PLENARY SESSION

Sixty years of environmental change in the world's largest lake – Lake Baikal, Siberia

Stephanie Hampton, Professor, School of the Environment; Director, Center for Environmental Research, Education and Outreach; Washington State University

Lake Baikal is a lake often described in superlatives. It is the highest volume, oldest, and most biologically diverse freshwater lake, harboring many endemic cold-adapted species. Russian-American collaboration has provided us with an unusual opportunity to examine the nature of Lake Baikal's responses to both long-term warming trends and shorter term climate variability. Three generations of a single family of Siberian scientists have collected over 60 years of high-resolution data on plankton, temperature, and water clarity in Lake Baikal. Using time-series statistical approaches we have established that Lake Baikal has been warming rapidly, and that seasonal timing and species composition have shifted over time. Although Lake Baikal is a notorious 'outlier' in ecosystem comparisons, such as biodiversity-latitude gradients, cross-system comparisons also reveal similarities with other large deep lakes that together help us understand past, present and future change for freshwater resources of the world.

POSTERS

Role of Log Mat Biofilm in Nutrient Cycling of Spirit Lake, Mount St. Helens National Volcanic Monument

Shantelle Reamer (Undergraduate Student) and Jim Gawel, University of Washington Tacoma

Following the 1980 eruption of Mount St Helens, Spirit Lake was transformed. The blast and landslide resulted in complete physical, chemical, and biological alteration of the lake. Tens of thousands of trees were blown down and washed off the hillsides into the water, creating a log mat over two square kilometers in area. With nearly twenty percent of the lake surface still covered in logs more than 30 years later, we seek to examine ways in which the logs are affecting lake ecology. We hypothesize that the addition of a large shallow-water substrate area, as is created by the log mat in Spirit Lake, provides an extended habitat for primary production and enhances lake productivity following a large-scale disturbance. In this study, we examine the impact of this enormous log mat as a potential biofilm substrate and evaluate its role in the nutrient budget of Spirit Lake. Historically, humans have failed to understand the role of woody debris in water systems and have practiced the removal of logs for purposes ranging from timber harvest to the maintenance of waterway navigability. It has only been a couple of decades since ecologists have recognized the value of woody debris in streams and rivers. In undisturbed lakes throughout the Pacific Northwest, woody debris is ubiquitous; however, its role in lake productivity has been ignored almost completely. This study has implications for modifying our approach to the management of floating woody debris in oligotrophic lakes.

Analysis of new organic sediment material in Spirit Lake, Mount St. Helens National Volcanic Monument

Julieann Palumbo (Undergraduate Student) and Jim Gawel, University of Washington Tacoma

Disturbances due to human activity or natural forces can have significant impacts on ecological systems. It is important to understand the physical, chemical and biological changes in these systems in order to inform lake management strategies. Spirit Lake within Mount Saint Helens National Volcanic Monument offers an ideal setting to study how natural disturbance influence productivity in lake ecosystems through changes in lake morphology and chemistry. After the 1980 eruption, Spirit Lake was essentially remade a shallower basin with larger surface area and inorganic sediments, and thus measuring the accumulation of new organic sediment material is of great importance for understanding the cycling of nutrients and thus productivity in this changing system. In this study, six sediment traps were suspended above the bottom at various locations from June through September of 2014. Sediment collected was dried and analyzed for total nitrogen, phosphorous and carbon content. Results will provide information on the possible sources of nutrients and organic matter in the lake and surrounding watershed. Combined with work done on the log mat present in the lake, the spatial distribution of sediment accumulation rates will help determine how the movement of the logs affects the rate of sediment accumulation. The data obtained from analysis of sediment composition and accumulation in Spirit Lake can also be applied to understanding other natural and human disturbed lake ecosystems.

Establishing Carrying Capacity for Brook Trout on Owhi Lake, WA to Evaluate Current Stocking Strategies

Timothy Nathanial Taylor (Graduate Student) and Barry C. Moore, Washington State University, and Benjamin K. Cross, Colville Confederated Tribes, Fish and Wildlife Department

Carrying capacity of an ecosystem denotes the maximum population that can be sustained, given finite resources, such as food and space. Fisheries managers may use bioenergetics to quantify carrying capacity for maximizing sport fisheries; this requires accurate understanding of fish physiological requirements and elucidation of food webs. Owhi Lake, on the Reservation of the Colville Confederated Tribes in northeastern Washington, is the principal source of Brook Trout (*Salvelinus fontinalis*) used in reservation hatchery programs. Diet studies have identified crayfish, littoral invertebrates, and zooplankton as their principal prey. We are using Fish Bioenergetics 3.0, a model that couples species

energy requirements, prey abundance, and available habitat, to estimate Brook Trout carrying capacity in Owhi Lake. Gee minnow traps and SCUBA surveys have been utilized to estimate crayfish abundance, and plankton net methods for zooplankton densities. Benthic and littoral invertebrates communities have been quantified using Ekman dredge and D-frame kick net methods, respectively. Prey densities and caloric values, coupled with fish energy requirements, are modeling parameters used to estimate Brook Trout carrying capacity and to guide harvest and stocking management decisions.

