Plenary Talk

Capitol Lake: Past, present, and future

Mindy Roberts - Washington State Department of Ecology, Environmental Assessment Program

Capitol Lake was created in 1951 by damming the Deschutes River estuary to create a reflecting pool for the Washington State Capitol. The 260-acre shallow lake has experienced a number of water quality and habitat problems over the years, including high bacteria concentrations, sediment deposition from the Deschutes River watershed, luxuriant aquatic plant growth, Eurasian milfoil, algae blooms, and most recently an infestation of the invasive New Zealand mud snails. The Department of Ecology began a water quality investigation in 2003 that includes Capitol Lake as well as the Deschutes River watershed and Budd Inlet. The project goal is to identify what contributes to violations of the water quality standards for numerous parameters, identify reduction targets, and implement management actions to control sources. Independently, the Department of General Administration, now part of the Department of Enterprise Services, initiated the Capitol Lake Adaptive Management Plan to manage the lake into the future. In 2010, a majority of the CLAMP steering committee recommended that the lake revert to an estuary after reviewing the Capitol Lake Alternatives Analysis. The Departments of Ecology, Fish and Wildlife, and Natural Resources cited long-term benefits to water quality, habitat, and sediment management. The Department of Ecology determined that watershed nonpoint sources contribute to violations of the lake dissolved oxygen standards. In addition, Budd Inlet dissolved oxygen is worse with the lake in place, and nutrient reductions will be needed. Ecology is working with partners to determine the next steps in controlling pollution in the system.

Session 1A

Washington DNR aquatic lands management for Eastern Washington lakes and rivers

Jacob McCann - Washington State Department of Natural Resources

Washington State Department of Natural Resources is steward of 2.6 million acres of state-owned aquatic land, of which a good portion are lakes and rivers in Eastern Washington. On behalf of the people of Washington, we manage the resources attached to or embedded in aquatic lands as well as the man-made structures in the water and air space above these lands. Through the state constitution and legislature, DNR must ensure a balance of benefits for the citizens of Washington from the use of aquatic lands. These benefits include commerce and navigation, public use and access, use of renewable resources, protection of the environment, and, when feasible, generation of an economic return to citizens. This talk will outline how DNR's Aquatic Lands Division interacts with navigable waterbodies in Eastern Washington and what that means in reference to lake management strategies.

Initial habitat and food web studies in Rufus Woods Lake, Columbia River, WA, USA

David C. Richards[1]*, Jack Rensel[2], and Zach Ziegrist[2] - [1]EcoAnalysts Inc.; [2]System Science Applications

We provide a baseline and preliminary understanding of the physical habitat and food web of the 83 km long Rufus Woods Lake (RWL), a run-of-the-river hydropower reservoir, in relation to its fisheries. We created the first bathymetric map of RWL and conducted studies of primary and secondary productivity, standing stock, assemblage structure, and food web analysis from August 2010 through September 2011, two unusually extreme high flow years. Methods included; cobble scrapes and artificial substrate

sampling of periphyton, benthic invertebrate cobble baskets and benthic suction dredge sampling, game fish stomach sample analysis, and stable isotope analysis. RWL can be physically delineated into three distinct sections. Algal assemblages varied spatially and temporally and often dominated by noxious and potentially toxic species. Chlorophyll a varied by site and depth, AFDM was not observed to vary by location, season, and autotrophic conditions occurred in October 2010. Benthic invertebrate assemblages varied spatially and temporally and often were dominated by an invasive crayfish. Game fish diets also varied spatially and temporally. Stable isotope analyses suggest that fisheries may be affected by a commercial fish farm.

Beaver: Restoration and community engagement

Joe Cannon and Amanda Parrish* - The Lands Council

Our project studies the changes beaver dams have on local ecosystems over time. We work with land managers/owners to find solutions to perceived beaver problems by fencing trees, lowering pond levels, and in some cases relocation. By allowing beavers to maintain existing wetlands or by relocating them to allow for an opportunity for new wetlands, the environmental benefits associated with beaver dams remain: beaver ponds provide vital habitat for a myriad of wildlife species and help store and purify water. We are collecting baseline data on vegetation and water quality at various stages of beaver activity. By continuing our monitoring program, we hope to capture the rate at which beaver convert stream ecosystems to wetlands and to better quantify the amount of water stored by dams. Concurrently we present to various community groups and are capitalizing off of major media opportunities and developing outreach strategies to demonstrate the importance of beaver to the public.

The ongoing effort to control riparian invasive plants in the Grand Coulee Waterway - including Moses Lake

Dave Kluttz - Lakeland Restoration Services LLC

Since 2008, a multiple agency process has been developed to map and treat riparian invasive plants in Grant County, Washington. This effort has resulted in a county wide treatment performed by Lakeland Restoration Services covering hundreds of miles from Moses Lake to Park Lake. Invasive *Phragmites*, yellow flag iris, purple loosestrife, Tree of Heaven, and salt cedar are among the plants targeted to improve aquatic and riparian habitats on public and private lands.

Session 1B

Evaluation of hypolimnetic oxygenation effects on trout condition and survival

Benjamin K. Cross[1]*, Barry C. Moore[1], and Ed Shallenberger[2] - [1]Washington State University, School of the Environment; [2]Colville Confederated Tribes, Fish and Wildlife Department

Eutrophication may lead to summertime hypolimnetic anoxia in lakes which poses a growing threat to coldwater fisheries. Hypolimnetic oxygenation has been suggested as a means to restore appropriate deepwater salmonid habitat. We compare coldwater fisheries of North Twin, which began summertime hypolimnetic oxygenation in 2009, to non-oxygenated South Twin Lake. Upon oxygenation, trout

immediately utilized the cooler hypolimnetic waters in North Twin. Analysis of rainbow (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) relative weights revealed no statistical difference between lakes throughout the April to October sampling period. However, significant reduction in rainbow trout relative weights was noted among both lakes, while brook trout relative weights remained stable. Catch per unit effort data from 2010 revealed that North Twin has significantly higher annual carryover of rainbow trout stocking classes compared to non-oxygenated South Twin and significantly higher total trout catch per unit effort. Although trout condition appears not to have been influenced by oxygenation in the short-term, our results indicate that hypolimnetic oxygenation can provide increased survival of trout, potentially leading to a greater abundance.

