does not mean that they are not having impacts. These issues are necessarily interdisciplinary and interagency if we are to accommodate the range of spatial and temporal scales, and the multiple policies that govern ecosystems at the landscape scale. It will require strategic planning at large spatial (and temporal) scales to ensure that needs for water by aquatic ecosystems and humans can be accommodated. In the absence of planning for an uncertain future we will react without options that could have been available with some foresight.

Edwin Hubert

BC Ministry of Environment

A framework for identifying valued components for use in natural resource decision making in British Columbia

Abstract:

The BC government is in the process of developing a framework for identifying environmental, social and economic components relevant to managing natural resources in British Columbia. This structure seeks to find a balance between having a provincially consistent set of valued

components and indicators that can be used for monitoring and reporting at a regional and provincial scale, and having the flexibility to identify valued components and indicators for impact assessments at a regional and local scale. This approach will lead to greater clarity and consistency in the identification, tracking, assessment and communication of valued components in natural resource decision making.

Rowan Schmidt

Earth Economics

Spearheading natural capital accounting: Water utility case study

David Batker, Jennifer Harrison-Cox, Rowan Schmidt

Abstract:

Watershed-filtered water utilities like Seattle Public Utilities (SPU) contribute billions of dollars to local and regional economies by managing lands that provide ecosystem services such as fresh water filtration, storage and supply, flood protection, habitat and recreation. However, 20th century accounting and management standards are focused on “built” solutions to water management such as filtration plants, pipes and storage tanks.

SPU acquired the Cedar River Watershed more than a century ago, and to replace the work of this watershed with a filtration plant would cost \$200 million and a new plant every 40 years. Under national rules set by the Governmental Accounting Standards Board (GASB), the Watershed is not counted as a capital asset on SPU’s books, though it is intuitively their most valuable asset. As a result, SPU cannot justify a sufficient management and operations budget, borrow money (e.g. by issuing municipal bonds) to invest in restoration, or include watershed management costs in rate structures.

Earth Economics, SPU and five other major water utilities (representing over two million acres in managed lands and 16 million water consumers) are leading a national effort to explore the implications of a change in national accounting standards. Following a recent workshop, a taskforce was formed to propose and justify changes to GASB rules for natural capital, look at rate structures, review asset management plans, and to identify funding mechanisms for watershed management activities. A change in national accounting rules would apply to government assets at all levels and shift needed investment towards green infrastructure. The case of water utilities presents a clear and definitive case of the need for better natural capital accounting.

Pat Pearson

Washington State University Jefferson County Extension

A water discussion course: Our watershed

Pat Pearson, Linda Smith

Abstract:

Confronting the challenges of water issues requires a new level of water wisdom across the board—from individual household users to communities, corporations and government agencies. We all need to become more informed and engaged water citizens, so that we can think about and intelligently discuss difficult issues and work together for the best possible water solutions. The Water Discussion Course: Our Watershed was created to facilitate this process.

Our Watershed was designed to:

- Provide basic knowledge about our water and watersheds in the Pacific Northwest
- Raise awareness about water issues confronting watersheds and the communities within them
- Provide a structure to learn more about watersheds and actions an individual can take

There are two versions of the water discussion course:

- Our Watershed: Pacific Northwest (PNW) focuses on the waters of the states of Alaska, Idaho, Oregon and Washington, and the PNW Tribal Nations.
- Our Watershed: Puget Sound focuses on the waters of the Salish Sea located in the state of Washington and the related Tribal Nations.

Both version of the course are offered at no charge to participants. The course sessions may be read online or downloaded in a PDF format.

The website is:

<http://county.wsu.edu/jefferson/nrs/water/courses/Pages/>

The course was developed in a “study circle” format. A study circle is a small group of people who agree to meet to discuss an issue in depth. The course book is comprised of 7 sessions, designed for informal weekly discussions that usually take place in peoples’ homes. Each week a different group member facilitates the group. This format encourages group members to apply their personal experience and critical thinking to the material. Each section opens with a reflection question to start the session process. This is followed by articles, discussion questions, a section with suggestions for how to become more personally involved in the protection and stewardship of water, and sources for further reading and internet links. As discussion group members explore, discuss and question, they learn and develop a sense of place and community.

Eight pilot groups have been conducted in Washington. Course feedback was evaluated and the course materials revised and updated. Participants have initiated follow-up water related activities and projects.

Kathleen M. Herrmann

Snohomish MRC/Northwest Straits Foundation

The Port Susan Marine Stewardship Area: Ecosystem based management in practice

Kathleen M. Herrmann, Abby Hook

Abstract:

Port Susan is a region of exceptional biodiversity with a distinct sense of place within the greater Salish Sea. Because both the ecosystem and the jurisdictions responsible for its protection are complex, we are using the Conservation Action Planning (CAP) process developed by The Nature Conservancy (TNC) to develop a Marine Stewardship Area (MSA). The MSA is a non-regulatory planning designation that works among jurisdictions, cultures, and expertise to protect and improve the health of the entire marine and estuarine ecosystem while increasing the stewardship ethic among residents. With multiple jurisdictions and management frameworks; including two counties, one city, two marine resource committees, two salmon recovery entities, and two federally recognized Indian tribes, the project offers a unique example of both cross jurisdictional and cross disciplinary collaboration. CAP provides a mechanism to bring together resource managers, scientists, and citizens to coordinate their diverse expertise, interests, and authorities into a single ecosystem based management plan. This type of plan is unique to this area due to the depth of cross-disciplinary participation.

The Marine Stewardship Area is being developed by a non-regulatory body and depends on volunteer time. The planning process attempts to supplement traditional resource management structures which often manage a single species or a distinct geographic jurisdiction that may not align with the MSA project boundary. The results of collaboration create strategies that benefit a suite of species and habitats not normally managed together.

This project is led by two Marine Resource Committees that are made up of volunteer community members appointed by the local governments with two Indian tribes with management authority. Many agencies that encourage ecosystem based management attempt to implement plans from the top-down. Engaging local resource managers in the CAP process with citizens encourages ecosystem-based management that starts at the community level. Because local resource manager's expertise is both place-based and tied in with local decision makers, the project scale provides a plan that is more likely to be implemented. The intensive participation from local resource managers in the CAP process encourages ownership which is critical to the plan's success. The Port Susan MSA is particularly unique as it requires participants to adopt and implement the MSA Strategies that are most appropriate to their agency or jurisdiction.

We have learned two primary lessons to date. The first is the importance of scale and regional identification. Port Susan is geographically distinct and therefore a natural planning area. Residents identify themselves more closely with Port Susan than either of the counties they live in. Another key success of the project is the cooperation among the agencies, tribes, and stakeholders. This gives the players equal management in the project and has led to a successful collaboration. Significant trust building and coalition building has taken place with members of the scientific and management community who were initially leery of the CAP process. This trust building was possible because of the wide representation of stakeholders in the planning process.

10C: Seaweeds and seagrasses in the Salish Sea II

Benthic marine aquatic vegetation provides complex structure, buffering against water motion, carbon sequestration, and primary production in the Salish Sea ecosystem, yet the value of these services and responses of aquatic vegetation to multiple stressors remain poorly quantified. Current research seeks to address these gaps in understanding and contribute to sound decision-making. Topics related to the services provided by aquatic vegetation include: productivity rates and transport of materials among habitats and through food webs; their habitat functions for many important fish and invertebrates; and responses in terms of geomorphological processes. Topics related to threats include responses to eutrophication and other types of water quality issues; harvest for biomass or biofuels; and invasive species impacts, including those of a non-native seagrass. Recent advances in subtidal surveys have made it possible to begin to expand existing intertidal knowledge and explore the full biodiversity and distribution of seaweeds and seagrasses. Continued research concurrent with technological progress provides the best available science to manage the restoration, mitigation, conservation and protection of marine benthic vegetation in the Salish Sea. This session will explore the current scientific research on marine benthic vegetation in British Columbia and Washington State. It will also provide an overview and comparison of the policies that manage these habitats and the activities that affect them under the laws set by both governments. Presenters and participants will be encouraged through an organized panel discussion to develop strategies to promote transboundary research and monitoring projects and policy change that will further protect marine benthic vegetation in the Salish Sea.

This session will also feature Summaries of Seaweeds & Seagrasses, followed by a 20 minute facilitated discussion.

Conveners: Tom Mumford, Cynthia Durance

PRR Facilitator: Rita Brogan

Thomas Mumford

Washington Department of Natural Resources

Kelp: An old group receiving new recognition in Washington

Abstract:

There are 23 species of kelp (Phaeophyceae, Laminariales) found in Salish Sea. This group not only contains many of the physically largest seaweeds in the region, but also is also likely to be the largest group in its distribution and abundance. While much is known about the distribution of the two floating canopy-forming species, giant kelp (*Macrocystis*), and bull kelp (*Nereocystis*), we are only now becoming aware of the massive amounts of the 21 other non-floating species such as *Laminaria* and *Saccharina*. These species provide large amounts of detritus to the food web, not only in-situ, but also in the wrack and in deep areas well below the photic zone. They provide important biogenic habitat, and some species are now recognized as critical habitat for recently-ESA listed juvenile rockfish. There is renewed interest in kelp cultivation as a producer of biomass for biofuel production. Kelp can also play an important role on the movement of substrate and the resulting geomorphology with uncertain effects in beach biota. Harvest for human consumption continues to be high in certain times and locations. Comparison of the management between Washington and British Columbia show that regulations for protection, conservation, and harvest are in place but often poorly enforced or understood. I will discuss the recent efforts for restoration and compensatory mitigation. Kelp is now becoming to be increasingly recognized realized, along with eelgrass, as an important component of the Salish Sea ecosystem.

Colin Campbell

Sierra Club, British Columbia

Blue carbon – The role of coastal marine vegetation in carbon sequestration

Abstract:

Climate change impacts associated with a 2°C global average increase are now considered to occupy the threshold between dangerous and extremely dangerous, and there is a very high likelihood of temperature increases into the 4-6°C range. In this context, all sinks for carbon achieve crucial importance.

Biological carbon stored in marine coastal vegetated ecosystems (blue carbon) is characteristically sequestered for millennia cf. decades or centuries in terrestrial forests, and the by-area annual storage capacity exceeds all terrestrial ecosystems, in many instances by a factor of 50 or more. Ongoing and potential mitigation of global warming and ocean acidification generates the possibility of carbon offsetting by means of habitat conservation and restoration.

Globally, 55% of all carbon fixed by photosynthesis is in mangrove, salt marsh and seagrass ecosystems which occupy just 0.5% of the world's ocean area. A large contribution comes from planktonic and microbial populations. A key habitat characteristic is continuous sedimentation, which buries organic carbon. Meanwhile, sulphate in the water inhibits anaerobic conversion into methane. Global annual storage is estimated to be in the range 0.235 – 0.450 GtC/yr (billion tonnes of carbon per year), which is approximately 4.0% of the 10 GtC emitted by human activities every year.

British Columbia has 335 km² of intertidal eelgrass and 60 km² of salt marsh (but no mangroves). Using a global average carbon burial rate for saltmarsh (210 gmC/m²/yr) and global average and local maximum burial rates for eelgrass (83-500 gmC/m²/yr) an estimated range of annual carbon burial can be calculated, i.e. 40,505 – 180,200 tonnes C (equal to 148,653 – 661,334 tonnes CO₂ equivalent). This is a significant underestimate since areas of subtidal eelgrass are unknown but extensive. For comparison, BC's 100,000 km² of boreal forest sequesters carbon at the rate of 0.8 – 2.2 gmC/m²/yr for a total of 80,000 - 220,000 tonnes C per year, not significantly different from the blue carbon total but requiring an area approximately 90 times greater.

Clearly Blue Carbon sequestration is a process worth protecting, recovering and perhaps enhancing. It is in estuaries where the process prevails. BC has 442 estuaries and excluding the Fraser River and Boundary Bay only 13.5% of the area of the remaining 440 estuaries has any level of protection. This implies 123 estuaries with some protection in the intertidal zone while the remaining 317 medium and small estuaries have no conservation protection at all; nor does any subtidal component of any estuary. A marine protected areas strategy based on critical process, in this case carbon sequestration, is a campaign priority for the Sierra Club BC now that integrated marine planning is underway in the Pacific North Coast Integrated Management Area (PNCIMA). The feasibility of using offset sales as a funding mechanism is under investigation.

Helen Berry

Washington Department of Natural Resources

Canopy-forming kelp beds: How has this important resource changed over time?

Helen Berry, Thomas F. Mumford

Abstract:

Two canopy-forming kelp species, *Nereocystis luetkeana* and *Macrocystis pyrifera*, form extensive beds in nearshore waters of The Salish Sea. These algae are important contributors to the productivity of shallow marine ecosystems and provide habitat for invertebrates, fish, and birds. Little is known about canopy-forming kelp status and trends in the region. This information is needed to inform management approaches that protect these species from future impacts and that restore areas that have been impacted. We are investigating observed trends over time by integrating results from multiple canopy-forming kelp data sets within sub-areas of greater Puget Sound and the outer coast. Key data sources include historical maps dating from the late 1800's on the first "t-sheets," a comprehensive survey by Rigg in 1912-15, various surveys associated

with the Coastal Zone Atlas during the 1980's, DNR's annual airphoto-based mapping along the Strait of Juan de Fuca and outer coast (1989-2010), and DNR's mapping of sub-areas within Puget Sound proper and the San Juan Islands (between 2004 and 2006). Canopy-forming kelp abundance and distribution is known to fluctuate dramatically in response to climate. Our annual monitoring from the Strait of Juan de Fuca and outer coast shows high annual variation; for example, annual maximum canopy area is more than double the minimum canopy area over the study period. As elsewhere, high inter-annual variability appears to be linked to ENSO events. In addition to high year-to-year variation, total area increased significantly between 1989 and 2010 along the Strait of Juan de Fuca and the outer coast. We interpreted observed differences between historical and modern surveys in other areas with caution, given that annual variability in kelp canopy area is known to be large and given that there is considerable uncertainty related to mapping resolution and effort. These comparisons show that while the fidelity of the location of "beds" has been remarkably consistent, substantial changes are apparent along some individual shorelines. We conclude that there is a high likelihood of localized losses of *Nereocystis* in the San Juan Archipelago, and more widespread losses in central and southern Puget Sound. This finding differs from the findings of other analysis – yet, all analyses acknowledge a high degree of uncertainty. Priorities for future work include: more extensive characterization of changes in kelp canopies and exploration of hypothesis related to past, current and future stressors. Factors that might be driving changes are not well understood, but potential causes include climate, substrate changes, grazing pressure, water quality changes, and community shifts following disturbances.

- Summary of eelgrass stressors - all Session 9C speakers (2 minutes each)
- Summary of kelp talks - all session 10C speakers (2 minutes each)
- Overall summary discussion - discuss and summarize the similarities and differences about the stressors affecting eelgrass and macroalgae and what we need to research and monitor - all speakers.

10D: Numerical models of land and sea

Simulation of Salish Sea oceanographic and ecosystem properties is a rapidly advancing field, with extraordinary potential to help us understand and manage the links between watersheds and the sea. This session includes presentations on Salish Sea marine simulations, coupled model systems that integrate terrestrial freshwater processes with marine processes, as well as, models with high spatial resolution and detail, rigorous methods for validation against observations, methods for data assimilation, real time forecasting, and forecasting of climate and human influences, although simple tools linked to particular applied problems. This session is intended to foster communication and collaboration among oceanographic and hydrological modelers in the Salish Sea region, and also between modelers and policy makers who require tools to manage the Salish Sea ecosystem.

Conveners: Neil Banas, Mindy Roberts, Parker MacReady, Andrea Copping, Krista Bartz
PRR Facilitator: Kirsten Hauge

Michael Foreman

Fisheries and Oceans Canada

Fluxes to/from the North: A high resolution circulation and transport model for the Discovery Islands

Michael Foreman, Kyle Garver, Dario Stucchi, Ming Guo, Darren Tuele

Abstract:

A finite volume, ocean circulation model is applied to the northern Strait of Georgia and Discovery Islands and used to simulate the three-dimensional velocity, temperature, and salinity fields that will be required by companion biological transport models. The circulation model is initialized with a combination of climatological and recent temperature and salinity observations, and forced with i) winds measured at seventeen weather stations, ii) the discharges from eleven rivers, and iii) five tidal constituents. Specific simulations are evaluated against simultaneous observations from current meter moorings and the harmonics computed from historical measurements at twenty-four tide gauges. Results from a run simulating the water-borne transmission of the infectious hematopoietic necrosis virus (IHNV) originating on salmon farms will be described, and future work to overcome model deficiencies will be briefly outlined.

Olivier Riche

University of British Columbia

Estuarine circulation and nutrients uptake in the Strait of Georgia

Olivier Riche, Rich Pawlowicz

Abstract:

The Strait of Georgia (SoG) is an estuarine system in the Salish Sea. During 2002-2006 a comprehensive set of observations covering physical, biological, and atmospheric parameters was obtained from the southern Strait by the STRATOGEM program. Using data from 47 surveys carried out, monthly time series of estuarine layer transports over 2002-2005 in a time-dependent 2-box model were estimated using a formal inverse approach. These transports are then consistent with the temperature and salinity fields, as well as freshwater inflows and atmospheric heat fluxes. The quantitative transport time series were then combined with observations of nutrient concentrations to create a monthly time series of nutrient uptake in the Strait for nitrate, phosphate, and silicic acid.

Analysis of these time series suggests that the SoG estuarine circulation is not very sensitive to the seasonal changes of the freshwater inflow R from rivers. Although these flows change slightly with the freshet, a 5 fold change in freshwater inflow results only in a 40% change in the estuarine surface outflow. Based on the calculated sink of near-surface nitrate, new primary productivity is estimated to be $212 \text{ gC/m}^2/\text{year}$, which is similar to values obtained in different ways in other similar systems. Comparison of the nitrate and phosphate uptake rates suggests that the primary

production is mainly new production during the spring and summer blooms. Thus primary productivity is mainly controlled by the physics of the system, i.e. the factors controlling the upwelling supply of nutrients through deep inflow and entrainment. The uptake of silicic acid is almost two times larger than the uptake of nitrate during diatom spring blooms, while it is similar during the summer blooms.

R. Ian Perry

Fisheries and Oceans Canada

An ecosystem framework for incorporating climate regime shifts into fisheries management

Caihong Fu, Jake Schweigert, R. Ian Perry, Yunne-J. Shin, Hui Liu

Abstract:

Ecosystem-based fisheries management (EBFM) attempts to account for either fishing or climate variability (or both processes), in conjunction with species interactions when formulating fisheries management advice. Ecosystem models that investigate the combined effects of ecological processes are vital to support the implementation of EBFM by assessing the effectiveness of management strategies in an ecosystem context. In this study, an individual-based ecosystem model was developed for the Strait of Georgia Ecosystem. It was used to study how species at different trophic levels and with different life histories respond to climate regime shifts, and how well single- or multi-species fisheries perform in terms of human benefits (yield) and trade-offs (fishery closures) as well as their impacts on the ecosystem. In addition, simulation results were used to evaluate the performance of different ecological indicators based on their robustness to varying fishing strategies and climate regimes. The simulation results favour efforts to detect changes in productivity related to climate regimes and to implement regime-specific fishing levels; under EBFM, it is also necessary to consider what species are to be fished or not to be fished in order to achieve the most economic benefits while maintaining ecosystem health and function. Comparisons among fishing scenarios and climate regimes enable identification of ecological indicators that indicate fish community changes in response to a variety of stresses.

Parker MacCready

University of Washington

Numerical simulation of the Salish Sea: the MoSSea modeling framework

Parker MacCready, Neil S. Banas, David A. Sutherland, Sarah N. Giddings

Abstract:

Many ecosystem processes in our region are strongly shaped by ocean circulation and mixing. Low pH waters upwelled on the shelf contribute to acidification in Hood Canal. These same waters fuel high rates of primary production on the shelf and in the inland waters of the Salish Sea. The incubation and transport of Harmful Algal Blooms (HABs) is controlled by complex interactions of the Columbia River Plume and the estuarine exchange flow emerging from the Strait of Juan de Fuca.

In the past decade a number of large observational programs have fostered the development of accurate numerical models capable of simulating ocean and estuarine circulation, and ecosystem function, across the entire region.

Here we describe the modeling framework developed by the “MoSSea” (Modeling the Salish Sea) project at UW. The model domain spans the inland waters of the Salish Sea as well as the coastal and offshore waters of OR, WA, and BC. It is forced with realistic tides, rivers, winds, surface heat fluxes and ocean open boundary conditions. This allows the creation of multi-year realistic hindcasts, and these have been extensively validated against observations at both estuarine and coastal scales.

The validated model has many practical applications, from the calculation of residence times, to HAB transport patterns and biogeochemical studies. Results of these applications will be shown.

URL: <http://faculty.washington.edu/pmacc/MoSSea/index.html>

Andrea Copping

Pacific Northwest National Laboratory

Snow caps to white caps – Numerical modeling in the Snohomish Basin to assist resource managers

A. Copping, J. Richey, N. Voisin, M. Wigmosta, Z. Yang, R. Taira, M. Constans, T. Wang, S. Geerlofs

Abstract:

Management priorities in the Salish Sea are highly dependent on understanding the interaction of freshwater and saltwater with the land and sea. Predicting flood levels, estimating contaminant loads in stormwater, determining the inundation of critical salmon habitat, water quality trends in the Salish Sea, and evaluating the effects of land use change, and predicting impacts of climate change, all depend on estimating and predicting the timing and quantity of freshwater that enters coastal rivers and streams, the rate at which those waters enter the Salish Sea, and the circulation of nearshore marine waters.

Researchers at Pacific Northwest National Laboratory and the University of Washington have combined their knowledge and modeling expertise in the Snohomish Basin to develop an integrated watershed-to-estuary system that models water and major constituents from the snow pack of the Cascade Mountains to the Snohomish estuary and nearshore waters of Whidbey Basin and Puget Sound. The Snohomish Basin is the second largest watershed in the Puget Sound Basin, and one of the fastest developing in the region. Drained by the Snohomish River and its tributaries, the basin is home to Everett, the fourth largest city in the region, expanding suburbs and smaller municipalities, extensive agricultural lands, and significant forests and wetlands.

The model integration approach links the fully distributed land surface hydrology model DHSVM to the finite volume, unstructured coastal ocean model, FVCOM. Both models have already been applied independently and successfully to the Snohomish Basin. The linkage is performed through an application of the model framework, FRAMES. For this proof of concept PNNL and UW researchers will establish a baseline for existing climate conditions in the Snohomish Basin and assess the effects of watershed development and future climate change, based on IPCC scenarios. Collaborators including Snohomish County, the City of Everett and King County are working with the PNNL and UW researchers to define issues that will be informed by the Snow Caps to White Caps system, including the effects of urban stormwater runoff on nearshore estuarine waters, effects on downmigrating juvenile salmon, recharge rates of shallow aquifers and wetlands, and the future outlook for snow pack in the Cascades.

This paper will demonstrate the linkages of the modeling systems, discuss the challenges of building out a linked modeling system from freshwater to saltwater, and develop decision-support tools and output that meet the expectations of water resource, salmon, and watershed managers. After applying Snow Caps to White Caps system to the Snohomish Basin, researchers and resource managers will examine the potential to replicate and extend the system to other major watersheds in the Salish Sea.

Guy Gelfenbaum

U.S. Geological Survey

Modeling fine sediment dispersal and geomorphic change in the restored Nisqually River Delta
Guy Gelfenbaum, Andrew Stevens, Eric Grossman, Kelley L. Turner, Chris Curran

Abstract:

Removal of century-old dikes within the Nisqually River delta in October 2009 restored tidal processes to over 300 ha of freshwater wetlands in southern Puget Sound with the goal of

increasing salt marsh habitat and aiding in the recovery of salmon and wildlife populations. Following dike removal, saltwater intrusion has altered freshwater vegetation and initiated sediment transport into and out of the restoration area resulting in mostly unvegetated tidal flats with a branching tidal channel network. Initially, the elevation of the restoration area was lower than similar vegetated areas outside the dikes due to a reduced sediment supply and decades of sediment compaction. Since wetland elevation is an important parameter for plant growth, renewed sediment supply will be critical to the success of the restoration project. Sediment accumulation within the restoration area will determine both whether salt marsh vegetation emerges and the long-term viability of salt marsh habitat as sea-level rises.

In this study we use a coupled hydrodynamic and sediment transport model (Delft3D) to examine the pathways of fine-sediment dispersal from the Nisqually River and possible morphologic change within and just beyond the restoration area. The model is forced with tides and river flow, and validated with time-series measurements of water levels and currents at several stations within and directly seaward of the restoration area. Medium-term (5 year) morphologic change within the restoration area is predicted using a range of sediment supplies from the river covering potential anthropogenic changes to the watershed. Initial results indicate that fine sediment (silt and clay) from the river enters during a portion of the tidal cycle and deposits within the restoration area. Further modeling will examine whether the sediment supply from the river is sufficient to allow the wetland to keep pace vertically with actual and projected rates of sea level rise.

10E: Threats to the Salish Sea ecosystem: Perception and reality

This discussion forum brings together Canadian and American scientists, policy-makers and members of environmental organizations to discuss the most pressing threats facing the Salish Sea ecosystem. The bewildering array of environmental threats discussed by media, government and advocacy organizations, usually with differing opinions on urgency, frequently leaves the public confused about what would be an appropriate use of limited resources to address such problems. This session includes presentations by a four-member panel about the policy priorities, community values and current scientific understanding of the effects on the region of various local and global stressors and their cumulative effects, followed by a facilitated discussion that will determine what action could or should be taken now and what further research is required.

This session will also feature a 45 minute facilitated discussion.

Conveners: Dave Ward, Katharine Wellman, Elizabeth Skewgar

PRR Facilitator: Mike Rosen

Scott Redman (10 minutes)

Puget Sound Partnership

Threats to the Puget Sound ecosystem: perspectives from the Puget Sound Partnership

Scott Redman, Ken Currens

Abstract:

Understanding threats to an ecosystem -- what is threatened? by what? how much? where? -- and using this information to guide management action is anticipated as a key feature of science-based ecosystem recovery. The Puget Sound Partnership has adopted the Open Standards for the Practice of Conservation to guide science-policy interaction: identifying and assessing threats, and demonstrating how threats are addressed by various contributing factors and by recovery strategies and activities are key tools in the Open Standards. The Partnership's Science Panel has adopted integrated ecosystem assessment as a framework for developing, coordinating, and communicating scientific investigations and understandings to support ecosystem-based management. A key step in this framework is to conduct risk analyses to estimate how major threats, drivers, and stressors affect the ecosystem as means of understanding the most imperiled parts of the system and the likely causes of degraded conditions. The Partnership's recent experiences in describing the threats to ecosystem function and resilience have not been satisfying to scientists or decision-makers. Assessing threats at scale of the Puget Sound ecosystem and across the scope of the Partnership's concerns about the ecosystem has proven challenging. The Partnership has relied on qualitative assessments to guide development and revision of the Action Agenda for Puget Sound recovery. This type of assessment may reflect a priori assumptions about threats and perceptions of threats. Developing a more robust and systematic approach to assessing threats to the ecosystem is a key priority of the Partnership's science program.

Don Radford (10 minutes)

Fisheries and Oceans Canada

Threats to the Georgia Basin ecosystem - A manager's perspective

Abstract:

As the Area Director for DFO's South Coast Area, I am responsible for implementation of many of the department's plans and management decisions in the Strait of Georgia and Juan de Fuca Strait. Historically, these decisions which were focused on the timing of fisheries openings, have become more complex in recent years, due to new legislation, increased expectations and participation by wider range of stakeholder interests, coupled DFO's new focus on ecosystem-based management. My portfolio includes managing fisheries to achieve conservation and economic prosperity objectives, monitoring fisheries and evaluating and assessing salmon

populations, addressing access to resources, including aquaculture, and protecting fish habitat. My staff and I receive science advice on many of these topics; however, the capacity to generate science advice in a manner that keeps pace with the rate of change we see in the environment is a challenge. By participating in this panel discussion, I hope to inform British Columbians about the some of the challenges of managing this complex area and to learn more about how we can improve our capacity to request advice and incorporate it into our dynamic world.

Christianne Wilhelmson (10 minutes)

Georgia Strait Alliance

Issues and threats: a community perspective

Abstract:

The Strait of Georgia is among the world's most biologically rich ecosystems, supporting thousands of species of plants and animals. Since almost 70% of British Columbians live around the shores of the Strait, the health of this ecosystem is central to the economic and social health of BC's human population. With almost 7 million people living around the entire Salish Sea, the pressures on these waters are intense.

As those who conduct research in the region realize, the breath of the issues impacting the entire ecosystem are seemingly overwhelming. From urbanization to pollution, from stormwater and habitat destruction to toxic discharges and emissions, from hydrocarbon pollution to coastal sprawl and development, prioritizing which issues need to be addressed first is daunting.

As part of our assessment of where to focus our limited capacity, Georgia Strait Alliance recently completed a strategic assessment of issues of concern. To no one's surprise, this assessment continued to identify the overarching stresses of pollution and habitat destruction – heightened by the increasing impacts of climate change - as major threats to the region.

Our work continues to focus on ongoing threats (for e.g., open-net cage fish farms, inadequate implementation of federal Species at Risk Act leaving the habitat of at risk species unprotected, etc) and we promote processes to improve how we address all threats (marine planning in the region starting with a declaration of a National Marine Conservation Area in the Southern Strait of Georgia). We also continue to address the cumulative impacts of small discharges from the over 500,000 recreational boats that come through the region through our Clean Marine BC program.

However, an issue we've identified as a growing threat to the region is the myriad of effects from shipping traffic, from noise to marine mammal hits to the pollution that results from their passage through our waters. More specifically is the threat that comes from the content of some of these ships – oil and gas. An increase in volume of fossil fuels exported through the Westridge Terminal in Burnaby has risen from approximately 400,000 metric tons in 2004 to nearly 4 million metric tons in 2009. In just the last 2 years, the number of oil tankers coming out of Burrard Inlet has risen from 48 in 2007 to 65 in 2009.

This increase has many asking questions: is increasing tanker traffic through Burrard Inlet and under Second Narrows a sound idea? Is it safe to increase the numbers of tankers and the amount of cargo each carries, as is currently planned? Are we prepared for a catastrophic oil spill should one of these tankers run aground? What will the effects be to our economic, social and environmental fabric when a spill happens? These are questions we don't have answers to because the decision to increase oil tanker traffic in this region has been done without any public or community consultation. Assessing what do to next will need ongoing conversations with industry, scientists and the public, which we have begun to undertake.

Sophia Johannessen (10 minutes)

DFO, Institute of Ocean Sciences

Local and global change in the Strait of Georgia

Abstract:

The oceanography and ecosystem of the Strait of Georgia are changing. Warming riverwater and seawater, sea-level rise, declines in oxygen and pH of deep water, and the increased frequency of storms all result from global climate change. These global changes interact with local activities to put stress on marine animals. For example, sea-level rise and storms will interact with coastal development to threaten critical, intertidal habitat. The decrease and earlier peak in zooplankton biomass limit food available to some fish and birds, which are already stressed by contamination. Southern resident killer whales, a species at risk, are threatened by a decline in Chinook salmon, together with marine traffic and biomagnifying contaminants. Some stressors can be controlled only through international action to mitigate climate change. However, we have local control of fishing, habitat destruction, release of some contaminants and, to some extent, river flow and temperature. Acting to control these local stressors will support resilience of marine biota in the face of inevitable global changes.

10F: Transboundary Collaboration II – Raising the Next Generation of Transboundary Projects

The 2011 Salish Sea Ecosystem Conference program is rich with topics and issues for which transboundary coordination, cooperation, and/or information exchange is vital. Examples include species conservation; contaminant science and management; and invasive species management. In the second session, which will be held immediately before the closing plenary, a facilitator and group of discussants will initiate and catalyze discussion upon major activities or initiatives described in preceding regular sessions. Conference attendees engaged in potentially transboundary efforts are urged to attend and participate in this discussion. Through facilitated discussion, discussants and audience will identify challenges to effective transboundary collaboration in specific activities and work together to generate ideas for productive next steps. Finally, the session will return to the question of what role, if any, existing transboundary coordination mechanisms and forums (e.g., IAS, SoC, ECC) can play in facilitating the success of transboundary projects.

This session will feature a facilitated discussion.

Conveners: Lisa Chang, Geoff Reid

PRR Facilitator: Mike Rosen

Ginny Broadhurst

Director, Northwest Straits Commission

Rod Dobell

Professor Emeritus of Public Policy and Senior Research Associate, Centre for Global Studies, University of Victoria

David Grace

Senior Policy Advisor, British Columbia Ministry of Environment

Larry Hildebrand

Senior Advisor, Environmental Protection Operations, Environment Canada

Charlie O'Hara

Planning Director, Swinomish Indian Tribal Community

3:00 pm - 4:30 pm

Closing Plenary—Regional Leaders Panel: "Which comes first? Science and decision-making for protecting the Salish Sea"

Regional leaders discuss the challenges of making policy and program decisions to protect and restore the Salish Sea in the face of scientific uncertainties, while exploring how policy-makers and scientists can work together. Audience questions to be invited.

- Dennis McLerran, EPA Regional Administrator, Panel Facilitator
- Dr. Tom Bancroft, Executive Director, People for Puget Sound
- Martha Kongsgaard, Chair, Leadership Council, Puget Sound Partnership
- David Marshall, Executive Director, Fraser Basin Council
- Dr. Mark Zacharias, Assistant Deputy Minister, Environmental Sustainability and Strategic Policy Division, BC Ministry of Environment

Poster Presentations

Contaminants: Sources, fates, transport and impacts

Bernadita Anulacion

NOAA Fisheries Northwest Fisheries Science Center

Somatic growth rates and chemical contaminant levels in English sole from Puget Sound, WA

B. Anulacion, P. Chittaro, D. Boyd, R. Pearce, J. Bolton, G. Ylitalo

Abstract:

To investigate the suitability of somatic growth rates in fish as an ecosystem health indicator, somatic growth rates and chemical contaminant levels were measured in English sole (*Parophrys vetulus*) to identify any potential correlations. Levels of persistent organic pollutants (POPs) and polycyclic aromatic hydrocarbons (PAHs) were measured in young-of-the-year English sole from different sites in Puget Sound, WA, together with otolith-derived somatic growth rates. Fish were collected from six sites, representing a gradient of highly urbanized (highly contaminated) to semi-rural/non-urban (minimally to moderately contaminated) areas. At least 30 fish were collected by beach seine at each site, during two sampling points in June and August, 2010. Growth rates were measured for individuals collected at both time points, and contaminant analyses were conducted on 3 composite samples made up of 10 individuals each, from fish collected in August. Fish collected in August were aged at 5 to 6 months, and presumed to be resident at these sites for at least 1 month. The somatic growth rates were determined from the last 21 days of life, by microstructural analyses of otoliths of each fish. Whole body samples were analyzed for a large suite of POPs and PAHs using gas chromatography/mass spectrometry. In general, concentrations of POPs and PAHs were low (< 10 ng/g wet weight); however, there do appear to be site-related differences in contaminant levels measured in whole bodies. Statistical evaluation of growth rates showed significant differences between sites, within each month. Additional contaminant analyses are being conducted; however, our initial findings suggest that varying levels of contaminants are a likely influence on the rate of growth of these animals. Thus, measurements of growth rates in conjunction with contaminant burden of young flatfish may be a useful indicator of ecosystem health.

Jack Bell

Kwaht and University of Washington Friday Harbor Marine Laboratories

Development of a method for the analysis of diethylhexyl phthalate (DEHP) in the San Juan Islands

Jack Bell, Russel Barsh, Leah Lindstrom, Riley Eltrich

Abstract:

Although Washington's San Juan Islands are relatively pristine, with legacy pollutants sequestered in some harbor sediments, the influx of emerging contaminants has received little attention. We use the plasticizer phthalate DEHP as an indicator of a persistent bioaccumulative toxic with possible endocrine disruptive properties. Seawater and terrestrial runoff samples are adsorbed on solid phase extraction (SPE) cartridges and selectively eluted with alcohol for a 100:1 concentration of DEHP. The eluates are separated by high performance liquid chromatography (HPLC) with UV detection. This methodology provides a selective and accurate assay of DEHP at parts-per-billion (ppb) levels. Spiking samples and blanks with analytically pure DEHP reveals contamination common to laboratories worldwide. We find DEHP in parking lot and storm sewer runoff samples, generally below EPA's maximum contaminant level of 6 ppb in drinking water. DEHP in a Friday Harbor seawater sample is a few tenths of a ppb, as expected for the dilution of terrestrial runoff.

Funded by San Juan County through their Marine Resource Committee.

Neil Dangerfield

Fisheries and Oceans Canada

PCBs and PBDEs in sediments and blue mussels in the Strait of Georgia

Neil Dangerfield, Paul B.C. Grant, Pat Shaw, Peter S. Ross

Abstract:

The partitioning of persistent contaminants in the aquatic environment has profound consequences for food web accumulation and the health of biota. While polychlorinated biphenyls (PCBs) have declined significantly in aquatic biota since their bans in Canada and the USA in the 1970s, polybrominated diphenyl ethers (PBDEs) have increased rapidly between 1980 and the present, and are only now facing elimination from the marketplace. We measured PCBs and PBDEs in samples of Pacific blue mussels (*Mytilus trossulus*) and surface sediments collected in 2005 from 22 adjacent sites in the Strait of Georgia, British Columbia. Total PCB and PBDE concentrations were highest in near-urban locations for both sediments and mussels. Total PCB concentrations in mussels range from 910 to 48600 pg/g lipid weight. Total PBDE concentrations (sum of all detected congeners) in mussels ranged from 1140 to 11700 pg/g lipid weights. While BDE-209 contributed 7% to total PBDEs in mussels, this congener contributed 66% in sediments. Principal Component Analysis (PCA) revealed near-urban locations to be dominated by heavier (i.e. more halogenated) congeners of both contaminants. PCB patterns were consistent with historical point source emissions in urban areas, and environmental distillation towards lighter profiles in remote sites over time. PBDE patterns suggested a clear divergence into clusters in proximity to urban sources vs. sites outside of urban influences. PBDEs had greater biota-sediment accumulation factors (BSAFs) relative to PCBs of similar hydrophobicity (Kow). Since PBDEs overwhelmingly dominate waste water effluent profiles in the Strait of Georgia, this dichotomy in BSAFs may reflect the different histories captured by the two sample matrices. Mussels are more likely to capture more recently released contaminants such as PBDEs, while Petit Ponar surface grabs (~6 cm depth) typically sample a mixed sediment layer spanning multiple years and effectively 'dilute' recent PBDE inputs. PBDE concentrations exceeded PCB concentrations in 21 % of sediment samples and 45 % of mussel samples, highlighting the rapid emergence of this current use flame retardant in the Salish Sea environment.

