31st International Symposium of the North American Lake Management Society

Symposium Program

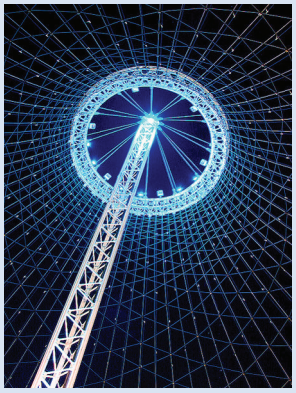
Diverse and Sustainable Lake Management

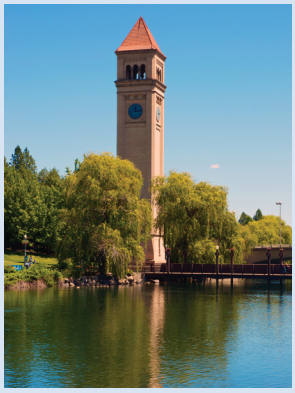
NALMS 2011

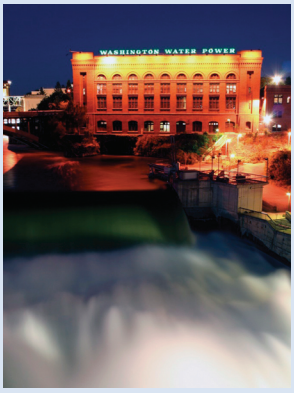
SPOKANE, WA

October 26 - 28, 2011

Spokane Convention Center
Spokane, Washington







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US Army Corps of Engineers
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The North American Lake Management Society's mission is to forge partnerships among citizens, scientists and professionals to foster the management and protection of lakes and reservoirs.

NALMS
PO Box 5443
Madison, WI 53705-0443
p: 608.233.2836 • f: 608.233.3186
www.nalms.org

Disclaimer

The information and suggestions presented at the International Symposium of the North American Lake Management Society are subject to constant change and, therefore, should serve only as a foundation for further investigation. All information, procedures and materials contained or used as part of the International Symposium should be very carefully reviewed and should serve only as a guide for use in specific situations. Questions regarding such information, procedures and products should be directed to the specific individuals, companies and/or organizations submitting said items and information.

The opinions expressed by presenters, speakers, discussion panelists, committee members and exhibitors are those of said individuals and are not necessarily those of the North American Lake Management Society nor the conference sponsors.

Program subject to change.

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1986-87	Richard Wedepohl
1985-86	Wayne Poppe
1984-85	William Funk
1983-84	Eben Chesebrough
1982-83	Bob Johnson
1981-82	Thomas Gordon
1980-81	Dennis Cooke

NALMS Symposium Locations

2011	Spokane, Washington
2010	Oklahoma City, Oklahoma
2009	Hartford, Connecticut
2008	Lake Louise, Alberta, Canada
2007	Lake Buena Vista, Florida
2006	Indianapolis, Indiana
2005	Madison, Wisconsin
2004	Victoria, British Columbia, Canada
2003	Mashantucket, Connecticut
2002	Anchorage, Alaska
2001	Madison, Wisconsin
2000	Miami, Florida
1999	Reno, Nevada
1998	Banff, Alberta, Canada
1997	Houston, Texas
1996	Minneapolis, Minnesota
1995	Toronto, Ontario, Canada
1994	Orlando, Florida
1993	Seattle, Washington
1992	Cincinnati, Ohio
1991	Denver, Colorado
1990	Springfield, Massachusetts
1989	Austin, Texas
1988	Saint Louis, Missouri
1987	Orlando, Florida
1986	Portland, Oregon
1985	Lake Geneva, Wisconsin
1984	McAffee, New Jersey
1983	Knoxville, Tennessee
1982	Vancouver, British Columbia, Canada
1981	None Held
1980	Portland, Maine

NALMS Award Recipients

Secchi Disk Award

Bestowed upon the individual member considered to have contributed the most to the achievement of NALMS' goals.

2010 Roger Bachmann
2009 Steve Heiskary
2008 Tom Conry
2007 Tom Davenport
2006 Ann St. Amand
2005 Jeff Schloss
2004 Steve Colvin
2003 Ken Wagner
2002 Greg Searle
2001 Chris Holdren
2000 Bill Jones
1999 Jim Flynn
1998 Lisa Conley
1997 Jim Vennie
1996 Bruce Wilson
1995 Dan Canfield
1994 Jay Sauber
1993 Jim LaBounty
1992 Virginia Garrison
1991 Richard Wedepohl
1990 Bob Kirschner
1989 Garth Redfield
1988 Bill Funk
1987 Donna Sefton
1986 Eben Chesebrough
1985 Bob Johnson

Jim Flynn Outstanding Corporation Award

Given to the corporation considered to have contributed the most to NALMS' goals.

2010 No award given
2009 Hach Hydromet
2008 USACOE, Waterways Experiment Station
2007 ENSR Corporation
2006 AW Research
2005 Osgood Consulting
2004 Princeton Hydro, LLC
2003 Sweetwater Technology
2002 No award given
2001 YSI, Inc.
2000 F.X. Browne, Inc.
1999 PhycoTech
1998 Ecosystems Consulting Service
1997 Hydrolab Corporation
1996 Aquarius Systems
1995 TVA
1994 Coastal Environmental Services
1993 ACRT, Inc.
1992 Aquarius Systems
1991 Baystate Environmental Consultants
1990 Judith Taggart & Associates
1989 General Chemical
1988 Aqua Technique
1987 Living Lakes
1986 Hydrolab
1985 Mudcat

Friends of NALMS Award

Awarded to individuals or corporations making major contributions to NALMS. Recipients do not have to be NALMS members, and "contributions" extend beyond monetary donations.

2010 Associate Editors of *Lake and Reservoir Management*
2009 Marty Kelly
2008 Bev Clark
Jim LaBounty
2007 Florida Lake Management Society
2006 Jeff Schloss & Philip Forsberg
2005 Mary-Arthur Beebe
2004 Cynthia Mahigian Moorhead
2003 New England Water Pollution Control Commission
2002 Will Young, Aquatic Research Instruments
1998 Kelly DiNatale
Lawrence Enterprises
1997 US Environmental Protection Agency
1996 State of Minnesota
1995 Jim Vennie
1994 Aquarius
Minnesota Pollution Control Agency
University of Florida

1993 Kramer, Chin and Mayo
Tennessee Valley Authority

1992 Jim LaBounty
Vince Williams

Dan Canfield
William Jones
Steven McComas
Laura Taggart
Bob Humphrey
Lynn Moore
Tom Davenport
FTN Associates
Ohio Lake Management Society
Pat Tobin
Frank Lapensee
US Bureau of Reclamation
American Fisheries Society
Wisconsin DNR
Rep. Les Aspin
Rep. J. Oberstar
Rep. T. Lewis
Rep. A. Strangeland
Rep. R. Roe
Sen. Patrick Leahy
Sen. D. Durenberger
Sen. William Proxmire

Jim LaBounty Best Paper Award

This annual award established in 2003 recognizes the best paper published in *Lake and Reservoir Management*.

2010 *Phosphorus reduction by dilution and shift in fish species in Moses Lake, Washington*
Gene Welch

2009 *Relative influence of lake age and watershed land use on trophic state and water quality of artificial lakes in Kansas*
E. Carney

2008 *Monitoring periphyton in lakes experiencing shoreline development*
D. Lambert and A. Cattaneo

2007 *Whole-lake herbicide treatments for Eurasian watermilfoil in four Wisconsin lakes: Effects on vegetation and water clarity*
K.I. Wagner, J. Hauxwell, P.W. Rasmussen, F. Koshere, P. Toshner, K. Aron, D.R. Helsel, S. Toshner, S. Provost, M. Gansberg, J. Masterson and S. Warwick

2006 *Determining ecoregional reference conditions for nutrients, Secchi depth and chlorophyll* a *in Kansas lakes and reservoirs*
W.K. Dobbs, E. Carney and R.T. Angelo

2005 *Long-term changes in iron and phosphorus sedimentation in Vadnais Lake, Minnesota, resulting from ferric chloride addition and hypolimnetic aeration*
D.R. Engstrom

2004 *Artificially induced* Planktotrix rubesces *surface bloom in a small kettle lake in Southern Ontario compared to blooms world-wide*
Gertrud K. Nürnberg, Bruce D. LaZerte and Daniel D. Olding

2003 For four papers published in LRM Volume 19-2
John R. Jones

Technical Merit Awards

This award may be selected from four categories: Successful Projects, Volunteer Actions, Research Efforts and Public Education/Outreach

2010 Wetland & Hydrologic Restoration of the Grand Prairie Site, Flying Eagle Wildlife Management Area, Southwest Florida WMD (Projects)

The Sugar Lake Association, Wright County, Minnesota (Volunteer Actions)

Dana Rizzo & Susan Boser – Pennsylvania State Coop. Extension (Public Education & Outreach)

J. Clark, B. Swistock, T. McCarty & M. Barkley – Penn State Cooperative Extension (Public Education & Outreach)

Dr. Robert Doyle (Public Education & Outreach)

2009 Long Pond, Towns of Brewster & Harwich, Mass. (Projects)

Town of Warrenton, Virginia (Projects)

Jane & Carroll Johnson (Volunteer Actions)

Woodridge Lake Property Owners Association (WLPOA) (Volunteer Actions)

2008 Alberta Lake Management Society (Volunteer Actions)

Bow River Basin Council (Public Education & Outreach)

Dick Lathrop (Reseach)

2007 Doug Larson (Research)

Brian Kotak & Ron Zurawell (Research)

St. Johns Water Management District & Southwest Florida Water Management District (Research)

2006 Cobbossee Watershed District (Public Education & Outreach)

Tennessee Valley Authority Stream, River & Tailwater Assessment (Public Education & Outreach)

2005 LakeSuperiorStreams.org (Public Education & Outreach)

Tennessee Valley Authority Spring Sportfish Survey (Public Education & Outreach)

Lake Hopatcong Commission (LHC) (Public Education & Outreach)

2004 Las Vegas Wash Coordination Committee (Volunteer Actions)

2003 Lake Mohawk Lake Community (Project)

Champlain 2000 (Public Education & Outreach)

Maine Lakes Conservancy Institute (Public Education & Outreach)

Tennessee Valley Clean Marina Initiative (Public Education & Outreach)

Gertrud Nürnberg (Research)

2002 Chocorua Lake Project (Project)

White Meadow Lake Property Owners Association (Volunteer Actions)

Mount Arab Preserve Association (Volunteer Actions)

2001 Bhoj Wetland Project, India (Project)

TVA Clean Marina Initiative (Project)

Third Lake Project – Mark Pfister, Leader (Project)

Hartford Union High School Environmental Club (Volunteer Actions)

Michael Martin (Public Education and Outreach)

2000 Stafford Pond (Project)

Lionel Dallas (Volunteer Actions)

Peter Siver (Research)

Gordon Davis (Public Education and Outreach)

Sidney Post (Public Education and Outreach)

Scott Williams (Public Education and Outreach)

WOW/Lake Access Team at University of Minnesota-Duluth (Public Education and Outreach)

1999 Steve LaMere (Public Education and Outreach)

John Holz (Research)

Madeleine Ducham (Volunteer Actions)

Bass Bay/Big Muskego Lake Management District and Wind Lake Management District (Volunteer Actions)

1998 Robert Korth (Public Education and Outreach)

Pine Lake Restoration Society, Alberta, Canada (Volunteer Actions)

Paul Garrison (Research)

James LaBounty (Research)

1997 Upper Tippecanoe Water Quality Project (Project)

Oster Creek Community (TX) Environmental Action Network (Volunteer)

1996 Lake Shaokatan Restoration

Lake Bemidji Watershed Management Project (Project)

1995 Steve Effler (Research)

Friends of Menotomy Rocks Park (Volunteer)

1994 Wally Christiansen (Volunteer)

Tom Murphy (Research)

Terry Bovee (Volunteer)

Patricia Chambers (Research)

Interactive Lake Ecology (Project)

Craig Heaton (Volunteer)

1993 Vadnais Lake/Lambert Creek Watershed Improvement Project (Project)

John P. Smol and the Paleoecological Environmental Assessment & Research Laboratory (Research)

John Barko (Research)

Joanna Buehler (Volunteer)

Florida Lake Watch (Project)

1992 Ellie Prepas (Project)

Little Rock Lake, Whole Lake Acidification (Project)

1991 Lake Delavan (Project)

Corps of Engineers WES (Research)

Bruce Wilson (Research)

1990 Robert Munyon (Volunteer)

Newroth/Welch/Peterson/Cooke (Research)

Joe Shapiro (Research)

1989 Lake Summerset (Project)

Lake Morey, VT (Project)

David Sutton (Research)

1988 Ken Reckhow (Research)

Bob Carlson (Research)

Bill Walker (Research)

1987 Lake Jackson, FL (Project)

1985 Lake Geneva, WI (Project)

General Conference Information

Name Badges & Event Tickets

For most events and functions at the symposium, your name badge is your only ticket. Wear it to all activities during the Symposium. **All individuals participating in any of the Symposium events or activities must be registered and have a name badge.**

Poster Session Set Up

All Posters will be on display from Wednesday morning through Friday noon. If you are presenting a poster, please make sure that your poster is set-up on Tuesday, October 25, between the hours of 1:00 pm and 5:00 pm. The Poster Display Area will be located in Ballroom BC.

Hospitality Room

The NALMS Hospitality Room is open nightly Tuesday–Thursday (check daily schedules for times) and is located in the Spokane Falls Ballroom of the Doubletree Hotel. Relax with your friends and meet new friends.

Silent Auction

Be sure you stop by the Silent Auction table, located in Ballroom BC, during the conference. Many and varied items will be on display for your bid. All proceeds go to the Eberhardt Memorial Fund which provides support to NALMS' Student members. Not only does the money raised go for a good cause, you won't want to miss the exciting and unique items awaiting your bid.

Photo Contest

Help pick the covers for upcoming issues of *LakeLine Magazine*! The 2011 NALMS Photo Contest entrants will be displayed in Ballroom BC. Cast your vote for your favorite photos. Winning entries may appear in your mailbox in the near future!

Certified Lake Manager/Professional Program

The Certified Lake Manager/Professional (CLM/CLP) program has been established to aid in NALMS' mission of gaining a better understanding of lakes, ponds, reservoirs, impoundments and their watersheds, through the identification of individuals who have exceptional training and experience in lake management. A lake manager is a person who is directly involved in the comprehensive management of ponds, lakes, reservoirs or other bodies of water and their watersheds and makes decisions that affect the quality and uses of the body of water. This person will be primarily responsible for implementing appropriate measures and/or for making recommendations to the governing management body. A CLM/CLP is an individual who has satisfied the NALMS requirements intended to properly prepare that person to perform the above duties with maximum competence. CLMs/CLPs establish themselves as both knowledgeable and experienced professionals by meeting the requirements. For additional information on the CLM/CLP program, stop by the NALMS booth during exhibit hours, or contact:

Mr. David Rosenthal, CLM
NALMS CLM/CLP Program
PO Box 5443
Madison, WI 53705-0443 USA

CLMs/CLPs must obtain the two-part Continuing Education Forms at the NALMS Registration Desk to document attendance at technical sessions and workshops. The session moderator or workshop instructor must sign the forms to verify attendance. The white copy must be returned to the Registration Desk by 1:30 pm on Friday, October 28, 2011. A total of ten (10) hours will result in one Continuing Education Unit (CEU).

Come learn more about the CLM/CLP Program at a special luncheon get-together on Thursday, October 27. Grab your buffet lunch and meet in Meeting Room 202BC of the convention center and meet David and the other CLMs/CLPs.

Join us for next year's NALMS Symposium

November 7–9, 2012 • Madison, Wisconsin

Registration Desk & Meal Function Hours

Registration

Hours:

Tuesday, October 25	7:00 am – 6:00 pm
Wednesday, October 26	7:00 am – 5:30 pm
Thursday, October 27	7:30 am – 5:30 pm
Friday, October 28	7:30 am – 3:30 pm

Meal Functions

Unless noted otherwise, all meals listed below are provided to all full conference registrants on Wednesday, Thursday & Friday. Daily registrants receive all meals on the day that they are registered for the conference. All Meals are in Spokane Convention Center.

** Available to workshop participants only.*

Continental Breakfast

***Tuesday, October 25**	7:30 am – 8:00 am	Ballroom Lobby
Wednesday, October 26	7:00 am – 8:30 am	Ballroom BC
Thursday, October 27	7:30 am – 8:30 am	Ballroom BC
Friday, October 28	7:30 am – 8:30 am	Ballroom BC

Morning Break

***Tuesday, October 25**	9:30 am – 10:00 am	Ballroom Lobby
Wednesday, October 26	10:00 am – 10:30 am	Ballroom BC
Thursday, October 27	10:00 am – 10:30 am	Ballroom BC
Friday, October 28	10:00 am – 10:30 am	Ballroom BC

Lunch

***Tuesday, October 25**	12:00 pm – 1:00 pm	Meeting Room 201ABC
Wednesday, October 26	12:00 pm – 1:30 pm	Ballroom BC
Thursday, October 27	12:00 pm – 1:30 pm	Ballroom BC
Friday, October 28	12:00 pm – 1:30 pm	Ballroom BC

Afternoon Break

***Tuesday, October 25**	3:00 pm – 3:30 pm	Ballroom Lobby
Wednesday, October 26	3:00 pm – 3:30 pm	Ballroom BC
Thursday, October 27	3:00 pm – 3:30 pm	Ballroom BC
Friday, October 28	3:00 pm – 3:30 pm	Ballroom Lobby

Exhibitors' Reception and Poster Session

Wednesday, October 26	6:30 pm – 8:30 pm	Ballroom BC

NALMS' Awards and Recognition Reception & Banquet

Thursday, October 27	5:30 pm – 11:00 pm	Bay 111AB

Tickets are required for this event. Tickets are free with a full conference registration or Thursday-only registration, however, there are a limited number available.

Exhibitors

A.W. Research Laboratories, Inc.
16326 Airport Road
Brainerd, MN 56401
218-829-7974
awc@awlab.com
www.awlab.com

Abraxis LLC
54 Steamwhistle Drive
Warminster, PA 18974-1450
215-357-3911
info@abraxiskits.com
www.abraxiskits.com

Applied Polymer Systems
519 Industrial Drive
Woodstock, GA 30189
866-200-9868
info@siltstop.com
www.siltstop.com

Aquarius Systems
200 N Harrison St.
PO Box 215
North Prairie, WI 53153
262-392-2162
info@aquarius-systems.com
www.aquarius-systems.com

Aquatic Eco-Systems, Inc.
2395 Apopka Blvd
Apopka, FL 32703
407-886-3939
AES@aquaticeco.com
www.aquaticeco.com

BC Lake Stewardship Society
203 - 1889 Springfield Road
Kelowna, BC V1Y 5V5
Canada
250-717-1212
info@bclss.org
www.bclss.org

BioSonics, Inc.
4027 Leary Way NW
Seattle, WA 98107
206-782-2211
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Blue Water Satellite
440 E. Poe Rd., Ste. 203
Bowling Green, OH 43402
419-728-0060
jharpen@bluewatersatellite.com
www.bluewatersatellite.com

Clean Lakes, Inc.
PO Box 3548
Coeur d'Alene, ID 83816
877-FIX-LAKE
info@cleanlake.com
www.cleanlake.com

Dredge America
9555 NW Highway N
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www.dredgeamerica.com

EcoAnalysts, Inc.
1420 S. Blaine St., Ste. 14
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www.ecoanalysts.com

Ecosystem Consulting Service, Inc.
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Electronic Data Solutions
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Eureka Environmental
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Fluid Imaging Technologies, Inc.
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1013 Vera St.
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General Environmental Systems, Inc.
5209 Blue Stem Court
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919-324-8883
bill@airation.com
www.airation.com

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www.habaquatics.com

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Sonic Solutions LLC
77B West St.
West Hatfield, MA 01088
866-562-5423
info@sonicsolutionsllc.com
www.sonicsolutionsllc.com

Sweetwater Technology, TeeMark Corp.
1132 Air Park Dr.
Aitkin, MN 56431
218-927-2200
pde@aitkin.com
www.teemarkcorp.com/sweetwater/

Taylor & Francis
325 Chestnut St
Philadelphia, PA 19106
215-625-8900
amanda.patterson@taylorandfrancis.com
www.taylorandfrancis.com

Turner Designs
845 W Maude Avenue
Sunnyvale, CA 94085
877-316-8049
sales@turnerdesigns.com
www.turnerdesigns.com

US Army Engineer Research and Development Center (USAERDC)
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
866-ERDC-USA
www.erdc.usace.army.mil

Washington State Lake Protection Association (WALPA)
PO Box 4245
Seattle, WA 98194
info@walpa.org
www.walpa.org

YSI, Inc.
1725 Brannum Lane
Yellow Springs, OH 45387
800-765-4974
environmental@ysi.com
www.ysi.com

Program at a Glance: Tuesday, October 25

Time	Event	Location
7:00 am – 6:00 pm	Symposium Registration	Ballroom Lobby
7:30 am – 8:00 am	Continental Breakfast – Workshop Participants Only	Ballroom Lobby
8:00 am – 5:00 pm	Workshop: Collection, Identification, Ecology & Control of Freshwater Algae Workshop: Hach Hydromet Training Workshop Workshop: Internal Phosphorus Loading Workshop: Lake Phosphorus Inactivation & Interception Workshop: Simple Tools for Lake and Watershed Assessment	Meeting Room 102D Meeting Room 101 Meeting Room 102C Meeting Room 102B Meeting Room 102A
9:00 am – 3:00 pm	East Spokane County Lake Restoration Tour	Meet at 8:45 am on Spokane Falls Blvd. at the Breezeway
9:30 am – 10:00 am	Refreshment Break – Workshop Participants Only	Ballroom Lobby
12:00 pm – 1:00 pm	Luncheon – Workshop Participants Only	201ABC
1:00 pm – 5:00 pm	Exhibitor & Poster Display Set-up	Ballroom BC
3:00 pm – 3:30 pm	Refreshment Break – Workshop Participants Only	Ballroom Lobby
6:00 pm – 11:30 pm	Welcome to Spokane Meet & Greet / Pub Crawl	Meet in Spokane Falls Ballroom, Doubletree Hotel

All rooms are in the Spokane Convention Center unless noted otherwise.

Workshop
Collection, Identification, Ecology and Control of Freshwater Algae

8:00 am – 5:00 pm
Meeting Room 102D

Sponsored by PhycoTech, Inc.

This workshop is an all day introduction to the taxonomy, identification and ecology of algae. Lectures on algal methodology and each algal division alternate with microscope sessions in which participants will view preserved and live specimens and receive hands-on training in algal identification. This workshop targets a fairly technical audience, one with substantial background in biology and scientific methods, although no direct experience with algae is required.

