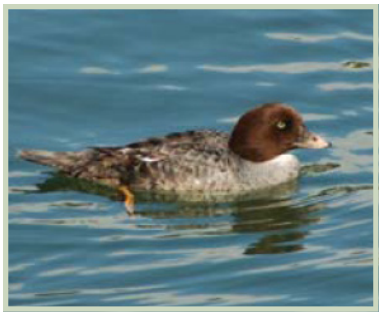
SOUTH SOUND SCIENCE SYMPOSIUM

Making Connections across the Ecosystem



Welcome to the South Sound Science Symposium!

March 26th, 2008
8:00 a.m. to 4:30 p.m.
Tacoma Landmark Convention Center
47 St. Helens Ave.
Tacoma, WA

South Puget Sound

This event is a unique opportunity for scientists to explore how we can work together to identify and relate changes in the health of the South Puget Sound ecosystem. In addition to the general session presentations, scientists and technical staff from educational institutions, government and tribal natural resource agencies, non-profit groups and the private sector were invited to contribute their knowledge to this event in the form of technical posters and research abstracts.

All submitted abstracts are compiled below. Underlined type indicates the presenting authors for the poster session. Additional information on the event can be found online at www.ecy.wa.gov/puget_sound/symposium.html.

Special thanks to all of the partners that made this event possible!

Poster Presentations

1. MODELING FECAL COLIFORMS IN OAKLAND BAY

Anise Ahmed[1] *and John Konovsky*[2]
[1]Washington Department of Ecology, [2]Squaxin Island Tribe

The purpose of modeling fecal coliform bacteria in Oakland Bay was to provide an effective management tool to assess the impact of source control on bacteria concentrations observed in the bay. Biweekly flow, fecal coliform concentrations and water quality parameters were measured at the mouths of all major tributaries to Oakland Bay and Hammersley Inlet for one year. Water quality and hydrodynamic data were also gathered at various locations. A model for Oakland Bay was developed using the "generalized environmental modeling system for surface water" (GEMSS). The model was calibrated to hydrodynamic parameters and observed bacteria in the bay. Since salinity varied throughout the bay both temporally and spatially due to the influence of freshwater, tides and rainfall, and both temperature and solar radiation data were available, the decay rate used included the impact of all three variables. This was deemed more appropriate then using a single overall die-off rate. Sediment re-suspension was included in the model. It was triggered by a re-suspension or scouring velocity. Sediment re-suspension is believed to be predominantly caused by wind and tidal action. A multiple regression analysis, using wind speed, wind direction and fecal coliform concentration at DOH station 614 showed that wind speed and direction was ten-times better at predicting observed coliform concentrations relative to using tributary loads alone (even with zero bacteria die-off rates). Sediment fecal coliform concentrations were varied until a good fit was obtained for the observed fecal coliform populations observed in the bay. Various scenarios are presented showing the impact of reducing bacteria at the source by ten, thirty, fifty and seventy percents, on fecal coliform concentrations in the bay. As different source control levels were evaluated, it was presumed that the level of reductions at the source was the same for sediment bacteria. In addition to evalu-

ating the impact on cumulative bacteria populations within the bay, critical individual stations were also evaluated to see the impact of source control. It was envisioned that the model could be used to evaluate bacteria populations at any location within the bay, e.g. at individual shell fish beds.

2. THE WASHINGTON BEACH PROGRAM – 5 YEARS OF BACTERIA MONITORING IN SOUTH PUGET SOUND

Jessica Archer and Lynn Schneider – Washington Department of Ecology

High levels of *Enterococcus* bacteria in marine waters can be indicative of an increased risk of illness for recreational beach users. In South Puget Sound, the health risk from contact with contaminated water can be exacerbated by shallow inlets with long retention times and poor circulation. The Beach Environmental Assessment, Communication, and Health {BEACH} Program is currently implemented in Washington State in response to the BEACH Act which was passed by the US Congress in 2000 to create a uniform system to protect users of marine waters. The Departments of Ecology and Health implement the EPA funded program in collaboration with county health jurisdictions and volunteer organizations. Water samples are collected once per week at approximately 70 beaches from May through September and analyzed for *Enterococcus* bacteria. Since 2002 we've collected over 14,000 samples from beaches located in 14 coastal counties. This presentation will include a brief overview of the Program and an analysis of five years of bacteria data, focusing on South Puget Sound beaches that have levels of *Enterococcus* above background levels. Several factors are known to cause increases in *Enterococcus* in marine waters. These factors include proximity of known contamination sources, bather load, freshwater input from streams and rivers, rainfall, and sediment type. The presentation will include a few examples of beaches where the identification of increased bacteria levels has lead to remediation efforts.

3. DISSOLVED COPPER AND THE SALMON NOSE: NEUROBEHAVIORAL INDICATORS OF STORMWATER TOXICITY

David H. Baldwin, Jenifer K. McIntyre and Nathaniel L. Scholz – NOAA Fisheries

Dissolved copper is a ubiquitous contaminant in urban stormwater. Copper and other pollutants are deposited on roads and other impervious surfaces and then transported via runoff to waters that provide habitat for salmon. Exposure to non-point source pollutants such as copper is an emerging concern for many populations of Pacific salmon (*Oncorhynchus* spp.). Copper is known to interfere with the normal function of peripheral sensory neurons in the olfactory system of fish. By reducing the ability of salmon to detect and respond to ecologically important chemical cues, copper has the potential to disrupt behaviors that are critical for survival, migration, or reproduction. To address this concern, we used neurophysiological recordings to investigate the impacts of short-term, ecologically relevant copper exposures on the sensitivity of the olfactory system of juvenile coho salmon (*O. kisutch*). In addition, we used computer-assisted video analyses of behavior to evaluate the responsiveness of copper-exposed coho to a chemical predation cue (conspecific alarm pheromone). Olfactory recordings were also used to assess the extent to which natural variation in conventional water quality conditions (hardness, alkalinity, and dissolved organic carbon) might be protective against copper neurotoxicity. Copper exposure reduced the responsiveness of the olfactory system to naturally occurring odorants as well as the alarm pheromone in a dose-dependent manner. Additionally, copper exposure significantly reduced the behavioral responses to the olfactory predation cue in a dose-dependent manner. Notably, the copper-induced reductions in olfaction and behavior had similar thresholds and were highly correlated. While the olfactory toxicity of copper was only slightly diminished by increasing water hardness or alkalinity, it was partially ameliorated by increasing dissolved organic carbon (DOC). Natural water quality conditions in the western U.S. suggest that water hardness and alkalinity are unlikely to protect salmon from the sensory neurotoxicity of copper, while river systems with high DOC may partially reduce the toxicity of copper. Therefore, copper-containing stormwater runoff from urban landscapes has the potential to reduce the olfactory function as well as increase the predation mortality of exposed salmon.

4. SHELLFISH FARMS AND SALMON STREAMS: PARTNERS FOR HEALTHY ESTUARIES

Peter Becker, Ph.D. – Little Skookum Shellfish Growers LLC

In 1977, Little Skookum Shellfish Growers (LSSG) took over management of 2.19ha of shellfish beds and 7ha of uplands from the pioneer Lynch family who had operated a clam, oyster and dairy farm in Little Skookum Inlet since 1883. Management responsibilities included over 300m of Lynch Creek stream bed (WRIA 14 stream 00026) historically used for low-

head hydroelectric power, agricultural and domestic consumption. LSSG started to monitor water quality and flow in Lynch Creek and stream counts of the fall run of Chum (*Oncorhynchus keta)* and Coho (*Oncorhynchus kisutch*). Cooperative enhancement programs with the Squaxin Island Tribe and WDF&W over the past 30 years to remove salmon migration barriers and old hydroelectric structures, put in weirs have resulted in run increases from 250 Chum and Coho (1978) to over of 6000 fish in Lynch Creek and opened over 1.2 km of stream bed to spawning. LSSG's long term interest is in sustained release of natural nutrients to maintain shellfish production and to sustaining high water quality in Lynch Creek to protect the health of shellfish beds in Totten and Skookum inlets, good practice for Little Skookum Inlet's ecological health and good business practice for us as a company.

5. TRIPLE BOTTOM LINE MANILA CLAM *(Tapes philippinarum)* FARMING: AN ENVIRONMENTALLY, SOCIALLY AND CULTURALLY AND ECONOMICALLY SUSTAINABLY CLAM FARM IN SOUTHERN PUGET SOUND

Peter Becker Ph.D. – Little Skookum Shellfish Growers LLC

Little Skookum Shellfish Growers (LSSG) operates 2.19ha of shellfish beds obtained in 1977 from the pioneer Lynch family. Three generations of Lynch family cultured and harvested of Olympia oysters (*Ostrea conchaphila* (Carpenter, 1851)) and Native Littleneck clams (*Protothaca staminea* (Conrad 1837)). Manila clams (*Tapes philippinarum* (Adams & Reeve, 1850)) were probably introduced in 1937 with the first plantings of Pacific Oysters (*Crasostrea gigas* (Lamarck, 1818)). Since 1977, our quantitative benthic surveys have documented the mollusk populations and substrate conditions of our shellfish beds. Surveys include bivalve mollusk size frequency, biomass distribution and biodiversity. While maintaining the historical biodiversity, we increased sustainable harvest rates of Manila clams from 16,200kg/ha/y in 1977 to 79,000kg/ha/y in 2007 through controlled seeding with hatchery Manila clam seed from our own brood stock and continuous monitoring of bed environmental parameters. LSSG maintains the highest levels of worker compensation and benefits in the industry, has extremely low employee turnover and achieves a profit margin favorably comparable to the largest aquaculture companies in the world. We publish records of our research in international journals. Our research supports the conclusions of other shellfish researchers world wide: sustainably farmed shellfish beds are indistinguishable in terms of benthic biodiversity and substrate conditions from near by undisturbed areas.