Margaret Dutch

Washington State Department of Ecology

Polybrominated Diphenyl Ethers in Puget Sound sediments - A baseline update (2004-2011)

Margaret Dutch, Sandra Weakland

Abstract:

Polybrominated diphenyl ethers (PBDEs) are synthetic flame retardants introduced in the late 1970s to reduce the flammability of household and commercial products. They have been more recently recognized as pollutants of concern in Puget Sound, and in 2007, the Washington State Legislature passed a ban on the use of PBDEs in manufactured products. Structurally similar to polychlorinated biphenyls (PCBs), PBDEs break down and enter the food web. Like PCBs, PBDEs bioaccumulate in marine organisms and humans, potentially causing serious health problems.

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 (PBDE-47, -99, -100, -153, and -154) were measured at 30 sediment stations in Hood Canal in June 2004.

Twelve congeners (PBDE-47, -49, -66, -71, -99, -100, -138, -153, -154, -183, -184, and -209) were measured at:

- 10 stations collected throughout Puget Sound (April 2005, April 2010).

- 40 stations in the Strait of Georgia (June 2006).
- 30 stations in the Whidbey Basin (June 2007).
- 30 stations in Elliott Bay/Lower Duwamish (June 2007).
- 30 stations in the Central Basin (June 2008, June 2009).
- 30 stations in Commencement Bay (June 2008, June 2009).
- 55 stations in South Puget Sound (June 2011)
- 30 stations in Budd Inlet (June 2011)

Levels of PBDEs in these sediments are reported and compared here. This study provides environmental managers with baseline data indicating current levels, distribution, and spatial extent of PBDEs in Puget Sound sediments. This information can be used in current and future source control and cleanup.

Margaret Dutch

Washington State Department of Ecology

Pharmaceuticals and personal care products measured in Puget Sound sediments

Margaret Dutch, Sandra Weakland, Bharat Chandramouli

Abstract:

Environmental concentrations of pharmaceuticals and personal care products (PPCPs) and perfluorinated chemicals (PFCs) are of growing concern worldwide, and have never been measured in Puget Sound sediments. In April, 2010, sediments were collected for two ongoing Puget Sound monitoring programs. Ten long-term ambient monitoring stations were sampled from locations throughout Puget Sound for the Puget Sound Assessment and Monitoring Program. Thirty randomly-selected stations were also sampled from Bellingham Bay, using a probabilistic sampling design developed for the Washington State Department of Ecology's Urban Waters Initiative.

Sediments were tested for the presence of 119 PPCPs and 13 PFCs. Analyses were conducted by AXYS Analytical Services Ltd., Sidney, BC, Canada, using AXYS Method MLA-075 (US EPA 1694) for PPCPs and MLA-041 for PFCs. These methods use liquid chromatography with tandem mass spectrometry (LC/MS/MS).

PPCPs were detected in <2% (91 of 5536) of all results, while 12% (14 of 119) of all chemicals were detected. The 14 detected chemicals included antibiotics, antibacterial agents and calcium channel blockers, and an antidepressant, an antifungal, an antihistamine, an anti-inflammatory, a pain reliever, and a stimulant. Chemicals most frequently detected include diphenhydramine, triclocarban, and triamterene. Challenges encountered in the analysis of these compounds are discussed.

PFCs were detected in <4% (13 of 359) of all results, while 23% (3 of 13) of all chemicals were detected. The three PFCs detected included perfluorobutanoate, perfluorooctane sulfonamide, and perfluorosulfonate, chemicals (and break-down products) used in the manufacturing of photo film and Scotchgard™.

Final concentrations are summarized and presented graphically to indicate the concentration and distribution of PPCPs and PFC in Puget Sound sediments at these 40 urban and non-urban study locations.

Li-Jung Kuo

Pacific Northwest National Laboratory

Atmospheric deposition of metals and combustion-derived aerosols to the surface of Puget Sound

J. Kuo, P. Louchouart, J.M. Brandenberger, E.A. Crecelius, V. Cullinan, G.A. Gill, C. Garland, J. Williamson

Abstract:

Coastal urban centers can be a major source of combustion-derived particulate matter to the aquatic system through direct atmospheric deposition as well as more “distributed” deposition over the watershed, followed by surface runoff inputs. To estimate the overall atmospheric inputs and sources of combustion-derived particulates over the Puget Sound, we measured the bi-weekly bulk deposition of organic and inorganic constituents (metals, PAHs, PBDEs, PCBs and anhydrosugars) during both the wet and dry season for 1.5 year at several sites (industrial, urban, suburban, rural). We then used these integrated deposition rates to evaluate the contribution of the air-sea fluxes to the annual sediment-water accumulation rates at different sites in the Puget Sound. The atmospheric depositional fluxes of fossil fuel combustion by-products were predominantly driven by local emission activities (large industrial and port facilities and urban areas) rather than seasonality. The industrial site in the port of Tacoma was thus characterized by the largest depositional fluxes of aerosols, primarily derived from fossil fuel combustion. In contrast, biomass-burning emissions were strongly influenced by seasonality. Our observations confirm that late summer wildfires, during the driest season of the year, contribute to a substantial flux of charcoal-derived particulates to the surface of Puget Sound. This flux peaked in early fall following the first rain events, suggesting a stripping of PM from the atmosphere through wet deposition. Signature ratios of anhydrosugars and methylated PAHs point to softwoods as the predominant source of biomass combustion in the summer/fall seasons. The fluxes in anhydrosugars increase 5-10 folds from early fall to the winter-early spring season showing the influence of domestic stove heating activities on air quality of the region. Signature ratios of anhydrosugars in the winter, suggest either that softwood becomes an insignificant source of biomass combustion or that combustion temperature in wood stoves is high enough to remove the most thermally sensitive anhydrosugars (i.e. mannosan). Air-sea depositional fluxes of PAHs averages 4-18% and 9-70% of sedimentary fluxes in the Main Basin and the Hood Canal, respectively, showing the large spatial heterogeneity of watershed inputs vs. atmospheric deposition in the region. In contrast, atmospheric depositional fluxes of anhydrosugars are 2-3 orders of magnitude greater than recorded fluxes at the sediment-water interface suggesting a strong incorporation of these polar biomarkers into the dissolved organic matter pool, or a large degradation rate in the water column. Comparison of the atmospheric depositional fluxes to historically measured fluxes at one site in Tacoma and sedimentary fluxes in the Puget Sound suggest that the atmospheric fluxes of combustion-derived PAHs have declined markedly in the last ~20 years. Similar PAHs signatures suggest, however, that the potential source mixes have remained relatively unchanged. Semi-quantitative source apportionment models, based on endmember signature ratios and PCA, demonstrate the influence of biomass combustion (both from wildfire and domestic heating stoves) on the quality of aerosols in rural areas of the Puget Sound, and the importance of fossil fuel combustion and vehicular traffic on emissions of atmospheric particulates in the urbanized south eastern region of the Sound.

Deb Lester

King County Department of Natural Resources

Synthesis of toxic chemical loading studies in the Puget Sound Basin – Hazard assessment

Deb Lester, Jenee Colton, Richard Jack, Dave Serdar, Dale Norton

Abstract:

The Puget Sound Toxics Loading Analysis (PSTLA), initiated in 2006, included a number of studies designed to estimate loadings of select chemicals to Puget Sound through various pathways. The primary goal of the PSTLA is to provide information to guide decisions about

chemical control strategies for the Puget Sound Basin. While the numerous studies conducted as part of the PSTLA greatly increased the knowledge regarding the primary pathways and amounts of these chemicals reaching Puget Sound, they were not intended to evaluate the possible impacts these chemicals may have on aquatic life or people. Therefore, the process used to synthesize the results of the numerous PSTLA studies included an overall hazard assessment (HA) to provide context for the study findings. The purpose of the HA was to rank the relative importance of the chemicals of concern in various media and for a variety of receptors. The results of the HA were combined with information on sources and pathways to fill data needs and better understand how to focus control strategy efforts. The HA included a high level evaluation of the potential for 17 chemicals (or chemical groups) to cause adverse effects to aquatic life and, to a lesser extent, wildlife and people. Exposure data used in the HA included environmental data from PSTLA studies and readily available environmental data collected over the past 10 years. Readily available toxicity data from existing databases and/or established thresholds were used as effects data in the HA. The HA included 5 types of evaluations: 1) Direct effects to aquatic life via water exposure; 2) Direct effects to benthic organisms through sediment exposure; 3) Direct effects to aquatic life based on tissue residue levels; 4) Effects to wildlife based on ingestion of prey, water and sediment and 5) Effects to human health through fish/seafood ingestion. The outcome of the HA provided a means to rank the relative importance of the chemicals of concern in various media and receptors. The process and data used to conduct the hazard assessment, in addition to the uncertainties and outcomes will be presented.

Lincoln Loehr

Snohomish County Marine Resources Committee

Mussel Watch data from Snohomish County illustrate spatial and seasonal trends

Emily Whitney, Kathleen Herrmann, Mary Cunningham, Alan Mearns, Lincoln Loehr

Abstract:

Blue mussels (*Mytilus* species) accumulate contaminants from the water at concentrations reflecting ambient environmental levels and thus are useful for monitoring contaminants in the marine environment. NOAA's National Mussel Watch Program has monitored for pollutants for more than two decades. The program collected mussels and oysters from U.S. coastal water including the Great Lakes and analyses samples for over 140 contaminants. Data trends from this program are useful for monitoring the impact of environmental contaminants and events such as oil spills and the effectiveness of management decisions. In 2007, the Snohomish County Marine Resources Committee (MRC) built on this national monitoring framework by adding additional sites along the entire county coastline. In addition, the Stillaguamish Tribe added one new site on Camano Island. Additional stations were added in 2009 and 2010. Mussel availability sometimes prevented sampling at some stations. The NOAA program samples only in the winter. The MRC added summer time sampling in order to evaluate differences in mussel contaminants between wet and dry seasons. Collectively these sampling sites (NOAA, Snohomish County MRC and Stillaguamish Tribe) provide overall coverage of Snohomish County's marine waters and a platform for monitoring trends of chemical pollution in this region.

This poster presents the Mussel Watch results for Snohomish County, and makes comparisons to NOAA West Coast stations, and NOAA Washington State stations. The data show spatial differences and seasonal changes perhaps related to land use and stormwater.

Patrick Louchouart

Texas A&M University-Galveston

Historical inputs of combustion-derived Pb and Hg to watersheds of the Hood Canal, USA

P. Louchouart, L-J. Kuo, J. Brandenberger, F. Marcantonio, G. Gill, C. Garland

Abstract:

Here we present a series of historical reconstructions of metal inputs from combustion emissions in a rural watershed/airshed of the Hood Canal, over the last century. A complex suite of combustion proxies and metals in sedimentary records (black carbon, PAHs, Pb, Hg, and Zn

concentrations, as well as stable Pb isotopic signatures) assisted in elucidating major changes in the type of atmospheric inputs of anthropogenic Pb and Hg to the system of study. To assess the impact of watershed inputs vs. direct atmospheric fallout of combustion-derived contaminants to the Hood Canal, we then calculated metal fluxes and PAH inventories in the two cores studied and corrected these for sediment focusing. For most of the 20th Century, biomass combustion has remained a major source of combustion-derived aerosols in the study area. During the early to mid-20th Century, however, oil and potentially coal combustion have become substantial additional sources of atmospheric contamination. The strong relationships between the organic combustion markers and Pb levels in the cores suggest that this metal is derived from combustion emissions. Although the timing in increasing and decreasing concentrations are synchronous with tetraethyl lead (TEL) usage in North America and the stable Pb isotope signatures point to a predominant Canadian gasoline source, the Hg and Zn concentrations suggest an industrial source instead. At this point, it is difficult to assign with certainty what is the source of these anthropogenic metals to the Hood Canal. However, the North-South gradient in metal fluxes (corrected for sediment focusing) and their atmospheric deposition inventories suggest a transport of combustion-derived contaminants from the Strait of Georgia region where the major urban systems of Vancouver and Victoria lie. The corrected peak fluxes of total Pb and Hg in both cores are higher than expected for the rural land use characteristics of the Hood Canal, suggesting that the higher accumulation rates observed between 1965-75 in Hood Canal may be the product of local/regional inputs that overshadow the average atmospheric deposition rates in this rural area. Finally, the corrected PAH peaks occur within ~10-15 years offset at both sites with the peak atmospheric flux occurring in the mid-1950s in the northern Hood Canal and in the late 60s-early 70s in southern Hood Canal. These results confirm the earlier reports of peak PAH inputs to the sediments of the northern HC in the mid 1950s, and suggest the potential contributions of combustion-derived constituents from local/regional anthropogenic activities (pulp mills, naval base) in the north. In contrast to metals, which showed a substantial fraction of background inputs (~40-50% of totals), anthropogenic PAH fluxes comprise $90 \pm 4\%$ of the total peak fluxes suggesting that background inputs of these combustion by-products were minimal prior to the industrialization of the region. The comparison between these results and peak PAH flux data for water bodies in other regions of the U.S. and Canada suggests that inputs of these combustion by-products are extremely variable from one region to the next.

Chris Lowe

Capital Regional District

Pharmaceuticals, personal care products, illicit drugs and their metabolites in municipal wastewater

Abstract:

The Capital Regional District (CRD) has undertaken a number of projects to characterize pharmaceuticals, personal care products, illicit drugs and their metabolites in the region's screened municipal wastewaters. Beyond simple characterization efforts, attempts have been made to utilize sub-regional pharmaceutical prescription rates and population demographics to predict wastewater concentrations for a subset of compounds. The challenges encountered with these predictive attempts, particularly with respect to sampling frequency, will be discussed.

Maggie McKeon

University of Washington, Department of Civil and Environmental Engineering

Observations of salt-wedge dynamics and sediment resuspension in the Duwamish Estuary

Maggie McKeon, Alex Horner-Devine

Abstract:

The Duwamish Estuary is fed by the Green River and empties into Elliott Bay just south of downtown Seattle. Continuously modified for over a century to accommodate industrial, transportation, and waste disposal needs, the Duwamish Estuary has lost 98% of its intertidal area and accumulated enough legacy contaminants to justify four EPA designated Superfund sites. Yet the estuary still maintains a surprising level of biological activity, supporting salmon

runs, aquatic birds, otters, sea lions, and benthic organisms.

In estuaries, the zone of fresh and saltwater convergence is often observed to form an area of elevated suspended sediment concentrations (SSC), which is generally associated with biological activity due to the convergence of flow and nutrient availability. Hydrophobic contaminants present in the Duwamish Estuary, such as PCBs, PAHs, dioxins, and furans, sorb onto fine sediment particles with high organic carbon content and are concentrated in bed sediments in the lower reaches of the estuary under moderate to low flow conditions. For river discharge rates greater than $30 \text{ m}^3\text{s}^{-1}$, the Duwamish Estuary is a strongly stratified 'salt-wedge' estuary characterized by a distinct wedge of ocean water overlain by fresh river water that moves up- and downstream with the tidal flow. We observe a region of significantly elevated SSC that tracks closely with the upstream toe of the salt-wedge. Under moderate to high discharge conditions, when the wedge is in the lower reaches of the estuary, this mechanism may be responsible for high contaminant re-suspension and potentially enhanced biological uptake. Although sediment transport processes are notoriously complex, they are simplified in this system by historical channelization and ongoing dredging in the navigation channel. By observing salt-wedge dynamics and associated sediment re-suspension variability we can characterize internal longitudinal and lateral fluxes of contaminated sediments, as well as net export to Puget Sound.

During lower river flows the system switches to a partially mixed state in which the upstream extent of salt intrusion exhibits more vertical homogeneity and no longer has a distinct 'toe'. Monthly field observations beginning in May 2011 are presented as the first steps towards characterizing tidal-scale hydrodynamic and sediment transport processes at the salt-wedge toe. May 2011 observations located the downstream extent of the salt-wedge excursion at River Kilometer 6.0 during high river discharge conditions and confirmed the presence of significant sediment re-suspension immediately upstream of the salt-wedge toe with SSC roughly three-times ambient concentrations in the river. Subsequent observations through August will describe the transition from the high to low river discharge regimes.

Patrick Moran

U.S. Geological Survey

Sediment contaminants in urban streams: Distribution and sources of pyrethroid insecticides

P. Moran, K.M. Kuivila, M.L. Hladik, D.L. Calhoun, N.E. Kemble, C.G. Ingersoll, R.J. Gilliom

Abstract:

Pyrethroid insecticides are being used increasingly in urban environments with the mandated phase-out of diazinon and chlorpyrifos (organophosphate insecticides) in 2001. Applications of pyrethroid insecticides include commercial use on golf courses, landscapes, and structures, homeowner use on lawns and gardens, and public health agency use for vector control such as for West Nile virus. In contrast to the organophosphate insecticides being replaced, pyrethroids are more likely to sorb to sediments, which changes their fate and effects in the ecosystem. As part of a 2007 national study of sediment-associated contaminants in urban streams, depositional bed sediments (98 samples- including 21 from Puget Sound) were analyzed for 14 pyrethroids (allethrin, bifenthrin, cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, esfenvalerate, fenpropathrin, fluvalinate, permethrin, resmethrin, sumithrin, tefluthrin and tetramethrin). Samples were collected from urban areas near seven major U.S. cities: Atlanta, Boston, Dallas/Fort Worth, Denver, Milwaukee/Green Bay, Salt Lake City, and Seattle/Tacoma. The sampling sites in each area spanned a wide range of urbanization. Bifenthrin had the highest detection frequency (41%), and occurred in every urban area. Four other pyrethroids were detected, but much less frequently: cyhalothrin (11%); permethrin (5%); resmethrin (3%); and cypermethrin (1%). Detected concentrations of individual pyrethroids ranged from 0.2 to 38 ng/g, dry weight. The Dallas/Fort Worth area had the highest pyrethroid detection frequency (20%), the greatest number of pyrethroids (4) and some of the highest concentrations. Distributions of pyrethroids were compared to levels of urbanization and potential sources. Pyrethroid concentrations were also compared to sediment toxicity in whole-sediment exposures using the amphipod *Hyalella azteca* and the midge *Chironomus dilutes*.

Marie Noel

University of Victoria- School of Earth and Ocean Sciences

Contaminant-related alterations of genomics endpoints in Puget Sound harbour seals (Phoca vitulina)

Marie Noel, Steven Jeffries, Monique Lance, Nik Veldhoen, Caren C. Helbing, Peter S. Ross

Abstract:

The Salish Sea is receiving contaminants, including polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and mercury (Hg), from both local sources and long range atmospheric transport. These persistent, toxic and bioaccumulative contaminants often reach concentrations that can represent a risk for the health of those species at the top of the food web. Harbour seals (*Phoca vitulina*) are ~ non-migratory top predators that consume a wide variety of prey, making them useful indicators of marine ecosystem health in the Salish Sea. In 2009, we collected blood, fur, and blubber/skin samples from 24 live-captured harbour seal pups from four sites in Puget Sound (Hood Canal; Whidbey Basin, Main Basin, and South Sound). We measured PCB, PBDE, Hg levels and applied newly developed genomics techniques to quantify the expression of a number of genes considered to be sensitive to contaminants using real-time polymerase chain reaction (PCR). Harbour seal pups from Hood Canal had the lowest PCB, PBDE, and Hg concentrations (1.57 ± 0.21 mg/kg lipid weight (lw), 0.25 ± 0.05 mg/kg lw, and 3.52 ± 0.32 mg/kg dry weight (dw), respectively), while pups from the Main Basin were the most contaminated (6.34 ± 1.53 mg/kg lw, 0.82 ± 0.14 mg/kg lw, and 11.11 ± 2.12 mg/kg dw, respectively). Body weight, length, and girth did not influence gene expression, and there were no differences between males and females for any endpoints. Three of the nine gene expression endpoints in inner blubber were positively associated with contaminant concentrations. The expression of estrogen receptor alpha (ER α) and heat shock protein 70 (hsp 70) were strongly correlated with Hg concentrations ($r^2 = 0.72$, $p = 0.005$; and $r^2 = 0.73$, $p = 0.002$, respectively). The expression of peroxisome proliferator-activated receptor gamma (PPAR γ) was positively correlated with Σ PCBs and Hg ($r^2 = 0.57$, $p = 0.035$; and $r^2 = 0.63$, $p = 0.015$, respectively). Although the population level consequences of these observations are presently unclear, our results suggest that the risk of adverse health effects increases in harbour seals exposed to PCBs and Hg in the Salish Sea.

Jeffrey Stern

King County Dept. Natural Resources and Parks

Temporal effects of cleanup remedy-related releases on fish tissue concentrations – Implications to net risk reduction goals using different cleanup approaches.

Jeffrey Stern, Bruce Nairn

Abstract:

Dredging has been the primary remedy to address contaminated sediments. But recent studies have demonstrated dredging releases to the environment can be as significant as long-term releases from material left in place. Calibrated sediment transport / recovery potential and bioaccumulation modeling paired with empirical data from a highly urbanized salt-wedge estuary on Puget Sound provides the opportunity to investigate differences in effects to the food web predicted to occur from different cleanup approaches. Detailed contaminant and fate and transport modeling using EFDC was conducted to investigate how dredge-generated contaminated sediment residuals, along with associated releases of contaminants into the water column, can temporarily increase the bioavailability and compare that to remedies that leave contaminants in place but are an ongoing source to the food web. The data set includes fish tissue concentrations of PCBs that spiked by a factor of three to five and then returned to previous levels. Several sediment remedial actions occurred in the estuary six to nine months before the sampling that exhibited the high tissue concentrations. Comparison of measured tissue level reductions over time to bioaccumulation modeled responses also provides information on the persistence of dredging-related releases in the system. Combined with results of recent national studies, relative contributions of sediment-associated and porewater contaminants

released by the various remedies can be predicted and the temporal responses of the food web can be estimated. Combined with information on consumption rates of various at-risk populations, results can help inform evaluations of short-term increase and longer term reduction in risk to determine the timing of achieving net risk reduction from sediment cleanup options. Implications for cleanup decisions and the approach to remediation for such sites are discussed.

Hazel Walling

Simon Fraser University

Response of stream invertebrate communities to metal-enriched leaf litter: An experimental approach

Hazel Walling, Leah Bendell

Abstract:

Metal pollution and contamination are persistent global issues. Depositions of metals from vehicle exhaust, industrial and agricultural activities are a reality in urbanized watersheds. The impacts on stream community ecology are only beginning to be fully understood. How does metal-enrichment of basal food resources, such as plant leaves impact the structure and function of stream invertebrate communities? We grew red alder, *Alnus rubra* saplings under two metal-enriched treatments, corresponding to British Columbia's sediment quality guidelines (ISQG) and probable effect level (PEL) for Cd, Zn and Cu. Leaf tissue uptake was significantly different between treatments. Ten-millimeter mesh leaf packs were deployed in six Vancouver-area streams in October, 2010. After four weeks immersion, we sampled mass remaining, invertebrate density and diversity that had recruited to those leaves. Exploratory analysis indicates greater mass loss from leaves grown at the PEL metal enrichment, as opposed to those grown at or below BC sediment quality guidelines, potentially a result of lower leaf quality. This could have implications to organic matter cycling in contaminated freshwater ecosystems and highly impacted urban watersheds.

James West

Washington Department of Fish and Wildlife

Time trends and ecosystem recovery targets for toxic contaminants in Puget Sound fish

James West, Sandra M. O'Neill, Gina Ylitalo, Scott Redman

Abstract:

Targets for twenty Dashboard Indicators of ecosystem health are currently being developed in support of efforts to recover Puget Sound ecosystem health by 2020. These targets are meant to define expectations for recovered conditions, or a trajectory towards such conditions. They reflect an effort to simplify science reporting and link it to policy, ultimately resulting in easily communicated policy statements (i.e., targets) that define the desired condition or goals. The Toxics in Fish indicator is one of these twenty indicators. Its purpose is to condense key information regarding exposure of Puget Sound biota to toxic contaminants, deleterious effects of exposure, and time-trends in exposure-and-effects. The Toxics in Fish indicator currently relies on two species representing two key ecosystem food webs or compartments: a bottom-dwelling flatfish, English sole (*Parophrys vetulus*), and a small, schooling mid-water planktivore, Pacific herring (*Clupea pallasii*). English sole generally represent the sediment-to-biota contaminant link, and Pacific herring generally represent the pathway of contaminants to higher level predators including Pacific salmon, killer whales, and humans. Although these species are exposed to a wide range of toxic contaminants, the Toxics in Fish indicator is focused on three classes: 1) persistent bioaccumulative toxics such as polychlorinated biphenyls (PCBs) and brominated flame retardants, or polybrominated diphenylethers (PBDEs), 2) polycyclic aromatic hydrocarbons (PAHs), and 3) endocrine disrupting compounds (EDCs). Although there is crossover between some individual chemicals among these groups and they are not comprehensive, these contaminant groups help to simplify communication. Recovery targets currently under review include three options to achieve by 2020:

1. a declining trend in Toxics in Fish,

2. a condition wherein exposure of biota to toxics is below a science-based threshold of deleterious effects, or
3. the best condition that could be reasonably expected, defined by background conditions of biota in the least contaminated areas of Puget Sound.

Using long-term status and trends data collected by the Puget Sound Assessment and Monitoring Program (PSAMP) paper we evaluate long-term time trends in these contaminants for these species by region, compare exposures to relevant thresholds of deleterious effects, and propose a definition for background conditions. It is expected these results will be used to help guide decisions regarding prioritization of investments in reducing loadings of toxic contaminants to Puget Sound.

The conservation imperative for the marine birds and mammals of the Salish Sea

Andrew (Cheng-An) Huang

University of British Columbia

The role of Great Blue Herons in the food web ecology of eelgrass beds

Andrew (Cheng-An) Huang, Mary O'Connor

Abstract:

Ardea herodias fanini is a subspecies of great blue heron that reside along the southern coast of British Columbia. In the summer, these herons forage intensely in eelgrass beds at low tide. Eelgrass beds provide food, shelter, and nursery habitats for heron prey, specifically many species of fish, amphipods, bivalves, crabs, and other marine animals. In the eelgrass meadows of British Columbia, gunnells, sculpins, and shiner perch are the herons' main source of food. Despite the ecological and commercial importance of eelgrass beds and their associated fauna, the effects of heron foraging on eelgrass community trophic structure is poorly studied. To explore the consequences of predation by herons on benthic predators, we studied heron foraging behaviours at two sites along the southern coastline of Strait of Georgia: Tsawwassen Beach and Crescent Beach. In observational and experimental studies, we addressed the following questions:

1. How do the diversity and/or abundance of benthic marine organisms differ between the eelgrass community of Tsawwassen Beach and Crescent Beach?
2. If they do differ, how does that affect the foraging success and/or foraging site preference for Great Blue Herons?
3. Does the exclusion of Great Blue Herons have cascading effects on benthic food web structure?

To address these questions, we sampled benthic eelgrass-associated invertebrates at each site. To determine whether differences among sites affected heron foraging, we observed foraging success rate of herons once a week at each site. A total of eight 10-minute observation periods are made within 2 hours, with the first one starting from one hour before the predicted time for the lowest tide of the day. Over each 10-minute interval, total number of herons present, and both attempted and successful strikes of an arbitrarily chosen heron are recorded down. To address question 3, five exclusion plots designed to deter Great Blue Herons, plus five control plots were set up at the intertidal zones of each site. Each treatment area is 3m x 3m, with a total of eight 1-meter PVC poles in the outer perimeter, and two within the plot. Pink ribbons are tied at the top of each pole. Pink and yellow strings are also used to enclose the plots. Every second week we measured the density of amphipods, fish, and other invertebrates, eelgrass shoots, and epiphytes.

The combined approach of observational studies of heron foraging and experimental exclusions allow us to quantitatively assess the role of herons in the eelgrass food web. Specifically, we will be able to determine whether there are small-scale effects of heron foraging on food web structure. This information is critical to strengthening our understanding of eelgrass ecology, as well as heron ecology. COSEWIC has already listed *Ardea herodias fanini* as a subspecies of "special concern" due to its recent decline in population size.

Our study is underway in Summer 2011, and final results will be known by October 2011. We predict that the enclosure plots will show an increase in the herons' preys (e.g. fish), and a decrease in the biomass in which these preys feed on (e.g. epiphytes and eelgrass). Also, if there is a significant difference in the diversity and abundance of marine organisms between the two sites, we expect that the difference in the abundance of herons and also their striking success rate will be correlated with it.

Lisa Spaven

Fisheries and Oceans Canada

Deciphering their stories: Assessing threats to marine mammals in BC, 2008-2010

Lisa Spaven, Paul Cottrell, John Ford, Stephen Raverty, Eva Stredulinsky, Candice Salmon

Abstract:

Whether a sick Steller sea lion, an injured grey whale, or a dead harbour porpoise, marine mammals have important stories to tell about the threats they face at sea. There are 31 marine mammal species known to British Columbia (BC) waters; of which 12 populations are protected under the Species at Risk Act (SARA). Population recovery is often hindered by a lack of understanding of the environmental and human-caused factors affecting these animals (e.g. disturbance, vessel strikes, entanglements and disease).

In January 2008, DFO established the Marine Mammal Response Program to provide a national capacity for tracking and responding to marine mammal incidents. The BC Marine Mammal Response Network (BCMMRN) is a collaboration involving governments, researchers, conservation and rescue groups, and the general public, to monitor and assess threats throughout BC waters. In three years, the program has experienced increased awareness and reporting, resulting in 1456 cases of dead, injured, or sick marine mammals province-wide; 1005 of those occurring within the Salish Sea alone. This translates to a 374% increase over the average annual reports filed between 2003 (SARA enactment) and 2008 (BCMMRN establishment). Although some of this increase may reflect improved awareness, identifying additional or more frequent threats is paramount to conservation efforts.

For this reason, thanks to volunteer recruitment and member involvement, BCMMRN has collectively responded to 962 individual cases since 2008; 692 of these in Salish Sea boundaries. On-scene responses to assess live animals, conduct external exams and necropsies, as well as disentanglement efforts, have led to improved understanding of threats in local waters. Human-related interactions (HI) reported between 2008 and 2010 directly account for 21% of all marine mammal incidents in BC. Over half (62%) of HI reports involved entanglement in marine debris or fishing gear, and 10% involved vessel strikes.

However, it remains unclear what proportion of occurrences are being reported, and therefore what degree of under-representation of threats is reflected in these data. Continued efforts to encourage incident reporting, and to provide on-scene responses, is necessary to further the ability in assessing threats to marine mammal – a critical step towards effective threat mitigation and population recovery.

Climate change

Jerry Desmul

University of Washington Tacoma

Spatial and temporal distribution of pollen in Sequim Bay, Washington

Jerry Desmul, Anna Wallace, Julie Masura, Cheryl Greengrove

Abstract:

Flora and fauna in the Puget Sound region have changed dramatically over the last hundred years due to logging, industrialization, and development. Pollen analysis is a valuable tool to learn about the historic landscape and can provide insight into paleoclimates of the region. This study, the first of its kind in this area, looks at the historic pollen distribution in the sediments of Sequim Bay, Washington. We examine the variation of historic pollen diversity with documented anthropogenic changes over time and compare current watershed conditions with surface sediment pollen diversity and distribution. In the summer of 2009, surface sediment samples were collected with a Van Veen and a two-meter core was obtained using an open barrel Kasten gravity corer. Surface samples and core samples (taken every ten centimeters) were processed to concentrate the pollen. One hundred individual pollen grains were identified in each sample to determine the concentration and variability of pollen in the bay over space and time. A Pb210 analysis was used to date the core. Surface sediment samples showed a 64% distribution of pollen from pioneer species across bay. Preliminary analyses of the core show high numbers of early successional species, such as alder and grasses, near the surface. Deeper in the core, pollen concentrations transition to higher numbers of pioneer species, such as hemlock and pine. Watershed landscape changes associated with these variations in pollen diversity will be discussed.

Richard Dewey

VENUS, University of Victoria

Long-term high-resolution monitoring of the Salish Sea marine ecosystem using VENUS

Richard Dewey, Ken Denman, Verena Tunnicliffe

Abstract:

The VENUS cable observatory network has been making high-resolution measurements in the Salish Sea since 2006. In 2008, a suite of networked stations were established in the southern Strait of Georgia. Real-time, high-resolution measurements of a variety of marine health indicators have revealed rapid, seasonal, and inter-annual variations in the marine conditions. With an expected operating life of over 25 years, the observatory will contribute significantly to our understanding of how the ecosystem works, the magnitude and what causes change, which characteristics are subject to natural seasonal variations, and how climate change is impacting our local waters. New sensors are also planned to measure and track ocean acidification. Mobile instrumented platforms (Ferries, Gliders, and AUVs) will soon map out geospatial variations. An overview of the observatory will be presented, with high-light examples of some fascinating variations observed over the past few years.

Visit us at: www.venus.uvic.ca

Lyse Godbout

Fisheries and Oceans Canada

Linkages between salmon survival, their timing of sea entry and marine productivity

Abstract:

Marine survival of Coho and Sockeye salmon has declined in the last 20 years potentially as a result of a mismatch between the smolts and their prey. Changes in the phenology of outmigration timing were assessed using long time series of Coho and Sockeye salmon smolts

from the Strait of Georgia and the West Coast of Vancouver Island, British Columbia.

The overall trend and the annual variations (associated with early spring temperature) in outmigration timing was assessed using autoregressive model. Our results for Coho suggests that timing is negatively related to year and early spring temperature, i.e. migrating earlier in the spring through the years, and even earlier in years of warm spring conditions. In contrast, Sockeye salmon does not show a strong trend over time but large annual variations in the outmigration timing. We also investigate if there is a mismatch between salmon smolts and their prey, where the zooplankton (*N. plumchrus*) or phytoplankton bloom are used as a surrogate for prey. The dates of the phytoplankton bloom were derived from a one-dimensional biophysical model or from satellite imagery. This study provides a quantitative estimation of the phenological shifts of Coho and Sockeye salmon smolt outmigration timing and of the importance of a mismatch with their prey on their marine survival.

Rebecca Gooding

Dept. of Zoology, University of British Columbia

Thermal coping behaviors of three littorine snails with salinity and ocean acidification

Rebecca Gooding, Christopher D.G. Harley

Abstract:

Acute thermal events, such as heat waves, are predicted to increase in frequency and severity as climate change progresses. Marine organisms in the high intertidal are especially prone to lethal and sublethal consequences of these events. Littorine snails inhabiting the uppermost fringe of the rocky intertidal utilize various behaviors, such as aggregation and microhabitat use, to mitigate thermal stress. However, concurrent abiotic stressors may not only reduce their physiological thermal tolerance but may also alter their thermal coping behaviors. We tested the salinity and pH tolerances of *Littorina sitkana*, *L. plena*, and *L. scutulata*, and found no difference between species. We then investigated the effects of salinity and pH stress on their thermal coping behaviors during a simulated summer low tide. We found that low salinity reduced coping behaviors and survival, but this effect disappeared when pH was concurrently reduced. If stressors associated with climate change alter the thermal coping behaviors of intertidal littorines, this could make acute thermal events (i.e. hot summer days) an even greater threat to littorina performance and survival. However, the antagonistic effect of multiple stressors on littorine behavior could serve to mitigate this threat. On a broader scale, unexpected interactions between multiple climate variables, such as found here, may be more common than first believed, and could play an important role in the overall community responses to future climate change.

Kara Kuhlman

Western Washington University

Sea level rise and sediment elevation dynamics in a hydrologically altered Puget Sound estuary

Kara Kuhlman, John M. Rybczyk

Abstract:

The accelerated rate of sea level rise due to climate change threatens the survival of coastal ecosystems around the world. Padilla Bay, a National Estuarine Research Reserve in the northern Puget Sound, contains one of the largest contiguous eelgrass (*Zostera marina*) meadows along the North American Pacific coast. In addition to the threat of submergence posed by eustatic sea level rise (ESLR), the region has been anthropogenically isolated from historical freshwater and mineral sediment inputs. Reductions in sediment inputs may limit vertical accretion of the estuarine surface and provide a mechanism whereby deteriorative processes including shallow sediment subsidence and erosion may lead to losses in surface elevation over time. Eelgrass is adapted to specific depths within the intertidal range; therefore, sediment elevation relative to mean sea level directly impacts eelgrass distribution and survival. The objective of this study was to quantify long-term trends in surface elevation change throughout Padilla Bay. To this end, we monitored 19 sediment elevation table (SET) sites located systematically throughout Padilla Bay from 2002-2010. A SET is an instrument used to make

repeated, high precision measurements of surface elevation relative to a stable benchmark. Analysis of SET data indicated a mean surface elevation change of -0.22 ± 0.27 cm/yr. Accounting for the current rate of ESLR (0.33 cm/yr) and regional estimates of isostatic rebound (0.09 cm/yr), we calculated a net elevation deficit of -0.46 ± 0.27 cm/yr (elevation deficit = elevation change – ESLR + isostatic rebound) for Padilla Bay. We expect an increasing elevation deficit will be observed over time as ESLR continues to accelerate, a factor that may affect the long-term stability of the eelgrass habitat. Data from this study are being incorporated into ongoing modeling efforts integrating non-linear feedback mechanisms and providing a spatially explicit analysis of changes in eelgrass distribution and productivity across Padilla Bay.

Andrea MacLennan

Coastal Geologic Services

Screening restoration and conservation priorities for potential implications of sea level rise in San Juan County, Washington

Andrea MacLennan, Tina Whitman

Abstract:

Sea level rise and climate change present additional constraints and opportunities to nearshore restoration and conservation. This restoration and conservation screening tool was developed as part of the final phase of a comprehensive prioritization of salmon recovery actions for San Juan County. The restoration and protection prioritization was developed to highlight process degradation at the shoreform unit and integrated priority nearshore habitats for forage fish and juvenile Chinook. This climate change and sea level rise tool was intended to offer a reality check on the sustainability of different salmon recovery actions identified restoration/conservation actions, as well as highlight nearshore habitats that may be at risk due to the combined effect of shoreline modifications, process degradation as well as both natural and anthropogenic (upland) constraints to SLR/CC adaptation. The GIS-based screening tool integrates shoreform resilience, the presence of stressors and, opportunities for added habitat benefit and risks associated with infrastructure. The tool relies on habitat data, level of intact sediment supply (within drift cells and pocket beaches), toe elevation of shoreline armoring and other infringing shore modifications and surface geology. In addition, a MHHW + 2 ft shoreline was created in GIS to identify at risk infrastructure and highlight restoration opportunities – such as road relocation to and tide gate removal. Methods and results are highlighted in this poster presentation.

