Thursday October 6, 8:30am-10:00am

PLENARY SESSION

Welcome and Opening Remarks

How do we balance the (possibly) conflicting goals of phosphorus removal, ecosystem services and sustainability in the Spokane River Basin?
SPEAKER: **Mike Brett, University of Washington**

Dr. Mike Brett is Professor in Civil and Environmental Engineering at the University of Washington. He obtained his PhD from Uppsala University, Sweden, in 1990. His research is in biological limnology, in particular, nutrient discharges and eutrophication in lakes, streams and estuaries. Mike also does research on the production and bioaccumulation of omega-3 fatty acids in aquatic food webs, coupling between aquatic and terrestrial ecosystems, and zooplankton ecology. Mike teaches courses in Applied Limnology, Lake and Watershed Management and Environmental Engineering. Mike was President of WALPA in 2000-2001 and served on the WALPA Board for 3 years.

Thursday, October 6, 10:30am-12:00pm

LAKE MONITORING AND MANAGEMENT

Moderator – Andrew Child, WSU andrew.child@wsu.edu

Review of King County's continuous lake temperature monitoring data
Curtis DeGasperi, King County Water and Land Resources Division

Water temperature is an important factor controlling the biological activity and chemical reactions of a lake. Temperature also commonly controls lake water density and the potential for lake stratification or mixing. Relatively inexpensive equipment can be obtained and deployed to monitor lake temperatures on a continuous basis. King County has used relatively inexpensive continuous monitoring equipment to monitor the temperature of Lake Washington and Lake Union since 2005. This presentation will describe the history of King County's continuous temperature data collection efforts and some of things we have learned over the years. Implications of some recent research on continuous temperature monitoring in small lakes will also be presented.

Real time monitoring for cyanotoxins in recreational waters
David C. Deardorff, Abraxis, Inc.

Most of the harmful algae blooms in recreational water throughout the world are due to cyanobacteria which include species that can produce toxins that are broadly called cyanotoxins. In 2015, the U.S. EPA issued a 10 day health advisory in finished drinking water for two of the more common hepatotoxins, microcystins and cylindrospermopsin. The U.S. EPA is expected to issue health advisories later this year for the same two cyanotoxins in recreational water. Children are at greater risk because of their smaller body mass. The presentation is intended to provide approaches and examples for recreational water monitoring, risk assessment, response protocols and management options for harmful algae blooms and associated cyanotoxins. Both a historical background and an overview of rapid test methods will be presented along with the importance of sample collection, preparation, treatment, storage and transportation.

Treatment of cyanobacteria by superoxide
Michael Mangham

Research has now proven that cyanobacteria can be treated with a form of oxygen called superoxide (SO). SO is an oxygen with an extra electron (O_2^-). This anion has extraordinary cleaning and disinfecting properties that include treatment of cyanobacteria blooms. SO is toxic to living cells that are unable to protect themselves from it. Unprotected

cells suffer cell lysis (rupture) and quickly die. This protection is afforded by an enzyme called superoxide dismutase (SOD). It converts SO immediately to water. Cyanobacteria lack this enzyme and die in less than 5 minutes. This was first documented by Shepard (1998) and again by Medina (2015). It was found, that the neurotoxin, microcystin, was also destroyed by SO. Medina also found that photosynthesis was inhibited by SO at the point in the light spectrum that is most critical to cyanobacteria (680nm). No secondary pollution is left as the cyanobacteria and microcystin are converted to CO_2 and water. A technology is now available that creates SO on a large scale. A single unit can treat water to a distance on one mile and can be installed and operated in the field. This scale of operation makes it useful for bays, near-shore areas where people swim, and water utility intakes.

Environmental benefits dredging soft sediment from a small recreational lake in Western Washington
Robert Plotnikoff, Harry Gibbons, Jr., Tetra Tech, Inc.

Sediments were dredged from Lake Limerick, Mason County, WA in two coves (King's Cove and Cranberry Cove). Approximately 5,000 cubic yards of sediment were removed from areas of creek inflows. Dredging of these sediments improved fisheries habitat and recreational use. Permit requirements for dredging included pre-project sediment analysis (pesticides and metals), dredge profile grade, and description of water quality (especially Turbidity) and benthic community condition. Bathymetric surveys during pre- and post-project showed inflow from creeks would begin to move in-lake sediments. A significant amount of sloughing of nearshore fine sediments occurred following dredging from fifteen foot-wide trenches. Dredge depth was up to two feet in the trenches and promoted movement of fine sediment away from the shoreline. Effectiveness of this dredging project will be measured with a long-term monitoring program including depth profiles for water quality and benthic community analysis.