Participants will receive a manual that covers algal methods, identification, ecology and control, prepared by the instructors and based on two decades of experience with this workshop and their combined professional experience. This workshop will create a foundation for understanding algal taxonomy and provide intensive identification experience. This workshop has proven to be a very enjoyable, as well as educational experience. If you can't imagine fun with algae, let us show you how it's done!

Instructors

Dr. Ann St. Amand of PhycoTech and **Dr. Ken Wagner** of Water Resource Services.

Workshop
Hach Hydromet Training Workshop

8:00 am – 5:00 pm
Meeting Room 101

Sponsored by Hach Hydromet

Ensure that your Hydrolab Series 4a/4X/5/5X water quality monitoring equipment is working at its best by attending a Hach Hydromet's Hydrolab Maintenance and Calibration Workshop. This workshop is lead by a Hach Hydromet factory technician and covers the following areas:

- Applications and instrument/sensor selection
- Deployment considerations and instrument configuration
- Communications, menus, and equipment set-up
- Maintenance, sensor replacement, and calibration procedures
- Basic troubleshooting
- Review of additional parameters (blue green algae, rhodamine WT, chlorophyll *a*, total dissolved gas, ions, etc.) and other products (OTT) not covered during maintenance segment.

Workshop participants should bring their own instruments (including displays or computers) as the workshop is a "hands on" affair. All maintenance and calibration supplies will be provided. If time permits, we will also present the "Hall of Shame" slide show, and cover web page tools Hydrolab Bench Service Partnerships.

Instructor

TJ Sisson is the territory manager for Hydrolab in the Pacific Northwest. TJ has worked with Hydrolab equipment since 1997, and covered the Northwest territory for Hydrolab since 2003. TJ, along with his tech support and service team conduct these training class's across the Northwest annually. This workshop will round out the 6th and final training for 2011 here in Spokane.

Workshop
Internal Phosphorus Loading

8:00 am – 5:00 pm
Meeting Room 102C

Internal phosphorus loading as phosphorus (P) released from anoxic sediment surfaces often represents the main summer P load to lakes. Because of its high biological availability, the lack of dilution, and the timing, it can have an immense effect on summer water quality of a lake, reservoir, or pond. However, depending on the stratification of the lake, it is not always easy to determine the quantity of internal load (especially in polymictic lakes), and it may be difficult to estimate the ultimate effect it may have on surface water quality (especially in stratified lakes).

This workshop presents a way of quantifying internal load in polymictic as well as stratified lakes. Considering lake characteristics and data availability, such quantification can be done in a step-wise fashion, where missing data may be predicted by subsidiary models. After the mere quantification of internal load the participant will learn how to combine it with external load in a simple mass balance model to predict seasonal phosphorus concentration. Knowing this, other water quality characteristics (algal biomass, bloom frequencies, Secchi disk transparency, and hypolimnetic anoxia) can be arrived at. Applications regarding lake quality assessment, nutrient criteria, total maximum daily load (TMDL) computations, and restoration options will be discussed.

Each workshop topic will include a description of the theory and presentation of case studies covering US, Canadian, and European lake assessment and restoration projects. Open discussion with attendees is encouraged, and comprehensive handouts and references will be provided. For preparation, see publications listed at http://www.fwr.ca

Instructor

Gertrud K. Nürnberg, Ph.D. is an environmental scientist

at Freshwater Research located in Baysville, Ontario, Canada. She has 30 years of experience studying and modeling the geochemistry of lakes and reservoirs.

Workshop
Lake Phosphorus Inactivation & Interception

8:00 am – 5:00 pm
Meeting Room 102B

Sponsored by Sweetwater Technology

Eliminating or mitigating excess phosphorus from the watershed, lake sediments or both may be difficult, expensive or require many years. Alum has been one of the most effective lake management tools and may be used to safely, quickly and efficiently eliminate problems with excess phosphorus. Alum's use will be presented in the form of planning, design, application, and monitoring. Case studies will be discussed from a lessons learned and potential future use perspective. In addition to discussing partial and whole lake applications, alum use to remove phosphorus from the water column, or to inactivate sediment phosphorus or intercept phosphorus in stormwater runoff and alum use in ponds; other inactivation and water stripping alternatives will also be presented and discussed. Participants will learn about technologies and strategies through published literature overviews, case histories and participant interaction. Other topics include internal and external phosphorus sources, alum precipitation chemistry, dose determination (inactivation), phosphorus interception, effectiveness, longevity of phosphorus inactivation, and project examples. Techniques for evaluating the timing and magnitude of internal and external phosphorus inputs will be reviewed in the context of designing alum application strategies. Other approaches and materials not involving alum will also be discussed. Differences between thermally stratified versus unstratified (polymictic) lakes will be discussed relative to application strategy. Regulations and permitting will be also be outlined and discussed. Participants will be encouraged to share their experiences during the workshop. Workshop includes a workshop manual with worksheets and a detailed bibliography.

Instructors

Harry Gibbons of Tetra Tech, Inc. is Tt's Discipline Lead for Lake/Reservoir Management/Restoration Services including Water Quality, AIS and Habitat planning, design and implementation activities, he has authored scientific articles, makes frequent presentations on lake management and participated in his first whole lake alum treatment in 1974 and has been actively involved in over 250 alum applications. **Dick Osgood** of Osgood Consulting has conducted hundreds of diagnostic/modeling evaluations, authored numerous scientific articles and makes frequent presentations on lake management. **Ann Shortelle** of the Florida Department of Environmental Protection has authored numerous scientific articles and has been very active in lake management and water quality issues, including design and implementation of alum treatments.

Workshop
Simple Tools for Lake and Watershed Assessment

8:00 am – 5:00 pm
Meeting Room 102A

Sponsored by the US Army Engineer Research and Development Center

This workshop is a problem-oriented introduction to a suite of simpler tools from the Army Corps of Engineers that are used to assess lake and reservoir water quality in a watershed context. We use the remodeled FLUX32 mass transport software as a basis for discussing watershed delivery, stream transport, and load estimation. FLUX32 is a Windows® application with a user-friendly interface and continuing enhancements. Both new and experienced FLUX users will want this new version with its greatly expanded graphics and host of new capabilities. From FLUX and mass transport, we move to a discussion of in-lake trophic response using the Windows version of the Bathtub model. Finally, we briefly introduce a software package called TASTR (Trophic Assessment Screening Tool for Reservoirs), to illustrate an integrated watershed-reservoir assessment. TASTR uses the Bathtub model, simple watershed models, and a self-contained GIS capability to put the reservoir (or lake) water quality into a watershed context. TASTR lets the user quickly (with low resolution) and easily explore a lake's potential trophic response to changing conditions or operations. TASTR's capabilities also let it serve as a convenient "front end" for Bathtub modeling and as a license-free, stand-alone, GIS tool for performing basic geospatial tasks.

A CD will be distributed that includes all course notes and copies of the software. Participants should bring a laptop to the workshop if possible (but not absolutely required). Software will be provided to registrants prior to the conference (via FTP or CD) and MUST be installed and tested by the participant prior to the workshop (simple instructions included). A simultaneous Webcast of this workshop is under consideration.

Instructor

Dave Soballe, Ph.D. is a senior researcher with the U.S. Army Engineer Research and Development Center (ERDC) Environmental Laboratory in Vicksburg, MS. Dave has taught versions of this course at NALMS for the last five years and has nearly 30 years of experience with river, reservoir and watershed processes and assessments.

Special Event

East Spokane County Lake Restoration Tour

Meet at 8:45 am on Spokane Falls Blvd at the Breezeway
9:00 am – 3:00 pm

Join us for a tour of two area lakes that have implemented successful restoration programs, as well as an overview of an upcoming project which will restore hydrologic functions to a historic lake bed which was ditched and drained over 100 years ago.

The first stop will be Newman Lake, the largest natural lake in Spokane County. With internal phosphorus load being a main driver for cyanobacterial productivity and other negative water quality parameters, a hypolimnetic oxygenator was installed in 1992 to address anoxic conditions on the lake bottom. This system was bolstered with a micro-floc alum injection system in 1997 to bind and remove phosphorus from the water column. In recent years watershed efforts have become an added focus in long-term plans for continued water quality improvements. The tour will stop at one such area, where proposed projects hope to provide improved water storage, generate wildlife habitat, and serve as a nutrient sink to decrease watershed sediment loading.

The second stop will be Liberty Lake; a 708-acre lake situated 2.5 miles east of the City of Spokane Valley and 3 miles west of the Idaho border. The story of Liberty Lake dates back to the late 1800s where settlement and development impacts were causing intense algal blooms. By the 1960s residents established a special purpose sewer district. Since 1973, the District has taken many measures to protect the lake including a multifaceted $14.8 million restoration effort. The tour will guide you through the historical restoration efforts and how they are being managed today.

The final stop is Saltese Flats. Known as Saltese Lake until being drained around 1900 for agricultural use, the former lake covered approximately 1200 acres and was likely a mix of shallow open water and wetlands that would fill with spring runoff and decline in water level through the summer. Saltese Flats is an important area for wildlife habitat in the Spokane Valley. Spokane County recently purchased 510 acres of the former lake bottom with the intent of restoring wetlands to the site. The wetland restoration project will improve wildlife habitat; provide an area for public access, recreation and education; delay water runoff for more natural regional hydrographs; and allow for future wetland enhancement with reclaimed water. The tour will share some of the site history, outline current conditions, and explain major design features of the wetland restoration project.

Special Event

Welcome to Spokane Meet & Greet / Pub Crawl

Meet in the Spokane Falls Ballroom, Doubletree Hotel
6:00 pm – 11:30 pm

NALMS and the 2011 Local Host Committee welcome attendees to Spokane with a meet and greet reception and pub crawl. If you're new to NALMS or to NALMS's symposia, we encourage you to take this opportunity to meet NALMS members and fellow symposium attendees. The evening starts out with the Local Host Committee Meet & Greet Reception in the Convention Center. From there, we venture into historic downtown Spokane. A hip, urban culture has embraced Spokane bringing with it a nightlife scene that is second to none in the Inland Northwest. From ballet and Broadway to award winning wines, local brews, swanky martini joints and hot night clubs, Spokane's got the ingredients for a successful night out on the town. NALMS symposium attendees will receive food and drink discounts at several downtown establishments.

Program at a Glance: Wednesday, October 26

Time	Event	Location
7:00 am – 5:30 pm	Symposium Registration	Ballroom Lobby
7:00 am – 8:30 am	Continental Breakfast	Ballroom BC
8:30 am – 10:00 am	Opening Plenary Session	Bay 111AB
10:00 am – 10:30 am	Refreshment Break, Exhibits Open	Ballroom BC
10:30 am – 12:00 pm	Session A-1: Stewardship 1 Session A-2: Hypolimnetic Aeration / Oxygenation Session A-3: National Lake Assessment Session A-4: Paleolimnology Session A-5: Adaptive Management	Meeting Room 206A Meeting Room 206B Meeting Room 205 Meeting Room 206C Meeting Room 206D
12:00 pm – 1:30 pm	Luncheon, Exhibits Open NALMS Student Luncheon & Panel Discussion	Ballroom BC Meeting Room 202BC
1:30 pm – 3:00 pm	Session B-1: Stewardship 2 Session B-2: Shallow Lake Aeration Session B-3: Lake Assessment Session B-4: Mercury 1	Meeting Room 206A Meeting Room 206B Meeting Room 205 Meeting Room 206C
3:00 pm – 3:30 pm	Refreshment Break, Exhibits Open	Ballroom BC
3:30 pm – 5:00 pm	Session C-1: Stewardship 3 Session C-2: Alum Session C-3: Algae / Zooplankton Growth Session C-4: Mercury 2	Meeting Room 206A Meeting Room 206B Meeting Room 205 Meeting Room 206C
5:15 pm – 6:30 pm	NALMS' Annual Membership Meeting	Meeting Room 205
6:30 pm – 8:30 pm	Exhibitors' Reception and Poster Session	Ballroom BC
8:30 pm – 11:30 pm	Hospitality	Spokane Falls Ballroom, Doubletree Hotel

All rooms are in the Spokane Convention Center unless noted otherwise.

Opening Plenary Session

8:30 am – 10:00 am
Bay 111AB

Welcome to NALMS' 31st International Symposium

Bev Clark
President, North American Lake Management Society

BiJay Adams
President, Washington State Lake Protection Association

Mayor Mary B. Verner
City of Spokane, Washington

Mary B. Verner was sworn in as the 43rd Mayor of the City of Spokane on November 27, 2007. The Mayor has led on the issue of sustainability and making Spokane a hub for green and clean-tech businesses. The Mayor's Sustainability Task Force developed a comprehensive action plan for the City to address both climate change and energy security. The City is now implementing a variety of recommendations to reduce the City's impact on the environment and is building an Energy Plan for the City with the assistance of Avista.

Mayor Verner was born and raised in the southeastern U.S. She settled as a young adult in the U.S. Virgin Islands, where she was a high school teacher, legal assistant, and eventually an Environmental Programs Manager in the Territorial Government.

While completing her Master's Degree back on the mainland, she was offered a position in Natural Resources Management with the Spokane Tribe of Indians. Mary moved to the Spokane area in 1992, and immediately immersed herself in her community as an active citizen and volunteer. She attended Gonzaga Law School while working full-time, and achieved her law degree in 1999.

The Mayor has a broad range of experience in business, law, planning, policy development, program design, and management. She has a law degree from Gonzaga University, a master's in environmental studies from Yale University, and a bachelor's from Davidson College.

Senator Lisa Brown
Washington State Senate Majority Leader

Senator Lisa Brown is the Washington State Senate Majority Leader and an Associate Professor in the Masters of Organizational Leadership program at Gonzaga University.

Lisa was born and raised in Robinson, Illinois. She studied economics at the University of Illinois, in Champaign-Urbana and at the University of Colorado, in Boulder, where she received a Ph.D. She moved to Spokane in the 1980s. As an Associate Professor of Economics at Eastern Washington University, Lisa became involved in public policy advocacy for working families. Her early activities included lobbying the Legislature for dental benefits for low-income people, as part of the "Molar Majority" and organizing the first "Take Back the Night" march in Spokane to bring awareness to victims of domestic violence.

At the request of friends and colleagues, she decided to run for a seat in the state House of Representatives in 1992, and her election helped make that year the "Year of the Woman", when Washington State led the country in the percentage of public offices held by women.

After serving two terms in the House, Lisa was elected to the Senate in 1996, where she was quickly appointed to serve as chair of the Ways and Means Committee in her first term. In 2002, she was elected minority leader. In 2005, she became the first Democratic woman in state history to hold the position of Senate Majority Leader.

Plenary Speaker

Dr. John Stockner
Eco-Logic Ltd & University of British Columbia Fisheries Centre • West Vancouver, British Columbia

Dr. Stockner's research interests focus on pelagic and littoral nutrient dynamics, food web interactions and carbon flows in aquatic ecosystems, notably lakes and reservoirs. He is well known for his work on British Columbia's large lacustrine ecosystems where he has extensively studied the carbon flow and C production by phytoplankton, nutrient fluxes, sediment -P retention, relating these findings to estimates of carbon 'productive capacities' of both pelagic and littoral habitats, using isotopic (^{15}N, ^{14}C) and paleolimnological techniques. His work relating carbon (C) and phosphorus (P) budgets to fisheries stock production and management, and innovative 'nutrient prescription' technology (lake and stream fertilization) as a restorative technique for salmonid enhancement has brought him international recognition as one of the world's leading authorities in the field. He is a skilled phytoplankton taxonomist, studying diatom taxonomy with Drs. Patrick and Reimer (Academy of Natural Sciences, Philadelphia) and with Dr. JWG Lund FRS (Freshwater Biological Association, Ambleside, England). He has an extensive database on freshwater phytoplankton and periphyton and an extensive library of limnological and paleolimnological papers. His pioneering works in paleolimnology as a tool to detect trophic changes and assess historic levels of 'paleo' C production using fossil diatoms and cladocerans continues to be applied to on-going studies in Pacific Northwest lakes and reservoirs. His work on microbial food-webs as 'drivers' of C metabolism in oligotrophic lakes has resulted in 3 edited books and recognition as one of the world's authorities on picoplankton and microbial food-webs in microbial ecology, notably the role of photosynthetic pico-cyanobacteria, their distribution, production, and role in whole-system C production. Recently his work has included dynamics of periphyton communities in the Upper Columbia Basin and in the NW Territories, utilizing key species as indicators of N or P limitation.

Abstract
Holistic or 'ecological' lake management starts with a basic understanding and comprehension of the various components of the ecosystem, and recognizing how intimately interconnected and important each part is to the overall stability and balance of the whole system. I use some examples from studies of Pacific Northwest salmon 'nursery' lakes to illustrate how dependent and finely-tuned production cycles were on 'salmon' nutrients provided by returning adult salmon carcasses; and how easily they became imbalanced by anthropogenic over-fishing and habitat destruction at the turn of the century. Some examples of 'engineering' or 'quick-fix' solutions to common eutrophication problems can be effective following application in the short-term but seldom over the long-term. I submit that lake/reservoir, wetland and stream managers will now be challenged more than ever before, largely by ever increasing effects of population growth and climate change, to manage our fresh-water resources wisely by seeking where possible more holistic or ecological management solutions, *e.g.*, food-chain bio-manipulation, single N or P additions to restore imbalances, habitat restoration, etc. The days using "got a headache – take an aspirin" approach to health management is slowly dying, replaced by questions like "why, when, how persistent, how frequently," *i.e.*, holistic questions of overall system wellness! In my world view, this analogy is fitting for resource managers when setting prescriptions for water management, perhaps even more so now as we enter the second decade the 21st century with a warming planet!

Continental Breakfast / Exhibits Open / Poster Viewing

Ballroom BC
7:00 am – 8:30 am

Opening Plenary Session (Details on page 20)

Bay 111AB
8:30 am – 10:00 am

Refreshment Break / Exhibits Open / Poster Viewing

Ballroom BC
10:00 am – 10:30 am

Session A-1
Stewardship 1

Meeting Room 206A
10:30 am – 12:00 pm

Moderator

***Don Kretchmer**, AECOM, Wolfeboro, N.H.*

Presentations

Looking at Lake Watershed Planning from both Sides of the Table

***Don Kretchmer**, AECOM, Wolfeboro, N.H. and Lake Wentworth Association, Wolfeboro, N.H.*

Managing Ecosystems, Not Leases

***Carol Cloen**, Washington Dept. of Natural Resources, Olympia, Wash.*

Shoreline Inventory: Resource Management and Lakefront Community Growth – Can We Find Synergy?

***Wayne Wright**, GeoEngineers, Inc., Seattle, Wash.*

Institutional Mechanism of Payments for Improving Ecosystem Services on the Watershed Scale (PIES-W): Innovation and Challenges

★***Hebin Lin**, Kyoto Univ., Kyoto City, Japan*

Session A-2
Hypolimnetic Aeration / Oxygenation

Meeting Room 206B
10:30 am – 12:00 pm

Moderator

***Gene Williams**, Snohomish County Public Works – Surface Water Management, Everett, Wash.*

Presentations

Hypolimnetic Oxygenation and Nürnberg Anoxic Factors in Newman Lake, Washington

***Barry Moore**, Washington State Univ., Pullman, Wash.*

Water Quality Changes at Lake Stevens with Hypolimnetic Aeration and Persistent Non-point Loading

***Gene Williams**, Snohomish County Public Works – Surface Water Management, Everett, Wash.*

Observations Using Hypolimnetic Oxygenation to Improve Water Quality in Water-Supply, Hydropower, and Fish Habitat Reservoirs

***Paul Gantzer**, Gantzer Water Resources Engineering LLC, Kirkland, Wash.*

Ecological Development and Water Quality Management In a New Reservoir

***Bob Kortmann**, Ecosystem Consulting Service, Inc., Coventry, Conn.*

Session A-3
National Lake Assessment

Meeting Room 205
10:30 am – 12:00 pm

Moderator

***Paul Garrison**, Wisconsin Dept. of Natural Resources, Madison, Wis.*

Presentations

National Lakes Assessment: Overview of 2007 Results and Plans for the 2012 Assessment

***Amina Pollard**, US Environmental Protection Agency, Washington, D.C.*

Assessing Statewide and Regional Lake Trophic Conditions in Michigan: A Comparison of State Agencies, Volunteer Monitoring, and Remote Sensing Approaches to the National Lakes Assessment (NLA) Survey at the State-Specific Level

***Ralph Bednarz**, Michigan Dept. of Environmental Quality (Retired), Lansing, Mich.*

An Assessment of Washington Lakes: National Lake Assessment Results

***Maggie Bell-McKinnon**, Washington Dept. of Ecology, Olympia, Wash.*

Lessons Learned from the 2007 National Lakes Assessment

***Dennis McCauley**, Great Lakes Environmental Center, Inc, Traverse City, Mich.*

Session A-4
Paleolimnology

Meeting Room 206C
10:30 am – 12:00 pm

Moderator

***Darren Brandt**, Advanced Eco-Solutions Inc., Newman Lake, Wash.*

Presentations

An Introduction to Microscopy in Paleolimnology: Opportunities and Challenges for Using Soft Algae in Addition to Diatom and Chrysophyte Biomarkers

***Ann St. Amand**, PhycoTech, Inc., St. Joseph, Mich.*

Diatoms in Riding Mountain National Park Lakes: Indicators of Water Quality and Ecosystem Change

*★**Carrie White**, Univ. of British Columbia Okanagan, Kelowna, B.C., Canada*

A Paleolimnological Assessment of Past Nutrient Conditions in Coquitlam Lake

Darren Brandt, Advanced Eco-Solutions Inc., Newman Lake, Wash.

Anthropogenic Impacts on Alpine and Sub-Alpine Lakes of the Cascades: A Four Lake Transect from Southern Oregon to Central Washington

***Joseph Eilers**, MaxDepth Aquatics, Inc., Bend, Oreg.*

Session A-5
Adaptive Management

Meeting Room 206D
10:30 am – 12:00 pm

Moderator

***Sally Abella**, King County Dept. of Natural Resources, Seattle, Wash.*

Presentations

Trophic Changes in Otsego Lake, NY Following the Introduction of the Alewife (*Alosa pseudoharengus*), Subsequent Stocking of Walleye (*Sander vitreus*), and Establishment of Zebra Mussels (*Dreissena polymorpha*)

***Holly Waterfield**, SUNY College at Oneonta Biological Field Station, Cooperstown, N.Y.*

Minnesota's Sentinel Lakes Program – A Research and Management Plan for Conserving Minnesota Lake Resources While Confronting Major Ecological Drivers of Change

***Jesse Anderson**, Minnesota Pollution Control Agency, Duluth, Minn.*

LID as a Lake Management Tool

***Stanley Miller**, Inland Northwest Water Resources, Spokane, Wash.*

Integrating Build-out Scenarios with Lake and River Response Models to Guide Management Decisions

***Nancy Turyk**, Univ. of Wisconsin-Stevens Point, Stevens Point, Wis.*

Luncheon / Exhibits Open / Poster Viewing

Ballroom BC
12:00 pm – 1:30 pm

NALMS Student Luncheon & Panel Discussion: "Success in Lake Management"

Meeting Room 202BC
12:00 pm – 1:30 pm

Grab your lunch in the Exhibit Hall and join other NALMS student, professional, and board members in Meeting Room 202BC for an informal discussion among the panelists and attendees. The panel is composed of a variety of NALMS members, ranging in careers from industry to academia. The panelists (Bill Jones, Ann St. Armand, Alan Cibuzar, and Kyle Borrowman) have a wealth of knowledge and experience to share.