The effects of hypolimnetic oxygenation on fish diet in a mixed warm- and cold-water fish community in Twin Lakes, Washington

Megan M. Skinner* and Barry C. Moore - Washington State University

A temperature/dissolved oxygen "habitat squeeze" is a common problem impacting cold-water fisheries in deep, eutrophic lake systems. A habitat squeeze may increase competition, reduce access to food sources, increase physiological stress, reduce fecundity, and generally negatively impact fish. Hypolimnetic oxygenation (HO) is an increasingly popular management tool that may be applied to address the temp/DO squeeze. HO has been shown to increase available habitat, and our previous studies have demonstrated that fish respond rapidly to utilize that habitat. However, long-term fishery benefits and even basic ecological impacts of HO have not truly been documented in a comprehensive manner. Our study assesses the effects of HO on diet of largemouth bass (*Micropterus salmoides*), golden shiner (*Notemigonus crysoleucas*), rainbow trout (*Oncorhynchus mykiss*), and eastern brook trout (*Salvelinus fontinalis*) in Twin Lakes, Washington. Fish diets in treated North Twin Lake and untreated South Twin Lake are compared with gut content analysis utilizing the Relative Importance Index and Schoener's Overlap Index. Rainbow trout and eastern brook trout diets are also compared monthly between lakes. We anticipate observing a difference in trout diet between treated North Twin and untreated South Twin Lakes as trout access habitat created by HO, however, it is still unclear what effect HO will have on largemouth bass and golden shiner populations in the lakes.

Fish habitat utilization and reduced phosphorus cycling with hypolimnetic oxygenation at Twin Lakes, WA

Barry C. Moore[1]* and Ed Shallenberger[2] - [1]Washington State University, School of the Environment; [2]Colville Confederated Tribes, Fish and Wildlife Department

Line diffuser hypolimnetic oxygenation was implemented in North Twin Lake during the 2009 summer stratification season, and appears to be highly efficient in maintaining target oxygen levels. Prior to oxygenation, both North and adjacent South Twin Lakes exhibited rapid depletion of oxygen with stratification. South Twin summer hypolimnion in June 2009 contained <20% of stratification onset oxygen (SOO), while North Twin HO was 135% of SOO all summer. Fish distributions were tracked with hydroacoustics, sonic tags, and net surveys. Cold-water species were found primarily in the NT hypolimnion, but were confined to the meta- and epilimnion of anaerobic South Twin. Internal cycling of total phosphorus, estimated by hypolimnetic accumulation rates was about 1.4 mg/m^2/day in South,

compared to a loss of about -0.8 mg/m^2/day for North Twin. Very rapid water quality response expanded habitat utilization in North Twin, and plans for installation in South Twin in 2010 are proceeding. Interestingly, fishery indicators such as overall survival and catch-per-unit-effort (CPUE) appear to have improved for both lakes, but data are far from certain. Potential explanations and needs for future research directions are discussed.

Effects of the aquatic herbicide endothall on the survival of salmon and steelhead smolts during seawater transition

Lauren Courter[1]*, Tommy Garrison[2], Ian Courter[2] - [1]Mount Hood Environmental; [2]Cramer Fish Sciences

Pacific Northwest salmon and steelhead utilize fresh and saltwater habitats during their life-cycle, and their osmoregulatory transition to seawater is a critical determinant of survival. The aquatic herbicide endothall exhibits low acute toxicity to salmonids; however, effects on osmoregulatory performance of seagoing juveniles (smolts) following exposure remains uncertain. Previous research implies latent toxicity, but small sample sizes, inappropriate life-stages, static exposures, and insufficient seawater challenge durations generated contradicting results between studies. Here, coho, Chinook, and steelhead were subjected to a ten-day seawater challenge following acute exposure to endothall dipotassium salt (Cascade®) in a flow-through system. Acute exposure (96h) ranged from 0 to 12 ppm acid equivalent (a.e.) endothall . The seawater challenge yielded mean survival rates of 82% (n=225), 84% (n=133), 90% (n=73) and 59% (n=147) for 0, 3-5, 6-8, and 9-12 ppm a.e. exposure groups, respectively. Steelhead exhibited a statistically lower survival rate for all treatments relative to coho and Chinook. Surviving fish of all species did not experience significant changes in osmoregulatory function, as revealed by plasma sodium analysis. Lowest observable effect concentrations (LOEC) were 9 and 12 ppm a.e. for steelhead and coho/Chinook, respectively, indicating a lower LOEC compared with previous acute toxicity studies, but a higher threshold compared with previous seawater challenge studies. Our findings emphasize the importance of considering the unique life-cycle of salmonids and carefully designing assays when defining the toxicity of aquatic herbicides applied in the presence of salmon and steelhead.

<u>Session 2A</u>

The Columbia River Eurasian watermilfoil control project

Mike Mackey - Chelan County Noxious Weed Board

This presentation will describe the step by step process of writing a CWMP that includes 35 County, State, Tribal, and Canadian weed boards and federal agencies all with management responsibilities on the Columbia river. We will also talk about planning the first project, which is being written by several agencies.

Noxious aquatic plants: Historical perspective and looking towards the future

Kathy Hamel - Washington State Department of Ecology

Eurasian watermilfoil first came to the notice of the state in the early 1970's as it made its way down the Okanogan chain of lakes in Canada into Washington waters. Since that time, the Washington State Department of Ecology has been in the forefront of working to manage and contain populations of

Eurasian watermilfoil. When the state legislature established the Aquatic Weeds Program with dedicated funding in 1991, Ecology and others were starting to realize that Eurasian watermilfoil was just one of numerous invasive, non-native freshwater plants that were altering ecosystems. The program expanded to include species like hydrilla, Brazilian elodea, and purple loosestrife. The State Noxious Weed Board started adding aquatic plants to its state weed list. County boards surveyed for and controlled aquatic weeds. Now there is infrastructure in place and the future of aquatic weed management seems promising (although the invaders keep arriving).