Jeff Marliave

Vancouver Aquarium

Biodiversity of Pacific NW seabed communities through climate regimes from 1967 - 2010

Jeff Marliave, Donna Gibbs, Charlie Gibbs, Andy Lamb

Abstract:

Biodiversity monitoring with SCUBA diving, centered in the Strait of Georgia region, has been conducted by Pacific Marine Life Surveys, Inc. (PMLS) from 1967 to the present, with over 4,500 dives entered into a database from which different data summaries can be extracted. It was necessary to restrict temporal analysis of trends for climate regimes to the species list that was generated during the earliest climate regime of 1967-1976, with a total of 328 species (versus 1,185 for the most recent period). Puget Sound had the greatest absence of species (26 species), and both Puget Sound and Johnstone Strait had the highest numbers of species (23 and 22, respectively) occurring at trace abundance. The only species absent from the Strait of Georgia was *Astraea gibberosa*, an exposed coast snail particularly associated with the kelp *Macrocystis integrifolia*. In contrast to the Strait of Georgia, Puget Sound was lacking 23 species that occurred in all other regions. The Strait of Georgia and Alaska/north BC had the lowest numbers of species occurring at the highest levels of abundance. Puget Sound differs considerably in biodiversity from the Strait of Georgia, as does Johnstone Strait at the northern end of the Strait of Georgia. It is noteworthy that the entire Strait of Juan de Fuca was categorized as exposed outer coast, including southern shores of San Juan and Lopez Island and the west coast of Whidbey Island. A north to south trend can be detected from species absence where the outer coast of Washington

and Puget Sound are both lacking species that occur everywhere else, including in the Strait of Georgia. Some abundant species peak at extremely high abundance in one area or another. When biodiversity of these regions is considered for more abundant species in terms of two prominent climate regime shifts (1977, 2000) for the original 328 species from the first regime, not considering the lowest trace abundances, species biodiversity is quite stable for animal phyla in the Strait of Georgia and nearby regions. For all 328 species, a drop in biodiversity was evident during the last, 2001-2010, regime, in every region including Strait of Georgia, where the highest level of effort (and arguably the greatest level of expertise) was during that last regime. Thus, when all species including trace levels of occurrence are included for the list of the original 328 species, it appears that the regime shift of 2000 did lead to reduced biodiversity, but probably only for more rare species. If climate regimes are considered to have shifted in 1977, 1989 and 2000, then for seaweeds, all species were being identified during the latest two climate regimes. For these later two climate regimes there were apparent increases in seaweed biodiversity for red algae in both the west coast of Vancouver Island and in Johnstone Strait, as well as an increase in brown algae diversity in Johnstone Strait during the latest regime. The seaweed biodiversity in the Strait of Georgia remained very stable through the two most recent climate regimes. The region designations presented here are not based on any existing literature or governmental statistical areas for fisheries surveys, but they serve to illustrate very stable biodiversity differences. The unifying concept of the Salish Sea does not serve study of seabed biodiversity as well as the current zoogeographic area groupings.

Penny White

Living Rivers Trust Fund

The First Nation Legacy Strategy: Facilitating capacity to lead and engage in watershed projects
Penny White, Tom Rutherford

Abstract:

Pivotal resources in British Columbia, such as salmon rivers, have been negatively affected with an accelerating rate of damage from after colonization up to the present day. Compounded stressors include anthropomorphic ecological degradation, confounding cross-jurisdictional governance, and most recently, anthropomorphic global climate change. To address some challenges of this order within B.C., the provincial government established the Living Rivers Georgia Basin/Vancouver Island Trust Fund (LR-GB/VI). The mission of this fund is to work towards healthy watersheds, sustainable ecosystems, and abundant fish populations through shared responsibility and stewardship, and wise use of water, based on a foundation of thriving communities. The spirit of this trust fund is one of building partnerships, especially with First Nations. Financial and human resources allocated to a variety of undertakings in the Fraser Basin, Vancouver Island, and the Sunshine Coast has created multiple success stories. One such program, the First Nations Legacy Strategy (FNLS), has its main mission of working towards increased environmental stewardship capacity from within aboriginal communities.

The FNLS strengthened partnerships and forged new relationships with and between the A-Tlegay fisheries society, Nuu-chah-nulth Tribal Council, Saanich Tribes, and Cowichan, 'Namgis, Kwakiutl, Sliammon, Squamish, Pacheedaht and Weaykum First Nations. Further, two cross jurisdictional and interdisciplinary watershed roundtables were formed; The Theodosia Watershed Stewardship Roundtable and the San Juan Watershed Roundtable. During these meetings, FNLS supported members provide leadership towards implementing innovative solutions to address long-standing watershed issues. The FNLS has also made possible First Nations involvement across the total spectrum of Living Rivers technical projects including habitat restoration, water stewardship, effectiveness monitoring, estuarine assessment, and production planning. Finally, through FNLS financial leveraging, varied funding partnerships have resulted in four full-time First Nations fisheries biologists and ten fisheries technicians.

This "living legacy" is facilitating career minded First Nation members to gain diverse environmental skill sets in technical, scientific, and governance arenas. In the future of B.C., First Nations will appropriately have more responsibility for the resources in and affecting their

territories. Greater capacity built through the FNLS has already increased the frequency of fisheries and environmental program success stories. These projects will continue to transfer environmental stewardship and governance safely into the embrace of its ecologically and culturally connected First Nation caretakers.

Estuary science to support adaptive management

Kit Crump

The Nature Conservancy

Development of a River Delta Monitoring Framework for Puget Sound

Kit Crump, Roger Fuller

Abstract:

Development of a River Delta Monitoring Framework for Puget Sound for evaluation of monitoring proposals submitted to the Estuary and Salmon Restoration Program River Deltas have been identified as key habitat components within Puget Sound. Monitoring is a key component to ensuring the success of river delta restoration efforts individually and to make sure that these site-specific efforts are delivering tangible benefits at scales approaching the systems level. To aid in developing this framework, a workshop was convened that consisted of 50 river delta restoration experts from throughout Puget Sound. Their goal was to identify the critical gaps in knowledge, to share lessons learned, and to catalyze collaborative monitoring focused on addressing critical knowledge gaps and greater knowledge exchange regionally. Experts identified 71 priority restoration questions that we need to answer to be more successful and efficient at restoring river delta function and resilience. These questions fell into seven categories. Participants identified 75 lessons learned from past delta restoration experience, which fell into five broad categories.

Based on the workshop output, there were eight key restoration uncertainties that we determined could be very effectively addressed through focused and coordinated monitoring of restoration projects. This emphasis would lead to more rapid learning and faster improvements in the effectiveness, scale, public support and implementation of river delta restoration projects. The eight key uncertainties are: hydrodynamics, sediment transport, channel structure, vegetation and soils, vertebrate community composition, floods and drainage, salmon and social constraints. Products from this effort were a conceptual model outlining the relationship of how these key processes and structural elements lead to valued ecosystem services. This included a description of the critical need, difficulty and policy impacts related to addressing restoration questions within these eight broad categories. This framework will ultimately assist ESRP with selecting monitoring proposals that address key uncertainties that have the greatest impact in improving the way delta restoration projects are carried out in Puget Sound. The development of the River Delta framework was made possible through a grant from ESRP.

Angela Danyluk

The Corporation of Delta/Royal Roads University

The impact of vegetation removal on water levels, vegetation and Sphagnum growth in Burns Bog, Delta

Abstract:

For my thesis I will investigate the impacts of vegetation removal, specifically non-bog tree species, shore pine (*Pinus contorta*) and birch (*Betula* spp.) on water levels, vegetation communities and Sphagnum growth. Burns Bog is a raised estuarine bog located within the municipality of Delta, B.C. This rare and unique ecosystem is approximately 2800Ha, and is owned and managed by Canada, British Columbia, Metro Vancouver, and the Corporation of Delta. Burns Bog is the largest natural area in an urban setting in Canada and "is globally unique due to its large size, flora, fauna, chemistry and form". It is important habitat to a range of water fowl, bird species, mammals and plants within the Salish Sea ecosystem. My research focuses on the ecological restoration of bog hydrology and ecosystem processes related to vegetation processes. For my presentation I will talk about adaptive management, partnership, climate change, restoration, monitoring and methods related to this project.

Burns Bog is a raised dome shaped landform perched above the surrounding groundwater table,

and the result of thousands of years of abiotic and biotic processes. The dominant vegetation is the non-vascular moss species, Sphagnum. Oligotrophic conditions and a high water table favour Sphagnum moss species and other distinct bog vegetation. In 2005, a major fire occurred in Burns Bog burning approximately 200Ha of peatland. As a result, rapid growth and establishment of non-bog species, shore pine and birch occurred within the burn zone. The establishment of pine and birch likely lowers the water table through evapotranspiration and interception. By lowering the water table, non-bog species out compete bog vegetation thereby compromising the ecological integrity of Burns Bog. Burns Bog is undergoing extensive restoration work that so far uses ditch blocking only. After five years of monitoring and restoration water levels appear to have stabilized. However, in a future subject to uncertain climate it is expected that the precipitation deficit season (April-September) may become longer and hotter. As the trees grow and proliferate, water lost by evapotranspiration will exacerbate the soil moisture deficit. Therefore, adaptive management efforts must be taken to test new restoration efforts. To date, vegetation manipulation for the purpose of ecological restoration has not been performed in Burns Bog.

I will investigate how the removal of shore pine and birch saplings may affect water table levels, vegetation communities and sphagnum growth within the 2005 burn zone in Burns Bog. Saplings were removed within one 75mx50m test plot; vegetation was assessed before the cut, after and one year later. Three Sphagnum plots were also struck. Piezometers were installed within the test plot so that water levels may be monitored. A control plot with two transects, ten vegetation plots, three Sphagnum plots, and four piezometers was established within an uncut plot so that water levels and vegetation may be assessed. The results of this investigation will be available fall 2011 and used to make recommendations as to how future ecological restoration efforts for Burns Bog and other wetlands may be made.

Roger Fuller

The Nature Conservancy

Multi-estuary data and tools to support restoration and socio-economic decision making

Abstract:

Recovery of Puget Sound and its iconic species requires large-scale restoration in many estuaries around the Sound. Habitats and species continue to decline due to altered ecological processes and habitat loss. Progress in restoration and recovery has been limited, due in part to gaps in our understanding of ecosystem response to restoration, and to competing land uses that provide valued socioeconomic benefits to the human community. To date, restoration has largely been galvanized by legally mandated single species recovery (e.g. Chinook salmon). As a result, restoration and monitoring has tended to be narrow in both scope and social mandate, and is seldom coordinated among watersheds. With the added pressures of population growth and climate change, there is an urgent need to increase the rate, scale and effectiveness of restoration and to justify this need to communities and policy decision makers that continued investment is worthwhile. Addressing this need requires a better understanding of both the ecological constraints limiting recovery and the broader socio-economic benefits provided by a functioning estuary ecosystem. Filling these socio-economic and ecological data gaps is possible through strategic and collaborative effort. This talk will describe efforts to generate baseline data sets across multiple estuaries in Puget Sound, and to use that data to build new decision-support tools that link ecological and socio-economic outcomes.

Multiple Benefits Approach: Integrating social and ecological values to recover the Salish Sea

Stephanie Williams

Coastal Geologic Services, Inc.

Nearshore restoration through a shared vision - MRC initiated projects

Stephanie Williams, Jim Johannessen, Andrea MacLennan, Jonathan Waggoner

Abstract:

Several coastal processes analyses, nearshore assessments, and nearshore and estuarine restoration designs have been completed for the Marine Resources Committees (MRCs) dating back their inception in 1999. Working through the shared vision of the Marine Resources Committees and parent organization the Northwest Straits Commission, Coastal Geologic Services (CGS) has produced several estuaries/coastal wetlands restoration designs, one of which has recently been implemented at Chuckanut Marsh in Whatcom County. Juvenile salmonid utilization of the Chuckanut Marsh was recently documented following implementation of restoration designs, which included parking lot removal from the backshore and replacement of an undersized culvert with a larger box culvert. In 2004 a successful shore armor removal and beach nourishment project at Marine Park initiated by the Whatcom County MRC has received national recognition by winning one of America's Best Restored Beaches award in 2009 from the American Shore and Beach Preservation Association. Current and historic geomorphic shoretype (feeder bluff) mapping had also been conducted by CGS for several MRCs. Feeder bluff mapping has often led to subsequent restoration projects, such as beach nourishment or debris and derelict structure removal projects as protocol for feeder bluff mapping often involves field team members inventorying the shoreline by boat and viewing shoreline conditions first hand.

One of the goals of the Northwest Straits Commission is to mobilize science to focus on key priorities and coordinating regional priorities for the ecosystem. It is through this vision and goal that CGS has contracted with Whatcom, Skagit, San Juan, Island, Snohomish, and Jefferson County to assess, prioritize, and implement countless restoration directed projects with MRCs. Several MRC initiated nearshore restoration assessments and designs completed by CGS will be highlighted in this poster presentation.

Puget Sound watershed framework - Using the Puget Sound Characterization Project to guide planning and development

Ginger Shoemaker

Washington State Department of Natural Resources

Prioritizing marine nearshore areas for conservation on state-owned aquatic lands in Washington State

Lowell Dickson, Carol Cloen, Ginger Shoemaker, Dave Palazzi, Melissa Whitman

Abstract:

In order to protect and restore the health of Puget Sound, decisions about what uses are appropriate on state-owned aquatic lands must be made in the context of the best available science and conservation knowledge. The Washington Department of Natural Resources (DNR) has recently developed a Landscape Prioritization Decision Tool to help assess the conservation potential of DNR managed nearshore habitats. This GIS-based tool assesses conditions at a 1-km² scale with each grid cell intersecting some portion of state-owned aquatic lands. The Tool ranks cells based on three factors: 1) the occurrence and distribution of 22 state and federally listed species; 2) the presence of forage fish, kelp, eelgrass, and salt marsh vegetation; and 3) the intensity of development in the nearshore environment.

The Tool identifies areas for potential conservation and protection based on current conditions. These are relatively undeveloped areas important to state or federally listed species, with natural processes and functions assumed to be still largely intact.

For any new uses proposed on state-owned aquatic lands in these areas, DNR may require additional site-specific biological assessments in order to ensure that habitat will not be negatively impacted, and that natural processes and functions remain intact. In these areas DNR will work closely with project proponents and permitting agencies to ensure that habitat and unique characteristics are protected.

Once finalized, the Tool will provide local governments and others with an important dataset to consult when making decisions about shoreline use, and permitting in-water development. When used in conjunction with other regional assessments such as the Washington Department of Ecology's Watershed Characterization, Washington Department of Fish and Wildlife's Nearshore Habitat Assessment, and the Puget Sound Nearshore Restoration Project's process-based priorities, the tool will provide a richer and more complete picture of regional-scale habitat priorities.

Implications of ocean acidification for the Salish Sea

Bryan Bylhouwer

Simon Fraser University

Changes in coastal upwelling and implications for Salish Sea deep water

Bryan Bylhouwer, Debby Ianson, Karen Kohfeld

Abstract:

The properties of deep water in the Salish Sea are generally determined by coastal upwelling dynamics in the Pacific Ocean off the coast of Vancouver Island and Washington State. Northwesterly winds combine with the Coriolis force to pull surface ocean waters offshore and draw intermediate depth water to the surface. Upwelled ocean water is relatively cold, acidic, high in nutrients, low in dissolved oxygen, and fuels the majority of primary production along the Pacific coast of North America during the spring and summer. At the same time, interactions with the Fraser River freshet cause this newly upwelled water to enter the Salish Sea by sudden, density-driven pulses. The deep-water pulses end in the fall as the freshet diminishes and southeasterly winds terminate the upwelling season.

There is evidence that worldwide coastal upwelling has increased due to an enhancement of the pressure gradients along coastal areas. There is also evidence in the Pacific Northwest that increasingly acidic waters are reaching the continental shelf. Most coastal upwelling studies have focused on regional or global trends, and so little research exists on the ecosystem level. Possible ecosystem level effects include changes in primary production and pH leading to long-term regime shifts. There are also no objective criteria establishing the boundaries of the upwelling 'season', and therefore, no systematic way of determining how upwelling intensification manifests itself in the Pacific Northwest.

Our research analyses wind data from meteorological buoy stations along the west coast of Vancouver Island, Washington, and Oregon to identify the above trends in upwelling over the previous 20 years. Our results show that a simple ratio of northwesterly (NW) and southeasterly (SE) winds is an effective criterion for determining the beginning and end of the upwelling season. This result is supported by the near-constant NW-SE principal axis of rotation through time and SeaWiFS satellite chlorophyll data. Other preliminary results indicate that while the summer upwelling season has not changed significantly over time, the transitional period between summer and winter conditions is getting longer. These analyses will help improve future forecasts of primary production and ocean acidification along the coastal shelf, but will also forecast changing physical water properties of the Salish Sea.

Karen Matsumoto

Seattle Aquarium

Working with Tribal youth: Ocean acidification community awareness and monitoring

Karen Matsumoto, Paul Williams

Abstract:

A program jointly developed by the Suquamish Tribal Fisheries Department and Seattle Aquarium is currently working with tribal youth to raise community awareness about ocean acidification. Ocean acidification is already directly affecting Tribal shellfish resources in the Salish Sea ecosystem. Tribal communities need to respond to these effects and adapt by developing effective strategies to protect their natural and cultural resources. Tribal youth are an underutilized resource in raising community awareness about how ocean acidification is impacting tribal communities both economically and culturally.

Tribal youth have also been working with the Suquamish Tribal fisheries department and NOAA to learn about ocean acidification issues in the Salish Sea ecosystem, as well as interviewing Tribal elders to understand changes that have occurred in their shellfish resources over past

generations. By working directly with Tribal fisheries staff on locally relevant issues that effect the livelihood of their families, students have gained experience and exposure to potential careers in marine science and empowered to be part of the next generation of managers of their tribal resources.

Suquamish tribal high school youth are also taking action now by investigating their tribal beaches and gathering data to help scientists to monitor changing conditions. They are working directly with Seattle Aquarium's Citizen Science program and their tribal fisheries department to conduct clam inventories, raise oysters and monitor their survival, and conduct surveys on shellfish beds on tribal beaches. These data will be utilized by their resource managers and shared with the tribal community.

Tribal youth are facilitating a dialog with community members, including elders, tribal shellfish harvesters, tribal leaders, and local legislators to help understand the causes and effects of ocean acidification and how coastal indigenous communities will be impacted and respond to changing environmental conditions. This intergenerational approach to raising community awareness on ocean acidification is a model that can be replicated in other Salish Sea communities.

Students have presented on the potential impacts of ocean acidification on coastal indigenous communities at a national student climate change summit at the Smithsonian Museum of Natural History in Washington DC sponsored by Coastal America, and have produced a public service film that has been widely shown through the Smithsonian website and other venues. Students have also given presentations to their Tribal Council, at the Smithsonian Museum of the American Indian, and the Washington Science Teachers Association/Environmental Education Association of Washington 2011 annual conference on this topic.

Website: www.suquamishechs.wikispaces.com

Paul Williams

Suquamish Indian Tribe

Addressing long term crisis in a society focused on the short term. Tools to address ocean acidification

Abstract:

The goal of this talk is to introduce key concepts and provide materials useful to those involved in addressing the cause and impacts of ocean acidification and climate change on local and national levels. We will briefly review the primary threats posed by ocean acidification to the Salish Sea Tribes, shellfish industry, and residents, as well as to the billion people in the rest of the world who depend on seafood for their primary source of protein. We will then introduce some of the strategies being used to address immediate impacts the shellfish industry. In addition, we will suggest ways to help tribal and non-tribal harvester communities understand the potential impacts of ocean acidification, develop mitigation strategies, and prepare to adapt to unavoidable impacts. We will then briefly highlight some of the legal concepts supporting and hindering efforts to address the cause of ocean acidification, including those found in the public trust doctrine, Federal Indian treaties and the protected speech rights of corporations. Finally, we will explore the many commonalities among populist groups on both sides of the political divide and suggest a strategy to unite them along universal goals.

Restoring estuaries of the Salish Sea: Case studies and social and scientific challenges

Kim Larsen

USGS - Western Fisheries Research Center

The use of juvenile Chinook Otoliths related to restoration efforts on the Nisqually River

Angie Lind-Null, Kim Larsen, Karl Stenberg, Lisa Wetzel, Christopher Ellings, Sayre Hodgson

Abstract:

The Nisqually Fall Chinook salmon population is one of 27 stocks in the Puget Sound evolutionary significant unit (ESU) listed as threatened under the Endangered Species Act (ESA). Preservation and extensive restoration of the Nisqually delta ecosystem has taken place to assist in recovery of the stock as juvenile Fall Chinook salmon are dependent upon the estuary. Furthermore, a Chinook salmon recovery priority of the Nisqually Tribe is to develop a self-sustaining, naturally spawning population. Currently, this population consists of offspring from both hatchery and natural spawners. A pre-restoration baseline that includes characterization of life history types, estuary residence times, growth rates, and habitat use is needed to evaluate the potential response of hatchery and natural origin Chinook salmon to restoration efforts and to determine restoration success. Otolith microstructure analysis was selected as a means to examine Chinook salmon life history, growth, and residence in the Nisqually Estuary pre- and post-restoration. More recently, this research has developed into a collaborative effort with the Nisqually tribe and other U.S. Geological Survey (USGS) researchers involving extensive post-restoration monitoring of the Nisqually delta as related to the response of the delta in support of Chinook salmon. We will report on differential usage of the estuary by natural and hatchery reared juvenile Chinook salmon and their expression of life history diversity during mid-recovery of the population prior to restoration efforts.

Stephen Rubin

U. S. Geological Survey

Response of fish distributions and benthic habitats to Nisqually Delta restoration

Stephen Rubin, Christopher Ellings, Eric Grossman, Michael Hayes

Abstract:

The Nisqually River delta is the site of the largest estuary restoration project in Puget Sound to date. The culminating event was the return of tidal inundation to 750 acres of the delta following dike removal in fall, 2009. Coordinated, multidisciplinary monitoring of fish populations; benthic habitats including bathymetry, sediment characteristics, macroinvertebrate communities, and eelgrass extent and character; and physical processes including hydrodynamics and sediment transport/deposition are being conducted to evaluate ecosystem response to restoration. We will highlight our methods/approaches and results to date with emphasis on salmonid spatial and temporal distributions, and the habitat characteristics and physical processes that are influencing those distributions. Questions addressed will include: What patterns of fish spatial and temporal distributions are apparent? How are benthic habitats and physical processes influencing fish distributions? How are fish distributions, habitat characteristics, and physical processes changing in response to restoration?

Isa Woo

USGS Western Ecological Research Center

Monitoring and applied research framework for large-scale estuarine restoration in the Nisqually Delta

I. Woo, C. Ellings, J. Y. Takekawa, K. Turner, E. Grossman, K. Larsen, S. Rubin, F. Leischner, S. Hodgson, J. Cutler, J. Barham, J. E. Takekawa

Abstract:

The return of tidal inundation to over 750 acres of the U. S. Fish and Wildlife Service Nisqually National Wildlife Refuge (Refuge) in fall of 2009 was the crowning moment in the effort to protect

and restore the Nisqually estuary. The Refuge project complemented three earlier restoration projects completed on Nisqually Tribal property to restore over 900 acres of the estuary, representing the largest estuary restoration project in the Pacific Northwest and one of the most significant advances to date towards the recovery of Puget Sound. The first estuary restoration project was 9 acres in 1996 —estuary restoration has since grown in size, cost, and complexity. As a result of the increasing scale, investment, and expectations for the restoration projects, the Nisqually Tribe (Tribe), Nisqually NWR, U. S. Geological Survey (USGS), and others have expanded their research and monitoring efforts.

The USGS, Tribe, and Refuge are now conducting integrated research at multiple scales in order to examine the impact of estuary restoration on the linkages between physical processes, habitat structure changes, and the functional response of fish and birds. These linkages are being assessed through strategic research and monitoring of: 1) sediment delivery to the delta via the Nisqually River; 2) hydrodynamics affecting sediment transport and estuarine mixing; 3) geomorphic change; 4) vegetation community colonization and succession; 5) terrestrial (insect), benthic, and neustonic invertebrate community response; 6) bird response (monthly distribution, abundance and behavior) to restored estuarine habitat; and 7) Chinook salmon functional response to restoration including distribution and relative abundance, feeding ecology, estuarine residence time and growth, and life history diversity. Additionally, modeling of sediment delivery and hydrodynamics will allow assessment of future changes to the delta as a result of climate change. Here we present our monitoring rationale and framework. Project summaries are updated on the partner website: <http://www.nisquallydeltarestoration.org>.

The Salish Sea as a coupled social-ecological system

Diane Capps

School of Marine and Environmental Affairs, University of Washington, Seattle

Patterns of human influence on the nearshore landscape and the condition of submerged vegetation habitats in Puget Sound, Washington, USA

Abstract:

The ability to identify and characterize stressor/response relationships between human activities and ecological function is a potentially powerful tool for predicting environmental outcomes of different policy alternatives. This study illustrates one approach to investigating the link between human-altered landscapes and nearshore habitat through the use of spatial pattern association, making use of existing monitoring data for eelgrass (*Zostera marina*) bed size and classified landcover maps of the Puget Sound region of Washington State. I found no statistical correlation between spatial pattern of the adjacent landcover and eelgrass bed size, however, few observations were available for beds adjacent to areas of intense land development, and properties other than adjacency were not investigated. Metrics describing landscape composition, as opposed to configuration or diversity, were most indicative of a potential association, and suggest that this method can be useful in exploring the spatial relationship between human alteration of the landscape and the status of nearshore habitats.

Heather Hewitt

University of Washington, School of Marine and Environmental Affairs

Assessing seabird vulnerability to declines in forage fish within Puget Sound

Abstract:

The use of indicators to measure change in desirable environmental attributes is increasing, as is our understanding of what makes a good indicator. Seabirds have long been hailed as good indicators for marine environmental health; however, further study has revealed that not all species respond to changes in their environment in the same way. Careful study and understanding of the response of seabirds to their environment is needed. In this study I developed a vulnerability index based on attributes that should make seabirds more or less vulnerable to changes in prey abundance. Given significant declines in forage fish within Puget Sound, I expected to see a relationship between relative declines in seabird abundance within Puget Sound to the vulnerability index. I found no strong relationship between seabird declines and relative vulnerability to declines in forage fish. However, I illustrate the difficulties in determining how species will respond to shifts in their environment, and I list other attributes that require further study in order to understand seabird responses to shifts in forage fish abundance in Puget Sound. Managers should proceed with caution when considering the use of marine birds as indicators for environmental health within Puget Sound.

Meghan Massaua

University of Washington, School of Marine and Environmental Affairs

Navigating information flow in collaborative marine management to investigate the role of science

Abstract:

In recent years, conservation practice has shifted from a principal focus on natural systems, to a viewpoint that looks to the coupled nature of social and ecological systems. This shift represents recognition of the need to incorporate human dimensions in management practice. To that end, collaborative approaches to management increasingly are being employed as a way to include diverse viewpoints in the policy process. This shift in practice does not diminish the need for scientific information as a key component of environmental problem solving. Despite the need for science in collaborative processes, the role of science in collaborative environmental management efforts remains largely unexplored. To address this gap, I employ case survey methodology to examine the role of science in collaborative marine management practice.

Studying an assemblage of U.S. coastal and marine cases (with representation from Washington State) allows a systematic synthesis of previous case-based research, and enables a wider generalization than from single case studies. Considering the role of science to be based largely upon information transfer, I employ a typology of public engagement based on the flow of information in participatory processes. This framework defines three types of public engagement via information transfer: communication, in which information flows from the project lead to participants; consultation, in which information flows from participants to the project lead; and participation, in which information flows both ways via dialogue between the lead and participants. This framework provides a conduit to navigate the jumbled lexicon of public engagement by focusing on information flow. Employing it enables an empirical mapping of information transfer and helps elucidate the role of science in collaborative management processes. Additionally, instrumental attributes of scientific information, such as peer review and the acknowledgement of uncertainty are investigated to further define the role of science in collaboration. Finally, the development of management outputs (plans, policies, protections etc.) is considered as a measure of process effectiveness.

Ilon Logan

ESA

Informing coastal restoration planning decisions in a changing climate

Abstract:

Climate change presents new challenges and opportunities for the protection and restoration of coastal ecosystems worldwide.

Accelerated rates of sea level rise, increases in air and water temperatures, changes in precipitation patterns, and increased frequency and severity of extreme weather events are some of the anticipated effects on coastal systems. The complexity, variability, dynamism, and diversity in the effects of climate change results in tremendous uncertainty for the planning of coastal ecosystem restoration. Furthermore, the range of social responses and adaptations to a changing climate is extensive and complex.

Principles to support restoration planning in the face of these challenges include futuristic thinking, building resilience, use of relevant and contemporary rationales, adaptive management, and a focus on opportunities. To apply these principles, I present a decision support framework for informing restoration planning and implementation. Integrating climate change effects into restoration begins with a spatially explicit assessment of vulnerabilities and opportunities across a coastal landscape. Identification of the distribution of constraints and opportunities resulting from climate change (e.g. social, economic, ecological, hydrological, geomorphological) across the landscape will lead to an ability to prioritize areas for restoration. Information regarding the vulnerability and adaptive capacity of social-ecological systems can be used to inform restoration strategies. In summary, the principles and the decision framework suggest that achieving desirable outcomes for coastal restoration will require integrative and adaptive approaches to planning and implementation that can account for complex connections between humans and nature under conditions of persistent uncertainty.

Ecology of forage fish

Fred Felleman

WAVE Consulting

Another look at Cherry Point Herring

Abstract:

Maintaining abundant and diverse forage fish is crucial to the recovery of many avian and marine species of the Salish Sea (Therriault et al 2009). The Puget Sound Leadership Council included Pacific herring as one of 21 'Dash Board Indicators of its recovery in US waters. However, the target of recovery and what actions are to be taken to achieve those goals remains to be defined.

Cherry Point herring once comprised half of Puget Sound herring abundance but has declined from 15,000 tons of spawning biomass in the 1970s, to less than 800 tons currently. The purported migratory nature of this stock (based on one scale sample and a fast growth rate) has been used to assert that anthropogenic impacts from the construction and operation of three large industrial facilities, their associated docks, ships and wastewater discharges along the core area of the spawning beds have had negligible contribution to the stocks' decline.

This paper provides new information on how an acute oil spill during a large herring spawn (Bellingham Herald 6/8/72), for which there are no official State records, could have contributed to the stock's decline. The chronic acoustic, visual and water quality impacts of the operations of existing industrial facilities are also shown to be potential contributors. Recommendations for future studies to be conducted prior to the construction of new facilities such as the proposed Gateway coal terminal are provided.

While the existence of both migratory and non-migratory herring stocks in the Salish Sea are recognized (Therriault et al 2009), the Cherry Point stock cannot be characterized without further information. The unusually late spawning time (4-8 wks) of this stock has resulted in their temporal and genetic isolation. Comparative otolith studies indicate that Cherry Point herring are exposed to more fresh water than other stocks in the Salish Sea (Gao 2002), which may indicate a nearshore residence. In addition, stocks on the eastern shores of the Salish Sea tend to be less migratory and even migratory stocks do not migrate until their second summer (Therriault et al 2009). Regardless of their migratory status, sufficient exposure time is present to cause anthropogenic impacts during their most vulnerable life history stages.

Brown and Carls studies of the Exxon Valdez oil spill amply document the significant impacts of PAH exposure during early life stages. Spinal deformities are increasingly prevalent from Cherry Point downstream of the NPDES discharges. These impacts are exacerbated by UV light, to which spring spawning stocks such as Cherry Point are particularly exposed.

The Department of Natural resources called for studies of the impact associated with the Cherry Point dock operations to these visually and acoustically sensitive prey species as a condition of its expansion. However, the studies were never completed. Similar studies called for in a settlement agreement with State agencies, environmental groups and SSA Marine as a condition of constructing a new bulk commodities facility and dock along Cherry Point have not been completed and SSA is attempting to renegotiate terms of the agreement.

Theresa Liedtke

U.S. Geological Survey

Intertidal habitat use by Pacific sandlance: seasonal distribution and habitat characteristics

Theresa Liedtke, Collin D. Smith, Dennis W. Rondorf

Abstract:

Pacific sandlance (*Ammodytes hexapterus*) are known to burrow in soft sediments in intertidal and subtidal areas to escape predation and conserve energy. Like other forage fish species in Puget Sound, the basic biology of these fish is poorly understood. For example, little is known about their distribution and habitat characteristics in intertidal areas, and whether these areas are occupied seasonally or throughout the year. In addition to their burrowing activity in the intertidal, these fish are obligate upper intertidal spawners. These life history characteristics closely link these fish to Puget Sound shorelines, making them vulnerable to human and environmental disturbances. Greater understanding of their basic life history will enable more effective protection and restoration efforts for this important forage fish. We describe the intertidal aggregation of sandlance at a beach in North Puget Sound by monitoring their distribution through spring-summer (May – August) and fall-winter (Nov – Feb) when the beach was exposed at low tide. Beach transects (approximately 150 m long) were established at +2 ft, +1 ft, 0 ft, -1 ft, and -2 ft tidal elevations. We added a transect at -2.5 ft elevation when tidal conditions allowed. Along each transect we dug holes (25 cm x 25 cm x 25 cm) at 1 m intervals, looking for burrowed sandlance. Fish were located in the surface layer of the sediments (approximately 3-5 cm deep), and would aggressively re-burrow when exposed. We collected 225 fish from the beach, ranging in size from 50 mm to 160 mm TL. The highest catch was in January, and no fish were detected in July. During spring-summer we found fish low on the beach, from -2.5 to -1 ft elevation. During the fall-winter fish expanded their distribution up beach and were collected from -2.5 to +2 ft elevation. Juvenile (<100 mm TL) and adult fish (>100mm TL) were found together, with adults becoming more scarce as the summer progressed. The size of collected fish increased from spring-summer (mean of 65 mm in June) to fall-winter (mean of 100 mm in February). We noted gravid females in December and sandlance spawned at the beach in January. Sediment where sandlance were collected was composed primarily of medium to coarse sand. The presence of sand dollar and eelgrass beds excluded sand lance burrows. Collected fish were preserved and will be used for examination of age structure (otoliths), reproductive status, and stomach contents.

Dan Penttila

Salish Sea Biological

Upper intertidal sediment coarsening on armor-impacted Surf Smelt spawning beaches over time

Dan Penttila, Kirk Krueger

Abstract:

The surf smelt (*Hypomesus pretiosus*), an important forage fish, deposits its eggs on upper intertidal sand-gravel beaches with a certain characteristic grain size spectrum. This critical habitat is vulnerable to various impacts from shoreline development, particularly armoring. The surf smelt spawning beaches of Fidalgo Bay, Skagit Co., WA, have been heavily-impacted by shoreline armoring and the subsequent cessation of erosion inputs of sediments for the maintenance of fine-grained beaches. The physical coarsening of beaches has long been hypothesized to be a long-term negative impact of armoring. However, local quantitative evidence of this impact has largely been lacking.

Surf smelt spawning beaches in Fidalgo Bay were sampled for grain-size data in 1981-83 during the assessment of a large shoreline development proposal. Over following years, these beaches were subjectively observed to be coarsening in sediment texture, to a degree that might eventually preclude smelt spawning usage. Sets of 1981-83 sample sites were re-sampled in 2009-2010 to objectively document any changes in the distribution of particle sizes and statistically test for coarsening.

The "Weaverling Spit" beach, not directly armored but possibly impacted by the armoring of the entire up-drift portion of its drift cell for 100 years, was re-sampled at 45 sites. The "East Fidalgo Bay" beach, directly riprap-armored for a similar period, was re-sampled at 38 sites. Both beaches have subsequently been targeted for restoration (sediment nourishment) projects.

Beach-surface sediment samples were collected from the smelt spawning habitat zone at +7 to

+8 feet in local tidal elevation. Air-dried samples were processed through a stack of nine Tyler Standard Screens ranging in mesh-size from 26.7 mm down to .1 mm. Percent dry weights by mesh size were compared. Outwardly, both sampled beach reaches had showed visual evidence of the diminution of "sand-sized" material over time. Sand-sized material typically comprises a significant proportion of surf smelt spawning substrate on Puget Sound beaches.

We found for a significant increase (1-tailed t-tests, $p < 0.0001$) in the average beach sediment size between 1981-83 and 2009-10 for each sampled beach reach. We tested whether the mean D/50 (particle diameter where 50% of the particles in a sample have a larger diameter) of the samples at each beach was significantly larger in 2009-10 than in 1981-83. We examined plots of particle size distributions from both time periods to determine that increases in D/50 were mostly due to loss of medium and fine sands.

Thus our data confirm that the hypothesized coarsening of beaches in the long-term presence of armoring, positioned either directly on the shoreline or at a distance up-drift in the drift cell, does in fact occur. While the degree of coarsening over the 28-year period was not yet enough to totally preclude surf smelt spawning, it was perceptible, and strongly suggests that armoring impacts should continue to be a major concern for the conservation of surf smelt spawning habitats.