Analysis of bioretention soil media for improved nitrogen, phosphorus, and copper retention
Curtis Hinman, Herrera Environmental Consultants

The current municipal Nation Pollutant Discharge Elimination System stormwater permit for Washington State requires the use of low impact development (LID) practices as the first option for managing stormwater where feasible. Bioretention is the most widely applicable and flexible BMP in the suite of LID practices. While bioretention can provide very good water quality treatment for many contaminants, regional and national research indicates nitrogen, phosphorus, and copper may be exported from these systems. This presentation will focus on the pollutant capture performance of new, high-performance bioretention media blends with emphasis on the ability of these media to meet challenging phosphorus reduction requirements in the Lake Whatcom watershed. The analyses and media design consisted of three phases: leaching analysis (to select individual media components for media blends); flush media blends (to tests effluent with deionized water); and dose media blends to determine the pollutant capture capability of the media blends with stormwater). Eight media blends (treatments) were developed from the components meeting leaching and other criteria. Each treatment was replicated three times and a 45.7 cm layer of the media placed above a 30.5 cm drainage layer in the columns. Media blends, including a compost-based media control, consisted of various ratios of volcanic sand, bulk organic material, and amendments used for specific pollutant capture characteristics.

Contaminants of emerging concern as source tracers of anthropogenic impacts in surface waters
Andrew James, Alex Gipe, University of Washington Tacoma; Shawn Ultican, Kitsap Public Health District; Justin Miller-Schulze, California State University at Sacramento

Contaminants of Emerging Concern (CECs) describe a broad class of compounds which occur in the environment at low levels, are unregulated, and may pose some level of environmental risk. They include pharmaceuticals and personal care products, food additives, industrial and medical chemicals, and agricultural products. Many of them can be associated with a specific activity (e.g., beef cattle operations) or waste stream (e.g., human sewage) which can make them valuable as source tracers. In addition, use patterns and chemical properties can all very widely affecting their occurrence, and fate and transport in the environment; this may provide additional information relevant to source tracking. We have performed field investigations to evaluate the effectiveness of a suite of CECs as source tracers of effluent from septic systems. The results indicate that there are several common-use compounds that can be useful as tracers. Results of the work will be summarized and next steps presented.

Thursday, October 6, 1:30pm-3:00pm

PROBLEM BACTERIA AND INVASIVE SPECIES

Moderator – Tim Clark, King County Timothy.Clark@kingcounty.gov

Bacteria source tracking in Thornton Creek
Jonathan Frodge, Seattle Public Utilities

NO ABSTRACT

Ecology's invasive aquatic plant projects
Jenifer Parsons, Lizbeth Seebacher, Washington Department of Ecology

The Department of Ecology's Aquatic Weed Management Fund provides support for many invasive aquatic plant projects in lakes and reservoirs. Some, such as eradication of Class A noxious weeds, are directly managed by the agency, other projects are managed by local governments. An update and highlights of these projects will be provided, including (cautiously) hopeful results with variable leaf milfoil eradication, an uphill battle with flowering rush, and several projects targeting Eurasian watermilfoil and *Egeria*.

Game changing strategies to target Eurasian milfoil and flowering rush
Terry McNabb

Eurasian Milfoil has been a major problem in Washington State Lake and River systems for a number of decades. This weed was first discovered at problem levels in the Okanogan Chain of Lakes in British Columbia which is hydraulically connected to the Columbia River system, it is thought to have migrated down through fragmentation and spread from there by boat trailer. Flowering Rush is coming at us rapidly was well. There are hundreds of acres of this noxious weed in Flathead Lake Mt, and it is moving down the Clark Fork River into the Pend Oreille System and will be advancing down the Columbia as well. Flowering Rush is replacing Eurasian Milfoil in many of these areas and is much harder to target and remove. There are a number of new treatment approaches that show promise in restoring systems impacted by these species. This paper will discuss new chemistries and treatment approaches.