Collaboration with Canada to explore bio-controls for Eurasian watermilfoil

Anna Lyon - Okanogan County Noxious Weed Control Board

Eurasian watermilfoil is non-native and can quickly overtake your favorite swimming or fishing hole. Dense floating mats can cause recreational hazards, and negatively impact aquatic habitats. Southern British Columbia and Washington State have differing preferences in controlling Eurasian watermilfoil. We concur that exploring the control potential of the milfoil weevil, *Euhrychiopsis lecontei*, is beneficial for both sides of the border. The milfoil weevil, a native species, prefers Eurasian milfoil over its' intended host, Northern milfoil. Several small scale experiments have provided promising results for using the weevil in a much larger endeavor. In fact, rearing and distributing the weevils has become a major component of business for an Ohio company. Because of concerns over importing other, and possibly even more devastating, invasive species, this route is not available for us. With help from DOE, OCNWCB and the Lake Osoyoos Association were able to purchase supplies, collect milfoil and weevils, and attempt a rearing operation. We wanted to determine if this would be a reasonable project for individual lake associations. It was successful and we were able to release more weevils than collected. We are now working to determine if the rearing process can continue through the winter months in an "Endless Summer" environment. Issues over other control methods have prompted Canadian organizations, OCNWCB and the Lake Osoyoos Association to work together, rearing weevils in vast numbers, to make it a feasible alternative for controlling Eurasian milfoil.

Expanding aquatic weed issues

Tom Woolf - Aquatic Ecologist

A number of invasive aquatic plants are expanding in Idaho and throughout the region. Treatments for some species have seen outstanding success. Other species are rapidly expanding and have limited control options. Early detection is critical for successful treatment of new weed populations. Public awareness and involvement help to protect local waterbodies from expanding invasive aquatic species.

Session 2B

The role of the water column in the nutrient budget of Spirit Lake, WA

Chelsie Strowbridge* and Jim Gawel - University of Washington Tacoma, Environmental Science

The 1980 Mount St. Helens eruption greatly impacted the health of the surrounding ecosystem, especially Spirit Lake – located northeast of the mountain and in the direct path of the blast and landslide. As part of a larger effort to create a nutrient budget for Spirit Lake we collected water column samples throughout the summer of 2010. Nitrogen and phosphorus, zooplankton and phytoplankton,

alkalinity, chlorophyll a, temperature, dissolved oxygen, specific conductivity, pH and Secchi depth were analyzed to examine the physical, biological and chemical processes controlling nutrient cycling in the disturbed lake. These results are essential for understanding the lake ecosystem and for lake management decisions in the future.

How variable are mercury biomagnification rates across aquatic systems?

Jason Williams[1]*, Ceila Chen[2], Darren Ward[3], Marc Beutel[1] - [1]Washington State University; [2]Dartmouth College; [3]Humboldt State University

Mercury biomagnification rates in aquatic food webs are frequently quantified using trophic magnification factors (TMFs). TMFs are calculated as the slope of a regression between organism Hg and $\delta^{15}N$ or trophic level ($\log_{10}$ Hg = a + b $\delta^{15}N$, where b indicates the biomagnification rate). Values of b are often noted to be remarkably constant across systems, but little is known about how methodology and ecological factors affect TMFs. A literature review was performed to assess the comparability of TMF studies and examine trends in b values across systems. 178 mercury TMFs were identified among 47 studies. TMFs were reported for freshwater lentic (52% of TMFs), freshwater lotic (20%), and marine systems (28%) and values of b ranged from 0.08 to 0.53 for CH_3Hg TMFs and -0.28 to 0.66 for total Hg TMFs. Studies that reported both total Hg and CH3Hg TMFs for the same food web were used to test for differences between total Hg and CH_3Hg b values; CH_3Hg b values were significantly greater than corresponding total Hg values and consistently biomagnified whereas total Hg b values were highly variable. Preliminary analyses indicate no statistically significant differences in CH3Hg b values between freshwater lentic, freshwater lotic, and marine systems, but there is substantial variation in biomagnification rates that requires further research. CH_3Hg b values decreased with increasing Chl a concentration, suggesting mercury 'biodilution', but the range of Chl a values reported among studies was relatively small.

Elevated pH as a management tool to control invasive mollusks

Amber Barenberg[1]*, Christine M. Moffitt[2], and Barnaby J. Watten[3] - [1]University of Idaho, Department of Fish and Wildlife Sciences; [2]US Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit; [3]US Geological Survey, Conte Anadromous Fisheries Laboratory

Aquatic invasive species can be transported from infested regions to new locations on the surfaces of boats and gear, and inside ballast and cooling systems of ships. Ballast systems can be especially difficult to disinfect because of poor circulation and residual sediments that could interfere with the effectiveness of reagents. We are testing the efficacy of aqueous sodium hydroxide NaOH or calcium hydroxide Ca(OH)2 solutions, 12 pH, at different temperatures as agents to kill New Zealand mud snails, quagga mussels, and Asian clams. Static exposure tests conducted in fresh and in brackish sea water (15 ppt) show some promise. The three species demonstrated a cline of sensitivity. We observed 100% kill of adult quagga mussels in solutions of pH 12 after 22 h. Exposure to pH 12 at 17°C took up to 3 d to achieve 100% mortality. We observed a longer time to complete mortality in tests with New Zealand mudsnails. We observed 100% mortality after 51 h at 19°C and after 44 h at 22°C. The most resilient species were Asian clams in which some resistant individuals survived exposure to pH 12 for more than

5 d. We plan additional experiments to more fully model our responses, and to compare the responses at different temperatures.

