2013 OLA – WALPA Conference

1A **Comparing Risks of Applying Copper Algaecides to the No Action Alternative**

Bishop, West - SePRO Corporation

Following copper algaecide applications, there is often concern of risks to non-target aquatic organisms. However, copper toxicity is rarely observed in field applications despite the applied copper concentrations being in excess of published lethal concentrations to non-target freshwater organisms. Toxicity of copper algaecides to non-target aquatic organisms is overestimated in many published bioassays. Environmentally relevant exposure components (e.g. application techniques, concentration, duration, formulation, algae affinity) and label guidance (e.g. rate, timing) need to be considered prior to predicting non-target aquatic species risks. Copper algaecides are typically applied to efficiently target a specific nuisance algae infestation and advanced formulations are specifically designed to enhance the amount of applied copper that partitions to the algae, thereby altering the bio-available exposure to other organisms. The risks of not addressing a nuisance or potentially toxic algae infestation often greatly outweigh the risks that could incur following a copper algaecide application. Blue-green algae are of particular concern due to their rampant presence throughout the United States, including the Pacific Northwest, and the ability to produce a variety of secondary metabolites (toxins, taste/odor compounds, etc.) that we are just uncovering the negative implications to human and animal health (neurodegenerative diseases, endocrine disruption, liver failure). The risks of reactively addressing a nuisance algae infestation, even with copper, are greatly outweighed by the no action alternative. An overview of implications of no action will be compared with a copper algaecide application in terms of exposure and risk to terrestrial and aquatic organisms.

1A **Genetics and toxigenicity of Anabaena-dominated blooms in the Pacific Northwest**

Dreher, Theo - Oregon State University

Various morphotypes/species of planktonic Anabaena are commonly found in the Pacific Northwest. Based on reports of toxicity in the literature, Oregon considers Anabaena blooms to be potentially associated with four cyanotoxins: microcystin, anatoxin-a, cylindrospermopsin and saxitoxin. We are studying the genetic and toxigenic properties of Anabaena from three Willamette Valley reservoirs (2011-2013) and from Anderson Lake near Port Townsend in Washington (2012-2013). In the Willamette Valley, Anabaena-dominated blooms in Dexter, Dorena and Detroit Reservoirs were essentially non-toxic, although low levels of microcystin and cylindrospermopsin (< 1 µg/L) were detected in a minority of samples. Genes required for the biosynthesis of microcystin, anatoxin-a and cylindrospermopsin were detected by PCR, also in a minority of samples, except for a greater prevalence of cylindrospermopsin biosynthetic genes in Detroit Reservoir. Based on analysis of the phycocyanin gene locus of isolated colonies and of bloom samples by high-throughput DNA sequencing, blooms are dominated by one or two of five distinct phycocyanin gene variants. The Willamette Valley Anabaena blooms thus include a handful of genetically distinct variants of low toxicity, and our studies suggest that currently mandated toxin analyses in reservoirs used as drinking water sources could perhaps be relaxed. On the other hand, levels of anatoxin-a >100 µg/L have been recorded in Anderson Lake. Anatoxin-a was detected in isolated Anabaena colonies, whose phycocyanin genotype differed from those prevalent in the Willamette Valley. An assessment of the genetic diversity and toxigenicity of bloom-forming Anabaena present in the PNW is important in understanding which of these blooms represent public health threats.

1A **Cyanobacteria biomass dynamics within Oswego Lake, Oregon, 2000 through 2012**

Gehres, Lillian - Portland State University

Nuisance algae populations, particularly those dominated by cyanobacteria are a worldwide water quality problem that is anticipated to increase in frequency, distribution, and impact due to a warming climate. Forecasted increases in temperature are predicted to benefit cyanobacteria as their tolerance of higher water temperatures allow them to proliferate. Oswego Lake has already experienced nuisance blooms, and has taken management steps to combat conditions favorable to algae and rapidly exploited by cyanobacteria. The intent of this study is to determine what environmental factors influence the percent contribution of cyanobacteria to the total algal community in Oswego Lake. Time series pots and Classification and Regression Tree (CART) analysis was used to assess a 13 year (2000–2012) dataset. Aluminum sulfate applications sharply reduced soluble reactive phosphorus, cyanobacteria biomass, and cyanobacteria percent contribution to the total algal community. CART analysis of annual data showed water temperature of 18.3 C is the primary factor that determines percent cyanobacteria contribution. Analysis of summer growing season data showed total phosphorus is the environmental variable best able to distinguish percent contributions.

1A **Application of high throughput molecular diagnostics to better inform cyanobacterial harmful algal bloom monitoring strategies**

Otten, Timothy - Oregon State University

An area of uncertainty with regard to cyanobacterial harmful algal bloom (CHAB) monitoring is the frequency in which lakes/reservoirs should be tested in order to maximize public health while minimizing the costs associated with oversampling. In particular, what is the appropriate sampling approach to take when cyanobacteria are present, but below an action limit? The application of high throughput sequencing and quantitative molecular diagnostics such as QPCR to the study of cyanobacterial harmful algal blooms (CHABs) enables new insights into their physiological potential (e.g., toxigenicity, nutrient demands), spatiotemporal patterns and niche adaptation strategies. The combination of these data, with other commonplace metrics such as cell counts and toxin analysis, can be used to better inform water quality monitoring and management practices. Here we propose a new sampling framework for monitoring CHAB impacted water bodies which incorporates field and laboratory measurements of cell doubling times, toxin quotas (pg/cell) and strain succession rates for two of the most ubiquitous CHAB genera–Microcystis sp. and Anabaena sp. The goal of this work is to reduce the inherent variation in monitoring approaches, which can be subject to personal interpretations of water quality conditions, by empirically validating a sample collection schedule that: 1) is protective of human and animal health; 2) can be widely applied to diverse freshwater ecosystems; and 3) minimizes financial encumbrances and specialized training requirements.

1A **Microcystin in Puget Sound Mussels**

Preece, Ellen - Washington State University

Direct exposure or consumption of water with cyanobacteria toxins, such as microcystin (MC), present 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. Initial mussel analysis, by ELISA, detected MC concentrations above the safe threshold set by the World Health Organization. However, LC-MS/MS results indicated no MC presence. It is unclear if ELISA is yielding false positives and further analyses is needed to determine if Puget Sound mussels are contaminated with MC.

1B **Biotic and Abiotic Factors Influencing the Survival of Juvenile Salmonids Migrating Through the Lower Columbia River Hydrosystem**

Elder,Timothy1, Christa Woodley2, Gene Ploskey2, Mark Weiland2, and Angela Strecker1
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2 Pacific Northwest National Laboratory 390 Everg - Portland State University

Pacific salmon populations have been in decline for decades. Juvenile and adult salmon runs on the Columbia and Snake Rivers have been impacted by a wide variety of environmental and anthropogenic factors, including hydropower development. This study examines the biotic and abiotic variables affecting the survival of juvenile Chinook salmon (Oncorhynchus tshawytscha) passing through three lower Columbia River hydropower projects and associated reservoirs. In the spring of 2011, the Juvenile Salmon Acoustic Telemetry System (JSATS) was employed to track individual salmon on their outward migration. Acoustic transmitters and passive integrated transponders were surgically implanted into yearling Chinook salmon (n=7,692) at the John Day Smolt Monitoring Facility. The fish were tracked through the lower Columbia River hydropower system, including three large reservoirs, using in-river autonomous hydrophone arrays and dam-mounted hydrophones. Environmental data was collected at The Dalles Dam and applied to survival data using logistic regression and hierarchical partitioning in order to identify the factors that most influence survival. Based on preliminary findings, the most influential biotic and abiotic variables affecting the survival of juvenile Chinook salmon differs based on the number of hydroprojects and reservoirs encountered. Accounting for the confounding environmental and anthropogenic factors involved with the survival of Columbia River salmon remains a major obstacle in addressing the decline of anadromous fishes in this system. Continued investigation into the effects of biotic and abiotic variables on fish passing through the hydrosystem will help inform future management options for endangered and threatened species on the Columbia River.