Past, present and future development of *Corbicula fluminea* and other aquatic invasive species in two drinking water reservoirs in Whatcom County, Washington
Rachel Garcia, Teagan Ward, City of Bellingham

In 2011, *Corbicula fluminea*, invasive clams, were confirmed in multiple locations in Lake Whatcom, Lake Padden and Whatcom Creek in Bellingham Washington. Being that this species has been present in Washington State for several decades, monitoring efforts in Whatcom County regarding this species were practically non-existent. However since Lake Whatcom is a drinking water reservoir serving over 100,000 residents in Whatcom County including the city of Bellingham, concerns regarding their impact as well as other aquatic invasive species (AIS) resulted in the development of the Whatcom Boat Inspection program. Initial locations of 5 clam populations, 3 sites in Lake Whatcom, 1 in Whatcom Creek (downstream of the lake) and another in Lake Padden (5 miles away) were found in 2011. In 2012, dive and shoreline surveys resulted in no new population sites. In 2015, 6 new populations were found in Lake Whatcom. This fall, our team conducted population density surveys of previously confirmed sites. We also discovered 3 previously unknown clam sites. Surveys of Lake Samish have found no evidence of invasive clams. Our efforts in establishing baseline data of population densities and locations of *C. fluminea* and other AIS have resulted in further understanding of the spread of invasive species and will play a definitive role in the future of aquatic invasive species management in Whatcom County.

Thursday, October 6, 3:30pm-5:00pm

NEXT GENERATION OF LIMNOLOGY

Moderator – Jim Gawel, UW Tacoma jimgawel@u.washington.edu

Arsenic in shallow polymictic and seasonally stratified urban lakes: mobility, bioaccumulation and ecological toxicity
Erin Hull, Jim Gawel, University of Washington Tacoma; Pamela Barrett, Rebecca Neumann, University of Washington

Many urban lakes in the Puget Sound region contain elevated levels of arsenic as a result of heavy metal pollution from the former ASARCO smelter in Ruston, WA. Arsenic is a neurotoxin, carcinogen, and priority Superfund contaminant, yet its mobility and toxicity is not fully understood. Processes that lead to high arsenic levels in lake water and aquatic organisms are well studied in thermally stratified lakes, but not in periodically mixed (polymictic) oxic lakes. This project examines the mobility, bioaccumulation and toxicity of arsenic in four urban lakes in south King County that range from seasonally stratified and anoxic to polymictic and oxic. Usually, arsenic is only mobilized from sediments when lakes become anoxic during stratification; thus we aim to understand why the polymictic lakes have elevated levels of arsenic (> 40 ppb) in surface waters, yet mix regularly and hence stay oxygenated. Plankton in polymictic oxic lakes accumulated more arsenic than plankton in thermally stratified lakes, although levels of arsenic contamination in lakes were similar. This suggests that arsenic in polymictic urban lakes is bioavailable, and has potential to enter the food web due to spatial overlap between high arsenic concentrations and optimal (oxic) habitat for aquatic organisms. This project aims to model arsenic bioavailability based on lake physical and biogeochemical characteristics to predict toxicity with important implications for lake management.

Phytoremediation of arsenic by aquatic plants in contaminated urban lakes in the South-Central Puget Sound region
Anthony Endresen*, Jim Gawel, University of Washington Tacoma

Phytoremediation, a plant-based technology for cleaning hazardous waste sites, has received increasing attention in recent decades. This work focuses on the possibility of using aquatic plants to take up arsenic (As) from contaminated urban lakes in the "zone of deposition" for the former ASARCO smelter located in Ruston, Washington. The smelter specialized in As extraction from copper ores. During the summer of 2015, we collected emergent, floating-leaved and submergent aquatic plant species from 11 lakes contaminated by smelter emissions. After washing, drying and microwave-assisted acid digestion, plant samples were analyzed for total As by ICP-MS. Our results reveal that the highest concentrations of As are found in submergent plant species, with concentrations exceeding 300 mg As/kg. We are now investigating seasonal trends in As uptake and the relationship between As concentrations in lake sediment and water column and As uptake in submergent plants. Samples were collected from 6 lakes representing a range of As contamination in the sediments (32-208 mg As/kg) and the shallow water column (2-40 µg As/L). For identification of seasonal trends, plant samples were gathered from a boat using a rake over multiple collection dates during the summer of 2016, and analyzed as described above. Our results will help elucidate the dominant As uptake pathway in aquatic plants and the implications of this work for phytoremediation and potential grazer toxicity will be discussed.

From farm to table: tracking availability and bioaccumulation of heavy metals in freshwater zooplankton in northeastern Washington lakes
Andrew Child*, Barry Moore, Jeffrey Vervoort, Washington State University; Marc Beutel, University of California-Merced

Heavy metal pollution from mining and smelting operations into adjacent aquatic ecosystems can cause long-term biological impacts. Several studies have addressed the biological accumulation and consequences of direct discharge of mining slag into aquatic habitats, but little work has been done on the biological availability of perpetual deposition of diffuse atmospheric heavy metal pollution in remote freshwater environments. Since 1896 one of the largest zinc/lead smelters in the world, located in Trail B.C., has been discharging heavy metal laden emissions into the northwestern United States. Our recent work has addressed the geographic extent of these airborne smelter emissions deposited in lakes. However, no studies have addressed whether these contaminants are biologically available to aquatic organisms.