The birds and the bees of paleolimnology: Did sockeye salmon historically spawn in Lake Roberta?

Andrew Child (Graduate Student) and Barry C. Moore, Washington State University

Historically, the Sanpoil River had productive spawning Chinook salmon and Steelhead trout runs. Since the Sanpoil River was connected to Lake Roberta, Washington, the river may also have sustained a productive Sockeye salmon population; reports suggest salmon spawned in the lake up to the 1940's. This study will employ stable isotope analysis to determine if salmon historically returned to Lake Roberta. Because salmon obtain >95% of their growth in ocean environments, their isotope signature differs from the nutrients and food sources available to freshwater organisms. As salmon return to freshwater to spawn, and eventually die, marine-derived nutrients become available for use by freshwater organisms. In that manner, marine isotopic signatures are transferred to freshwater algae and archived in lake sediments over time. Our study will compare carbon, nitrogen and sulfur isotope compositions of organic matter from Lake Roberta sediments to those collected from control lakes in the region. If Sockeye salmon historically spawned in the lake we would expect sediment organic matter to reflect a marine signature related to the large pulses of nutrients released from post-spawning salmon carcasses. Our study will guide fishery scientists in assessing if Lake Roberta should be reconnected to the river for restoring Sockeye salmon migration patterns.

Methods for tracking diel vertical migrations of zooplanktivorous Kokanee (Oncorhynchus nerka) and their zooplankton prey

Brian Lanouette (Graduate Student) and Barry C. Moore, Washington State University

Predator prey interactions in lake ecosystems often involve contrasting diel vertical migrations. For example, when kokanee, land-locked sockeye salmon that feed exclusively zooplankton, are present, zooplankton migrate below the photic zone during the day and into the epilimnion during the night to feed. This reduces predation risk from the sight feeding kokanee. Quantifying these predator/prey interactions is essential to understand availability of the kokanee food resources; sampling techniques must be adapted to this diurnal pattern. In Buffalo Lake, kokanee are the primary pelagic and planktivorous fish species. We have employed hydroacoustic surveys and profile net sampling to quantify zooplankton densities and their migration patterns. Our goal is to apply a realistic measure of food availability for application in bioenergetics modeling to determine Kokanee carrying capacity that will guide fishery management decisions.

Stable isotope analysis of fish liver in food web studies: a methods investigation

Megan M. Skinner (Graduate Student) and Barry C. Moore, Washington State University

Understanding fish diet is essential to effectively manage fish populations, especially those facing the dual threats of climate change and cultural eutrophication that may alter lake food web dynamics. Stable isotope analysis (SIA) is becoming an increasingly powerful tool to examine diet, predator-prey relationships, competition, and community feeding ecology. The use of liver in carbon (C) and nitrogen (N) SIA diet studies shows great promise, but methods need further refinement. The purpose of this study is to (1) assess the relationship between C:N ratios and $\delta^{13}C$ in the livers of rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), largemouth bass (*Micropterus salmoides*), and golden shiner (Notemigonus crysoleucas) sampled during the growing season in Twin Lakes, WA; (2) determine if mathematical normalization equations can be developed to account for lipid content; and (3) determine C and N isotopic fractionation in hatchery-raised trout liver and white muscle relative to that of hatchery

feed. These key SIA methods investigations ensure best methods are used to determine fish diet in future studies. Additionally, we believe mathematical lipid normalization equations derived from this study can reduce effort associated with liver SIA, improving the economy and ease of application.

First Detection of the Harmful Algal Toxin, Microcystin, in Puget Sound Mussels: Ecological Implications and Human Health Risk

Ellen Preece (Graduate Student), Washington State University

Direct exposure or consumption of water with cyanobacteria toxins, such as microcystin (MC), presents known health risks to humans. However, other exposure pathways, including consumption of contaminated seafoods is much less understood. Studies have documented MC accumulation in seafoods from freshwater environments, but monitoring for MC presence in marine ecosystems has been minimal, even though it is known that MC contaminated freshwater enter these environments. Shellfish are good bioindicators of the marine environment since they filter polluted waters and can bioaccumulate a wide range of toxins and pollutants. Shellfish are also an important dietary and economic resource in many coastal communities. In Puget Sound Washington, recent immigrants in lower socio-economic communities, depend on harvesting shellfish, such as mussels, for an inexpensive protein source. There is concern that mussels are exposed to MC from nearby lakes that drain into Puget Sound. In a pilot study, conducted in 2012, presence of MD was detected by liquid chromatography-mass spectrometry in mussels (*Mytilus trossulus*) from Puget Sound Washington. MC was found in all but one mussel exposed to discharge from a lake with maximum concentrations of 52.4 ppb. This is the first known report of marine bivalves in the Puget Sound region accumulating MC from freshwater sources.