1B **Patterns in bacterial community responses to eutrophication in Puget Sound Lakes**

Jankowski, KathiJo - University of Washington

Urban development has caused widespread nutrient enrichment and eutrophication of lake ecosystems. Increasing lake eutrophication has been shown to alter the diversity, composition, and ecology of many lake communities. However, the response of the bacterial communities that underlie most crucial ecosystem functions is not as well understood. In addition, existing work has only evaluated the effects of increasing resource abundance (trophic status) on bacterial community responses and has not evaluated whether heterogeneity in resources within lakes may influence bacterial responses to eutrophication. We quantified how bacterial communities varied with the trophic status of lakes and whether community responses differed in surface and deep habitats in response to heterogeneity in nutrient resources. We found that bacterial communities were more abundant, richer, and more distinct among habitats as lake trophic state and vertical heterogeneity in nutrients increased, and that spatial resource variation produced habitat specific responses of bacteria in response to increased trophic status. Furthermore, changes in communities in high nutrient lakes were not produced by turnover in community composition but from additional taxa augmenting core bacterial communities found in lower productivity lakes. These data suggests that bacterial community responses to nutrient enrichment in lakes vary spatially, differ from the response of larger lake organisms to eutrophication, and are likely influenced disproportionately by rare taxa.

1B **Larval fish mortality in lakes**

Markel, Doug - Oregon State University

The typical teleost cohort from a stable population experiences an order of magnitude decline in biomass from the biomass of adult gametes to an inflection, usually in the juvenile stage, where an increase in total biomass compensates or exceeds loss from mortality. This pattern is due to the interaction of mortality and growth and mortality seems to be the more important factor in most systems. Causes of mortality are usually attributed to starvation and predation but in freshwater systems, especially lakes, loss from the lake due to vagrancy or entrainment are also important. I use data from endangered suckers to explore factors associated with cohort losses in Upper Klamath Lake. Most factors can only be described in qualitative terms, but three, vagrancy of larvae, entrainment of larvae, and the effects of a parasite on early juveniles could be quantified. Vagrancy and the parasite add substantially to background mortality and appear to have prevented the biomass inflection needed to form meaningful year classes.

1B **Influences of landscape connectivity and environmental drivers on zooplankton community composition in lakes of the Columbia Plateau, Washington**

Strecker, Angela - Portland State University

Anthropogenic alterations to natural systems can have severe consequences for ecological processes, changing the conditions under which species have adapted and interactions between species. Globally, aquatic habitat has been rapidly and irreversibly altered by damming and irrigation projects. The Columbia Basin Project in eastern Washington built six dams and >300 miles of canals for irrigation, flood protection, and power production, permanently flooding areas of the geologically significant channeled scablands. Early ecological studies determined that the many small natural lakes and ponds of this region ranged across broad environmental gradients of salinity, seasonality, and productivity, and contained distinct assemblages of zooplankton species. However, hydrological manipulations have changed both abiotic and biotic conditions in waterbodies through varying groundwater levels and altered connectivity via dams and irrigation canals. Thirty-eight lakes and ponds were sampled during the summer of 2012, including 23 that were originally sampled prior to the completion of the Columbia Basin Project. By design, waterbodies were chosen from both within and outside the zone of influence of the project, allowing for consideration of other environmental changes. Environmental variables explained greater variation in zooplankton community composition compared to spatial factors corresponding to aquatic habitat connectivity across the landscape. These results indicate that strong environmental gradients may overwhelm the effects of increased connectivity of aquatic habitats. Quantifying the effects of abiotic and hydrologic changes on aquatic community structure is imperative to improve understanding of how humans alter freshwater ecosystems, particularly in light of the rapid pace of irrigation development on a global scale.

2A **Oregon Harmful Algae Blooms Surveillance Program Guidelines and Illness Trends**

Farrer, David - Oregon Health Authority

In the absence of federal standards for cyanobacterial toxins in recreational or drinking water, Oregon's Harmful Algae Bloom Surveillance (HABS) Program has established its own health-/risk-based guideline values for drinking water and human and dog specific uses of recreational surface water. This presentation will present these guideline values and

discuss their intended uses. The HABS program also tracks illnesses in animals and humans related to exposure to cyanobacterial toxins. This presentation will discuss the process Oregon HABS uses to document, classify and track illnesses related to cyanobacteria. Although not statistically significant, there seems to be an increase in the number of people reporting illnesses related to exposure to cyanobacteria, but a decrease in the percentage of those reports resulting in classifications of "possible," "probable," "suspect" or "confirmed" cases. This apparent trend may indicate that public awareness of cyanobacteria is increasing but that more work is needed to educate the public about how to determine whether or not their illnesses are related to exposures to cyanobacteria.

2A **Washington's Freshwater Algae Program**

Seebacher, Lizbeth - Washington State Dept of Ecology

Toxic blue-green algae (cyanobacteria) are an emerging environmental and public health concern in Washington's lakes. Washington Departments of Ecology and Dept of Health (DOH) work with local health partners and federal and county natural resource scientist to track toxic blooms throughout the state. To provide a consistent approach to toxic blooms, the DOH developed provisional human health guidance values for the four most common toxins which have been incorporated into a protocol for lake managers. Ecology's Freshwater Algae Control Program (FWACP) was created by the state legislature in 2005 and funds a passive surveillance system in the state. King County Environmental Laboratory tests water samples for phytoplankton identification and toxicity for microcystin, anatoxin-a, cylindrospermopsin, and saxitoxins. The FWACP also provides funds for small grants to investigate and control harmful algal blooms. Some examples of the current projects supported by the grant program include: Snohomish County's whole-lake sediment inactivation of phosphorus release from sediments for Lake Ketchum, King County's use of floating wetland islands for water quality improvement in Hicks Lake and DOH's anatoxin-a genetic identification research in Puget Sound lakes. We will discuss Ecology's program as well as past and current projects funded by this program.