Session B-1
Stewardship 2

Meeting Room 206A
1:30 pm – 3:00 pm

Moderator

***Terry Anderson**, Lawrenceburg, Ky.*

Presentations

IDAH$_2$O: Master Water Stewards Serving Idaho Through Volunteer Monitoring

***Ashley McFarland**, Univ. of Idaho Extension, Coeur d'Alene, Id.*

A Collaborative Approach to Lake Monitoring and Stewardship

***Kristi Carter** and **Skye Dunbar**, British Columbia Lake Stewardship Society, Kelowna, B.C., Canada*

The Alberta Lake Management Framework: Empowering Communities in Lake Watershed Stewardship

***Arin MacFarlane-Dyer** and **Steph Neufeld**, Alberta Lake Management Society, Edmonton, Alta., Canada*

Adventures in Volunteer Monitoring: Lessons Learned in 30+ Years with the New Hampshire Lakes Lay Monitoring Program

***Jeffrey Schloss**, Univ. of New Hampshire Center for Freshwater Biology and Cooperative Extension, Durham, N.H.*

Session B-2
Shallow Lake Aeration

Meeting Room 206B
1:30 pm – 3:00 pm

Moderator

***Beth leDoux**, King County Dept. of Natural Resources, Seattle, Wash.*

Presentations

Benefits and Lessons learned from Rehabilitation of an Urban, Shallow, Eutrophic Lake in Colorado by Submerged Aeration

★***Xiaoju Zhang**, Dept. of Civil and Environmental Engineering, Colorado State Univ., Fort Collins, Colo. and Urban Water Center, Dept. of Civil and Environmental Engineering, Colorado State Univ., Fort Collins, Colo.*

Evaluation of Aeration/Oxygenation Options for a Shallow, Urban Lake

***John Nolan**, Parsons, Somerset, N.J.*

SuperOxygenation: Managing Dissolved Oxygen for TMDL Compliance

***David Clidence**, ECO2, Indianapolis, Ind.*

Enhancing Trout Production and Health in Aquaculture and Hatcheries Facilities Using Oxygenation

***Marc Beutel**, Dept. of Civil and Environmental Engineering, Washington State Univ., Pullman Wash.*

Session B-3
Lake Assessment

Meeting Room 205
1:30 pm – 3:00 pm

Moderator

***Jack Jones**, Univ. of Missouri, Columbia, Mo.*

Presentations

Chlorophyll Maxima and Chlorophyll Blooms in Missouri Reservoirs

***Jack Jones**, Univ. of Missouri, Columbia, Mo.*

The Aging (Eutrophication) of Reservoirs: A Comparison of Smith Mountain Lake and Claytor Lake, Virginia Water Quality?

***Carolyn Thomas**, Ferrum College, Ferrum, Va.*

Blooms of Cyanobacteria Reported in Ontario, Canada from 1994 to 2010

***Jennifer Winter**, Sport Fish and Biomonitoring Unit, Ministry of the Environment, Toronto, Ont., Canada*

Documentation and Assessment of a Polyaluminum Chloride Treatment of Stephen Foster Lake, Bradford County, Pennsylvania

***Fred Lubnow**, Princeton Hydro, LLC, Exton, Pa.*

Session B-4
Mercury 1

Meeting Room 206C
1:30 pm – 3:00 pm

Moderator

***Barry Moore**, Washington State Univ., Pullman, Wash.*

Presentations

Comparison of Modeled and Measured Mercury Deposition in Pullman and Twin Lakes, Washington

★***Lanka DeSilva**, Washington State Univ., Pullman, Wash.*

Influence of Macrobenthos on the Cycling of Mercury at the Sediment-water Interface of Lakes

★***Suzanne Cox**, Washington State Univ., Pullman, Wash.*

Mercury Biomagnification in Twin Lakes in 2011 Under Oxygenated and Non-oxygenated Conditions

★***Piper Marshall**, Washington State Univ., Dept. of Civil & Environmental Engineering, Pullman, Wash.*

Important Considerations for Managing Mercury Accumulation in Aquatic Food Webs when Implementing a Hypolimnetic Oxygenation Treatment

***Stephen Dent**, Washington State Univ., Pullman, Wash.*

Refreshment Break / Exhibits Open / Poster Viewing

Ballroom BC
3:00 pm – 3:30 pm

Session C-1
Stewardship 3

Meeting Room 206A
3:30 pm – 5:00 pm

Moderator

***Glen Rothrock**, Idaho Dept. of Environmental Quality, Coeur d'Alene, Id.*

Presentations

Community-Based Participatory Research (CBPR): A Tool for Developing Partnerships for the Management of Lake Diefenbaker, Saskatchewan

***Lalita Bharadwaj**, School of Public Health, Univ. of Saskatchewan, Saskatoon, Sask., Canada*

Stakeholder Accessibility to a Lake Champlain Management Plan

***Eric Howe**, Lake Champlain Basin Program, Grand Isle, Vt.*

Citizen Monitoring of Freshwater Cyanobacteria Phytoplankton in Petenwell and Castle Rock Lakes

***Reesa Evans**, Adams County Land & Water Conservation Dept., Friendship, Wis.*

Volunteer Lake Monitoring in New York: 26 Years of Collaborative Effort

***Nancy Mueller**, New York State Federation of Lake Associations, Inc., LaFayette, N.Y.*

Session C-2
Alum

Meeting Room 206B
3:30 pm – 5:00 pm

Moderator

***Harry Gibbons**, Tetra Tech, Inc., Seattle, Wash.*

Presentations

The Case for Alum

***Dick Osgood**, Osgood Consulting, Shorewood, Minn.*

Science - Policy Conflict on Grand Lake St. Marys, Ohio

***Harry Gibbons**, Tetra Tech, Inc., Seattle, Wash.*

Can Sediment Inactivation Be Successful in Shallow Lakes? - A New Look at an Old Paradigm

***Harvey Harper**, Environmental Research & Design, Orlando, Fla.*

Effects of Nutrient Inactivation (Alum) on Water Quality and Algal Toxins in a Hypereutrophic Sandpit Lake

***John Holz**, HAB Aquatic Solutions, Lincoln, Nebr.*

Session C-3
Algae / Zooplankton Growth

Meeting Room 205
3:30 pm – 5:00 pm

Moderator

***Mike Brett**, Univ. of Washington, Seattle, Wash.*

Presentations

Oxygen Consumption Rates for *Aphanizomenon flos-aquae* are a Function of Temperature, Previous Light Exposure, and Dissolved Oxygen Concentrations

***John Rueter**, Portland State Univ., Portland, Oreg.*

Evaluation of Methods for Estimating Benthic Primary Production in Waldo Lake, Oregon

***Rich Miller**, Portland State Univ., Portland, Oreg.*

The Nexus of Assumptions and Conclusions in Stable Isotope Allochthony Calculations: Reanalysis Suggests Little Zooplankton Terrigenous Support

***Mike Brett**, Univ. of Washington, Seattle, Wash.*

Remediation of Eutrophic Lakes: Is Iron Treatment Safe for Aquatic Invertebrates?

★***Lindsey Wilson**, Univ. of Alberta, Edmonton, Alta., Canada*

Session C-4
Mercury 2

Meeting Room 206C
3:30 pm – 5:00 pm

Moderator

***Marc Beutel**, Washington State Univ., Pullman, Wash.*

Presentations

Effects of Reservoir Hydrodynamics on Mercury Speciation and Transport

***Richard Wildman**, Harvard School of Public Health, Boston, Mass.*

The Effect of Nitrate on Methylmercury Efflux from Profundal Sediment of Freshwater Lakes

★***Ricardi Duvil**, Washington State Univ., Pullman, Wash.*

Controlling Sediment Release of Methylmercury via Nitrate Addition

***John Nolan**, Parsons Corp., Somerset, N.J.*

Suppression of Mercury Methylation by Hypolimnetic Liquid Calcium Nitrate Amendment in Round Lake, Eden Prairie, Minnesota

***David Austin**, CH2M HILL, Mendota Heights, Minn.*

NALMS' Annual Membership Meeting

Meeting Room 205
5:15 pm – 6:30 pm

All NALMS members are encouraged to attend and participate in our annual membership meeting.

Special Event
Exhibitors' Reception and Poster Session

Ballroom BC
6:30 pm – 8:30 pm

NALMS, the Symposium Host Committee and our exhibitors invite you to join us in kicking off the symposium and welcome attendees to Spokane. Take time to relax, view the poster presentations and visit with our exhibitors and with fellow attendees.

Poster Presentations

Perceptions By the General Public of Cyanobacterial Blooms and Remediation Strategies in Lakes: What Can Scientists Learn?

★***Cindy Adams***, *Univ. of Idaho, Moscow, Id.*

The Role of Sediments and Aquatic Plants in the Nutrient Budget of Spirit Lake, Washington

★***Laura Alskog***, *Univ. of Washington Tacoma, Tacoma, Wash.*

Nutrient Loading to Wapato Lake from Park Sheet Flow

★***Steve Ayers***, *Univ. of Washington Tacoma, Tacoma, Wash.*

Secchi Disc Transparencies in Waters of the United States

★***Dana Bigham***, *Univ. of Florida, Gainesville, Fla.*

Assessing the Role of Zooplankton Grazing on the Development and Decline of Cyanobacteria Blooms in Vancouver Lake, Washington, USA

Stephen Bollens, *Washington State Univ., Vancouver, Wash.*

Growth and Developmental Performance of the Milfoil Weevil (*Euhrychiopsis lecontei*) on Various Ecotypes and Hybrids of Eurasian Watermilfoil (*Myriophyllum spicatum*) Present in Ontario, Canada

★***Kyle Borrowman***, *Trent Univ., Peterborough, Ont., Canada*

Pleistocene Groundwater Emplacement into Basalt Aquifers from Glacial Lake Columbia in Northeast Washington State

Lindsay Chutas, *Spokane Conservation District, Spokane, Wash.*

Rapid Assessment, Monitoring and Aesthetic Evaluation of Lake Shorelines Using Geospatial Techniques

David Cordner, *Dept. of Geography, Central Washington Univ., Ellensburg, Wash.*

The Role of Surface and Ground Waters in the Nutrient Budget of Spirit Lake, Washington

★***Danielle Dahlquist***, *Univ. of Washington Tacoma, Tacoma, Wash.*

Prioritizing State-Owned Aquatic Lands in Washington State Lakes for Conservation and Study

Lowell Dickson, *Washington Dept. of Natural Resources, Olympia, Wash.*

Paradox of the Paradox: Linking Climatic Extremes to Episodes of Small-cell Phytoplankton Dominance in a Large Southeastern Reservoir

Joseph Dirnberger, *Kennesaw State Univ., Kennesaw, Ga.*

Developing a Habitat Monitoring Program to Inform Design and Placement of Over-water Structures on Washington State Owned Aquatic Lake Shore and Bedlands

Cinde Donoghue, *Washington Dept. of Natural Resources, Olympia, Wash.*

Soft Armoring to Improve Essential Salmonid Fish Habitat: A Drift Cell Success Story

Judy Dudley, *AMEC E&I, Inc., Bellingham, Wash.*

Past Performance Can Predict Future Returns

Roger Edwards, *Oregon Lakes Association, Oreg.*

Cumulative Impacts of Lake Level Drawdown and Shore Protection to Nearshore Habitats, Moses Lake, Washington

Anthony Gabriel, *Dept. of Geography, Central Washington Univ., Ellensburg, Wash.*

Modeling Bioavailable Phosphorus as a Function of Total Phosphorus to Estimate Watershed Soil Phosphorus Loading

★***Scott Groce***, *Western Washington Univ., Bellingham, Wash.*

Sediment Role in Wapato Lake Nutrient Budget

★***Cierra Hancock***, *Univ. of Washington Tacoma, Tacoma, Wash.*

Assessment of Bottom Sediment Quantity and Quality in Noxon Rapids Reservoir Prior to the Removal of Milltown Dam

Gary Ingman, *Atkins North America, Inc., Helena, Mont.*

Polymer Enhanced Technologies Used to Reduce Eutrophication by Controlling Sediment and Nutrients

Seva Iwinski, *Applied Polymer Systems, Woodstock, Ga.*

A Eurasian Milfoil Invasion – Lessons Learned: Seattle Public Utilities Aquatic Nuisance Species Plan

Elizabeth Johnson, *Seattle Public Utilities, Seattle, Wash.*

The Role of the Water Column in the Nutrient Budget of Spirit Lake, Washington

★***Erika Klein***, *Univ. of Washington Tacoma, Tacoma, Wash.*

Methods for Monitoring Vertical Trout Movement and Distribution in Natural Lakes

★***Brian Lanouette***, *Washington State Univ., Pullman, Wash.*

Short-term Biological Response to Hypolimnetic Oxygenation in North Twin Lake on the Colville Reservation

★***Brian Lanouette***, *Washington State Univ., Pullman, Wash.*

A Water Balance Model for a Complex Shallow Floridian Lake

***Scott Lowe**, Manhattan College, Riverdale, N.Y. and HDR Engineering, New York, N.Y.*

The Atlas of Oregon Lakes

***Richard Lycan**, Portland State Univ, Portland, Oreg.*

From Ambivalent to Engaged: Getting Adult Audiences to Participate in Voluntary Behavior Change with Beaver LakeSmart

***Jane Maginot**, Univ. of Arkansas-Cooperative Extension Service, Fayetteville, Ark.*

Sediment Gas Production, Composition, and Ebullition in Lake Elsinore, California

★***Denise Martinez**, Univ. of California, Riverside, Riverside, Calif.*

Residential Build-out Assessment of the Upper Saint Croix Watershed

***Dan McFarlane**, Univ. of Wisconsin-Stevens Point, Stevens Point, Wis.*

Algae Identification Projects and Outreach Workshops

***Raymond Murrell**, Agriculture & Agri-Food Canada, Regina, Sask., Canada*

Recreational Boating and Shoreline Erosion; Is There A Compromise?

***Charlie Peterson**, Spokane Conservation District, Spokane, Wash.*

Allelopathic Chemicals Isolated From Reed Canary Grass Roots

***Beth Proctor**, Minnesota State Univ.-Mankato, Mankato, Minn.*

Field Measurements of Blue-green Algae Blooms in Taihu Lake, China

***Xin Qian**, Nanjing University, Nanjing, China*

Saltese Flats Wetland Restoration, Spokane, Washington

***Mike Rotar**, Atkins North America, Bozeman, Mont.*

The Spatial Relationship Between the Lakes of the Cascade Lakes Region, Oregon

★***Arick Rouhe**, Portland State Univ., Portland, Oreg.*

The Role of Insects in the Nutrient Budget of Spirit Lake, Mount Saint Helens, Washington

★***Katie Royer**, Univ. of Washington Tacoma, Tacoma, Wash.*

Development of a State-wide Conservation Strategy for Aquatic Vegetation in Lakes

***Ginger Shoemaker**, Washington Dept. of Natural Resources, Olympia, Wash.*

Effects of Water and Methanol Extracts of Common Buckthorn Berries on the Germination and Growth of Lettuce

★***Jordy Veit**, Minnesota State Univ.-Mankato, Mankato, Minn.*

Zebra and Quagga Mussel (*Dreissena polymorpha* and *D. rostriformis bugensis*) Early Detection Monitoring Efforts Throughout the Western United States

***Steve Wells**, Portland State Univ., Portland, Oreg.*

Ultrasonic Algae Control – How it works

***Kirk Whatley**, SonicSolutions LLC, West Hatfield, Mass.*

Lake Eutrophication and Criteria and Control Standard of Total Phosphorus in China

***Liuyan Yang**, Nanjing Univ., Nanjing, China*

Hospitality Reception

Spokane Falls Ballroom, Doubletree Hotel
8:30 pm – 11:30 pm

Program at a Glance: Thursday, October 27

Time	Event	Location
7:30 am – 5:30 pm	Symposium Registration	Ballroom Lobby
7:30 am – 8:30 am	Continental Breakfast	Ballroom BC
8:30 am – 10:00 am	Session D-1: Cyanobacteria Analysis	Meeting Room 205
	Session D-2: Lake Management	Meeting Room 206A
	Session D-3: Coeur d'Alene Lake	Meeting Room 206B
	Session D-4: Fish Studies 1	Meeting Room 206C
10:00 am – 10:30 am	Refreshment Break, Exhibits Open	Ballroom BC
10:30 am – 12:00 pm	Session E-1: Cyanobacteria Toxin Accumulation	Meeting Room 205
	Session E-2: Floating Wetlands and Streambeds	Meeting Room 206A
	Session E-3: Lake Mead	Meeting Room 206B
	Session E-4: Fish Studies 2	Meeting Room 206C
	Session E-5: Zebra / Quagga Mussels	Meeting Room 206D
12:00 pm – 1:30 pm	Luncheon, Exhibits Open	Ballroom BC
	Certified Lake Manager / Professional Luncheon	Meeting Room 202BC
12:00 pm – 1:00 pm	Special Event: Clean Lakes Classic 5k Run/Walk	Meet in Doubletree Hotel Lobby
1:30 pm – 3:00 pm	Session F-1: Cyanobacteria in Washington	Meeting Room 205
	Session F-2: Sediment Management	Meeting Room 206A
	Session F-3: Lake Pend Oreille	Meeting Room 206B
	Session F-4: Regional Assessment of Lake Habitats	Meeting Room 206C
	NALMS Student Workshop: How to Publish in *Lake and Reservoir Management*	Meeting Room 206D
3:00 pm – 3:30 pm	Refreshment Break, Exhibits Open	Ballroom BC
3:30 pm – 5:00 pm	Session G-1: Cyanobacteria in Reservoirs	Meeting Room 205
	Session G-2: Voice of Experience	Meeting Room 206A
	Session G-3: Clear Lake, Manitoba	Meeting Room 206B
	Session G-4: Stream / River Bioassessment	Meeting Room 206C
5:30 pm – 11:00 pm	NALMS' Awards and Recognition Reception and Banquet	Bay 111AB
10:30 pm – 12:30 am	Hospitality	Spokane Falls Ballroom, Doubletree Hotel

All rooms are in the Spokane Convention Center unless noted otherwise.

Continental Breakfast / Exhibits Open / Poster Viewing

Ballroom BC
7:00 am – 8:30 am

Session D-1
Cyanobacteria Analysis

Meeting Room 205
8:30 am – 10:00 am

Moderator

***Jennifer Graham**, US Geological Survey, Lawrence, Kans.*

Presentations

Analysis of Cyanobacterial Toxins from Washington Lakes

***Gabriela Hannach**, King County Dept. of Natural Resources and Parks, Environmental Lab, Seattle, Wash.*

Variations in the Microcystin Congener Composition Among Temperate Lakes

***Frances Pick**, Center for Advanced Research in Environmental Genomics, Univ. of Ottawa, Ottawa, Ont., Canada*

High Throughput Sequencing Analysis of Cyanobacterial Bloom Populations

***Connie Bozarth**, Dept. of Microbiology Oregon State Univ., Corvallis, Oreg.*

Genetic and Toxin Analysis of Blooms and Single Colonies to Catalogue the Toxigenicity of Pacific Northwest Bloom-forming Cyanobacteria

***Theo Dreher**, Oregon State Univ., Corvallis, Oreg.*

Session D-2
Lake Management

Meeting Room 206A
8:30 am – 10:00 am

Moderator

***Chris Mikolajczyk**, Princeton Hydro LLC, Ringoes, N.J.*

Presentations

Phosphorus, Algae, and Water Quality: Interrelationships and Management Implications

***West Bishop**, SePRO Corporation, Whitakers, N.C.*

An Ecologically-Based, Systems-Approach to Freshwater Management

***H Kenneth Hudnell**, SolarBee, Inc., Chapel Hill, N.C. and Univ. of North Carolina, Chapel Hill, N.C.*

Lake Management Needs to Rediscover its Limnology Roots

***Bob Kortmann**, Ecosystem Consulting Service, Inc., Coventry, Conn.*

Stocking the Tool Box: Understanding Lesser Known Options

***Kenneth Wagner**, Water Resource Services, Wilbraham, Mass.*

Session D-3
Coeur d'Alene Lake

Meeting Room 206B
8:30 am – 10:00 am

Moderator

Dave Lamb, Coeur d'Alene Tribe, Plummer, Id.

Presentations

Historical Perspective of the Coeur d'Alene Tribe's Management of Coeur d'Alene Lake

***Phillip Cernera**, Coeur d'Alene Tribe, Plummer, Id.*

Limnology of Coeur d'Alene Lake as Impacted by Two Major Rivers

***Rebecca Witherow**, Idaho Dept. of Environmental Quality, Coeur d'Alene, Id.*

Education and Outreach Needs Assessment for the Coeur d'Alene Lake Management Plan (LMP)

***Glen Rothrock**, Idaho Dept. of Environmental Quality, Coeur d'Alene, Id.*

Chinook Salmon and Kokanee Fisheries in Coeur d'Alene Lake, Idaho

***Jim Fredericks**, Idaho Dept. of Fish and Game, Coeur d'Alene, Id.*

Session D-4
Fish Studies 1

Meeting Room 206C
8:30 am – 10:00 am

Moderator

***Frank Wilhelm**, Univ. of Idaho, Moscow, Id.*

Presentations

Lake Habitat Improvements for the Machado Lake Ecosystem Rehabilitation Project

***Brian Murphy**, CDM, Denver, Colo.*

Our Resilient Reservoirs: Assessing the Robustness of a Fish Community after a Major Environmental Event

***Jason Yarbrough**, Tennessee Valley Authority, Chattanooga, Tenn.*

The Role of the Opossum Shrimp (*Mysis diluviana*) in the Food Web of Lake Pend Oreille, a Large (380 km^2) and Deep (>350 m) Oligotrophic Lake in Northern Idaho, USA

***Frank Wilhelm**, Univ. of Idaho, Moscow, Id.*

Tackling Total Dissolved Gas in the Lower Clark Fork River – Lake Pend Oreille System, Idaho

***Joseph M. DosSantos**, Avista Corporation, Noxon, Mont.*

Refreshment Break / Exhibits Open / Poster Viewing

Ballroom BC
10:00 am – 10:30 am

Session E-1
Cyanobacteria Toxin Accumulation

Meeting Room 205
10:30 am – 12:00 pm

Moderator

***Ann St. Amand**, PhycoTech, Inc., St. Joseph, Mich.*

Presentations

Efforts to Screen Microcystins in Fish from Western Washington Lakes with Toxic Cyanobacteria Blooms

***Joan Hardy**, Washington Dept. of Health, Olympia, Wash.*

Cylindrospermopsis raciborskii: Abundance and Toxin Accumulation in Harvested Food Products

***Laura Dávalos-Lind**, Baylor Univ., Waco, Tex. and Universidad Veracruzana, Xalapa, Veracruz, Mexico*

Cyanobacteria and Fish: A Toxic Health Threat to Tribal Communities?