6. FIDALGO BAY SEDIMENT CHARACTERIZATION, ANACORTES, WA

Ted H. Benson, M.S.[1] *and John Nakayama*[2]
[1]Washington State Department of Ecology, [2]Science Applications International Corporation

In 2007, Fidalgo Bay was identified by the Washington State Department of Ecology under the Toxics Cleanup Program's Puget Sound Initiative for focused sediment cleanup and source control. Previous sediment quality investigations in some areas of Fidalgo Bay have found contaminants that exceeded the Washington State Sediment Management Standards. The bay-wide sediment characterization study was designed to identify the nature and extent of potential sediment contamination in water depths of five fathoms or less in Fidalgo Bay. The study included a comprehensive sediment profile imaging survey to determine the physical conditions of the bottom substrate and benthic habitat types, surface and subsurface sediment chemistry analysis, sediment toxicity testing, sedimentation rate determination, and collection of fish, crab, and clams to potentially evaluate uptake of contaminants by ecological receptors. The results of the study will be used to determine whether further investigation of areas for potential cleanup action(s) is warranted to minimize the potential for adverse impacts to the biotic community.

7. TOXICS-FOCUSED BIOLOGICAL OBSERVING SYSTEM FOR THE PUGET SOUND

Claudia F. Bravo[1]*, Lyndal L. Johnson*[1]*, Mark S. Myers*[1]*, Sandra O' Neill*[1]*, Nathaniel Scholz*[1]*, Jim West*[2]*, Gina Ylitalo*[1] *and Tracy K. Collier*[1]
[1]NOAA Fisheries, [2]Washington Department of Fish and Wildlife

Over the past 30 years, human activities have caused the release of many toxic chemicals into Puget Sound. Given current regional projections for population growth and coastal development, loadings of contaminants will increase dramatically in the future, unless serious measures are taken to address the issue now. Currently, toxics monitoring is focused on abiotic matrices, primarily water and sediments, with sediments viewed as repositories for many toxics. However, data show that toxics affect biota at all trophic levels, including

humans, and not just the benthos. Consequently, ecosystem-based monitoring is needed to protect estuaries from toxics. We recommend a toxics focused biological observing system (TBiOS) to incorporate such monitoring into regional programs. The TBiOS will assess exposure and effects of toxics in biota across ecologically relevant habitats, life histories and food webs, within an ecosystem framework that defines important functions and processes related to the uptake, transfer, and impacts of toxics in Puget Sound. It will also incorporate focused research studies to establish cause and effect linkages between toxicant exposure and biological impacts that can serve as a basis for management actions.

8. NEARSHORE ECOSYSTEM SERVICES – A FRAMEWORK FOR CONSERVATION AND RESTORATION OF PUGET SOUND ECOSYSTEMS

Jan Cassin – Parametrix, Inc.

Marine/nearshore conservation and restoration in the South Sound faces significant challenges –competition for funding; rapid development rates; escalating land prices, and limited suitable sites. Population growth and pressures for economic development make it more and more difficult to keep pace with impacts. The extractable goods from natural ecosystems (timber, gravel, water) have always had market value, but the equally important ecosystem services (clean water, flood mitigation, biodiversity, carbon sequestration) provided by intact, functioning systems are not currently valued by most markets, or adequately considered in decision making. This lack of market value hides the societal costs of impacts to, and ignores the benefits of, functioning ecosystems. Market mechanisms that provide financial reward for environmental stewardship and restoration (e.g., tradeable credits for conservation easements, mitigation banking, tradeable development credits, biodiversity offsets, payments for ecosystem services) show great promise around the world for achieving conservation and restoration results. Such markets require ways of measuring ecosystem services, understanding the linkages between landscape conditions, ecosystem function, and the quality/quantity of ecosystem services, and landscape level, spatially explicit inventories of ecosystem services. Science-based accounting methods for measuring units of ecosystem services can address a number of these needs. Based on literature review and a survey of ecosystem functional models, we present a conceptual model and framework for quantifying and measuring uplift in Puget Sound marine/nearshore ecosystem services to support conservation and recovery, and present scenarios for implementing incentives for conservation based on ecosystem services accounting. Critical issues in the development of accounting tools for PNW marine/nearshore ecosystems include: tradeoffs between capturing the complexity of natural systems and the simplicity needed in a practical tool; establishing consensus among multiple stakeholders, dynamic/connected nature of nearshore systems, and incorporating spatial scale and landscape context. Despite the challenges, accounting methods that allow tracking of multiple ecosystem services have great potential for supporting market-based incentives for conservation and restoration, for informing environmental impact assessments, and making sound environmental management decisions.

9. HABITAT CONSERVATION PLANNING FOR STATE-OWNED AQUATIC LANDS

Carol Cloen – Washington Department of Natural Resources

Washington DNR is completing an ecosystem based multiple species Habitat Conservation Plan for over 2.4 million acres of state-owned fresh- and saltwater habitats. The poster will outline the methods used in developing the plan, how take was modeled, species and activities to be covered, and potential conservation strategies.

10. STATUS AND TRENDS OF FECAL COLIFORM POLLUTION IN SHELLFISH GROWING AREAS OF SOUTH PUGET SOUND

Tim Determan – Washington State Department of Health

The Washington State Department of Health uses a systematic random sampling strategy mandated by the National Shellfish Sanitation Program (NSSP) to monitor fecal coliform pollution in shellfish growing waters. Under the NSSP, DOH uses geometric means and 90th percentiles to classify shellfish growing areas. DOH also uses 90th percentiles uses to measure status and trends in fecal pollution in Puget Sound for the Puget Sound Assessment and Monitoring Program (PSAMP). I developed for PSAMP a “fecal pollution index” (FPI) to estimate fecal pollution impact. I show how the FPI is derived and use it to track temporal trend of fecal coliform pollution in each of 29 South Sound shellfish growing areas from 1998 through 2007.

11. RELATIONSHIPS BETWEEN SEDIMENT QUALITY, DISSOLVED OXYGEN, AND BENTHIC INVERTEBRATES IN HOOD CANAL

Margaret Dutch[1], Edward Long[1], Sandra Aasen[1], Valerie Partridge[1], Kathy Welch[1] and David Shull[2]
[1]Washington Department of Ecology, [2]Western Washington University

Sediment quality data and concentrations of water-column dissolved oxygen (DO) collected in Hood Canal from 1932 to 2005 were evaluated as part of the Hood Canal Dissolved Oxygen Program. The influence of these measures on the composition of sediment-dwelling invertebrate assemblages (benthos) was examined. Sediment chemical contamination and toxicity was low, and confined to Port Gamble, Port Ludlow, and Dabob Bay. Coarse sands were found in northern Hood Canal and along shorelines. Fine-grained silts and clays were found in central and southern regions, at depth, and in shallow bays. Organic carbon concentrations increased in fine-grained sediments. DO concentrations decreased from north to south and from shallow to deep water. Minimum DO levels measured from 1932 through 2005 decreased over time, periodically falling below critical values at most southern stations and at an increasing number of central and northern stations. Benthic assemblages were identified for three regions and nine sub-regions of Hood Canal. The number of individuals and species decreased and stress-tolerant species became dominant southward as sediment grain size and near-bottom DO decreased, and organic carbon content and depth increased. These factors, in this order, acting together may have influenced the composition of the benthos. Obvious changes in assemblage structure occurred within DO ranges of >3 to 6 mg/L and $\leq$ 1 mg/L. These two ranges may represent critical DO concentrations for Hood Canal benthos. Patterns of species succession over decreasing DO ranges were similar to responses by the benthos to stressors reported in fjords elsewhere. Additional analyses indicated that there had been little change in northern Hood Canal benthos that could be attributed to declining oxygen levels. However, southern stations near the Great Bend have experienced changes consistent with declining DO concentrations since 1991. Steps taken to develop initial critical DO values for the protection of the benthos, and a summary of data gaps and associated recommendations for future work on this topic, are presented.

12. A COMPARISON OF LIFE HISTORY STRATEGIES FOR TWO COHABITATING BAT SPECIES FOUND IN LARGE MATERNITY COLONIES IN SOUTH PUGET SOUND, YUMA BATS AND LITTLE BROWN BATS

Greg A Falxa[1], Lori J. Salzer[2] and Mary J. Linders[2]
[1]Cascadia Research Collective, [2]Washington Department of Fish and Wildlife

Little information exists on the life history strategies of bats in the Puget Sound region; most studies have focused on forest associations. As historic habitat features have changed from urbanization and modern forest practices, so have the strategies of bats occupying those landscapes. Habits of a large mixed-species maternity colony formed of adult female Yuma Bats and Little Brown Bats (*Myotis yumanensis and M. lucifugus*) were observed over multiple years by a group of volunteer biologists and naturalists. Census and species data was collected using visual counts and call analysis methods. During 2003 through 2006 we radio-tracked bats from the largest known South Puget Sound colony, consisting of approximately 70% Yuma Bats and 30% Little Brown Bats, to investigate foraging and roosting behavior. Detailed foraging data was collected on 11 bats from this colony. During their reproductive period most made nightly commutes to Capitol Lake, a distance over twice that reported in other studies. Little Brown Bats captured at Capitol Lake were tracked to a second large mixed-species colony in north Thurston County. We found that although these two species cohabitate at both large roosts, Yuma Bats were only found in the large colonies (> 3,400 adults at the larger one), while Little Brown Bats were also found in smaller maternity colonies (38-110 bats). It is unknown why these Yuma Bats colonize only in large groups. Both Yuma colonies are in close proximity to a large (ca. 1,000 acre), mature forest fragment with greater tree species diversity than managed forests, while most of the smaller Little Brown Bat colonies identified in this study are located distant from cohesive forest structure. Perhaps prior to commercially management forests, large trees with hollows or features (such as Big-leaf Maple) provided roost habitat for Yuma Bat colonies, with that habitat association continuing to influence site selection for this species. Fewer, larger colonies may indicate that the distribution of this species is more habitat limited than their closely related Little Brown Bat, and management strategies may need adjustment to reflect these differences. Additional Yuma Bat research could be designed to test this hypothesis.