James Selleck

Washington Department of Fish and Wildlife

Historic sampling effort and nearshore distribution of Pacific Sand Lance in the Salish Sea, WA

James Selleck, Caroline Gibson, Suzanne Shull, Joseph Gaydos

Abstract:

Pacific sand lance (*Ammodytes hexapterus*) are an important component of the food web in the marine waters of the Salish Sea. These energy-dense fish constitute important prey for a variety of salmonids, groundfish, marine mammals, and seabirds. Sand lance have been well documented in nearshore surveys in Puget Sound since the early 1970's, yet little life history or biological information is available outside of intertidal spawning habitat use. We conducted a retrospective analysis of nearshore sand lance distribution using historical data from throughout the region to elucidate basic biological parameters for sand lance, including spatial and seasonal distribution, and size class information. Beach seine and tow net data were gathered from federal, state and county agencies, tribes, universities, private consulting businesses, and non-profit organizations. The majority of beach seining was intended to capture salmon smolt in the nearshore, and for studies documenting general species composition. We compiled 15,192 records collected between 1970 and 2009, from 1431 unique sites, representing 13% of Puget Sound's shoreline. Sand lance were present in 21% of the records, and captured during every month of the year. Sites were separated into seven watershed basins, as outlined by the Puget Sound Nearshore Ecosystem Restoration Project. Maps were produced outlining sand lance presence and catch size by basin. Whidbey Basin had the highest sampling effort, with sand lance presence ranging from 58% to 95% by basin. Of stream mouths sampled along the shoreline, sand lance were present at 30%. The maximum number of fish captured per individual sample increased between May and August. The three northern basins comprised 87% of large captures. All captures greater than 10,000 fish were also from these three basins, during the mid summer months. A subset of the data found fork length ranging from 1.7 cm to 19.0 cm, with only 6.5% of measured fish greater than 12 cm. This could suggest that adult sand lance are smaller in Puget Sound than other regions, or that the majority of sand lance observed were not adults. Low variability in fork length for individual samples suggests similar length classes are being caught in each net. Extensive nearshore fish surveys throughout Puget Sound and the Northwest Straits over the past 40 years demonstrate that sand lance are ubiquitous throughout the region year round, and in some instances in great abundance. Despite the presumed ecological importance of sand lance in Washington's inland waters, little is known about the basic biology or population status of this species. Without this information, it is impossible to understand the effects that potential anthropogenic or natural impacts could have on regional food webs. Future

studies should focus on subtidal habitat associations such as with deep water sand wave fields, stock structure, spatial or regional distribution, habitat use by separate life history stages, size at maturity, length-at-age classification, recruitment strength, vertical migration in the water column, and gene flow and connectivity between possible subpopulations.

Tina Whitman

Friends of the San Juans

Forage fish spawning habitat protection and restoration- case studies from the San Juan Archipelago

Abstract:

Forage fish play a key role in marine food webs, with a small number of species providing the trophic connection between zooplankton and larger fishes, squids, seabirds and marine mammals. Beach spawning forage fish such as surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) are threatened by land use activities along shorelines, where development is also concentrated. Human population increases and the impacts of climate change and sea level rise are expected to exacerbate the problem of forage fish spawning habitat loss and degradation in the future. Forage fish spawning activity occurs along only a small portion of the sand and gravel shorelines within the San Juan Archipelago and the larger Salish Sea marine ecosystem. Comprehensive information on spawning habitat distribution, as well as long-term protection and restoration of known spawning sites, will be necessary to support marine ecosystem recovery as well as the recovery of multiple endangered species including Chinook salmon (*Oncorhynchus tshawytscha*) and marbled murrelet (*Brachyramphus marmoratus*). Over the past ten years Friends of the San Juans, a small nongovernmental organization located in San Juan County, Washington, has fostered public private partnerships and implemented a multifaceted approach to forage fish spawning habitat conservation, including research, outreach, protection policy, cumulative impact and climate change risk assessment, and habitat restoration. A case study approach, highlighting key findings and lessons learned, will be presented in the areas of assessment, protection and restoration.

Transboundary air: Shared Canada and U.S. issues

Shabtai Bittman

Agriculture and Agri- Food Canada,

Temporal and spatial variation in ammonia emission from agricultural in the Lower Fraser Valley, BC

S. Bittman, J. Tait, D.E. Hunt, S. Sheppard, K. Chipperfield, R. Vingarzan, K. Jones

Abstract:

Intensive production of livestock, notably dairy and poultry, contributes greatly to the loading of gaseous ammonia into the atmosphere in the Lower Fraser Valley (LFV). While some emissions come from vegetation, crops and applied nitrogenous fertilizers, the majority of the emissions originate with manure, and in particular, the urine or uric acid excreted by livestock and poultry, respectively. Emissions occur almost immediately after urine is excreted because of rapid hydrolysis of urea into ammonia. The loss of ammonia into the atmosphere is a major energy loss as reduced N is a primary energy import into agricultural systems. The chemical reaction of ammonia with acid gases in the atmosphere leads to the formation of secondary particulates that affect visibility and potentially impact human health especially through cardiopulmonary action. The deposition of the ammonium may occur at considerable distance from source may cause significant N loadings leading to acidification and other impacts on sensitive species especially in oligotrophic ecosystems. To understand the effects of ammonia the action of the atmosphere needs to be considered and this must be done in as fine a temporal and spatial resolution as possible. This paper will describe a detailed analysis of ammonia emission from agricultural sources in the LFV using local farm activity data and published emission factors applied with careful regard to local agricultural practices and conditions. The time resolution is one week and the spatial resolution in 4x4 km. We will show that LFV emissions have very large temporal variation due to manure spreading practices and weather variation; greatest emissions occurred in spring and lowest in winter. Spatial variation in livestock and crop contributed to large spatial variation in emission; greatest annual emissions occurred in grids with many 'landless' farms. Since the study was performed over the period when poultry numbers were reduced due to Avian Influenza outbreak, variation in some grids reflects the change in poultry numbers. The variation can be seen in ambient ammonia concentration values measured at two sites, one affected and one largely unaffected by the poultry cull. Mitigation of ammonia in spring will require greater use of low emission manure applicators whereas mitigation in late summer and winter will depend on use of bedding additives or scrubbers in barns, and covers on manure storages. The inventory will be used for regional atmospheric modeling and model outputs will help guide best management practices for minimizing environmental impact of ammonia from farms. The inventory is also being used to develop a soil nitrogen-balance map.

Markus Kellerhals

British Columbia Ministry of Environment

Clearing the Air: Managing Visual Air Quality in the Lower Fraser Valley

Abstract:

This poster is intended to provide a brief, easily understandable overview of the visibility issue to stakeholders who may be unfamiliar with it. The poster will provide a simple introduction to the idea of atmospheric visibility and then provide an overview of the nascent atmospheric visibility management program in the Lower Fraser Valley (LFV) region of British Columbia, Canada.

The LFV is home to 2.6 million people, 80% of whom live in Metro Vancouver. The communities of the LFV are noted for their spectacular mountain, ocean and urban scenery. However these views can at times be degraded or obscured by smog that builds up during periods of poor air quality. Visibility (or visual air quality) is one of the key ways that the public judges the quality of the air. Beginning in the 1990s, surveys of LFV residents indicated that they were concerned about the degradation of views resulting from smog in the LFV.

Groundbreaking scientific work was done in the 1990s to investigate the causes of degraded visibility in the LFV, and to investigate public perception of visibility. In 2006 the focus of the responsible agencies moved towards visibility management with the formation of the BC Visibility Coordinating Committee (BCVCC). The BCVCC has conducted work in several areas: 1) science studies and monitoring of visibility, 2) development of a visibility improvement goal and a metric to measure improvement, 3) development of a “business case” that attempts to list and quantify the benefits of improved visibility, and 4) public and interagency communication about visibility.

The poster will describe some key findings on visibility in the LFV and outline the BCVCC’s vision for piloting a visibility management program in the LFV. Managing visibility in the Lower Fraser Valley links to federally mandated visibility management in wilderness areas of the United States, including the immediately adjacent North Cascades National Park. It also serves to support the Canadian commitment in the Canada US Air Quality Agreement to develop visibility protection programs for sources that could cause trans-boundary pollution.

Rita So

Environment Canada

Statistical modeling of visibility improvements and air quality in the Lower Fraser Valley of British Columbia

Rita So, Roxanne Vingarzan, Andrew Teakles

Abstract:

Two statistical models employing 1) Multiple Linear Regression by Ordinary Least Squares (MLR-OLS) and 2) Quantile Regression (QR) were developed to establish statistical relationships between reconstructed light extinction coefficients and fine particulate matters concentrations ($PM_{2.5}$) for the Lower Fraser Valley (LFV) of British Columbia. These meteorologically adjusted models were used for scenario analyses to determine impacts of ambient $PM_{2.5}$ reductions on the annual visibility distribution as a whole, as well as for determining resultant $PM_{2.5}$ concentrations given specific visibility objectives such as improvements in visual range and visibility perception. Air quality data comprising of gaseous, speciated and gravimetric PM measurements were obtained from two stations in the LFV, Burnaby South and Abbotsford, for the period 2003 to 2008. 24-hr reconstructed light extinction was determined using a modified version of the IMPROVE equation which calculates light extinction due to individual gaseous and particulate pollutants, under specific relative humidity conditions. Results from MLR-OLS indicate that to achieve a 1 deciview improvement on an annual average basis in the LFV, a perceptible change in visibility from the perspective of a human observer, the annual average TEOM-derived $PM_{2.5}$ concentrations would have to be reduced by $0.5 \mu g/m^3$, from the current $4.8 \mu g/m^3$ to $4.3 \mu g/m^3$. This change would bring about an increase in the annual average objective visual range from the current 69 km to 76 km, representing an approximate 10% improvement. In addition, results from the QR model indicate that a reduction of $1.9 \mu g/m^3$ on annual average $PM_{2.5}$ concentrations would be required to eliminate days in the Poor and Very Poor visibility perception categories, which were developed for the proposed Visibility Index under the current LFV Visibility Pilot Project of the British Columbia Visibility Coordinating Committee. Eliminating days in these two categories would ensure that the objective visual range did not drop below 32 km (the visual range threshold between the Poor and Fair categories). Information derived from these models are currently being used as inputs in visibility valuation modeling aimed at quantifying the health and economic benefits of visibility improvements, which serves as a vital component of a business plan for visibility management in the LFV.

Science and management of killer whales

Megan Baker

Cetus Research & Conservation Society

Characterizing boater interactions with Southern Resident Killer Whales in their critical habitat

Doug Sandilands, Nic Dedeluk

Abstract:

A population of killer whales (*Orcinus orca*) ranging in British Columbia and Washington state, known as Southern resident killer whales (SRKW) are listed as endangered in Canada (under the Species at Risk Act) and the United States (under the Endangered Species Act). Recovery plans in both countries have identified a variety of threats facing this population, including reductions in prey populations, high levels of toxins, disturbance from vessels and acoustic disturbances. It is highly likely that these threats are cumulative, interactive, and synergistic. Further, this population is the focus of a significant whale watching industry and also attracts viewers from a high number of recreational vessels in the region.

The Be Whale Wise Marine Wildlife Guidelines for Boaters, Paddlers and Viewers (BWW) were established with input from scientists, government, non-governmental organizations and industry to reduce the threat caused by vessel disturbance. Numerous studies have linked situations where vessels exceed the BWW guidelines to changes in whale behaviour, including: swimming faster; adopting less predictable travel paths; making shorter or longer dive times; moving into open water; and, altering normal patterns of behaviour at the surface.

From 2007 to 2011, the Victoria, BC based Straitwatch program has educated boaters about whale watching guidelines and has monitored the type and level of vessel interactions with SRKW throughout the area identified as SRKW critical habitat by the responsible Canadian and US agencies. Monitoring data collected by Straitwatch measures both the number of vessels following a focal group of SRKW and a rate of vessel operator non-compliance with the BWW guidelines. Analysis of these data characterize the interactions of SRKW with vessels both spatially and temporally throughout their critical habitat and provide management with a tool to identify where and when management actions would be most effective.

Sharon Banick

Marine Science and Sustainability School

*Movement and Surface Active Behavior of Killer Whale (*Orcinus orca*) in Response to Tidal Height, Current Velocity, and Salinity*

Abstract:

Southern resident killer whales (SRKW) are an endangered sub-species of killer whales (*Orcinus orca*). Little is understood about these animal's behavior and navigation patterns with respect to physical environmental parameters. A number of studies suggest currents may influence marine mammal behavior by reducing energy expenditures in hunting and migration. Haro Strait, an important foraging habitat for the SRKW, has a unique bathymetry and may have distinctive water characteristics that influence the behavior and travel of killer whales. We investigated physical factors, such as current, salinity, and temperature will play a role in surface active behaviors (SABS) frequency and navigational direction using both historical and field data collected in fall 2011. Archived data of SRKW sightings from the San Juan Island Whale Museum was correlated with past current data to investigate the relationship between current and direction of travel over time. In addition, Field data on physical factors and behavioral observations was collected daily from September 19 to October 13, 2011. Movement and SABS were measured and examined with respect to current, salinity, and temperature. Daily current, salinity, and temperature measurements were taken with and without whales present using observational data, a CTD instrument package, and a YSI sensor. Daily current average was calculated using nearby current prediction models. SQLShare was used to run queries between whale directional

movement and current direction. Though much of the physical data shows extreme variability, the short term current data for Haro Strait seems to have a weak relationship with SABS in SRKW.

Charla Basran

Beam Reach Marine Science and Sustainability School

*Correlating Southern Resident Orca (*Orcinus orca*) Sightings with Pacific Salmon Densities: A Three Part Analysis*

Abstract:

The Southern Resident Killer Whales (SRKWs) inhabit the Salish seas of Northern Washington, USA and Southern British Columbia, Canada, during the summer and fall months. These whales have been listed as endangered, and feed very selectively on threatened Chinook salmon which migrate through the area on their way back to their native streams. This study investigates the correlation between Orca sightings and Chinook salmon abundance in the Salish Sea region on three different scales. For a broad scale analysis, an archive sightings database was used to obtain Orca sightings data in the San Juan Islands, WA, which was correlated with Chinook catch data obtained for the Fraser River from the Department of Fisheries and Oceans. Data was used from April to October of 2006 to 2010. Number of “whale days” from the sightings database was regressed against catch per unit effort (CPUE) of Chinook, binned by week. For seasonal scale analysis, echosounder data from the spring of 2008 was analyzed to determine densities of large target fish at Lime Kiln State Park, San Juan Island, WA. The depth in the water, and size of the targets, were analyzed to determine which could be counted as salmon. These salmon densities were regressed against sighting data specifically at Lime Kiln State Park. For a fine scale analysis, field data was collected over a twenty day period through the end of September and beginning of October, 2011. On each “whale day”, foraging behaviour was noted and timed to obtain percent of time foraging. Fish finder images were collected each day and surface area of large targets was used to calculate estimated salmon densities. Trolling at depths where large targets were seen was performed in order to confirm the presence of salmon species. The percent time the Orcas were observed foraging was regressed against the salmon densities estimated from the fish finders. Preliminary results suggest that peak numbers of Orca sightings positively correspond with peaks in Chinook salmon runs in the Salish Seas, and the amount of time foraging was observed also positively corresponds with estimated salmon numbers. This reinforces the idea that SRKWs are highly dependent on their salmon prey, and this dependence is reflected in the time spent, and movements within, the Salish Seas region.

Hayley Dorrant

Beam Reach Marine Science and Sustainability School

Can Click Rate be a Proxy for Foraging of Killer Whales?

Abstract:

Foraging is of great importance in understanding the biology of killer whales. One of the three major threats to the southern resident killer whales (SRKW's) is limited prey availability. It is particularly hard to decipher when killer whales are engaged in foraging because this activity mainly takes place below the water's surface. It is believed that killer whales use pulsed calls and whistles to communicate, while echolocation clicks are thought to be associated more with foraging than communicating. The SRKW's are thought to be particularly vocal during foraging due to their preference in prey. To determine whether click rate (number of clicks per minute) may be a proxy for observing foraging behavior, acoustic data was collected from September thru October in 2011. A linear 4 hydrophone array was used to record clicks made by the SRKW's while observational data was collected. Behavior data and recordings from the 4 hydrophone array were synchronized in time. The orientation of the focal group in relation to the hydrophones was also documented. Click rate for foraging behavior was compared to click rate during other known behaviors. This data was localized using Ishmael to insure that the recorded clicks were received from the focal group cataloged as foraging. This data was then analyzed and compared to data collected from similar experiments using the same experimental set up.

Kari Koski

The Whale Museum

Soundwatch Recommendations for Special Management Areas for Killer Whales

Abstract:

On April 8, 2011, NOAA Fisheries announced new vessel regulations to protect Southern Resident Killer Whales from vessel disturbance. The new rules prohibit vessels from approaching any killer whale closer than 200 yards and forbid vessels from intercepting a whale or positioning the vessel in its path. The rules went into effect May 16 and apply to all types of boats, including motor boats, sail boats and kayaks, in Washington's inland waters. When NOAA originally proposed vessel regulations in July 2009, they included a half-mile wide no-go zone along the west side of San Juan Island from May 1 through the end of September where vessels would be prohibited. NOAA decided to postpone the creation of a vessel restriction area and will instead continue to gather information to consider the concept in future rulemaking. Since 1998 The Whale Museum's Soundwatch program has collected data characterizing vessel activities near Southern Resident Killer Whales. Despite expanded outreach efforts through the trans-boundary Be Whale Wise partnership campaign, the implementation of Washington State vessel laws for killer whales in 2008 and an increased presence of law enforcement on the water, data trends portray recreational and commercial vessel operators routinely out of compliance with guidelines and laws throughout the whales' summer range, especially in the NOAA proposed no-go zone. The Soundwatch program highlights vessel activity trends in this high use zone, as well as other "hot spot" areas in the trans-boundary region and recommends specific strategies for the creation of Special Management Areas in these places.

Laura Moe

Beam Reach Marine Science and Sustainability School

Variation of calls used among all pods of the Southern Resident Killer Whales (Orcinus orca)

Abstract:

In killer whales (*Orcinus orca*), vocal calls appear to be an important aspect of communication. Preferences of prey, travel patterns, and vocal "dialects" are distinguishing features among the different ecotypes of northeast Pacific killer whales. Fish eating resident killer whales frequently associate with other whales outside their own pod. A vocally distinct clan may contain up to eight pods. Although clans are classified by their vocal similarities, pods share little of another's repertoire. However, there are reports of some calls that are shared among pods, particularly Southern Resident Killer Whales (SRKW). The S10, S6, and S19 calls have all been claimed to be calls that are shared between all pods of the SRKW, yet they have not been quantified to assess specific similarities or differences. This study was designed to investigate whether or not variations in common calls are pod specific in SRKW. In fall of 2011, SRKW pods were often seen intermingling in a superpod structure around the San Juan Islands, but typically spend winters apart, which may suggest differences in calls. A towed underwater hydrophone array and a fixed hydrophone array were used to record calls of SRKW specifically for this study. Archived calls will also be considered to broaden sample size and heighten quality of samples. Time and frequency parameters will quantify the differences in perspective call "dialects" that may be present in SRKW.

Donald Noviello

Washington State Department of Fish and Wildlife, Habitat Program, Oil Spill Team

Responding to the threat of oil spills to Southern Resident Killer Whales

Abstract:

The Southern Resident Killer Whale (SRKW) population is listed as endangered under the Endangered Species Act. Major oil spills pose a significant threat to this population, which spends most of its time in the Salish Sea. In recognition of this threat, the Department of Fish and Wildlife, NOAA and other stakeholders have developed response strategies to try to protect whales from spilled oil. This presentation describes the threat posed to the Southern Resident

Killer Whale population by oil spills as identified in the Recovery Plan For Southern Resident Killer Whales (*Orcinus Orca*) published in January 2008 and describes ongoing planning efforts to be able to implement an effective hazing program to dissuade killer whales from entering or remaining in an area where the surface waters are contaminated by an oil spill. Currently steps are being taken to be able to use Oikomi pipes (reverberant metal pipes) suspended in the sea, seal bombs (small explosive devices) and low flying helicopters to produce acoustic signals that may alter the course of killer whales traveling in or toward an oil contaminated area. The presentation identifies both regulatory and logistical impediments to effective implementation. A brief review of the limited scientific basis for hazing Killer Whales is presented along with suggestions for future research that could help improve the effectiveness of hazing efforts.

Benjamin A. Wheeler

Hemmera Inc.

Underwater noise modeling as a less-invasive planning and management tool for Southern Resident Killer Whales and port terminal construction in the Salish Sea

Benjamin A. Wheeler, David Hannay, Juergen Baumann

Abstract:

The Canadian Recovery Strategy for Southern Resident Killer Whales (SRKWs) identifies anthropogenic underwater sound as a potential principal threat to population recovery. Stakeholder input relating to recent port facility construction at Roberts Bank (within critical SRKW habitat) also raised concerns regarding acoustic effects to SRKWs. To better understand these effects Port Metro Vancouver undertook (2007-2010) several novel acoustic studies including: predictive modeling of underwater sound from terminal construction (using surrogate sound signatures for these activities); weighting of modeling results to reflect likely killer whale hearing and ambient sound conditions; field collection of underwater sound from construction equipment; and validation of predictive models based on actual sound from construction equipment. Results indicate ambient (baseline) sound conditions at Roberts Bank and Strait of Georgia are variable and frequently elevated (sometimes reaching 110 dB re μ Pa); the shallow and sedimentary nature of Roberts Bank restricts in-water propagation of low frequency sounds more than high frequency sounds; potential effects to SRKW hearing from construction are very unlikely; the area of disturbance to SRKWs (e.g., where sound levels may result in active avoidance) from construction is less than one kilometer (from the equipment) and that SRKW communication masking by underwater construction noise is possible up to 7-10 km. These studies are useful examples of less-invasive study techniques that can be used to inform decision makers and resource managers (in Canada and the US) on potential effects to SRKWs from Port and other marine activities.

Shorelines: Ecology, restoration, shore-friendly development, local and regional management tools and issues

Alexis Blue

Coastal Geologic Services

Beach nourishment design and performance in west Fidalgo Bay, WA

Alexis Blue, Jim Johannessen, Christine Woodward

Abstract:

Fidalgo Bay is located in northern Puget Sound in northwestern Skagit County. The bay is approximately 1,575 acres. It is an area rich in biological resources which include expansive native eelgrass beds and tide flats that support spawning and rearing of several forage fish populations. This unique area is also home to bald eagles, blue herons, peregrine falcons and a mix of shellfish from Dungeness crab to butter clams. The Samish Indian Nation owns 40 acres of tidelands, 22 acres of uplands and 7.7 acres of conservation area in Fidalgo Bay.

In the fall of 2009, The Samish Indian Nation worked with landowners and contractors to restore 550 feet of eroding shoreline with an engineered soft shore protection and beach enhancement design. This project, designed by Coastal Geologic Services with the Skagit County Conservation District, was the first phase of a larger beach nourishment design and performance effort in west Fidalgo Bay. A second phase of the project was recently designed for the 500 ft of adjacent shoreline.

The second phase of the beach enhancement design includes beach enhancement/nourishment design details, identification of vegetation zones, and development of final design drawings with site plans, cross sections, and materials descriptions and quantities. This second phase will take place along 500 feet of the tideland and upland areas that are located on the NW end of the Tribe's property and will abut with the first 550 ft completed in 2009.

The objectives of the both phases were to protect an archeological site that was in danger of eroding onto the beach, enhance forage fish spawning habitat, restore riparian vegetation (shade) and restore the upper beach along the Tommy Thompson Trail. Seven (7) planting beds have been put in place along the first 550 feet of shoreline to begin creating shade. These planting beds were installed above existing ground elevation as to not disturb the culturally sensitive sediments.

The project area is located within a drift cell which no longer has any intact sediment sources due to shore armoring. Mitigating for the loss of sediment supply was recommended in this area in a bay-wide restoration prioritization plan in 2007. Fidalgo Bay is noted for historic spawning areas of forage fish however, armoring of the shoreline, loss of fine-grained each sediment, and removal of native vegetation seriously hinders the habitat suitable for spawning areas. This project will give a total area of habitat restoration and beach enhancement along a single beach in Fidalgo Bay to 1,050 feet.

A beach monitoring plan has been developed for the project location and the first phase monitoring has begun. The plan includes documentation of measurement methods and boundaries (including map), beach profile locations, beach characterization procedures, survey monument information, and references. The monitoring plan is of sufficient detail and clarity for the Samish nation to conduct future follow-up beach monitoring. The Samish nation staff member(s) will also be trained in the field on data collection for carrying out the beach monitoring plan in the following years.

Anthony Gabriel

Central Washington University, Department of Geography

SoundMap: Puget Sound Public Resource Mapping Project

David Cordner, Anthony Gabriel

Abstract:

The Puget Sound ecosystem is a management priority for Washington State, federal agencies, tribal governments, and private stakeholders. Current initiatives aimed at restoring and protecting ecosystem functions include the Puget Sound Partnership, Puget Sound Nearshore Ecosystem Restoration Project, Washington State Shoreline Management Act, and Department of Natural Resources (DNR) Aquatic Reserves Program. To succeed and be embraced by communities, these initiatives require public input and as well as public education. Local knowledge regarding resident's uses, perceptions, and value of the Puget Sound shorelines must be incorporated with expert data to develop management plans that are adapted to local values, while at the same time residents must be educated about potential effects of those values on the ecosystem.

To facilitate the incorporation of local knowledge into shoreline management planning processes and promote ecosystem education, RGIS-Pacific Northwest (PN) developed SoundMap an internet-based data collection methodology that uses a public participation geographic information system (PGIS). An interactive map allows participants to digitize points, lines, or polygons representing important instrumental uses, aesthetic resources, and cultural meanings associated with locations along the shoreline and store them in a database for analysis. The internet-based PGIS was created using free open source software.

A pilot study implemented SoundMap to collect data at locations of proposed additions to the Aquatic Reserves Program on Puget Sound. The program establishes reserves to protect state-owned aquatic lands that provide direct and indirect benefits to the health of native aquatic habitats and other resources of Washington. SoundMap provides for informed public input, as well as a forum for educating the public using a wide variety of spatial datasets associated with the goals and objectives of the Aquatic Reserves Program. Besides environmental protection, reserves are to encourage public use and access, as well as provide for public participation in conservation management. Each reserve requires extensive stakeholder participation in the proposal process, development of site-specific management plans, and ongoing implementation stages. An essential part of this process is collecting information on consumptive and non-consumptive direct use values (e.g. shellfish harvest or recreational dive locations), indirect use values associated with ecosystems services (e.g. wetland protection of water quality), as well as non-use values such as aesthetic resources.

SoundMap data layers include general site information (e.g. proposed boundaries and ownership of neighboring lands), ecological conditions such as quality of the site (e.g. nuisance species), values (e.g. priority marine habitats), processes (e.g. drift cells), and potential stresses (e.g. adjacent land uses, stormwater outfalls etc.). The compiled data layers can also be used to meet goals of the Aquatic Reserves Program after a site is established, including educating citizens on the value of aquatic habitats, gathering monitoring data and updating management strategies to address changes in environmental impacts. For example, common DNR-managed activities within Aquatic Reserves that may be addressed include siting of public docks and mooring buoys, outreach and education efforts, and determining additional public access needs.

Sally Hawkins

Friends of the San Juans

Marine and freshwater riparian inventory for San Juan County, Washington

Sally Hawkins, Tina Whitman, James Slocomb

Abstract:

The Puget Sound region of Northwest Washington State has a resource rich history and scenic beauty which has attracted ongoing human growth and development for the past century. The islands that compose San Juan County, located at the north end of Puget Sound are uniquely positioned at the confluence of the inland estuaries of Straits of Georgia, Straits of Juan De Fuca, and Admiralty Inlet. The shores of these islands are part of the greater marine ecosystem that

provides significant food web support and habitat for multiple federally listed species, including Chinook salmon, marbled murrelet and the southern resident orca whale. Washington state governance has adopted a “no net loss” policy regarding ecological functions and values from human development. Effective implementation and monitoring of this policy requires closure of data gaps defining existing habitat conditions along its shorelines.

While much data exists on valued ecosystem components, wide data on riparian condition (marine or freshwater) is lacking in many regions, including San Juan County. This study tests a methodology for quantifying vegetation types and characteristics along the marine shoreline and fresh water creeks. Using a combination of remote sensing data (LIDAR, Aerial Orthophotometry) and GIS tools, the sample study defines procedures for coarse identification of vegetation type and density, also overhanging vegetation categories. Results will be applied to landscape scale shoreline management efforts including salmon recovery planning and shoreline master program updates. Results can also inform site specific protection and restoration efforts.

Sarah Heerhartz

University of Washington

Effects of shoreline armoring on nearshore fish, birds and invertebrates of the Salish Sea

Sarah Heerhartz, Megan Dethier, Jason Toft, Jeffery Cordell, Andrea Ogston, Helen Berry

Abstract:

Armoring of marine shorelines is increasing as human populations grow throughout the Salish Sea region. One of the main functions of seawall and riprap armoring is to stabilize sediments that would otherwise be eroded or deposited over time by natural processes. Shoreline armoring often overlaps with important habitat for nearshore fish, birds, and invertebrates, but relatively little is known about how armoring impacts these organisms. Armoring may diminish ecosystem functions for nearshore organisms by reducing habitat space at the terrestrial-aquatic interface and therefore reducing important food-web connections, but only a few local-scale studies have documented these types of impacts. The objectives of this study are to 1) characterize habitat functions of the supralittoral ecotone for nearshore fish, birds, and invertebrates of the Salish Sea, and 2) identify the impacts of shoreline armoring on those habitat functions. Shoreline armoring likely impacts the nearshore ecotone at multiple levels. In this study, several survey and experimental methods were used to evaluate impacts across a broad range of paired armored-unarmored beaches throughout central Puget Sound. One main focus was at the wrack-line of beaches at high tidal elevations, where algae, eelgrass, and terrestrial debris such as leaves are deposited by tidal and wave forces. We measured the abundance and composition of wrack and the abundance and density of wrack-associated invertebrates along transects in the upper intertidal zone of study beaches. We deployed two types of experimental wrack decomposition tubes that either excluded or allowed entry of talitrid amphipods to test if these ecologically important invertebrates influence the rate of wrack decomposition. We used pitfall traps placed along the wrack line or at the base of armoring to examine density and composition of talitrids and other organisms that occupy the upper intertidal. Insect fallout traps were deployed among backshore vegetation or on armoring to estimate the relative densities of insects. We are also taking observations of species composition and behavior of birds in the upper intertidal zone and fish in shallow waters. Our initial results show that more wrack accumulates on the upper intertidal zone of unarmored beaches compared with armored beaches. Consequently, wrack-associated invertebrates such as talitrid amphipods are more abundant on the unarmored beaches. We will discuss food-web implications of such differences between armored and unarmored beaches, as they pertain to data on fish and birds. Results of this study will provide data on the habitat functions of the upper intertidal ecotone, the effects of shoreline armoring, and the potential for restoration of lost functions.

Jim Johannesson

Coastal Geological Services

Saltmarsh and coastal restoration projects on private property in San Juan County, WA: Small projects are cheaper and easier

Jim Johannesson, Tina Whitman

Abstract:

Four recent salt marsh and beach restoration projects completed in San Juan County will be compared and contrasted in terms of project selection, development, design, implementation, and lessons learned. The projects include a range of small to moderate sized restoration and enhancement projects that have been completed in recent years through a variety of funding sources. The projects were the result of the key partners of the non-profit Friends of the San Juans as project manager and sponsor, with technical and design work by Coastal Geologic Services. A wide variety of project partners were involved. Most of these projects were selected and developed as a result of systematic resource inventory and nearshore assessments and prioritizations (San Juan County Soft Shore Restoration Blueprint), while the early project was driven by private owners concerns. Different approaches to make ensure that the projects were of benefit to the exclusively private landowners were used in each project. The following projects will be briefly outlined in terms of project initiation, design challenges, design features, and partnerships, with emphasis placed on key reasons projects were able to be developed all the way through implementation, and lessons learned:

Driftwood Beach, Blakely Island – This was an earlier San Juan County fill removal and beach restoration project in the county, completed in early 1999. The project restored 900 ft of an active gravel beach, and served as a catalyst for other projects that have occurred or are in the project development stage. Results of 10 years of monitoring and the role of the private homeowner association will be outlined.

Shoal Bay Tide Gate and Bulkhead Removal, Lopez Island - The remains of a derelict concrete tide gate and a concrete structure at a barrier lagoon were identified through a nearshore restoration prioritization for removal. The deteriorated tide gate constrained tidal flushing and fish passage into the lagoon. Pre and post monitoring will be presented. A key element for project development was participation of private landowners who were interested in water quality benefits as a result of the project.

Turn Bay Saltmarsh/beach Restoration – A small, unnecessary rock revetment was removed and a critical back-barrier saltmarsh and potential forage fish spawning beach were restored. After fill removal was completed, beach nourishment sediment was imported to recreate the beach profile and impacted wetland plants were replanted along the new marsh face. The owners cooperated in allowing restoration on their land.

Blind Bay Forage Fish Habitat Restoration, Shaw Island - Designs were developed for the highest ranking shore reach in the county-wide prioritization. The project consisted of a beach nourishment project waterward of a county road to improve degraded forage fish spawning habitat substrate at a documented surf smelt spawning beach. This cooperative project had a key project partner, County Public Works, which has provided some of the materials. The project was implemented in 2011 with initial monitoring data presented.

Scott Steltzner

Squaxin Island Tribe

A landscape based strategy for prioritizing catchments along the nearshore of Budd Inlet

Scott Steltzner, Kyle Brakensiek

Abstract:

Effective implementation of shoreline restoration and conservation projects requires that the association between the nearshore, the associated uplands as well as surrounding areas be considered. We used catchments generated by Northwest Indian Fisheries Commissions (NWIFC) Salmon and Steelhead Habitat Inventory and Assessment Program (SSHAP) to devise a landscape based prioritization methodology for the Budd Inlet nearshore environment. This consisted of 1) the formation of a science advisory panel, 2) a literature search for proposed

projects within the Inlet, and 3) a landscape based analysis. For the analysis catchments were designated as either nearshore- associated with the shoreline, or upland- one catchment landward of the nearshore. The catchments were then rated by for their level of disturbance based on a suite of human induced stressors. Individual catchments and groupings of catchments were then designated for management strategies of: conservation, enhancement, restoration or creation.

Marine Protected Areas in the Salish Sea - a transboundary exploration

Chris Harvey-Clark

University of British Columbia

Moving past "The Tragedy of the Stakeholders": Fully protected marine reserves in and around the Salish Sea

Chris Harvey-Clark, Roy Mulder

Abstract:

The concept of inherent and intrinsic ecological values of living entities, as opposed to their commodity value, has more traction on land than under the sea in Canada. Although Canada has had an Oceans Act for more than 20 years, the creation of fully protected marine reserves that foster intact, undamaged, unexploited marine ecosystems remains elusive for a variety of reasons. Government agencies have become increasingly entrenched in regulating the exploitation of marine resources for the maximum benefit of consumptive users and assuaging stakeholders than providing complete protection to sensitive marine nursery areas as a living resource for the benefit of the entire population. The basic premise of complete protection of representative biota for the benefit of all Canadians in even limited amounts of the marine water column and benthos has been diluted by the new "tragedy of the commons", namely, the "tragedy of the stakeholder". Under this paradigm, a single stakeholder who objects to marine reserves inevitably assures that complete protection is unattainable in every corner of the oceans around Canada. This discussion acknowledges that other countries have moved past this to create a new reserve paradigm for the benefit of the majority of the population, and outlines a unique set of factors in Howe Sound, British Columbia that align to make this a priority for government.

Howe Sound is one of the most biologically diverse marine regions in coastal British Columbia adjoining the Salish Sea, and has been undergoing a quiet rebirth after a century of damaging human activity including pulp mill and mine effluent, damage from logging and log boom transport and over fishing. Howe Sound is also unusual in that while adjacent to a major population center, Vancouver, it possesses unique marine ecological values, particularly in the form of glass sponge bioherms found only in a few locations on the planet outside the Antarctic. In another paradigm shift, new discoveries are being made by non aligned citizen scientists seeking complete protection for sensitive and rare marine biota within marine reserves. The mapping, biological characterization, and the increased public profile of the associated biota around sponge bioherms of Howe Sound is due in part to efforts by groups like the Marine Life Sanctuaries Society of British Columbia (MLSS). Similarly the Underwater Council of British Columbia has funded a mooring buoy program to decrease bottom damage from anchoring. Recently MLSS made the first discovery of deep water gorgonian corals in Howe Sound. A proposal for designating 10 percent of Howe Sound's unique marine resource areas as fully protected reserves, under a voluntary stewardship model, is presented.

Applying environmental indicators for ecosystem-based management

Randy Carman

Washington Department of Fish and Wildlife, Habitat Program

Recent trends in shoreline armoring in Puget Sound

Randy Carman, Brian Benson, Tim Quinn, David Price

Abstract:

Marine shorelines along Puget Sound are often armored to prevent erosion from wind and waves and protect property investments. Armoring of shorelines may result in loss of the upper beach zone and can interrupt ecological processes such as delivery, transport, and accretion of beach sediments - problems likely to be exacerbated by sea-level rise. In addition, armoring often occurs in association with other changes to the nearshore environments consistent with human development including removal of shoreline vegetation and increased inputs of nutrients. The trend in shoreline armoring in Puget Sound is an important indicator of shoreline ecological function that may be used by the Puget Sound Partnership as one of several indicators of the general health of Puget Sound.

To better understand trends in shoreline armoring in Puget Sound, we selectively reviewed Hydraulic Project Approvals (HPAs) issued by the Washington Department of Fish and Wildlife, for years 2005 through 2010. HPAs are required for construction activities on the shorelines in Washington State. We recorded a total of 941 permits issued specifically for shoreline armoring within Puget Sound during this six year period. These permits indicated that new armoring was installed along 6.5 miles of shoreline, 14.5 miles of existing armor was replaced, and armor was removed along 0.61 miles. Evaluation of the geographic trends in armoring indicated that 51% of the new armoring along marine shorelines was concentrated in three (Mason, Kitsap and Island) of the twelve counties that border Puget Sound. Additionally, two of these three counties were also among the highest for armor replacement rates. Approximately 75% of the new armoring in Puget Sound was for single-family residential properties. In contrast, 63% of armor removal projects occurred at publicly owned sites.

Tim Determan

Washington Department of Health, Office of Shellfish and Water Protection

Status and trends in fecal pollution in shellfish growing area of Puget Sound through 2010

Abstract:

The Washington State Department of Health used a Fecal Pollution Index (FPI) to describe the status of fecal pollution in shellfish growing areas of Puget Sound in 2010. The FPI was also used to rank Puget Sound shellfish growing areas according to fecal pollution impact, and show 13-year (1998-2010) fecal pollution trends in six selected growing areas with extensive histories of remedial action (Drayton Harbor, Portage Bay, Samish Bay, Henderson Inlet, Eld Inlet, Oakland Bay).