*★**Ellen P. Preece**, Washington State Univ., Pullman, Wash.*

The Calculus of Risk: How Do We Weigh Lake Recreational Benefits Against Potential Exposures to HABs?

***Curtis Cude**, Oregon Health Authority, Portland, Oreg.*

Session E-2
Floating Wetlands and Streambeds

Meeting Room 206A
10:30 am – 12:00 pm

Moderator

***Rob Zisette**, Herrera Environmental Consultants, Seattle, Wash.*

Presentations

Floating Treatment Streambeds to Enhance Fisheries and Mitigate Lake Eutrophication

***Mark Reinsel**, Apex Engineering, PLLC, Missoula, Mont.*

Floating Islands Provide Fish Spawning Habitat

***Bruce Kania**, Floating Island International, Inc., Shepherd, Mont.*

Canal Restoration Using Wetland and Stormwater Treatment Systems in Ningbo, China

***Rob Zisette**, Herrera Environmental Consultants, Seattle, Wash.*

Evaluation of Small-Scale In-Lake Management Techniques for Westtown Lake, a Shallow Impoundment in Chester County, Pennsylvania

***Fred Lubnow**, Princeton Hydro, LLC, Exton, Pa.*

Session E-3
Lake Mead

Meeting Room 206B
10:30 am – 12:00 pm

Moderator

***Kent Turner**, Lake Mead National Recreation Area, Boulder City, Nev.*

Presentations

Long Term Aquatic Resources Monitoring and Research Plan for Lakes Mead and Mohave, Lake Mead National Recreation Area

***Kent Turner**, Lake Mead National Recreation Area, Boulder City, Nev.*

A Detailed Phosphorus Budget for Lake Mead

***Imad Hannoun**, Flow Science Incorporated, Harrisonburg, Va.*

Determining the Chlorophyll Yield of Phosphorus Additions to Lake Mead Phytoplankton

***Todd Tietjen**, Southern Nevada Water Authority, Las Vegas, Nev.*

Phytoplankton Community Dynamics in Lake Mead, Nevada (2007-2011): A Multivariate Analysis

***John Beaver**, BSA Environmental Services, Beachwood, Oh.*

Session E-4
Fish Studies 2

Meeting Room 206C
10:30 am – 12:00 pm

Moderator

***Marc Beutel**, Washington State Univ., Pullman, Wash.*

Presentations

Using Chemical and Isotopic Tracers to Track Biogeochemical Processes Under Ice Cover at Georgetown Lake, Montana

★***William Henne**, Montana Tech of the Univ. of Montana, Butte, Mont.*

Evaluating Lake Oxygenation Using Changes in Salmonid Movement

★***Brian Lanouette**, Washington State Univ., Pullman, Wash.*

The Influence of Hypolimnetic Oxygen Depletion on Diet Patterns of Brook Trout Using Stable Isotope Analysis in Dimictic Owhi Lake

★***Amy A. Martin**, Washington State Univ., Pullman, Wash.*

Monitoring of Freshwater Fish in Florida Lakes Using Electrofishing: Lessons Learned

***Mark Hoyer**, Fisheries and Aquatic Sciences, School of Forest Resources and Conservation, Univ. of Florida/IFAS, Gainesville, Fla.*

Session E-5
Zebra / Quagga Mussels

Meeting Room 206D
10:30 am – 12:00 pm

Moderator

***Chris Holdren**, Bureau of Reclamation, Denver, Colo.*

Presentations

Quagga Mussels in the West: The Promises, Perils, and Politics of Early Detection

***Chris Holdren**, Bureau of Reclamation, Denver, Colo.*

The Use of Whole Lake Manipulations to Manage Quagga Mussels (*Dreissena bugensis*) in Western U.S. Drinking Water Reservoirs

***William Taylor**, Metropolitan Water District of Southern California, La Verne, Calif.*

Using Shell Morphology to Quantitatively Identify Freshwater Planktonic Mussel Larvae in Early Detection Monitoring Efforts for Zebra and Quagga Mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*)

***Steve Wells**, Portland State Univ., Portland, Oreg.*

Dreissenid Veliger Detection and Enumeration Technology Enhanced to Improve Reliability and Sample Processing Using a Continuous Imaging Particle Analyzer (FlowCAM)

***Harry Nelson**, Fluid Imaging Technologies, Yarmouth, Me.*

Luncheon / Exhibits Open / Poster Viewing

Ballroom BC
12:00 pm – 1:30 pm

Attendees of the Certified Lake Manager / Professional Luncheon should get their buffet lunch in the Exhibit Hall and take it to Meeting Room 202BC.

Special Event
Clean Lakes Classic 5k Run / Walk

Runners meet in the Doubletree Hotel lobby.
12:00 pm

Lunch for the run / walk participants will be available in the Convention Center after the run.

Session F-1
Cyanobacteria in Washington

Meeting Room 205
1:30 pm – 3:00 pm

Moderator

***Jean Jacoby**, Seattle Univ., Seattle, Wash.*

Presentations

Evaluating Toxic Cyanobacteria in Washington State

***Joan Hardy**, Washington Dept. of Health, Olympia, Wash.*

Regional Examination of Harmful Algal Blooms: Findings at the Half Way Point

***Beth leDoux**, King County WLRD, Seattle, Wash.*

Progress Report on the Phytoplankton Analyses Associated with the Regional Harmful Algal Blooms (REHAB) Project in the Puget Sound Lowlands

***Sally Abella**, King County, Seattle, Wash.*

Rapid Detection and Public Notification of Toxic Cyanobacterial Blooms at Three Lakes in Snohomish County, Washington

***Marisa Burghdoff**, Snohomish County - Public Works Surface Water Management, Everett, Wash.*

Session F-2
Sediment Management

Meeting Room 206A
1:30 pm – 3:00 pm

Moderator

***Chris Mikolajczyk**, Princeton Hydro LLC, Ringoes, N.J.*

Presentations

Sediment Quality of the Lower Snake River, 2011

***Russell Heaton**, US Army Corps of Engineers, Walla Walla, Wash.*

Lake Aeration and Sediment Sampling Systems

***Dennis Haag**, Burns & McDonnell, Kansas City, Mo.*

Passive Dosing Methods of Water Clarifying Polymers for Dredging Projects

*⋆**Kyla Iwinski**, Northern Michigan Univ., Marquette, Mich.*

How Deep to Dredge? Pre-dredge Experimental Tests

***Alex Horne**, Univ. of California, Berkeley, Calif.*

Session F-3
Lake Pend Oreille

Meeting Room 206B
1:30 pm – 3:00 pm

Moderator

***Jim Fredericks**, Idaho Dept. of Fish and Game, Coeur d'Alene, Id.*

Presentations

An Overview of Large-Scale Predator Suppression Efforts in Lake Pend Oreille, Idaho

***Jim Fredericks**, Idaho Dept. of Fish and Game, Coeur d'Alene, Id.*

Social Considerations for Implementation of an Intensive Fishery Restoration Program on Lake Pend Oreille, Idaho

***Chip Corsi**, Idaho Dept. of Fish and Game, Coeur d'Alene, Id.*

The Effects of Large-scale Predator Suppression Efforts in Lake Pend Oreille, Idaho

***Andy Dux**, Idaho Dept. of Fish and Game, Coeur d'Alene, Id.*

An Evaluation of Bull Trout *Salvelinus confluentus* Bycatch From Predator Reduction Netting in Lake Pend Oreille, Idaho

***Nicholas Wahl**, Idaho Dept. of Fish and Game, Coeur d'Alene, Id.*

Session F-4
Regional Assessment of Lake Habitats

Meeting Room 206C
1:30 pm – 3:00 pm

Moderator

***Pat Rivers**, Minnesota Dept. of Natural Resources, St. Paul, Minn.*

Presentations

Using Innovative Technologies to Access Environmental Data

***Won Kim**, Oregon Dept. of Environmental Quality, Portland, Oreg.*

Indexing Fish Habitat: Development of Metrics for Nearshore Littoral Zones of Wisconsin Lakes

*⋆**Jessica Orlando**, Wisconsin Cooperative Fishery Research Unit, Stevens Point, Wis.*

An Analysis of Landscape Factors Influencing Variation in Lake Phosphorus Levels Across Minnesota for Use in Directing Fish Habitat Protection and Restoration Efforts

***Timothy Cross**, Minnesota Dept. of Natural Resources, Hutchinson, Minn.*

Modeling Fish Habitat Conditions for Midwest Lakes: A GIS Approach

***Patrick Rivers**, Minnesota Dept. of Natural Resources, St. Paul, Minn.*

NALMS Student Workshop: How to Publish in Lake and Reservoir Management

Meeting Room 206D
1:30 pm – 3:00 pm

Ken Wagner, editor-in-chief for the NALMS Journal of Lake and Reservoir Management, will provide tips to successfully get published in the Journal. His presentation will be followed by a question and answer period.

Refreshment Break / Exhibits Open / Poster Viewing

Ballroom BC
3:00 pm – 3:30 pm

Session G-1
Cyanobacteria in Reservoirs

Meeting Room 205
3:30 pm – 5:00 pm

Moderator

***Debra Bouchard**, King County Dept. of Natural Resources, Seattle, Wash.*

Presentations

Alteration of Nutrient Regimes in Large-scale *In situ* Enclosure Experiments to Reduce Cyanobacterial Biovolume and Toxicity

★***Ted Harris**, Univ. of Idaho, Moscow, Id.*

Cyanobacteria Abundance and Toxin Production in a Drinking Water Supply Reservoir

★***Kari Reynolds**, Missouri State Univeristy, Springfield, Mo. and City Utilities of Springfield, Missouri, Springfield, Mo.*

Seasonal Microcystin Dynamics in Missouri Reservoirs

***Jennifer Graham**, US Geological Survey, Lawrence, Kans.*

Co-Occurrence of Cyanobacterial Toxins and Taste-and-Odor Compounds in Midwestern Drinking-Water Supply Reservoirs

***Lenore Tedesco**, Center for Earth and Environmental Science, and Dept. of Earth Sciences, Indianapolis, Ind.*

Session G-2
Voice of Experience

Meeting Room 206A
3:30 pm – 5:00 pm

Moderator

***Ken Wagner**, Water Resource Services, Wilbraham, Mass.*

Presentations

Forty Plus Years of Lake Management and NALMS

***G. Dennis Cooke**, Kent State Univ., Kent, Oh.*

Recollections and Observations

***Kenneth Reckhow**, RTI, Research Triangle Park, N.C.*

From Limnologist to Corporate Lackey (aka "Senior Advisor")

***Wayne Poppe**, Tennessee Valley Authority, Chattanooga, Tenn.*

Now, Then and In Between

***Bill Funk**, Washington State Univ., Manti, Ut.*

Session G-3
Clear Lake, Manitoba

Meeting Room 206B
3:30 pm – 5:00 pm

Moderator

***Marlow Pellat**, Parks Canada, Western and Northern Service Centre, Vancouver, B.C., Canada*

Presentations

Keeping the Clear in Clear Lake: Managing for Ecological Integrity and Visitor Expectations in Riding Mountain National Park of Canada's Aquatic Ecosystems

***Marlow Pellatt**, Parks Canada, Western and Northern Service Centre, Vancouver, B.C., Canada*

Catchment Flowpath Distributions and Hydroecological Implications for Clear Lake, Manitoba, Canada

★***Natasha Neumann**, Univ. of British Columbia Okanagan, Kelowna, B.C., Canada*

Biogeochemical Cycling of Phosphorus in Clear Lake, Manitoba

***Ryan Whitehouse**, Univ. of British Columbia, Okanagan, Kelowna, B.C., Canada*

Aquatic Macrophytes and Algae as Environmental Threshold Indicators for Lakes within Riding Mountain National Park, Manitoba

★***Heather Gray**, Parks Canada, Vancouver, B.C., Canada and Univ. of British Columbia Okanagan, Kelowna, B.C., Canada*

Session G-4
Stream / River Bioassessment

Meeting Room 206C
3:30 pm – 5:00 pm

Moderator

***Ann Shortelle**, Florida Dept. of Environmental Protection, Tallahassee, Fla.*

Presentations

A Review of Stream Biological Assessment Methods in the 50 States of the U.S.

***Ann Shortelle**, Florida Dept. of Environmental Protection, Tallahassee, Fla.*

Riparian Buffer Decision Support Tool: A Canadian Example

***Sharon Reedyk**, Agriculture and Agri-Food Canada, Edmonton, Alta., Canada*

Instream Assessment of Biota and Migration Patterns of the South Fork Palouse River Watershed

***Shannon Brattebo**, Tetra Tech, Inc. Surface Water Group, Spokane, Wash.*

Relations Between Benthic Macroinvertebrates and Vegetative Communities Along an Elevation Gradient in the Southern Andes of Ecuador: Baseline Data for Indigenous Communities and Long-term Resource Management

★***Carrie Anderson**, Univ. of Idaho, Moscow, Id.*

Special Event

NALMS' Awards and Recognition Reception & Banquet

Bay 111AB
Reception: 5:30 pm– 6:55 pm
Banquet: 7:00 pm – 11:00 pm

NALMS' Annual Awards and Recognition Reception & Banquet is the climax of the Society's year. This year, the awards portion of the program will take place as part of a special reception and the awards to be presented include Technical Merit Awards, the Jim Flynn Outstanding Corporation Awards, The Jim LaBounty Best Paper Awards and Friends of NALMS Award. The program concludes with our most prestigious award, the Secchi Disk Award. This final honor is bestowed upon a NALMS member who has made extraordinary contributions to the goals and objectives of the Society.

Following the reception and awards presentations, attendees are invited to enjoy the banquet and after-dinner entertainment featuring The McManus Comedies, based on the writing of Patrick McManus, whose work has appeared in *Field & Stream*, where he also served as Associate Editor, and *Outdoor Life*, where he was Editor-at-Large. He wrote for those two magazines for over forty years. McManus' humor is based on his life growing up and living in Idaho and eastern Washington.

Hospitality Reception

Spokane Falls Ballroom, Doubletree Hotel
10:30 pm – 12:30 am

Program at a Glance: Friday, October 28

Time	Event	Location
7:30 am – 3:30 pm	Symposium Registration	Ballroom Lobby
7:30 am – 8:30 am	Continental Breakfast	Ballroom BC
8:30 am – 10:00 am	Session H-1: Invasive Species	Meeting Room 205
	Session H-2: Drinking Water Assessment	Meeting Room 206A
	Session H-3: Hydroacoustics	Meeting Room 206B
	Session H-4: Anthropogenic Impact Assessment	Meeting Room 206C
10:00 am – 10:30 pm	Refreshment Break, Exhibits Open	Ballroom BC
10:30 am – 12:00 pm	Session I-1: Milfoil Weevils	Meeting Room 205
	Session I-2: Reservoir Management	Meeting Room 206A
	Session I-3: Remote Sensing	Meeting Room 206B
	Session I-4: Best Management Practices	Meeting Room 206C
	Session I-5: Climate Change	Meeting Room 206D
12:00 pm – 1:30 pm	Luncheon, Exhibits Open	Ballroom BC
	Lake and Reservoir Management Editorial Board Luncheon	Meeting Room 202A
	WALPA Luncheon Meeting	Meeting Room 202BC
1:30 pm – 3:00 pm	Session J-1: Macrophyte Management 1	Meeting Room 205
	Session J-2: Reservoir Aeration / Oxygenation	Meeting Room 206A
	Session J-3: Monitoring Design and Data Analysis	Meeting Room 206B
	Session J-4: TMDLs	Meeting Room 206C
3:00 pm – 3:30 pm	Refreshment Break	Ballroom Lobby
3:30 pm – 5:00 pm	Session K-1: Macrophyte Management 2	Meeting Room 205
	Session K-2: Reservoir Hydromodification	Meeting Room 206A
	Session K-3: Phosphorus Loading	Meeting Room 206B
	Session K-4: Combined Sewer Overflow	Meeting Room 206C
7:00 pm – 8:30 pm	Movie Night	Meet in the Doubletree Hotel lobby at 6:45 pm

All rooms are in the Spokane Convention Center unless noted otherwise.

Continental Breakfast / Exhibits Open / Poster Viewing

Ballroom BC
7:00 am – 8:30 am

Session H-1
Invasive Species

Meeting Room 205
8:30 am – 10:00 am

Moderator

***Mark Sytsma**, Portland State Univ., Portland, Oreg.*

Presentations

Aquatic Invasive Species Management in Wisconsin: Containment and Prevention

***Reesa Evans**, Adams County LWCD, Friendship, Wis.*

Aquatics in Idaho: Survey, Treatment and Prevention

***Thomas Woolf**, Idaho State Dept. of Agriculture, Boise, Id.*

New Zealand Mudsnails in Washington

***Allen Pleus**, Washington Dept. of Fish and Wildlife, Olympia, Wash.*

Asian Clam (*Corbicula fluminea*) Rapid Response Efforts in Lake George, New York

***Meg Modley**, Lake Champlain Basin Program, Grand Isle, Vt.*

Session H-2
Drinking Water Assessment

Meeting Room 206A
8:30 am – 10:00 am

Moderator

***Moya Joubert**, Seattle Public Utilities, Seattle, Wash.*

Presentations

Environmental Factors that Influence Cyanobacteria and Geosmin Occurrence in Two Southeastern United States Reservoirs

***Celeste Journey**, US Geological Survey, Columbia, S.C.*

Thermoconvective Mixing as a Possible Mechanism for the Transport of Taste and Odor Compounds

***Reed Green**, US Geological Survey, Little Rock, Ark.*

Unraveling Algal Mysteries Impacting Seattle's Drinking Water - Two Case Studies: *Botryococcus* and *Cyclotella*

***Moya Joubert**, Seattle Public Utilities, Seattle, Wash.*

Filter Clogging and the Continuing Investigation of the Zooplankter *Holopedium gibberum* in Lake Chaplain Reservoir

★***Anna Thelen**, City of Everett, Everett, Wash.*

Session H-3
Hydroacoustics

Meeting Room 206B
8:30 am – 10:00 am

Moderator

***Bob McClure**, BioSonics, Inc., Seattle, Wash.*

Presentations

Lake Bathymetry: Why You Need It and How It Can Be Cost Effectively Acquired

***Mark Reller**, Constellation Services, Helena, Mont.*

Amount of Hydroacoustic Survey Effort Required to Accurately Assess Water Body Volume

★***Benjamin Cross**, Washington State Univ., Pullman, Wash.*

Whole-Lake Mapping of Total Phosphorus in Reservoir Bottom Sediments Using Acoustic Echosounder Data

***Mark Jakubauskas**, Kansas Biological Survey, Lawrence, Kans.*

Hydroacoustic Signatures of *Gleotrichia* blooms in Owhi Lake, Washington

***Ed Shallenberger**, Colville Confederated Tribes, Nespelem, Wash.*

Session H-4
Anthropogenic Impact Assessment

Meeting Room 206C
8:30 am – 10:00 am

Moderator

***Jonathan Frodge**, Seattle Public Utilities, Seattle, Wash.*

Presentations

Linking Long-term Watershed-based Research with Natural Disturbance and Industrial Landscape Planning in the Canadian Boreal Forest

***Ellie E. Prepas**, Lakehead Univ., Thunder Bay, Ont., Canada and Univ. of Alberta, Edmonton, Alta., Canada*

Identification of Legacy Pollution Sources and Estimation of Nearshore Habitat Modifications in the Lake Washington Watershed Using Historic Documents and Georeferenced Maps in GIS

***Jonathan Frodge**, Seattle Public Utilities, Seattle, Wash.*

Anthropogenic Impact on Bangalore Lakes and Prospective on Restoration and Management and Conservation Aspects

★***R. Abitha***, *Indian Institute of Science, Bangalore, India*

Implication of Bangalore Urban Development on Wetlands and Sustainable Management

Sanna Durgappa, *Indian Institute of Science, Bangalore/ Karnataka, India.*

Refreshment Break / Exhibits Open / Poster Viewing

Ballroom BC
10:00 am – 10:30 am

Session I-1
Milfoil Weevils

Meeting Room 205
10:30 am – 12:00 pm

Moderator

Jenifer Parsons, *Washington Dept. of Ecology, Yakima, Wash.*

Presentations

Assessment of Genetic Variation in the Milfoil Weevil, *Euhrychiopsis lecontei*, a Biocontrol Agent for Eurasian watermilfoil

★***Lara Roketenetz***, *Univ. of Akron, Akron, Oh. and EnviroScience, Inc., Stow, Oh.*

Survey of Eurasian Watermilfoil (*Myriophyllum spicatum*) Ecotypes and Hybrids and Associated Milfoil Weevil (*Euhrychiopsis lecontei*) Populations in Central Ontario, Canada

★***Kyle Borrowman***, *Trent Univ., Peterborough, Ont., Canada*

Milfoil Weevils: Native Population Densities and Panfish Predation

Martin Hilovsky, *EnviroScience, Inc., Stow, Oh.*

Milfoil Weevils and Other Potential Milfoil Biocontrol Agents, A Summary of Work from Washington State

Jenifer Parsons, *Washington Dept. of Ecology, Yakima, Wash.*

Session I-2
Reservoir Management

Meeting Room 206A
10:30 am – 12:00 pm

Moderator

Imad Hannoun, *Flow Science Incorporated, Harrisonburg, Va.*

Presentations

Water Quality Management Considerations for Winter Pool Level Drawdown Policies for Hydropower Reservoirs

Richard Ruane, *Reservoir Environmental Management, Inc., Chattanooga, Tenn.*

Results From the First Four Years of a Nutrient Supplementation Project on Dworshak Reservoir

Sean Wilson, *Idaho Dept. of Fish and Game, Lewiston, Id.*

Estimation of Reservoir TP Loading, In-lake Concentrations and Assimilation Capacity in Southern Reservoirs

Mark Ernst, *Tarrant Regional Water District, Fort Worth, Tex.*

Development of a Three-dimensional Hydrodynamic Model to Assess Future Water Quality in San Vicente Reservoir

Imad Hannoun, *Flow Science Incorporated, Harrisonburg, Va.*

Session I-3
Remote Sensing

Meeting Room 206B
10:30 am – 12:00 pm

Moderator

Alan Cibuzar, *A.W. Research Laboratories, Inc., Brainerd, Minn.*

Presentations

Using Remote Sensing to Monitor and Assess Geospatial and Temporal Trends of Water Clarity in Minnesota

★***Leif Olmanson***, *Univ. of Minnesota, St. Paul Minn.*

Comparison and Evaluation of Medium to Low Resolution Satellite Imagery for Regional Lake Water Quality Assessment

★***Leif Olmanson***, *Univ. of Minnesota, St. Paul, Minn.*

Use of Satellite Water Quality Imaging and Surface Water Instrumentation for Comprehensive TMDL Compliance Monitoring

Louis Sanderson, *Blue Water Satellite, Bowling Green, Oh.*

Aerial Detection of Aquatic Invasive Plants

Alan Cibuzar, *A.W. Research Laboratories, Inc., Brainerd, Minn.*

Session I-4
Best Management Practices

Meeting Room 206C
10:30 am – 12:00 pm

Moderator

***BiJay Adams**, Liberty Lake Sewer and Water District, Liberty Lake, Wash.*

Presentations

Impact of Different Wastewater Treatment Technologies on Bioavailability of Phosphorus

★***Bo Li**, Univ. of Washington, Seattle, Wash.*

Phosphorous-Free Detergent in Hangman Creek; A Squeaky Clean Solution?