SESSION 1

An Emerging Threat: Freshwater Harmful Algal Blooms and the Marine Environment

Ellen Preece (Graduate Student) and Barry C. Moore, Washington State University, and F. Joan Hardy, Washington Department of Health

Cyanobacteria toxins, such as the hepatotoxin microcystin (MC), are well known to contaminate freshwater ecosystems. However, monitoring MC in marine ecosystems has been minimal, despite evidence that MC derived from inland lakes can contaminate marine receiving waters. Freshwater organisms, such as finfish and shellfish, can accumulate MC, but due to minimal monitoring in marine environments, poisonings of marine biota have only occasionally been reported. In the western United States, numerous freshwater lakes subject to cyanobacteria blooms drain into the Pacific Ocean. Shellfish in this region are important economic resources that are commercially harvested for worldwide distribution and harvested locally for an inexpensive protein source. Our research has confirmed MC presence in Puget Sound mussels growing in water subject to runoff from a lake with maximum MC concentrations of 52.4 ppb. Other recent studies suggest marine shellfish in the Baltic Sea are accumulating MC from freshwater sources. Increased frequencies and duration of harmful algae blooms in worldwide water supplies increase the risk of food-web exposures to MC and other cyanobacteria-derived toxins. We believe freshwater cyanotoxins constitute an underappreciated hazard to marine organisms, and ultimately, to human health. The ecology of cyanotoxin movement in aquatic food-webs and potential for human exposure through consumption of seafood warrants greater research attention.

Using Peroxygen Algaecides to mitigate harmful algae blooms and other potable water contaminants

Terry McNabb, Aquatechnex, LLC

Increasingly, potable water reservoirs are experiencing eutrophication resulting in a shift towards cyanobacteria populations. In the Western United States this may be accelerating because of drought conditions in many areas. In addition to the acute and chronic treat cyanobacteria pose to human health, they also produce a number of compounds that when levels are elevated violate water quality standards. This can impact the delivery of that water for potable use. Traditionally, copper based algaecides were a key tool used by water utilities to reduce toxic algae blooms to the point where water delivery was possible. May states however have posed a regulatory environment where it is no longer possible to utilize these US EPA registered materials. Washington State does not allow the use of copper under their NPDES permit for the application of aquatic products to surface waters of the state. The California NPDES permit poses sampling requirements and if an exceedance is detected this is a permit violation. Peroxygen based algaecides are a newer tool that can perform very well in the role of providing relief when toxic algae blooms are present in surface water reservoirs. This paper will present information on how these products functions, their regulatory status and provide a case study for Silverwood Lake with results. Silverwood Lake is the terminal reservoir for the California Aquaduct and has a recent history of HAB blooms.

An Evaluation of Factors Associated with Microcystins in Nine Lakes in the Puget Sound Region (Washington, USA)

Jean Jacoby, Seattle University, Marisa Burghdoff and Gene Williams, Snohomish County Public Works, Lorraine Read, TerraStat Consulting Group, and Joan Hardy, WA Department of Health

Four cyanotoxins, cyanobacteria species abundance, and limnological variables were monitored bimonthly June-October 2012 in nine lakes in the Puget Sound lowlands region. The objective of this study was to evaluate factors that were associated with cyanotoxicity in these lakes. Microcystin (MC) was the most commonly detected cyanotoxin and was detected in all nine lakes at least once. Anatoxin-a was detected at lower frequency in six lakes whereas saxitoxin was measured in only one lake and cylindrospermopsin was not found in any of these lakes. The highest MC concentrations were found in the lakes with the highest nutrients, lowest TN:TP ratios, highest cyanobacterial abundance, and the

highest composition of potential MC-producing cyanobacteria. Microcystis was present in half of the samples where MC was detected and in the majority of observations above 1 µg/L (91%). Non-parametric classification trees and decision forests were used to predict membership in MC concentration categories for two models: 1) Presence/Absence of MC, and 2) Four MC categories: Non-detected (≤ 0.05 µg/L), Low (> 0.05 and ≤ 1 µg/L), Moderate (> 1 and ≤ 6 µg/L), and High (> 6 µg/L). The presence/absence of MC in the lakes was largely predicted by TN:TP ratio and the abundance of potential MC-producing cyanobacteria. These models indicate that thresholds for TN:TP ratios and cyanobacterial abundance may be useful in evaluating public health risk due to MC in lakes in this region.

The puzzle of managing lakes when the blooms are both toxic and patchy: Green Lake as a case study in difficult choices.

Sally Bartley Abella, King County Water and Land Resources Division

Green Lake has experienced measurable microcystin toxicity from midsummer through fall since at least 2012, which concentrates along downwind shorelines due to the large fetch and shallow depth of the lake. This causes transitory small areas of very dense algae, while other areas appear almost free of cyanobacteria. High recreational demand complicates management decisions and activities to allow as much recreation as possible while still safeguarding public health and safety.