2A **Monitoring Results of Four Cyanotoxins in King, Pierce, and Snohomish Counties, Washington**

Hardy, Joan - Washington Department of Health

The Center for Disease Control and Prevention funded a five-year cooperative agreement with Washington State Department of Health (DOH) to investigate toxicity of cyanobacterial blooms in 30 lakes in western Washington. DOH and partners also determined public health impacts of cyanotoxins during this period (2009-2013). Microcystins, anatoxin-a, saxitoxin, and cylindrospermopsin were measured bimonthly June-October for three years and in 10 lakes for a fourth year, with additional samples collected during bloom events. Microcystins were the most prevalent cyanotoxin observed, followed by anatoxin-a, then saxitoxin. Cylindrospermopsin was rarely detected. The number of microcystin samples that exceeded Washington's state recreational guidance value for microcystins of 6 µg/L was progressively higher from late summer to early fall each year (219 samples above the standard; maximum concentration 25,200 µg/L). Anatoxin-a was observed above the state recreational guidance value for anatoxin-a of 1 µg/L in 18 samples from four lakes, with the majority of exceedances occurring during winter (maximum concentration 1,170 µg/L). Saxitoxin was observed primarily in one lake, with highest values observed in late summer through October (maximum concentration 193 µg/L). Information from monitoring allowed development of a targeted education and outreach approach, including an online database of cyanotoxin and phytoplankton results (NWtoxicalgae), animal safety alert posters, and a reference card for veterinarians.

2A **The 2013 Harmful Algae Bloom Season; Bloom Trends; Outreach Efforts and Future Activities**

Hillwig, Rebecca - Oregon Health Authority

Oregon's Harmful Algae Bloom Surveillance Program has established procedures to help educate people about harmful algae blooms, and to alert them of blooms on monitored lakes through news releases, email, phone calls and social media. Outreach to individuals and waterbody managers before, during and after a bloom is essential to ensure the public has the most up-to-date information needed to make informed decisions about their recreational activities. This presentation will provide information about program activities and outreach efforts in response to cyanobacterial blooms, and about how toxin based monitoring (TBM) of blooms over the past two years has changed bloom management and public messaging. As more lake managers opt to use this actual toxin measurement vs. the potential for toxins based on species and cell counts, TBM will continue to have a profound impact on the number of advisories issued. With funding for the HABS program going away September 30, 2013, this presentation will also discuss how OHA, in partnership with lake managers, will need to modify how information on blooms is dissemintated, and what adaptations to the advisory process will be necessary.

2A **Rapid Indicators for Assessing the Potential for Toxic Algal Blooms**

Williams, Gene - Snohomish County Surface Water Management

From 2009 through 2012, as part of a 30-lake regional examination of harmful algal blooms, ten lakes in Snohomish County, WA were monitored for environmental parameters that could help with early detection and rapid public notification of toxic cyanobacterial blooms. In particular, in-situ phycocyanin and in-situ chlorophyll a measurements were taken to correlate with the presence and intensity of algal scums and cyanotoxins. During the study period, eight of the lakes had cyanotoxins present above detection levels. Three of these lakes were studied more intensively, and all three experienced cyanobacterial blooms with toxin levels exceeding Washington State recreational guidelines. Microcystin concentrations in one lake reached as high as 18,400 µg/L. The monitoring results revealed that in-situ chlorophyll a values were not well-correlated with toxin levels or even with the presence of cyanobacterial scums. In-situ phycocyanin was a much more reliable indicator of cyanobacterial toxins and scums. In addition, the presence/absence of algal scums was a strong predictor of the presence and location of cyanotoxins in these lakes. Together, in-situ phycocyanin measurements and scum tracking were found to be rapid and inexpensive methods for assessing the likelihood of cyanotoxins and providing early public health warnings to lake users.

2B **Increased development in the last 17 years has not raised phosphorus in Lake Sammamish as predicted: Why?**

Bouchard, Debra; Welch, Gene - King County; Tetra Tech

By late 1970s, early 1980s, Lake Sammamish had largely recovered after wastewater diversion in1968, with the annual total phosphorus (TP) declining from 32 to 18 µg/L. But, increasing development threatened to raise TP to 28 µg /L at full build-out without controls (Perkins, 1995). However, TP and trophic state have not significantly changed since the 1980s, despite a 2.8 fold increase in developed land and a correspondingly substantial loss of forest. Although conductivity and alkalinity have increased about 20%, TP has remained stable. That stability was partly due to decreased hypolimnetic TP resulting from a long-term, 60% reduction in sediment P release. Had hypolimnetic TP not decreased, annual whole-lake TP would have increased 30%. Also, inflow volume has decreased and the stratified period has probably lengthened, as it has in Lake Washington, both allowing more water residence time for non-conservative TP to settle. King County's land-use controls, instituted in the late 1990s, may have also reduced TP in runoff from new development.

2B **The Long-Term Impact of Metal Smelting Operations on Arsenic Availability in Urban Lakes of the South-Central Puget Sound Region**

Gawel, Jim - University of Washington Tacoma

The ASARCO smelter in Ruston, Washington, contaminated the south-central Puget Sound region with heavy metals, including arsenic and lead. Arsenic and lead distribution in surface sediments of 26 lakes is significantly correlated with atmospheric model predictions of contaminant deposition spatially, with concentrations reaching 208 mg/kg As and 1375 mg/kg Pb. The temporal distribution of these metals in sediment cores is consistent with the years of operation of the ASARCO smelter. In several lakes arsenic and lead levels are highest at the surface, suggesting ongoing inputs or redistribution of contaminants. With 83% of the lakes in the deposition zone having surface sediments exceeding published “probable effects concentrations” for arsenic and lead, this study provides evidence for possible ongoing environmental health concerns. Moreover, this study finds that arsenic is highly mobile in these urban lakes, with maximum dissolved arsenic concentrations proportional to surface sediment levels and reaching almost 90 ppb As. Current knowledge of the chemical, physical and biological factors affecting arsenic mobility in these lakes will be discussed, and initial data on biotic effects explored.

2B **Identification of stressors to stream benthic communities that result from stormwater impacts originating from drainage network ponds and direct input.**

Plotnikoff, Robert - Tetra Tech, Inc.

Biological assessments were completed in two Puget Sound streams to evaluate the health of aquatic habitat in these watersheds and identify principle stressors responsible for the observed conditions. Biological communities (benthic macroinvertebrates and periphyton) were influenced by multiple stressors from three categories: hydrology, water chemistry and physical habitat. Hydrological modifications from storm event delivery volumes or timing were related to response in the biological community and reflected in Benthic Index of Biotic Integrity (B-IBI) and River InVertebrate Prediction and Classification System (RIVPACS) scores.

Biological expressions including multi-metric index score, RIVPACS score, and biometrics were related to: water quality, geomorphology, riparian condition, landscape condition, and toxics in sediments parameters. Water quality and geomorphology conditions in stream channels were correlated with biological response metrics such as temperature and fine sediment deposition and those result in limitation to salmon and steelhead spawning success. Wetlands and ponds that are part of the stream network had negative impacts in depositing fine substrate and toxics downstream.

Biological monitoring and stressor identification confirmed that multiple stressors related to pollutant loading, embeddedness, and stream hydrology were the principle cause of impairment. Watershed land use development and stormwater runoff, from direct input and from drainage network ponds, were identified as common causal agents for both pollutant delivery and hydrological changes. These stressors might be used as meaningful restoration targets for improving attainment of water quality standards and in-stream habitat and biological integrity goals.