Sean Fleming

Environment Canada

Prototype fuzzy logic approach for an integrated groundwater sustainability index

Sean Fleming, Cecilia Wong, Gwyn Graham

Abstract:

Indicators and indices (combinations of individual indicators) can be an effective method for tracking environmental conditions and changes over time, as well as associated issues, such as the effectiveness of policy measures or remediation actions. Relative to surface water resources, however, groundwater has received little attention in this respect. A third of British Columbia's population and two-thirds of Washington State's population rely directly on groundwater for water

supply, and aquifers also play a central role in watershed hydrology by attenuating peak flood flows, providing baseflow and associated aquatic habitat, moderating water temperatures, and providing a communication pathway for contaminants from the land surface to the open freshwater environment. Here, we provide proof-of-concept for a groundwater sustainability index. It is integrated in the sense that it incorporates both quantity and quality indicators. A fuzzy inference system is employed to readily combine these unlike metrics, and has the additional advantages of explicitly encoding expert knowledge and directly acknowledging subjectivity in environmental condition "grading," through the use of linguistic rules and fuzzy sets, respectively. The outcome is a groundwater sustainability index ranging from 0 to 100. The index is demonstrated using both synthetic time series and examples from the Salish Sea region, including the Abbotsford-Sumas aquifer, an important and managerially challenging transboundary water resource.

Gina Lemieux

Archipelago Marine Research Ltd.

Seabed Imaging and Mapping System (SIMS) – A survey tool for change detection and monitoring in nearshore marine environments

Trisalyn A. Nelson, Steve N. Gillanders, John Harper, Mary Morris, Gina Lemieux

Abstract:

Archipelago's Marine Environmental Services division recently assisted researchers from the Universities of Victoria (UVic) and British Columbia (UBC) in their evaluation of Archipelago's proprietary, towed underwater video camera system (SIMS), typically used in nearshore biophysical survey work, for use in detecting and monitoring significant change in shallow-water marine environments over time.

Using data acquired from SIMS surveys in 2006 and 2009 for a coastal area on southern Vancouver Island, spatial statistics were applied to species abundance maps to identify 'hot spots' of epifaunal and floral change between the two years. Several local areas of significant change were detected by the analytical methodology indicating that SIMS survey data, in combination with GIS and spatial analysis, is suitable for analyses at fine spatial resolution. This pairing of the analytical tools with SIMS provides improved means to identify and monitor change in nearshore habitats providing an indication of the health of the ecosystem. Some applications include detecting change in habitats from anthropogenic factors or environmental variation, or evaluating the success of habitat compensation projects.

1. Spatial Pattern Analysis & Research Lab, UVic
2. Department of Forest Resources Management, UBC
3. Coastal & Oceans Resources Inc. Victoria, BC
4. Archipelago Marine Research Ltd. Victoria, BC

Theresa Mitchell

Washington Department of Fish & Wildlife

Moving towards a strategic approach to nearshore restoration project identification

Theresa Mitchell, Jenna Norman, Randy Carman, Curtis Tanner

Abstract:

A common goal of restoration programs is to identify the best opportunities to achieve program objectives. It is widely recognized that implementing an ecosystem-based approach and restoring ecosystem processes would likely improve results, however project selection is often opportunistic and poorly coordinated to achieve maximum ecosystem benefit. The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) is developing a more strategic ecosystem-

based approach to project selection and implementation by utilizing science-based tools to identify areas where restoration can most effectively benefit nearshore processes.

PSNERP has completed analysis of historic and existing conditions within the Puget Sound nearshore. This analysis informed our understanding of critical problems and the prevalent stressors that have degraded nearshore processes. Within the Puget Sound restoration community there is an existing backlog of identified projects that has been captured in the Nearshore Project Database. PSNERP evaluated these potential projects using our understanding of problems and restoration needs, which has resulted in a list of 36 candidate restoration actions. Conceptual design work was done for these 36 projects which allows for quantification of project benefits and cost/benefit analysis, leading to our first portfolio of projects.

While PSNERP's first portfolio of projects will be derived through analysis of identified ecosystem needs and existing opportunities, we continue to develop improved methods to more precisely define priority locations for ecosystem restoration and protection. This will both increase our ability to evaluate existing opportunities and promote development of projects in priority locations.

This poster will describe the process utilized to prioritize and reduce the list of potential restoration actions from 700 to 36, what scientific tools were used in making these decisions, and how these tools can be used in identification of future restoration actions.

www.pugetsoundnearshore.org

Gary Winans

Northwest Fisheries Science Center, NOAA

A genetic inventory of marine organisms of the Salish Sea

Gary Winans, Jon Baker

Abstract:

To monitor and manage for the health of the Salish Sea marine ecosystem, we need to include information on the stock structure for a diverse array of marine organisms. Data for stock structure, i.e., the amount and pattern of genetic differentiation, provide a framework to evaluate the evolutionary potential of species, the spatial scale of local adaptation, and the potential for broad or narrow geographic response of species and communities to environmental change or disasters. Because many marine organisms have a pelagic larval stage, it is presumed tacitly that each species consists of one panmictic population and therefore evolves and can be managed as one unit. However preliminary studies of genetic variability of as diverse group of animals such as Dungeness crabs, Pacific herring, and red sea urchins in the Salish Sea indicate that genetic homogeneity among populations is not the case. We summarize available genetic information for marine plants and animals in the Salish Sea, synthesize general patterns of variability over taxa and habitats/food webs, and highlight data gaps. We argue that to understand marine ecosystem functionality and to monitor and conserve its constituent species and species stocks more studies of biodiversity are still required.

Threat and risk assessments in the Salish Sea

Zachary Hughes

NOAA - National Marine Fisheries Service

Using GIS and habitat data to enhance analysis of effects to ESA Listed Species
Species

Abstract:

Incorporating geospatial data into the daily operations of the National Marine Fisheries Service has the potential to reduce consultation time on Endangered Species Act (ESA) consultations and enhance NOAA's ability to perform meaningful, accurate consultations that help preserve ESA listed species.

Many human land uses constitute ongoing threats to quality of habitat for protected fish species. Urban development, impervious surfaces, agriculture, and forestry practices all contribute to the degradation of habitat quality for fish in rivers and streams through pollution and habitat alteration. Here we describe two applications of geospatial techniques that enhance our understanding of threats to ESA listed fish in Washington State by incorporating human impacts to and biological requirements for those species:

1. We use land use cover information from the USGS Land Cover database and relevant literature to estimate baseline impacts to habitat quality at the scale of 6th Field Hydrologic Unit Code (HUC). The resulting threat index can then be used to help characterize cumulative impacts and threats to fish when analyzing potential impacts from development or restoration projects. This information is helpful when determining how much of a potential threat or benefit a specific project is to listed fish species.
2. Regional habitat information can also play an important role in preserving fish in Puget Sound. Salmonids listed under the ESA use a variety of life history strategies and depend on a variety of different habitat types for these strategies. We explore how using geospatial and habitat data combined with information about habitat requirements for different life history strategies for Puget Sound Chinook salmon can be used to enhance our ability to predict losses to specific life history strategies for Puget Sound Chinook. Vulnerabilities based on losses to specific life history strategies can reduce the ability of Chinook to express plasticity of behavior that enhances the ability of the species to survive perturbations.

Robert Johnston

US Navy Marine Environmental Support Office - NW

An integrated risk assessment framework to advance environmental quality and species recovery

Abstract:

In developing an integrated ecosystem assessment approach for the Puget Sound, the Puget Sound Partnership has adopted a model of drivers, pressures, states, impacts, and responses (DPSIR) to relate ecosystem recovery to the Partnership's goals. Recently, the threats and drivers were evaluated based on their scope, severity, and irreversibility to rank threats on a Puget Sound-wide basis. However, to "ensure that activities and funding are focused on the most urgent and important problems facing the sound" (PSP 2008) effective ecosystem management and recovery will require a rigorous and holistic assessment of the relative risks. There is a critical need to relate sources of stress like toxic loadings, hypoxia/anoxia events, nuisance species, and loss of habitat to the structure and function of the food web and the critical provisioning and sustaining ecological processes needed to obtain ecosystem recovery. To address this need, an integrated risk assessment conceptual model framework is proposed that links the sources of stress (threats and drivers) to secondary stressors (environmental media and structures) and identifies the pathways (pressures and

processes) by which primary and food web receptors can be impacted. The framework allows identification of assessment endpoints, measurement endpoints, and available data sources that can be used to assess relative ecological and human health risks. Application of a numerical modeling framework linking watershed scale processes to the food web and cumulative net ecosystem benefit will improve the risk assessment by increasing the capacity to assess risk to higher levels of ecological organization (population and community) and allow spatially explicit characterizations of risk to be developed. Regional or watershed scale approaches are necessary to properly bound and address the complexity of the problem and develop meaningful management actions. The framework encompasses and harmonizes requirements for three of the major regulatory drivers for ecosystem recovery – restoration (Endangered Species Act), cleanup (Comprehensive Environmental Response, Compensation, and Liability Act), and water quality improvement (Clean Water Act). By providing an effective feedback between what is causing risk and actions to manage risk, the framework also supports adaptive learning and improves the understanding needed for effective ecosystem management. While the framework includes some aspects of human health, for example assessing the potential human health risk of contaminants in seafood, assessing the risks of and risks to human quality of life (human well being) will require further development. An important aspect of this approach is to combine fate and transport modeling with food web modeling, develop procedures for evaluating cumulative ecosystem improvement, and incorporate stressors from pollution, habitat alteration, and other sources into the same risk assessment framework so that their relative impacts on ecosystem recovery can be evaluated and ranked. This will allow response actions to be geared to making real improvements in environmental quality.

Building towards a better informed Salish Sea constituency through education and outreach

Janice Mathisen

Seattle Aquarium

Ripple effects of the Beach Naturalist Program: Communicating science and conservation to the public

Janice Mathisen, Andrea Anderson

Abstract:

What do you do with 200 eager volunteers from many academic backgrounds who want to educate the general public on local beaches? Encourage them to become Beach Naturalists, and let the training begin!

The Beach Naturalist Program is a grass roots volunteer program that encourages beach conservation through education and example. Puget Sound citizens are recruited to work on local beaches with the general public on extreme low tide days. These volunteers are trained in natural history, conservation issues, current research on the health of Puget Sound, and learn techniques for successfully sharing this information with beach users.

Many Beach Naturalists participate year after year, and this base of knowledgeable volunteers allows us to build on previous knowledge and training. They understand human impacts, see how the beach is connected to the nearshore, watershed, and Puget Sound. They become advocates for Puget Sound as they share their knowledge and passion for this ecosystem with beach visitors, friends and family. They are present on ten beaches from the end of May through July.

Over the past twelve years Beach Naturalists have had over a quarter of a million conversations (232,000) on marine topics with beach visitors.

This program continues to be a model for others throughout Puget Sound.

Evaluation:

Education is only part of the program picture. How can we measure the impact of programs like these?

We collect public response cards from beach visitors and compile data on what they report they learn. We note beach visitors' behavior, record observations, and conduct interviews. We survey the volunteers about what works about this program and what doesn't. Most transformative impacts we see has been when we've asked former and current Beach Naturalist volunteers what other actions involvement in this program has led them to. What is the "ripple effect" of programs like these, beyond those described above?

Session participants will leave with suggestions on how to effectively work with volunteers, program evaluation strategies and training ideas.

Donna Sandstrom

The Whale Trail

The Whale Trail: Encouraging cross-boundary stewardship through eco-tourism

Abstract:

The Whale Trail (www.thewhaletrail.org) is a series of sites around the Northwest where the public may view orcas, other whales and marine mammals from shore. Our mission is to inspire appreciation and stewardship of whales and our marine environment by establishing a network of viewing sites along the whales' trails through Puget Sound and the coastal waters of the Pacific

Northwest.

Our goals are to increase awareness that our marine waters are home to orcas and other species; connect visitors to orcas, other marine wildlife and their habitat; inspire stewardship and build community; and promote land-based whale watching.

The Whale Trail is being developed by a core team including NOAA Fisheries, Washington Dept of Fish and Wildlife (WDFW), People For Puget Sound, the Seattle Aquarium, the Whale Museum, and the Olympic Coast National Marine Sanctuary. The project was founded and is led by Donna Sandstrom. Many members of the team first met when they worked together on the successful project to return Springer, an orphaned orca, to her pod and native waters.

There are 25 sites on the Whale Trail so far, in city, county, and state parks; Tribal lands; and the Washington State Ferries. The project is cross-boundary, extending eventually, we hope, throughout the orcas' range.

Whale Trail sites may include interpretive signs, customized to show which marine mammals are likely to be observed there, and when. Each site is also featured on our website, where users may comment, upload photos, and join the Whale Trail community. Through the current signs alone, the Whale Trail will reach over one million people this year.

As communities galvanize, The Whale Trail also provides programs to turn awareness into action. In 2011, we are piloting an Orca Steward program in Seattle, sponsoring a Whale Trail shuttle on San Juan Island, and spearheading a Sound-wide Welcome the Orcas month in October.

The Whale Trail has created a new platform for Sound stewardship and orca recovery. The presentation and poster will address the role of The Whale Trail in each, and include samples of our signs, programs and outreach materials.

We will tell the history of the Whale Trail, share our tips for building successful relationships with a wide variety of partners and the public, and encourage new ideas and collaborators for our next phases.

It is our hope that The Whale Trail will remind future generations of a moment in history when the orcas almost went extinct, but didn't; and when Puget Sound almost crashed, but didn't; because we collectively rose to this challenge with the urgency, skill, and resources it required.

Amy Sprenger

Applied Physics Laboratory, University of Washington

Ocean observing data and products for informal and formal education and outreach

Amy Sprenger, Sarah Mikulak

Abstract:

Connecting science with education through technology and real and near real time data provides local relevance and excitement for educators, students and life-long learners as well as outreach opportunities for researchers. NANOOS, the Northwest Association of Networked Ocean Observing Systems, the Regional Association that manages and operates the Regional Coastal Ocean Observing System (RCOOS) for the Pacific Northwest as part of the U.S. Integrated Ocean Observing System (IOOS), provides extensive resources to support learning about the coastal ocean and estuaries in the Pacific Northwest for formal and informal educators as well as targeted user groups.

This presentation will share specific examples of how NANOOS has successfully engaged with K-14 educators, informal learning centers and the general public to engage learners in using technology and information from ocean observing systems.

We will elaborate on how we are providing support for classroom teachers via professional development experiences and classroom materials designed to engage students in authentic science and aid teachers in bringing this unique material into the classroom.

NANOOS has partnered with informal learning centers to provide data visualizations and interactive computer exhibits using local real time ocean observing data to educate visitors about the local marine ecosystem.

NANOOS' web portal, www.nanoos.org, provides on-line access to data, data visualizations, animations and information on key ocean topics relevant to the Pacific Northwest for the general public and targeted user groups including fishers, shellfish growers and those living or traveling in potential coastal hazard areas.

We will discuss our successes and challenges in the online arena as well as our plans for future education efforts including outreach opportunities for researchers.

Web portal: www.nanoos.org

Fritz Stahr

Ocean Inquiry Project

Bringing ocean researchers, students and marine volunteers together through field research

Fritz Stahr, Amy Sprenger

Abstract:

Ocean Inquiry Project (OIP – www.oceaninquiry.org), a non-profit organization in Seattle, WA, delivers inquiry-style marine science education while gathering research-quality data in Puget Sound for scientific partners. As a full partner now in COSEE Ocean Learning Communities, OIP brings together ocean researchers, volunteers from environmental organizations, informal educators, and local youth groups for day-long, hands-on field-research learning experiences on Puget Sound. These experiences give the diverse participant groups a better appreciation for the process of science, how oceanographic data is collected, and an increased understanding of the Puget Sound ecosystem and the role humans play in that ecosystem's health. This collaboration has benefited the non-scientists and scientists alike. In this presentation, we will discuss our approach, and provide examples of successes and challenges encountered during this collaboration. Through professional evaluations of OIP's various audiences and partners, we can now document some of the benefits to the mix of scientists, participants, and ship-partners. We can also begin to look at hydrographic stations that now have over 8 year long time-series at them.

Scott Veirs

Beam Reach Marine Science and Sustainability School

Beam Reach Marine Science and Sustainability School: An integrated experiential science program

Scott Veirs, Robin Kodner, Val Veirs, Jason Wood

Abstract:

Beam Reach Marine Science and Sustainability School is an independent, 10-week-long field research program approved for credit by the University of Washington. Beam Reach has an integrated curriculum that focuses on the health of the Salish Sea ecosystem and the iconic endangered Southern Resident Killer Whales (SRKW). With SRKW at the focal point, Beam Reach is able to teach about the multidimensional issues facing the Salish Sea though some of its most vulnerable and charismatic organisms, including the listed populations of salmon that the SRKW prey upon.

Beam Reach gives advanced undergraduates and recent graduates a rare chance to pose and address their own research questions. They are trained in marine biology, oceanography, and

bioacoustics ashore at the University of Washington's Friday Harbor Labs. Their first observations of SRKW and their environment are made by visiting the Lime Kiln lighthouse acoustic observatory (maintained by The Whale Museum in collaboration with the State Park). Equipment and techniques are introduced using the docks and computer facilities provided by the Labs. After drafting their research proposal, they go to sea to test their methods, gather preliminary data, and learn to sail. In subsequent weeks, they revise their proposals, gather and analyze more data, and then return to the Labs to prepare final papers and present within a public forum.

Beam Reach students also have the opportunity to learn about and practice sustainability science. They help solve local marine environmental problems instead of just studying them. The curriculum introduces them to human impacts. They monitor their resource use aboard a 42' biodiesel-electric hybrid sailing research vessel. They report on how to reduce their impacts or the School's. And they participate in a service project that aids a local marine environmental organization. Ultimately Beam Reach is able to fully integrate the complex social, political, and scientific challenges facing the Salish Sea by providing a field-based, place-based personal research experience.

Christianne Wilhelmson

Georgia Strait Alliance

Connecting communities to a healthy Strait: the Georgia Strait online map

Abstract:

There is an indelible connection between people and the landscapes that support the ecosystems and communities in which we live. However, though 70% of British Columbians are very concerned about the region and feel it needs more protection (April 2011 poll - Organizing for Change), many residents of the region, and the communities of which they are a part, are not connecting their own actions to the negative impacts on the Strait, and therefore cannot make changes to reduce those impacts. With an increasing population, and related economic and land use changes in the Salish Sea region, the threats to Georgia Strait are increasing – and their impacts on iconic species speak to this.

The recent fate of salmon, a keystone species in the region, illustrates the problem. The marine survival of Coho salmon is declining. In 2009, we saw the crash of the Fraser River Sockeye, and despite their return in record numbers in 2010, the reasons for the crash are still unknown.

Up the food chain, the killer whale is also threatened. With increasing toxins and pollution finding their way into southern resident killer whales, they are one of the most contaminated marine mammals on the planet, and with only 85 individuals left, are endangered. Our northern resident killer whales are threatened, with approximately 200 individuals remaining.

Building on our years of successful outreach to communities in the region, in early 2011, Georgia Strait Alliance launched an online map (<http://www.mapping.uvic.ca/gsa/>), which visually represents the Strait of Georgia, the people who steward this inland sea, the creatures that make it their home and the many threats to its health. The map is interactive, engaging – with videos, links, and up to date information - and has the potential to increase networking and public engagement among those who care about these waters and increase awareness for those who want to learn more. As it grows, this map will become increasingly a reliable resource guide and directory for environmental issues in and related to the Georgia Strait, as well as a resource for action and solutions that individuals and communities can take to mitigate threats.

Our goal is that this map will educate residents wherever they live about the Strait, provide links to information to help them make sustainable changes in their activities and take action on issues of concern. The map will also provide links to strong science for community leaders to guide their decision making on coastal issues. By engaging communities along the shores of the Strait in understanding local threats that have a regional impact and by getting community leaders to make protection of the Georgia Strait a priority in their community planning, our online map will

become an important tool that will result in communities that are more engaged stewards of Georgia Strait. The result will be increased sustainability in community development in the region and a corresponding improvement in ecological health.

In this session we will give an overview of the map, including special features and potential for growth.

Stormwater: Science and management

Robert Johnston

US Navy Marine Environmental Support Office - NW

Integrated watershed and receiving water modeling is helping achieve effective water cleanup plans

R. Johnston, P. F. Wang, W. Choi, K. Richter, B. Skahill, C. May, V. Cullinan, M. Roberts, C. Erickson, S. Lawrence

Abstract:

An integrated watershed and receiving water model was developed to simulate fecal coliform (FC) fate and transport in Sinclair and Dyes Inlets, Puget Sound, WA. The integrated model consisted of a watershed model (Hydrologic Simulation Program Fortran – HSPF), an empirical fecal coliform loading model based on upstream land use and cover (LULC), and an estuarine fate and transport model, Curvilinear Hydrodynamics in Three Dimensions (CH3D), previously calibrated to match the hydrodynamics of the Inlets and modified to include FC kinetics (CH3D-FC). The integrated model was used to simulate the release, transport, and fate of FC loading from watershed pour points corresponding to stream mouths, stormwater outfalls, waste water treatment plant discharges, and shoreline drainage areas. A total of 20 simulation scenarios were run to verify model performance, assess sensitivity and uncertainty, and provide results needed to establish waste load and load allocations for the Total Maximum Daily Load (TMDL) of FC loading in Sinclair and Dyes Inlets. Model verification consisted of comparing model predictions to observed data collected during three storm events sampled in April, May, and October 2004 and observed data collected during water year 2003. The analysis also helped to identify sources of uncertainty and measure confidence in the model predictions. Under-prediction of FC concentrations where measured marine samples were higher may be due to additional sources not explicitly included in the model such as failing onsite sewage systems, wildlife, waterfowl, agricultural runoff, and/or leaking sewer infrastructure. An expansive growth buildout scenario was used to simulate future conditions to evaluate the effect of changing land use on the water quality of Northern Dyes Inlet. This was accomplished by re-programming the watershed model HSPF with the projected changes in LULC to generate future flow conditions, recalculating the FC concentrations assigned to the streams and stormwater drainage basins in watershed based on the expansive buildout scenario, and then, simulating the future loading conditions with CH3D-FC for the May 2004 storm event. The future scenario assumed that the modeling system developed to represent present conditions was also applicable to future expansive buildout and that the relationships between LULC and modeled flow and LULC and predicted FC concentrations were still valid. Model results indicated that for marine waters to meet standards, FC targets more stringent than the freshwater quality standards were needed for three streams that discharged in nearshore areas with reduced flushing. Overall, the integrated watershed-receiving water model performed very well. The integrated model was able to recreate a wide range of dynamic loading within the inlets, from large-scale storm events with high flow conditions to dry, low-flow conditions during the summer months. The integrated watershed monitoring and modeling approach to water quality management is assisting the development of management plans worthy of stakeholder acceptance, helping to achieve reductions in FC loading, and resulting in improvements to the environmental quality of the inlets.

Rex Porter

Island County Marine Resources Committee

Storm and waste water phyto treatment strategy for Salish Sea

Rex Porter, Louis Licht, Joe Hillers

Abstract:

The ecological health of many Salish Sea estuaries is threatened by storm water runoff and sewage treatment plant discharges. Coupeville Washington, located adjacent to Ebey Prairie in central Whidbey Island surrounded by Puget Sound has confirmed storm water and other non-

point pollution exceedences to state standards at discharge points into Penn Cove and Admiralty Inlet. A phyto treatment pilot swale has been installed designed to treat water runoff from 5 acres of commercial development. The 7,500 square foot swale retains approximately 50,000 gallons and then percolates through a poplar and willow root zone growing in a blended sand/silt/compost soil. The root zone is dewatered either by transpiration, infiltration or drainages via an ADS pipe wrapped in Root Guard™. Ecolotree staff developed the phyto design with local government staff members and concerned citizens. The Town of Coupeville staff built, operate, maintain, and monitor the phyto swale. It will demonstrate the straight forward and understandable concept of: "Each drop of waste water passes within an inch of a root before pipe discharge or percolation." Bi-weekly water samples are analyzed for water quality parameters that currently exceed TMDL standards in the Penn Cove estuary and at the discharge point of Ebey Prairie. Concurrently the Town is also conducting a state-funded aquifer recharge and recovery assessment for temporary storage of the waters treated by a comprehensive phyto swale system in the Coupeville area.

The next strategic task is to test the use of phytoremediation to remove pollutants and pathogens in the 35 million gallons of secondary effluent from the Town's sewage treatment plant which is now discharged into Penn Cove, a state listed '303(d) at risk water body'. A series of experimental units will be used to test the efficacy of percolation of secondary effluent through deep dense poplar and willow roots. The adsorption, entrainment, mineralization and plant uptake of pollutants will be measured on a year-round basis.

This phyto alternative is designed for year-round secondary effluent irrigation of agricultural crops in the growing season and percolation through dense poplar roots to the deep aquifer in the winter. The metered water dose will pass through the root system where specific pollutants are adsorbed, entrained, mineralized or taken into the plant at predictable rates. Collected storm water and waste water will be used to provide essential nutrients and water needed for sustainable crop production on the 2000 acre Ebey Prairie.

Essentially, rhizosphere processes will provide tertiary treatment instead of more extensive and expensive mechanical and biological processes contained in existing permitted treatment approaches.

Jim Simmonds

King County Department of Natural Resources and Parks

Watershed Modeling and In-Stream Flow and Water Quality Indicators and Targets to be used in the Development of a Stormwater Retrofit Plan for WRIA 9

Abstract:

Stormwater is one of the biggest threats to Puget Sound. This project will develop a cost estimate and prioritization plan for systematically implementing stormwater BMPs and LID techniques in previously developed areas of WRIA 9. The estimate will be based on flow and water quality data, watershed models, the EPA's SUSTAIN model (System for Urban Stormwater Treatment and Analysis INtegration), and stakeholder input. In-stream flow and water quality goals will be developed, and the combination of retrofits needed will be optimized to meet the in-stream goals at minimum cost. The study area includes the Green / Duwamish River and central Puget Sound watersheds in WRIA 9, excluding the area upstream of the Howard Hanson Dam and the City of Seattle. Planning level cost estimates for the Puget Sound basin will also be developed via extrapolation. Implementing stormwater retrofits in developed areas is prioritized in the 2020 Action Agenda. Project information may be found here:

<http://www.kingcounty.gov/environment/watersheds/green-river/stormwater-retrofit-project.aspx>.

This presentation will focus on the methods used for this project, the preliminary results of the watershed modeling activities, the selection of in-stream flow and water quality indicators, and the preliminary target setting for each indicator. Of key interest is the focus on in-stream flow indicators that are related to biological health. The project team has selected high pulse count,

high pulse range, time above 2-year mean flow, and the ratio of the 2-year peak flow to the winter base flow for use as the hydrologic indicators. In-stream targets will be developed for each of these indicators for each stream basin in WRIA 9, then the stormwater retrofits necessary to achieve these targets will be assessed.

The Salish Sea food web—From description to quantification

Claude Dykstra

International Pacific Halibut Commission

Fish Population Census and Sampling in the Strait of Juan de Fuca and Puget Sound

Abstract:

In the summer of 2011, the International Pacific Halibut Commission (IPHC) expanded its current standardized stock assessment work into the Strait of Juan de Fuca and Puget Sound. This work entailed fishing standardized gear and bait in a standardized way on a 10nmi x 10nmi spatial grid. IPHC biologists aboard the contracted research vessel inventoried catch, took biological samples, and collected oceanographic data.

Conducting research in these inside waters presented unique permitting, communication and fishing challenges, as well as unique observations. Consideration needed to be given to shipping channels, marine protected areas (under multiple jurisdictions), encounters with threatened and endangered species and communication of our activities. This presentation portrays key elements involved in conducting this work, and presents some examples of the types of data elements produced by it.

Alejandro Frid

Vancouver Aquarium

Body size relationships between lingcod and rockfish: implications for trophic cascades

Alejandro Frid, Brendan Connors

Abstract:

Body size is a fundamental influence on predator-prey relationships, particularly for gape-limited aquatic predators. Fisheries, however, skew the size structure of predatory fishes towards smaller sizes. In Howe Sound, an overexploited area within the Salish Sea, large size classes of lingcod are relatively rare. Accordingly, we hypothesized that in Howe Sound small size classes of rockfish would be vulnerable to predation risk from lingcod whereas large size classes of rockfish would occupy a body size refuge from lingcod risk. Count data collected with SCUBA-based transects indicated strong inverse relationships between counts of lingcod and small size classes of copper rockfish, suggesting that these rockfishes were under top-down control from lingcod. Inverse relationships between small size classes of quillback rockfish and lingcod had similar negative trends but were more variable and lacked statistical support, suggesting a weaker effect of lingcod risk on the local abundance of these rockfishes. In contrast to smaller rockfish, counts of large quillback and copper rockfish were either unrelated or positively related to counts of lingcod. These results are consistent with the notion that larger rockfishes occupied a size refuge from predation risk due to the local rarity of large lingcod and the gape-limited predation capacity of abundant but smaller lingcod. Our earlier work indicated that lingcod may initiate trophic cascades that are mediated by small size classes of rockfish, but our current work suggests that, in Howe Sound, large size classes of rockfish are not likely to be involved in such trophic cascades. Predator-prey relationships and the strength of trophic cascades involving lingcod and rockfish likely will differ where body sizes are less altered by fishing.

Correigh Greene

NW Fisheries Science Center

Evaluating the ecological health of Puget Sound's pelagic food web

C. Greene, C. Rice, L. Rhodes, K. Fresh, H. Daebenberger, B. Beckman, J. Hall, J. Chamberlin, P. McCollum, S. Steltzner

Abstract:

Puget Sound's pelagic food web contain many well known constituents: resident and transient marine mammals, seabirds, salmon, and forage fish. Recent observations of apparent declines in

forage fish and seabirds raise the questions: how healthy is Puget Sound's pelagic ecosystem, and how are people influencing its food web? To address these questions, we are conducting a multi-trophic level monitoring effort in multiple oceanographic basins within Puget Sound using a sampling design that will allow analysis of basin-wide differences, as well as influences of land use in catchments surrounding the sound. We sample over 80 sites distributed across six of Puget Sound's basins monthly during neap tidal cycles from April through October. At each site, we sample water column characteristics, water quality, bacteria/archaea, phytoplankton, zooplankton (including jellyfish), fish, and seabirds and marine mammals. Our design will identify structural differences in the pelagic food web across Puget Sound basins and permit explicit tests of whether measurement endpoints are sensitive to gradients in land use. Identification of biological indicators and metrics for monitoring pelagic ecosystem health are potential management tools from this project.

Shawn Larson

Seattle Aquarium

Six years of rockfish surveys in the Strait of Juan de Fuca: 2005-2010

Shawn Larson, Jeff Christiansen

Abstract:

The region in and around Cape Flattery and the Strait of Juan de Fuca is noted for its abundance and diversity of temperate marine species. From 1984 to date the Seattle Aquarium has performed annual field scientific diving in this region. Divers participating in this effort since its inception have informally observed changes in rockfish (*Sebastes* sp.) and other bottom fish abundance, composition and size class over time. While large scale reductions were rarely noted between single seasons, chronic, smaller changes were observed. These anecdotal observations, though shared with fellow researchers, were not quantified or documented on a formal basis. In an effort to fill this gap in 2005 the Seattle Aquarium began formal annual strip transect video documentation in an area just southeast of Neah Bay to record changes and track long term trends. Since 2005 stability in numbers of rockfish in these areas was evident with no significant change between years in adults observed. The only significance found was in 2006 and 2008 when there were significant increases in juvenile rockfish on reef systems. These spikes in juvenile rockfish recruitment are correlated with lower sea surface temperatures the preceding winter and spring of those years. Juvenile rockfish survival may be linked to these lower sea surface temperatures and thus may be negatively affected by increases in water temperature associated with global warming. In 2010 the aquarium added a fifth survey site just west of Neah Bay in an area that is being considered a potential site for rockfish conservation with no take allowed.

Patrick Moran

US Geological Survey

Methylmercury accumulation in the base of an estuarine food web; Sinclair Inlet, Washington

Patrick Moran, Robin A Stewart, Amy Kleckner, Jason Toft, Jeff Cordell, Anthony J Paulson

Abstract:

As part of a larger study evaluating mercury in Sinclair Inlet, WA, methylmercury (MeHg) was examined in the base of the estuary's pelagic food web. Sinclair Inlet is a shallow (<15 m), terminal arm of Puget Sound and is also the location of the Bremerton naval complex. Previous studies have indicated that the Inlet has mercury concentrations in sediment and Rockfish (*Sebastes* sp.) that are among the highest in Puget Sound. As uptake of mercury into the base of the food web is a critical bioaccumulation step, we examined seasonal and spatial variability of MeHg concentrations in zooplankton as well as MeHg content of their food (suspended particles). Methylmercury was measured in dissolved (0.45 µm filtered), particulate and composite samples of individually picked zooplankton at four sites in Sinclair Inlet every month for 1 year and at three additional sites around Puget Sound once in August 2008. Factors known to influence the bioavailability and uptake of MeHg into the base of the food web were also measured, including phytoplankton (as chlorophyll a), TSS, DOC, particulate carbon, particulate nitrogen, and their

stable isotopes. Mean zooplankton MeHg concentrations in the summer and autumn of 2008 from Sinclair Inlet generally were less than 50 ng/g dry weight and similar to those measured at other locations in Puget Sound. Large seasonal variability of chlorophyll a and zooplankton abundance were observed, with chlorophyll levels ranging from >70 µg/L in late summer to <2 µg/L in winter. Filtered methylmercury concentrations and DOC levels in the water, however, remained consistently low; the former often less than the 0.04 ng/L detection limit. Further analysis of this mercury in Sinclair Inlet, in particular to its behavior in sediments, is presented in a companion paper by Paulson et al.

Bruce Nairn

King County WTD

The role of plankton in a PCB Bioaccumulation Model for Puget Sound's Central Basin

Bruce Nairn, Jeff Stern

Abstract:

The PCB body burden in phytoplankton and zooplankton was identified as a key data gap during the development of a bioaccumulation model for the transport of polychlorinated biphenyls (PCBs) through the marine food web of the central basin of Puget Sound, WA was developed. In response to this, a limited sampling effort collected plankton samples from net tows with two mesh sizes (32, 500 µm) along with water samples. The two net mesh sizes were deployed to primarily capture phytoplankton on the finer net, and zooplankton on the larger net. PCB analysis of these samples gave total PCB concentrations of 14 – 48 pg/L in whole water samples and 500 – 17,000 pg/g in plankton samples (wet weight basis). These results were used to modify the inputs into a steady-state PCB bioaccumulation model for the Central Basin of Puget Sound. The effect of this data on the model calibration is discussed along with the implications for the relative importance of water and sediment pathways in the bioavailability of PCBs.

Ross Whippo

Friday Harbor Labs, University of Washington

Effects of the red sea urchin on benthic invertebrate communities: A link to spatial subsidies

Ross Whippo, Jeff Stern

Abstract:

Spatial subsidies are fluxes of organic material from one habitat to another and are important in many ecosystems, including the subtidal zone of the San Juan Archipelago (SJA). The red urchin (*Strongylocentrotus franciscanus*) is a ubiquitous member of the Salish Sea marine community ranging from the shallow subtidal to depths greater than 100m, and is a primary recipient of the SJA macroalgal subsidy. Despite the absence of attached algae on which to feed in the deep subtidal, red urchins are quite common in these habitats. They are able to subsist primarily on detrital seaweeds produced in the shallow photic zone, capturing these fluxes of organic material from the water column using their spines. Red urchins are also known to be strong interactors in shallow algal habitats, but very little is known about interactions between urchins and the surrounding community in the deep subtidal. These urchins are large (up to 20cm test diameter), move very little, and extensive field observations suggest that the presence of urchins dramatically alters benthic invertebrate abundance patterns. This study tested the hypothesis that red sea urchins alter benthic invertebrate community structure and abundance patterns in the deep subtidal zone. This was accomplished through the use of underwater photography pairing invertebrate communities underneath and adjacent to (control) randomly selected urchins across two sites in the San Juan Channel. Analysis revealed that sea urchins are significantly altering abundance patterns of sessile fauna in the subtidal, while effects on mobile fauna were present but less clear. The influence of urchins on sessile communities also varied widely between sampling depths. Future work will include the addition of a third sampling site and experimental trials aimed at understanding the mechanism (i.e. consumption vs. spine abrasion) by which urchins alter these communities. This study increases our ecological understanding of deep subtidal environments in the Pacific Northwest and highlights the complex, indirect pathways through which spatial subsidies may alter biological communities.

Knowledge translation and exchange: Improving ecosystem management through novel collaborations

Norma Serra

PacMARA

Marine ecosystem-based management implementation strategy roadmap

Norma Serra, Heather Coleman, Eli Enns, Melissa Evanson, Ruta Fluxgold

Abstract:

The main goal of the Marine Ecosystem-based Management (EBM) Implementation Working Group is to create a Strategy Roadmap for British Columbia that provides a basis for consistent legislation, planning, regulation, enforcement, monitoring and adaptive management. To do this, we are currently assembling the desired strategic outcomes for EBM in BC with sets of associated enabling outcomes and causal actions, drawing on processes in different phases of defining, incorporating, planning, and implementing marine EBM in BC.

Part of the Roadmap creation process is vetting the draft through a review process, including presenting the Working Group's intentions and progress at key workshops and conferences (e.g., the Salish Sea Ecosystem Conference). This will help the group link the map to ongoing processes in various stages of marine EBM definition, framework design, implementation, etc., and entice signatories to acknowledge support of the document. The Roadmap is intended to be interactive, in that outcomes will be clickable for more information and examples of implementation. The group also intends to link the Roadmap with a position paper to increase public digestibility (and thus political pressure), and provide a list of recommendations to operationalize EBM in a fair and just way on multiple scales.