13. SITE CHARACTERIZATION AND THE DESIGN OF ALTERNATIVES FOR SHORELINE STABILIZATION, PUGET SOUND, WASHINGTON

Wendy J. Gerstel[1] and Jennifer F. Brown[2]
[1]*Qwg* Applied Geology, [2]JFB Environmental, LLC

Adverse impacts of shoreline armoring, exceeding 75% in some counties of Washington State's Puget Sound, is resulting in increased bulkhead permit application scrutiny by regulating agencies, and increased interest in alternative slope stabilization and beach restoration techniques.

The Federal Environmental Protection Agency (EPA) funded the Puget Sound Action Team, a state agency in the Governor's office, to evaluate the performance of alternatives and compile recommendations for future applications. This study, investigating more than 20 sites around Puget Sound, is the first to systematically evaluate these alternatives.

Project sites were classified as low-no bank (<15 ft) stabilization, high bank (>15 ft) stabilization, bulkhead removal, and bulkhead protection based on concerns triggering initial permit applications. We characterized the geology, geomorphic processes, and vegetation for each site reach. Landowners and contractors were interviewed for perspectives on project performance, hurdles in the permitting process, construction specifications, and access to project materials.

Our study suggests that inadequate characterization of site geology, hydrology, and geomorphic processes often led to inappropriate mitigation design or unnecessary shoreline armoring. We also found that planted vegetation, even when native, was often not site-compatible. Regulating jurisdictions are recommended to obtain geotechnical reports and third-party reviews of those reports to assure appropriate mitigation design. In many cases observed slope instability might have been better mitigated with improved upland land-use practices. Permit conditioning should incorporate existing state and county guidelines for shoreline development and vegetation management.

14. SOUTH PUGET SOUND WATERTYPE ASSESSMENT

Jamie Glasgow – Wild Fish Conservancy

When urban / suburban development occurs too close to streams, those watersheds suffer significant alterations to their natural hydrographs; fall and winter stormflows increase in magnitude and frequency, and summer baseflows reduce or disappear altogether. When streamside vegetation is removed or encroached upon, water temperatures are artificially elevated. Bank erosion, aggravated by the removal of riparian vegetation and the altered hydrograph, can cause channel incision that unravels stream channels and mobilizes large amounts of fine sediments. Increased impervious areas accumulate and deliver automotive, household, and industrial pollutants, channeling them into streams through stormwater infrastructure. Septic drainfields built too close to streams leach into streams and subsequent ecological and human health concerns.

The amount of protection that streams receive in most local governments, including Thurston County, is regulated by the water type classification system developed by the Washington Department of Natural Resources (WDNR). The ability of this classification system to protect fish and their habitats is directly related to the accuracy of the water type classifications assigned to the streams

During the spring months of 2005, 2006, and 2007, Wild Fish Conservancy crews performed watertype assessments on 125 streams that flow directly into South Puget Sound near Olympia. Surveys were conducted along streams at public road right-of-ways as well as private parcels of land where permission was granted. WFC staff employed state-sanctioned watertype field protocols (see WAC 222-16-031 and Section 13 of the Forest Practice Board Manual).

The surveys covered approximately 53,000 acres, encompassing 135 miles of stream channel. Fish species encountered during the surveys included cutthroat trout, rainbow trout, coho salmon, chinook salmon, sculpin, stickleback, Olympic mudminnow, and brook lamprey.

As expected based on previous Wild Fish Conservancy watertype assessments, significant discrepancies existed between the modeled Washington Department of Natural Resources (WDNR) water type regulatory maps and on the ground survey results. Summary statistics for the survey results to date show that WDNR had identified 113.9 miles of streams while WFC mapped 135.1 miles of stream. The results of the Assessment, including over 1600 photographs, are presented in an interactive Web-based GIS, available at: www.wildfishconservancy.org.

15. URBANIZATION AND SHELLFISH PROTECTION IN PUGET SOUND

Stuart Glasoe – Washington Department of Health

Puget Sound is a populated and fast growing part of the country. The growth pressures and related water quality problems threaten many of the region's prized shellfish growing areas and the state's position as the leading producer of farmed bivalve shellfish in the nation. In 2002, the Puget Sound Action Team designed a study to assess the relationship between urbanization and microbial contamination of shellfish growing areas. The study consisted of (1) a literature review to define the problem and better understand the effects of coastal development on nearshore water quality, (2) research conducted by the University of Washington Urban Ecology Research Lab to explore the relationship between development patterns and fecal pollution levels in Puget Sound shellfish growing areas, and (3) management recommendations to improve long-term protection of the region's shellfish areas. Among other findings, the study showed that microbial pollution is a chronic problem in developed coastal areas and is closely associated with population levels, development densities, stormwater flows and numerous other landscape metrics. Pollution impacts tend to correlate strongly with changes in watershed hydrology that reduce the landscape's natural capacity to attenuate flows and break down pollutants. Among other indicators, increasing levels of impervious cover and decreasing levels of forest cover are good predictors of shoreline water quality. The research underscores the need for integrated watershed management and land use planning to protect Puget Sound's shellfish growing areas. This includes measures to preserve and connect forest cover, preserve and restore wetlands and other natural drainage systems, preserve continuous riparian corridors, limit and disconnect impervious cover from surface drainages, implement pollution prevention practices, limit and guide growth away from sensitive water resources, and promote appropriate use of low-impact and decentralized infrastructure for stormwater and sewage management.

16. SEA-LEVEL RISE AND COASTAL HABITATS IN THE PACIFIC NORTHWEST

Patty Glick – National Wildlife Federation

The National Wildlife Federation recently completed the most comprehensive and detailed analysis to date of the potential impacts of sea-level rise on the region's coastal habitats, with a specific focus on key areas of Puget Sound, the southwestern Washington coast, and the northwestern Oregon coast. The purpose of this project is to provide science-based information to coastal managers and other relevant decision makers in the region to help them take sea-level rise into consideration in the ongoing efforts to protect and restore the region's important nearshore habitats. We engaged sea-level rise expert Jonathan Clough, of Warren Pinnacle Consulting, Inc., to apply the Sea Level Affecting Marshes Model (SLAMM), which simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea-level rise. We looked at a range of scenarios based on 2001 IPCC projections, from a mean 3.0 inch rise in global sea level by 2025 to a max 27.3 inch rise by 2100. We also looked at results for a 1 meter, 1.5 meter, and 2 meter rise by 2100 to accommodate for recent studies that suggest that sea-level rise may be occurring much more rapidly. Results for each study site are based on relative sea-level rise for the given region, taking into consideration regional changes in land elevation due to geological and ecological factors. Model results vary considerably by site, but overall the region is likely to face a dramatic shift in the extent and diversity of its coastal marshes, swamps, beaches, and other habitats due to sea-level rise. For example, under the 27.3 inch sea-level rise scenario, estuarine beaches across the study sites will undergo inundation and erosion to the tune of a 65 percent loss. As much as 44 percent of tidal flats will disappear. 13 percent of inland fresh marsh and 25 percent of tidal fresh marsh will be lost. These and other projected changes are likely to fundamentally alter the region's coastal ecosystems and the species they support, making it prudent for coastal managers and other relevant decision makers to consider global warming in planning future use and restoration of coastal resources.

17. MODELING ECOSYSTEM DYNAMICS AND TROPHIC SHIFTS IN SOUTH PUGET SOUND 1970-1999

Sarah Haque and Scott Steltzner – Squaxin Island Tribe

Marine survival rates for coho salmon (*Oncorhynchus* kisutch) in Puget Sound began a precipitous decline in the late 1980's. This was especially pronounced in South Puget Sound (SPS) where survival rates plunged from an average of approximately 25% in the mid 1980's to less than 1% by the late 1990's. Conversely, during this same time period populations of wild chum were steadily increasing. To investigate this phenomenon Ecopath software was employed to create a mass balance model for SPS. Changes in biomass and trophic interactions from 1970 to 1999 were then simu-

lated using the Ecosim model. Static models for the 1970's and 1990's were created with inputs consisting of 50 compartments representing: primary producers, marine mammals, birds, invertebrates, demersal and forage fishes, and salmonids. The static models showed a strong decrease in biomass for several vertebrate groups including: coho, diving ducks, dogfish, flatfishes, hake, herring, lingcod, rockfish, forage fish, pacific cod, pollock, skates/rays, and rockfishes. Strong increases in biomass were shown for: resident Chinook juveniles, chum, and seals. Another model output suggested that the combined biomass for all organisms residing in the higher trophic levels were much lower in the 1990's than in the 1970's. Additionally all trophic levels showed a general trend towards lower species diversity. Ecosim was then used to create a year to year dynamic food web based simulations for SPS. Outputs from this exercise closely replicated biomass estimates with the exception of dogfish, pollock, and skates. The model results strongly suggest a trophic shift occurring in SPS from the mid 1970's to the late 1990's. These results show a strong association with the Pacific Northwest Index that is used to characterize climate patterns in coastal waters and freshwater habitats. This suggests that bottlenecks in marine carrying capacity for coho in SPS may exist while the Pacific Northwest is in an era of warmer and drier weather patterns.