2B **Identifying dominant phosphorus sources in the Lake Loma watershed**

Roberts, Mindy - WA Dept. of Ecology

Lake Loma is on Ecology's 303(d) list of impaired waters for total phosphorus. Monitoring conducted by Snohomish County has found high chlorophyll levels. Ecology assessed the relative contributions from different sources within the watershed using information obtained by Snohomish County. Total phosphorus levels will require a 48% reduction to achieve a concentration of 20 ug/L. Onsite sewage systems (OSS), animals, and lake sediments are the dominant sources, while fertilizer applications and atmospheric deposition are secondary sources. Fish stocking and recreational use produce little phosphorus. These patterns held whether analyzed on an annual average or peak seasonal basis, and both with and without considering attenuation. Management actions should focus on reducing dominant external sources, although lake conditions may not reflect reductions for years to decades due to internal loading.

3A **Building Oregon's first boat wash station to prevent the spread of AIS**

Dolphin, Glenn - Oregon State Marine Board

After a two year planning process a first of its kind project was completed in Oregon to build a boat wash station to help mitigate the impacts of recreational boats transporting aquatic invasive vegetation. This new boat wash station was constructed at the Coos County boat ramp facility at Tenmile Lake. Early August was the opening date. A presentation could be given to tell the story of this project from conception, planning, securing funding, engineering design and finally implementation. Portland State University was funded by the Marine Board to conduct a boater survey during the summer of 2012 (pre-wash station) to gauge the level of awareness of boaters about AIS issues and then to repeat the survey during the summer of 2013 (post-wash station) to see if boaters awareness levels increased and to see if boater's would use the wash station to clean their boats prior to and after boating in Tenmile Lake.

3A **Developing an understanding of the distribution vectors of invasive species via qualitative surveys of boaters at Tenmile Lake**

Cimino, Sam - Portland State University

Public awareness, more specifically boater awareness, of invasive species and proper boat cleaning procedures, may prove to be highly beneficial in reducing the transport and establishment of nonindigenous invasive species like New Zealand mudsnails and zebra and quagga mussels. Educational signs instructing one on identifying invasive species, properly checking one's boat for attached aquatic "hitchhikers", and thoroughly cleaning one's boat can be seen throughout the state of Oregon at public boat ramps; but have these efforts made an impact on the public? The Tenmile Lake Watershed Council, Oregon State Marine Board, and USFS have undertaken an initiative to increase public awareness of invasive species and proper cleaning procedures by building a boat wash station at the Tenmile Lake boat launch. In the summer of 2012, 199 qualitative human subject surveys were administered at Tenmile Lake in Lakeside, Oregon to boaters on their boating habits and knowledge of invasive species prior to building the boat wash ("pre-boat wash"). An extension of the 2012 study was conducted in the summer of 2013 to 200 boaters after the completion of the Tenmile Lake boat wash station ("post-boat wash"). Comparisons were made on the observations and answers of boaters prior to and after the boat wash installation. These results seek to identify the potential knowledge gaps boaters have on invasive species and proper boat cleaning procedures. In addition, this study aims to distinguish whether low budget (signs) and high budget (boat wash station) initiatives have a lasting impression and influence on boaters.

3A **State of Oregon Aquatic Invasive Species Prevention Program**

Dolphin, Glenn - Oregon State Marine Board

The Oregon Marine Board in cooperation with the Department of Fish and Wildlife co-manage the state's AIS Prevention Program. A presentation could be given to outline the program structure, present annual boat inspection data, review law enforcement statistics along with data regarding the state AIS boat permit program (revenue and boater compliance).

3A **Invasive mussel monitoring in the Columbia River Basin - past, present, and future**

Bollens, Stephen; Gretchen Rollwagen-Bollens; Tim Counihan; Jill Hardiman - WSU; USGS

Zebra and quagga mussels are native to Eurasia and have invaded the Great Lakes of North America, where they have caused several billion dollars of economic and ecological damage. More recently, zebra and quagga mussels have invaded several western U.S. water bodies, but have not yet been observed in 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 specific 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 water bodies with both high and low risk of establishment (based on calcium concentrations) and introduction. We also observed a substantial amount of monitoring occurring in areas with unknown risk. Our results suggest that reallocating future monitoring efforts and better understanding risk across the landscape may be desirable. Furthermore, our preliminary results 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.

3A **Holding The Line Against Aquatic Invasive Species**

Woolf, Thomas - Idaho Department of Agriculture

Idaho initiated an agressive treatment,survey and prevention program in 2006 to address the threat of invasive aquatic species. A lot has been learned along the way. Data will be presented summarizing watercraft inspection, survey and treatment from Idaho's invasive species program along with initiatives and plans for moving forward into the future.

3B **Vancouver Lake Watershed Partnership: How agencies, citizens, neighborhoods, and organizations are working to improve a community treasure**

Stone, Eileen - PC Trask & Associates

Vancouver Lake is a tidally influenced 2,300-acre shallow lake in Vancouver Washington. This historical floodplain lake has been altered by many factors, including management of the Columbia River hydrosystem. An early 1980s lake restoration project centered on the construction of a flushing channel between the lake and the Columbia River. In 2004, the Vancouver Lake Watershed Partnership formed as a community response to lake closures due to cyanobacteria. This 22 member Partnership includes local citizens along with representatives from local, state and federal agencies. There are three main funding partners, but many other agencies and groups have donated funds and/or resources to support the effort. The work of the Partnership has evolved from hosting discussions on people's knowledge of the lake, to planning for and guiding research, to its current undertaking of using Partnership-developed lake management objectives and incoming research results to develop recommendations for future lake management.

3B **Assessing the role of zooplankton grazing on the development and decline of harmful cyanobacteria blooms in a tidally-influenced floodplain lake (Vancouver Lake, WA, USA)**

Rollwagen-Bollens, Gretchen - Washington State University Vancouver

Since 2007 we have been investigating the factors that influence the development of intense seasonal cyanobacteria blooms in Vancouver Lake – a large, tidally-influenced shallow lake in the lower Columbia River flood plain in Washington state, USA. Over two complete bloom cycles (May – October) in 2008 and 2009, we conducted bi-weekly

dilution experiments and grazer incubation experiments to concurrently measure cyanobacteria/algal growth rates, microzooplankton (ciliates, dinoflagellates) community grazing rates, and mesozooplankton (copepod and cladoceran) clearance and ingestion rates. From April to June of both years, algal/cyanobacterial growth rates were maximal and microzooplankton grazing rates were relatively low. By contrast, from mid-June to mid-July (immediately preceding each year's cyanobacteria bloom), both algal growth rates and microzooplankton grazing rates were often negative, suggesting a "trophic cascading" effect may have led to conditions which promoted rapid cyanobacteria growth. Algal growth rates rapidly increased back to maximal rates after the cyanobacteria bloom began, and remained high during the bloom from late July to early September. However grazing rates of both microzooplankton and copepods also increased markedly as the bloom progressed, such that by September/October of 2008 and 2009 grazing rates were approximately equal to algal growth rates. This suggests grazers may have contributed to the rapid decline in cyanobacteria abundance, and demonstrate that zooplankton grazing may play an important role in the overall development and decline of cyanobacteria blooms.