Effects of long-term hypolimnetic oxygen restoration on spatial and temporal variation of $\delta^{13}C$ in lake sediments and benthic macroinvertebrate communities

Andrew W. Child* and Barry C. Moore - Washington State University

Depletion of dissolved oxygen (DO) in hypolimnetic waters create ideal environments where biogenic methane can be generated. Due to the unique $\delta^{13}C$ signature of methane, stable isotope analysis is a powerful tool for estimating contribution of methane-derived energy within benthic invertebrate communities. Previous studies have found significant levels of methane-derived biomass (depleted in ^{13}C in comparison to surrounding sediment) in benthic food webs (methane oxidizing bacteria consumed by Chironomidae) when DO concentrations above the sediment/water interface are <2 mg/L. Hypolimnetic oxygen restoration (HOR) is a common procedure used to decrease effects of cultural eutrophication by forming an oxygen "cap" at the sediment/water interface. Our hypothesis is that long-term oxygenation will reduce biogenic methane production and thus, methane-derived biomass from entering the benthic and pelagic food webs. We gathered sediment cores and benthic invertebrates on 4 dates throughout summer stratification from three lakes: Newman Lake, Washington (20 years HOR); North Twin Lake, Washington (5 years HOR); and South Twin, Washington (0 years HOR). This report provides preliminary results and questions on the effects of long-term HOR on the $\delta^{13}C$ compositions of benthic invertebrate communities and the sediments, which they inhabit.

Session 3A

Origin, history and distribution of introduced freshwater mollusks in the Western United States

Ed Johannes - Deixis Consultants

Some of the earliest records for freshwater mollusk introductions in North America were from the western U.S. Most of these introductions originated from Asia. Later western U.S. introductions had origins from Europe, eastern U.S., Hawaii, New Zealand, Central and South America. The aquarium trade, use as a food source, ship ballast water, aquaculture industry, recreational fishing and boating have helped facilitate the transport and introduction of freshwater mollusks into various U.S water bodies. Once established, it is possible natural pathways (transport by birds, fish or mammals) could also further the spread of freshwater exotic mollusks. Efforts to eradicate or control the spread of these mollusks have proven to be a difficult if not an impossible task. Knowledge of introduced freshwater mollusk occurrences has mostly been the result of fortuitous discoveries, so the actual extent of most introductions is poorly known in the western U.S. Not only should the focus of governmental agencies be on the prevention of new introductions, but also on conducting surveys specifically for introduced freshwater mollusks."

Washington Department of Fish and Wildlife Aquatic Invasive Species Unit prevention management actions

Jesse Schultz - Washington Department of Fish and Wildlife

The Washington Department of Fish and Wildlife (WDFW) Aquatic Invasive Species Unit (AISU) is tasked to protect aquatic habitats across the state from the introduction and proliferation of aquatic invasive species (AIS). The AISU uses a variety of management actions that include internal decontamination protocols, public outreach and education, watercraft surveys and inspections, enforcement of AIS laws, decontamination of infested conveyances, and early detection monitoring to achieve this goal. The environmental, economic and human impacts of AIS can be catastrophic. For instance, costs for managing zebra and quagga mussels and mitigating for impacts if they become established in the Columbia River Basin could run into the hundreds of millions of dollars annually. In 2005, the Washington State Legislature established funding for the AISU through dedicated fees on resident recreational watercraft. The primary focus for this funding has been directed at preventing AIS introductions into Washington State, especially zebra and quagga mussels. Aquatic plants are also regulated by WDFW when being transported overland due to their ability to harbor AIS."

Attack of the clones: New Zealand mud snail spread in the Pacific Northwest
Jonathan Frodge - Seattle Public Utilities

In Washington State, invasive New Zealand mud snails have established populations in the Columbia River, Capitol Lake, Thornton Creek, and most recently in Kelsey Creek. New Zealand mud snails were first detected in the Snake River in 1987. The probability for containment of NZMS is small; the probability for eradication is close to zero. First priority is to minimize contamination of additional waterbodies. Draft decontamination protocols have been implemented and a survey has been designed to determine the distribution of New Zealand Mud Snails in Washington.

Invasive species: Coming to a lake near you!
Tom Woolf - Aquatic Ecologist

How invasive aquatic species could affect your lake and how you can keep the bad stuff out.

Session 3B

An assessment of nutrients in Washington lakes
Maggie Bell-McKinnon - Washington State Department of Ecology

In 2007, the Washington Department of Ecology collected biological, chemical and physical data at 30 randomly selected lakes, from a pool representing 620 lakes over 10 acres in size in Washington State. This study was part of EPA's National Lake Assessment which encompassed monitoring at 1,028 lakes in the lower 48 U.S. States. Measurements of environmental stress were evaluated using the reference site approach. This approach involves setting a reasonable expectation, or reference condition, for each measured parameter. Threshold criteria for reference condition were developed at both the national and regional scale, depending on the environmental parameter. The data collected allowed for an analysis of Washington lakes in terms of good, fair and poor condition. Results showed nutrients and chlorophyll-a were the parameters of highest concern. The study's phosphorus results were also compared to the current Washington State Water Quality standard where total phosphorus action values are established based on a lake's ecoregion. 78% of the lakes in the Coast Range, Puget Lowlands, and Northern Rockies Ecoregions were below the state's total phosphorus action value. 72%

of the lakes in the Columbia Basin Ecoregion were below the standard's total phosphorus action value while only 29% of the lakes in the Cascades Ecoregion were below the total phosphorus action value.

Addressing massive internal phosphorus loading and historical watershed pollution at Lake Ketchum

Gene Williams - Snohomish County Surface Water Management

Lake Ketchum is the most polluted lake in Snohomish County, and one of the worst in Washington State. Phosphorus concentrations during the last 15 years have averaged 275 µg/l in the epilimnion and nearly 3,000 µg/l in the hypolimnion. In response to this high level of nutrients, the lake suffers from severe and frequently toxic blue-green algal blooms, with average chlorophyll a values of 77 µg/l. The primary historical source of phosphorus in the lake is runoff from a former dairy farm. However, over the years, phosphorus has built up in the lake sediments, and internal loading is now the principal cause of water quality problems. Snohomish County worked with local citizens and consultants to analyze the sediments and develop a lake nutrient budget. This analysis showed that internal loading from the lake sediments supplies 73% of the phosphorus in the lake, with the sediment release rate reaching a phenomenal 42 $mg/m^2/day$. Restoration of the lake cannot happen unless this source is controlled. At the same time, runoff from the former dairy farm still provides 23% of the phosphorus, even though all agricultural activities on the farm have ceased. The lake restoration plan calls for a large scale, buffered aluminum sulfate (alum) treatment to control internal loading, as well as small, annual water column alum doses to inactivate external phosphorus loading. Because no large State grants are available for alum treatments, funding to implement the $500,000 plan is being pieced together from local sources and small grants.