Habitat restoration in the Salish Sea: Headwaters to marine waters

Jeffrey Cordell

University of Washington

Initial responses by juvenile salmon and invertebrates in a restored floodplain on Hansen Creek, WA

L.A. Stamatiou, J.R. Cordell, J. Toft, L. Rich, C. Gourley, L. Hainey

Abstract:

The Hansen Creek Restoration Project was created in 2009-2010 with the goal of recovering lower elevation freshwater floodplain functions recognized as essential to juvenile salmonids, by converting 140 acres of isolated floodplain into 53 acres of alluvial fan and 87 acres of forested flow-through wetlands. Rivers with intact floodplain connections are important to many salmonids during their freshwater residence, offering refugia during periods of high flow as well as potential energy subsidies from allochthonous inputs and emergent marsh and terrestrial riparian invertebrate production. To quantify the developing potential of the Hansen Creek project to provide prey resources for juvenile salmonids we measured the temporal and spatial abundance and composition of terrestrial invertebrates and aquatic prey resources at the site. We also collected diets from the two dominant salmonids in the creek, juvenile Coho Salmon (*Oncorhynchus kisutch*) and Steelhead Trout (*O. mykiss*), in order to relate the invertebrate data with the prey being selected. Diet and invertebrate samples were collected monthly within 3 areas of the project area, and in one reference area outside the project, March through August 2011. Also, salmonid abundances and diets were sampled during periodic seasonal flooding that occurred on the restored floodplain. Diets of both Steelhead Trout and Coho Salmon consisted of aquatic drift, terrestrial insects, and benthic prey items. In general, higher instantaneous rations, a measure of feeding intensity, were recorded from diets collected during periodic inundation events than during regular monthly in-channel sampling. Terrestrial insect productivity peaked in late summer, July and August. Despite relatively warm water temperatures and decreased visibility due to high turbidity, the floodplain appeared to provide favorable feeding opportunities to salmonids, likely due to greater availability of drift and emergent insect prey. These results will contribute to our knowledge about the benefits to salmon of re-connecting previously isolated floodplain habitats.

Chris Gourley

Upper Skagit Indian Tribe

Hansen Creek: Early Habitat Formation in a Restoring Floodplain

Chris Gourley, Lauren Rich, Lisa Hainey

Abstract:

In 2009 construction began to restore vital wetland and alluvial fan habitat along 2 reaches of Hansen Creek, a tributary to the Skagit River in central Skagit County, Washington. This freshwater floodplain restoration encompasses 140 acres and boasts a 1.2 mile perimeter boundary trail. The goals of the project were to:

- improve salmon habitat (both in-stream and riparian)
 - improve stream flows and water quality, and
 - reduce downstream rural agricultural flooding.
- These goals will be achieved through restoration of the hydro-geomorphic floodplain processes and native freshwater floodplain vegetation.

Downstream flood reduction was successful from the start in the 2009-2010 and 2010-2011 wet seasons. Agricultural interests that had disbelieved the science behind the restoration are now

collaborating on needed additional restoration plans.

Initial monitoring and site observations suggest considerable improvements have already occurred in habitat restoration. Along with the hydrogeomorphic changes, and the fish and food web initial responses covered in two other posters, this poster presents the early results on key metrics for habitat restoration. They include biological complexity of the restoration habitat, with vegetation types and cover, in-stream wood quantity, channel developments, wetland holding capacity and other species utilization.

Early avulsion of the historic, straightened and diked 1000 meter mainstem has increased stream lengths several-fold. High flow rain events in the first 2 years of restoration transported sufficient bedload to avulse the mainstem into constructed channels that were not yet adequately established with vegetation. Hansen Creek has formed new, longer and wider channels in the fan reach, increasing stream length and sinuosity along with extensive anabranching through the wetland reach. Channel developments have been tracked, as well as the wetland inundation levels related to holding capacity and off channel flood refugia. Roughly 105,000 plants (33 species), were installed during project construction. The sheer quantity of installed plants and the size of the restoration area were key in determining the most feasible protocol for monitoring, including quadrats of percent cover and species diversity. Plots were set along transects and on channel edges to best capture important habitat information. Over 40% of plants observed were naturally recruited native vegetation and less than 10% of observed cover was invasive plant species. Water quality impairments include frequent high turbidity in precipitation events and high temperatures in the dry season. Until canopy formation, vegetative stabilization, and channel gravel sorting advances, water quality will be impacted. According to large woody debris (LWD) surveys conducted within the project, the addition of over 1300 logs was insufficient to mimic a natural stream environment in the North Cascade foothills. LWD recruitment had been reduced in the system due to the historic agricultural land use, dredging, impaired upstream riparian habitat, and transport restrictions. Despite the early restoration shortcomings that may be characteristic of initiating habitats, the site is attracting attention from raptors, migratory waterfowl and songbirds, amphibians, beaver and elk. Initial habitats are beginning to develop and establish while species are maximizing use of the site.

Lisa Kaufmann

Washington State Department of Natural Resources

Secret Harbor estuary restoration

Lisa Kaufmann, Christine Woodward, Todd Woodard

Abstract:

This poster session will highlight the planned restoration and monitoring of a continuum of 28 acres of estuarine, riverine, and palustrine wetlands and adjacent upland habitats within Secret Harbor which is located within Washington DNR's Cypress Island Natural Resource Conservation Area (NRCA) and Aquatic Reserve.

Historic land clearing, ditch and pond creation, and the diking of the estuary have altered the hydrologic functions and connectivity of the area. The site, however, is surrounded by functioning forests all within the bounds of the NRCA which provide the ground and surface water flow to the area. The project will transform the site from one of previous agricultural and homestead features with disconnected hydrologic functions to naturally connected systems linking upland forests to lowland freshwater streams, marsh and wetlands with the Secret Harbor estuary.

DNR and the Samish Tribe are collaborating on the monitoring components of the project to allow for at least five years of pre and post-construction data collection. The site is protected from development, but receives inputs from nearby populations of Anacortes, Guemes Island, and surrounding communities. Restoration of saltmarsh habitat in a protected area will allow for future studies on carbon sequestration and climate change mitigation. The restoration project will allow

for upland migration of estuarine habitats in anticipation of sea level rise. Our monitoring efforts will provide data useful to describe the rate of change in habitat conditions over time.

Andrea MacLennan

Coastal Geologic Services, Inc

Feeder bluffs and shoreline armoring: Spatial and temporal analysis and implications of impounded sediment supply

Andrea MacLennan, Jim Johannessen

Abstract:

Coastal geomorphic processes drive and sustain nearshore ecosystem structure and valuable habitat functions, goods and services. Eroding bluffs (commonly referred to as “feeder bluffs”) supply the majority of sediment to Puget Sound littoral or net shore-drift cells, replacing sediment that is continuously transported to maintain down-drift habitats such as spits and pocket estuaries.

CGS has developed and applied field-based, mapping criteria that documents the current geomorphic conditions within each drift cell. This mapping typology has been applied to over 1200 miles of Puget Sound shoreline since 1999. CGS has researched and mapped the historic geomorphic shoretypes of modified shores of close to 700 miles. The historic geomorphic mapping approach measures the level of impairment to coastal geomorphic processes and the relative quality of historic sediment sources. By comparing current and historic conditions mapping, the level of intactness/degradation of nearshore sediment supply can be quantified within a given drift cell or larger geographic area.

Results can also be used to highlight optimal bluffs to restore and conserve as nearshore sediment sources. Where bluff processes cannot realistically be restored, this method can help to identify areas ideal for enhancement efforts such as augmenting sediment supply with beach nourishment. A number of bulkhead removal and feeder bluff conservation projects are in the process now.

This presentation will summarize mapping results at the Soundwide scale, highlighting results from San Juan and Clallam Counties, which were most recently mapped in 2010-11. Historic analysis of sediment supply will also be presented from approximately 200 drift cells in the region. This data documents the regional scale and magnitude of sediment supply loss, which is often overlooked due to the ubiquitous nature of bluffs in the region.

The impact of armored feeder bluffs was explored through shore change mapping and GIS analysis to document coastal landform change within 2 drift cells on Bainbridge Island. Both drift cells had incurred 80% (or more) loss of sediment supply based on results of CGS mapping. Results of this analysis documented upper beach loss and shoreform migration within the two cells. Together these data begin to document the link between coastal processes, feeder bluffs, shoreline armoring and upper beach habitat loss in the Puget Sound region.

Jack Minard

Tsolum River Restoration Society

The Tsolum River Challenge: Restoring an ecosystem under today's constraints

Jack Minard, Kathy Campbell

Abstract:

In 1989 Kathy Campbell began analysing water samples from headwaters of the Tsolum River as a DFO Fisheries Technician.

Over 20 years after the mine site was closed and the community and DFO were just beginning to understand what the effect of copper leachate may be having on salmon in the Tsolum.

She watched coho fry die within 24 hours in the toxic zones and took samples at the mine site that registered as 3, as acidic as vinegar....

The levels were high, the fish were not returning and the copper just kept leaching out of an abandoned mine that no one was willing to take full responsibility for.

When she returned from teaching and community outreach work in Thailand (a whole other partnership building and restoration story), Kathy became the first Coordinator of the Tsolum River Task Force and began the work that sparked the establishment of the Tsolum River Restoration Society.

Kathy has interviewed many of the people who have put this partnership together and who have given years of their lives to returning the Tsolum to Health and Productivity.

She is presently a Director of the Society, and an "in the field volunteer" working hands on in restoring the river.

This story is about all of us 200 or more who have worked together over the past 2 decades to bring the Tsolum back to life.

None of us could have done this alone, but all of us did this together.

John Lenth

Herrera Environmental Consultants

Hansen Creek: Hydrogeomorphic changes of a re-activated alluvial fan

Ian Mostrenko, Christina Avolio, Lauren Rich, Chris Brummer, Kris Lepine, Jose Carrasquero

Abstract:

The Upper Skagit Indian Tribe partnered with Skagit County to restore a one-mile reach of Hansen Creek (tributary to the Skagit River) and 140 acres of alluvial fan floodplain and adjacent wetlands. The project site is located east of the City of Sedro-Woolley, Washington at the transition between Hansen Creek's steep headwaters and an historical alluvial fan and extensive wetland at the edge of the Skagit River floodplain. Levee construction and Hansen Creek channelization since the 1930s, combined with land cover changes at the site and in the upper watershed, altered the geomorphic and hydrologic regime of the creek and floodplain. Channel confinement and straightening through the alluvial fan completely disconnected the channel from the floodplain and shifted sediment deposition to the downstream reach, resulting in frequent flooding and regular dredging by the local community to maintain flood conveyance. These historical alterations simplified the physical habitat and restricted salmonid use to the mainstem channel. In the last decade, the decline of Chinook and Coho salmon returns reached a critical state, with less than a dozen Chinook returning some years.

Project goals include 1) rehabilitating alluvial fan function and sediment transport and deposition characteristics, 2) improving salmonid habitat, and 3) restoring hydrologic connectivity between Hansen Creek, its floodplain, and the adjacent wetlands. Project construction began in 2009 and was completed in 2010. It included partial levee removal and setback, constructing one mile of new alluvial fan distributary channels, constructing over two network miles of wetland channels, installing over 1,300 key logs in 302 floodplain roughening structures, and planting approximately 105,000 trees, shrubs, live stakes, and emergent plugs.

The project has already experienced a significant number of sediment rich flood events. Immediate and rapid sediment deposition and channel evolution in the alluvial fan was observed in the first year. Downstream monitoring data demonstrated no bedload deposition, eliminating the need for downstream dredging. This poster identifies key design components, performance, and constructed alluvial fan evolution from a geomorphic perspective. Design alternatives included several options to activate the fan over time. The selected option includes a passive

activation approach, providing complex channel roughness to promote aggradation and forcing the channel to avulse into the alluvial fan floodplain in strategic locations with a higher concentration of engineered wood structures. This option was to allow the floodplain vegetation a few years to establish. The high sediment load events forced the avulsion into the floodplain earlier than planned. Positive results included the formation of a very complex meandering channel network in and around the engineered log structures within the first year, with riffle-pool habitat and complex gravel bars far superior to engineered and constructed features. The drawback was creating new aquatic areas that lacked protection from a mature riparian canopy. The rapid response also resulted in losing many plantings and raised concerns over short-term water quality during the receding limb of the flood hydrographs. This poster presents the temporal tradeoffs associated with physical habitat and geomorphic changes induced by a re-activated alluvial fan.

Paul Schlenger

Anchor QEA, LLC

Investigation of juvenile salmon distributions among the large piers along the Elliott Bay Seawall
Paul Schlenger, Jim Shannon, Merri Martz, Sandy Gurkewitz, and Emily Pizzichemi

Abstract:

The City of Seattle is currently underway with the planning and designing of a replacement of the 7,000 foot long seawall supporting the downtown waterfront. The seawall and associated urbanization of downtown Seattle have markedly altered the aquatic habitat conditions along the waterfront. Specifically, the seawall was built waterward of the historic shoreline and nearly eliminates all shallow water habitats. The seawall is also lined by a series of large historic piers which extend far out into the water and create large shaded areas where no direct sunlight reaches the water. The waterfront is also located within five miles of two major river systems which support populations of salmon that out-migrate as juveniles and utilize the marine nearshore shorelines to different extents depending on species. Chinook salmon are produced in both river systems and the Puget Sound populations are listed as threatened under the federal Endangered Species Act. Chinook are also one of the two salmon species that most extensively use shoreline marine nearshore habitats after out migrating from their natal rivers. Previous studies have shown that juvenile salmon migrating along the marine shoreline tend to avoid shaded areas when there is a sharp light-to-dark contrast. This avoidance of shaded areas is documented to result in several hours of delay to the juvenile salmon's migration. These studies are based on fish observations around single large pier structures, but no studies have documented juvenile salmon movements and potential delays along a waterfront with a series of large overwater structures. In order to better inform the design of restoration elements being considered as part of the seawall replacement, the City of Seattle is conducting a fish study to investigate juvenile salmon distributions and movements along the seawall. The study is using snorkel and land-based visual techniques to monitor juvenile salmon and other fishes near the seawall between February and September 2011. We are also conducting light monitoring to correlate light levels with fish behavior. This poster will present the findings of the investigation.

Karen Topelko

BC Parks, Ministry of Environment

A transboundary pilot project to remove lost and abandoned fishing gear in the Canadian Salish Sea

Karen Topelko, Manish Om Prakash, Joan Drinkwin, Jeff June, Tomas Tomascik, Wayne Bourque

Abstract:

Lost, discarded, or abandoned fishing lines, nets, pots, and other gear associated with commercial and recreational fishing can unintentionally kill hundreds of thousands of marine animals annually. Derelict fishing gear can also damage marine habitat, pose a hazard for boaters by entangling propellers and anchors, and endanger humans, particularly divers. The impacts of derelict gear are well known in Puget Sound, where an aggressive derelict fishing gear

reporting and removal program has been in place for almost a decade. In other parts of the Salish Sea however, both historical and ongoing debris accumulation is unknown. This presentation reports on the results of a small, multi-agency effort to locate, recover, and properly dispose of derelict crab pots in the Canadian waters of the Boundary Bay Marine Wildlife Area. Approximately 5.58 km² was surveyed along 60.87 km of transects, and 1,829 potential derelict crab pots were identified. Divers removed a total of 214 pots over four days. Over 110 animals (22 dead) were found in the pots. The project also included the removal of a known derelict seine net that became snagged over a rocky pinnacle off North Pender Island in Swanson Channel. The net was estimated to cover 26,000 m² of seabed. Approximately 50% of the net was removed, and a total of 1,799 live and dead animals were recovered. Results suggest that the impact of derelict fishing gear in BC may be significant. The derelict crab pot target density found is nearly three times higher than derelict crab pot densities recorded by the Northwest Straits Initiative in U.S. waters of the Salish Sea. A long-term, well-funded program is needed in Canada to remove legacy gear and to prevent the accumulation of new gear.

Jonathan Waggoner

Coastal Geologic Services

Beach restoration at Seahurst Park: 5 Years of project success

Jonathan Waggoner, Jim Johannessen

Abstract:

Seahurst Park in Burien, WA is one of the largest shoreline parks in the Puget Sound. The park consists of nearly 1 miles of shoreline situated below steep, forested bluffs with two perennial streams. Extensive shoreline modifications had been put in place in the late 1960s and early 1970s. Armoring in the form of concrete bulkheads, perched beaches held by rock revetments, gabion baskets and rock groins extended for the majority of the shoreline. Much of the park backshore had been converted to upland use through extensive filling.

With relatively undeveloped adjacent beaches and copious potential nearshore habitat Seahurst Park was identified as providing a great opportunity for nearshore restoration. With a great deal of public input a park restoration master plan was established, and the southern half of the park was selected for Phase I of the restoration effort. Constructing of a final restoration design took place in 2004. Restoration involved removal of the rock and gabion baskets and addition of a base layer of coarse sediment with a layer of pebbly coarse sand.

Annual Physical beach monitoring was included in the project not only to track project performance, but to be used to inform other restoration projects in the Puget Sound. Five year of monitoring have been completed to date, and are covered in this presentation. Additional monitoring included benthic invertebrate sampling, forage fish sampling, and park user surveys.

Physical beach monitoring consisted of a topographic survey of the project site and adjacent beach from the base of the bluff down to MLLW and sediment sampling for grain size analysis. Beach profiles, surface change analysis, and sediment samples were examined to assess project performance. Beach profiles and surface change analysis have shown that the project has exceeded expectations for stability and longevity. Sediment samples relate the story of sediment sorting and closely match the reference beach, indicating the nourishment sediment was a good match to the conditions at the site.

Connecting citizen science to research, monitoring and management

Carrigail Abanes & Marissa Wyll

Everett Community College and Ocean Research College Academy

Metacognitive approaches to citizen science research on a nesting osprey population on Snohomish River.

Carrigail Abanes, Marissa Wyll

Abstract:

Students at the Ocean Research College Academy (ORCA) developed a study to assess the changes in attitude and knowledge of community members as a result of participating in a scientific research project. The ORCA students predicted that the participants would gain a greater appreciation of science as a result of involvement in an investigation on a nesting population of osprey. The question arose as a result of their enrollment with ORCA, an interdisciplinary early-college program that provides high school students with the opportunity to participate in inquiry research in the local marine environment. ORCA students conduct independent research and collaborative citizen-science projects gathering scientific data in their local community to gain a better understanding of nature, science, and scientific research. ORCA students questioned whether community members would demonstrate similar gains by using the format of a pre- and post-questionnaire that employed a Likert scale to capture the attitudinal and scholastic changes of participants as a result of their involvement with the osprey research. Participants met at the Everett waterfront, an area that hosts one of the greatest abundances of nesting osprey in the northwest region of the United States. After a brief training at the site, the participants observed osprey to learn about their abundance and behavioral differences as a function of tide height. The ORCA students hoped that participants would gain a greater understanding of scientific processes and the natural world as a result of their involvement. In addition, the ORCA students' experience with the project helped them become more metacognitive about their own role as citizen scientists with ORCA and how to inculcate new Cohorts of ORCA students to scientific ways of thinking and conducting research.

Susan Berta

Orca Network

Networks 'R Us: How to involve and inspire citizens in preserving the diverse habitats and inhabitants of the Salish Sea

Abstract:

The use of volunteer citizen monitoring has increased over the past two decades due to public interest in the ecosystem and a desire to be a part of the solution to the issues facing the Salish Sea. Scientists and agencies have become more receptive to using data collected by citizen volunteers, and new ways of collecting and sharing data including use of email, websites, and social media has facilitated this cooperative effort.

This presentation focuses on the use of citizen volunteers in two marine mammal programs that provide valuable information to researchers and agencies involved in Orca Recovery and marine mammal health in the Salish Sea:

1. Orca Network's Whale Sighting Network
2. Central Puget Sound Marine Mammal Stranding Network

The Whale Sighting Network addresses current issues surrounding the decline of endangered Southern Resident orcas by increasing data on their travels in inland and coastal waters, educating the public, and providing a valuable networking and communication system shared by researchers, governments, NGO's, educators and citizens.

The Network provides a forum involving a diverse audience, offering opportunities for the public to collect whale sightings valuable to researchers and agencies working toward the recovery of Southern Resident orcas, and species such as gray and humpback whales. The Network improves communication between researchers, government and the public, while raising awareness about whales and related issues. Learning about these issues through the eyes of an orca reaches out to those beyond “the choir,” inspiring and motivating people to take action.

As people become educated through the network, an ever-increasing amount of data is collected; and the public and researchers share information, learning together about issues affecting whales and how to best address them.

The project is a unique way to reach out and involve people, creating a connection to this charismatic species, and offering a novel approach to face the challenging issues which threaten the fragile Southern Resident Orca Community.

The Central Puget Sound Marine Mammal Stranding Network (CPSMMSN) is officially recognized by NOAA Fisheries as the primary responder for Island and Skagit counties, and portions of Snohomish County (a total of over 400 miles of shoreline), providing stranding response, sample and specimen collection, and necropsy.

CPSMMSN is responding to an increasing number of strandings each year in this key geographic area with diverse marine mammal populations and increasing human population growth.

Staff and volunteers assess and document the condition of live and dead stranded marine mammals, and collect samples, specimens, and perform necropsies on fresh dead or priority species to detect emerging diseases, contaminants, and human interaction. Specimens are also used for educational presentation and display, such as the articulation of a gray whale, Dall’s porpoise, and Steller sea lion skeleton.

This program is possible only because of our cadre of over 160 trained volunteers who assist with all aspects of the stranding network. The general public also plays an important role by reporting stranded marine mammals or seal pups on the beach to CPSMMSN.

For more information visit www.orcanetwork.org or the Orca Network Facebook Page.

Ramona C. de Graaf

Coastal Conservation Institute of British Columbia

The British Columbia Shore Spawners Alliance – Citizen’s science protecting critical shoreline fish

Ramona C. de Graaf, Judy Williams, Dianne Sanford

Abstract:

In 2008, the Coastal Conservation Institute of British Columbia, Wreck Beach Preservation Society and Emerald Sea Biological launched the BC Shore Spawners Alliance the first Province-wide outreach program to inform communities about critical nearshore fish habitats along our shorelines: 1) intertidal forage fish spawning habitats (surf smelt and Pacific sand lance) and 2) marine riparian buffers. I will present an overview of the development of the program, training standards, and research results to date.

Cited as the cornerstone of many marine food webs, forage fish connect zooplankton to a host of secondary predators (e.g. seabirds, salmon, lingcod and rockfish) that become prey for larger animals (e.g. pinnipeds and whales) and form commercial fisheries.

Surf smelt, capelin and Pacific sand lance use certain intertidal sandy-gravel beaches for spawn deposition/incubation, high on shorelines near the log line. This narrow ribbon of habitat is among the most finite habitat in our province. Their unique spawning behaviour puts these beach spawners directly in a zone vulnerable to shoreline use and modification. Marine riparian

vegetation is an important source of “windfall” insects for migratory juvenile salmon.

Protection of these spawning habitats is provided under Section 35 of the Fisheries Act, although no BC government surveys have been undertaken to inventory these critical habitats. Adding to this challenge, the need to protect these beaches and their ecological value is largely unrecognized. The goal of the BC Shore Spawners Alliance is to address these issues through science, education, community stewardship, and habitat restoration.

The BC Shore Spawners Alliance is a Provincial network of volunteer biologists, First Nations, scientists, students, stewards, and government agencies from Northern British Columbia to Puget Sound.

Kathy Heise

Cetacean Research Lab, Vancouver Aquarium

Pacific white-sided dolphins: how the public has helped to increase our understanding of BC

Kathy Heise, Heather Lord, Caitlin Birdsall, Lance Barrett-Lennard

Abstract:

Prior to the late 1970s, most ‘gray’ literature described Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) as a species that generally travelled offshore, feeding primarily on mesopelagic fish and squid, and that was relatively rare in the coastal waters of British Columbia. A survey of mariners (tug-boat operators, commercial fishers, ferry crew etc.) indicated that there has been an ever increasing rate of sightings of Pacific white-sided dolphins along the inshore waters of the British Columbia coast since the mid-1980s (Heise 1996). However, historical evidence suggests that this was not the first time dolphins had appeared on the coast. Evidence from midden sites in both the Salish Sea and areas further north indicated that they had previously been a food source for First Nations.

The British Columbia Cetacean Sightings Network (www.wildwhales.org) has been maintaining records of dolphin sightings collected opportunistically by volunteers throughout BC coastal waters since the late 1950s. Prior to 1980 there were 74 reported sightings along the entire coast. From 1980-1989 there were 101 sightings, and from 1990-1999 this number increased by an order of magnitude to 1063 sightings. This number almost doubled to 1975 sightings between 2000 and 2009, and from 2010 to April 2011 there were at least 605 sightings along the BC coast. Of particular note is the fact that in 2010 alone, there were 197 sightings in the Salish Sea, including a significant proportion in Howe Sound. This trend appears to be continuing in 2011, and in May 2011 this included three sightings of groups of dolphins travelling inshore of the First Narrows bridge leading into Burrard Inlet in Vancouver harbour.

Herein we discuss the value of engaging citizens in contributing to opportunistic data collection programs, and how such data can contribute to increasing our understanding of a species for which relatively little data exists. We also discuss reasons that may help to explain the appearance/ return? of Pacific white-sided dolphins to relatively new areas of the coast such as the Salish Sea.

Justin Longo

Centre for Global Studies, University of Victoria

Digital Fishers: Data from the deep, judgment from the crowd, wisdom from the process

Darryl Bidulock, Tim Boesenkool, Rod Dobell, Eric Guillemot, Maia Hoeberechts, Murray Leslie, Tony Lin, Justin Longo, Marjolaine Matabos, Dwight Owens, Benoit Pirenne, Ronald Schouten, Jodie Walsh

Abstract:

Digital Fishers represents a joint project of NEPTUNE Canada and the Centre for Global Studies (both at the University of Victoria, with additional support from eBriefings.ca) to use the power of crowd sourcing to help filter and annotate the large volume of video data being collected from the

NEPTUNE Canada seafloor observatory using a game-like interface. As this video data is not currently amenable to machine processing, the guiding position of the Digital Fishers project is that - in the absence of an alternative - this volume of video data will eventually overwhelm the capacities of the NEPTUNE Canada scientific community. A Digital Fishers crowd sourcing option provides the possibility of using the Internet-based volunteer efforts of a large number of non-expert participants as a first-pass alternative to machine processing or analysis by experts. The ultimate objective of the Digital Fishers project is to provide a platform for web enable science-oriented crowd sourcing which can assist scientists in managing the firehose of video-data emanating from the NEPTUNE Canada seafloor observatory.

This table presentation at the data fair will include three computer workstations in which visitors will be able to "play" the Digital Fishers "game" by viewing video from the NEPTUNE Canada seafloor observatory and "tagging" the video for the benefit of marine scientists and other users of the NEPTUNE Canada database.

Alex Rinaldi

Ocean Research College Academy at Everett Community College
Eutrophication in the Possession Sound

Abstract:

Pollution in the Puget Sound area caused by local farms, storm drains, and combined sewer outfalls (CSOs) is accelerating the rate at which anthropogenic eutrophication impacts the estuarine ecosystem. As a result, problematic algal blooms contaminate large areas of water, leading to light attenuation, loss of submerged aqua vegetation, fish kills, and in some cases paralytic shellfish poisoning (PSP). These areas of high biological oxygen demand (BOD) are found to be more susceptible to nutrient inputs than other mesotrophic areas. The susceptibility of the water is dependent on a number of factors including low tidal exchange and level of freshwater dilution. Point and non-point source sampling in the Puget Sound correlate nutrient input to vulnerability of the water. Using a Niskin bottle, both surface and halocline samples were gathered and analyzed for phosphates, nitrates, nitrites, and ammonia. In particular, nitrates will be targeted, as they are among the most abundant and detrimental to the marine environment. Concentrations of nitrates as high as 340.5 mg/l have been identified at the surface of the Mount Baker Terminal (MBT) in the North East arm of the Whidbey Basin in the Puget Sound. Closer to the mouth of the Snohomish River nitrates were found as low as 26.5 mg/l, indicating that water tolerance to outside pollution is influenced by location, along with other factors. By pinpointing the most susceptible areas, pollution can be reduced, particularly in those regions, minimizing the issue with little effort. The six-month data collection and compilation by Ocean Research College Academy (ORCA) early-college students at Everett Community College has brought an increasing awareness to the public about such issues as eutrophication and the impact on the marine ecosystem.

Paul Russel

Ocean Research College Academy
Effect of precipitation over the Snohomish River Watershed on salinity in Whidbey Basin
Paul Russel, Aseel Alsamarraie

Abstract:

The salinity of estuarine systems is commonly understood to be affected by many factors, including tides, currents, and weather systems. This study focused on the effects of precipitation and river input from the Snohomish River Basin on daily surface salinity in the north-eastern arm of the Whidbey Basin in Puget Sound. Citizen science student researchers questioned what amount of precipitation over the Snohomish River watershed was required to cause a change in the surface salinity. It was hypothesized that it would take large (over .25 inches/day) amounts of rainfall in order for any significant effect on salinity to be seen. Data for salinity was taken from a near-surface (2-3m) probe established as part of a joint partnership between the Port of Everett, the Washington State Department of Ecology, and the Ocean Research College Academy in

2009. The probe is a Seabird 19 CTD that is deployed on a Port of Everett pier and transmits data every 15 minutes (ftp://ecy.wa.gov/eap/Mooring_Raw/Puget_Sound/Mukilteo/). Data for rainfall was taken from <http://www.beautifulseattle.com/mthsum.asp>, while river outflow data was collected from a probe in the Snohomish River near the Quil Ceda Village and recorded at <http://waterdata.usgs.gov/WA/nwis/current/?type=flow>. When the data were compared, the hypothesis was shown to be supported, as rainfall of .25 inches/day or more would raise the level of the Snohomish River enough to effect salinity in the north-eastern arm of Whidbey Basin.

Scott Veirs

Beam Reach Marine Science and Sustainability School

Listening for orcas with the Salish Sea Hydrophone Network

Scott Veirs, Val Veirs, Jason Wood, Chrissy McLean, Jeff Hogan, Candice Emmons

Abstract:

The Salish Sea Hydrophone Network has enabled citizen scientists to participate in the study and management of the endangered southern resident killer whales (SRKW). Hydrophone in five locations within the critical habitat of the orcas provide live audio streams that can be monitored or recorded using free software like iTunes. Because the SRKWs are vocal about 75% of the time and audible at ranges of 5-10km, citizens can gather presence/absence data about the orcas by reporting their detections by email, an web-based form, or by logging their listening sessions in a Google spreadsheet. Volunteer listeners have affected the management of SRKWs by reporting anomalous underwater noise sources, including U.S. Navy mid-frequency sonar, submarine-ship communications, pile driving, and commercial ship noise. Improved mapping and query mechanisms will enable citizen scientists to analyze historical SRKW location data, helping to understand migratory patterns. New web-based tools will allow listeners to learn to recognize common underwater sounds, search a database of detections, and classify the sound samples after passing a training procedure.

Brianne Ward

Ocean Research College Academy

Temporal plankton abundance in Possession Sound

Brianne Ward, Bryan Jacobson

Abstract:

Plankton is crucial to the biogeochemical cycle of the planet to recycle and reuse carbon in the atmosphere. Recent research has focused on environmental factors influencing plankton abundance within Possession Sound, located in the northeast arm of the Whidbey Basin inside Puget Sound. This research project was designed to observe the changing temporal abundance of plankton, taking into consideration the depth of the halocline. To gather plankton data in Possession Sound, citizen scientists from the Ocean Research College Academy (ORCA) counted samples that were collected on monthly research cruises beginning in September of 2004, where basic water quality parameters were taken at 4 different locations. Plankton sampling was done using a 1.7 Liter Niskin bottle water sample decanted through a 20 micrometer plankton net. Data collected shows the predicted abundance in plankton and species diversity during the spring and summer blooming months, as opposed to the reduced amount of plankton during the fall and winter months. With the data previously acquired and the methods used, plankton sampling will continue to occur twice monthly throughout the remainder of the year; gathering quantitative data concerning the diversity and abundance of plankton species in Possession Sound. Student researchers hypothesize that plankton concentrate in the stratified layers of this estuarine system, and as the halocline depth changes, so too will the plankton abundance.

www.everettcc.edu/orca

Environmental challenges to safe shellfish harvest and aquaculture

Jolene Brokenshire

University of Washington - Tacoma

Determining flow bias in the use of passive tube traps to study Geoduck larval transport in situ

Jolene Brokenshire, Bonnie J. Becker, Michael Behrens, Jamie Sloan

Abstract:

Our ability to study the dispersal of marine larval invertebrates has been limited to the ineffectiveness of current sampling, sorting, and identification methods. We are currently using time integrated passive tube traps to study Pacific geoduck (*Panopea generosa*) larvae in Quartermaster Harbor, WA. There is concern that these traps are biased by the amount of water flow moving past them. To test for this bias, we conducted experiments in the lab and in situ. Different concentrations of cultured larvae were placed in large columns with traps deployed in them. The concentrations in the traps were highly correlated to the known column concentrations. In the field, we deployed an inexpensive water flow monitoring system, “pucks” made out of dental chalk, that were used during larval sampling to provide a relative water velocity. The “puck” monitoring system was compared with larval data counts found from the traps using a new molecular identification tool, Fluorescent In Situ Hybridization with Cell Sorting (FISH-CS). This tool enabled us to identify the species of the sampled bivalve larvae and automated the sorting process. We found that the relative water flow and larvae captured were not correlated, indicating that the traps are recording larval abundance and not just flow differences. Our trapping and FISH-CS approach can be used more broadly and help create a greater understanding of the larval distribution of Pacific geoduck and other bivalve larval across our region.

Tim Determan

Washington State Department of Health, Office of Shellfish and Water Protection

Reduced fecal pollution in Henderson Inlet: Remediation or reduced rainfall

Abstract:

Fecal pollution in Henderson Inlet decreased from “High” fecal pollution impact in 2001 to “Low” fecal pollution impact in 2009 (WDOH 2010). Remedial programs and change in rainfall patterns likely contributed to the reduction. The author used three independent analytical approaches to study fecal pollution in inner Henderson Inlet and its relationship to both short-term climate fluctuations and remedial action. The three analyses strongly confirm that fecal pollution has significantly declined. Only one of the three methods measuring fecal pollution showed a weak connection with decreasing rainfall. Remedial action is difficult to evaluate directly. Observations suggest that an upturn in rainfall in 2009 did not produce an increase in fecal pollution. By inference, remedial programs are likely the dominant factor in reduced fecal pollution in Henderson Inlet.

Sean Naman

National Marine Fisheries Service

Relative contributions of freshwater and marine inputs to shellfish diets in Puget Sound

Sean Naman, Leticia Conway-Cranos, Peter Kiffney, John Bucci, Neil Banas, Mark Plummer, Mark Strom, Rohinee Paranjpye, Krista Bartz, Mary Ruckleshaus

Abstract:

Shellfish are economically, socially and ecologically important to the Salish Sea region. They are likely to be affected by both freshwater entering nearshore habitats and inputs from marine waters. The extent to which shellfish growing areas are influenced by freshwater vs. marine sources may be a combination of natural (e.g. river flows, local marine circulation) and anthropogenic (e.g. N- loading from agriculture) processes. Our study uses stable isotope analysis ($\delta^{15}\text{N}$ and $\delta^{13}\text{C}$) to delineate nutrient sources in shellfish tissue, potential food sources and ambient water conditions. We assess the relative contribution of freshwater vs. marine inputs

in shellfish diets by examining the isotopic composition of shellfish tissue, particulate organic matter (POM) and primary producers in economically important shellfish growing areas downstream of three Puget Sound watersheds, the Dosewallips, the Hamma Hamma and the Samish Rivers. Dietary end members examined include organic material entering from freshwater, marsh plants, eelgrass and benthic algae collected from each growing area and ocean derived phytoplankton. Because shellfish bed closures are driven by excessive quantities of both freshwater and marine derived nutrients and pathogens, understanding the relative influence of marine and watershed inputs to shellfish populations can be useful to prioritize actions to minimize future closure events.

Yvonne Shevalier

University of Washington, Tacoma

Determining geoduck larval distribution relative to oceanographic physical parameters in Quartermaster Harbor, Puget Sound, Washington (QMH)

Yvonne Shevalier, Brenda Lemay, Bonnie Becker, Michael Behrens, Christine Henzler, Elizabeth Hoaglund

Abstract:

Marine invertebrate larvae are notoriously difficult to study in the field due to their microscopic size. Bivalve larvae are particularly difficult to identify to species, as many look nearly identical during their pelagic stages. To gain a better understanding of larval distribution of the Pacific geoduck clam (*Panopea generosa*), our group integrated a new molecular identification tool, Fluorescent In Situ Hybridization with Cell Sorting (FISH-CS), with a trapping approach to target geoduck larvae. We deployed and retrieved passive larval tube traps weekly from March through July of 2010 to take time-integrated plankton samples in Quartermaster Harbor, WA. Oceanographic data was concurrently collected via CTD to identify the status of the water column at the time of retrieval. During the early spring, the water column was well-mixed; if geoduck larvae were present, we expected to find them in traps at various depths. Later in the season, the water column became more stratified and large blooms of phytoplankton were documented; we expected that larvae would also peak at this time and would be found at the thermocline. We found that larvae were present in Quartermaster Harbor throughout our sampling season, although there was a large peak of larvae above the thermocline in late May and early June, during a time of high stratification when water was warmer and fresher. Comparing oceanographic and larval data, we found depth, temperature, and salinity are all significant oceanographic variables in explaining geoduck larval distribution. Upon completion of sample analysis, we will be able to map the distribution of geoduck larvae in QMH. Resulting data can be used to build a model of regional geoduck populations, both natural and farmed, for management purposes. Some broader applications of this technique include monitoring ballast tanks for target invasive species, and creating a large-scale, multi-species larval distribution atlas.

Shayla Stagers

University of Washington Tacoma

Size frequency distribution of Geoduck in Quartermaster Harbor

Shayla Stagers, Bonnie J. Becker, Michael Behrens, Christine Henzler, Elizabeth Hoaglund, Yvonne Shevalier

Abstract:

We have determined the size frequency distribution of Pacific geoduck larvae in Quartermaster Harbor (QMH) in order to estimate the degree of larval exchange between QMH and surrounding waters. QMH was chosen as the test site because there is evidence that there is limited water exchange between it and the main basin, allowing larvae to remain there throughout their development. If there is more rapid exchange between QMH and the surrounding waters, larvae would leave the harbor during early larval stages then some would return as larger larvae that are ready to settle. In that case, we expected to find relatively high numbers of early stage larvae, a lack of larvae in intermediate stages followed by moderate numbers of later larval stages. If there is little exchange, we would predict large amounts of smaller larvae, with a moderate decline in

abundance in intermediate and larger size classes due to natural mortality. A linear model was created using a variety of mortality and growth rates to create expected size frequency distributions in either case. Geoduck larvae were sampled in QMH on a weekly basis in spring 2010 using passive larval traps. Bulk samples were then analyzed using Fluorescent In Situ Hybridization with Cell Sorting (FISH-CS) in order to identify and isolate the desired larvae from each sample. Actual larval sizes were then measured and size frequency distribution was compared to the models that were made earlier to see which scenario is more likely. We found smaller larvae throughout the sampling season, with few intermediate sized individuals. A pulse of large individuals was detected in late May and early June. These results indicate that there is a high amount of larval exchange between QMH and its surrounding waters and that the geoduck populations in QMH are not self seeding.