***Walt Edelen**, Spokane Conservation District, Spokane, Wash.*

Natural Filtration to Treat Runoff from Seasonal Livestock Areas

***Sharon Reedyk**, Agriculture and Agri-Food Canada, Edmonton, Alta., Canada*

Natural Stormwater Treatment System

***Dennis Haag**, Burns & McDonnell, Kansas City, Mo.*

Session I-5
Climate Change

Meeting Room 206D
10:30 am – 12:00 pm

Moderator

***Rob Plotnikoff**, Tetra Tech, Inc., Seattle, Wash.*

Presentations

Climate Warming and the Onset of Salinization: Rapid changes in the Limnology of Two Northern Plains Lakes

***Jeff Sereda**, Univ. of Saskatchewan, Saskatoon, Sask., Canada*

Statistical Modeling to Assess Potential Climate Change Induced Impacts to Water Quality in Deer Creek Reservoir

★***Oliver Obregon**, Brigham Young Univ., Civil and Environmental Engineering Dept., Provo, Ut.*

Predicted Climate Change Impacts on Lake Ecosystem Dynamics and How This Information is Used for Selecting Effective Restoration Projects and Indicators for Measuring Progress

***Robert Plotnikoff**, Tetra Tech, Inc. Surface Water Group, Seattle, Wash.*

Psychology, Perception and Risk Communication through Dialogue: The Climate Change Implications for Lake Management

★***Albelee Haque**, Bangladesh Environment Network, Boxborough, Mass.*

Luncheon / Exhibits Open / Poster Viewing

Ballroom BC
12:00 pm – 1:30 pm

Attendees of the *Lake and Reservoir Management* Editorial Board Luncheon and the WALPA Luncheon should get their buffet lunch in the Exhibit Hall and take it to Meeting Rooms 202A & 202BC, respectively.

Session J-1
Macrophyte Management 1

Meeting Room 205
1:30 pm – 3:00 pm

Moderator

***Toni Pennington**, Tetra Tech, Inc., Portland, Oreg.*

Presentations

A Review of Demonstration and Research Project Activities to Evaluate a Littoral Zone Treatment Technology for the Control of Submerged Aquatic Vegetation

***Thomas McNabb**, Clean Lakes, Inc., Coeur d'Alene, Id.*

The Perfect Storm: Aquatic Vegetation Management in a Hyper-Eutrophic Lake, a Case Study of Eloika Lake

***Daniel Ross**, Spokane Conservation District, Spokane, Wash.*

Differential Aquatic Herbicide Responses in Eurasian X Northern Watermilfoil Hybrids (*Myriophyllum spicatum* X *M. sibiricum*) and Implications for Future Management

***Mark Heilman**, SePRO Corporation, Carmel, Ind.*

Influence of Water Exchange on the Dissipation of Granular Triclopyr and Dye in the Pend Oreille River, Idaho

***Toni Pennington**, Tetra Tech, Inc., Portland, Oreg.*

Session J-2
Reservoir Aeration / Oxygenation

Meeting Room 206A
1:30 pm – 3:00 pm

Moderator

***Stephen Dent**, Washington State Univ., Pullman, Wash.*

Presentations

A 25 Year Study of Source Water Quality Improvement by Layer Aeration

***Bob Kortmann**, Ecosystem Consulting Service, Inc., Coventry, Conn.*

Improving Dissolved Oxygen at Long Lake HED by Draft Tube Aeration

***John Koreny**, HDR, Bellevue, Wash.*

Oxygen Diffuser System to Create Fish Habitat and Enhance Hydropower Water Quality at J Strom Thurmond Reservoir

***Mark Mobley**, Mobley Engineering, Inc., Norris, Tenn.*

Application of Modeling for Developing the Operational Guide for an Oxygen Diffuser System for Striped Bass Habitat in J Strom Thurmond Reservoir

***Richard J. Ruane**, Reservoir Environmental Management, Inc., Chattanooga, Tenn.*

Session J-3
Monitoring Design and Data Analysis

Meeting Room 206B
1:30 pm – 3:00 pm

Moderator

***Dana Bigham**, Univ. of Florida, Gainesville, Fla.*

Presentations

QA/QC Programs in Water Quality Monitoring - What They Are and Results They Generate

***Erik Host-Steen**, Hach Hydromet, Loveland, Colo.*

Guidelines for Design and Sampling of Water, Sediment, and Biological Quality in Lakes and Reservoirs – A New Chapter in the U.S. Geological Survey *National Field Manual for the Collection of Water-Quality Data*

***Reed Green**, US Geological Survey, Little Rock, Ark.*

Data Driven Strategies to Guide Shoreland Restoration and Protection

***Jennifer McNelly**, Univ. of Wisconsin-Stevens Point, Stevens Point, Wis.*

Comparing Linear Regression and Time Series Methods to Detect Trends in Lake Water Quality

★***Dana Bigham**, Univ. of Florida, Gainesville, Fla.*

Session J-4
TMDLs

Meeting Room 206C
1:30 pm – 3:00 pm

Moderator

***Maggie Bell-McKinnon**, Washington Dept. of Ecology, Olympia, Wash.*

Presentations

A TMDL-Weighted Approach to Evaluating Project Efficacy

***Lance Lumbard**, AMEC E&I, Inc., Orlando, Fla.*

Como Lake: An Urban Lake TMDL Implementation Success Story

***Mark Doneux**, Capitol Region Watershed District, St. Paul, Minn.*

Spokane River and Lake Spokane Dissolved Oxygen TMDL – Development and Implementation

***David Moore**, Washington State Dept. of Ecology, Spokane, Wash.*

Hangman Creek Sediment and Phosphorus Implications to the Lake Spokane Dissolved Oxygen Total Maximum Daily Load Evaluation

***Rick Noll**, Spokane Conservation District, Spokane, Wash.*

Refreshment Break

Ballroom Lobby
3:00 pm – 3:30 pm

Session K-1
Macrophyte Management 2

Meeting Room 205
3:30 pm – 5:00 pm

Moderator

***Josh Wozniak**, Herrera Environmental Consultants, Seattle, Wash.*

Presentations

Aquatic Weed Eradication in Washington – Successes, Attempts, and Lessons Learned

***Jenifer Parsons**, Washington Dept. of Ecology, Yakima, Wash.*

Milfoil Eradication by Hand Pulling in Walsh Lake, Washington

***Josh Wozniak**, Herrera Environmental Consultants, Seattle, Wash.*

What We're Learning from Early Season, Large-scale Herbicide Treatments for Eurasian Watermilfoil in Wisconsin

***Timothy Asplund**, Wisconsin Dept. of Natural Resources, Madison, Wis.*

The Tinmouth Pond Milfoil Project: A Non-chemical Strategy for Controlling Eurasian Watermilfoil (*Myriophyllum spicatum* L.) in Tinmouth Pond, Vermont

***Christopher Knud-Hansen**, SolarBee, Inc., Westminster, Colo.*

Session K-2
Reservoir Hydromodification

Meeting Room 206A
3:30 pm – 5:00 pm

Moderator

***Jonathan Frodge**, Seattle Public Utilities, Seattle, Wash.*

Presentations

Effects of Reduced White River Inflow on Lake Tapps Water Quality

***Nancy Rapin**, Muckleshoot Indian Tribe Fisheries Division, Auburn, Wash.*

Flow Routing with Bottom Withdrawal to Improve Water Quality in Walnut Canyon Reservoir, California

***Michael Anderson**, Univ. of California, Riverside, Calif.*

Will a Shift in Algal Composition in Response to Artificial Whole Lake Mixing Help Achieve the Chlorophyll *a* Standard?

***Craig Wolf**, GEI Consultants, Inc, Denver, Colo.*

A Tale of Two Reservoirs: The Spokane Lake and Tenkiller Reservoir Case Studies

***Mike Brett**, Univ. of Washington, Seattle, Wash.*

Session K-3
Phosphorus Loading

Meeting Room 206B
3:30 pm – 5:00 pm

Moderator

***Jim Gawel**, Univ. of Washington Tacoma, Tacoma, Wash.*

Presentations

The Quest for Adequate Phosphorus Measurements in Lakes

***Gertrud Nürnberg**, Freshwater Research, Baysville, Ont., Canada*

Internal Phosphorus Loading and Vertical Transport Drives Algal Blooms in Cedar Lake, Wisconsin

***William James**, ERDC Eau Galle Aquatic Ecology Laboratory, Spring Valley, Wis.*

Developing a Data-intensive Nutrient Budget for Wapato Lake, Tacoma, Washington, With an Eye Towards Future Management

***James Gawel**, Univ. of Washington Tacoma, Tacoma, Wash.*

The Use of a "Mobile Alum Injection Dosing" (MAID) System to Improve Treatment Efficiencies of Existing Stormwater Ponds

***Ronald Novy**, Orange County Lake Management, Orlando, Fla.*

Session K-4
Combined Sewer Overflow

Meeting Room 206C
3:30 pm – 5:00 pm

Moderator

***Duane Studer**, AECOM, Spokane, Wash.*

Presentations

Use of Spatial Rainfall Variability for CSO Facility Design at Spokane, Washington

***Kiana Eller**, AECOM, Spokane, Wash.*

Challenges of Continuous Simulations to Validate Compliance for CSO Facility Design

***Duane Studer**, AECOM, Spokane, Wash.*

Combined Sewer System Management: Hydraulic Flow Control Structure Performance Testing and CTI Channel Design for the City of Spokane, Washington

***Alex Sylvain**, AECOM, Spokane, Wash.*

Cochran Basin I&I Reduction Effectiveness for the City of Spokane Combined Sewer Overflow Program

***Beryl Childs**, AECOM, Spokane, Wash.*

Special Event
Movie Night

Magic Lantern Theatre
(meet in the Doubletree Hotel lobby at 6:45 pm)
7:00 pm – 8:30 pm

Sponsored by the Spokane Riverkeeper

The symposium host committee and the Spokane Riverkeeper have organized a movie night at the Magic Lantern Theatre.

The featured movie will be *Poison in the Rockies*, a 56-minute film that documents the serious threat to water quality, sub-alpine ecosystems and public health in the Colorado Rockies from mining operations, acid rain and urbanization.

Tickets will be $5.00 and will be pre-sold at the symposium registration desk. This movie will also be open to the public.

Program at a Glance: Saturday, October 29

Time	Event	Location
9:00 am – 3:00 pm	Coeur d'Alene Lake Boat Cruise and City Visit	Meet in Doubletree Hotel Lobby at 8:45 am

Coeur d'Alene Lake Boat Cruise and City Visit

Meet in Doubletree Hotel Lobby at 8:45 am
9:00 am – 3:00 pm

Coeur d'Alene Lake is the Gem of North Idaho! This 12,000 ha lake is co-managed by the Idaho Department of Environmental Quality and the Coeur d'Alene Tribe. But its sparkling clear waters and mountainous surroundings belie the impact of 100 years of mine waste contamination from the Silver Valley area of the Coeur d'Alene River: millions of tons of heavy metal waste deposited on the lake bed and dissolved zinc inhibition of algal growth. This cruise will take us from the upscale Coeur d'Alene Resort to the mouth of the Coeur d'Alene River at Harrison, Idaho. Presentations will be made along the way to describe the many water quality investigations that have been conducted on the lake, as well as some of the implementation measures that have been conducted under the 2009 Lake Management Plan. The cruise will be followed by an opportunity to lunch in Coeur d'Alene and perhaps take a hike along the trails of Tubbs Hill, an undeveloped part of the City of Coeur d'Alene which has beautiful views of the lake and its City.

NALMS 2011 SPOKANE, WA

Abstracts

Session A-1: Stewardship 1

Wednesday, October 26
10:30 am – 12:00 pm
Room 206A

Looking at Lake Watershed Planning from both Sides of the Table

Don Kretchmer
AECOM, Wolfeboro, N.H. and Lake Wentworth Association, Wolfeboro, N.H.

Abstract
The author draws on over 25 years of professional experience as a certified lake manager conducting lake and watershed studies as well as his volunteer role as a director and monitoring coordinator for a local lake association. This talk will contrast his experiences as a consultant on numerous lake and watershed studies with his recent role as a key member of the lake association/steering committee that applied for and received a 319 grant and is now directing a large watershed study, including hiring and management of a consultant. The steering committee includes a municipal planner, public works director, an elected planning board member, agricultural interests, as well as representation from the lake association. This presentation will include examples of consensus building, management of expectations, public feedback, and unintended consequences. It is hoped that the lessons learned can help all parties in these projects create successful partnerships and better watershed management plans.

Managing Ecosystems, Not Leases

Carol Cloen and Ginger Shoemaker
Washington Dept. of Natural Resources, Olympia, Wash.

Abstract
The Washington Department of Natural Resources manages approximately 40 percent of the lakes in Washington State, with the agency mandated to balance environmental stewardship with commerce and public use. Until recently, agency staff had very little common understanding of what that balance looked like, how it was to be achieved, or what factors should drive decisions related to the appropriateness of a use. As a result, decisions related to siting and the construction of new uses of state lands were frequently deferred to regulatory entities and the project's proponent. Research undertaken as part of the development of the Aquatic Lands Habitat Conservation Plan has begun moving the agency toward more active stewardship of aquatic habitats, providing guidance for site-specific criteria, measures for avoidance and minimization of impacts to submerged habitats, and focusing the state's efforts to protect sensitive nearshore habitats. This presentation will focus on implementation of stewardship efforts, strategic elements of the work, and the evolving cultural elements of the shift from managing leases to managing ecosystems.

Shoreline Inventory: Resource Management and Lakefront Community Growth – Can We Find Synergy?

Wayne Wright
GeoEngineers, Inc., Seattle, Wash.

Abstract
Over the ages, places where land meets the water connote life, success, and prosperity. Humans prefer to live in these places presenting a specific conflict with preservation mandates. The last two decades however, has witnessed a new societal focus on shoreline preservation which commonly involves excluding humans from the environment they innately prefer. Several smaller communities were interviewed to obtain real-time input to the shoreline inventory and management programs guiding today's regulation development. Shoreline inventory in the State of Washington is mandated by the state as part of the Growth Management Act and Shoreline Management Act, which explicitly states that ecological services and human uses must be considered. Methods for shoreline inventory range from use of aerial photographs to in-depth assessment of the shoreline environment via on-the-ground survey. Obviously, the aerial photographic review is a good place to start but cannot provide the level of detail necessary to effectively manage local shoreline resources. Three simple elements can promote a better outcome in almost all cases: 1) a better, more integrated planning process, 2) better collaboration through the inventory process, and 3) develop protections/regulations that accommodate natural resource protection as well as community growth. Synergy is rarely accomplished under current practices and is often ultimately defined by court order after a lengthy and expensive legal process.

Institutional Mechanism of Payments for Improving Ecosystem Services on the Watershed Scale (PIES-W): Innovation and Challenges

★Hebin Lin and Kazuhiro Ueta
Kyoto Univ., Kyoto City, Japan

Abstract
This paper addresses the limitation of the current tendency of conceptualizing the innovative "Payments for Ecosystem Services" (PES) approach on "ecosystem services" (ES) provided by one specific ecosystem. Drawing on this insight, this study promotes a watershed governance methodology of "Payments for Improving Ecosystem Services on a Watershed Scale (PIES-W)" focusing on an institutional mechanism developed from New Institutional Economics. PES was introduced to direct public perceptions from the constant dilemma between scarce resources and conflicts of utilizing the resources by disconnected stakeholders to a cooperative perspective of sustaining the resource bases to deliver ES to human society. PES has been typically implemented in the form of "Payments for Watershed Services" (PWS) projects in developing countries in the past 15 years whereas PES-like policies in the form of agri-environmental programs in developed countries much earlier. In this study, PIES-W is

defined as a framework of upstream-downstream co-financing for optimizing ES, composed of 21 essential elements for 3 structural parts (system, add-on and institution aspects), 3 innovative linkages for watershed management (extended cause-effect, stakeholder and explicit governance connectivity), and 9 interactive components of an institutional mechanism (public goods/services, property rights, land use, externality, payment principles, incentives, valuation, information and transaction costs). Relative advantages and challenges of different institution aspects (feasible organizing boundaries, effective exchange intermediaries, valid monitoring units, various types of capitals and contractual relationships) in applying PIES-W to developed countries versus developing countries are discussed with illustrations of PWS projects regarding lakes and reservoirs.

Session A-2: Hypolimnetic Aeration / Oxygenation

Wednesday, October 26
10:30 am – 12:00 pm
Room 206B

Hypolimnetic Oxygenation and Nürnberg Anoxic Factors in Newman Lake, Washington

Barry Moore and Marc Beutel
Washington State Univ., Pullman, Wash.

Abstract
Oxygen status at the sediment/water interface is a well-established factor in regulating internal phosphorus loading in lakes. In dimictic lakes, degradation of accumulated organic matter leads to sediment anoxia with subsequent enhanced hypolimnetic phosphorus accumulation. Phosphorus mixed into photic zone by entrainment, diffusion, or by turnover may contribute to increased primary productivity. While hypolimnetic aeration has been utilized for about 4 decades in lake restoration to prevent anoxia and decrease internal phosphorus load, recent trends are to utilize hypolimnetic oxygenation, which may offer performance and economic advantages. In Newman Lake, hypolimnetic oxygenation has been utilized to varying degrees since 1992, when the first lake application of downflow contact bubble oxygenation technology (Speece Cone) was installed. Oxygenation has reduced growing season Nürnberg Anoxic Factors (AF) from a range of about 30 to 60 days to less than 10 days. Operating the system at full capacity is important, as lower oxygen delivery rates do not produce proportional hypolimnetic oxygen concentrations. We propose that differences in predicted versus observed AF based on phosphorus may be utilized to assess performance of hypolimnetic oxygen delivery.

Water Quality Changes at Lake Stevens with Hypolimnetic Aeration and Persistent Non-point Loading

Gene Williams[1] and Harry Gibbons[2]
[1]Snohomish County Public Works - Surface Water Management, Everett, Wash. [2]Tetra Tech, Inc., Seattle, Wash.

Abstract
In 1994, a hypolimnetic aeration system (the world's largest at the time) was installed in Lake Stevens, Washington to help control internal phosphorus loading. The lake is a deep (46 meter maximum), oligo-mesotrophic lake that suffered from nuisance algal blooms. Over 80% of the lake's phosphorus loading was from internal sources prior to aeration. Eighteen years of aerator operation have significantly increased hypolimnetic dissolved oxygen levels, lowered phosphorus concentrations, and reduced algal blooms. However, phosphorus concentrations and chlorophyll *a* levels have been steadily increasing in recent years. A study was conducted in 2009 to identify long-term changes in the sediments and address concerns about declining aerator effectiveness. The study found that iron concentrations in the water and sediments were lower than required to fully bind phosphorus. Additionally, phosphorus concentrations in the sediments, while lower than pre-aeration, were still very high compared to other lakes. The study concluded that the aeration system would lose effectiveness within 5 to 10 years because of iron deficiency and continued watershed loading. The study recommended implementation of an aluminum sulfate treatment to control internal loading and more aggressive non-point actions to address the on-going external loading. The study evaluated the effectiveness of three alum treatment options that could be implemented with or without continued operation of the aeration system, recognizing that watershed BMPs may take several years to result in measurable effects.

Observations Using Hypolimnetic Oxygenation to Improve Water Quality in Water-Supply, Hydropower, and Fish Habitat Reservoirs

Paul Gantzer
Gantzer Water Resources Engineering LLC, Kirkland, Wash.

Abstract
During summer months, stratified lakes and reservoirs in the northern hemisphere experience oxygen demands that exceed the available oxygen content in the hypolimnion. The resulting anoxic condition leads to increased fluxes of soluble metals to the water column as well as compromised habitats for aquatic life. Installing hypolimnetic oxygenation systems (HOS) in lakes and reservoirs is an oxygen maintenance strategy used to improve water quality by specifically addressing the oxygen budget of the hypolimnion. This strategy has been implemented in several water supply and hydropower reservoirs as well as natural lakes throughout the United States. The focus of this presentation is to show an overview of results for several different HOS applications. Two water supply reservoirs in Roanoke, Virginia, USA have observed a significant decrease in manganese concentrations during the past several years. Fish habitat in a natural lake system near Spokane, Washington, USA has shown improvements in the oxygenated hypolimnion compared to an un-oxygenated hypolimnion. Results from initial testing of two hydropower reservoirs in North and South Carolina, USA, have demonstrated meeting discharge requirements within the first days of operation. Through proper and consistent DO maintenance, HOS can be an effective tool to manage raw water quality in water supply and hydropower reservoirs to suppress metals and meet discharge requirements as well as natural lakes to improve fish habitat.

Ecological Development and Water Quality Management In a New Reservoir

Bob Kortmann[1] and Rob Karl[2]
[1]Ecosystem Consulting Service, Inc., Coventry, Conn. [2]BTMUA, Brick Township, N.J.