3B **The influence of environmental variables on cyanobacteria blooms in Vancouver Lake, Washington**

Lee, Tammy - Washington State University

The increasing frequency of cyanobacteria harmful algal blooms in freshwater systems is a serious problem due to their detrimental effects on water quality. Current research suggests various biotic and abiotic interactions influence bloom formation, persistence, and decay in freshwater systems. Vancouver Lake, located in Clark County, Washington, is a large shallow lake of recreational and natural resource importance, where annual summer cyanobacteria blooms have been recorded over several decades. Our research objectives were to first investigate which abiotic environmental variables influence cyanobacteria blooms; secondly, examine which environmental variables influence toxin production, specifically microcystin; and finally, analyze how changes in environmental variables contribute to the fluctuations observed in toxin and non-toxin producing cyanobacteria.

From 2007 through 2010, we quantified phytoplankton abundance and community composition and measured several environmental variables (i.e. nutrients, temperature, and total lake depth). From 2009 to 2010, we monitored intracellular and extracellular microcystin concentrations using ELISA test kits, and toxin and non-toxin producing cyanobacteria populations using qPCR. In 2007, Microcystis and Anabaena were the most abundant cyanobacteria species present during the summer bloom. Blooms in subsequent years were dominated by Anabaena and Aphanizomenon. Microcystin concentration varied throughout each bloom ranging from <1 ppb to 15 ppb in 2009, and approximately 2 ppb to 14 ppb in 2010. Non-metric multidimensional scaling revealed that high levels of orthophosphate was the environmental factor most strongly associated with seasonal cyanobacteria bloom, increased microcystin concentrations, and increased toxin-producing cyanobacteria species.

3B **A water and nutrient budget for Vancouver Lake, Vancouver, WA**

Sheibley, Rich, James Foreman, and Cameron Marshall - USGS

Lake Vancouver is a large, shallow (mean depth 3-5 feet) lake that has been experiencing summer time cyanobacteria blooms which result in recreational beach closures. It is suspected that increased nutrient delivery, particularly phosphorus, is one of the triggers for these blooms; however, fundamental information on the timing and amount of nutrient delivery to the lake is lacking. We monitored flow and measured water quality for two years (2010-2012) at the three major inlets and outlets to the lake, and two locations within the lake in order to estimate monthly loads of nitrogen and phosphorus. Lake River, a tidally influenced tributary to the lake, can flow into and out of the lake and was the largest contributor of nutrients to the lake (range 20,000-80,000 kg/month for nitrogen; 3,000-9,000 kg/month for phosphorus). Lake River contributed more than an order of magnitude higher load when compared to other sources. Net loads from Lake River indicated that most months, Lake River acts as a net source of nutrients to the lake. Nutrient losses from the lake through Lake River were observed occasionally in summer months (June-August). During wet months (October-May), Burnt Bridge Creek was the second largest contributor of nutrients to the lake. During the warmer, drier months (June-September) flow and nutrient load was higher at Flushing Channel compared to Burnt Bridge Creek. In comparison, nutrient loads from groundwater and precipitation were small relative to surface water inputs. Across all sources, nitrogen loads were always an order of magnitude greater than phosphorus loads.

4A **Mason County's Most Precious Resource: "IT'S ONLY WATER"**

Booth, Steve; Bob Dick: Josh Wozniak - Friends Of Lake Nahwatzel; Herrera Environmental Consultants, Inc.

The Story of Lake Nahwatzel and the Road to a Lake Management District. The geology of the Olympic Peninsula forms great aquifers. The Cascadia subduction zone thrusts through miles of marine sediments resulting in vertical sandstone and shale formations, including the Olympic Mountains and the watershed of the lake. Ice age Glaciers and temperate rain forest climate shape the landscape and deposit multiple layers of gravel. Mason County forests colonize the new landscape. Plant and animals (and people) repopulate. 12,000 years of Salmon help build the forest. Fire and industrial forestry alter the ecosystem. Homesteads, fish hatcheries, oysterbeds, garbage dumps, sewage treatment plants, and pulp mills affect the watershed and water conditions. Olympic Biosphere designation for the area is established. The area includes Satsop River, John's Creek Aquifer, and 144 sq. miles of wetlands and springs. Nine spring fed creeks and rivers, resource value, development and utilization. Ecology of Lake Nahwatzel is exceptional. Water quality is high, flora and fauna are diverse and include rare species. Invasive species have been identified and control measures established. The undeveloped shoreline provides a high ecological value. Friends of Lake Nahwatzel begin effort to preserve re-zoned north shore. 2011 Change in Mason Co. law alters Growth Management Plan. FOLN created meetings held with County Commissioners and officials. July-September 2012 DNS appeal filed and hearings. Mason Co. Commissioners find for FOLN in January 2013, reversed in March 2013. FOLN begins partnership in conservation together with Forterra. North shore is listed for sale with real estate broker. FOLN begins formation of Lake Management District.

4A **IdaH2O Volunteer Water Monitoring Program: A Case Study**

Ekins, James - University of Idaho Extension Water Quality

University of Idaho Extension Service has created a unique volunteer water quality monitoring program at the confluence of education and data collection called IDAH2O Master Water Stewards. Maintaining water quality is necessary for drinking supply, recreation, and fisheries. Water monitoring is integral to maintaining quality, and successful monitoring programs are coupled with a robust outreach program. However, in Idaho, funding constraints require that state agencies prioritize only areas with known TMDL or other water quality problems; funding for educational programming is equally sparse. Volunteer monitoring by IDAH2O helps to meet substantial gaps in statewide data collection and outreach.

The proposed presentation is a case study for the benefit of those interested in starting a volunteer water quality monitoring program. Quantitative data from the case study includes patterns of volunteers and monitoring site increases, spatial distribution of sites, active v. passive volunteer ratios, active v. inactive registered sites, percentages of trained volunteers v. active volunteers. Qualitative data will include rich descriptions of processes employed in program development, constructive (and sometimes otherwise) critiques of the program, and unanticipated delays.

IDAH2O was launched in fall 2010 and currently has over 100 certified volunteers. Participants in the program attend an 8-hour workshop, and then adopt a stream location to conduct regular monitoring. Volunteers can monitor lakes or streams. The IDAH2O project has recently commissioned a customized online, real-time Hydrological Information System to allow volunteers to enter data through online forms and immediately publish this data via an interactive map. [This presentation proposal can be packaged either as a presentation or as a poster.]

4A **Innovations in Citizen-Based Aquatic Plant Monitoring and Collaborations**

Johnson, Matt - Contour Innovations LLC

Natural Resource Managers have long recognized the critical importance of observer networks and volunteer citizen monitoring. With citizen monitoring networks, Managers and Scientists acquire useful data for making more informed predictions and management decisions, while involved citizens gain an ownership stake in building the "knowledgebase" about the condition of ecosystems and the climate.

Citizen protocols for water quality (e.g., Secchi clarity) and meteorology (e.g., rainfall) data collection are largely objective and are becoming increasingly standardized throughout the nation. As a result, comprehensive datasets are being merged at large geographic scales to assess the current status and trajectory of water resource and climate conditions. Despite well-intentioned citizen programs to map and monitor aquatic plants in several US states, most are subjective and non-standardized. Consequently, results will differ across surveyors, systems, and geographic regions. This strongly limits the power and usefulness of data collected from these programs. This is unfortunate because of the importance of aquatic plants for fish habitat and water clarity, and the vulnerability of lakes to invasive aquatic plants.