In this study we analyze the biological extent of smelter emissions by analyzing the heavy metal body burden and lead isotope composition of zooplankton in lakes ranging from 20 to 145 km downwind of the smelter. The lead isotope composition of the primary ore used by the Trail smelter has a unique fingerprint. Therefore, we hypothesized if lead emissions are assimilated by zooplankton, their composition will mirror the ore's fingerprint. Heavy metals are powerful biological contaminants, and if these metals are biologically available in aquatic food webs there is a potential for bio-magnification and transfer across aquatic and terrestrial food webs.

Comparison of two methods to estimate within-lake regenerated phosphorus in a reservoir
Sarah H. Burnet*, University of Idaho, Frank M. Wilhelm, University of Idaho

The increasing occurrence of harmful algal blooms (HABs) in waters world-wide not only decreases the aesthetic and recreational value of surface waters, but also their use as potable source waters. This is especially important in the face of the expanding human population that relies on access to clean water. In many stratified lakes and reservoirs, internal loading of phosphorus (P) from an anoxic hypolimnion can be a significant contribution to the annual mass balance and can fuel summer HABs. A dual approach was used to quantify the internal P load at Willow Creek Reservoir (WCR), Oregon. The volume-weighted concentration of P was calculated from field-collected samples during summer anoxia and from laboratory incubations of sediment cores collected from various sites in WCR; both commonly used approaches, but rarely applied together. The load calculated from field collected samples was 1.7 fold higher than that calculated from sediment core incubations over a 90-day period indicating that the latter could severely underestimate internal loading rates in WCR. A large interannual difference was found between 2014 and 2015 that was likely related to annual precipitation and reservoir drawdown. The comparison of internal loading along with external P sources is needed to select appropriate in-lake and watershed remediation efforts to reduce HABs.

Landscape position defines lake water level fluctuations in response to past climate in the Pacific Northwest
Vincent O. Jobin*, University of Washington, Julian D. Olden, University of Washington

Lake water levels fluctuate in response to interactions between precipitation, temperature and watershed hydrogeology, as well as being influenced by human land-use change (e.g., urbanization and agriculture). Although climate change impacts on river hydrology has been well studied, potential effects on lake hydrology are less well understood. This study aims to understand how natural and anthropogenic factors influence water level regimes in lakes (variability, magnitude, frequency of change, etc.). Specifically, we explored the patterns and drivers of multi-decadal trends in water level across 60 small lakes in the Puget Sound lowlands of Washington State. We found that landscape position, defining the extent of upstream urbanization and other geomorphic factors, modulates the effects of local precipitation and temperature conditions on lake level regimes. By gaining a better understanding of how lake level fluctuations are driven by landscape position we provide insight into the vulnerability of lakes to the impacts of climate change on snowpack and air temperatures. This may call for either more active management of outlet weirs or inform new urban planning of green spaces.

**student presenter*

Thursday, October 6, 5:00pm-7:00pm

POSTERS

Evaluating the precision of lake-dwelling brook trout age structures
Timothy Taylor*, Barry C. Moore, Washington State University

Aging fish has always been important to fisheries managers because fish age can be used to understand how populations change (population dynamics), including growth, mortality, predation, and harvest rates. In order to age fish, calcified structures like scales, fin rays, or otoliths are removed from fish, processed, viewed under a microscope, and growth rings are counted. However, some structures require the fish to be sacrificed in order to obtain accurate ages. In systems with small fish populations that remain an important form of sustenance, routinely sampling fish using lethal means may not be sustainable. Previous methods suggest using otoliths to age Brook Trout, but we are interested in determining if we can precisely age these fish using non-lethal means (e.g. scales, fin-rays). We collected scales, pectoral fin rays, and saggital otoliths seasonally. Age from each structure will be determined by three readers. We will then utilize common age precision statistical tests to compare each age structure, including age bias plots, percent agreement, and coefficients of variation. Age bias plots identify biases associated with reader and structure. Percent agreement determines how often reader's age assessments were similar, and coefficients of variation are used to create unbiased estimates of precision. These results will allow us to determine if scales or fin-rays are viable structures to precisely age Brook Trout nonlethally.

Sediment and phosphorus inputs from perennial streams to Lake Whatcom, Northwestern Washington State
Robert Mitchell, Western Washington University, Katherine Beeler, Associated Earth Sciences, Inc.