18. AN EMPIRICAL WATER QUALITY MODEL FOR STREAM AND STORM WATER RUNOFF BASED ON WATERSHED LAND USE IN PUGET SOUND

Robert K. Johnston[1], Jill Brandenberger[2], Valerie I. Cullinan[2], Christopher W. May[3], Bruce Beckwith[4], Victoria S. Whitney[4], Brian E. Skahill[5] and David Mettallo[6]

[1]U.S. Navy, Marine Environmental Support Office: NW, Space and Naval Warfare Systems Center, [2]Pacific Northwest National Laboratory, [3]Seattle Public Utilities, [4]Puget Sound Naval Shipyard & Intermediate Maintenance Facility, [5]U.S. Army Engineer Research and Development Center, [6]Taylor Associates, Inc

A watershed-based assessment of stream and storm water pollution runoff in the Sinclair -Dyes Inlet watershed was conducted as part of Project ENVironmental InVESTment (ENVVEST) being conducted by the Puget Sound Naval Shipyard & Intermediate Maintenance Facility in partnership with the U.S. Environmental Protection Agency, Washington State Department of Ecology, the Suquamish Tribe, Kitsap County, Kitsap County Heath District, the City of Bremerton, and other local stakeholders. Contaminant concentrations in representative streams and outfalls discharging into Sinclair and Dyes Inlets were evaluated during 18 storm events and wet/dry baseflow conditions between Nov. 2002 and May 2005. Samples were analyzed for metal contaminants (mercury, arsenic, cadmium, chromium, copper, lead, silver, and zinc), organic contaminants (polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs)), nutrients (total inorganic nitrogen and total phosphorus), and fecal coliform bacteria to determine event mean concentrations as a function of total event rainfall and upstream land use and cover. Samples were also analyzed for aluminum, total suspended solids, and total and dissolved organic carbon to examine relationships with particulate matter and organic carbon. The results showed that event mean concentrations (EMCs) for outfalls were often five times higher than streams for the metals and 24 times higher for PAHs; however, calculated loadings from outfalls were lower than streams due to the greater volumes discharged from streams. EMCs for total copper, lead, zinc, and mercury in streams were positively correlated with storm size, but an inverse relationship for outfalls was found suggesting a dilution effect with larger storms. Data from this effort were used to develop empirical models relating stream and storm water quality to upstream land use and cover so that water-quality parameters could be estimated for the entire watershed without having to monitor all sources. Combined with a calibrated and verified hydrology model for the watershed, the empirical model can be used to predict contaminant loadings from a wide range of land uses into the receiving waters of the Puget Sound. This work holds great promise for use in other areas of Puget Sound.

19. SOUTH PUGET SOUND SALMON RECOVERY PLANNING

Tom Kantz[1], Scott Steltzner[2], Sayre Hodgson[3], Doris Small[4], Cindy Wilson[5] and John Kleim[6]

[1]Pierce County Special Projects, [2]Squaxin Island Tribe, [3]Nisqually Indian Tribe, [4]Washington Department of Fish and Wildlife, [5]Thurston County, [6]Creative Community Solutions

During the development of the South Puget Sound Chinook recovery plan, which focuses on nearshore habitat south of the Tacoma Narrows, the South Puget Sound Salmon Recovery Group created stressor conceptual models to better describe and understand how human-induced stresses to the nearshore (such as bulkheading) may affect salmon habitat and populations. In addition, we developed estimates of nearshore carrying capacity of juvenile Chinook by using an area by fish density calculation summed over habitat types.

We have recently expanded our planning effort to include multiple salmon species. We are identifying specific management actions at specific sites based on an understanding of the natural processes and stressors at both a local and a landscape-level scale. We have also developed a Microsoft Access data entry tool to assist us in creating a GIS data layer which shows stressors and management recommendations along specific shoreline reaches.

20. VARIABILITY OF ABOVEGROUND PRIMARY PRODUCTIVITY AND DIVERSITY IN THE LOWLAND PUGEST SOUND PERMANENT PLOT NETWORK

Alexandra Kazakova, Justin Kirsch and Dylan Fischer – The Evergreen State College

Understanding variation in net primary productivity (NPP) in forest ecosystems is a major research priority in an age of global carbon concern. While forest productivity can vary over both abiotic and biotic gradients, other factors such as disturbance, succession stage, and biodiversity can also affect forest productivity. We used a new permanent plot observation network on the Evergreen State College Forest reserve to measure NPP an carbon stocks in a lowland Puget Sound second-growth forest. Allometric relationships between size and biomass were used along with repeat measures to calculate biomass, and biomass change within the plots. Interestingly, we found a positive relationship between forest tree diversity and forest productivity in our plot network. These findings could suggest more diverse forests are better carbon sinks in lowland South Puget Sound second-growth forests.

21. EFFECT OF IMPERVIOUS SURFACE ON MARINE WATER QUALITY IN SOUTH PUGET SOUND

Levi Keesecker, John Konovsky and Scott Steltzner – Squaxin Island Tribe

Impervious surface (IS) is widely used as an indicator of urban development and ecosystem health. The degradation of aquatic systems in urban landscapes can often be attributed to the amount of IS in a watershed which, in turn, is associated with changes in riverine hydrology, natural water filtration, and stormwater volume. Numerous studies have linked watershed imperviousness to water quality in streams; however, relatively few studies have explored the relationship between imperviousness and marine water quality. This study explores the relationship between watershed imperviousness and a suite of water quality parameters (ammonium-ammonia, chlorophyll, dissolved oxygen, fecal coliform, nitrite-nitrate, and orthophosphate) in seven marine regions in South Puget Sound. Yearly averages for Department of Health and Department of Ecology water quality measures were aggregated by marine region from 1995 - 1999. Shorelines considered to impact these regions were used to generate contributing watersheds using a 30-m digital elevation model in a GIS. Imperviousness by watershed was calculated using remotely sensed land use/land cover (LULC) data for Western Washington. The contributing watersheds for Budd Inlet, Carr Inlet, and Henderson Inlet contained the highest proportions of IS while the corresponding marine regions contained the highest concentrations of fecal coliform (FC); Pearson correlation analysis revealed a positive correlation between watershed imperviousness and average annual FC concentration ($r = 0.713$, $P < 0.001$). Correlations between imperviousness and the remaining water quality measures were not significant. The results suggest that, even at the landscape scale, imperviousness may be a good indicator of fecal bacteria in marine waters. That a significant correlation was detected at such a coarse scale suggests that future, more detailed analyses may yield additional relationships between LULC and marine water quality. The use of water circulation patterns to more precisely identify the impact of specific shoreline segments on water quality stations would likely improve results. Additionally, analysis that accounts for the spatial arrangement of IS, such as the proximity of IS to streams and shorelines, may yield additional relationships. In light of the adverse effects of elevated FC levels on economic, cultural, and recreational interests in South Sound, further investigation is warranted.

22. INFLUENCE OF WIND ON RE-SUSPENSION OF BACTERIA ON INTERTIDAL SEDIMENT IN OAKLAND BAY

John Konovsky, Levi Keesecker and Joe Puhn – Squaxin Island Tribe

In upper Oakland Bay, the critical period for elevated levels of fecal coliform (FC) is late summer when primary sources and transport mechanisms are limited. The intertidal water quality station in question (Station 614) is surrounded on all sides by others with lower bacteria levels. An investigation of potential secondary sources focused on bacteria growth on intertidal sediment and in marine snow. During 2007 low tides, weekly sampling of the sediment-marine snow interface documented a seasonal rise in FC levels peaking in September (544 MPN/100 grams DW). Over 27 weeks/54 samples, bacteria counts were lower in May (119) and November (393). Differ-

ences in monthly means were not statistically significant because of considerable variability and small sample size. A weak relationship was noted between FC levels on sediment and in the water column (R2 = 0.38). Wind and wave action is a likely transport mechanism to re-suspend bacteria in the water column. To test the hypothesis, FC levels in 65 marine water samples collected by the Department of Health at Station 614 between May 2002 and June 2006 were correlated with mean daily winds speeds and directions at the Shelton airport on collection day. An ANOVA with wind as a covariate was significant (P = 0.035). Wind speed was a significant covariate (P = 0.036) but the differences between wind direction quadrants were not significant (P = 0.829) likely due to data limitations. The investigation suggests that FC do survive and reproduce in summer on the surface of intertidal sediment. Under the right conditions, they can re-suspend and form a secondary source of pollution in marine water. Oakland Bay is particularly susceptible to wind and wave action. It is oriented along a SW-NE axis—prevailing winds come from the southwest. Station 614 is located at the northeast end of the bay—that geographic orientation provides a 5 mile fetch to accentuate the effect. Under these conditions, achieving water quality standards may be a challenge. However, it is important to recognize that recent extreme summer FC exceedances are limited to 2005-06. In 2002-04 and 2007, overall bacteria levels were much lower.

23. TEST OF A FIBER OPTICS SYSTEM TO MITIGATE IMPACTS OF OVERWATER STRUCTURE ON JUVENILE SALMONIDS

Kotaro Ono – University of Washington

Overwater structures play an important role in Puget Sound, Washington as part of WSDOT ferry terminal operations. But previous studies have shown that these structures induce several impacts on adjacent ecosystems. Overwater structures cause changes in light, wave energy, and substrate regimes in the environment and make significant modifications in the distribution of aquatic organisms underneath. Moreover, the light limitations from these overwater structures have some impacts on juvenile salmonids. They constitute a behavioral barrier for these organisms and can reduce prey availability underneath the dock. Particularly, small subyearling Chum and Chinook are affected because they must migrate in shallow water.

To mitigate these effects of overwater structures on juvenile salmonids, we are conducting experiments at the Port Townsend ferry terminal where a fiber optics lighting system is being installed to introduce light underneath the dock. This design is intended to reduce the shadow line beneath or adjacent to the dock. We will study the behavioral changes induced by the system on juvenile salmonids. Over and underwater video filming surveys in addition to snorkel surveys will be deployed to analyse and quantify changes in salmon behavior. Results from the study will be useful in guiding future overwater structure designs to mitigate potential adverse behavioural changes on salmon.