Homeowner groups and government agencies recognize the urgency of proactively protecting lakes from harm but have lacked tools to evaluate the effectiveness of their aquatic plant management efforts or collaborate in this effort. We present how an automated cloud-based aquatic vegetation mapping system has opened the door to cooperative and objective citizen-based monitoring of aquatic plants with two case studies where public and private lake management entities are working in collaboration with lake homeowner associations.

4A **Volunteer Lake Monitoring: The Pierce Conservation District Approach**

Ragland, Isabel - Pierce County Conservation District

Pierce Conservation District protects and conserves the natural resources of Pierce County by assisting local individuals and communities. Formed in 1949 by authority of the State Legislature, Pierce Conservation District primarily served rural farmers in unincorporated Pierce County focusing on soil erosion prevention and improving production yields for livestock and row crop farmers. Today we work with local jurisdictions and private landowners in rural, suburban, and urban settings providing technical assistance, public education and assistance with finding funding resources to protect water quality, conserve our soil, improve local habitat function for fish and wildlife and increase our local healthy food options. Since 1994 the District has managed a robust stream water quality monitoring program engaging citizens in better understanding water quality impacts and providing technical water quality information to local jurisdictions and other partners. In 2000 the District's Water Quality program began working with one local jurisdiction to create a citizen volunteer lake monitoring program, and since this time PCD has worked with several additional jurisdictions and lake association groups to assist them in a better understand their lakes' function. This talk will cover the nuts and bolts of Pierce Conservation District's volunteer lake monitoring program.

4B **A Slow, but Dramatic Recovery of Lake Spokane following Waste Water Phosphorus Reduction**

Brattebo, Shannon - Tetra Tech, Inc.

Lake Spokane water quality recovered gradually from eutrophy following a reduction in wastewater phosphorus (P) to 0.5 mg/L in 1977. Initial recovery was documented as inflow total P (TP) declined from 104 to 22 µg/L over a seven-year period (Patmont, 1987). Summer chlorophyll (chl) also declined from 21 to 9 µg/L and volume-weighted (V-W) hypolimnetic minimum dissolved oxygen (DO) increased from 1.4 to 4.5 mg/L over that same period. Recent data (2010-2012) have shown even more improvement with minimum hypolimnetic V-W DO nearly 7 mg/L, and TP and chl at 12.4 and 3.4 µg/L, respectively. Areal hypolimnetic deficit rate (AHOD) (0.7- 0.8 g/m2 per day) is now less than sediment DO demand rate in the 1970s (1 g/m2 per day) and 80% less than the pre-P reduction AHOD. This degree of recovery in DO resources is unique, especially for reservoirs, which usually have higher AHODs than lakes.

4B **Assessing Water Treatment Residuals as a Filtration Media for Phosphorus Removal at Wapato Lake - Tacoma, WA**

Hite, Brian - Center for Urban Waters, UW Tacoma

Wapato Lake in Tacoma, WA is a 23 acre urban lake that has had problems of eutrophication and toxic algae blooms for over a hundred years. Inputs of phosphorus from both environmental and anthropogenic sources contribute to this problem. Much of the 900-acre watershed consists of residential or commercial development, increasing the amount of stormwater containing increased levels of phosphorus. Past management efforts designed to control eutrophication at Wapato included constructing a diversion structure to route phosphorus rich stormwater around the lake. This plan increased the retention time of Wapato to ≈ 8.5 years. We have been tasked by the City of Tacoma to research the prospects of introducing filtered stormwater runoff into the lake to reduce retention time. Our plan includes creating a media filter using a waste product from the drinking water industry “Water Treatment Residuals” (WTR) as an amendment to a sand filter to adsorb and trap phosphorus. To determine WTR’s viability as a media filter we have compared WTR from three drinking water facilities with commercial stormwater filtration media. The WTR and media mixes were compared using a series of experiments including kinetic and batch adsorption isotherm tests to determine the contact time and maximum adsorption of phosphorus as well as tests looking into dissolved metals in the leachate. In phase 2 of this experiment we will compare the best working WTR mixture to proprietary mixes in terms of its physical filtration capabilities, total and ortho-phosphorus removal using water from Wapato Lake.

4B **Three Years of Operational Experience with Phoslock Phosphorus Sequestering Technology**

McNabb, Terry - Aquatechnex, LLC

In 2009, the Orange County Regional Park system in Southern California awarded our group a contract to manage 15 lakes in their 9 Regional Park system. While all of these lakes experienced problem planktonic algae bloom, the premier park in the system was also lake that receives reclaimed water.

During this process, we discovered Phoslock, a technology developed by the Australian National Science Academy to target cyanobacteria problems in that Country. We because the first group in the United States to import and utilize this technology.

Since that time, we have treated over 15 water bodies in the Western United States including Washington systems. This paper will present background on the development of this technology, sampling protocols to calculate dose rates and present real world results through case studies.

4B **A phosphorus loading sensitivity analysis for Long (Spokane) Lake using CE-QUAL-W2**

Brett, Michael, Brown, H.K., Brynestad, B.E., Butcher, T.W., Curtis, C.A., Dara, J.T., Finley, J.D., Garguilo, N.J., Gray, K.W., Grinnell, C., Kattainen, S.K., Lawler, A.M., Li, Bo, Martinkosky, L., Miller-Schulze, J.R., White, F.P., and Wurden, P.G. - University of Washington

Long Lake in Spokane County, Washington, has historically experienced very low hypolimnetic dissolved oxygen (DO) concentrations due to eutrophication. Phosphorus discharges from various wastewater treatment plants (WWTPs) within the basin have been a major contributor to this problem. Prior to 1977, these WWTPs had an average Total Phosphorus (TP) concentration of 3,500 Âµg/L. In 1977, the City of Spokane WWTP added an alum phosphorus removal step, which lowered effluent TP to approximately 500 Âµg/L. To further reduce phosphorus loading to Long Lake, most WWTPs in this basin have agreed to implement state-of-the-art technologies to reach effluent TP concentrations of 50 Âµg/L or less. Some entities have advocated for effluent targets as low as 10 Âµg/L. A graduate course at the University of Washington, used the model CE-QUAL-W2 as it is configured to Long Lake to conduct a series of phosphorus input sensitivity analyses. Hypothetical effluent TP concentrations of 3,500, 500, 100, 50, 35, 10 and 0 Âµg/L were tested for all of the WWTPs that currently discharge to the Spokane River/Long Lake system. Model output reservoir inflow TP concentrations, model daily average hypolimnetic DO concentrations, and model vertical DO profiles in the late summer were assessed for each scenario. These simulations suggest Long Lake was very strongly influenced by the reduction in effluent concentrations from 3,500 to 500 Âµg/L, and moderately responsive a hypothetical change from 500 to 100 Âµg/L. Effluent TP concentrations in the range of 100 to 10 Âµg/L resulted in much smaller DO differences in the CE-QUAL-W2 outputs. The CE-QUAL-W2 model exhibited several features, such as extreme diurnal DO fluctuations in the hypolimnion during the highest TP loading scenarios, which were also considered.