SESSION 2

Didymosphenia geminata Nuisance Mats in the Intermountain Pacific Northwest: Present Status and Future Management Strategies for a Misunderstood Diatom

Mary K. Coyle (Graduate Student) and Frank Wilhelm, CNR, Megan Nissley, CRISSP REU Intern, and Bahman Shafii, Statistical Programs, University of Idaho

Covering river bottoms with thick mats resembling sewage or wet toilet paper, the diatom *Didymosphenia geminata* has rapidly gained notoriety among aquatic ecologists and water recreationists. The objective of this study was to analyze this species presence throughout the intermountain west and to experimentally examine phosphorus enrichment as a management strategy to reduce *D. geminata* nuisance mat infestation of the Kootenai River in Libby, Montana. By collecting and analyzing algae scrapings, *D. geminata* cell and mat presence throughout northern Idaho and northwest Montana was mapped with ArcMap v.10.1 establishing a historical reference for this species and nuisance mats for the region. Concurrently, an experimental flume system was designed and used to test applications of dissolved phosphorus. The addition of a potassium phosphate dose at all 6 concentrations, ranging from 0.5 to 8 µg/L, resulted in a statistically significant decrease in in the stalk length of *Didymosphenia geminata* relative to control flumes which only received additions of river water. Seasonality of frequency of dividing cell (FDC) patterns were observed in the summer 2013 and the spring 2014 studies. While the longitudinal reach of a phosphorus management strategy is not yet fully understood, the results from this study show that this could be a viable strategy for managers to reduce nuisance mats of *D. geminata* in the Kootenai River system.

Invasive Mussel Monitoring in the Columbia River Basin — Past, Present, and Future

Steve Bollens, Gretchen Rollwagen Bollens, Julie Zimmerman, Whitney Hassett, and Josh Emerson, Washington State University, Tim Counihan and Jill Hardiman, United States Geological Survey

Zebra and quagga mussels are native to Eurasia and have invaded the Great Lakes and several western U.S. water bodies, and now threaten the Columbia River Basin (CRB). Enhanced monitoring and early detection of invasive mussels are now high priorities for the CRB. A new project funded by the Bonneville Power Administration is supporting WSU and USGS to work collaboratively to address the following objectives: i) contribute to the coordination of regional early detection efforts, ii) summarize past efforts in the context of risk assessment data, iii) provide a framework for prioritization of boat cleaning stations, iv) assess the use of new technology (e.g., the FlowCAM) to process veliger monitoring samples from the CRB, and v) conduct research that will help to assess the causes and effects of biological invasions in the CRB. We found that current monitoring efforts in the CRB are spread across sites with both high and low risk of establishment (based on Ca concentrations) and introduction, as well as sites of unknown risk. Our results suggest that reallocating future monitoring efforts and better understanding risk across the landscape may be desirable. Our results also suggest that the FlowCAM has great potential to process veliger samples more rapidly and economically than traditional microscopy, although the efficacy of this new technology in the CRB, given the region's particular water quality and plankton composition, needs to be determined experimentally.

Beach Blanket Bingo, an innovated way of communicating with your client

David Kluttz, Lakeland Restoration Services

Lakeland Restoration Services has been thinking about ideas to get lake residents involved in the treatment of their lake, we wanted to have them informed and really understand the positive outcome herbicide treatment has on making the lakes they live on healthier. We send out the required notices, postings, web page updates, and a phone hotline for information. All of these seem so formal and do they really understand the "whys" and what plants are invasive? Lakeland treated Loon Lake in Stevens County, and came across a sign a resident made that said "Spray here" just a basic cardboard sign. That sign had us thinking, what a great way to get the lake residents involved. Our next scheduled treatment was Diamond Lake. Lakeland Restoration contacted the Diamond Lake Improvement Association and

presented them with a contest, "Beach Blanket Bingo" have the residents make signs visible from the lake and incorporated the "No Spray" signs for the Yellow Flag Iris. Lakeland also wrote an article in the lake association paper explaining why treatments are a positive way to improve their lake. The contest was a great success. People obviously read the article in the paper, because most of the signs incorporated words "save our lake", "Fish need to breath" "Kill weeds for Kids (swimming)" We had one sign that was made by an autistic child that dove down by his dock and decorated his sign with invasive weeds! This was a fun way to interact with our clients!

Aquatic Plant and Algae Management NPDES General Permit: Revisions and Reissuance

Nathan Lubliner, Washington State Department of Ecology

The current Aquatic Plant and Algae Management NPDES General Permit will expire in March 2016. The process of revising and reissuing this permit will begin in spring 2015. Changes being considered by Ecology for inclusion in the next issuance of the permit will be presented. Ecology would also like to solicit input from permit users on what they feel needs revision in the upcoming reissuance of the permit.