24. FORAGE FISH SPAWNING IN LIBERTY BAY

Theresa L. Liedtke, Collin D. Smith and Dennis W. Rondorf – U.S. Geological Survey

Significant portions of the shorelines in Puget Sound have been armored to support development. As part of a U.S. Geological Survey's Coastal Habitats in Puget Sound (CHIPS) investigation of urbanization effects on nearshore ecosystems, we initiated a study in 2007 of how shoreline armoring might affect beach dynamics and forage fish spawning. Egg sampling activities were focused on Pacific sand lance and surf smelt, two species of forage fish that spawn in the upper intertidal zone. We collected 480 sediment samples at 20 study beaches along 10 km of shoreline in and near Liberty Bay near Poulsbo, Wash. At each beach we sampled sediments using both transect and random sample approaches, and also measured a variety of shoreline attributes (e.g., sediment grain size, land use patterns, freshwater inputs, upland condition, shade, and bulkhead material, location and age). We counted 40,043 forage fish eggs in the samples, 94% of which were surf smelt. The highest egg densities were found in samples collected more than 8-ft above mean low low-water with fine to very-fine gravel substrate. Our overall goal is to develop a model to predict the probability of forage fish spawning on a segment of shoreline based on its shoreline attribute data and urban indicators of adjacent lands (e.g., densities of impervious surface, parcel size, septic systems). We sampled additional beaches near Port Susan during winter 2008 in our pursuit of developing a broadly applicable predictive equation. While the first few years using this approach may be somewhat descriptive, it will ultimately lead us toward understanding the dynamics that lead to forage fish spawning on some beaches and not on others.

25. RESULTS FROM THE SOUTH PUGET SOUND DISSOLVED OXYGEN STUDY: 2006-2007

Carol Maloy, Julia Bos, Skip Albertson, Mya Keyzers, Mindy Roberts and Greg Pelletier – Washington Department of Ecology

In 2006, the Washington Department of Ecology embarked on an intensive data collection and modeling effort to characterize water quality and hydrodynamics of South Puget Sound. We present results from monthly profiles at 80 marine water stations and monthly tributary and waste-water treatment plant monitoring. These findings are used to evaluate nitrogen inputs and persistent water column stratification effects on near-bottom dissolved oxygen for several inlets, including Budd, Case and Carr inlets. In addition, findings from current meter studies show that wind patterns determine the net direction of circulation in the western part of the basin, which influences distribution of low dissolved oxygen zones. Benthic flux studies in these low oxygen zones show that sediment processes alone are not responsible for low near-bottom dissolved oxygen. These studies will be used in the South Puget Sound model to simulate current conditions. The model will be applied to a variety of management scenarios in order to determine nitrogen load reductions necessary to improve water quality.

Reference

Albertson, S., J. Bos, K. Erickson, C. Maloy, G. Pelletier, M. Roberts, 2007. Quality Assurance Project Plan: South Puget Sound Water Quality Study Phase 2: Dissolved Oxygen. Washington State Department of Ecology and Western Washington University. Ecology Publication No. 07-03-101. http://www.ecy.wa.gov/biblio/0703101.html

26. ENVIROINMENTAL FACTORS INFLUENCING THE ABUNDANCE AND DISTRIBUTION OF *Alexandrium catenella* IN QUARTERMASTER HARBOR

Julie Masura, Laura Nokes, Cheryl Greengrove, Audrey Hackett and Kelly Scholting – University of Washington-Tacoma

Quartermaster Harbor (QMH), on the south end of Vashon Island, is a documented hot spot for blooms of *Alexandrium catenella,* a dinoflagellate that causes paralytic shellfish poisoning (Nishitani and Chew 1984). *A. catenella* spends part of its life cycle as a cyst in the sediment before germinating to become a bloom. In 2005-2006, as part of a UWT/UWS ECOHAB/NOAA funded study, surface sediments of QMH were found to have two orders of magnitude higher *A. catenella* cyst concentrations than anywhere else in Puget Sound (Horner *et al.* 2006). Our work is focused on learning more about the environmental factors influencing the abundance and distribution of this organism in QMH.

Monthly water sampling and plankton surveys were carried out from October 2006 – December 2007 along a seven-station transect in QMH. CTD profiles of temperature, salinity, dissolved oxygen, chlorophyll, fluorescence and transmissivity were obtained and water samples collected and analyzed for dissolved oxygen, chlorophyll, nutrients and plankton. In addition, an instrumented mooring in central QMH recorded timeseries of near surface and near bottom temperature and salinity over this sampling period.

The entire water column in QMH was well mixed in winter and stratified in summer with a pycnocline at about 4 m. Slight differences in water properties existed between the inner (6 m average depth) and outer portions (12 m average depth) of the bay in both seasons. Water characteristics and plankton communities were substantially different from inside the bay to Commencement Bay just outside the mouth. Seasonal and spatial comparisons of water properties and plankton community and abundance will be presented.

Future work will include continued monitoring of environmental conditions in QMH, as well as collaborations with a number of agencies to model circulation in the bay in an effort to understand the distribution of *A. catenella* cysts in the sediment.

References

Horner, R.A., C.L. Greengrove, J.R. Postel, J.E. Gawel, K.S. Davies-Vollum, A. Cox, S. Hoffer, K. Sorensen, J. Hubert, J. Neville, and B.W. Frost. Alexandrium cysts in Puget Sound, Washington, USA. In: Ø. Moestrup et al. (Eds.) Proceedings of the XII International Conference on Harmful Algae, Copenhagen, DK, 4-8 September 2006. International Society for the Study of Harmful Algae and Intergovernmental Oceanographic Commission of UNESCO.

Nishitani, L. and K.K. Chew. 1984. Recent developments in paralytic shellfish poisoning research. Aquaculture 39:317-329.

27. CHARACTERIZATION OF DIOXINS/FURANS AND OTHER CHEMICALS OF CONCERN IN SEDIMENTS AND TISSUES, BUDD INLET, OLYMPIA, WASHINGTON

Russ McMillan, M.S.[1] and John Nakayama[2]
[1]Washington Department of Ecology, [2]Science Applications International Corporation

In 2007, the Washington State Department of Ecology conducted a study of Sediment Management Standard (SMS) chemicals and dioxins/furans in Budd Inlet, Olympia, Washington, to determine the nature and extent in sediments, possible sources, and uptake by biota. The study was prompted by the presence of elevated dioxin/furan (dioxin) concentrations in areas scheduled for routine maintenance dredging within the Olympia Harbor Navigation Channel and Port of Olympia berthing area. Sediment sampling included surface grabs and cores, and tissue sampling targeted Starry flounder, littleneck clams, bent-nosed clams, and ghost shrimp. Sediment standards were exceeded in three of twenty five surface sediment samples. Chemicals that exceeded the standards included polycyclic aromatic hydrocarbons, phthalates, and mercury. Dioxins were dispersed throughout Budd Inlet, with TEQ concentrations in surface sediments (0-10cm) ranging from 2.9 to 60.3 pg/g. Dioxin concentrations were highest in ghost shrimp at each of the three locations where shrimp and clams were collected. Also, tissues of clams and ghost shrimp generally reflected the dioxin levels in sediments they were collected from. Starry flounder had lower average tissue dioxin concentrations than clams or shrimp. All sediment samples in Budd Inlet had a similar dioxin/furan congener profile, or fingerprint, with a clear visual match to the known profile of congeners in pentachlorophenol, a wood preservative. The results of this study will provide information necessary for developing possible alternatives and priorities for source control or cleanup of dioxins in Budd Inlet.

28. FISH HABITAT USE AND CHEMICAL CONTAMINANT EXPOSURE AT RESTORATION SITES IN COMMENCEMENT BAY, WASHINGTON

O. Paul Olson[1], Lyndal L. Johnson[1], Gina M. Ylitalo[1], Casimir Rice[1], Tracy K. Collier[1] and Jeff Cordell[2]
[1]NOAA Fisheries, [2]University of Washington

Commencement Bay, WA was the first Superfund site designated in marine waters of the United States. Under the NRDA process, several sites have been subject to restoration activities; of these, seven sites were sampled in 2002 and 2003 for fish assemblage composition, sediment chemistry, and tissue and stomach content residue analysis in selected species (Chinook, coho, pink and chum salmon, and Pacific staghorn sculpin). This poster presents the results of the first two years of a multi year monitoring effort. The objectives were to monitor potential changes in fish usage, and degree of chemical contaminants in sediments and fish after restoration of these sites. Sampling showed that all sites were being utilized by fish species, with differences in fish assemblage and salmon usage which largely reflected the habitat types. Species richness as well as total number of fish captured increased from spring to maximum values in early summer. Hatchery Chinook and coho greatly outnumbered unmarked juveniles in both sampling years. Juvenile hatchery Chinook and coho were larger than unmarked juveniles in both sampling years, although only significantly so only in 2002. Diet analysis of Chinook revealed a shift to fish prey at sizes over 90mm at most sites. There was evidence of chemical contamination in fish and sediments from all sites. Sediments at all sites were contaminated by PAHs at concentrations above sediment cleanup goals, and DDTs were unexpectedly high at one site, with evidence of a relatively fresh source of DDT. Body burdens of PCBs in juvenile Chinook and chum salmon from two sites were at threshold concentrations associated with adverse effects in salmon. These results raise interesting questions regarding restoration of smaller areas within a larger Superfund site undergoing remedial activities.