5A **Elevated pH as a disinfection tool against three invasive mollusks of concern**

Barenberg, Amber - University of Idaho Fish and Wildlife Sciences Co-op Unit

Many non native mollusks are easily transported on aquatic gear, boats and in ship ballast. We are evaluating hydrated lime (calcium hydroxide: Ca(OH)2) and sodium hydroxide (NaOH) that could be used to raise the pH of treatment waters (11-12) easily with little comparative cost to other compounds. The elevated pH solutions can be neutralized easily by addition of CO2 or simple aeration. We conducted replicated laboratory based, static exposure tests with three invasive mollusk species: New Zealand mud snail (Potamopyrgus antipodarum) (NZMS), quagga mussel (Dreissena bugensis), and Asian clam (Corbicula fluminea). The temperature of test system, pH, size, as well as the test chemical affected the time to mortality. NZMS and quagga mussels exposed to solutions of NaOH or Ca(OH)2 of equal pH died slightly faster in Ca(OH)2 test solutions. Adult sized Asian clams were the most difficult to kill and required more than a week of exposure to reach 100% mortality. The veligers of quagga mussels and Asian clams were highly sensitive to solutions of elevated pH. Quagga mussel veligers tested with Ca(OH)2 at 15°C and 20°C showed 100% mortality within 8 min. Quagga mussel veligers were killed within 0.5 h in solutions of NaOH (12 pH) at temperatures from 15°C to 20°C. However, Asian clam veligers required longer than a 2 h exposure at 20°C and 12°C to reach 100% mortality. We are repeating our testing to determine the range of safety and options for scaled up field trials.

5A **Influence of lake hypolimnetic oxygenation on a brook and rainbow trout fishery**

Cross, Benjamin - Washington State University

Lake eutrophication can threaten deep lake coldwater fisheries by causing a summertime temperature and dissolved oxygen habitat squeeze. Anthropogenic eutrophication in North Twin and South Twin Lake, Washington has apparently degraded brook (Salvelinus fontinalis) and rainbow trout (Oncorhynchus mykiss) habitat, reducing trout condition, growth, and survival. To address these concerns, external nutrient inputs have been limited and hypolimnetic oxygenation was implemented throughout the summer stratification season in North Twin Lake beginning in 2009. South Twin Lake has been used as a non-oxygenated reference lake. Trout in North Twin Lake immediately expanded their habitat use and began to occupy the oxygenated hypolimnion. We compared trout condition, growth, and survival in oxygenated North Twin Lake to South Twin Lake. Our results suggest oxygenation has not had a significant influence on brook or rainbow trout condition, in terms of relative weight. Both lakes continue to see significant reductions in rainbow and brook trout relative weights during early summer and stabilize at lower relative weights in later summer. Some years, brook trout relative weights remain stable throughout the summer in both lakes. Growth rates for rainbow and brook trout are also similar between lakes throughout the summer. However, catch per unit effort data from 2010 revealed that North Twin may have a higher annual carryover of rainbow trout stocking classes compared to non-oxygenated South Twin. Although trout condition and growth appear not to have been influenced by oxygenation, hypolimnetic oxygenation may benefit the fishery by increasing trout survival necessitating fewer stocked trout.

5A **Use of high resolution sampling to identify candidate sub-catchments for potential remediation to improve water quality in receiving water bodies.**

Rajkovich, Hallie - University of Idaho

The burgeoning human population, combined with anthropogenic changes to land use have greatly altered the quantity and ratios of limiting nutrients (phosphorus (P), and nitrogen) delivered to water bodies worldwide resulting in cultural eutrophication often manifested in blooms of cyanobacteria. To maintain and remediate surface waters requires we understand the source of nutrients to effectively target corrective actions on the landscape. Willow Creek Reservoir (WCR) in Heppner, OR, completed in 1983, experiences annual long-duration blooms of toxic cyanobacteria related to high loads of catchment-derived nutrients, primarily P. To understand the origins of these loads, we instrumented sub-watersheds with automated samplers and depth loggers to obtain daily samples over the course of one year to calculate loads of sediment and P. Annual loads of sediment and P differed by sub-catchments, land use, and prior implementation of best management practices. High loads originated from high-elevation sub-catchments with a land cover of forest and grasslands used for free-range grazing. Our results suggest future remediation efforts should be concentrated in these high elevation sub-catchments to optimize monetary investment and reduction of sediment and nutrient loads.

5A **Sedimentary History of Loon Lake, Oregon**

Richardson, Kris - Oregon State University

Lakes are a useful sedimentary sink to study catchment ecosystem changes and perturbations such as earthquakes, fires, floods, and human land use. Sedimentary stratigraphy records changes in the mass accumulation rate, and the composition and source of materials delivered to the lake over time. The questions addressed in this research are, how are perturbations recorded in the stratigraphy of lake sediments, and what determines the fidelity of the record? The study site is Loon Lake and its catchment in the Oregon Coast Range portion of the Umpqua River basin. During the summer of 2013, several sediment cores are being removed from this 1400 year-old landslide dam lake, where much natural and anthropogenic disturbance in its catchment has occurred over its lifetime. The coring location and the cores' subsequent analysis will test several hypotheses. One hypothesis is that it is expected that different events in the catchment will result in identifiable, characteristic deposits in the sediments. Different characteristics are expected for deposits of other types of events (i.e. land clearance, fire, and flood). Also, it is expected that of the many variables which may affect the fidelity of the record, the magnitude of the event, the temporal position of the event relative to other events, and the in-lake conditions will be the critical variables. To test these and other hypotheses, the cores will be analyzed (including tests of mineral magnetic susceptibility, bulk density, grain size, absolute dating, charcoal abundance, elemental analysis, 210Pb spectroscopy) and then correlated by strata between cores.

5A **The influence of hypolimnetic oxygenation on the diets of rainbow trout (Oncorhynchus mykiss), brook trout (Salvelinus fontinalis) and golden shiner (Notemigonus crysoleucas) in Twin Lakes, WA**

Skinner, Megan - Washington State University

Line-diffuser hypolimnetic oxygenation (HO) was initiated in North Twin Lake, WA (NT) in 2009 to mitigate loss of coldwater fishery habitat due to temperature/dissolved oxygen squeeze and to reduce internal phosphorus cycling. Active tracking, net-captures, and hydroacoustic analyses demonstrated that trout populations rapidly expanded into increased hypolimnetic habitat in the first few years of oxygenation. However, long-term fishery benefits and many basic ecological aspects of hypolimnetic oxygenation have yet to be established. Diet and food web analyses indicate significant changes in feeding ecology of principal fish species in NT 2012, compared to pre-oxygenation (2005) and to un-oxygenated South Twin (ST) in 2012. Rainbow trout (Oncorhynchus mykiss) in NT consumed significantly more large-bodied daphnia during midsummer 2012 than those in ST, where rainbow trout fed primarily on littoral amphipods. Additionally, relative gut weight for brook trout (Salvelinus fontinalis) in August 2012 was significantly higher in NT, compared to ST, apparently due to increased access to hypolimnetic zooplankton. Golden shiner (Notemigonus crysoleucas) diets also appear to include more zooplankton in oxygenated NT. Observed changes in feeding ecology following HO have significant implications for future fishery management in the Twin Lakes.