Science and management of eutrophication and hypoxia in the Salish Sea

Austin Higuera

Everett Community College and Ocean Research College Academy

The inverse relationship between nitrates and dissolved oxygen, corresponding with phytoplankton photosynthesis

Austin Higuera, Jared Gunderson

Abstract:

Plankton, as the world's most abundant photosynthesizing organism, has a large influence on water chemistry and marine life. Previous research indicates that during plankton blooms the absorption of nutrients and a corresponding jump in dissolved oxygen (DO) can be observed during the day. This research led to the further questions in the local estuarine system revolving around the relationship between plankton counts, tidal height, and the time of day and how they correspond with changes in dissolved oxygen and nutrients. Multiple dissolved oxygen, nutrient, and plankton samples were gathered from Mount Baker Terminal during different tide cycles and times of day. Located off of the North-eastern arm of the Whidbey Basin, students at Ocean Research College Academy (ORCA) participate in a long term citizen science monitoring project. It was hypothesized that as the sun sets at dusk, nutrient levels will rise and dissolved oxygen will decrease due to increased respiration by phytoplankton and the lack of photosynthesis. Since phytoplankton absorbs nutrients when undergoing the photosynthesis process, there will be a reverse correlation between nitrate levels and DO counts. At dawn the dissolved oxygen will begin to increase, while nitrate levels fall due to increased sunlight, leading to photosynthesis and an increase in nutrient utilization.

Julie E. Keister

University of Washington

Zooplankton distribution and species composition in relation to bottom hypoxia in Hood Canal

Julie E. Keister, Loren B. Tuttle

Abstract:

We used CTD casts and zooplankton net tows to examine the influence of seasonal bottom hypoxia on plankton distributions in lower Hood Canal, WA in spring through fall 2008. The study was conducted as part of the Hood Canal Dissolved Oxygen Program and was run concurrently with fish surveys by the Washington Department of Fish and Wildlife and the University of Washington. We surveyed the zooplankton and hydrographic conditions in July, September, and December 2008 to capture the seasonal development of hypoxia. The strength and location of bottom hypoxia varied seasonally: in July, the shallow (<50 m) regions of lower Hood Canal were hypoxic (<2 mg DO l⁻¹) while the deeper waters seaward of the Great Bend were not. By September, a moderately hypoxic mid-depth layer had developed at upper Hood Canal stations; bottom waters in the lower Canal were strongly hypoxic. By December, hypoxic conditions had relaxed; hypoxic bottom water was found only at the lower Hood Canal stations. We conducted depth-stratified, diel zooplankton sampling using closing, 200- μ m mesh, 60-cm diameter nets to examine changes in vertical and horizontal distributions of animals in relation to oxygen concentrations. From the data collected, we examined the effects of seasonally changing DO levels on the spatial distribution of the dominant zooplankton species in lower Hood Canal, as well as effects of bottom hypoxia on the diel vertical migration behavior of zooplankton. Here we will show the variability in response among species. Many species showed little evidence of an affect of hypoxic conditions, but some demonstrated avoidance of low-oxygen waters. Species composition also changed dramatically from July to December—hypoxia-tolerant species increasingly dominated the zooplankton community over the season, especially in areas where oxygen concentrations declined to <1 mg l⁻¹ and persisted through fall.

Marine survival of salmon in the Salish Sea

M. Bradley Hanson

NOAA, Northwest Fisheries Science Center

Estimates of the number of salmon consumed by southern resident killer whales in their summer range

M. Bradley Hanson, Eric J. Ward, Dawn P. Noren

Abstract:

Southern resident killer whales are a small (87) population of fish-eating killer whales that generally inhabit the inland waters of Washington and southern British Columbia during the summer months. Recent research has documented that not only are adult Chinook salmon their primary prey item but that these fish are removed from stocks returning primarily to the Fraser River. In addition, more detailed information has recently become available on the energetic requirements of these whales. The recent data on prey selection and whale energetic requirements were combined with caloric estimates of prey by species, and for Chinook by stock, in a bioenergetics model to estimate the number of salmon consumed for each species and for Chinook, each stock, during the summer. Species and stock specific estimates of consumption are influenced by the whale occurrence in the region, which typically varies from 50-80% of days, depending on the month and year. From June to September, this population was estimated to consume as many as 150,000 salmon, a substantial portion being Chinook from the Fraser River. Comparisons of the timing and estimates of recent Chinook stock levels indicate that under average return conditions prey abundance levels exceed whales' caloric needs. However, in some recent years, the number of fish consumed by killer whales from spring runs, which have experienced relatively low returns, could constitute a notable portion of those runs. The results of this bioenergetics model demonstrate that a good understanding of key predators' prey preferences and energetic requirements can aid in assessing impacts of natural mortality on prey populations.

Sayre Hodgson

Nisqually Indian Tribe

Migration and survival patterns of Nisqually River Steelhead Trout smolts

Sayre Hodgson, Christopher Ellings

Abstract:

Low run sizes of Nisqually River steelhead trout (*Oncorhynchus mykiss*) since the 1990's have led to concern about their continued viability. Despite closed fisheries and fairly good freshwater habitat condition, low escapements persist. For 3 years, outgoing steelhead smolts in the lower Nisqually River were surgically implanted with acoustic tags to track their movement patterns and early marine survival in the Salish Sea. Patterns varied between years but most of the tagged steelhead passed directly through the Nisqually estuary in less than a day. Detections along the migration to the ocean indicated a gradual decline in the number of fish detected along the route, and the majority of the tagged fish were presumed to have died at various points along the migration. The data did not indicate any specific areas of presumed higher mortality but indicated substantial mortality along the whole migration through the Salish Sea. Based on the available data from receivers along the route, most fish appeared to take directed migrations along the route but there were some cases of substantial backtracking. Of the small portion of tagged fish (4-17% annually of those detected in the estuary) that survived all the way to the Strait of Juan de Fuca, that migration took on average about 2 weeks (ranged from 1-3 weeks), with average travel speeds of about 20 km/day. These movement, migratory timing, and survival patterns provide some insight into a migration that has not previously been well studied. The results will be compared with those from other tagged steelhead from the region and used to identify future study needs.

Iris Kemp

University of Washington

The potential importance of competition between herring and juvenile Chinook salmon in Puget Sound

Iris Kemp, David A. Beauchamp, Elisabeth J. Duffy

Abstract:

Since early marine feeding and growth of Puget Sound Chinook salmon are tightly correlated with smolt to adult returns, factors such as competition that affect feeding success during this life stage could have important influences on marine survival. During the critical summer growing season, herring dominated the biomass of the shallow pelagic planktivorous fish community and exhibited extensive diet and spatial overlap with juvenile Chinook and other salmon. A bioenergetic analysis indicated that herring consumed 10-47 times more biomass of the key prey resources eaten by Chinook salmon during the critical early marine growth period. These results suggest that any assessment of marine carrying capacity will need to account for the population and feeding dynamics of all major daylight planktivores, especially herring. Determining factors that affect growth performance during this critical period and the consequent influences on mortality during subsequent life stages will inform managers and researchers about the role of the Puget Sound food web in supporting production and survival of Chinook and associated pelagic species.

Nathan Mantua

University of Washington, School of Aquatic and Fishery Sciences

*Spatial and temporal covariation in the marine survival rates of Coho salmon (*Oncorhynchus kisutch*)*

Nathan Mantua, Jessica Beetz

Abstract:

We investigated temporal, spatial, and geographic patterns of coherence in 28 timeseries of marine survival (MS) rate estimates for populations of Coho salmon (*Oncorhynchus kisutch*) originating in western Washington State. Populations considered here have three different early life history types (hatchery, net-pen, and wild), and are distributed across a region of approximately 100,000 km² that encompasses two distinct oceanographic settings: Puget Sound and the west coast of Washington State. Our analysis reveals that these Coho salmon populations exhibit a diversity of MS patterns in space and time. Specifically, we find that spatial coherence exists on a subregional scale (~150km) that is largely determined by the oceanographic domains occupied--either Puget Sound or the outer coast--by a given population in its early marine period. We also find that hatchery, wild, and net-pen Coho salmon populations sharing the same oceanographic settings have different MS patterns. Marine survival rates for Puget Sound Coho salmon declined precipitously between the early 1980s and mid-1990s, then increased modestly in the late 1990s through 2005. In contrast, coastal Coho populations tended to show more interannual variability over the 1970-2005 period of record, albeit around a generally lower MS rate baseline. The survival rates of the net-pen populations that we investigated are not significantly higher than other hatchery populations, and over the period of study declined more precipitously than those for other life history types. Our sample size for Puget Sound net-pen populations was small (n=3), however the pattern we observed may indicate that the majority of mortality on both net-pen and traditionally reared hatchery populations in Puget Sound may occur after the period during which net-pen fish are held, i.e. after spring of ocean entry year. Perhaps surprisingly, holding fish through this period is not increasing their MS rates relative to those for more traditional hatchery programs in Puget Sound. Our results demonstrate that coherent patterns in MS are related to early life history types and rearing conditions, and provide new evidence that biodiversity in MS for Pacific salmon populations of the same species plays an important role in salmon productivity at regional and sub-regional scales.

Megan Moore

NOAA Fisheries

Survival of steelhead smolts in the Salish Sea
Megan Moore, Barry A. Berejikian, Eugene P. Tezak

Abstract:

Marked declines in Salish Sea salmon and steelhead populations have prompted recent efforts to understand the biological, spatial and temporal patterns governing survival in the marine environment. Pacific salmonid species experience differential survival rates that depend on life history strategies, body size, migration timing, rearing history, and other factors. Steelhead in the Salish Sea in particular have suffered declines in smolt-to-adult survival rates (SAR) beginning in the late 1980's and SARs have not improved as they have in other regions (e.g., along the Pacific coast and Columbia River Basin). Acoustic telemetry studies on steelhead smolts originating in Hood Canal suggest that survival rates for steelhead are substantially lower during the first few weeks after seawater entry than after they enter the Pacific ocean. Marine survival of steelhead smolts raised in hatcheries is typically lower and more variable among years and populations than it is for wild steelhead smolts. Hatchery smolt survival rates vary by location and likely depend on hatchery rearing conditions and strategies. Poor survival of steelhead in the Salish Sea has important implications for the productivity of both hatchery and natural populations and should be considered in designing conservation programs that include hatchery steelhead. It is crucial that we begin to understand the spatial distribution and mechanisms (competition and predation) associated with survival of steelhead and Pacific salmon in the Salish Sea in order to guide management actions to improve the status of populations.

Peter Olesiuk

Fisheries and Oceans Canada

Patterns of pinniped (seal and sea lion) predation on Salish Sea salmon stocks

Abstract:

Abundance of Steller sea lions in British Columbia and neighbouring waters has been slowly increasing since the mid-1960s. The increases are partly attributable to the recovery from predator control programs, but populations appear to have fully recovered and in recent years have exceeded peak historic levels. Salmon comprise about 11% of the overall diet of Steller sea lions in southern B.C. and Washington. Steller sea lions prey mainly on adult salmon along the outer coast during summer and fall as fish enter coastal waters en route to spawning areas. The main sea lion foraging areas are around the large breeding sites on the Scott Islands off northwest Vancouver Island (mainly pink, Sockeye and chum salmon), and along the west coast of Vancouver Island (mainly pink, Sockeye, Coho and Chinook salmon). During the non-breeding season (September-May), Steller sea lions disperse from breeding sites and some animals enter the protected waters of the Salish Sea, along with California sea lions that have dispersed from breeding sites off California. Salmon (mainly chum and Chinook salmon) can be important prey in inshore areas, especially in estuaries and adjacent to rivers. Sea lions in southern B.C. and Washington now consume about the same amount of salmon as taken in commercial fisheries.

Abundance of harbour seals in B.C. and Washington has increased 10-fold since the species was protected in the early 1970s. Populations grew rapidly during the 1970s and 1980s, but growth rates slowed during the 1990s, and numbers have now stabilized at historic levels. Harbour seals are non-migratory and widely distributed throughout the Salish Sea. Salmon comprise about 4% of the overall diet of harbour seals, and total salmon consumption by seals is probably an order of magnitude less than salmon consumption by Steller sea lions or landings in commercial fisheries. However, salmon can be an important prey for seals as fish concentrate in the narrow channels, estuaries and rivers en route to spawning areas. Harbour seals can thus be largely regarded as a terminal predator that takes mainly pre-spawning adult salmon. Salmon predation by seals in these terminal areas tends to be compensatory, with predation rates lowest for large/healthy stocks and highest for small/depressed stocks. Thus, much of the focus has been on assessing seal predation in systems supporting threatened and endangered salmon stocks.

Scott Steltzner

Squaxin Island Tribe

Results from a regionally scaled acoustic network used track salmonid smolts in South Puget Sound in 2005- movement and apparent survival.

Scott Steltzner, Kyle Brakensiek

Abstract:

In 2004 a year round acoustic network was installed in seven of the narrow passages that characterize Puget Sound south of the Tacoma Narrows. By 2006 the array had been expanded to cover nine passages and inlets and was being used to support the studies of several different agencies. Species tagged include: hatchery and wild Coho, hatchery Chinook, hatchery and wild steelhead, coastal cutthroat, and lingcod. The array has allowed us to determine timing, routes, and holding areas prior to out-migration. Observations of early marine survival for Coho, steelhead, and Chinook have shown high early mortality occurring in South Puget Sound that approaches 90%.

Non-native and invasive aquatic species in the Salish Sea: Ecosystem impacts, status, trends, monitoring and control techniques

Rachel Benbrook

People For Puget Sound

Skilled citizen scientists paddle Puget Sound: Volunteer sea kayakers' survey for invasive Spartina

Abstract:

Since 2007, People For Puget Sound has been recruiting and training volunteer sea kayakers to conduct shoreline surveys for invasive *Spartina anglica*. This innovative citizen science program has resulted in surveys of over 275 miles of shoreline in Puget Sound and the NW straits, and the location of over 450 square meters of invasive *Spartina*. This poster will illustrate program methods and results, as well as innovative techniques to get the word out and engage new audiences.

Claire Levy

University of Washington School of Aquatic and Fishery Sciences Wetland Ecosystem Team

Evaluating effects of invasive Tunicates on epifaunal communities in Puget Sound

Claire Levy, Jeffery R. Cordell, Oisín Gunning

Abstract:

The introduction and spread of non-native tunicates in the Salish Sea is of concern because of their ability to rapidly spread and colonize available habitat and negatively affect communities that they invade. Previous studies in other regions have shown that invasive tunicates are able to effectively overgrow other epifaunal species and, as such, represent a potential threat to native communities. The fouling of aquaculture gear and cultured shellfish is also a major concern. Our study focuses on *Didemnum vexillum*, *Botrylloides violaceus*, *Ciona savignyi* and *Styela clava*; two colonial and two solitary species respectively. *D. vexillum*, *B. violaceus* and *C. savignyi* are native to Japan and *S. clava* is native to the Northwest Pacific from Shanghai north to the Sea of Okhotsk. With the exception of *B. violaceus*, these species are considered a primary priority for management and monitoring by the Washington State Department of Fish and Wildlife because of their potential to out-compete native species in terms of nutrient acquisition, colonization and growth. Between May and October 2010 we collected paired samples of tunicate-infested and uninfested substrata at six marinas and two mussel aquaculture sites in Puget Sound. The substrates for tunicate growth were mostly other invertebrate species, including mussels (*Mytilus* spp), oysters (*Crassostrea gigas*) and the sabellid polychaete *Eudistylia vancouveri*. In order to evaluate community-level effects of the tunicates, we quantified the macro- and meiofaunal invertebrate communities from these substrata in the presence and absence of each tunicate species. We also measured the effects of *D. vexillum*, *B. violaceus* and *C. savignyi* on the condition and shell thickness of *Mytilus* spp. and the effects of *C. savignyi* and *B. violaceus* on the tube size of *Eudistylia vancouveri*. We compared the condition of infested and uninfested mussels from the same site using 1) shell thickness, 2) the ratio of dry meat weight to dry shell weight, and 3) the ratio of dry meat weight to shell surface area. Preliminary results found that infested mussels from two of three sites evaluated had significantly higher average shell thickness compared with uninfested mussels from the same sites, but there were no effects on the other measures of condition. The differences in shell thickness between uninfested and infested mussels could be a response to fouling by tunicates but may also be a consequence of other biotic or abiotic factors.

Amanda Summers

Samish Indian Nation Department of Natural Resources

Samish River Watershed Japanese Knotweed Control Project and Riparian Restoration Program

Abstract:

In 2010 the Samish Indian Nation was awarded a grant through the Region 10 Environmental Protection Agency, Tribal Implementation Project to fund our Samish River Watershed Japanese Knotweed Control Project and Riparian Restoration Program. The Samish River, an important salmonid bearing system in North Puget Sound, is extensively infested with invasive Japanese Knotweed. The Samish Indian Nation Department of Natural Resources has initiated a coordinated systematic knotweed control project. This project is a very dynamic, multiagency, and multiyear invasive species control effort that utilizes a neighbor to neighbor approach. Conservation issues tend to be controversial topics and Japanese Knotweed seems to bridge the gap between stake holders that often sit on opposite side of the table. Project outputs and outcomes include: surveying/mapping the extent of the infestation throughout the watershed; landowner education/outreach; control strategy design/implementation, and native riparian replanting. Japanese knotweed most commonly inhabits riparian areas because it is readily spread by downstream flow. Knotweed presents several threats to the ecosystem including; bank destabilization, loss of habitat, displacement of native vegetation, loss of shade providing species for salmon bearing streams, and loss of macro invertebrate food, loss of nitrogen to the soil. Due to the tenacious nature of this plant, it can take several years to fully eliminate infestations. Because we are working directly with a large number of landowners over the course of several years it has become important to track a range of information including site information, conversation histories, special requests from land owners, contract status, project status, priority level, knotweed patch characteristics and changes over time, photo documentation per site, etc. This data is recorded in an innovative relational database. We utilize Trimble GPS to collect patch specific information for every patch we find. We use these GPS points relate the patch information to parcel number, owner information, to track and prioritize our effort, as well as to track the reduction of knotweed in the watershed. This poster presentation will outline our methods for survey, treatment, photo documentation, project partner tracking, and data organization, as well as outreach strategy. There will be photos of all the on the ground work for visual aids and to display the successfulness of the project we have several maps that display knotweed infestation densities, distribution and our treatment efforts.

Hydrologic analysis, water resources, and freshwater ecosystems in the Salish Sea watersheds

Gary Borstad

ASL Environmental Sciences Inc., ASL Borstad Remote Sensing Inc.

The green hills of the Salish Sea watershed: how are they changing?

Gary Borstad, Leslie Brown, Scott Akenhead, Jim Irvine

Abstract:

As part of a fisheries related project funded by the Fraser Salmon & Watersheds Program, we used satellite data to produce a high-level indicator of watershed condition that should be useful for many kinds of natural resource management, including but not limited to salmon. We used a well-established remote sensing indicator of the 'greenness' of terrestrial vegetation called the Normalized Difference Vegetation Index (NDVI). The original dataset was assembled by the Canada Centre for Remote Sensing from daily weather satellite imagery for 1985 to 2006, at 10-day and 1-km resolution for all of BC. Following further corrections and quality control, we extracted spatially averaged time series for several Fraser watersheds and developed a set of secondary indicators, including the long-term means, trends and annual anomalies of summer greenness. Comparison of these metrics to salmon abundance and survival at the watershed level suggests that changes captured by the NDVI time series relate to salmon success in the Fraser basin.

In this poster we illustrate some of the dramatic, spatially varying changes in vegetative cover that have occurred across British Columbia and particularly within the Salish Sea watershed since 1985. Much work remains to be done, but these indicators already provide a completely new lens through which to examine changes related to factors such as urbanization, logging, fire and forest disease. This database contains invaluable information regarding the recent environmental history of British Columbia. Our work generates more questions than answers and should be of interest to managers and scientists of all disciplines. We are actively soliciting interest in this database as the basis for future research projects.

Pat Pearson

Washington State University Jefferson County Extension

A water discussion course: Our watershed

Pat Pearson, Linda Smith

Abstract:

Confronting the challenges of water issues requires a new level of water wisdom across the board—from individual household users to communities, corporations and government agencies. We all need to become more informed and engaged water citizens, so that we can think about and intelligently discuss difficult issues and work together for the best possible water solutions. The Water Discussion Course: Our Watershed was created to facilitate this process.

Our Watershed was designed to:

- Provide basic knowledge about our water and watersheds in the Pacific Northwest
- Raise awareness about water issues confronting watersheds and the communities within them
- Provide a structure to learn more about watersheds and actions an individual can take

There are two versions of the water discussion course:

- Our Watershed: Pacific Northwest (PNW) focuses on the waters of the states of Alaska, Idaho, Oregon and Washington, and the PNW Tribal Nations.
- Our Watershed: Puget Sound focuses on the waters of the Salish Sea located in the state of Washington and the related Tribal Nations.

Both version of the course are offered at no charge to participants. The course sessions may be read online or downloaded in a PDF format.

The website is:

<http://county.wsu.edu/jefferson/nrs/water/courses/Pages/>

The course was developed in a “study circle” format. A study circle is a small group of people who agree to meet to discuss an issue in depth. The course book is comprised of 7 sessions, designed for informal weekly discussions that usually take place in peoples’ homes. Each week a different group member facilitates the group. This format encourages group members to apply their personal experience and critical thinking to the material. Each section opens with a reflection question to start the session process. This is followed by articles, discussion questions, a section with suggestions for how to become more personally involved in the protection and stewardship of water, and sources for further reading and internet links. As discussion group members explore, discuss and question, they learn and develop a sense of place and community.

Eight pilot groups have been conducted in Washington. Course feedback was evaluated and the course materials revised and updated. Participants have initiated follow-up water related activities and projects.

Anne Savery

Tulalip Tribes of Washington

Groundwater monitoring for protection of fisheries and natural resources

Anne Savery, Darla Boyer

Abstract:

The Tulalip Tribes monitor groundwater levels in a well reserved solely to supply water to the Hatchery for incubation of Chinook, Coho and chum eggs. Based on monitoring of the well, a decision was made to use the well to supplement diminished surface water supplies in the summer and fall in order to provide adequate flows to juvenile and adult salmon reared at the hatchery. Seven years of pumping the well at rates of 600 gallons per minute show a slight decline in the aquifer level. Continued monitoring efforts over the years should help managers decide if water supply should be supplemented by an additional well, or if hatchery production should be scaled back.

Cynthia Wright

Institute of Ocean Sciences, Fisheries and Oceans Canada

Freshwater discharge into the Strait of Georgia: seasonal and geographic trends for coloured dissolve organic matter and relationships to the marine aquatic pool

Cynthia A. Wright, Sophie Johannessen, Robie Macdonald

Abstract:

Coloured (Chromophoric) dissolved organic matter (CDOM) is composed of chemical constituents that absorb ultraviolet and visible radiation, influencing light penetration in the aquatic environment. The marine waters of the Strait of Georgia receive freshwater input from the surrounding rivers, contributing terrestrially printed organic matter to the marine in-in-situ algal pool. In addition to influencing light penetration, CDOM can also be broken down by photobleaching, providing carbon dioxide and nutrients to the aquatic system.

Six Vancouver Island rivers and two lower Mainland rivers were sampled seasonally in 2008 and 2009 for CDOM, as well as DOC, TOC, nutrients, particulates and $f_{0.180}$. In 2010 a brackish to marine transect along the Fraser River plume and two marine stations in the north and south of the Strait of Georgia were sampled seasonally for the same parameters, as well as other water properties such as temperature and salinity.

The absorption and slope coefficients for CDOM both show a wide range of values but each water type, river, brackish and marine, are distinguishable from each other. For river samples, the two important variables appear to be the absorption coefficient $a_{CDOM}(350)$ and DOC as well as there being seasonal and geographic trends that may be related to such factors as drainage basin size, peak discharge volumes, soil types and urbanization factors. For samples from the brackish plume transect, there is clear conservative mixing patterns related to salinity and possibly evidence of photobleaching related to seasonality. In the marine stations, the upper 15m of the water column is the region of primary variability for CDOM, but in all waters, including the deep, there is clearly a terrestrial fingerprint to the CDOM as determined by the slope coefficients.

Transboundary Monitoring Partnerships

Sarah Grossman

Swinomish Indian Tribal Community
Tribal Journey Water Quality Project
Sarah Grossmann, Eric E. Grossman

Abstract:

Since 2008, the Coast Salish Nation and Swinomish Indian Tribal Community in partnership with the U.S. Geological Survey (USGS) has examined the coastal waters of the Salish Sea providing a new strategy that blends western science and Coast Salish culture to study water-quality and its effects on ecosystem dynamics. The foundation of the Tribal Journey Water-Quality Project (TJWQP) is the annual Tribal Journey, whereby canoe families traveling their ancestral highways collect surface-water samples producing simultaneous water property profiles across the Salish Sea. Through the partnership, Coast Salish enable the synthesis of scientific measurements and observations of the environment, helping to quantify environmental patterns, identify areas of impairment, and through time, detect changes and trends related to climate change and other environmental factors.

Methods applied include monitoring water-properties (surface-water temperature, salinity, pH, dissolved-oxygen, and turbidity) along four pathways traveled by the Coast Salish canoes. Near real-time results of the canoe tracks are posted on the web at <http://www.usgs.gov/coastsalish> providing the scientific community and public an opportunity to observe water-quality across the Salish Sea and respond to areas of interest or impairment. In 2009, supplemental studies including water-property depth profile measurements, the collection and analysis of water samples for plankton community composition, dissolved nutrients, and chlorophyll, and deployment of three moorings to measure water properties continuously at Samish Bay, Nanaimo estuary, and Nisqually delta over a three month period surrounding the annual Tribal Journey were added to enhance the scope and understanding of the track data. The canoe track data are unique in mapping out spatial patterns at multiple scales, detecting large-scale oceanographic/climate and site-scale land-use influences. The project examines the spatial relation of water-properties and nutrients with plankton community structure, with the potential to determine presence and extent of harmful algal blooms, and impacts and vulnerability along gradients in urbanization, watershed activities, and regional oceanography. The TJWQP also examines the spatial and temporal variability in habitat quality of shallow river-delta and nearshore settings that experience extreme ranges in temperature, salinity, and turbidity that impact valued marine resources and ecosystem connectivity for culturally important salmonids, shellfish, and their prey.

The TJWQP has built strong collaborative relationships and scientific capacity to capture summer water-quality conditions and quantify variability across the vast Salish Sea region. Tribal canoes traveling across the nearshore waters of the Salish Sea are helping to fill critical gaps in environmental monitoring. The TJWQP's adaptive study design allows for extra monitoring to occur when, for example, algal blooms are spotted on the water. In 2009, an algal bloom was observed by the canoe pullers north of Vancouver BC. The TJWQP was able to map the bloom which extended from Horseshoe Bay to Burrard Inlet and measure the water properties both across the bloom and with depth.

Life history and ecology of salmon: Implications for management and conservation in the Salish Sea

Asha M. Ajmani

Department of Earth and Ocean Sciences, University of British Columbia

Diet and growth of juvenile Sockeye salmon on ocean entry into a coastal fjord in British Columbia

Asha M. Ajmani, Brian P.V. Hunt, Evgeny A. Pakhomov

Abstract:

It is hypothesized that the prey available to juvenile Sockeye salmon (*Oncorhynchus nerka*) for growth during their first summer at sea is critical to their overall marine survival. To investigate this hypothesis, juvenile Sockeye from Rivers Inlet were sampled during their marine entry period (May to June) in 2008, 2009 and 2010. Five surveys were conducted each year to measure smolt diet and growth during the estuarine phase of their seaward migration. Gut content analyses found that inter-annual differences in diet were larger than intra-annual spatial and temporal variability. In 2008, Cirripedia (28%) was the most abundant prey item, while Cladocera was the most abundant in 2009 (61%) and 2010 (39%). Biomass estimates indicated that fish larvae (2008, 37%), Copepoda (2009, 34%) and Cirripedia (2010, 37%) contributed the most by weight. Growth was slowest in 2008 (0.23 mm/day) and more similar in 2009 and 2010 (0.82 and 0.98 mm/day, respectively). Tukey's HSD test revealed no significant relationship at the 0.05% level between growth and diet composition (abundance / biomass), or between growth and temperature, salinity, fluorescence, or river flow. As opportunistic feeders, juvenile Sockeye must balance the energy gained and spent pursuing available prey items. We suggest that the fine scale surface distribution of zooplankton and / or the caloric content of available prey items may be more important for growth of Sockeye salmon.

Dave Beauchamp

U.S. Geological Survey, Washington Cooperative Fish & Wildlife Research Unit School of Aquatic and Fisheries Sciences, University of Washington

Do pink salmon affect the productivity and life history characteristics of Fraser River Sockeye salmon?

Greg Ruggerone, Dave Beauchamp

Abstract:

Recent studies indicate that Bristol Bay Sockeye salmon compete for food at sea with Russian pink salmon, leading to 1) significant reduction in survival of Sockeye smolts at sea, 2) reduced adult abundance, and 3) smaller adult length-at-age. Productivity of Fraser River Sockeye salmon has declined since the early 1990s (except for the 2006 brood that returned in 2010), therefore the potential effects of pink salmon on Fraser River Sockeye salmon were examined in a preliminary analysis using stock-specific Sockeye data provided by the Pacific Salmon Commission (PSC). Pink salmon abundance in the North Pacific Ocean and in the Salish Sea has been exceptionally high since the mid-1970s and abundance of maturing pink salmon is greater during odd-numbered years. For example, in 2009 more than 600 million pink salmon returned from the North Pacific Ocean. Analysis of PSC data indicated that mean productivity (residual from Ricker recruitment curve) of Fraser Sockeye salmon was significantly less from odd-year versus even-year broods, 1979-2005, leading to a 28% reduction in abundance during odd-year broods when standardizing values to mean parent escapement. This pattern was not directly associated with juvenile pink salmon produced in the Fraser River. Instead, mean annual productivity of 16 Sockeye stocks was inversely correlated with abundance of maturing pink salmon in the North Pacific Ocean since the early 1960s, corresponding to the year of Sockeye return. During 1953-2009, mean length of age-1.2 Sockeye salmon (mean of 4 stocks, while accounting for gender) was significantly smaller during odd versus even years of return. Age-at-maturation of Fraser Sockeye stocks was delayed in response to greater pink salmon abundance since the early 1960s. These findings indicate that high abundances of pink salmon affect

productivity, growth, and age-at-maturation of Fraser Sockeye salmon. The uniquely low Sockeye return in 2009 and the high return in 2010 are consistent with the pink salmon hypotheses, but the data indicate significant interaction with other factors during these two recent years.

Yongwen Gao

Makah Fisheries Management

Analysis on isotopic data from otoliths of anadromous fish

Yongwen Gao, David L.G. Noakes

Abstract:

In this paper, we present a statistical study on stable oxygen and carbon isotopic data ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) from otoliths of two anadromous fish species, Atlantic salmon (*Salmo salar*) and Pacific Sockeye salmon (*Oncorhynchus nerka*), in an attempt to analyze interactions between hatchery and wild salmon. The results indicated that the salmon otolith data were not normally distributed, so that linear discriminant function analysis and commonly-used statistical tests such as ANOVA and the t-test may not be appropriate. Using non-parametric k-sample nearest neighbor discriminant analysis, we were able to identify the origins of wild and hatchery Sockeye salmon and discriminate among five hatcheries for Atlantic salmon with high accuracy. Analyses also indicated that the sample sizes required to estimate $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ means based on the different sources of variability (between group or within group) and precision levels ($\pm 5.0\%$) were not large. These results and conclusions not only address the essential statistical features of isotopic data from otoliths, but also have practical importance for fisheries management as well.

Anna Kagley

NOAA/NMFS/NWFSC/FE Division

Movements of Chinook salmon throughout Puget Sound

A. Kagley, J. Chamberlin, K. Fresh, T. Quinn, D. Spilsbury-Pucci, F. Goetz, C. Greene, J. Scheuerell

Abstract:

Many of the world's most abundant fish are migratory. Puget Sound salmon show a particularly wide variety of migration patterns. For Chinook salmon in particular, we have documented a spectrum of spatial and temporal distributions from individuals that migrate to the ocean (ocean-type) to those that spend their entire lives in inland bodies of water (residents). We used acoustic telemetry to quantify individual movement, document behavior and make other comparisons in members of these populations. We also characterized both large- and fine- scale movements of individual residents and determined how a myriad of factors (including size and hatchery- versus naturally-produced status) relates to these patterns of movement. This presentation incorporates results from 100 Chinook salmon tagged in Central Puget Sound and the Skagit Basin. Approximately 25% displayed the Ocean-type behavior. As for movement, 62% of the detections on the San Juan Island and Strait of Georgia arrays were of from presumed resident fish (based on size and time collected) tagged and released in central Puget. Many of these fish did not enter the nearshore but returned to Puget Sound. Likewise, 65% of the detections on the Admiralty array were also from these fish tagged in central/main basin Puget Sound. Almost an equal number of detections of Skagit basin tagged and central tagged fish were detected in the Whidbey basin. 85% of central basin detections were comprised of fish tagged and released in that same areas they were detected. Surprisingly 73% of detections in the Skagit basin were of central tagged fish, and only 14% of all Skagit bay detections were attributed to Skagit tagged fish. Much of this is attributed to the low numbers of Skagit tagged fish in comparison to those tagged and released in the main basin. Most fish detected in the Skagit region went rapidly through the Whidbey Basin and crossed the San Juan array. This can help us give us important insight into this species habitat use, distribution, survival, and may reveal more alternative migratory strategies. All of this is particularly important when considering the importance of Resident fish as significant portion of the recreational fishery and Ocean-type fish as commercial industry throughout the Pacific Northwest.

Martin Liermann

Northwest Fisheries Science Center / NOAA

Imaging sonar as tool for estimating salmon escapement for small populations

Martin Liermann, Keith Denton, Dan Rawding

Abstract:

Stock specific escapement estimates are an essential part of salmon and steelhead management in the Pacific Northwest. Popular visual escapement methods such as Area-Under-the-Curve (AUC), peak count expansion, and redd counts are widely implemented but are believed to often have high measurement error due to factors including:

1. variable and unquantified observer efficiency, residence time, and redd life,
2. spatial and temporal variability in spawning patterns, and
3. environmental conditions (high turbid flows) that lead to missed surveys during critical times.

Imaging sonar provides an alternate approach to estimating escapement by tallying individuals as they move past a fixed location in the river below the spawning grounds. While sonar based escapement estimation has been used in Alaska and British Columbia for over two decades, these programs are for large high value stocks (millions of fish) where the high cost of equipment and labor can be justified. However, there has been a steady improvement in the quality of sonar output, our understanding of how to use the technology effectively in rivers, the ease of operation, and the cost relative to other approaches. Here we examine the feasibility of sonar based escapement estimation for the smaller stocks (hundreds to thousands) typical of Washington and Oregon. We use detailed information from two Washington rivers where we are currently using sonar based escapement estimation (Elwha and Coweeman), and more general information characterizing several representative Washington rivers. Factors we consider include:

1. errors introduced through species identification in rivers with overlapping run timing for multiple species,
2. the availability of sites with good acoustic characteristics, access, security, and power options,
3. the estimated error in sonar based escapement estimates relative to the current visual approaches, and
4. the estimated cost of a sonar based approach relative to the alternatives.

While the cost of buying and operating sonar for escapement estimation still limits its applicability in smaller systems, for cases where traditional methods fail (e.g. high turbidity during spawning) or the stock is of particular importance (e.g. index or ESA listed stocks) sonar may provide a attractive alternative.

Jonathan Thar

Pacific Ocean Shelf Tracking (POST) Program

Acoustic tracking of marine animals in the Salish Sea (and beyond)

Abstract:

The Pacific Ocean Shelf Tracking (POST) Program was conceived in 2001 to determine the scientific value and feasibility of building a permanent, large-scale acoustic telemetry network for studying the movement and behavior of marine animals. From 2001-2005, the concept of deploying highly efficient lines, or "curtains", of acoustic receivers on the ocean bottom was tested mainly in the Salish Sea. Concurrently, trials of the utility of those curtains for experimental

science were completed mostly by tracking the out-migrations of various salmonid stocks from regional river systems, taking advantage of the acoustic technology that works seamlessly between fresh- and saltwater. After a successful proof of concept phase, the initial permanent POST array was deployed in 2006, using lines of receivers running from shore to 200m depth that can detect nearly 100% of the acoustically tagged animals passing through them. Today, the array that originally rooted itself in the Salish Sea has grown to stretch along 3,000km of the Northeast Pacific coast, from Prince William Sound, Alaska to Point Reyes, California. Over 50 independent researchers from Canada and the United States contribute to and receive data from POST's freely accessible database, having tagged more than 16,000 individuals of 18 different species. The non-profit platform serves as an accessible research tool available to academe, resource agencies and the public, contributing to the advancement of scientific knowledge and the conservation and stewardship of marine resources.

Edith Tobe

Squamish River Watershed Society

Juvenile Chinook Outmigration Pilot Study in Howe Sound

Edith Tobe, Matt Foy, Joe Tadey, Colin Levings, Doug Swanston

Abstract:

For the past 20 years the Chinook salmon populations returning to the Squamish River have been in decline. Little is known on the behavior and survival patterns of the juvenile salmon as they migrate down the Squamish River and enter Howe Sound. However, an even larger information gap is knowledge on the juvenile Chinook salmon's distribution spatially and temporally as they move through Howe Sound towards the Salish Sea Basin (i.e. how juvenile salmon make use of nearshore). The intent of this study is to establish juvenile Chinook salmon migratory patterns in Howe Sound. To achieve this, sampling sites for sampling juvenile salmon will be established along the eastern shore of Howe Sound. They will be monitored weekly from March to September 2011 during the period in which the smolts are out migrating. Biological sampling will be undertaken on captured juveniles (including genetic sampling). Genetic sampling will help to establish patterns of interaction between Squamish Chinook salmon juveniles (hatchery and natural production) with other regional Chinook salmon populations that may be co-existing and potentially competing for juvenile habitat in Howe Sound.