29. GOLDSBOROUGH CREEK POST-DAM REMOVAL SMOLT MONITORING STUDY

Joseph Peters – Squaxin Island Tribe

Goldsborough Creek is located in Mason County, Washington within the Hammersley Inlet-Oakland Bay Watershed. It is the largest stream system within WRIA 14. Prior to 2001, Goldsborough Creek had been dammed since 1885 at river kilometer 3.4, limiting adult salmonid migration for over 100 years. Five salmon species, coho (*Oncorhynchus kisutch),* chum *(O. keta),* steelhead (*O. mykiss)*, cutthroat (*O. clarkii*) and Chinook *O. tsawytcha)* were documented as using Goldsborough Creek, but were limited to primarily the lower watershed, below the dam. A limited number of adult coho passed the dam using a failing fish ladder. Blocked passage and low survival rate of out-migrating coho from above the damn contributed to decreased coho production. Data indicating that removal of the dam would open over 25 miles of stream habitat and increase salmonid production led to its removal in September, 2001. Lead agencies of the project were The Squaxin Island Tribe, Green Diamond Resource

Co. (formally Simpson Timber Company) and the U.S Army Corps of Engineers. A five year post-dam smolt monitoring study was implemented in 2002 to investigate the effects of dam removal on salmonid production. Two Rotary Screw traps were installed above and below the dam site early April through late June when coho smolt outmigration occurred. Data from 2002 estimated 15,921 chum fry above the dam site. Pre-dam removal studies encountered zero chum fry above the dam. In 2003, an estimated 61,844 coho smolt left the Goldsborough creek watershed. Of these smolts 40,840 (66%) originated from above the dam site. In 2004 smolt outmigration estimates declined to 5,574. However, throughout the study there was an overall trend of an increase in coho smolt production. Data from 2003-2006, coho production showed 75% of the total out-migrating population to have originated from above the dam site. Based on existing data collected from the post-dam smolt monitoring study we can deduce that coho and chum salmon benefited from the removal of Goldsborough Creek dam.

30. DESCHUTES RIVER MAINSTEM BANK EROSION: 1991 TO 2003

Mary Raines[1], John Konovsky[2] and Colleen Seto[2]
[1]LEG, [2]Squaxin Island Tribe

Bank erosion along the mainstem Deschutes River, and particularly erosion of glacial terraces, is generally considered to be a major source of sediment entering the river. To support a TMDL for fine sediment, bank erosion along the mainstem was estimated for the time period 1991 to 2003 and compared with estimates for previous time periods. Erosion sites were identified and mapped by comparing sequential aerial photographs, a subsample was field checked, and area/volume calculations completed with GIS. Overall sediment yield from bank erosion for the period 1991 to 2003 was 62,000 yd^3/year. From 1981 to 1991, Collins (1994) reported 87,000 yd^3/year. More sediment was generated from fewer sites in the earlier period, and included more large volume glacial terrace erosion sites. Erosion of the floodplain dominated bank erosion in the later period. For both time periods, bank erosion in general is concentrated in the upper and lower reaches of the mainstem and along reaches immediately upstream of natural and man-made channel constrictions. The pattern of greater glacial terrace erosion in 1981 to 1991 may reflect erosion associated with the high magnitude storm of record in January 1990. Floodplain erosion patterns in the mainstem during the 1991 to 2003 period may be more reflective of post-1990 storm sediment redistribution during higher frequency, lower magnitude discharge events. Erosion estimates from the glacial terraces were also compared with net sediment inputs to the Deschutes River from other sediment sources in the basin. Estimates averaged from 1972 to 2003 indicate glacial terraces contribute 68% of the total, upper watershed landslides 23%, and unpaved forest roads 9%. Anthropogenic sources account for an average of 28% of net sediment inputs in the entire watershed and approximately 50% in upper watershed source area. Fines dominate the sediment input from all sources estimated at 76% of the total. The partial list of sediment sources quantified in this report accounts for 68-78% of estimated sediment exiting the Deschutes River as defined by dredging and bathymetric records of Capitol Lake during the 31 years from 1972 to 2003.

31. HENDERSON INLET WATERSHED CHARACTERIZATION

Owen Reynolds and Barb Wood – Thurston County

The objective of this study was to determine the feasibility of a watershed-based National Pollutant Discharge Elimination System (NPDES) Phase II permit in consultation with local partners and the Washington State Department of Ecology. Thurston County, in addition to the cities of Olympia, Lacey, and Tumwater have been designated Phase II permittees and Washington State Department of Transportation is a NPDES Phase I permittee in Thurston County. Separate permits could lead to duplicative efforts of planning, assessment, and monitoring as each entity addresses the six core programs of the Clean Water Act, and other requirements under the Safe Drinking Water Act, Clean Endangered Species Act, and Shoreline Management Act. This work presents the results of methods developed by Gersib et al. (2004), with refinements made by Thurston County staff. The report provides a scientific approach to analyzing the ecological and biological processes that maintain a healthy watershed. At a landscape scale, we subdivided the Henderson Inlet study area into 64 drainage analysis units (DAU) and used landscape attributes to characterize the condition of key ecological processes (movement of water, sediment, large wood, pollutants, and heat) and biological processes (aquatic integrity and upland habitat connectivity). We did this by interpreting existing land cover and natural resource data and by developing databases that identify the location and condition of wetland, riparian, and floodplain resources. We then identify targeted landscape areas having the potential to optimize environmental benefits if restored. At the site scale, we iden-

tify all possible candidate wetland, riparian, and floodplain restoration sites through photo and Geographical Information System (GIS) interpretation of the study area. In addition to creating these natural resource datasets, we developed a stormwater retrofit database to provide additional options for treating stormwater in urban areas. In the study area, we evaluated 172 riparian areas, over 262 wetland areas, and 26 floodplain areas for a total of 460 potential sites. Those sites were further evaluated for potential stormwater retrofit and fish habitat restoration potential. Of these sites, 207 potential wetland, floodplain and riparian restoration sites met our minimum criteria for potential use for restoration.

32. UNDERSTANDING THE CLAY CHEMISTRY OF THE PUGET SOUND: DISTINCTIONS IN ESTUARINE CLAY MINERALOGY

Nadine L. Romero[1] and John Konovsky[2]
[1]Thurston County, [2]Squaxin Island Tribe

This poster session presents the clay petrography of several depositional-weathering profiles in the Puget Sound including estuarine sediments from Oakland Bay, Little Skookum Inlet and an inland Pleistocene glacio-lucustrine body found at Skookum Creek. We will show comparisons and distinctions in clay mineralogies within the various Puget Sound waterways. The types of clay mineralogy found using X-Ray Diffraction were smectites, kaolinite, chlorite, illite, quartz and feldspars in various percentages.

Sorption characteristics and sorptive behavior of sediments from weathered basalts and older Pleistocene glacial terrane not only affects low-temperature aqueous geochemistry but may hold keys for biologists and water quality specialists in understanding the longevity and adherence of contaminants including viruses, bacteria and fecal-coliform, and other microbes in Puget Sound sediments. Very little research has been conducted in this area, yet without 'baseline' mineralogic analysis and attempts to characterize the clay mineralogies we miss out on a more robust understanding of the geo-microbial world and "making connections across the ecosystem".

33. EFFECTS OF WATERSHED HABITAT CONDITION ON COHO SALMON PRODUCTION IN THE DESCHUTES RIVER

Paul Schlenger[1], Mike Schiewe[1], Ray Hilborn[2], John Konovsky[3] and Scott Steltzner[3]
[1]Anchor Environmental, [2]Consultant, [3]Squaxin Island Tribe

Coho salmon (*Oncorhynchus kisutch*) production in the Deschutes River watershed has declined markedly since the 1980s. To inform decisions about habitat conservation and restoration strategies to support coho recovery in the watershed, the Squaxin Island Tribe initiated an investigation of the relationship between freshwater habitat conditions and coho production (project objective). The habitat-based population simulation model SHIRAZ was used to evaluate this relationship. The model inputs include: habitat condition data, coho population distributions, and functional relationships between habitat and coho production. The parameters used to characterize habitat conditions were: peak flows, low flows, high water temperatures, fine sediments, and large woody debris (LWD). By adjusting habitat condition inputs to the model to simulate habitat restoration, the model outputs provide estimates of resultant changes in the coho population size. Although freshwater conditions were intended to be the main focus of the investigation, model results indicated that marine survival was the primary factor influencing natural origin adult coho returns. Marine survival was defined as the survival of coho after their outmigration as smolts from Tumwater Falls to their return as adults approximately 18 months later. The model predicts that continuation of recently observed low marine survival rates will lead to extirpation of natural origin coho by 2039. Restoration of freshwater habitat can delay this outcome, but enhanced marine survival appears necessary for the full benefits of freshwater habitat restoration to be realized. Among the five freshwater habitat parameters whose restoration effects on coho were examined, the predicted improvements from greatest to least were: increase LWD, reduce fine sediments, reduce water temperatures, reduce peak flows, and reduce low flows. In conclusion, the poor salmon habitat conditions in the watershed decrease the coho population's productivity, making it vulnerable to periods of unfavorable conditions. Enhanced marine survival through habitat restoration and careful attention to management policies coupled with freshwater restoration of multiple habitat parameters should be implemented to reduce the likelihood of extirpation of the Deschutes River coho population.