Milfoil Eradication by Diver Hand Pulling in Walsh Lake, Washington

Rob Zisette and Josh Wozniak, Herrera Environmental Consultants

Walsh Lake is located in the Cedar River Watershed, which is protected for use as the primary water supply for the City of Seattle. Herbicide use is prohibited within the watershed. Eurasian watermilfoil (milfoil) was first discovered in this natural lake during a botanical inventory in 2001, but a detailed survey and removal plan was not initiated until 2005 when City staff became aware of this discovery. A total of 121 native plant species were identified in the lake and its adjacent wetlands, including 28 native submerged species, adding urgency to the need for milfoil control. Milfoil was primarily confined to a small area where a turbidity curtain was installed to contain fragments during hand removal by divers. Over 580 pounds of milfoil were removed from this site by hand pulling over a two-day period in 2005. In 2007, a new infestation site was detected deep within the cattail marsh near the lake outlet, which is located at a beaver dam 0.5 miles from the original site and was apparently infested by beaver transport of viable fragments. Milfoil removal amounts declined each year to only five small plants in 2008, but increased in 2009 at the original infestation site and in 2010 at the outlet site. Bottom barrier was applied at the original infestation site and survey intensity increased within the cattail marsh, and no milfoil plants have been detected since 2011.

SESSION 3

Water Quality and Lake Health: The role of Proactive Management

Patrick Simmsgeiger, CLM, Diversified Waterscapes Inc. (DWI)

Problems in lake management are often characterized by one of several key factors-environmental change, nuisance species, agricultural runoff. Yet, many of the most financially and ecologically significant problems have their true roots in lake misdiagnoses made early on, which lack foresight, and are founded upon mere visual observation of surface conditions. In this paper, I show how this classification of lakes based on visual appearance leads to inferior water quality, lake aesthetic, and ultimately, more expensive chemical and physical intervention compared with scheduled maintenance from a licensed professional. Within the paper, I will invoke case studies with scenarios that exemplify the kinds of aquatic issues not revealed by visual observation. In doing so, this analysis will inform an assessment of how proactive management strategies are the most cost-effective, sustainable,and secure method of protecting one's investment in their aquatic environment.

Lessons Learned from 23 Years of Volunteer Lake Monitoring in Snohomish County

Marisa Burghdoff and **Jennifer Oden**, Snohomish County Surface Water Management

Volunteers play an integral role in protecting and improving the health of Snohomish County lakes. Since 1992, Snohomish County Surface Water Management (SWM) has trained over 250 citizen volunteers to monitor lake water quality in 38 of the County's lakes. SWM uses volunteer-collected data to track the current and long-term condition of each lake, identify specific problems at individual lakes, prepare annual reports on the health of each lake, recommend steps to protect and restore lake health, prioritize lake management decisions, and obtain funding for lake restoration projects. Lake volunteers have, in some cases, also helped to initiate local lake protection and restoration actions. The talk will focus on lessons learned over the life of the program including: volunteer training and retention, data quality and management, successful (and unsuccessful) reporting to the public and agencies, the most effective uses of volunteer monitoring data, and the most interesting stories from 23 years of working with volunteers.

The Winding Road to Success: Stormwater Treatment the Hard Way

Joy P. Michaud, Herrera Environmental Consultants

Most of us think about heavy metals, petroleum products, and oddly named priority pollutants when we think about industrial site stormwater runoff. However, the fact is that COD in logyard stormwater may be the most difficult pollutant to remove. The same natural tannins and lignins in logs that make them great for building long lasting homes, are very difficult to break down through standard treatment techniques. We took on the challenge of treating stormwater runoff from the Port of Olympia's logyard site to meet the benchmarks set in the Industrial Stormwater General Permit. Along the way we evaluated many common and not so common stormwater treatment technologies; we did over 100 hundred bench scale tests of various bioretention media components and composites. Based on those results we set up a pilot project to test an innovative constructed wetland facility, and ultimately ended up somewhere quite different.

Holden Mine Cleanup Project History

Dave Cline, Rio Tinto

The Holden Mine Cleanup Project is a $200+ million effort to remediate past environmental problems at the mine, which is located in north-central Washington along Railroad Creek, the second largest tributary to Lake Chelan. Discovered by J.H. Holden in 1896, and later developed by the Howe Sound Mining Company, the site was one of the largest copper mines in the United States during its heydey, from 1938 to 1957. The mine and mill produced concentrated copper, gold, silver, and zinc ore, but also left behind approximately 300,000 cubic yards of waste rock and about 8.5 million tons of mine tailings covering nearly 90 acres. As a result, heavy metals have leached into Railroad Creek via groundwater pose a

threat to aquatic organisms. The mine closed in the late 1950s, and the adjacent mining town was deeded in 1961 to the Lutheran Bible Institute, currently known as Holden Village. Rio Tinto, one of the world's largest mining groups, acquired the site and took on the responsibility for managing and paying for the cleanup. The project began in 2011, is expected to take roughly five years, and builds upon several decades of work at the site including:

- Interim Emergency Actions by the USFS in the 1980s and early 1990s
- Remedial Investigation/Feasibility Study (RI/FS) work from 1996 to 2010.
- Coordination between Rio Tinto, predecessor companies, USEPA, USFS, and other agencies.
- Issuance of a Record of Decision by Federal agencies on the cleanup strategy in January 2012.