Abstract
Brick Township, New Jersey constructed an 860 million-gallon pumped raw water storage reservoir. 100% of the water and nutrients were imported over a four month period

during the initial fill in 2004. Transfer of Metedeconk River water to the reservoir is more cost-effective than treating river water directly, despite added pumping costs. The reservoir functions as a "first step in the water treatment process". This presentation reviews the development of ecological communities, raw water quality, and operational management during the first six years. Reservoir design included depth-selective withdrawal, layer aeration, chemical treatment capability through aerators, and source river flow stage selection. Storage of River water involves water quality challenges (DBP precursors, iron and manganese, suspended solids, taste and odor compounds, and nutrient loading). TP concentrations have become relatively stable in a lower mesotrophic range. Sparse distributions of attached algae (*e.g.*, *Oscillatoria* sp.) were identified by SCUBA. Anatoxin, cylindrospermopsin, microcystin, and saxitoxin were very low or non-detect. Secchi transparency increased and became more stable through time. Intake selection avoids the higher epilimnetic algae densities. The reservoir is beginning to exhibit typical seasonal succession of algae. Full circulation diffuser modules are operated in the spring to enhance the diatom peak and delay the shift to green algae and cyanobacteria, resulting in a 3 fold increase in diatoms and 75% decrease in cyanobacteria. Ongoing efforts focus on maintaining nitrate-N availability for assimilatory and dissimilatory reduction.

Session A-3: National Lake Assessment

Wednesday, October 26
10:30 am – 12:00 pm
Room 205

National Lakes Assessment: Overview of 2007 Results and Plans for the 2012 Assessment

Amina Pollard
US Environmental Protection Agency, Washington, D.C.

Abstract
The Survey of the Nation's Lakes is a partnership between the EPA, states, tribes and other federal agencies to assess the condition of the Nation's freshwater lakes and ponds using a statistically valid design. This Survey is designed to help us to provide regional and national estimates of the condition of lakes. It uses a statistically-valid dataset that represents the condition of all lakes in similar regions sharing similar ecological characteristics. States and tribes used consistent sampling and analytical procedures to ensure that the results can be compared across the country. This presentation is presented in two sections. First, we provide a brief review of the results from the 2007 National Lakes Assessment, which was released in a 2010 report. Approximately 1000 lakes were sampled across the conterminous United States and these lakes were assessed for ecological condition (*e.g.*, plankton, benthic macroinvertebrates, habitat quality) and human use (*e.g.*, algal toxins). In addition to the condition estimates, we present results of an analysis that ranked stressors based on their relative associations between indicators of condition and indicators of stress. Second, we discuss details about the plans for the 2012 National Lakes Assessment. We describe the planning process, objectives, and schedule for the 2012 National Lakes Assessment. In addition, we identify changes in the target population and indicators between the 2007 and 2012 National Lakes Assessments. Finally, we will provide a status update, describe upcoming efforts, and provide preliminary thoughts on the path forward.

Assessing Statewide and Regional Lake Trophic Conditions in Michigan: A Comparison of State Agencies, Volunteer Monitoring, and Remote Sensing Approaches to the National Lakes Assessment (NLA) Survey at the State-Specific Level

Ralph Bednarz[1], Kevin Wehrly[2,3] and Lori Fuller[4]
[1]Michigan Dept. of Environmental Quality (Retired), Lansing, Mich. [2]Michigan Dept. of Natural Resources, Lansing, Mich. [3]Univ. of Michigan, Institute for Fisheries Research, Ann Arbor, Mich. [4]US Geological Survey, Lansing, Mich.

Abstract
Michigan is blessed with more than 11,000 inland lakes, but their sheer number poses a physical and economical problem for the state agencies to collect the data needed to assess the water quality status and trophic condition of lakes state-wide. This paper compares the state-wide trophic-state indicator results and costs of three state-agency inland-lakes monitoring programs of differing designs, one with a remote sensing component, to the 2007 National Lakes Assessment (NLA) Michigan-specific survey results. The Michigan Department of Environmental Quality in partnership with the U.S. Geological Survey completed a 10-year comprehensive Lake Water Quality Assessment (LWQA) monitoring program on 730 targeted lakes state-wide. The LWQA monitoring program also included a remote sensing element for predicting water clarity and trophic condition on all Michigan lakes 20 acres or larger in size. The Michigan Department of Natural Resources reported results for the first six years of a Status and Trends monitoring program that included 233 lakes selected using a random survey design. Michigan has managed a volunteer lakes monitoring program, the Cooperative Lakes Monitoring Program, for over 38 years that currently provides trophic state indicator data on 200-250 lakes per year.

An Assessment of Washington Lakes: National Lake Assessment Results

Maggie Bell-McKinnon
Washington Dept. of Ecology, Olympia, Wash.

Abstract
In 2007, the Washington State Department of Ecology collected biological, chemical, and physical data at 30 randomly selected Washington lakes. Based on the survey design, the data results from these 30 lakes can be applied to a population of 620 lakes in Washington. Sample sites represented the following ecoregions of the state: Coast Range, Puget Lowland, Willamette Valley, Cascades, Northern Cascades, Columbia Plateau, and Northern Rockies. This study was part of EPA's National Lake Assessment which encompassed monitoring at 1,028 lakes in the lower 48 United 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. This report presents the state-wide status of lakes in terms of good, fair, and poor condition. This study showed over 80% of the lake sample population in Washington are in fair or good condition with regard to physical habitat. The results also showed that nutrients and chlorophyll *a* were the parameters of highest concern. Turbidity was in poor condition at only 3% of the

lakes in the lake sample population. This information could be useful for water resource managers when setting priorities for monitoring and restoring lakes.

Lessons Learned from the 2007 National Lakes Assessment

Dennis McCauley[1], Ellen Tarquinio[2] and Marsha Johnson[2]
[1]Great Lakes Environmental Center, Inc, Traverse City, Mich. [2]USEPA Office of Water, Washington, D.C.

Abstract
In 2007, EPA initiated a survey and assessment of randomly selected lakes and reservoirs throughout the conterminous U.S. to address the need for improved water quality monitoring at a national scale. This survey established a national baseline and will be used to track statistically-valid trends in water condition. The survey identified key stressors to these systems and explored the relative importance of each in restoring or maintaining lake health. Randomized design, and standardized field and laboratory protocols, allowed EPA to analyze data that are nationally consistent and regionally relevant. Probability-based surveys offer a scientifically-valid way to fulfill statutory requirements, complement traditional monitoring programs, and support management decisions. The National Lakes Assessment report summarizes the first-ever assessment of lakes across the contiguous United States using consistent protocols and scientifically-defensible probability-based approach. The NLA was completed after careful consideration of pre-survey planning, field sampling, sampling logistics, laboratory analysis, data analysis and reporting. Approximately 80 field crews were deployed and supported across the country; sampling/sample analysis was tracked from initiation; laboratory analysis was completed at EPA, state, regional and contract laboratories; and the data analysis and reporting was completed by EPA lead workgroups, states and contractors. Over 1,300 lakes were sampled all across the country in the space of just four months; "a phenomenal accomplishment"! The complexity and difficulty of each step offered unique challenges and opportunities and provided lessons learned for the following NARS assessments and for the upcoming 2012 National Lakes Assessment. The lessons learned are discussed in this presentation.

Session A-4: Paleolimnology

Wednesday, October 26
10:30 am – 12:00 pm
Room 206C

An Introduction to Microscopy in Paleolimnology: Opportunities and Challenges for Using Soft Algae in Addition to Diatom and Chrysophyte Biomarkers

Ann St. Amand[1], Peter Leavitt[2] and Joe Eilers[3]
[1]PhycoTech, Inc., St. Joseph, Mich. [2]Univ. of Regina, Regina, Sask., Canada [3]MaxDepth Aquatics, Inc., Bend, Oreg.

Abstract
Traditional paleolimnology relies on diatoms, Chrysophyte remnants, and pigments for creating stratigraphies dating back sometimes thousands of years. These microfossils have traditionally been used to create a timeline for the system, linking disturbances and shifts in the fossil record to major geological events or shifts in acidity related to acid precipitation. More recently, soft algal remnants have been added to the list of potential biomarkers. Certain Cyanophyte algae (Nostocales) produce resting cells called akinetes which can be well preserved in the sediments. Unlike diatoms and Chrysophytes, akinetes appear to remain viable for hundreds of years. Although somewhat ubiquitous, several species or species groups can identified and are associated with eutrophic waters and toxin production (including *Aphanizomenon flos-aquae*, *Anabaena planctonica*, and *A. lemmermannii*). Other soft algal biomarkers include Chlorophyte genera such as *Pediastrum*, *Tetraedron*, *Teilingia* and *Cosmarium*. Unlike traditional acid cleaning procedures, epifluorescence is used to visualize the akinetes and soft algae among high concentrations of particulates and diatom frustules, and is an alternate for determining pollen grain densities as well. Challenges in obtaining and dating cores will also be discussed.

Diatoms in Riding Mountain National Park Lakes: Indicators of Water Quality and Ecosystem Change

★Carrie White[1], Marlow Pellatt[2], Bob Reside[3] and Ian Walker[1]
[1]Univ. of British Columbia Okanagan, Kelowna, B.C., Canada [2]Parks Canada Western Northern Service Center, Vancouver, B.C., Canada [3]Riding Mountain National Park of Canada, Wasagaming, Manit., Canada

Abstract
Riding Mountain National Park of Canada (RMNP) was established in 1933. Since then, human influence and use of the Park has grown and potentially impacted the Park's freshwater systems. Clear Lake, the largest lake in RMNP, is known for its clear blue waters, and is especially highly used by park visitors during summer. To establish the presence and/or extent of an anthropogenic impact on the lake systems, paleoenvironmental analyses are being used to reconstruct past changes in the lakes' state and water chemistry. Diatoms are especially highly regarded as paleoecological indicators. They have been used over many decades as paleo-indicators, due to their unique silica frustule that preserves very well in lake sediments and their narrow ecological tolerances. The species assemblage of diatoms preserved reflects the composition and productivity of lakes both in the present and past. The preserved remains of diatoms are essential clues to understanding changes in lake productivity, lake state, and other environmental variables. Mathematical models relating current diatom communities with diverse environmental variables (*e.g.*, pH, salinity, and nutrient status) are being developed for lakes in RMNP. Reconstructions of past environmental changes will then be derived by applying these mathematical models to diatom assemblages preserved in long sediment cores taken from four lakes in RMNP: Clear, Katherine, Moon, and South Lake. These paleo-reconstructions will facilitate assessments of the current and natural states of each lake, their response to past human impacts, and effectiveness of park management strategies as means to maintain the lakes' ecological integrity.

A Paleolimnological Assessment of Past Nutrient Conditions in Coquitlam Lake

Darren Bos[1], John Stockner[2] and Darren Brandt[3]
[1]DNO Consulting Inc., Coquitlam, B.C., Canada [2]UBC Fisheries Centre, Eco-Logic Ltd., West Vancouver, B.C., Canada [3]Advanced Eco-Solutions Inc., Newman Lake, Wash.

Abstract
This study collected evidence from chemical and micro-fossil analysis of sediments in Coquitlam Reservoir, Coquitlam, British Columbia that elucidates what conditions were present in the lake prior to impoundment for hydroelectric purposes; a time when anadromous salmon, notably sockeye (*Oncorhynchus*

nerka), were present in the lake. These data were used to assess the 'past' nutrient conditions and lake productivity to improve our understanding of the potential impacts of salmon reintroductions and their 'new' nutrients to the present reservoir production and water quality. To achieve this objective, we used a multiple-indicator approach relying on a variety of sedimentary proxies related to nutrient levels - including algae, invertebrates, and the organic components of the sediment. Further, we analyzed nitrogen isotopes that are related to salmon abundance in order to estimate the past contribution of salmon to the lake's nutrient budget.

Anthropogenic Impacts on Alpine and Sub-Alpine Lakes of the Cascades: A Four Lake Transect from Southern Oregon to Central Washington

Joseph Eilers, Kellie Vache, Benn Eilers and Roger Sweets
MaxDepth Aquatics, Inc., Bend, Oreg.

Abstract
A set of four lakes, all located in wilderness areas of the Cascade Range, were monitored for five years to establish current conditions. The four study sites were lakes Notasha and Scout in Oregon, and lakes Summit and Foehn in Washington. Lake monitoring consisted of sampling nutrient chemistry, major ions, phytoplankton, zooplankton, and benthos. All lakes were mapped and sediment cores were collected to reconstruct historical changes in the lakes. Sediments were dated using ^{210}Pb and ^{14}C and diatom stratigraphies were analyzed to assess water quality changes in the 20th century. The current conditions and recent historical conditions were used to calibrate a hydrodynamic model (CE-QUAL-W2) to modeled deposition chemistry and assess the degree to which the lakes might respond to increases in nitrogen and sulfur deposition. Unlike lakes studied in the Rocky Mountains, these four lakes showed little effects from likely increases in nitrogen deposition, although the two Washington lakes did exhibit some degree of ANC loss from sulfur inputs. The lakes showed few other changes from anthropogenic activities, including camping and fish introductions. The sediment reconstruction showed that Foehn Lake, located in the Alpine Lakes Wilderness, was likely created in the early to mid 20th century as meltwater from a previously existing snowfield.

Session A-5: Adaptive Management

Wednesday, October 26
10:30 am – 12:00 pm
Room 206D

*Trophic Changes in Otsego Lake, NY Following the Introduction of the Alewife (*Alosa pseudoharengus*), Subsequent Stocking of Walleye (*Sander vitreus*), and Establishment of Zebra Mussels (*Dreissena polymorpha*)*

Holly Waterfield, Matthew Albright and Bill Harman
SUNY College at Oneonta Biological Field Station, Cooperstown, N.Y.

Abstract
Changes at several trophic levels in Otsego Lake from the 1930s to the present are described relative to the introduction and establishment of alewife (*Alosa pseudoharengus*), subsequent efforts to control them through re-establishment of walleye (*Sander vitreus*), and the establishment of zebra mussels (*Dreissena polymorpha*). Concurrent characterization of several trophic indicators has included chlorophyll *a*, Secchi disk transparency, areal hypolimnetic oxygen deficit (AHOD), zooplankton abundance, size, and biomass, as well as forage and game fish abundance and diet. While some trophic changes were consistent with those reported in the literature, some were not. Notably, 10 years of walleye stocking dramatically reduced alewife abundance. Also, following zebra mussel establishment, cladoceran mean size and biomass increased substantially concurrent with increasing Secchi disk transparency. Efforts to evaluate the success of various lake management strategies have been confounded by the establishment of exotic species.

Minnesota's Sentinel Lakes Program – A Research and Management Plan for Conserving Minnesota Lake Resources While Confronting Major Ecological Drivers of Change

Ray Valley[1], Steve Heiskary[2], Jesse Anderson[3] and Richard Kiesling[4]
[1]Minnesota Dept. of Natural Resources, St. Paul, Minn. [2]Minnesota Pollution Control Agency, St. Paul, Minn. [3]Minnesota Pollution Control Agency, Duluth, Minn. [4]US Geological Survey, Mounds View, Minn.

Abstract
The Minnesota Pollution Control Agency (MPCA) is working in partnership with the Minnesota Department of Natural Resources (MDNR) on the Sustaining Lakes in a Changing Environment (SLICE) Sentinel Lakes Program. The focus of this interdisciplinary effort is to improve understanding of how major drivers of change such as development, agriculture, climate change, and invasive species can affect lake habitats, water quality, and fish populations, and to develop a long-term strategy to collect the necessary information to detect undesirable changes in Minnesota lakes. The ultimate goal is for a more effective, better coordinated lake protection program based on strong, inter-disciplinary scientific analyses. In the Phase I pilot program (2008-2011), SLICE focused on monitoring and reporting on a diverse set of 24 lake watersheds spread across four of the state's major ecoregions. In these 24 lakes, MDNR, MPCA, and its partners are exploring watershed-scale processes and mechanisms that drive changes in water quality and fish habitat. In the Phase II operational program (2013 -), lessons learned from Phase I will be applied to improve the sentinel lakes monitoring schedule and incorporate less intensive surveys to a wider range of lake types. A subset of three "Super Sentinel" lakes, which harbor cold-water fish populations, are subject to further research, climate change forecasting, and watershed modeling led by the US Geological Survey. Results to date, lessons learned, and future research opportunities will be presented, focusing on the Super Sentinel lakes as case studies.

LID as a Lake Management Tool

Stanley Miller
Inland Northwest Water Resources, Spokane, Wash.

Abstract
Here we examine the pros and cons of Low Impact Design (LID) as a lake management tool. The goal of LID is to retain runoff generated by development onsite and dispose of it via infiltration, evaporation or plant transpiration. In so far as sediment management is the primary water quality goal all avenues of onsite disposal are good. However, if nutrient management is a water quality need in your basin, some

LID disposal methods are better than others. The discussion here will focus on how LID management approaches affect phosphorus reaching a receiving water. The wide variability in results from the many stormwater studies available suggests there is no typical stormwater; most of the literature indicates that residential runoff, the kind most likely associated with lakeshore development, has total phosphorus concentrations in the range of 0.25 to 1.0 mg P/L. Up to 20% of the total may be found in the dissolved state. Phosphorus transport modeling shows that without biological uptake, dissolved phosphorus will "break through" a 10 foot thick silt loam soil layer to underlying groundwater in about a year. Conversely, harvesting the vegetation from a bio-infiltration system can remove on the order of 6 kg P per hectare per growing season (0.12 lb per 1000 square feet). LID can be an effective tool for managing runoff in lakeshore environments. However, the most commonly employed LID practice, stormwater infiltration, is problematic. Limiting the amount of nutrients applied to landscaping and bio-infiltration are the most effective nutrient management tools.

Integrating Build-out Scenarios with Lake and River Response Models to Guide Management Decisions

Nancy Turyk, Paul McGinley and Dan McFarlane
Univ. of Wisconsin-Stevens Point, Stevens Point, Wis.

Abstract
Ideally, lake and river management strategies should be identified and implemented prior to the degradation of a water body. This could result in lower inputs of cost, time, and effort associated with the restoration of a degraded hydrologic system. However, preemptive land management decisions are often difficult for communities to make due to challenges in forecasting changes in land uses and perceiving how these changes may affect lakes and streams. The combination of a build-out scenario, based on zoning regulations, and lake/river response models can help to predict water quality or quantity challenges that may result from increased development within a watershed and provide some insight about strategies that would help to avoid undesired degradation. Build-out and water quality scenarios were developed for a group of 26 lakes in Portage County, Wisconsin. The numbers of developable parcels identified in the build-out were translated to acreage using a coefficient of average disturbance per parcel. Corresponding changes in water quality were predicted using phosphorus export calibrated to the current phosphorus concentrations and hydrologic budgets developed from groundwater flow modeling. Phosphorus concentrations predicted with the model were used to estimate the chlorophyll *a* concentrations in the lake at various levels of development. In the Upper St. Croix River watershed in Wisconsin, build-out impervious predictions were used in conjunction with a hydrologic and nutrient cycling model with a daily time-step to project both increases in daily flow and phosphorus loading to the stream from increased impervious surfaces in the watershed.

Session B-1: Stewardship 2

Wednesday, October 26
1:30 pm – 3:00 pm
Room 206A

IDAH$_2$O: Master Water Stewards Serving Idaho Through Volunteer Monitoring

Ashley McFarland
Univ. of Idaho Extension, Coeur d'Alene, Id.

Abstract
Maintaining water quality integrity in the state of Idaho is necessary to ensure a safe water source for drinking and recreating, and to support fisheries and wildlife. Pollutants are loaded into water bodies each day which have the potential of threatening these uses. Through education and outreach, citizens gain a better understanding of their interaction with the land and learn how to best conserve resources. Water monitoring is an integral tool in this outreach; however, most programs once supported by state agencies have been cut or suspended due to budget shortfalls. Monitoring by IDAH$_2$O Master Water Stewards fills substantial gaps in data created by termination of these programs. The primary goals of the IDAH$_2$O program are: (1) increasing citizen knowledge on water quality issues, (2) promote volunteer monitoring on Idaho streams, and (3) enhance watershed stewardship. IDAH$_2$O was developed into a "Master" program to make use of a highly successful extension model. IDAH$_2$O volunteers receive training and in return, conduct monitoring in Idaho watersheds. Collected data is published and used to inform citizens and agencies about watershed conditions. IDAH$_2$O targets established watershed groups that want to participate in organized water monitoring. Extensive outreach has occurred with these groups to heighten their awareness of watershed processes and comprehension of data. Since the program launch in fall 2010, over 75 volunteers have been certified, monitoring 20 different watersheds. Seventy-five percent of certified volunteers plan to monitor streams and over half of the volunteers plan to be more active in watershed stewardship.

A Collaborative Approach to Lake Monitoring and Stewardship

Kristi Carter, Norm Zirnhelt, Rick Nordin and Skye Dunbar
British Columbia Lake Stewardship Society, Kelowna, B.C., Canada

Abstract
The British Columbia (BC) Lake Stewardship Society (BCLSS) is a registered (1997) non-profit organization whose membership includes lakeshore residents, students, stewardship groups, and environmental professionals. Our vision is clean, healthy lakes that provide quality habitat for aquatic life, wildlife, and people throughout BC. The BCLSS assists in training, education, and technical support to lake stewardship groups interested in protecting their community's lakes by providing lake monitoring programs, educational materials, training courses, and workshops. The BCLSS is currently focusing its efforts on the BC Lake Stewardship & Monitoring Program (BCLSMP). With increased reliance on the public to play a greater role in stewardship activities, environmental monitoring, and water quality management, the BCLSMP was initiated in 2002 and launched in the spring of 2003 in partnership with the Ministry of Environment and the Vancouver Foundation. The BCLSMP enables a strong, quality-assured baseline of data to be established, which helps the health of a lake to be

determined, monitored, and managed over time. Volunteers are trained at various levels to collect water quality data. The program also provides information on lake-related issues and fosters awareness, concern, and support for the conservation and preservation of lake ecosystems. Through this initiative, the BCLSS has moved BC closer to a shared stewardship model for addressing lake water quality issues. With funding from the Royal Bank of Canada (RBC) Blue Water Project, the BCLSS successfully ran two LakeKeepers Courses, attracting participants from across British Columbia, and field-tested our Aquatic Macrophyte Survey Program.

The Alberta Lake Management Framework: Empowering Communities in Lake Watershed Stewardship

Arin MacFarlane-Dyer and Steph Neufeld
Alberta Lake Management Society, Edmonton, Alta., Canada

Abstract
Healthy lakes are a high priority for Albertans yet the practice of management of lake watersheds in Alberta is in its infancy. The Alberta Lake Management Society has developed a lake management guidance document to be used by lake stewardship groups. It fully describes the opportunities, processes and relationships that are unique to lake management in Alberta. This document, the Lake Management Framework, is intended to guide lake stewardship groups through a suite of planning initiatives that work to manage water and watersheds including government enabled Watershed Planning and Advisory Committees, regulatory requirements for individual industries, urban/municipal planning initiatives, and provincial-level cumulative effects initiatives. The Framework also assists lake stewards in developing an ecologically sound plan by suggesting biological indicator variables and establishing a clear process for objective setting specific to their lake's management priorities. In this presentation we will discuss the multi-stakeholder process that led to the development of the Framework and profile a case study of a lake stewardship group successfully working through the steps recommended in the Framework.