Lake Whatcom near Bellingham, WA is subject to a Total Maximum Daily Load to limit phosphorus input. Much of the phosphorus load to the lake occurs adsorbed to suspended sediment in streams during storm events. To assess phosphorus loading, water samples were collected near the mouth of Smith Creek in the watershed during 22 storm events between February 2013 and January 2014 and analyzed for total suspended solids and total phosphorus. We used data from Smith Creek and historical data from four other streams to examine the effects of varying basin features on loading and to develop sediment-discharge and phosphorus-discharge models to estimate loading to the lake during the 2013 water year. Relationships among sediment, phosphorus, and discharge vary temporally and spatially in the watershed. During most storm events, the sediment peak leads the discharge peak, indicating that transport is limited by sediment availability. Of the five streams studied, the steep, forested Smith Creek basin yielded the most sediment per area, likely sourced by eroding mass wasting deposits. The highest phosphorus yield was from a smaller, lower relief basin containing 29 percent residential development indicating potential anthropogenic sources. Total suspended solids and total phosphorus are significantly correlated to discharge in most streams, but variability within and among storm events results in uncertainty when calculating fluxes based on discharge.

Investigating the ability of substrates inoculated with mushroom mycelium to reduce fecal coliform bacteria contamination in surface water
Kellen Maloney*, Robert Turner, Keya Sen, David Jackson, Saiwa Conejo-Morales, University of Washington Bothell

Mycoremediation is the practice of using mushroom mycelium to remove a variety of contaminants from soil and surface water. This is a relatively new area of research, combining ecological restoration, environmental chemistry, and microbiology, with the potential to dramatically improve water quality in surface water runoff, and thus in the lakes that receive those remediated discharges. Our research project is investigating the application of mycelium-inoculated straw wattles in small streams to reduce fecal coliform bacteria contamination from a massive crow roost in the constructed floodplain wetland of the University of Washington Bothell/Cascadia College campus. The goal is to greatly reduce the concentrated discharges of E. coli bacteria to North Creek, which in turn is advected to Lake Washington via the Sammamish River. Preliminary laboratory tests found reductions of E. coli to be as much as 99% when contaminated water was passed through King Stropharia (*S. rugosoannulata*) inoculated woodchip cylinders, relative to controls

without mycelium. Experiments have also been conducted with Blue Oyster (*P. ostreatus*) mushroom mycelium. Observed variability in the ability of mycelium-inoculated substrates to reduce E. coli counts of contaminated water is dependent on factors such as the retention time of water in the substrate, species of mushroom, and maturity of the mycelium. Experiments with mycelium-inoculated straw wattles placed in contaminated streams are underway.

Macroinvertebrates as bioindicators of stream health in the Snake River drainage

Randi Bowman*, Dr. Michael Edgehouse, Lewis-Clark State College

From mining to agriculture, current and past land uses have impacted watersheds within the Snake River drainage and their ecological health, leaving behind altered ecosystems. As bioindicators of stream health, macroinvertebrates are ideal organisms to sample to determine the ecological health of watersheds. The Grande Ronde River, Wallowa River, Imnaha River, and Tammany Creek were chosen for analysis because they all have a history of mining and agricultural land use. By sampling and comparing macroinvertebrate assemblages near a river's headwaters and its mouth, it is possible to ascertain if pollution from agricultural and mining land uses is significant. Through this research we are able to determine the overall quality of aquatic ecosystems within the Snake River drainage and therefore inform future management decisions involving those watersheds.

An explorative study of aquatic macrophyte habitats in Canyon Lake, Washington

Raena Anderson*, Jesse Klinger, Huxley College of the Environment, Western Washington University

Aquatic macrophytes provide shelter for a variety of organisms and increase habitat complexity and heterogeneity for aquatic organisms like invertebrates, fish, and amphibians. Macrophyte habitats can vary over time by location, dominance, and extent. Canyon Lake was naturally formed in 1872 by a landslide that dammed Canyon Creek; 114 years later, little is known about the macrophyte habitats within the lake. In order to identify the macrophyte habitats, I traversed the littoral and pelagic zones of the lake gathering macrophyte samples with a rake, identified the macrophytes, noted visual changes in habitats, and mapped the habitats. Equisetum fluviatile is the most common macrophyte habitat at Canyon Lake; *Potamogeton natans*, *Potamogeton epihydrus*, and *Nuphar polysepala* habitats are also prevalent. The southern side of the lake has macrophyte habitats that are less dense than the northern, eastern, and western sides of Canyon Lake; this could result from decreased light availability and/or steeper topography.