34. IS RESTORING THE DESCHUTES ESTUARY FEASIBLE?

Tad Schwager – AMEC Earth & Environmental

The southern portion of Budd Inlet was dammed in 1951 to create Capitol Lake in Olympia, Washington. Water quality and sedimentation problems over time led to the formation of a Capitol Lake Adaptive Management Plan (CLAMP). The CLAMP Steering Committee initiated the Deschutes Estuary Feasibility Study in 2003, which attempted to evaluate the environmental, economic and social issues surrounding a proposal to remove the dam and restore tidal exchange to the lower Deschutes River. Four technical studies examined: 1) Sediment Transport & Hydraulic Modeling; 2) Reference Estuaries & Biological Conditions; 3) Engineering Designs & Cost Estimates; and 4) Net Social and Economic Benefits. These four studies and subsequent independent technical reviews did not identify any factors that would preclude restoration of estuarine processes to Capitol Lake. Dam removal was expected to result in re-establishment of estuarine hydrodynamics, mixing processes, and sediment transport processes typical of natural estuaries in Puget Sound. Estuarine habitats and ecologic processes would likely respond to these restored physical conditions. While the exact mosaic of a restored ecosystem will depend upon which design alternative is selected, there is no indication that the project would not establish ecologic benefits comparable to those provided by nearby reference estuaries in South Puget Sound. The next step is to address the environmental and socio-economic information gaps that were identified during review of the feasibility study, and to conduct a full comparative assessment of alternatives that includes restoration as well as continued lake management, using defined goals and objectives.

35. SURVEY TECHNIQUE FOR UNDERWATER DIGITAL PHOTOGRAPHY

Tim Siwiec and Sean Sheldrake – U. S. Environmental Protection Agency

This survey technique is an inexpensive method of conducting impact analysis and shoreline inventory of submerged aquatic resources by means of geo-located photo documentation. This technique is capable of identifying, mapping, and recording the exact x & y coordinates of submerged aquatic resources in low visibility waters. The geo-referencing of these objects is accomplished by a two person SCUBA dive team surveying the underwater environment by documenting the seafloor with an underwater digital camera taking photos at regular intervals along a contour of the shore. An inexpensive recreational GPS device is diver-towed in a raft directly above the dive team which records positions throughout the dive. Commercial software is later used to relate the GPS information to the digital photos resulting in geo-located digital photos that can be viewed on a map or in a GIS for later analysis of the seafloor environment.

36. QUANTIFYING SUBMARINE GROUND-WATER DISCHARGE AND NUTRIENT LOADING INTO THE LYNCH COVE AREA OF HOOD CANAL, WASHINGTON

F. William Simonds, Peter Swarzenski, Chris Reich, Jason Greenwood, Don Rosenberry and Anthony J. Paulson – U.S. Geological Survey

The loadings of nutrients to South Puget Sound from submarine ground-water discharge are likely controlled by hydrogeological and biogeochemical processes that are similarily controlling submarine ground-water discharge to Lynch Cove, Hood Canal. Although seawater entering the canal is the largest source of nitrogen, ground-water discharge also contributes significant quantities particularly during summer months, when increased nutrient availability in the canal directly effects eutrophication. The amount of nutrients entering Hood Canal from ground water is being estimated using direct and indirect measurements of ground-water discharge and analysis of nutrient concentrations. Ground-water discharge to Hood Canal is variable in space and time because of local geology, the hydraulic gradient in the ground-water system adjacent to the shoreline, and a large tidal range of 3 to 5 meters. Streaming resistivity surveys along the coastline of Lynch Cove and measurements of ground-water seepage and hydraulic-head gradients in the shallow near shore areas were used to characterize the spatial variability of submarine ground-water discharge and identify areas of enhanced ground-water discharge. In areas with confirmed ground-water discharge, shore-perpendicular resistivity profiles, continuous electromagnetic seepage-meter measurements, and continuous radon measurements were used to characterize temporal variations in ground-water discharge over several tidal cycles. The results of these investigations show that ground-water discharge into the Lynch Cove area of Hood Canal is highly dynamic and strongly affected by the large tidal range. In areas with a strong hydraulic gradient, ground-water discharge is spatially concentrated in or near the intertidal zone with increased discharge during low tide. Areas with a weak hydraulic gradient have lower discharge rates

and more spatial variability. Although nutrient concentrations in ground water are small, the flux of ground-water discharge may be large in some areas of the Hood Canal coastline; therefore, understanding the relative load of nutrients entering the canal from the ground-water pathway may be important.

37. DOES TURBIDITY OR GENETICS ACCOUNT FOR MORPHOLOGICAL DIFFERENCES IN EELGRASS (*Zostera marina*) AT TWO SITES NEAR LIBERTY BAY?

Renee Takesue, Jessie Lacy and Sandra Talbot – U.S. Geological Survey

The rooted marine plant *Zostera marina* (eelgrass) shows a high degree of phenotypic plasticity in response to environmental conditions. As part of a U.S. Geological Ssurvey's Coastal Habitats in Puget Sound (CHIPS) investigation of urbanization effects on nearshore ecosystems, we explored whether light limitation and/or genetics could account for observed morphological differences between two populations of *Z. marina* growing near Liberty Bay, Wash. At both eelgrass beds, we measured turbidity and pressure with *in situ* optical backscatter turbidity sensors to determine if resuspension of bottom sediment by boat wakes created a sub-optimal light environment for eelgrass growth. Plant metrics (shoot density, leaf length, leaf width) were measured near the sensors to relate leaf size to turbidity levels, and sediment grain size distributions were measured for comparison. Leaf tissue was collected for DNA genotyping to differentiate the two *Z. marina* populations and to measure the genetic diversity. Bed sediment at the eelgrass bed with smaller plants had a slightly larger mean grain size and was less well sorted than sediments at the bed with larger plants. Average water column turbidity was slightly higher over eelgrass bed with smaller plants and boat wakes were apparent in the pressure (water depth) record, but there was more variability in the turbidity data than could be accounted for solely by boat wakes. Thus, lower light levels could have accounted for smaller leaf sizes at one site, although boat wakes were not the only cause of higher turbidity. The *in situ* optical backscatter turbidity sensors were an effective way to record boat wake impingement on the low-tide terrace using the variance of pressure (water depth). Genetic analyses results were not yet available, but we expect to present them in our poster during the March 26 South Sound Science Symposium.

38. WASHINGTON COASTAL ATLAS: INFORMING MARINE SHORELINE RESOURCE PLANNING AND MANAGEMENT

Kathy Taylor[1], Darby Veeck[1], Dan Saul[1] and Tim Strickler[2]
[1]Washington Department of Ecology, [2]Washington Department of Natural Resources

The Washington Coastal Atlas http://www.ecy.wa.gov/programs/sea/sma/atlas_home.html provides geographically linked information to support coastal zone management and has been significantly improved in the past year. It now includes information on:

- habitat features such as wetlands and eelgrass,
- physical features such as drift cells and slope stability,
- regulated features such as rivers and streams regulated by the Shoreline Management Act,
- shoreline modifications such as piers and docks, and jurisdictional delineations such as cities and watersheds.

The Washington Coastal Atlas also offers:

- downloadable current and historic oblique aerial photography of Washington shorelines;
- land cover information for 1991, 1996, and 2001; and reports showing the amount of change in forest canopy cover and impervious surface cover between these years at a county, watershed and subbasin scale.

The Washington Coastal Atlas is easily used by local government planners and resource managers. Other groups using the coastal atlas include Tribal governments, state and federal land and resource managers, researchers, consultants, and interested citizens. The improved Washington Coastal Atlas is the result of a cooperative effort between Washington Department of Ecology, Puget Sound Action Team (now Puget Sound Partnership), and Washington Department of Natural Resources. Current work is directed towards forming an interagency group to collaborate on future development of the Washington Coastal Atlas and to determine additional data layers that would be appropriate add to the Atlas. Coastal Atlases have been used successfully, within the United States and in other countries, to improve data accessibility for environmental and resource management and efforts are currently underway to find ways to achieve interoperability among Coastal Atlases. Plans for the future of the Washington Coastal Atlas include adding information on public access to the marine shorelines of Washington. In addition, the Department of Ecology has submitted a proposal for a project which, if funded, would allow further development of the Washington Coastal Atlas to display information on Puget Sound shoreline erosion. The Washington Coastal Atlas is

currently an important tool providing information valuable for Shoreline Management and will contain even more relevant information in the future.

Abstracts Not Presented in Poster Format

39. OLYMPIA STREAM RECOLONIZATION STUDY

Jamie Glasgow – Wild Fish Conservancy

The City Of Olympia intends to replace two significant fish barrier culverts in 2008-2009. These culverts are located the mouths of Ellis and Schneider Creeks in Budd Inlet, where they prevent or compromise the upstream migration of the anadromous fish that were historically present. WDFW estimates that the Ellis culvert is currently 67% passable, while the Schneider culvert is a complete barrier. To evaluate the effectiveness of the proposed fish passage restoration efforts and assess the effects of recolonization on the watersheds' established fish populations, Wild Fish Conservancy (WFC) is characterizing fish use in these two watersheds before and after fish passage is restored. The study results will document changes in the fish populations that result from the restoration of 100% fish passage at the mouths of these two watersheds, and will allow for inter-basin, and inter-annual within basin comparisons of fish population parameters.

To this end, WFC has since 2005 been performing salmon spawning, redd, and prespawn mortality surveys in Ellis and Schneider Creek watersheds for six weeks between mid-October and late-December. In summer 2006 and 2007, WFC performed a single-pass electrofishing survey of the lower 400 meters of each watershed to identify, enumerate, measure, weigh, and PIT tag (as appropriate) the fish encountered.

As expected, we have observed no adult salmon in Schneider Creek where the purported full barrier exists. We documented adult chum and coho salmon in Ellis Creek upstream from the partial barrier at the mouth, but their distribution was found to be abbreviated by a full barrier culvert at Gull Harbor Rd. Both watersheds support significant coastal cutthroat trout and sculpin populations, and we documented brook lamprey in Ellis Creek. To date a total of 258 cutthroat have been brought to hand, measured, and weighed. 92 cutthroat have been PIT tagged; 7 that were tagged in 2006 were recaptured in 2007. Cutthroat densities were found to be greater in Ellis (0.06/m2) than in Schneider (0.04/m2), while mean cutthroat fork lengths were greater in Schneider (129mm) than in Ellis (84mm). WFC will monitor these and other salmonid population structure parameters in the years following the City of Olympia's fish passage restoration projects.