Toxic chemicals in freshwater fish from lakes and streams: Monitoring results from Washington Department of Ecology

Keith Seiders*, Casey Deligeannis, Patti Sandvik - Washington Department of Ecology, Environmental Assessment Program

The goal of Ecology's Washington State Toxics Monitoring Program is to characterize toxic chemicals in freshwater fish where historical data are lacking. Target analytes are persistent, bioaccumulative, and toxic (PBT) chemicals such as mercury, PCBs, chlorinated pesticides, dioxins/furans, and PBDE flame retardants. The monitoring effort from 2001-2008 characterized PBTs in 268 fish tissue fillet samples from 129 sites. Eighty of the approximately 1300 commonly fished lakes in Washington were sampled: the remainder of the sites being rivers and streams. About 80% of the samples were from 9 of 23 species sampled. Results show that PBTs are commonly found in fish. Detection frequencies for all samples were: mercury in 100% of samples; dioxin/furans in 95%, PBDEs in 87%, DDTs in 84%; PCBs in 64%; and hexachlorbenzene, chlordanes, dieldrin, and toxaphene in 45% to 8%. Levels of these contaminants in fish vary across the state and are often associated with species, size/age, and land use. Results have led to Clean Water Act Section 303d listings for PCBs, dioxin/furans, DDE, dieldrin, toxaphene, chlordane, and hexachlorobenzene. Health agencies use results to determine whether fish consumption advisories are warranted. A Long Term monitoring component was added to the program in 2009 with the goal of tracking changes in contaminant levels over time at selected sites.

Advancements in floating wetland systems for effective lake restoration
Rob Zisette - Herrera Environmental Consultants

A variety of floating wetland systems have been used for improving water quality in lakes and other water bodies. The primary mechanism for water quality improvement is the uptake of dissolved nutrients by biofilm growth on wetland plant roots, which reduces nutrient availablility for floating or attached algae growth in the water body. Advancements in wetland design provide aeration and circulation of water through the root system to increase nutrient uptake by the biofilm, and also reduce internal phosphorus inputs caused by low dissolved oxygen and high pH in the water and underlying sediments. This presentation will compare functional designs and treatment effectiveness data for floating wetland systems built by Biomatrix Water (Scotland) and Floating Wetlands International (Montana).

Session 4A

LakeWise: A new approach to reduce residential phosphorus pollution in Snohomish County lakes
Marisa Burghdoff* and Peggy Campbell - Snohomish County Public Works, Surface Water Management

Snohomish County Surface Water Management has been conducting long-term water quality monitoring of 30 lakes since 1992. The monitoring data show that several lakes within Snohomish County exhibit statistically significant increases in epilimnetic and hypolimnetic phosphorus and chlorophyll a. For most of these lakes, non-point source phosphorus pollution from residential sources is the primary cause, including: yard care practices, poorly maintained septic systems, stormwater runoff, and pet waste. Although many of the lakes are still in healthy condition, continued non-point pollution puts them at high risk for future sediment enrichment and increased internal phosphorus loading, which would require costly in-lake restoration. To achieve long-term phosphorus reduction, residential best management practices (BMPs) and shoreline restoration need to be voluntarily adopted by lake community residents. Snohomish County determined that a new outreach program based on social marketing techniques would be the most effective approach to gain willing adoption of BMPs by residents. To develop the program, a nationwide review of related outreach programs was conducted to identify the most successful strategies. Next, the local lake communities were assessed via telephone interviews to identify awareness of water quality problems and determine barriers to and incentives for implementing phosphorus BMPS. Based on this research, program concepts and messages were developed and tested with citizen focus groups. The final LakeWise program that emerged is being piloted at Lake Howard, a 26 acre lake in northwest Snohomish County.

Building an in-lieu fee program that meets regulatory criteria and addresses watershed needs
Suzanne Tomassi - The Watershed Company

The ability to implement standard on-site, in-kind mitigation may be limited in scope and area on highly developed lakes, where existing uses limit restoration efforts, effects of present and future actions are compounded by historic land conversion and other alterations, and private ownership impedes the ability to protect mitigation sites in perpetuity. An in-lieu fee (ILF) program for Lake Chelan's Wapato Sub-basin was recently developed to address the challenge of measuring and restoring lost function on a highly developed lake where most shoreline properties are privately owned; on-site opportunities are

limited, impracticable, or of low ecological value; and in-kind mitigation for impacts from docks, piers, and armoring is poorly defined by regulating agencies and often not feasible. The ILF program seeks to better define and measure the actual impact of actions on and along Lake Chelan using a specialized, lake-specific impact assessment tool, as well as to compensate for unavoidable impacts using off-site and often out-of-kind projects. Primary goals of the ILF program are to accurately measure ecological impacts, utilize a watershed approach to identify the most appropriate mitigation options available, combine required mitigation from individual small projects into collective mitigation at larger sites with greater ecological value, and apply mitigation resources toward the restoration of ecologically impaired natural areas of greatest value to the watershed. This presentation describes how the Lake Chelan ILF Program aims, through these goals, to obtain greater ecological benefits to Lake Chelan than could otherwise be achieved using on-site, in-kind mitigation.

A new technology for managing phosphorus pollution

Terry McNabb - Aquatechnex, LLC

Aluminum Sulfate has been the primary tool for sequestering in lake phosphorus loads since its development in the 1960's. While Alum remains a critical tool for phosphorus reduction, our team has been working in a number of environments where water quality parameters have a negative impact on this technology when applied. This lead us to search for alternatives and in 2010, we discovered Phoslock. Phoslock was developed by the Australian National Science Academy to address in lake phosphorus sequestration. Like all inventions, the scientists there were looking for ways to improve upon current technology. Phoslock is a combination of two earth elements. Bentonite clay is the primary carrier. Lanthanum is the phosphorus binding agent and replaces the sodium in the clay matrix. The material is applied to the lake surface and as it settles through the water column attracts and adsorbs free reactive phosphorus. The light layer created on the lake bottom captures additional free reactive phosphorus releasing from lake sediments and that released from decaying algae cells that fall to the lake bottom. This paper will discuss the use of Phoslock in the Western United States and present experiences through case studies to date.