Holden Mine Cleanup Project Remedial Construction

Tino Maestas, Magnus Pacific

The Holden Mine Cleanup Project is a $200+ million effort to remediate legacy environmental problems at the mine, which is located in north-central Washington along Railroad Creek, the second largest tributary to Lake Chelan. Rio Tinto, one of the world's largest mining groups, acquired the site and took on the responsibility for managing and paying for the cleanup. Magnus Pacific, the remediation contractor, and MWH the design engineer are working to complete several project elements aimed at restoring the site and preventing further release of heavy metals into Railroad Creek. The main project elements include:

- Realigning Railroad Creek away from tailings piles and installing armor and habitat structures.
- Removing tailings and restoring the bed of Copper Creek which flows into Railroad Creek
- Sealing mine portal bulkheads to control the flow of acid mine drainage
- Regrading tailings piles to stabilize them, installing rock/soil cover material, and revegetating the piles.
- Installing interceptor channels to divert surface water away from tailings
- Installing a low permeability slag-cement-bentonite barrier wall and groundwater interceptor collection system
- Building a mine water treatment plant.

The project has involved close coordination with the USFS, Washington State Department of Ecology, Holden Village, and other state and local entities. Remediation work began in 2011 with infrastructure improvements, and is expected to be completed in 2015.

Holden Mine Cleanup Project Construction Stormwater Management and Surface Water Quality Monitoring

George Iftner, Herrera Environmental Consultants and Dave Cline, Rio Tinto

The Holden Mine Cleanup Project is a $200+ million effort to remediate legacy environmental problems at the mine, which is located in north-central Washington along Railroad Creek, the second largest tributary to Lake Chelan. Rio Tinto, one of the world's largest mining groups, acquired the site and took on the responsibility for managing and paying for the cleanup. Herrera Environmental Consultants, a subcontractor to the remediation contractor Magnus Pacific, prepared the Master Stormwater Water Pollution Prevention Plan (SWPPP) and Railroad Creek Water Management and Monitoring Plan. This framework, along with daily monitoring and site inspections are helping minimize impacts to water quality during the 5-year span of the project. The SWPPP addresses surface water management over the 125-acre, 1.5-mile long mine site, 11 miles of USFS Rd. 8301, and the ferry/barge landing at Lucerne on Lake Chelan. The SWPPP includes over thirty Best Management Practices (BMPs); construction sequencing details; and assumptions for design storm duration, intensity, and runoff. The Railroad Creek Water Management and Monitoring plan outlines BMPs to control turbidity during in-water work activities in Railroad Creek and provides a framework for monitoring water quality. Magnus Pacific and Herrera Certified Erosion and Sediment Control Leads (CESCLs) have established a robust monitoring, recordkeeping and reporting program, and continually assess BMP effectiveness and performance.

SESSION 4

Lake Washington PCB/PBDE Loading Study

Curtis DeGasperi, Jenée Colton, Richard Jack and Carly Greyell, King County Science and Data Management Section

In 2010, King County was awarded a Puget Sound Action Agenda: Technical Investigations and Implementation Assistance Grant by the U.S. EPA to estimate loading of PCBs and PBDEs to Lake Washington, Lake Union and Puget Sound; and model potential reduction in Lake Washington fish tissue concentrations associated with select PCB loading reduction scenarios. The study was motivated by a Washington Department of Health Fish Consumption Advisory for Lake Washington. A field study was designed and implemented from 2011 to 2012 to measure PCB and PBDE concentrations in key contaminant loading pathways to Lakes Washington and Union (i.e., rivers, streams, stormwater, CSOs, highway bridges and atmospheric deposition) and measure the concentrations in the export pathway leaving the lake system through the Ship Canal locks to Puget Sound. PCB and PBDE loadings were estimated and PCB fate and bioaccumulation models were developed to evaluate the magnitude of load reduction needed to reduce levels of contaminants in fish to levels considered safe for human consumption. The presentation will summarize the approach and major findings of the study and the recommended next steps. More information, including the PCB/PBDE loadings report can be found on the project website: http://www.kingcounty.gov/environment/watersheds/cedar-river-lake-wa/pcb-pbde-loadings.aspx

Potential predation risk to anadromous salmonids reintroduced in Merwin Reservoir on the Lewis River, WA

Mark Sorel and Dave Beauchamp, Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fisheries Science, University of Washington

Anadromous salmonid reintroductions have been proposed above an increasing number of dams, requiring consideration of species interactions that affect salmonid production. Trap and haul passage around three dams was implemented in 2010 to reintroduce anadromous salmonids into the upper North Fork Lewis River. In addition, the utility that operates the dams is considering a reintroduction within the lowermost of the three reservoirs (Merwin), a requirement of their FERC relicensing agreement. Information on species interactions is needed to evaluate if the amount of salmonid production is worth the investment in infrastructure needed to enable anadromous passage. A study conducted in the 1960's to see if Merwin could be used to rear juvenile coho found that predation was occurring and could have contributed to low fry to smolt survival. Northern pikeminnow (*Ptychocheilus oregonensis*), a predator of juvenile salmon, is the most abundant fish species in Merwin. Their abundance is being estimated with a mark recapture study and seasonal diet and bioenergetics are being evaluated. Preliminary results suggest that the population of predatory sized northern pikeminnow (>200 mm fork length) is approximately 200,000 individuals. However, size structure of the population and thermal stratification of the lake during summer may limit predation losses of juvenile salmon. This ongoing study aims to help inform the utility's decision whether to reintroduce anadromous salmonids in Merwin.