40. MICROBIAL SOURCE TRACKING USING BACTEROIDES IN OAKLAND BAY

John Konovsky – Squaxin Island Tribe

Oakland Bay has two areas where increased levels of fecal coliform (FC) bacteria have been noted—the extreme upper end of the bay and in the more centrally located Chapman Cove. Several years of extensive efforts to track sources with conventional means was inconclusive, so Dr. Stephanie Harris at EPA Manchester Lab agreed to analyze 96 water samples for presence or absence of human and ruminant feces. The methodology used was a polymerase chain reaction (PCR) assay of host differences in *Bacteroides*. The primers tested included one for general bacteriodes (GB 32), two for human (HF 183 & HF 134) and two for ruminants (CF 128 & CF 193). Five sites were selected at the upper end with seven sites in Chapman Cove. Six days were sampled in the summer of 2006 and two days in the winter. In the upper bay, 15 summer samples had < 100 FC/100 ml and 15 were > 100. When levels were < 100, 39% of the samples had human markers present and 69% had ruminant. When levels were > 100, 94% had human markers and 87% had ruminant. In Chapman Cove, 27 summer samples had < 100 FC/100 ml and 15 were > 100. When levels were < 100, 19% of the samples had human markers present and 35% had ruminant. When levels were > 100, 89% had human markers and 100% had ruminant. Combining all 24 winter sample results from both areas, human markers were present in 12% of the samples and ruminant markers in 38%. The only site never to have human markers present was the uppermost site in Chapman Cove likely because no humans are resident nearby. The relatively common presence of human bacteria led Mason County to more thoroughly investigate septic failures. To date, several have been identified and repaired.

41. TEMPERATURE REGIMES AND COHO PRODUCTION IN SOUTH SOUND LOWLAND STREAM SYSTEMS

John Konovsky – Squaxin Island Tribe

Rain-fed, lowland streams in deep South Sound form important refugia for numerous resident and migrant fish and wildlife species. Most unique is a run of summer chum that arrives as early as August, and specializes in spawning in very small streams ((summer low flows = 5-15 cfs) dominated by groundwater gain just upstream of their mouths. These stream systems have uncommon gradient, temperature profile and seasonal habitat constraints. With little topographic relief, they begin in numerous, depressional lakes and wetlands, and often have additional lakes or wetlands mid-reach. Lower reaches increase in gradient as they cut down through the underlying hydrostratigraphic units to discharge into the sound. Their typical late summer longitudinal temperature profile begins in the mid-20^{o}C range upstream and cools to as low as 14^{o}C downstream. In WRIA 14, Skookum, Mill, Goldsborough, Johns and Cranberry Creeks had summer high resolution thermal infrared (TIR) imagery flown in 2003 or 2004 by Watershed Sciences. All were cooler at their mouths than their headwaters or mid-reach wetlands or lakes. Numerous springs and seeps were identified in their lower "canyon" reaches. The smaller the stream was the greater the cooling effect of groundwater influx. A 2007 study completed by Stillwater Sciences identified cool, summer juvenile rearing habitat as the primary factor limiting the size of coho populations in these lowland stream systems. Reaches upstream of mid-reach lakes or wetlands often provide suitable temperatures for rearing, but the lake or wetland currently forms a thermal barrier and limits available habitat. Many headwater and mid-reach lakes and wetlands have been extensively modified by nearby land development activities or direct conversion of wetlands into lakes. The impact of these changes on stream temperature regimes is poorly understood. No one has modeled natural conditions to understand if the current thermal barriers are a relatively recent phenomena. Until such analysis is completed, it is impossible to fully understand their history and importance in limiting coho populations.

42. DESCHUTES RIVER TRENDS IN SPAWNING GRAVEL FINE SEDIMENTS

John Konovsky and Joe Puhn – Squaxin Island Tribe

As part of a Washington State Department of Ecology TMDL technical study, the Squaxin Island Tribe investigated fine sediment trends in spawning gravel in the Deschutes River during the summer of 2004. The same five locations and TFW methods (riffle crest inventory, McNeil sampler and volumetric analysis of 69 samples) were used as in a 1995 investigation by Dave Schuett-Hames & Ian Child. The five sites are distributed evenly along the mainstem from near the upper falls on Weyerhaeuser property to Pioneer Park in Tumwater. For statistical analysis, a two-factor (location and year), fixed effects ANOVA model was run without any data transformations after Levene's test did not allow rejection of the hypothesis that the data have homogeneous group variances. Scheffe's multiple comparison procedure was used to compare locations. The model was significant in explaining the variability of the data (P = 0.002). The site (location) factor was significant (P = 0.003) while the year factor was not (P = 0.475). The interaction (location X year) was not significant (P = 0.095). The only sites that were found to be significantly different from each other (P < 0.01) were the uppermost (16%) and lowermost sites (22%). There were significant differences between sites when two years data were adjusted for year effects and averaged across years for each site. There was a weak trend of increasing fine sediment downstream. Such a trend is not unexpected—the river begins with bedrock as a substrate, then continues down through the mid-section where agricultural activity has damaged the riparian zone. Overall the results suggest that fine sediment levels in spawning gravel were consistent over the last 10 years. General conditions are poor with a mean of about 19% fine sediment. No change is yet evident after adoption of the 1999 Forest and Fish Agreement.

43. AN ANALYSIS OF POTENTIAL FACTORS LIMITING COHO SALMON POPULATIONS IN MILL AND SHERWOOD CREEKS, SOUTH PUGET SOUND, WASHINGTON

Scott Steltzner – Squaxin Island Tribe

In 2007 conceptual and life history models were developed for the Sherwood and Mill Creek systems. Limiting factors were identified in these systems and management actions were proposed to address the factors that were found to be most limiting. The largest drivers of the model were found to be low marine survival, summer high temperatures, and decreased attractant flows in the late fall/early winter that did not adequately seed the upper watersheds.

44. EDT ANALYSIS OF HABITAT POTENTIAL AND RESTORATION OPTIONS, SOUTH PUGET SOUND, WASHINGTON

Scott Steltzner – Squaxin Island Tribe

In 2004 a life history model estimates capacity, productivity, equilibrium were developed for the Johns, Skookum, Goldsborough, and McClane Creek systems. Limiting factors were identified in these systems and management actions were proposed to address the factors that were found to be most limiting. Restoration actions were proposed that if implemented would result in tripling of the coho populations in these systems.

45. JUVENILE SALMONID ACOUSTIC TRACKING 2004-2007

Scott Steltzner – Squaxin Island Tribe

Vemco VR2 acoustic receivers have been placed in the narrow inlets that characterize South Puget Sound (SPS) from 2004-2008. 27 individual receivers were placed in 8 discrete lines to intercept tagged animals. Juvenile hatchery coho salmon were implanted with Vemco tags from 2004-2006, wild coho smolts from Mill Creek in 2006, hatchery coho released into the Deschutes River in 2005, and hatchery yearling Chinook from the Deschutes hatchery in 2005. Wild cutthroat trout from the marine waters of SPS have been tagged and released from 2005-2007. In all cases early marine survival, migration routes, and gross habitat usage patterns have been established. The detection lines have also picked up animals from other investigations originating inside as well as outside of SPS including: six gill sharks, seven gill shark, opal eye squid, lingcod, steelhead, and adult and juvenile Chinook.

46. MASON COUNTY NEARSHORE HABITAT ASSESSMENT

Scott Steltzner – Squaxin Island Tribe

In 2004 a nearshore assessment of the Mason County Shoreline was conducted. An evaluation and model were employed that was geared toward juvenile salmonids. Priority areas for restoration and conservation were recommended. Attributes evaluated include: Riparian vegetation, salt water marsh, intertidal vegetation, eelgrass, forage fish, sediment transport, proximity to fresh water sources, shoreline armoring, docks, boat ramps, marinas, bridges.

47. MODELING COHO SALMON POPULATIONS IN MARINE AND FRESHWATER ECOYSTEMS OF SOUTH PUGET SOUND

Scott Steltzner – Squaxin Island Tribe

Coho salmon (*Oncorhynchus* kisutch) populations in South Puget Sound (SPS) began a precipitous decline in the late 1980's. Marine survival rates plunged from an average of over 25% in the mid 1980's to less than 1% by the late 1990's. This has corresponded with an equally steep drop in freshwater production. To investigate this phenomenon a suite of models were created to look at marine trophic interactions along with freshwater habitat based population simulations. Ecopath was used to create a mass balance model of SPS for the mid 1970's and the late 1990's. Ecosim was used to simulate a dynamic model that predicted the decline of coho production seen in SPS. Model results from this exercise suggest that SPS is experiencing a warmer and dryer weather pattern that is unfavorable for coho populations. Ecosystem Diagnostic and Treatment (EDT) was employed on Goldsborough, Skookum, McLane, and Johns Creeks in SPS to assess coho habitat potential, identify limiting factors and evaluate restoration alternatives. The EDT method estimates capacity, productivity, equilibrium abundance, and life history diversity for the current condition as well as for the hypothesized historic condition. EDT predicts that freshwater productivity has decreased by 42% due to degradation of key habitats. Two stock production models were also employed on the Deschutes River (Shiraz) and Mill, Sherwood, and Cranberry Creeks (unnamed model). Both of these models rely on establishing functional relationships between habitat conditions and coho production within the freshwater systems. Both models were extremely sensitive to the low marine survival currently being experienced and predict extirpation of coho by mid century under current habitat conditions. A restoration approach that increases marine survival, addresses fresh water temperature concerns, increases the amount of large woody debris in streams, decreases fine sediment in spawning beds, and address flow issues is necessary.