Beyond the lake: Practical and political considerations for implementing alternative mitigation programs

Mike Kaputa[1]* and Suzanne Tomassi[2] - [1]Chelan County Natural Resources Department; [2]The Watershed Company

The planning, design, permitting, and implementation of compensatory mitigation can be onerous for both applicants and planners, but new tools can streamline and standardize mitigation processes while promoting scientifically sound results. In-lieu fee (ILF) programs are a means of ensuring that mitigation funds and energy are invested in ways that are supported by best available science and promote the greatest functional improvement at the watershed scale, while simplifying the process for the applicant. ILF programs relieving applicants of the responsibility for short- and long-term management, and assures protection in perpetuity. They provide an opportunity to "shift gears and move forward," representing an efficient and dependable alternative to common existing mitigation methods. Lake Chelan ILF (ILF) Program Manager Mike Kaputa will describe the social and political challenges

associated with pursuing an ILF program in a recreational lake with a variety of competing biological, recreational and watershed-scale objectives. The Lake Chelan ILF Program covers impacts that include overwater structures, shoreline armoring, and lakeshore recreational activities and takes a watershed approach to mitigation rather than an in-kind approach. Development of the program required considerable outreach to educate and inform the local community about the basis and outcomes of the ILF program. The Program and the process that the County is following to adopt the program is a potential model for local jurisdictions to follow to address effective mitigation at a watershed or sub-watershed scale. The public participation process and point of view of potential applicants is highlighted in this presentation.

Session 4B

Animal safety alert: HAB veterinary outreach efforts in Washington

Joan Hardy* and Liz Carr - Washington Department of Health

Washington Department of Health (DOH) conducted a veterinary outreach project in 2011 – 2012 focused on raising awareness of potential impacts from exposure to cyanotoxins. An important part in the education of animal medical personnel is to provide information on differential diagnoses and treatment alternatives for various cyanotoxins. The first task identified options such as posters, brochures, reference cards, phone applications, and other approaches as potential outreach formats. Using this information, DOH collaborated with Washington State Veterinary Medical Association (WSVMA) to deploy a one-on-one survey instrument to attendees of WSVMA's annual conference in Yakima, October 2011. Based on survey results, DOH determined preferred materials for further development. The first format of choice was a poster for distribution to veterinarians with the goal of raising awareness of animal owners using the slogan, "When in doubt, stay out." The second format chosen by veterinarians for their own use was a "signs and symptoms" reference "tip" card (4" x 9"). To date, DOH has mailed materials to approximately 500 veterinarians, clinics, and local health jurisdictions (LHJs). Additional outreach efforts included a webinar for state veterinarians and a seminar for the Washington Veterinary Board of Governors. DOH expects exposure to and impacts from cyanotoxins to be reduced by providing information to veterinarians, clinics, LHJs, and animal owners. (To order materials, include your name, address, and number of signs/cards requested: zd@doh.wa.gov)

Evaluating cyanobacterial toxicity in a patchy world

Beth LeDoux* and Gabriela Hannach* - King County Department of Natural Resources and Parks, Water and Land Resources

There is currently great interest in the study of cyanobacterial toxins in Washington State. Thanks to increased awareness, funding and dedicated volunteers we have been able to better characterize and understand the dynamics of cyanobacterial blooms in many of our recreational lakes. At the same time, the difficulties associated with appropriate sampling and analysis of biotoxins, known to present great variations in time and space, has become more apparent. For example, toxicities associated with cyanobacterial blooms move around the lake based on prevailing winds and wave action. The resulting patchy distribution has significant implications for lake management decisions and has led to discussions on sampling strategies that are representative of lake conditions while protecting human health. The

presentation will include scenarios from ongoing studies that have forced efforts to evaluate spatial heterogeneity of toxicity around cyanobacterial blooms. In conjunction with the active sampling programs, ongoing studies are occurring with passive samplers containing selective resins, indicating that this is a promising alternative sampling tool that can capture toxin patchiness in time. The significance of these findings will be discussed in relation to risk assessment and lake management.

Identifying best methods for detecting microcystin in fish muscle

Ellen P. Preece* and Barry C. Moore - Washington State University

Toxic cyanobacteria (blue green algae) blooms have become a serious environmental problem worldwide due to factors such as eutrophication, climate change and increased utilization of freshwater resources. Direct exposure or consumption of water with cyanotoxins, such as microcystin (MC), present known health risks to humans. However, other exposure pathways, such as, consumption of contaminated fish is much less understood. Scientists have documented cyanotoxin accumulation in fish, but the human health significance remains unclear. A fundamental element in our uncertainties in elucidating cyanotoxins pathways in aquatic systems is related to analytical difficulties. Our work is focused on defining best methods for isolating the most common cyanotoxin, MC, from rainbow trout muscle. Preliminary results indicate a wide range of MC recovery between extraction and analytical protocols. Better detection methods for quantifying MC in fish will provide an important tool for assessing cyanotoxins propagation in aquatic systems. This will decrease variability between studies and help identify when wild caught fish are contaminated with MC above the threshold safe for human consumption, set by the World Health Organization. We anticipate that our work will contribute to improved risk assessments for communities, such as Native Americans, that depend on local fish as a major dietary component.

Trends in toxic algae blooms in Washinton State lakes and effective management methods in reducing these occurrences in tough economic times

Aaron Nix - City of Black Diamond, Natural Resources

Great strides have been made in the restoration and maintenance of the chemical, physical and biological integrity of Nation's waters, as a major goal through the Clean Water's Act. Historically, Washington State has had its share of water pollution problems, stemming primarily from wastewater discharges directly into receiving waters with minimal treatment. Significant changes brought forth by Clean Water legislation drastically improved the frequency of toxic algae blooms, but due the nature of modern urbanization, problems persist and close beaches periodically throughout the state as toxic blooms still persist. This discussion will review these trends in Washington State and offer, from a local government perspective, realistic, effective community management tools that help reduce the progression and frequency of these toxic events, as utilities struggle to meet all legislative mandates, while being flexible enough to promote elected officials strong desire of economic development.