Life history strategies of Rainbow Trout across a volcanic disturbance gradient

Tara Blackman and Matthew Sloat, Oregon State University, and Gordon Reeves, US Forest Service, Pacific Northwest Research Station, Charlie Crisafulli, US Forest Service, Pacific Northwest Research Station

Inland fish habitats in the Pacific Northwest are highly dynamic as a result of natural disturbances. Volcanism generates infrequent, but highly intense disturbances that can significantly alter stream habitat over extended periods of time. Due to the episodic nature of such eruptions the responses of fish are rarely observed. The Spirit Lake basin is located on the north side of Mount St. Helens, Washington which erupted on May 18, 1980 in a cataclysmic volcanic event that severely altered the surrounding landscape. Rainbow Trout (*Oncorhynchus mykiss*) were observed in Spirit Lake in 1993, likely the result

of clandestine stocking, and have since maintained a self-sustaining population utilizing stream habitat in the catchment system. This study looks at variability of Rainbow Trout demographics and life history in six streams across three major disturbance zones: Pyroclastic Flow, Debris Avalanche, and Blowdown Forest. These zones received varying degrees of intensity from the blast and consequently provide variable rearing environments for young fish. My findings suggest that multiple life histories exist within the population and may differ among streams and disturbance zones, highlighting the plasticity of life history strategies as a response to large-scale natural disturbance.

Potential Effects of Global Warming on Lake Sammamish kokanee thermal habitat

Curtis DeGasperi, King County Science and Data Management Section

Lake Sammamish becomes thermally stratified in summer with surface waters that become too warm for coldwater fish like kokanee while oxygen levels in the cold bottom waters become too low for these fish. Kokanee require suitable dissolved oxygen and temperature conditions to survive. It has been postulated that climate change (i.e., warming) could exacerbate the spatial and temporal extent of unsuitable dissolved oxygen and temperature conditions for kokanee in Lake Sammamish – the so-called temperature-dissolved oxygen squeeze. The potential effect of climate change on restoration efforts has yet to be considered, although recent research suggests that the potential success of salmon restoration efforts will be poorly characterized if climate change is not explicitly evaluated. This presentation will describe the data analysis and thermal modeling work conducted to evaluate the potential effects of global warming on kokanee thermal habitat. More information can be found on the web landing page for this project: http://www.kingcounty.gov/environment/animalsAndPlants/salmon-and-trout/kokanee/documents/climate-change-kokanee-habitat.aspx

SESSION 5

Factors contributing to the preference of engineered system to control near-shore phosphorus effluents

Eric C. Miller, Senior Hydrogeologist, and Wayne S. Wright, Senior Principal Wetlands Scientist, Geoengineers

Various researchers have linked phosphorus contamination of surface waters to septic system effluents. The average total phosphorus concentration in residential septic tank effluent is 10 mg/L while phosphorus concentrations as low as 0.02 mg L^{-1} are sufficient to induce harmful algae blooms (HABs) in surface waters. Although soils between the septic tank/SAS effluent and nearby water bodies can temporarily adsorb phosphorus, soil absorption sites are limited and the processes are largely reversible. In the case of nitrogen, this temporary retardation often provides sufficient time for denitrification and gaseous phase removal from the system. No analogous pathways for gaseous phase removal exist for phosphorus. Consequently, in most cases, once phosphorus is released in the near-shore environment, it is only a matter of time until it reaches a local surface water body. Despite this significant difference, the majority of septic system/SAS regulations are based on nitrogen management and do not explicitly address phosphorus releases. The lack of phosphorus-specific regulations in the near-shore environment is likely due to a variety of factors including the lack of scientific data necessary to determine the long-term phosphorus holding capacity of near-shore soils. Until such data becomes available, traditional approaches to nutrient management (e.g., minimum vertical separation & set-back distances) will largely be inadequate to manage phosphorus effluents.

Aquatic nutrient monitoring on process time scales

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Nutrient dynamics in aquatic systems are driven by a range of natural and anthropogenic forcing functions. Because nutrient dynamics broadly affect issues related to public health, ecosystem status and resource sustainability there are increasing needs to monitor nutrient loading and variability. Monitoring and modeling ecosystem dynamics and predicting changes in normal variability due to potentially adverse impacts requires sustained and accurate information on nutrient loads on the appropriate time scales. On site sampling is often resource limited which results in sparse data sets with low temporal and spatial density. For nutrient dynamics, sparse data sets will bias analyses because critical time scales for the relevant biogeochemical processes are often far shorter and spatially limited than sampling regimes. Recent technological developments have brought the ability to sample and remotely deliver data on the time scales that the forcing functions operate. These technological improvements, while still nascent, have delivered new understanding of process variability from the physiological to event to seasonal scales.