Adventures in Volunteer Monitoring: Lessons Learned in 30+ Years with the New Hampshire Lakes Lay Monitoring Program

Jeffrey Schloss and Robert Craycraft
Univ. of New Hampshire Center for Freshwater Biology and Cooperative Extension, Durham, N.H.

Abstract
The New Hampshire Lakes Lay Monitoring Program (NH LLMP) has undertaken considerable modifications to meet the interests and concerns of its participants over its 34 years of existence. Initially established to meet the information needs of New Hampshire's local lake associations, the program has moved well beyond its original intention to provide a long-term database to detect lake water quality changes. It has taken on a "participatory research" approach to provide answers to questions of interest on a local to regional geographic scale. Thus, not only do the participants gain information for the intelligent and informed stewardship of their local resources but the accumulation of the data and their wide range of cost effective monitoring efforts have advanced our understanding of statewide and regional issues of concern. Key to our success has been the modification of sampling protocols to meet ecoregional characteristics and understanding the various realities of citizen monitoring along with maintaining excellent quality assurance documentation. Where initially we met resistance from our state agencies, our program has been helpful in the initiation of state run monitoring programs and in providing our environmental and fish and wildlife agencies with useful data. More importantly, participation in the NH LLMP has helped local lake associations and citizen groups to qualify for watershed management assistance grants administered by our state environmental agency from EPA 319 support. The evolution of the NH LLMP will be discussed, successes and failures will be covered, and new directions in our monitoring including cyanobacteria blooms will be introduced.

Session B-2: Shallow Lake Aeration

Wednesday, October 26
1:30 pm – 3:00 pm
Room 206B

Benefits and Lessons learned from Rehabilitation of an Urban, Shallow, Eutrophic Lake in Colorado by Submerged Aeration

★Xiaoju Zhang[1,2], Larry Roesner[1,2], Kenneth Carlson[1] and Qian Liang[1]
[1]Dept. of Civil and Environmental Engineering, Colorado State Univ., Fort Collins, Colo. [2]Urban Water Center, Dept. of Civil and Environmental Engineering, Colorado State Univ., Fort Collins, Colo.

Abstract
Urban shallow lakes accommodate many different uses, which can make them more vulnerable to changes in water quality than natural lakes. Small volume, high accumulation of organic matter and nutrients, and the prevalence of internal loading can accelerate the lake eutrophication process. All of these factors may account for the perception that rehabilitation of heavily degraded shallow lakes appears to be less successful than for deep lakes. There has been significant research effort on aeration systems in deep water lakes, but a comprehensive science-based study of urban shallow lakes has been lacking thus far. Fossil Creek Lake, located in Fort Collins, Colorado, has been for many years the source of periodic pungent hydrogen sulfide odors and fish kills particularly during lake turnover events. A submerged aeration was introduced into the lake to increase the hypolimnetic dissolved oxygen levels and prevent thermal stratification. This research describes the results of the investigation of the urban shallow eutrophic lake before aeration, during startup, and for two years after implementation. The number of aerators required to achieve entire lake circulation was substantially less than would typically be used in a lake of this size, based on the hypothesis that by placing the aerators in the deeper pockets of the lake, density differences would cause the heavier bottom water to "flow downhill" toward the aerators, increasing the effective circulation cells of the individual aerators. In addition, the side effects and harmfulness of inappropriate aeration is summarized for lake managers.

Evaluation of Aeration/Oxygenation Options for a Shallow, Urban Lake

John Nolan[1], Daniel Ryan[1], Stephanie Bache[1], Alex Horne[2] and Brian Murphy[3]
[1]Parsons, Somerset, N.J. [2]Alex Horne and Associates, El Cerrito, Calif. [3]CDM, Denver, Colo.

Abstract
A design has been completed for an oxygenation system for a shallow, urban lake with a surface area of approximately 40 acres. Renovation of the ecosystem includes dredging the lake to a depth of 8 feet. An engineered supply of oxygen is needed to suppress nutrient fluxes from the sediments and thus minimize algal blooms, and prevent fish kills and malodors. An extensive review of options for maintaining oxygen levels was conducted, including surface aerators/mixers, aspirator aerators, full or partial-lift aerators, bubble diffusers such as line or disk diffusers, and downflow bubble contactors (Speece Cones). The key challenges for any system include: 1) dissolving oxygen into the short water column, and 2) distributing that oxygenated water throughout the target volume. Air-based systems are appealing because air is free. However, the low partial pressure of oxygen in air means that the driving force for oxygen dissolution into water is modest, requiring increased air flow rates and energy consumption. Pure oxygen systems require expenditures to purchase liquid oxygen or an oxygen generator (with its own energy consumption), but create a driving force for dissolution five times that of an air-based system. Therefore, the optimum system minimizes the cost or energy consumption per ton of dissolved oxygen. Such an analysis recommended the use of a Speece Cone, a sealed vessel in which lake water and pure oxygen are mixed under pressure for an extended residence time, producing a super-oxygenated effluent.

SuperOxygenation: Managing Dissolved Oxygen for TMDL Compliance

David Clidence
ECO2, Indianapolis, Ind.

Abstract
Dissolved oxygen impairment is the most frequent source of TMDL violations and is usually associated with excess BOD, low re-aeration characteristics of receiving waters, or non-point source pollutants. SuperOxygenation can be used to dissolve pure oxygen directly into water ways to bring them into D.O. compliance with their TMDL. SuperOxygenation can be located and used directly at the water body or located at point source discharges. Installed directly on the water body, the SuperOxygenation system would withdraw a side stream of water, SuperOxygenate it, and return the oxygenated water back to the receiving water body. The oxygenated water would be returned through a diffuser pipe to distribute the oxygenated water into the water body. SuperOxygeation can also be incorporated into point source discharges by raising the D.O. level in the effluent to offset the negative impact the residual BOD has on the receiving body. In this way, the D.O. of secondary treated effluents can be SuperOxygenated to a concentration equivalent to its ultimate BOD so that no net D.O. resources are extracted from the receiving waters, thus negating tertiary treatment. SuperOxygenation costs much less than tertiary removal of BOD. Dissolved oxygen plays an important role in the quality of our water ways. Adequate D.O. levels are needed in our drinking water reservoirs to prevent iron, manganese, and hydrogen sulfide production, improve impaired water ways, mitigate effects of harbor deepening, offset residual BOD in wastewater treatment plant effluent, and help meet TMDL limits.

Enhancing Trout Production and Health in Aquaculture and Hatcheries Facilities Using Oxygenation

Seyoum Gebremariam and Marc Beutel
Dept. of Civil and Environmental Engineering, Washington State Univ., Pullman Wash.

Abstract
A key constraint that limits trout aquaculture in the Pacific Northwest is limited water availability. Abundant quantities of cold, well-oxygenated source water are critical to growing plentiful and healthy trout. The mass flow rate of oxygen (water flow rate times dissolved oxygen concentration) into an aquaculture facility is a key factor that controls fish biomass production. Once source water supplies are "tapped out", fish production cannot expand, and if water availability decreases so must fish production. In addition, based on recent dialog with aquaculture representatives, a specific area where low dissolved oxygen (DO) conditions currently impedes aquaculture operations is during feeding in flow-through raceways. Rates of fish respiration can spike when trout are eating, resulting in a dip in DO. This drop in DO, if significant enough, can cause the trout to stop eating, which lowers their rate of growth. Oxygenation systems use oxygen gas rather than air as their oxygen source to enhance DO levels in surface waters. Oxygenation systems have a growing track record of economically improving water quality and fish habitat in a number of aquatic systems. This presentation will present results of a literature review related to the use of aeration and oxygenation to enhance fish production and the health of trout in an aquaculture and hatchery setting. The aim is to evaluate if oxygenation could play a key role in enhancing the sustainability of trout aquaculture and hatchery operations.

Session B-3: Lake Assessment

Wednesday, October 26
1:30 pm – 3:00 pm
Room 205

Chlorophyll Maxima and Chlorophyll Blooms in Missouri Reservoirs

Jack Jones, Dan Obrecht and Tony Thorpe
Univ. of Missouri, Columbia, Mo.

Abstract
An upper boundary delineating maximum algal chlorophyll (Chl_{max}) across the range of total phosphorus in Missouri reservoirs was developed using summer survey data (n = 8839) and fitted to 2 other large datasets (n = 8188 and n = 5151). The data envelope for cross-system Chl-TP represents the distribution pattern where other factors constrain responses below the maximum. Values of Chl_{max} are at least 3-times Chl criteria established to delineate trophic state. Most samples contained a fraction Chl_{max} with only about 6% of Chl_{obs} >0.70 of Chl_{max}. Maximum expression of Chl/TP varies systematically with trophic state with a sharp increase in this ratio across the least fertile reservoirs and a domed-shaped pattern among eutrophic systems. This pattern suggests nutrient control aimed at suppression Chl_{max} would be most effective in the lower half of the TP distribution with benefits potentially masked

in productive reservoirs. Bloom conditions were preliminarily identified as 70% of Chl_{max} and equate to more than double trophic state criteria for Chl. Individual reservoirs differ in their bloom history (from 0 to 43% of samples). Nutrient rich Missouri reservoirs support large Chl values more frequently than less productive ones. Within a given reservoir increasingly larger Chl values represent a progressively larger ratio of Chl_{obs} /Chl_{bloom} and, therefore, are less frequently observed.

The Aging (Eutrophication) of Reservoirs: A Comparison of Smith Mountain Lake and Claytor Lake, Virginia Water Quality?

Carolyn Thomas and Delia Heck
Ferrum College, Ferrum, Va.

Abstract
Water quality parameters have been monitored on Smith Mountain Lake, Virginia for 25 years and Claytor Lake for 17 years. Smith Mountain Lake is a 46 year old pumped storage reservoir of 20,000+ acres. Claytor Lake is a 72-years-old "run of the river" hydropower reservoir of 4,500 acres. The parameters measured include total phosphorus, chlorophyll *a*, water clarity, and other water quality measures. Most of these values indicate a mesotrophic condition and have not been indicative of an aging lake because the total phosphorus, and chlorophyll *a* have not been increasing significantly and the Secchi depth has not been decreasing, all indicators of an aging lake. Claytor Lake water quality parameter values are higher than the same parameter values for Smith Mountain Lake, however, these values are still within the mesotrophic range. Claytor Lake is older than Smith Mountain Lake so Claytor Lake should have higher values of phosphorus and chlorophyll *a* and lower values for Secchi depth. The aging of the two reservoirs may be influenced by both chronological age and type of lake circulation, which is dependent on the power generation characteristics. Another measure of lake age is the evaluation of its trophic status using the Carlson Trophic State index (TSI), which is based on the three primary water quality parameters measured on these two reservoirs. Values for the combined TSI for Claytor Lake range from 48 to 54, which is considered mesotrophic status. Smith Mountain Lake combined TSI values ranged from 30 to 70.

Blooms of Cyanobacteria Reported in Ontario, Canada from 1994 to 2010

Jennifer Winter[1], Anna DeSellas[2], Rachael Fletcher[1], Lucja Heintsch[1], Andrew Morley[3], Lynda Nakamoto[1] and Kaoru Utsumi[1]
[1]Sport Fish and Biomonitoring Unit, Ministry of the Environment, Toronto, Ont., Canada [2]Dorset Environmental Science Centre, Ministry of the Environment, Dorset, Ont., Canada [3]Eastern Region, Ministry of the Environment, Kingston, Ont., Canada

We observed a significant increase in the number of algal blooms reported each year in Ontario, Canada from 1994 to 2010 ($P < 0.001$). The greatest rate of increase was in blooms of cyanobacteria ($P < 0.001$). Several of the lakes from which these blooms were reported were characterized by higher median total P concentrations (15 μg/L) compared to a dataset from 1074 Ontario lakes (9 μg/L). However, 26 % of the lakes were classified as oligotrophic, indicating that an array of factors contributed to bloom occurrence. The most common taxa identified were *Anabaena*, *Aphanizomenon*, *Microcystis*, *Gloeotrichia* and various Oscillatoriales. We also observed that blooms are now being reported later into the fall than they were during the 1990s, with reporting extending well into November in recent years. We attributed these trends to increases in nutrient inputs in some areas which promote the growth of algae, factors associated with climate warming which may exacerbate bloom conditions, and an increase in public awareness of algal blooms and associated issues. In the absence of detailed water chemistry data, land use characteristics around a subset of lakes experiencing cyanobacterial blooms will be compared with those around lakes from which no blooms have been reported to see if there are any common characteristics. Preliminary analysis revealed that several of the lakes with blooms were surrounded by a greater proportion of human settlement, others by more pasture or more exposed sand and gravel, and others were surrounded by a large proportion of wetland.

Documentation and Assessment of a Polyaluminum Chloride Treatment of Stephen Foster Lake, Bradford County, Pennsylvania

Fred Lubnow
Princeton Hydro, LLC, Exton, Pa.

Abstract
As documented in a Phase I Diagnostic/Feasibility Study, Stephen Foster Lake, located in Bradford County, Pennsylvania, experienced severe bluegreen algal blooms and high rates of sedimentation in the 1990s primarily due to agricultural activities within the watershed. As a result of this study, a large number of watershed-based restoration measures have been designed and implemented over the last 15 years within the Stephen Foster Lake watershed. These watershed projects focused on reducing non-point source pollution, primarily phosphorus and suspended solids, through the use of agricultural Best Management Practices (BMPs) and streambank stabilization. These management efforts have resulted in a measurable reduction in the pollutant loads entering Stephen Foster Lake and an associated improvement in the lake's water quality, as demonstrated in its TMDL. As the watershed-based phosphorus loads have been reduced, the absolute and relative magnitude of the internal phosphorus load has increased. In turn, while watershed-based loads and surface water TP concentrations have declined, this did not translate to an associated decline in chlorophyll *a* concentrations. Therefore, an application of polyaluminum chloride was conducted in May 2011 to inactivate the internal phosphorus load. This presentation will review the preliminary bench tests in the development of the dosage rates and pre- and post-application water quality data over the 2011 growing season.

Session B-4: Mercury 1

Wednesday, October 26
1:30 pm – 3:00 pm
Room 206C

Comparison of Modeled and Measured Mercury Deposition in Pullman and Twin Lakes, Washington

★Lanka DeSilva[1], Marc Beutel[1] and Brian Lamb[2]
[1]Washington State Univ., Pullman, Wash. [2]Washington State Univ., Laboratory for Atmospheric Research, Pullman, Wash.

Abstract
Mercury deposition into the watershed of aquatic ecosystems is of concern within the U.S. as nearly one third of its water bodies are listed with mercury-related fish consumption

advisories. Numerous studies show freshly deposited mercury is a large contributor to the mercury accumulating within the aquatic food web. AIRPACT-3 is a numerical air quality forecast system that operates daily for the Pacific Northwest This system employs the Community Multi-scale Air Quality model and simulates mercury deposition on a gridded basis with an hourly time step. The objective of this study is to validate the model by measuring real-time dry and wet mercury deposition at two locations in Washington State: Pullman near our research laboratories at Washington State University, and Twin Lakes near Inchelium, which is the site of an ongoing study of mercury accumulation in aquatic biota. To measure dry deposition, we used a water surface sampler, which consists of a Teflon plate over which a sampling solution is circulated to trap deposited mercury. Small aliquots of sampling solution were analyzed for total mercury over time to estimate areal dry deposition rates. To measure wet deposition, we used a simple precipitation collector consisting of a borosilicate glass funnel, a glass vapor lock, and a Teflon sample bottle. Collected rain water was analyzed for total mercury and rates of wet deposition were estimated. This presentation will examine correlations between model predictions of mercury deposition and mercury levels in sediments for lakes throughout Washington.

Influence of Macrobenthos on the Cycling of Mercury at the Sediment-water Interface of Lakes

★**Suzanne Cox, Marc Beutel and Stephen Dent**
Washington State Univ., Pullman, Wash.

Abstract
The release of dissolved compounds from lake sediment can notably affect water quality. Macrobenthos that live in sediment can greatly affect the exchange of these compounds at the sediment-water interface due to bioturbation and bioirrigation. A number of studies have documented the significant effects of macrobenthos on nutrient cycling at the sediment-water interface, but few studies have examined their effects on mercury cycling, which is partly controlled by the extent of oxygen penetration into sediments. This presentation will discuss the effects of macrobenthos on the cycling of mercury at the water-sediment interface of lakes. A series of sediment chamber studies were conducted on sediment collected from Deer Lake, Washington (Z_{max} = 22.9m, A = 445 ha), an oligo-mesotrophic lake near Spokane, Washington. Three sets of triplicate chambers were incubated under low, medium, and high densities of *Tubifex* worms native to the lake sediments. Chamber water and surficial sediment were then monitored for total mercury and methylmercury, the toxic form of mercury produced by sulfate-reducing bacteria. Two competing outcomes are possible. Bioirrigation by the worms may promote oxygen penetration into sediments, thereby inhibiting methylmercury production by anaerobic microbes. Alternatively, bioirrigation may enhance the efflux of methylmercury out of the sediments and into the overlaying water. A better understanding of the effects of macrobenthos on mercury cycling at the sediment-water interface of lakes will inform the development of lake management practices to control mercury uptake into aquatic habitats and mercury's severe health effects on wildlife and humans.

Mercury Biomagnification in Twin Lakes in 2011 Under Oxygenated and Non-oxygenated Conditions

★**Piper Marshall[1], Marc Beutel[1], Stephen Dent[1], Barry Moore[2], Ben Cross[2] and Ed Shallenberger[3]**
[1]Washington State Univ., Dept. of Civil & Environmental Engineering, Pullman, Wash. [2]Washington State Univ., Dept. of Natural Resource Sciences, Pullman, Wash. [3]Confederated Tribes of the Colville Indian Reservation, Nespelem, Wash.

Abstract
Mercury (Hg) contamination in fish is a growing issue in this century as anthropogenic sources for atmospheric Hg pollution persist through this industrial age. The increased deposition of Hg in freshwater ecosystems led to 43% of the nation's lake acres being placed on a fish consumption advisory by the USEPA in 2008. This widespread health concern has spurred investigations into strategies to abate the bioaccumulation of methyl mercury (MeHg) in fish that may be consumed by wildlife and humans. Highly productive, eutrophic lakes develop hypoxic zones in the hypolimnion that often accumulate high levels of MeHg. Lake oxygenation systems have been shown to vastly improve overall water quality, ameliorate hypoxia, and enhance fish habitat, as well as potentially decrease the concentration of MeHg present throughout the water column. We aim to determine if this strategy would also effectively reduce the bioaccumulation of MeHg in the tissue of fish inhabiting such an environment. The study site is located at Twin Lakes, Washington, where, in May of 2009, a diffusion line hypolimnetic oxygenation system began operation in North Twin. In the summer of 2011, with the cooperation of the Colville Fish and Wildlife Department, trout from both North and South Twin will be sampled for Hg concentration. The results from this analysis will allow for the direct comparison of MeHg content in fish populating oxygenated versus non-oxygenated environments. This will demonstrate if hypolimnetic oxygenation can decrease Hg levels in fish tissue, and thus reduce the health risks associated with fish consumption.

Important Considerations for Managing Mercury Accumulation in Aquatic Food Webs when Implementing a Hypolimnetic Oxygenation Treatment

Stephen Dent, Marc Beutel, Brandon Reed, Barry Moore and Ed Shallenberger
Washington State Univ., Pullman, Wash.

Abstract
The accumulation of mercury in freshwater aquatic food webs is a growing health concern as over one-third of lakes in the US have fish consumption advisories in place due to elevated concentrations of mercury in fish tissue. Methylmercury, the biologically available form of mercury, can accumulate in the anoxic hypolimnetic regions of stratified productive lakes. North and South Twin Lakes, WA, are moderately deep (Z_{mean} ~10 m; Z_{max} ~ 15 m), meso-eutrophic, dimictic lakes that exhibit seasonal hypolimnetic anoxia during summer thermal stratification. Beginning in 2009, a hypolimnetic oxygenation system was operated in North Twin Lake to improve coldwater fishery habitat. The objective of this study was to evaluate spatial and temporal patterns of mercury in the water column and zooplankton in response to hypolimnetic oxygenation. Methylmercury accumulation in the bottom waters correlated negatively with dissolved oxygen concentrations. At North Twin Lake in 2009, high dissolved oxygen repressed methylmercury accumulation in bottom

waters (> 0.05 ng/L). But in 2010, lower dissolved oxygen in North Twin Lake correlated with an increase in methylmercury in the hypolimnion (up to 0.3 ng/L) and zooplankton. Surprisingly, mercury accumulation in zooplankton was lower in non-oxygenated South Twin for both years, even though methylmercury accumulated in bottom waters (up to 0.6 ng/L). This presentation will explore both the chemical and biological mechanisms that may contribute to the potential for enhanced mercury uptake in aquatic organisms when implementing hypolimnetic oxygenation.

Session C-1: Stewardship 3

Wednesday, October 26
3:30 pm – 5:00 pm
Room 206A

Community-Based Participatory Research (CBPR): A Tool for Developing Partnerships for the Management of Lake Diefenbaker, Saskatchewan

Lalita Bharadwaj[1], Jeff Sereda[2] and Howard Wheater[2]
[1]School of Public Health, Univ. of Saskatchewan, Saskatoon, Sask., Canada [2]Global Institute for Water Security, Univ. of Saskatchewan, Saskatoon, Sask., Canada

Abstract
Community Partnerships for the Management of Lake Diefenbaker (CPMLD) is a 7-year Community-Based Participatory Research (CBPR) program that emphasizes partnership building between the Lake Diefenbaker community ("stakeholders") and research scientists for the development of sustainable community-based environmental protection and management strategies for the Lake. CBPR is community situated, collaborative, and action oriented, and will be utilized as a tool to assess the health of Lake Diefenbaker and the links between its health and the economic, social, and health conditions of the community. Information will be gathered through the use of community workshops, surveys, questionnaires, focus groups, and key informant interviews. Local historical information and the communities' health, economic, and social values of the lake will be explored. Community members will attend a research orientation day and be provided training in data acquisition. Community research coordinators will be hired to facilitate community engagement with scientists and a community advisory group will be established. The CBPR program creates opportunities for the community to: partner, actively participate, and contribute to the overall assessment of the Lake; develop trusting and ethical relationships with scientists, governmental representatives, and amongst each other; learn of environmental and water issues from the perspectives of scientists, governmental and community representatives; and share their knowledge and create new understanding to form strategies and mobilize environmental protection and management plans with outside facilitation. Water resource management requires development of solutions for unique local situations, a task that is often best accomplished by engaging stakeholders and the public through a CBPR research process.