Session 5A

Phytoplankton community impacts of the 2004 Green Lake alum treatment

Rob Zisette - Herrera Environmental Consultants

Green Lake (Seattle, WA) was treated with aluminum sulfate (alum) in 1991 and 2004 to reduce excessive phytoplankton growth. Trophic state goals for the lake were met for 3 years following the 1991 treatment, but toxic cyanobacteria blooms resulted in beach closures by 1999. The alum dose was nearly tripled in 2004 (from 8.6 to 24 mg Al/L) and the trophic state goals have been met for the past 8 years. Water samples have been analyzed for phytoplankton composition on limited occasions that include two summers before any treatment (1959 and 1981), three summers following the 1991 treatment (1992-1994), and one summer at four years after the 2004 treatment (2008). This presentation will examine how the trophic state and phytoplankton composition of Green Lake have been dramatically affected by the two alum treatments.

Seasonal and age-based aspects of diet of the introduced Redside Shiner (Richardsonius balteatus) in Ross Lake, WA

Carmen Welch - Western Washington University

This study investigates the introduced population of the Redside Shiner (*Richardsonius balteatus*) in Ross Lake, Washington. Introduced around 2000, the Redside Shiner can be found in densities of hundreds per cubic meter in the shallow areas of Ross Lake during the summer months. Ross Lake is a reservoir in North Cascades National Park. Fish native to Ross Lake include: Bull Trout, Dolly Varden and Rainbow Trout. It is commonly accepted that the Redside Shiner offer no negative threat to the native fish in Ross Lake, rather serves as prey to the native fish. However, previous studies in other lakes have reported reduced growth and survival of juvenile Rainbow Trout as a result of Redside Shiner introduction. The main purpose of this study was to determine what the Redside Shiner in Ross Lake consumes and to evaluate the potential threat to the native fish in Ross Lake. Zooplankton and insects are the most important diet categories to the Redside Shiner in Ross Lake both in terms of frequency of occurrence and percent volume of total diet. According to the competitive juvenile bottleneck theory, the Redside Shiner in Ross Lake does pose a threat to the native fish of Ross Lake. A predator can be negatively impacted from its prey due to competition with its juveniles. The juvenile native fish in Ross Lake also primarily consume aquatic insects and zooplankton. Unless food resources are partitioned spatially and seasonally, the competitive juvenile bottle neck theory holds merit and direct competition seems likely.

Contemporary and historical comparisons of chemical and biological characteristics of lakes on the Columbia Plateau

Angela Strecker - Portland State University, Environmental Science and Management

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 arid 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. An important early ecological study 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 invertebrate species. However, hydrological manipulations altered both abiotic and biotic conditions in waterbodies through changing groundwater

levels and enhanced connectivity via irrigation canals. Thirty-eight lakes and ponds were sampled during the summer of 2012, including 23 that were originally sampled in 1949. By design, waterbodies were chosen from both within and outside the zone of influence of the Columbia Basin Project, allowing for consideration of other environmental changes. Almost all waterbodies within the zone of the Columbia Basin Project have declined in salinity from historical records, whereas waterbodies outside the Columbia Basin Project have been more variable, with some increases and some decreases in salinity. There were no consistent changes in pH between historical and contemporary samples, though some waterbodies have shifted pH by several orders of magnitude. Quantifying the effects of abiotic changes on aquatic community structure is imperative to improve understanding of how humans alter freshwater ecosystems.

Rock Island Lake nutrient loading assessment

Peter S. Burgoon - Water Quality Engineering

Hammond Lake is a shallow 35 acre lake with a history of hypereutrophic conditions: phosphorus (P) in excess of 500 µg/L, thick algae blooms, and fish kills. Located in an oxbow alongside the Columbia River, it is down gradient of the City of Rock Island. Septic systems and agriculture contribute to groundwater nitrogen problems and are suspected as the source of P loads to Hammond Lake. Internal and external sources of P were evaluated by sampling lake water, groundwater, well water, sediment, and soils. Septic systems do not appear to be a significant source of P loads since Putters Ponds, located between Hammond Lake and the septic systems, have low P concentrations (~45 µg/L TP and 5 µg/L srp) while Hammond Lake had 650 µg/L TP and 350 µg/L srp. High internal P loads are due to regular mixing of the shallow lake (average depth of 9 feet). Particulate bound phosphorus stays suspended and appears to contribute to high srp year round. Short periods of anoxia also occur in July and August which may be contributing to internal P loads from sediment. Concentrations of srp have increased significantly in the last couple decades and are likely due to fertilizer applications at the Rock Island golf course. Recommendations for reducing P loads are to change fertilizer use at the golf course and to dredge the lake. Located next to an active sand and gravel dredging operation, sediment can be removed and the lake can be deepened to improve the fishery.

Session 5B

Coupling satellite monitoring and instrumentation as a best practice for watershed management

Steve Holland[1]* and TJ Sisson[2]* - [1]Bluewater Satellite; [2]Hach Hydromet - Hydrolab & OTT

Traditionally lake managers have employed grab sampling and electronic instrumentation to monitor water quality. These effective methods provide water quality data on sampled data sets which are then extrapolated to understand the entire water body. A new tool is now available to lake managers to augment ground based and instrumentation sampling by using satellite based remote sensing. Satellite sampling can provide a picture of the entire water body (total water body monitoring) to increase the effectiveness of ground based sampling regimens as well as provide new insights into problems and solutions. This paper discusses the theory of satellite based water quality measurement, and its accuracy and correlation. The paper also presents use cases where total water body monitoring has helped lake managers to gain new insights, understand problems, and implement solutions.