The effects of beaver dams on the hydrology and nutrient release of stormwater in wetlands

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Wetlands are known to control flows and nutrient concentrations by slowly releasing water and trapping sediment and nutrients to prevent downstream flooding and erosion. Stormwater and ambient water quality monitoring was performed on a series of wetlands in the Lake Sawyer drainage of Black Diamond, WA from 2011-2014. Water samples and in situ field parameters were collected at sites upstream of the lake to determine nutrient loading during storm events and baseflow conditions. Water quality samples were analyzed for nutrients such as total and ortho phosphorus and flow and stage level measurements were collected. A series of beaver dams were established in the spring of 2014 that constricted flow directly upstream of the lake inlet so that water from the Rock Creek drainage area was slowed to a trickle. Results from samples collected before and after the beaver dams were introduced showed decreases in flow, nutrients and dissolved oxygen concentrations downstream and increased nutrient loads upstream of the beaver dam. Total phosphorus concentrations collected a month after the beaver dam appeared had more than doubled from previous conditions, and soluble reactive phosphorus

concentrations were greater than four times the previous amount. These data suggest that beaver dams can have a major effect on the ability of wetlands to efficiently control the release of stormwater and nutrients, lowering downstream water levels and potentially stressing downstream ecosystems.

Alum treatment of the most hypereutrophic lake in western Washington

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Lake Ketchum has a summer epilimnetic TP (total phosphorus) of 260 µg/L, a sediment release rate (SRR) of 42 mg/m^2 per day and toxic blooms of cyanobacteria. The lake's very high internal loading, a legacy of agricultural land use, contributed 73% of the lake's annual input of P in 2011 and hypolimnetic TP reached over 3 mg/L by late summer. Alum doses in May 2014 of 107 g/m^2 to the deep area (> 4.6 m) and 70 g/m^2 to the shallower area, to remove water column P and inactivate sediment mobile P (0.8 mg/g), was expected to reduce epilimnetic TP to 46 µg/L, assuming 85% effectiveness (Husser et al., 2011). Alum treatment of the lake was expected to be far more effective at reducing summer epilimnetic TP and cyanobacteria than treatment of the residual agricultural inflow, despite its 500-1,000 µg/L TP concentration and 23% of annual load. Initial results of the alum treatment will be presented as well as P mass balance modeling results.

The New Spirit Lake: Current Hydrology and Nutrient Cycling in a Disturbed Ecosystem

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Spirit Lake was changed biologically, chemically and physically by the 1980 eruption of Mount St. Helens and the concurrent landslide that essentially buried the old lake and created a new one in its place. The massive changes to the lake ecosystem immediately after the eruption have been well documented already. However, recent changes to the surrounding watershed spurred by ever-increasing regrowth of terrestrial vegetation continue to alter the biogeochemistry of Spirit Lake. In order to make sense of the changing ecology of the lake and to inform future management decisions regarding public access and appropriate use of the lake, it is imperative that we establish a better understanding of the processes that govern lake productivity currently so that future scenarios can be better modeled. Therefore, we outline here our work on Spirit Lake from 2005-2014 developing a hydrologic and nutrient mass balance model for the lake and compare recent measurements of lake productivity and chemistry to pre- and post-eruption data in the literature. This is the first attempt at quantifying nutrient fluxes and reservoirs in the lake, and this baseline study will allow us to track changes to the ecosystem in the future.

Characterization of dissolved phosphorus mineralization kinetics for effluents from advanced nutrient removal processes

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Given the importance of the watershed protection plans, direct determination of phosphorus (P) mineralization rates in advanced wastewater treatment facility effluents is crucial for developing the most protective strategies for minimizing eutrophication in receiving surface waters. In this study, bioassays were used to determine the mineralization rate of dissolved P in effluents from a broad range of advanced nutrient removal technologies (Membrane Biological Reactor, traditional biological, tertiary membrane, Blue PROTM, etc.). Mineralization kinetics were fit to a gamma model and three first-order decay models. A traditional one-pool model correlated poorly with the experimental data (i.e., $r^2 = 0.73 \pm 0.09$), whereas two-pool model and three-pool models performed much better (i.e., $r^2 > 0.9$). These models also provided strong evidence for the existence of recalcitrant P in the effluents from these tertiary facilities. The Gamma model showed the mineralization of organic P followed a reactive continuum and further suggested the partitioning of P loads with different bioavailability levels should be accounted for the future modeling practices. From a modeling perspective, the Gamma model should be considered to be the theoretically correct model as it gave the most parsimonious fit to the data using the fewest terms.