Tracking long-distance deposition of airborne smelter emissions in remote lake sediment cores

Andrew Child*, Barry Moore, Jeffrey Vervoort, Washington State University; Marc Beutel, University of California-Merced

Direct discharge of heavy metal pollution from mining and smelting operations into adjacent streams, lakes and rivers can cause long-term biological impacts. Several studies have addressed the biological effects of direct discharge of mining slag into aquatic habitats, but little work has been done on the biological impacts of diffuse atmospheric heavy metal pollution in remote freshwater environments. In fact, little work has been compiled on how far smelter emissions can be transferred downwind before complete deposition. Since 1896, one of the largest non-ferrous zinc/lead smelters in the world, located in Trail B.C., has been discharging heavy metal laden airborne emissions. These emissions frequently are transported into the northeastern Washington state, where particulate metals, including lead, can be deposited into lakes and watersheds. Lake sediment cores contain records of past environmental conditions within watersheds, and may provide a timeline of fundamental chemical and biological relationships within aquatic ecosystems. We hypothesized if lead emissions were reaching sample lakes, the composition of lake sediments would mirror the ore fingerprint. We analyzed the chemical composition and lead isotope compositions of sediment cores from six remote eastern Washington lakes to determine possible sources of atmospheric heavy metal deposition. Our results suggest that aerial deposition of smelter emissions may extend >130 km (80 miles) downwind of the smelter.

Biotic assessment of human lake shore degradation based on the composition of littoral macroinvertebrate communities

Oliver Miler, University of Washington; Gwendolin Porst, TU Berlin, Germany; Elaine McGoff, Freshwater Habitats Trust, United Kingdom; Francesca Pilotto, Umea University, Sweden; Louise Donohue, Trinity College Dublin, Ireland; Tamara Jurca, University of Novi Sad, Serbia; Angelo Solimini, La Sapienza University of Rome, Italy; Leonard Sandin, Swedish University of Agricultural Sciences (SLU) Uppsala, Sweden; Kenneth Irvine, UNESCO-IHE Institute for Water Education, The Netherlands; Jukka Aroviita, Finnish Environment Institute (SYKE), Finland; Ralph Clarke, Bournemouth University, United Kingdom; Martin T. Pusch, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Germany

Despite their importance, human lake shore alterations and their effect on littoral macroinvertebrate communities have rarely been studied systematically. We present here the multimetric assessment index LIMCO (Littoral Invertebrate Multimetric based on COmposite samples) that allows for a pressure-specific assessment of morphological shore degradations based on littoral macroinvertebrate community composition. LIMCO has been developed based on a pan-European macroinvertebrate dataset in accordance with the European Union Water Framework Directive (EU WFD). Littoral invertebrate sampling covered a range of natural to heavily morphologically degraded sites including natural shorelines, recreational beaches, rip-raps and retaining walls. Biological data were supplemented by physical habitat survey data that were used to develop a morphological stressor index. The metric composition of LIMCO was determined via correlations with the morphological stressor index. LIMCO - morphological stressor index correlations have been specifically optimized for four geographical regions in Europe due to strong spatial differences in littoral invertebrate community composition. The biotic assessment with LIMCO in compliance with the EU WFD is analogous to the use of Indices of Biological Integrity (IBI) in North America. The calibration, taxonomic resolution and metric composition of LIMCO enables its potential use and further development as an IBI for lake shore degradation in North America.

**student presenter*

Friday, October 7, 8:30am-10:00am

LAKES: COMING UP WITH SOLUTIONS

Moderator – Jen Oden, Snohomish County Jennifer.Oden@snoco.org

LakeWise: motivating and inspiring clear choices for healthy lakes
Peggy Campbell, Marisa Burghdoff, Jennifer Oden, Snohomish County Public Works Surface Water Management.

In 2012, Snohomish County Surface Water Management (SWM) launched LakeWise, a social marketing-based outreach program to address residential non-point source pollution. Long-term monitoring data of 35 County lakes show many are exhibiting statistically significant increases in epilimnetic or hypolimnetic phosphorus and/or chlorophyll a concentrations. The primary cause at most is residential non-point source phosphorus pollution. While most are still in healthy condition, many are at high risk for future algal problems and increased internal loading requiring costly in-lake restoration. SWM developed LakeWise to build awareness of water quality impacts that residents have on their lakes and effect behavior change through incentives and partnerships to implement best management practices (BMPs). SWM developed the program by researching other outreach programs to identify successful strategies and conducting targeted market research. The centerpiece is a property certification program where landowners complete a Clear Choices checklist of the most important actions they can take on their property to reduce nutrient pollution. Piloted at one lake in 2012/2013, LakeWise was expanded to eleven target lakes in 2014 and enhanced by the inclusion of financial incentives for septic system care and shoreline restoration. In this first talk, the overall program successes will be highlighted along with lessons learned after four years of implementation.