5B **Influence of hypolimnetic oxygenation on the dietary contribution of methane-oxidizing bacteria in lake zoobenthos**

Child, Andrew - Washington State University

Freshwater biogenic methane (CH4) is 13C-depleted in comparison to the organic sediments it is derived from. Methane-oxidizing bacteria (MOB) further discriminate against 13C in the oxidation process. Due to the unique δ13C signature of biogenic CH4, stable isotope analysis (SIA) is a powerful tool for estimating contribution of CH4-derived energy within lake freshwater food webs. Previous SIA studies have found significant levels of CH4-derived biomass in benthic invertebrates (i.e. Chironomidae, Oligochaeta) and zooplankton in eutrophic lakes. In eutrophic lakes, hypolimnetic oxygenation (HO) is used to restore DO levels at the sediment-water interface (SWI) to prevent internal phosphorous recycling, decrease reduced metal flux, and increase fish habitat. Because DO concentrations have strong influences on CH4 flux and oxidation, HO may have significant effects on invertebrate stable isotope compositions, and the amount of CH4-derived energy that can be transferred within aquatic and linked terrestrial food webs. Little work has been conducted on the effects of HO on the stable isotope compositions of profundal invertebrates, and whether HO effects MOB utilization within lakes. Our objective was to determine if HO decreases consumption of MOB, by limiting CH4 available to be oxidized at autumn turnover. To test whether HO had any influence on zoobenthos utilization of MOB, we compared δ13C compositions of chironomids, oligochaetes and Chaoborus sp. collected from three eastern Washington lakes: Newman Lake (20 years HO); North Twin Lake (5 years HO); and South Twin Lake (unoxygenated).

5B **Novel flow-through herbicide exposure experiment helps refine weed treatment program in the upper Columbia Basin**

Courter, Lauren - Mount Hood Environmental

Standard herbicide efficacy studies conducted in static exposure systems are used to establish application concentrations for the control of nuisance aquatic plants. It is unclear whether such results are applicable to the management of plants growing in hydrodynamic systems that experience changes in water flow due to variable stream discharge or wind patterns. We report results from a novel flow-through exposure system used to examine the efficacy of endothall dipotassium salt for the control of horned pondweed (HPW) (Zannichellia palustris) in a riverine environment. Seedlings were reared in a flowing system designed to simulate conditions in irrigation canals and laterals to replicate plant structure, leaf morphology and herbicide contact time. Water quality parameters were also customized to region-specific water temperature and chemistry. Results confirmed the efficacy of the current recommended application rate of 2.6 mg a.e. L-1 at 9 h, but found similar control at the 6 h exposure time point. Higher than expected efficacy after 6 h of exposure was attributed to the hydrodynamics of the exposure environment, whereby plants began to breakdown more rapidly due to shear stress from flowing water. Weed control measures in the Quincy Columbia Basin Irrigation District have been revised to reflect these findings. Flow-through experiments tailored to specific ecoregions improve understanding of herbicide efficacy and are vital for supplying weed management professionals with the data necessary to optimize control in riverine systems.

5B **Water Level Management Affects Methane Bubble Emissions from Reservoirs of the Upper Klamath River, Oregon**

Deemer, Bridget - Washington State University

Lakes and reservoirs are a globally important source of atmospheric methane (CH4), a potent greenhouse gas. The bubbling of CH4 from sediments (ebullition) is an important pathway for lentic CH4 release. However, CH4 ebullition is underrepresented in published datasets. The main goals of this project were to: (1) estimate summertime CH4 ebullition rates in two temperate reservoirs, and (2) quantify the effects of hydropower peaking on these rates. We measured CH4 ebullition via stationary gas traps on two eutrophic reservoirs that occur in series in the upper Klamath River Basin. One reservoir is managed to maintain a constant water level and the other experiences daily water level fluctuations to meet hydropower demands. Ebullition rates were measured over 6 days, including 2 days during which the hydropower reservoir was managed to attain maximum possible water level drop. Average CH4 ebullition rates in the hydropower reservoir were nearly three-fold higher than in the reservoir managed for constant water level (528 mg CH4 m-2 d-1 and 187 mg CH4 m-2 d-1 respectively). The highest ebullition fluxes were observed during the water level drawdown component of the hydropower peaking cycle (maximum rate of 14,300 mg CH4 m-2 d-1 during one of the extreme drawdown events). CH4 ebullition rates reported for both reservoirs are among the highest recorded in temperate lentic systems. The link between CH4 bubbling and water level drawdown may represent an exciting opportunity to manage reservoirs so as to reduce CH4 emissions.

5B **Impacts of Dam Removal**

Laura Schroeder - Schroeder Law Offices, P.C.

Despite political policy supporting upstream water storage, the West is seeing more dams removed generally for the perceived purpose of increasing or facilitating fish passage. This presentation will focus on two cases of dam removal in which Schroeder Law participated. The first, the removal of the annual push up dam to divert water to a small area in the Wallowa Mountains. The second, the removal of the Chiloquin Dam near Klamath Falls, Oregon. In both instances, the first and primary concern was financial. Neither dam would be removed by the constituency benefitted by the water diversion without those desiring the improved fish passage to first come forward with the dollars to fund the project, including removal, replacement facilities and on-going added costs. In the Wallowa example, the individuals taking off the diversion were able to obtain a National Resources and Conservation Service (NRCS) grant. In the Chiloquin example, the Bureau of Indian Affairs (BIA) provided the grant. In both cases, federal money supported the dam removal projects. A second concern in both instances was the effect on the water rights involved. Necessarily, taking out a dam requires legal changes to any water rights point of diversion. In both examples, the most complicated part of the change application was unraveling what acres were receiving water from the existing point of diversion usually uncovered issues such as abandonment and forfeiture. An additional water right issue is presented when a portion of the historic diversion must be used for fish passage and not diverted to the existing users. Approval to transfer water rights in a district to a non-consumptive use, require the owners of the benefitted acres to approve such a change. A final concern is the environmental impacts of the replacement facility which affect access and scenic prescriptive easements, including placement of fish screens over replacement facilities/pumps, fish ladders/passage easements, sediment release, and changes in water levels at the water sources. A complication arises when these issues involve federal, state, and private property interests whose various rights must be re-negotiated in some fashion for the dam removal.

5B **Which Blue Lake?**

Lycan, Richard - Portland State University

Relating data to particular lakes requires a unique identifier so that data for Blue Lake is connected to the correct Blue Lake in the database. The current national standard for identifying lakes and reservoirs is the reach code as used in the National Hydrography Dataset. Lake name from the Geographic Names Information System (GNIS) is a secondary identifier for lakes. At the outset we decided not to use the reach code in the Atlas as the unique feature identifier because the coverage of lakes and reservoirs in the NHD was incomplete and inaccurate. Most of the effort in building the NHD was directed toward building a stream network that could be used for modeling stream flow and lakes were incidental. The paper will describe the problems with the NHD and GNIS in cataloging of lakes. Early implementations of stream networks in the PNW used a unique concatenation of longitude and latitude identifier to identify water features (e.g. LLID 1232157454802 for Henry Hagg Lake) and were used by state agencies for lake data. However, The NHD reach code has been adopted in the Oregon Hydrography Data Standard and state agencies now are in the process of making the conversion and so the Atlas will as well. The paper will discuss some of the cooperative efforts with Oregon Water Resources and the PNW Hydro Framework Committee to make improvements in the lake coverage of the NHD and in the GNIS.