Advances in chemical control technologies for Eurasian milfoil

Terry McNabb* and Adam Kleven - Aquatechnex, LLC

Over the past year, the NPDES permit program that we have operated under in Washington State since 2001 was rolled out nationally. One thing in common through the nation now is that applicators are required to complete the control of noxious aquatic weeds using the lowest amount of herbicide possible. As such, new technologies are necessary to help us comply with these requirements. One of the most important considerations in completing these missions with the lowest amount of herbicide possible is having a very accurate understanding of the control site. Three mapping technologies we use in this mission are recent additions to the aquatic plant management field: SeMAPs, ArcGIS and Trimble. Another new tool aquatic plant managers have is the Biosonics MX scientific echo sounder and associated Habitat mapping software. This technology can help understand the exact water volume that needs to be treated and this is used to refine application rates based on very accurate calculations. Sonar Aquatic Herbicide is one of the key tools for targeting Eurasian Milfoil. The advent of a plant assay to support an exact rate that will target a population of milfoil also allows us to in some cases lower the rates of application. The advent of controlled release pellet technology with Sonar herbicide has also been a major development in our field. Control release pellet technology has also migrated to Triclopyr based herbicides. Barrier technologies also still have a potential place in milfoil management. We will provide three cases studies as part of this talk.

Lake Snapshots: How to make the most of your lake profiler system

Liz Cruise Johnson - Seattle Public Utilities, Water Quality Laboratory

Lake Youngs is an 11 billion gallon (33760 acre-ft) drinking water source for the City of Seattle. The lake is in a protected watershed with no public access allowed. Water quality is typically monitored weekly. The lake profiler system is used as a tool to capture real-time data tracking changes in oxygen and temperature as well as other parameters - pH, specific conductance, turbidity, ORP and chlorophyll throughout the water column. Analysis of the profiler data may prompt modification of the routine monitoring plan and/or prompt additional sampling of a water quality event such as an algae bloom. The profiler also has a weather station that is used to track wind speed, direction, solar radiation and humidity. The SPU Water Quality Lab produces a weekly report for various operational managers and engineers. Using Excel, water quality profile data are presented as weekly averages, while the hourly six meter depth reading and meteorological data are shown as trends over time for the week. Specialty graphing software is used to produce 3-D vector graphs annually. Reporting requires thorough data validation and interpretation.

Dredging up new data from the past

Jonathan Frodge - Seattle Public Utilities

Digitized historic geo-referenced maps are excellent sources of GIS data for locating and identifying legacy pollution sites and nearshore habitat loss along the shorelines of development altered watersheds. These data sources are useful for delineation of property ownership, potential liability, archeological resources and encroachment of public property.

Posters

A microscopic overview of commonly encountered cyanobacteria genera sharing similar morphological characteristics

Karl Bruun[1]*, Hedy Kling[2], Beth LeDoux[3] - [1]Nostoca Algae Laboratory; [2]Algal Taxonomy and Ecology; [3]King County Department of Natural Resources and Parks, Water and Land Resources

The increasing frequency of freshwater harmful algae blooms (HABs) has prompted state and other local jurisdictions to implement monitoring programs for the presence of cyanobacteria toxins along with genera identifications. Microscopic analysis provides timely information concerning the presence or absence of potential toxin producing algae before toxin results are available. Laboratory confirmation of cyanobacteria allows health departments to plan for the logistics of posting health advisories, the possibility of closing recreational swimming beaches and to communicate with the public concerning the health hazards associated with lake contact during HAB events. The identification of most Cyanobacteria genera is dependent upon the microscopic examination of a water sample. Genera are distinguished by the differences in colony, trichome and cellular appearances. Aspects of identifications that require consideration include: single cells or mucilage surrounding a group of cells (colonies); the presence or absence of gas vacuoles; cells in the periphery of a colony or dispersed throughout; the presence of a gelatinous stalk system; the presence or absence of heterocytes and akinetes (basal, intercalary) and their position related to each other in the trichome; cellular length to width ratios and free floating - laments single or in colonies (lakes as in the *Aphanizomenon os aquae* complex). These genera identifications, based on light microscopy, may be subject to future name changes and genera additions due to the increasing amount of polyphasic research currently being undertaken.

Developing a data-intensive nutrient budget for Wapato Lake, Tacoma, Washington, with an eye towards future management

Jim Gawel*, Heather Jennings, Anna Sonoqui, Cierra Hancock, Steve Ayers and Sonya Remington - University of Washington Tacoma, Environmental Sciences

Urban lakes are often taxed with the conflicting roles of serving as integral components of stormwater management systems and providing the public with access to recreational opportunities. Wapato Lake, in Tacoma, Washington, is one such example. This small, shallow waterbody is supplied almost solely by stormwater flow from densely populated residential and commercial areas of South Tacoma, including portions of I-5 and the mall. Since opening to public access in the late 1880s, it has had a checkered history of ongoing public health closures due to fecal coliform and harmful algae blooms. It has been dredged at least three times, has had several alum treatments, has been diluted with municipal drinking water, and has had a stormwater diversion system in operation since the early 1980s. Unfortunately, previous management attempts have not been able to access a fully characterized nutrient budget when designing remediation efforts for Wapato Lake. Our study has attempted to address this issue by carrying out an intensive one-year data collection effort in order to create a simple nutrient budget for the lake for use in modeling management scenarios for the future. Through a combination of student supported boat-based sampling, volunteer shore-based sampling and a concerted City-led stormwater and groundwater sampling effort, we were able to collect almost weekly physical, chemical, biological

and hydrological data to feed this modeling effort. The resulting nutrient budget will be presented and possible management scenarios discussed."

Ecology's freshwater algae program

Lizbeth Seebacher* and Kathy Hamel - Washington State Department of Ecology, Water Quality Program

Ecology's Freshwater Algae Control Program provides resources to Washington's aquatic and wetland managers. This program offers the toxicity testing of cyanobacteria (blue-green algal) blooms throughout the state along with an online database for current and past data as well as funds for algae management projects. The toxicity testing, through a contract with the King County Environmental Labs, allows local heath jurisdictions or aquatic managers to post recreational advisories or close the water body when an algal bloom is found to be toxic helping keep people and their pets safe from the toxins in the water body. Many lakes become toxic every year and typically with the same toxins. Ecology's algae grant program gives communities with these problem lakes the opportunity to research lake conditions, the cause of the blooms and begin with management options. Several research projects are in the works as well, including a Fish Bioaccumulation study, a Veterinary Outreach study, determining Recreational Guidance Values for toxicity and a Harmful Algae Bloom – Related Illness Surveillance System study. Future projects may include testing Floating Wetlands technology for reducing water quality conditions leading to frequent algal blooms.