LakeWise: the triumphs and tribulations of lake shoreline restoration
Marisa Burghdoff, Scott Moore, Marta Olson, Snohomish County Public Works Surface Water Management

In 2012, Snohomish County Surface Water Management (SWM) launched LakeWise, a social marketing-based outreach program to address residential non-point source pollution. This second talk will focus specifically on the lessons learned with planting residential shorelines including: landowner communications, planting plan design, plant success, and more.

Creating Washington's first freshwater Aquatic Reserve: Lake Kapowsin
Roberta Davenport, WA Department of Natural Resources

Lake Kapowsin is one of the few undeveloped, large, low elevation natural lakes in western Washington. DNR's Aquatic Resources staff worked with the community, technical experts and stakeholders to development a site proposal and management plan for the proposed aquatic reserve. The lake has an unusual geologic origin and contains the remnants of an ancient valley forest. The site supports abundant fish, amphibians, waterfowl, and raptors, and is a prized fishing spot. DNR and partners have carried out water quality and amphibian monitoring for several years at Lake Kapowsin. This talk will describe some of the special features, and tell the story of the development of the new reserve.

Hydrologic and nutrient budgets to support the Waughop Lake management plan
Jim Gawel, Corey King, Rebecca Rigg, University of Washington Tacoma; Mike Milne, Sharonne Park, Jon Turk, Brown and Caldwell; Greg Vigoren, City of Lakewood

Waughop Lake is the centerpiece of Fort Steilacoom Park located in Lakewood, WA. The park is very popular (nearly 1 million visitors/year) but use of the lake is severely limited by frequent toxic cyanobacteria blooms, related to elevated phosphorus loads. Potential phosphorus sources include regional groundwater, lake sediments, waterfowl, upgradient septic systems and stormwater from the park and a nearby college campus. The City received a grant from the WA Department of Ecology to develop a Lake Management Plan (Plan) for Waughop Lake. From Oct 2014-Oct 2015 we monitored hydrology, nutrient reservoirs in the lake water column, sediment, aquatic plants, plankton, and nutrient inputs from lake-bed sediment, waterfowl, stormwater, and groundwater in order to identify the largest phosphorus sources and support evaluation of potential management measures. Lake-bed sediment is the primary phosphorus

source supplying cyanobacteria in Waughop Lake. Much of the sediment enrichment likely occurred prior to the creation of Fort Steilacoom Park when the area was used for crop and livestock production by Western State Hospital. Stormwater runoff and groundwater inputs are small compared to internal cycling of phosphorus from lake-bed sediment. The City is now evaluating a range of in-lake and watershed management measures for potential inclusion in the Plan. The Plan will prescribe the most appropriate measures for Waughop Lake based on the monitoring results, planning-level costs, and stakeholder input.

A review of unit costs of selected stormwater phosphorus treatment practices
Chris Webb, Herrera Environmental Consultants

This presentation will review the comparative cost effectiveness of selected stormwater retrofits as Best Management Practices for phosphorus treatment based on recent design projects. Initially, background on Ecology's requirements for phosphorous treatment of stormwater will be presented along with typical high level options for stormwater phosphorus management. Several specific approaches then will be reviewed in detail including proprietary systems that have an Ecology TAPE GULD certification for phosphorous treatment, non-proprietary approaches, and an emerging technology using Iron- and Alumina-Amended Sand Filtration. The cost data presented will include typical total project costs including conveyance improvements, restoration, erosion control, etc., and not just the cost for the treatment practice. The cost effectiveness of the approaches will be normalized to a cost per pound of phosphorus removed annually. Finally, a focused review of the state of the technology of Iron- and Alumina-Amended Sand Filtration will be presented along with some data gaps where additional research is necessary.