Seaweeds and seagrasses in the Salish Sea

Sarah Amundrud

University of British Columbia

The relative importance of predators and eutrophication on eelgrass benthic food webs in BC

Sarah Amundrud, Mary O'Connor

Abstract:

Eelgrass (*Zostera marina*), one of the northern hemisphere's most common marine plants, acts as a crucial habitat provider for animals like waterfowl, fish, and invertebrates, as well as epiphytic algae, which is an important food source for many animals. Throughout the world, eelgrass is being lost at an alarming rate, probably because of coastal eutrophication and overfishing, which both result in increasing epiphyte densities on eelgrass blades to levels that are harmful to eelgrass. Eutrophication is thought to directly increase epiphytes, while overfishing is thought to indirectly increase epiphyte densities, by causing a shift in trophic interactions that decreases top-down control on epiphytes. Still, the relative importance of these two factors for the structure of eelgrass food webs in BC is not well understood. In this experiment, we experimentally excluded intermediate predators like larger crustaceans and smaller fish, and measured the impact on smaller invertebrates, including grazers. In addition, we determined the effect of nutrient addition, as well as the combined effect of nutrient addition and predator exclusion, on the eelgrass community. Using cages that excluded intermediate predators, but were permeable to grazers feeding on epiphytes, we monitored changes in epiphyte densities and grazer community assemblages on eelgrass blades in White Rock, BC, and determined how nutrient addition, releasing grazers from top-down control by excluding intermediate predators, and these two factors combined, impacted the eelgrass system over four weeks. We hypothesized that 1) nutrient addition increases epiphyte densities and does not change grazer assemblages, since grazers will still be controlled by predation, 2) predator exclusion results in increased grazer densities and a change in grazer assemblage, leading to a decrease in epiphyte density, and 3) nutrient addition together with intermediate predator exclusion results in a change in grazer assemblage and an increase in grazer densities, but not in an increase in epiphyte densities, since top-down control from an increased number of grazers released from predation should counteract any effects of eutrophication on epiphytes. Our results provide insight into the relative importance of two common perturbations to eelgrass communities and may provide further evidence that eutrophication and overfishing contribute to the worldwide eelgrass decline.

Shaughn Anderson

Friday Harbor Laboratories, University of Washington

SEM analysis of Z. marina seed coat morphology

S. Anderson, S. Wyllie-Echeverria, F. Dooley, A. Summers

Abstract:

The asexual reproductive strategy of *Zostera marina*, protected in the Salish Sea because of its valued ecosystem functions, as been well studied. However studies to elucidate sexual reproduction is less common. Because these plants rely on seed dispersal to colonize new sites that are environmentally suitable, investigation to uncover barriers to germination are needed. Successful germination of *Z. marina* seedlings depends on the embryo being released after the seed coat has split. Using a Scanning Electron Microscope (SEM) we examined seed coat structure to determine the direction of the split and found that the coat splits longitudinally exposing the embryo. We also found that the structure of the seed coat surrounding embryos, stored for more than six months, can lead to embryonic death. We will discuss the significance of these findings designed to restore *Z. marina* in the Salish Sea.

Nancy Elder

USGS-Western Fisheries Research Center

Scuba surveys to assess effects of Elwha River dam removal on shallow, subtidal benthic communities

Nancy Elder, Steve Rubin, Ian Miller, Reg Reisenbichler, Jeff Duda, Jon Warrick

Abstract:

The impending removal of the Elwha River dams will affect marine habitats when sediments that have accumulated behind the dams for over 95 years are transported to the Strait of Juan de Fuca. Scuba surveys were conducted during 2008-2009 to characterize nearshore biological communities prior to dam removal. Sites in the Elwha drift cell (west Freshwater Bay to Ediz Hook) and in reference areas farther to the west (Low Point) and east (Green Point) were randomly selected in a geographical information system after stratification by distance from the river mouth, depth, and substrate. Densities of benthic macroalgae, macroinvertebrates (>2.5 cm long), and fish, and overall taxa richness were controlled in part by substrate composition, seafloor relief, and water depth. Bedrock outcrops at shallow depths (3-6 m) in central Freshwater Bay supported the highest kelp densities (8.8 m⁻²) and taxa richness (37) in the Elwha drift cell. The highest invertebrate densities (4.6 m⁻²), and relatively high taxa richness (33) were found deeper in Freshwater Bay (9-18 m) on mixed sand-cobble substrates where large boulders provided seafloor relief. Mixed gravel-cobble substrates east of the river mouth lacked large boulders and supported lower invertebrate densities (1.3 m⁻²) and taxa richness (21) but moderate densities of kelps (2.2 m⁻²) that were primarily annual, understory species. Densities of fish (mean = 0.08 m⁻² across all habitats) were considerably lower than for kelps or invertebrates. In 2010, a different sampling design was initiated to track changes close to the river mouth immediately before, during, and after dam removal. Several sites were established around Angeles Point for periodic monitoring of sediment grain size with photographic techniques. Endpoints of transects for biological monitoring were permanently marked within a subset of these sites which will allow repeated sampling of the transects through time. The more spatially extensive 2008-2009 surveys will be repeated sometime after dam removal as dictated by results of continuous sampling near the river mouth. The scuba surveys are one component of a multidisciplinary effort to track restoration of physical and biological processes following dam removal.

Lisa Ferrier

WA State Department of Natural Resources

SeagrassNet: Seasonal monitoring of two seagrasses, Zostera marina and Zostera japonica, at Dumas Bay

Lisa Ferrier, Jeffrey Gaeckle

Abstract:

SeagrassNet is a global seagrass monitoring program that is now established in 32 countries with 115 monitoring sites around the world. Standardized protocols for scientific monitoring have been developed and are successfully implemented by trained teams of local 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. The Washington State Department of Natural Resources' Nearshore Habitat Program, established a SeagrassNet site at Dumas Bay in May 2008. Three years of sampling show seasonal patterns in seagrass species (*Zostera marina* and *Zostera japonica*) composition, shoot morphology and density, percent cover, and above- and below-ground biomass along transects established at + 1 m, 0 m, and -1.6 m MLLW. Light and temperature data correlate with seasonal changes in the monitored seagrass population characteristics. Long term assessment of seagrass resources elevates the visibility of this important nearshore habitat and provides a barometer of direct anthropogenic and global climate change impacts.

Jan Holmes

Island County MRC, WSU Island County Beach Watchers

Plant characteristics of Zostera marina in Holmes Harbor WA

Abstract:

Zostera marina (eelgrass) has long been recognized as a vital marine resource and habitat for thousands of species including forage fish, salmon and other commercially important fisheries. In 2008 the Island County Marine Resources Committee funded an eelgrass mapping and plant characteristics project to determine the extent of this habitat in Island County. Mapping work and data collection is carried out in partnership with WSU Island County Beach Watchers and Friday Harbor Labs. For part of the project we collect plant characteristics data from two intertidal (-2.5 ft.) permanent transect and 24 permanent quadrat locations at the south terminus of Holmes Harbor WA. Plant density, canopy height, leaf width and length, and rhizome internode length data is collected. We have also analyzed sediment samples and archived plant tissue for future genetic testing. Vegetative shoot densities from 2009-2010 ranged from 0 to 360 shoots per meter square quadrat. Reproductive shoot densities ranged from 0 to 52. Canopy height across the two transects at the -2.5 ft tide level reached 2 meters. Rhizome node data collected in 2009 will be compared to data collected June of 2011. Our plant characteristics data will be compared to other data collected in Puget Sound, the Pacific Northwest and other locations.

Gina Lemieux

Archipelago Marine Research Ltd.

Eelgrass habitat compensation: Thinking ahead in Esquimalt Harbour

Gina Lemieux, Mike Waters, Cynthia Durance

Abstract:

Many marine-related projects in Canada require habitat compensation pursuant to the federal Fisheries Act. Compensation options given highest preference are those creating 'like for like habitat in the same ecological unit'. In Esquimalt Harbour, the Department of National Defense (DND) has multiple marine foreshore interests requiring habitat compensation to offset project activities. There are limited locations proximal to proposed marine project areas that are suitable for creating like for like habitat. In an effort to produce high-value habitat compensation, DND has identified an area in the harbour to test the survivability of eelgrass transplants with a longer-range goal of potentially expanding the eelgrass test plots with large-scale transplanting to address future habitat compensation requirements. This poster discusses 1) methods for donor and test-plot site selection and transplanting, 2) survival of transplanted eelgrass material (changes in shoot count), 3) comparison of eelgrass shoot survival between donor sites and between test plots sites, and 4) comparison of relative productivity (LAI) between donor sites and test plots sites. Consideration is also given to suitability of additional areas for transplanting and continued suitability of donor sites.

Thomas Mumford

Washington Department of Natural Resources

The Banks of Washington: Algal biota of the unique submarine platforms in the Strait of Juan de Fuca

T. Mumford, B. A. Bookheim, H. Berry

Abstract:

In the eastern portion of the Strait of Juan de Fuca, over thousands of years the complex forces of glaciers, waves, and currents have shaped a series of broad submarine platforms or "banks" of unconsolidated material, often shallow enough to support a large and unique algal flora. In some cases, these banks are separated from the mainland by much deeper water (Hein, Middle, Partridge, Alden Banks) some are parts of offshore islands (Protection I./Dallas Bank Banks Smith/Minor Island), while Salmon Bank extends from San Juan Island. The pioneers of west coast phycology, William Setchell and the "local boy gone big time", Nathaniel Gardner, initially explored these banks. They also have been repeatedly dredged for as much as 100 years by biologists from the Friday Harbor Labs who long ago recognized their unique flora. This long time series of collections suggests that the flora is remarkably stable, likely because of the lack of

stressors from adjacent mainland activities. Recently, the Washington Department of Natural Resources established marine reserves on three banks. This designation will to help maintain their biodiversity by increasing protection and to increase our understanding of the areas by increasing monitoring. Some features of these banks that has only recently become apparent is their highly seasonal algal species composition and abundance, very deep occurrence of algae because of relatively clear water, movement of algae by high currents, and the large export of biomass into nearby deep water food webs.

Greg Ridder

Island County Beach Watchers & Marine Resource Council
Monitoring eelgrass bed areas in Island County
Greg Ridder, Neal Clark, Jan Holmes, Ken Urstad

Abstract:

The Marine Resource Council In Island County is sponsoring a citizen science project staffed by Beach Watcher volunteers in collaboration with the Washington State Department of Natural Resources to monitor eelgrass on our shores. The project uses three techniques to study the health and abundance of eelgrass. The first is to count and characterize the growth of eelgrass at the plant level for one site in Island County (see poster Plant Characteristics of *Zostera marina* at the Southeast Terminus of Holmes Harbor, Whidbey Island Washington USA). The second uses underwater videography to identify and measure the eelgrass bed areas at high tide in selected DNR sites. The third is an aerial photographic survey of green vegetation at extreme low tides for many sites in Island County. Here we will describe our methods and three year's results of data collection using underwater videography and aerial photography. Our results are both qualitative and quantitative and can measure the effects of human activity and natural processes. We will share our findings, demonstrate how the techniques compliment each other and show the benefits and limitations of each.

Andrew Stevens

U.S. Geological Survey
The influence of wave energy and sediment transport on seagrass distribution
Andrew Stevens, Jesse Lacy

Abstract:

Seagrass habitat is an important component of nearshore ecosystems. Recent worldwide losses in seagrass habitat have been attributed to a number of natural and anthropogenic disturbances. In order to understand the causes of observed declines and to predict future changes in seagrass distribution, we are conducting research into the factors that control its spatial distribution. While waves, currents, and sediment transport have been previously identified as important factors influencing the minimum depth of plant colonization and spatial heterogeneity of plant density, few field studies have quantified a direct correlation.

In this study, we apply a calibrated hydrodynamic model, Delft3D, to characterize the physical setting associated with a seagrass (*Zostera marina*) landscape in Puget Sound, WA. Hydroacoustic surveys produced high-resolution maps of seagrass percent cover and bathymetry. Sediment samples were collected and analyzed to quantify grain-size distributions. Comparison of hydrodynamic modeling results with field measurements suggests that wave energy is a primary factor controlling seagrass distribution along shallow, sandy portions of the coastline. Using a conceptual model relating wave energy to seagrass distribution, we explore the potential influence of sea-level rise on the landward and seaward limits of seagrass habitat in wave-exposed regions.

Renee Takesue

U.S. Geological Survey
Biomass partitioning in eelgrass: not all plants are created equal
Renee Takesue, Sandy Wyllie-Echeverria

Abstract:

Positioned at the land-sea interface, seagrass beds will likely be affected by future climate change components such as increased sea-level and temperatures. The presence of the seagrass *Zostera marina* (eelgrass) throughout the Salish Sea in a broad range of energy, light, and sedimentological environments attests to the adaptability of this species; however, the ability of eelgrass to cope with future stressors will ultimately depend on maintenance of a positive metabolic carbon balance. In short, leaves (above-ground biomass, AG) are net carbon sources while roots and rhizomes (below-ground biomass, BG) are net carbon sinks. Hemminga (1998) reported that eelgrass rhizomes become a metabolic burden when AG:BG biomass ratios are below 2. This criterion was used to assess potential vulnerability of intertidal eelgrass beds in Puget Sound and the San Juan Archipelago to metabolic imbalances. Eelgrass AG:BG ratios at 18 sites ranged from 0.9 to 5.5 and had a mean of 3.3. Five eelgrass beds had AG:BG ratios less than 2.0, and all of these were located on exposed shorelines with sediments containing less than 5% silt and clay. Eelgrass biomass partitioning was measured at two depths differing by 30–50 cm at six sites. Four of these had higher, more favorable, AG:BG ratios at the deeper depth, suggesting that gradual sea-level rise may not necessarily have a negative effect on the carbon balance of intertidal eelgrass. Higher water temperatures are expected to disproportionately affect eelgrass with low AG:BG ratios because their respiratory carbon demand would be greater than plants with high AG:BG ratios. The site characteristics (latitude, season, turbidity, sediment reduction-oxidation potential, and pore-water sulfide concentration) were also considered to explore whether particular environmental factors were associated with eelgrass biomass partitioning ratios. Such understanding could help identify Salish Sea eelgrass beds at risk from future stressors so as to allow pro-active management of this resource.

Sandy Wyllie-Echeverria

University of Washington

Tolerances and responses of Zostera marina seedlings to Hydrogen Sulfide (H₂S)

Frederick Dooley, Sandy Wyllie-Echeverria, Peter D. Ward, Mark B Roth

Abstract:

Unexplained loss and lack of recovery of the seagrass, *Zostera marina* L., especially in small embayment's, within the Salish Sea is a concern. After losses, we theorized that increased H₂S might prevent recovery. Because these plants can recolonize unvegetated areas through seed dispersal, we launched a series of experiments to determine if H₂S concentrations we recorded in the field would influence germination and seedling growth. We found that seed viability decreases with age, and that fresh seeds normal germination rate was approximately 78%, however when exposed to any H₂S concentration, those seeds, were unable to germinate. Likewise seedlings, which were grown under normal conditions, were consistently killed above 680 μM H₂S concentration. In addition to lethality we measured photosynthetic output. High doses (680 μM, 2.04 mM and 6.8 mM) of H₂S caused depression of photosynthetic output, as well as causing seedlings to switch from Photosystem II to Photosystem I. At low doses of H₂S (68 μM; 204 μM) it appears that Photosystem II is still active and Photosystem I may become more active. It is possible that one mechanism leading to mortality involves changes or total shutdown of the photosynthetic functions. Our observations also suggest that this plant may adapt to lethal H₂S concentrations if subjected to multiple, but gradually increasing sublethal H₂S concentrations. Additionally, this research provides new insight into early earth organisms and suggests that those organisms originally evolved in high sulfur, low oxygen environments, where sulfur was used as an electron receptor instead of oxygen, and this mechanism may be still preserved today in many different taxa.

Monitoring and modeling of harmful algal blooms and pathogens that threaten human health in the Salish Sea

Eva Crim

Kitsap Public Health District

Liberty Bay Marina Water Quality Study: Kitsap Public Health District, Bremerton, WA

Abstract:

The Liberty Bay Restoration project was launched by the Kitsap Public Health District in 2009. The goals of the project are to protect public health and improve water quality through the identification and correction of nonpoint sources of fecal coliform pollution. The project will incorporate an innovative approach to gather water quality data from freshwater drainages and marine waters of Liberty Bay, and identify fecal pollution sources that may include; failing onsite sewage systems, inadequate storm water maintenance, poor animal waste management, failing public sewer collection systems, including discharges from boats. To successfully complete the goals of the project, the Health District is working collaboratively with the Washington State Department of Ecology, Kitsap Conservation District, Kitsap County and City Public Works departments, and engaging the community through public meetings, workshops and door to door surveys.

The purpose for the Liberty Bay Marina study was to determine the impact to water quality from untreated sewage discharges from transient and permanently moored vessels within three Liberty Bay marinas. The marina study tested two hypotheses; that there is no significant difference in water quality inside versus outside marinas. The results showed a statistically significant difference between values inside the marina versus outside the marina during weekend monitoring events ($p = 0.006$), as well as during weekday monitoring events ($p = 0.04$).

The second hypothesis was to determine whether there was a significant difference in water quality when there were high numbers of transient boaters present in an area compared to periods of low transient boat use. The results showed no statistically significant difference.

The results from this study will be used to inform the Kitsap County Board of Health about the status of water quality in and around Liberty Bay marinas. It will also provide evidence to inform policy decisions regarding the effectiveness of the marina sewage ordinance.

Kirsten Feifel

University of Washington, School of Oceanography

*A historical *Alexandrium catenella* cyst record from Sequim Bay, WA and its relation to climate*

Kirsten Feifel, Rita Horner

Abstract:

Detection of paralytic shellfish toxins (PSTs) due to blooms of the harmful alga *Alexandrium catenella* has increased in Puget Sound, Washington since the 1970s. This increase has been linked to large-scale climate variability such as the Pacific Decadal Oscillation (PDO), and local variables such as air temperature, stream flow, and sea surface temperature. However, existing records of *A. catenella* bloom dynamics, based on toxins in shellfish, are relatively short, dating only to 1957, and therefore it is difficult to statistically assess the influence of short-term, stochastic environmental variability versus long-term, multi-decadal, trends in relation to climatology. Hence, we examined the relationship between historical climate variability and profiles of *A. catenella* cysts in a sediment core from Sequim Bay, WA, in order to better determine the influence of climate on *A. catenella* populations. The cyst record allowed us to extend the *A. catenella* history in Sequim Bay to 1878 and to statistically evaluate the historical relationship between the cyst record and available environmental parameters. There is no statistically significant relationship between the cyst record and PDO or stream flow, but there is a positive, significant relationship between local air temperature and sea surface temperature. The

disconnect between historical, large-scale North Pacific sea surface variability, as measured by the PDO index, may highlight the importance of local climate variability and the possible influence of recent warming in the Puget Sound due to anthropogenic climate change as driving factors of the *A. catenella* population increase in the 1970s.

Cheryl Greengrove

University of Washington Tacoma

The distribution of Alexandrium catenella cysts in the surface sediments of Puget Sound, WA in 2011

Cheryl Greengrove, Julie Masura, Stephanie Moore, Brian Bill, Jennifer Emenegger, Portia Leigh, Eric Salathe, Jr., Neil Banas, Nat Mantua, Don Anderson, John Stein

Abstract:

There is a long history of paralytic shellfish toxin (PST) presence in the Puget Sound region indicated by occurrences of paralytic shellfish poisoning (PSP) events in local Native American and First Nations lore and the logs of early European explorers. Since the 1950s, high PST events leading to shellfish bed closures in Puget Sound have been well documented by the Washington Department of Health (WDOH) shellfish monitoring program, however, little is known about the distribution or biology of the causative organism *Alexandrium catenella*. *A. catenella* is a dinoflagellate that spends part of its life cycle as a cyst in the sediment before germinating to become a vegetative form. This species produces a suite of neurotoxins, which can remain in the tissues of filter-feeding shellfish, and be lethal in small doses to humans if consumed (PSP). *A. catenella* blooms therefore pose significant problems for local human health officials, marine resource managers and shellfish growers.

The Puget Sound *Alexandrium* Harmful Algal Bloom (PS-AHAB - <http://www.tiny.cc/psahab>) study is a three year project funded by NOAA/ECOHAB designed to:

1. map interannual variations in *A. catenella* cyst distribution in Puget Sound;
2. do laboratory experiments to quantify the rates and timing of cyst germination related to exogenous and endogenous factors;
3. integrate the results from the first two objectives into coupled hydrodynamic and climate models to determine current favorable habitat areas for *A. catenella* and evaluate the effects of climate change on these habitats in the future; and
4. establish a time series with sufficient depth to provide seasonal forecasts of harmful algal blooms.

The first year surface sediment *A. catenella* cyst distribution mapping survey was completed in winter 2011 consisting of 98 stations throughout all of Puget Sound, the Strait of Juan de Fuca and the San Juan Islands. Sediment samples from the upper 0-1cm and 1-3 cm were collected using a Craib corer and processed for cyst enumeration, total organic content and grain size. Highest cyst concentrations were found in Bellingham Bay, Birch Bay and Semiahmoo Bay in the north, Port Madison, Liberty Bay and Port Orchard on the west side of the main basin and Quartermaster Harbor in central Puget Sound. A preliminary version of this map was shared with Salish Sea human health officials, marine resource managers and shellfish growers in spring 2011, as part of the PS-AHAB “just-in-time” information dissemination to stakeholders program. These data will also be used to inform coupled Puget Sound hydrodynamic and climate models to explore the possibility of providing seasonal harmful algal bloom forecasts in the future.

Nannette Huber

University of Washington Tacoma

Spatial and temporal trends in Quartermaster Harbor phytoplankton

Nannette Huber, Julianne Ruffner, John Pelerine, Julie Masura, Cheryl Greengrove

Abstract:

High abundances of *Alexandrium catenella* cysts were found in the surface sediments of Quartermaster Harbor in a 2005 NOAA/ECOHAB survey. These cysts germinate to become motile cells of *A. catenella*, a dinoflagellate that produces a powerful suite of neurotoxins, which can accumulate in filter feeding shellfish and, if ingested, can cause paralytic shellfish poisoning (PSP) in humans. State and local authorities monitor shellfish populations for their paralytic shellfish toxin (PST) levels throughout Puget Sound. While PST levels in Puget Sound are routinely surveyed, little is known about the organism *A. catenella*. A study of environmental conditions and the phytoplankton community in Quartermaster Harbor was undertaken starting in October 2006, in order to explore the possible mechanisms associated with these high concentrations of *A. catenella* cysts. Monthly surveys of seven stations in Quartermaster Harbor included CTD profiles of temperature, salinity, density, oxygen, fluorescence and transmissivity and discrete water samples for dissolved oxygen, chlorophyll, nutrients and phytoplankton. A summary of the phytoplankton community and diversity from 2007-2010 is presented here, with the occurrence of *A. catenella* highlighted. A statistical analysis was done to determine the similarity between stations in an effort to develop a more streamlined sampling scheme for the harbor in the future. Inner harbor stations were found to be statistically different from outer harbor stations and Commencement Bay stations were statistically different from all harbor stations. These results will allow us to adjust our future sampling scheme by reducing the number of samples needed to describe the system spatially, and possibly allow us the resources to increase temporal sampling of phytoplankton at one location. These phytoplankton data will also be used as input into a hydrodynamic/water quality model currently being developed by Washington State Department of Ecology and King County as part of the Quartermaster Harbor Nitrogen Management Study.

Julie Masura

University of Washington Tacoma

Spatial and temporal distribution of Alexandrium catenella cysts in Quartermaster Harbor, Puget Sound

Julie Masura, Mitchel Schatz, Jim Postel, Cheryl Greengrove

Abstract:

Alexandrium catenella is a dinoflagellate which is known to produce saxitoxin, a suite of neurotoxins, which when bioaccumulated in benthic filter feeding bivalves can result in Paralytic Shellfish Poisoning (PSP) if the bivalves are consumed by humans. *Alexandrium* sp. spends part of its lifecycle as a benthic cyst in the sediment until conditions are right to germinate and become a vegetative cell in the water column. A 2005 NOAA/ECOHAB surface sediment survey of 32 sites in Puget Sound found that Quartermaster Harbor (QMH), an urban bay in central Puget Sound, had cyst concentrations two orders of magnitude higher than anywhere else in Puget Sound. This study takes a more in-depth look at the spatial and temporal distribution of *Alexandrium catenella* cysts in surface sediments and sediment cores in QMH. Cyst abundance in QMH surface sediments show that the highest cyst concentrations are found in depositional environments dominated by silt-sized sediment with greater total organic content (TOC). Sediment cores show an exponential decrease in cyst abundance down core, with cysts present down to 84 cm below the sediment/water interface.

Elizabeth Tobin

University of Washington, School of Oceanography

An optical remote sensor for detection and prediction of Heterosigma akashiwo Harmful Algal Blooms

Elizabeth Tobin, Danny Grünbaum

Abstract:

Most harmful algal blooms (HABs) are detected only after they reach an advanced stage, when they have already caused significant ecological and economic damage. *Heterosigma akashiwo* is

a highly motile raphidophyte that forms toxic blooms in Washington State and temperate/sub-tropical coastal waters worldwide. *Heterosigma* severely threatens marine biota, particularly fish aquaculture. Negative effects from *Heterosigma* are strongly associated with the formation of dense surface aggregations in low-salinity waters. Presently, *Heterosigma* blooms in Washington State are detected by cell counts from collected water samples, or by visual identification of surface aggregations from aircraft. Both methods detect *Heterosigma* cell populations only after they reach relatively high densities. Detecting and quantifying dilute pre-HAB populations of *Heterosigma* is essential to understanding, modeling and predicting *Heterosigma* HABs.

We have developed a low cost remotely-operable optical instrument to quantify and characterize dilute in situ populations of *Heterosigma*. The instrument takes advantage of image-acquisition and motion analysis methods to track and quantify *Heterosigma* cell distributions and swimming characteristics. Previous studies have shown that *Heterosigma* cells and physiological state can be accurately classified by a combination of optical size and fine-scale movement statistics. Further, *Heterosigma* is euryhaline, capable of swimming through and aggregating above salinity jumps of >20 psu. Our optical instrument uses a low-salinity layer to collect cells from dilute populations of *Heterosigma*. We will report on the deployment, calibration and validation of this instrument in the field at the American Gold Seafood aquaculture facility on Bainbridge Island. Coupled with rapidly improving geophysical models predicting cell transport in coastal regions, remote sensors such as ours have the potential to significantly improve understanding and prediction of HAB events by *Heterosigma* and other harmful species.

Frameworks and case studies for ecosystem solutions

Jan Newton

Applied Physics Laboratory, University of Washington

Web-based and social networking technologies disseminate coastal hazard mitigation information

D. Martin, J. Allan, R. Blair, E. Mayorga, S. Mikulak, C. Risien, C. Seaton, A. Sprenger, T. Tanner

Abstract:

At 9:46:23 PM Pacific Time on March 10, 2011 (05:46:23 UTC on March 11), a magnitude 9.0 earthquake occurred 129 km (80 miles) off the coast of Sendai, a city in Honshu, Japan. The earthquake triggered a catastrophic tsunami that produced a wave height of over 30m which propagated throughout the entire Pacific Ocean basin. Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys positioned around the Pacific Ocean provided real-time data of the impending tsunami as it travelled across the ocean towards the US West Coast. Because of this warning, coastal communities in Washington and Oregon were on guard by the time the tsunami hit the US West Coast almost 9 hours after the earthquake occurred. Harbors along the Oregon coast, including Depoe Bay, Coos Bay, and Brookings, and in Crescent City, CA reported damage to docks and boats in the harbor.

In the Pacific Northwest, the Northwest Association of Networked Ocean Observing Systems (NANOOS), the Regional Association that manages and operates the Regional Coastal Ocean Observing System (RCOOS) for this area of the country as part of the National IOOS enterprise, provided extensive information to the public about the timing, severity, and government agency recommended actions to take as a result of this event. These included:

- Featuring "Tsunami Evacuation Zones for the Oregon Coast," a Google Map-based application for the public, planners, etc., at the top of its home page.
 - See: <http://www.nanoos.org/>
 - See also:
http://www.nanoos.org/data/products/oregon_tsunami_evacuation_zones/index.php
 - This application was made jointly by Oregon Dept of Geology and Mineral Industries and NANOOS (Washington State is interested in developing a similar system)
- Providing users of the NANOOS Visualization System with easy access to real-time current, water height, and other information for a wide variety of U.S. IOOS assets, including NDBC-, NOS-, and NANOOS-supported assets, as well as a variety of other sources in Washington, Oregon, northern California, and British Columbia.
 - See: <http://www.nanoos.org/nvs/nvs.php?section=NVS-Assets>
- Posting numerous NANOOS Facebook updates regarding the tsunami passage, including views of water levels at Crescent City, CA; Garibaldi, OR; Port Orford, OR; and La Push, WA.
 - See: <http://www.facebook.com/NANOOS.PNW>

We discuss the implications of the use of standard (web-based) means of disseminating coastal hazard mitigation and the opportunities that social networking technologies present for providing

such information as our society increasingly depends on real-time updates through mobile-technologies and applications.

Numerical models of land and sea

Storrs (“Skip”) Albertson

Washington Department of Ecology

Seasonal variations in flushing time for Quartermaster Harbor, an enclosed Puget Sound estuary

Abstract:

A (computer) model of Quartermaster Harbor (Vashon, WA) in Puget Sound has been developed as part of the Quartermaster Harbor Nitrogen Management Study, funded in part by a West Coast Estuaries Initiative grant from Region 10 of US EPA. The model consists of a structured grid with nearly 10,000 curvilinear cells (~100-meter horizontal dimensions), composed of 37 vertical depth layers with vertical bin sizes ranging from 1 meter throughout the euphotic zone, to 5 meter thicknesses at its deepest extent (60m). It is based on the Generalized Environmental Modeling System for Surface waters (GEMSS) three-dimensional hydrodynamic model, and is driven with data from monthly CTD cruises collected by UW-Tacoma and King County Dept. of Natural Resources (KCDNR), as well as results from a surface/bottom mooring positioned near the mouth of the bay and operated by KCDNR. The calibrated model is used to show seasonal and spatial variations in flushing time.

The presence of the Puyallup River near the mouth of the bay presents a special challenge. This dynamic boundary condition justifies the collection of data at more frequent intervals (every 15 minutes) than monthly cruises. At times, it is possible for the salinity within the bay to be higher (denser water) than water at the same depth outside of it, making it harder for tidal exchange to flush the bay under this inverse estuarine condition. Tidal forcing across the open boundary grid cells at the mouth of the bay varies by phase (offset of troughs and crests in tidal arrival time) at each grid cell to simulate cross-channel currents, although these are less important to water quality and transport along the channel within the bay.

Overall we are very satisfied with the agreement between the model and field data collected in the interior. Hydrodynamic results show root-mean-squared-errors (RMSE) of less than 0.1 m/s against four current meters distributed along the bay and arranged across the channel. RMSE error for salinity varies from 0.63 to 0.86 psu across the model domain weighted over the entire vertical profile at all locations for which there were data available, and the RMSE for temperature similarly varies from 1.58 to 2.3 degrees Celsius. All of these are fairly low. In the majority of models, RMSE gets lower as one approaches stations near the open boundary, because this is where it is being driven by real data. In our model, the RMSE goes down from the head moving seaward, but then back up again. This is presumably due to uncertainties in the applied boundary condition driven by high variability in the Puyallup River. The next step of the project will be to add a water quality module that will be used to run scenarios on different strategies of nutrient reduction.

Matthew Marsik

The Natural Capital Project

Linking watershed and estuarine transport models to evaluate tradeoffs among terrestrial and marine management strategies

Matthew Marsik, David Sutherland, Georgi Spiridonov, CK Kim, Jodie Toft, Mary Ruckelshaus, Anne Guerry

Abstract:

Coastal resource managers are interested in the effects of watershed based management strategies and activities on marine coastal resources. Understanding is limited on the impact of watershed land and water use practices onto marine management strategies. As a first step, we present a water yield and nutrient loading model linked with an estuarine physical transport model to quantify the relationship between key watershed processes and estuary circulation. We use the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) set of spatial tools, which

model and map the delivery, distribution, and economic value of key ecosystem services. We calibrate and apply the linked watershed and estuary models in Hood Canal and Whidbey Basin of Puget Sound to simulate watershed effects on two distinct estuarine systems. Initial water yield model calibration errors less than 15% are encouraging, while results from sensitivity analysis and simulation of future land cover and climate changes provide a plausible range of input discharge flow regimes to test the simplified hydrodynamic model. These models offer an applied and simplified, physically-based approach to model watershed and estuary processes that are easily parameterized and operationalized. This work provides an important foundation for linking with additional marine-based ecosystem service models (e.g. fisheries, aquaculture and coastal protection). Ultimately, this work will examine the trade-offs between watershed and marine management strategies to identify the conditions and influences of watershed process on key coastal and marine ecosystem services.

Greg Pelletier

Washington State Department of Ecology

Calibration of a three-dimensional model of water quality in South Puget Sound

Greg Pelletier, Anise Ahmed, Brandon Sackmann, Mindy Roberts, Robert Ambrose

Abstract:

South Puget Sound, west of the Tacoma Narrows, experiences low dissolved oxygen (DO) levels. Budd Inlet is one of the critical areas within South Puget Sound, and it is surrounded by a relatively large population center that contributes point and nonpoint sources of nutrient loading. Other critical areas do not have adjacent population centers with large point or nonpoint sources of nutrient loading (e.g. Carr and Case Inlets). A primary question is the extent to which human sources of nutrient loading to South Puget Sound, including sources from adjacent areas as well as indirect sources originating further away in South Puget Sound or from the main basin of Puget Sound, influence DO levels in the various sensitive areas of South Puget Sound.

A numerical model was considered to be a critical tool to quantify the relationships between human sources of nutrient loading at many different locations and the response of DO concentrations in the various sensitive areas. A three-dimensional hydrodynamic and water quality model of South Puget Sound was developed for this purpose. The water quality model simulates the concentrations of DO in response to primary production of phytoplankton, which is limited by light, temperature, and nutrient concentrations. Other important processes that affect DO are also included in the model (e.g. oxidation of organic material, reaeration, sediment oxygen demand, and nitrification). The model includes 15 water quality state variables and over 50 kinetic processes among these variables.

The model was calibrated to data collected over a 16-month period from July 2006 through October 2007. Calibration of the model involved running batches of up to 70 model runs at a time with a matrix of critical parameter estimates. The parameter estimates were constrained to be within the ranges of prior distributions of expected reasonable values. The results of each batch of runs were examined to compare the relative model skill with different combinations of parameter values. Information about which combinations of parameters improved skill was used to guide the selection of parameter combinations for the next batch of runs. This process was repeated numerous times and resulted in continuous improvement of the skill of the model from one batch to the next.

Collin Smith

U.S. Geological Survey

Modeling the potential effects of sea-level rise on the spawning habitat of Salish Sea forage fish

Collin Smith, Theresa L. Liedtke, Dennis W. Rondorf, Andrew W. Stevens, Christopher A. Curran, Paul Dorn

Abstract:

Nearshore habitats in the Salish Sea are likely to undergo significant changes due to sea-level rise because of the combined effects of increased water surface elevation and the likely response by landowners of increasing shoreline armoring. Two valued ecosystem components of the nearshore environment that provide ecosystem services are the sandy beaches used by beach-spawning forage fishes and eelgrass beds used for fish nursery areas. Beach dynamics important to beach spawning forage fish include inundation of the upper intertidal zone and accretion of sediments for beach nourishment. We used the Sea-Level Affecting Marshes Model (SLAMM) to determine the effect of sea-level rise on shoreline modifications and tidal habitats at the developed Point Monroe and undeveloped Fay Bainbridge State Park on Bainbridge Island, Washington. SLAMM is a flexible modeling tool used to predict sea-level induced changes to coastal ecosystems based upon local topography and user-defined climate change and sea-level rise predictions. Our objectives were to utilize SLAMM to model three climate change scenarios to predict the effects of sea-level rise on the coastal habitats within our study area. Under all sea-level rise scenarios, we observed a reduction in the surface area of undeveloped dry land (10-12%), developed dry land (10-53%), estuarine beach (1-13%), and tidal flats (19-47%). Additionally, these sea-level rise predictions indicate that the developed property located on Point Monroe will be regularly inundated without additional shoreline alterations. These results show that sea-level rise within Puget Sound has the potential to alter the critical nearshore habitats that are used by forage fish, and may be further exacerbated by the response of property owners to protect their property from sea-level rise. With 2500 miles of coastline in Puget Sound and predictions of sea-level rise from 0.4 to 2 m, the effects on the Puget Sound nearshore may be extensive.

Zhaoqing Yang

Pacific Northwest National Laboratory

Modeling of flood flows and tidal hydrodynamics over a coastal floodplain

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Abstract:

The interactions of physical processes between estuaries and upstream river floodplains are of great importance to the fish habitats and ecosystems in coastal regions. Traditionally, a hydraulic analysis of floodplains has used one- or two-dimensional models. While this approach may be sufficient for planning the engineering design for flood protection, it is inadequate when floodwaters inundate the floodplain in a complex manner. Similarly, typical estuarine and coastal modeling studies do not consider the effect of upstream river floodplains because of the technical challenge of modeling wetting and drying processes in floodplains and higher bottom elevations in the upstream river domain. While various multi-scale model frameworks have been proposed for modeling the coastal oceans, estuaries, and rivers with a combination of different models, this paper presents a modeling approach for simulating the hydrodynamics in the estuary and river floodplains, which provides a smooth transition between the two regimes using an unstructured-grid, coastal ocean model. This approach was applied to the Skagit River estuary and its upstream river floodplain of Puget Sound along the northwest coast of North America. The model was calibrated with observed data for water levels and velocities under low-flow and high-flood conditions. This study successfully demonstrated that a three-dimensional estuarine and coastal ocean model with an unstructured-grid framework and wetting-drying capability can be extended much further upstream to simulate the inundation processes and the dynamic interactions between the estuarine and river floodplain regimes.