Friday, October 7, 10:30am-12:00pm

LAKE WHATCOM: BIG LAKE, TOUGH ISSUES

Moderator – Rachael Gravon, King County Rachael.Gravon@kingcounty.gov

Lake Whatcom reflections, 1988-2016
Robin Matthews, Michael Hilles, Joan Vandersypen, Geoffrey Matthews, Robert Mitchell, Western Washington University

Lake Whatcom is the primary drinking water source for Bellingham and parts of Whatcom County. The City of Bellingham and Western Washington University (WWU) have collaborated on water quality studies in Lake Whatcom since the early 1960s. A monitoring program designed to provide long-term lake data for temperature, pH, dissolved oxygen, conductivity, turbidity, nutrients, and other water quality measurements, was initiated jointly by the City and WWU in 1988 and continues to this day. Lake Whatcom is comprised of two small basins (basins 1 and 2) and a large, deep basin (basin 3) that contains 96% of the lake's volume and is >100 m deep. In basin 1, hypolimnetic oxygen concentrations have declined over time, causing the lake to be placed on the 303d list of impaired waterbodies. In addition to the oxygen trend, concentrations of phosphorus and chlorophyll have increased throughout the lake. Water quality models developed by the Dept. of Ecology linked the declining oxygen to increasing amounts of phosphorus entering the lake from urban runoff, which increased algal densities, thus creating more organic matter for bacterial decomposition in the hypolimnion. It is this final, increasing rate of bacterial decomposition deep in the lake that has resulted in a more rapid loss of hypolimnetic oxygen in the basin 1. To address the impairment, a water quality improvement plan has been approved by the state of Washington that will restrict the amount of phosphorus entering the lake.

Tiny bubbles
Bill L. Evans, City of Bellingham

In 2009, the City of Bellingham had to invoke mandatory water restrictions due to an algae event in their source water that was preventing the water treatment plant from meeting the city's daily water demands. This presentation will document the process the City of Bellingham took to evaluate a new pre-treatment facility for their water treatment plant. The evaluation of the pretreatment looked at different raw water intake locations, Pilot testing a Dissolved Air Floatation (DAF) systems, and other pre-treatment investigations which eventually lead to the beginning of construction of a new DAF facility at the plant in summer 2016.

Lake Whatcom north shore on-site sewage system leachate detection plan
Rob Zisette, Herrera Environmental Consultants

Lake Whatcom is a drinking water source for over 80,000 people in the City of Bellingham and Whatcom County, Washington. A total maximum daily load implementation plan was prepared by Ecology to address lake impairment from total phosphorus and fecal coliform bacteria. The Lake Whatcom Water and Sewer District prepared a plan to extend the sanitary sewer system to an area bordering 2.3 miles of the north shore where 96 on-site sewage systems (OSS) are present. The District documented OSS conditions, including 54 systems built before 1990. The District was advised to conduct a water quality study proving that these systems impair human or environmental health because the area is outside the designated Urban Growth Area and sewers would require a change in land use designation that may enable development of vacant parcels. This presentation will summarize the various microbiological, chemical, biochemical, and molecular techniques considered for detecting OSS leachate in the lake, and will describe the methodology proposed for implementation in the winter of 2016-2017.

Whatcom boat inspections: preventing the spread of aquatic invasive species in Whatcom County
Teagan Ward, City of Bellingham

The Lake Whatcom Management Program began implementing the Whatcom Boat Inspection Program in 2012 to prevent the introduction of zebra and quagga mussels and other aquatic invasive species to Whatcom County waters. To date, the program has conducted over 25,000 watercraft inspections at Lake Whatcom and Lake Samish. The program has not only helped to prevent the spread of additional aquatic invasive species to these local lakes, it has also helped to increase community awareness regarding the threats that aquatic invasive species pose to Washington waters and how to prevent their spread. This talk will provide an overview of the Whatcom Boat Inspection Program highlighting outreach efforts, inspection results, and lessons learned from 2012 through 2016. Lake managers interested in learning more about program elements that can be implemented at the local level to protect Washington waters from aquatic invasive species are encouraged to attend.

How to compare dissolved oxygen from different model scenarios?
Steve Hood

Water quality criteria for dissolved oxygen requires comparing dissolved oxygen concentrations to natural conditions. When modeling a lake, how do we compare scenarios to determine if we are near enough to natural conditions to meet the criteria? Stratified, eutrified lakes can have more dissolved oxygen in the epilimion and less in the hypolimnion. Internal waves prevent a cell by cell comparison. Averages that would mask violations are not allowed. Judgments about where to define the hypolimion might influence the results. In the Lake Whatcom TMDL, we determined that aggregating the entire water column oxygen content of the most sensitive segments during the growing season would not mask non-compliance and allowed comparison of scenarios. In this talk I will show animations of the model data to describe why cell by cell comparisons and averages are not appropriate. I will describe how the aggregation method was chosen. I will also describe the tools used to aggregate the results and calculate cumulative volume comparisons.