Stakeholder Accessibility to a Lake Champlain Management Plan

Eric Howe, Nicole Grohoski, Margaret Modley and William Howland
Lake Champlain Basin Program, Grand Isle, Vt.

Abstract
The Lake Champlain Basin Program has worked to involve the public and to respond to current management, research, and monitoring needs in developing and implementing Opportunities for Action: An Evolving Plan for the Future of the Lake Champlain Basin (OFA), since 1991. In the recent 2010 revision, partners have committed to specific management tasks based on funding available in 2010 and anticipated in subsequent years. OFA establishes a plan for coordinated action by ten federal, state, and provincial jurisdictions within the basin, as well as public stakeholders, to restore and protect water quality and the diverse natural and cultural resources of the Lake Champlain Basin. Successful implementation of the plan will be achieved by developing many joint partnerships among natural resource agencies, citizens, and other lake and watershed stakeholders, to achieve the actions described therein. Stakeholders and management partners can view progress on each of these tasks via a web-accessible database that will be updated on a regular basis by each of the ten partners. A new online format for OFA will encourage accountability in the accomplishment of these tasks, improve allocation of annual funding toward project prioritization, and allow for the integration of an adaptive management process, a structured method for updating the plan as new information becomes available. This approach will allow OFA to remain current in a continually evolving process to protect and restore the Lake Champlain ecosystem (http://plan.lcbp.org).

Citizen Monitoring of Freshwater Cyanobacteria Phytoplankton in Petenwell and Castle Rock Lakes

Reesa Evans
Adams County Land & Water Conservation Dept., Friendship, Wis.

Abstract
The Wisconsin River Watershed drains 21% of Wisconsin. Castle Rock and Petenwell Lakes, the 5th and 2nd largest lakes in Wisconsin, are the largest impoundments on the Wisconsin River. In 2010, citizen volunteers from Petenwell and Castle Rock Lakes, along with the Adams County Land and Water Conservation Department, entered into a pilot project with the National Oceanic and Atmospheric Administration and the Center for Communicable Disease. Volunteers took samples approximately every two weeks at several sites on each lake. Data were entered into the federal phytoplankton network database. These two lakes have long been plagued with frequent heavy algal blooms and reports of negative effects on both humans and animals from activities in these lakes. Results of the first year (2010) of this program showed that *Microcystis* was the most common potentially-toxic cyanobacteria in these lakes, found in nearly 47% of the samples. *Oscillatoria* was second most-common, present in nearly 33% of the samples. *Aphanizamenon* was found in 25% of the samples, while *Anabena* was found in only a little over 12% of the samples. The least common potentially-toxic cyanobacteria found was *Cylindrospermopsis*, which is not native to Wisconsin. This was found in just over 6% of the 2010 samples. The project will continue into 2011 and 2012. The presentation will include data from 2010 and 2011 seasons.

Volunteer Lake Monitoring in New York: 26 Years of Collaborative Effort

Nancy Mueller[1], Scott Kishbaugh[2], Mary Gail Perkins[3] and Gregory L. Boyer[4]
[1]New York State Federation of Lake Associations, Inc., LaFayette, N.Y. [2]New York State Dept. of Environmental Conservation-Division of Water, Albany, N.Y. [3]Upstate Freshwater Institute, Syracuse, N.Y. [4]SUNY College of Environmental Science & Forestry, Syracuse, N.Y.

Abstract
The Citizens Statewide Lake Assessment Program (CSLAP) was initiated by the New York State Department of Environmental Conservation (DEC) in 1985 and modeled after successful volunteer programs in other states. Each participating lake association is a member of the New York State Federation of Lake Associations, Inc., a not-for-profit organization that partners with DEC to run the program. Sampling parameters are typical of volunteer monitoring programs and include surface samples for water temperature, transparency, conductivity, pH, true color, total phosphorus, nitrogen, chlorophyll *a*, calcium, and observational data. Hypolimnion samples are collected on selected, stratified lakes for total phosphorus, nitrogen, iron, manganese, and arsenic. Sample analysis is conducted by Upstate Freshwater Institute (UFI) in Syracuse, NY. UFI staff also assists with bottle and sample kit preparation. In recent years, CSLAP volunteers were utilized to collect harmful algal bloom (HAB) samples, from selected public water supply lakes, and other lakes with known bloom issues, for the New York State Department of Health through a grant from the Centers for Disease Control and Prevention. In 2011, this sampling was expanded to include nearly all CSLAP lakes, in partnership with the SUNY College of Environmental Science and Forestry, to evaluate HAB screening tools and early warning systems for recreational lakes. CSLAP volunteers were also encouraged to collect other information including, but not limited to: shoreline health assessments, aquatic plant surveys, zebra mussel "brick drop" data, angler surveys, boat counts, ice-on and ice-off data, and precipitation data. This allowed the program offerings to expand even during difficult fiscal times.

Session C-2: Alum

Wednesday, October 26
3:30 pm – 5:00 pm
Room 206B

The Case for Alum

Dick Osgood
Osgood Consulting, Shorewood, Minn.

Abstract
Aluminum sulfate or alum has been used in lake treatments since the 1970s. More recently, alum has been used in ponds as well. Alum is a viable, indeed often the only feasible lake management approach for attaining lake and pond phosphorus reduction goals. Here, I will make the case that 1) lakes impaired by excess phosphorus do not respond to watershed phosphorus reductions and best management practices (BMPs) alone are not effective, 2) alum may be applied using several strategies and are almost always effective, 3) alum is effective in ponds, and 4) cost comparisons for BMPs versus alum show alum to be 100+ times less expensive (per pound of phosphorus removed). Common myths about alum will be discussed.

Science - Policy Conflict on Grand Lake St. Marys, Ohio

Harry Gibbons and Gene Welch
Tetra Tech, Inc., Seattle, Wash.

Abstract
The rush to alleviate adverse effects of hypereutrophy in shallow GLSM has greatly reduced the potential effectiveness of alum to reduce the in-lake sources of phosphorus in Grand Lake St. Marys. A properly administered dose of alum preceding algal blooms could reduce lake TP and chl (100-200 μg/L) by at least half for possibly three years before external inputs restored high concentrations. External loads from agricultural practices are being reduced, but benefits will be slow in coming. Thus, lake users have pressed for action now in the face of lost revenue from recreation and increasing cost for potable water treatment. A much reduced (affordable) dose, while algal blooms are under way, risks: 1) failure of adequate floc formation, 2) interception of alum by algae, preventing sediment P inactivation, and 3) accumulation of algal mass near the bottom resulting in low DO and probable fish kills. Nearshore experiments in 2010 demonstrated ineffectiveness of a reduced alum dose in the presence of high blue-green biomass and low DO induced a fish kill. A sufficient dose of alum in 2011 experiments resulted in much greater initial effectiveness. Lake and watershed characteristics will be discussed along with the feasibility for the future and on-going management.

Can Sediment Inactivation Be Successful in Shallow Lakes? – A New Look at an Old Paradigm

Harvey Harper
Environmental Research & Design, Orlando, Fla.

Abstract
Current wisdom in the field of sediment inactivation suggests that sediment P inactivation is ineffective in shallow lakes due to the possibility of re-suspension of the alum floc and upper sediment layers by wind and boating activities. Sediment inactivation using metal salts was introduced in Florida during 1981, and since that time, more than 30 sediment inactivation projects have been conducted in "shallow" Florida lakes. Surface areas for treated lakes have ranged from 8-920 acres with mean depths ranging from 4-20 feet. Application rates have ranged from 9.2-215 g Al/m^2 with water column doses from 3-54 mg Al/l. Molar Al:P (available sediment P) ratios have ranged from 2 in early projects to 10 in recent projects. Immediate improvements in water quality have been observed in each of the treated waterbodies with more than half exhibiting improvements for 10 years or more. As examples, substantial reductions in TP concentrations have been consistently observed in Lake Conine ($d_{avg.}$ = 10 ft.) for more than 15 years following sediment inactivation. Lake Mizell ($d_{avg.}$ = 10 ft.) has exhibited steadily increasing water clarity and decreasing algal concentrations for 13 years and has converted from eutrophic to oligotrophic status. The success in Florida suggests that properly designed sediment inactivation can be effective in shallow lakes. A theory is proposed that sediment inactivation may also be effective in extremely shallow lakes ($d_{avg.}$ = 3-5 ft) due to sediment partitioning of the stable and mixed sediment layers.

Effects of Nutrient Inactivation (Alum) on Water Quality and Algal Toxins in a Hypereutrophic Sandpit Lake

John Holz[1], Tadd Barrow[1] and Paul Brakhage[2]
[1]HAB Aquatic Solutions, Lincoln, Nebr. [2]Nebraska Dept. of Environmental Quality, Lincoln, Nebr.

Abstract
Fremont State Lake #20 is public sandpit formed by gravel mining operations and is located along the Platte River near Fremont, NE. The 20-ha lake (mean depth = 3.4 m) is hypereutrophic (mean summer TP = 127 ppb; mean summer Secchi Disk depth = 0.4 m mean summer chl *a* = 95 ppb) and has a history of toxic blooms of *Planktothrix* sp. that closed the lake to primary contact recreation for 25 weeks from 2004 to 2006. In 2006, the lake was placed on Nebraska's Section 303(d) List of Impaired Waters due to elevated concentrations of nutrients. The lake is groundwater fed, has an extremely limited watershed, and internal loading accounts for the majority of phosphorus inputs. The lake was dosed with liquid aluminum sulfate and sodium aluminate in October 2007 to reduce internal phosphorus loading. Post-treatment sampling (October 2007 through September 2009) showed that mean water column TP was reduced by 83%, mean Secchi disk depth increased by 2.1 m (6.3 times), mean chlorophyll *a* decreased by 89%, and algal toxins were eliminated from the lake. Fremont State Lake #20 has remained open to primary contact recreation since the nutrient inactivation treatment.

Session C-3: Algae / Zooplankton Growth

Wednesday, October 26
3:30 pm – 5:00 pm
Room 205

Oxygen Consumption Rates for Aphanizomenon flos-aquae *are a Function of Temperature, Previous Light Exposure, and Dissolved Oxygen Concentrations*

John Rueter and Arick Rouhe
Portland State Univ., Portland, Oreg.

Abstract
Excess algal growth blooms are often followed by high oxygen consumption and anoxic conditions. The temporary dissolved oxygen deficit can leave the lake stinky and kill fish. It is generally assumed that the oxygen consumption is caused by the gross community respiration. We made three different observations of high oxygen consumption rates by *Aphanizomenom flos-aquae* (AFA) in Upper Klamath Lake. First, photosynthesis and oxygen consumption by filament clusters measured in an electrode chamber indicate that oxygen consumption increases up to nine times faster with temperature than photosynthesis. Second, depending on the light conditions, there can be post-illumination bursts of oxygen consumption. Third, photosynthesis is inhibited at high DO and there are preliminary indications that photosynthesis is inhibited at low DO. These observations indicate that physiological mechanisms of oxygen production and consumption may be the dominant drivers of DO in Upper Klamath Lake and Agency Lake (Oregon) that is approximately 95% AFA. We are currently addressing the question of how much the oxygen dynamics are driven by live AFA rather than resulting from algal death.

Evaluation of Methods for Estimating Benthic Primary Production in Waldo Lake, Oregon

Rich Miller and Mark Sytsma
Portland State Univ., Portland, Oreg.

Abstract
Waldo Lake, Oregon is an extremely clear lake with Secchi transparency depths often in excess of 40 m and a photic zone as deep as 130 m. Primary production in such clear lakes is often dominated by benthic cyanobacteria and algae rather than phytoplankton; however, long term monitoring in Waldo Lake has focused on pelagic production due to the difficulty in measuring benthic production. We evaluated several methods for measuring benthic production and respiration in the shallow waters of Waldo Lake. Production measurements were conducted in paired transparent and dark incubation chambers containing benthic core samples. The first method estimated gross primary production from the decrease in dissolved inorganic carbon (DIC) in transparent chambers and respiration from the increase in DIC in dark chambers. The second method estimated production and respiration from changes in dissolved carbon dioxide concentrations in water pumped in a continuous loop through the dark and light incubation chambers. Chlorophyll concentrations and benthic algal and cyanobacterial species composition were measured on each of the benthic core samples after incubations. Whole lake benthic productivity was estimated using the benthic core measurements and a bathymetric map of the lake and was compared with pelagic production estimates.

The Nexus of Assumptions and Conclusions in Stable Isotope Allochthony Calculations: Reanalysis Suggests Little Zooplankton Terrigenous Support

Mike Brett
Univ. of Washington, Seattle, Wash.

Abstract
The results of classic stable isotope analyses of allochthonous contributions to invertebrate and fish production in aquatic food webs can be strongly influenced by seemingly minor assumptions. We re-examined the results of the classic UNDERC and Abisko/Umeå lake case studies to determine how these analyses are influenced by specific assumptions. We also used basic mass balance analyses to test whether the conclusions of these studies can be reconciled with the relative fluxes of allochthonous and autochthonous basal resources to these lakes. Because the zooplankton allochthony response functions for the sensitivity analyses for the assumed dietary water contributions to zooplankton deuterium, and phytoplankton photosynthetic carbon and hydrogen fractionation were extremely steep and non-linear, conclusions cannot be separated from the assumptions built into these calculations. The recalculated outcomes of the Abisko/Umeå case study suggest zero zooplankton allochthony when realistic phytoplankton carbon fractionation values are used. For the UNDERC lake case study, a plausible range of parameter values for zooplankton dietary water and phytoplankton hydrogen fractionation resulted in calculated outcomes which overlapped approximately 50% with zero allochthony. The mass flux of basal resources to the UNDERC lakes was greatly dominated (*i.e.*, 80-90% of total flux) by algal production. The relatively low mass flux of terrestrial carbon and its very low food quality suggests allochthonous inputs support less than 5% of zooplankton production in the UNDERC lakes. We suggest the supposed emerging consensus in the limnological literature

regarding terrestrial support of zooplankton production in lakes is the product of many studies making similar unsupported assumptions.

Remediation of Eutrophic Lakes: Is Iron Treatment Safe for Aquatic Invertebrates?

★Lindsey Wilson, Diane Orihel, Heather Proctor and David Schindler
Univ. of Alberta, Edmonton, Alta., Canada

Abstract
In some regions, internal phosphorus loading can be responsible for over 80% of annual inputs of phosphorus to eutrophic water bodies. To improve water quality of these lakes, reductions in external phosphorus inputs must be accompanied by a strategy to reduce internal loading. Iron treatment is a potential remediation technique because iron can precipitate phosphorous from the water column and inhibit phosphorous release from the sediments. However, the use of iron to remediate eutrophic waterbodies has a short history worldwide, and the effects of iron addition on aquatic biota are poorly understood. To investigate the response of aquatic invertebrate assemblages (zooplankton, zoobenthos and emerging insects) to iron addition, an *in situ* mesocosm study was conducted in a eutrophic lake in Alberta, Canada. Different rates of iron (ferric chloride), ranging from 2.5 g/m^2 to 225 g/m^2, were applied to the mesocosms. Our analyses thus far suggest that immediate effects of iron amendment on invertebrates are minimal. Significant delayed effects on richness, evenness and diversity of some zooplankton communities became apparent one to two months following iron application, possibly owing to profound changes in their food source (phytoplankton). The abundance, richness, evenness and diversity of zoobenthos were not affected by iron application. The total number of emergent insects increased with the highest rates of iron application. Given the minimal adverse effects of iron amendment on aquatic invertebrates, the use of ferric chloride may be a suitable remediation technique for eutrophic lakes.

Session C-4: Mercury 2

Wednesday, October 26
3:30 pm – 5:00 pm
Room 206C

Effects of Reservoir Hydrodynamics on Mercury Speciation and Transport

Richard Wildman[1], Prentiss Balcom[2], Sami Ziara[3] and James Shine[1]
[1]Harvard School of Public Health, Boston, Mass. [2]Univ. of Connecticut, Groton, Conn. [3]Grand River Dam Authority, Langley, Okla.

Abstract
This project examines the extent to which the physical circulation of a large reservoir can affect the reactivity, speciation, and transport of mercury. We are studying Grand Lake, a reservoir (~80 km long; usually ~38 m deep at the dam) in northeast Oklahoma, USA. Circulation of large reservoirs is more complicated than that of natural lakes, which are primarily influenced by seasonal changes in surface water temperature. For example, advective flow, which can include seasonal overflow or underflow density currents, is non-negligible, and residence times are usually low. Additionally, water is often released out dams from below the thermocline, which can imply that overflow currents are forced downwards near the dam or that underflow currents never return to the surface as they would in a natural lake. Finally, water residence time varies spatially and temporally due to varying depth and dam operations. These circulation patterns can be important primary drivers of dissolved oxygen concentrations in reservoirs. Methylation of mercury, which increases accumulation of this toxic element in fish and health risks to humans and wildlife, is understood to occur when anoxic conditions stimulate the growth and metabolism of anaerobic bacteria. Thus, we are testing a hypothesis that physical circulation can also affect mercury chemistry in Grand Lake. We will present field data collected seasonally during 2010 and 2011 that assess circulation (T, SC), water chemistry (DO, Fe(aq), Mn(aq), pH), and mercury speciation (dissolved and particulate total mercury, dissolved and particulate methylmercury, and dissolved gaseous mercury).

The Effect of Nitrate on Methylmercury Efflux from Profundal Sediment of Freshwater Lakes

★Ricardi Duvil, Marc Beutel and Seyoum Gebremariam
Washington State Univ., Pullman, Wash.

Abstract
Mercury is ubiquitous in the environment at low levels due to deposition of inorganic mercury discharged mainly from fossil fuel power plants. Once in freshwater lakes, mercury enters a complex cycle in which inorganic mercury can be converted to organic methylmercury. Methylmercury, a known neurotoxin that bioaccumulates in aquatic food webs, is produced under anoxic conditions by sulfate-reducing bacteria in the presence of labile organic matter and sulfate. However, limited experimental and field-based studies have been undertaken to evaluate remedial actions to mitigate mercury contamination in aquatic ecosystems. This presentation will present results of an ongoing chamber study to examine the effects of nitrate addition on methylmercury efflux from profundal lake sediments. Triplicate chambers containing sediment-water interface samples from oligo-mesotrophic Deer Lake, Washington and meso-eutrophic South Twin Lake, Washington will undergo three treatments: oxic (bubbled with air), anaerobic (bubbled with nitrogen gas), and anoxic (bubbled with nitrogen and enriched with nitrate). It is expected that nitrate and oxygen will repress methylmercury efflux by inhibiting the activity of sulfate-reducing bacteria in surficial sediments. But nitrate could have the advantage over oxygen of precluding colonization of contaminated sediments by macrobenthos, which may act as a new conduit of mercury into the aquatic food web. This study is part my doctoral research, funded through a National Science Foundation at Washington State University, and is focused on nitrogen cycling and policy. Results of this work will inform policy and regulatory action aimed at effectively mitigating mercury contamination in aquatic systems.

Controlling Sediment Release of Methylmercury via Nitrate Addition

John Nolan[1], Steve Effler[2], Charles Driscoll[3], Betsy Henry[4] and Martin Auer[5]
[1]Parsons Corp., Somerset, N.J. [2]Upstate Freshwater Institute, Syracuse, N.Y. [3]Syracuse Univ., Syracuse, N.Y. [4]Exponent, New York, N.Y. [5]Michigan Tech Univ., Houghton, Mich.

Abstract
Methylmercury, a potentially toxic and bioaccumulative mercury species, is produced under anoxic conditions largely by sulfate-reducing bacteria. Redox parameters (including oxygen, nitrate, and sulfide), total mercury, and methylmercury

have been monitored in the water column of Onondaga Lake (Syracuse, New York) since 2006 to evaluate the roles of oxygen and nitrate in controlling net methylmercury production in the lake. Net production of methylmercury has been attributed to lake sediment, and the releases have decreased significantly since 2006 due to municipal wastewater treatment upgrades, which have doubled nitrate levels throughout the lake. The primary objective for deploying nitrate is to limit the release of methylmercury from Onondaga Lake sediment to the overlying lake waters as part of a Superfund remedy. Adding nitrate supports redox conditions which prevent the flux of MeHg from the sediment. Dye tracer tests were conducted in 2008 to quantify horizontal dispersion in the hypolimnion and a successful nitrate application field trial was conducted in 2009. A three-year pilot test will commence in the summer of 2011. Injection of a liquid calcium nitrate solution (diluted with epilimnetic water to match the appropriate density in the hypolimnion) will be carried out three times per week from a movable barge. Injection events will start in late June and continue until turnover. The presentation will review the evolution of the remedial plans for inhibiting the release of methylmercury, lab and field testing, design of the injection scheme, and preliminary results from the pilot test.

Suppression of Mercury Methylation by Hypolimnetic Liquid Calcium Nitrate Amendment in Round Lake, Eden Prairie, Minnesota

David Austin, Roger Scharf, Jason Carol and Mark Enochs
CH2M HILL, Mendota Heights, Minn.

Abstract
In 2010, a pilot project applied liquid calcium nitrate (LCN) to suppress methylmercury (MeHg) formation in Round Lake, Minnesota. Project goals were to determine the design basis for LCN application, treatment efficacy, practical means of application, dosage criteria, and fate of applied nitrate. When LCN was pumped to the lake bottom, the hypolimnion was in sulfate reduction (redox $<$ +100 mV, SHE scale, 5 minute probe equilibration). Within 24 hours, redox was over +100 mV (max +500 mv) and remained there for 8 weeks after application. While hypolimnetic NO_3^- ion concentrations were greater than 0.5 mg/L, MeHg formation was suppressed (6 weeks from LCN application). The initial MeHg concentration was 0.4 ng/L and dropped to 0.3 ng/L, but rebounded to 1.0 ng/L two weeks after the NO_3^- ion dropped below 0.5 mg/L. Of the possible competing NO_3^- ion demand reactions of heterotrophic denitrification, anaerobic sulfide oxidation, and anaerobic iron oxidation, the latter was clearly dominant. Dissolved hypolimnetic iron was consumed and pH rose. Competing reactions consume acid. A nearby control lake of similar depth and morphometry exhibited linear increases in hypolimnetic MeHg and dissolved Fe concentrations during the same period. In conclusion, the pilot project results strongly suggest that LCN is an effective means to suppress mercury methylation. Application by pumping LCN to the lake bottom is an effective method. Design should consider anaerobic iron oxidation as a principal sink for NO_3^- ions. Sediment oxygen demand is a useful guide for determining LCN application rates.

Poster Session

Wednesday, October 26
6:30 pm – 8:30 pm
Ballroom BC

Perceptions By the General Public of Cyanobacterial Blooms and Remediation Strategies in Lakes: What Can Scientists Learn?

★Cindy Adams and Frank Wilhelm
Univ. of Idaho, Moscow, Id.

Abstract
Blooms of cyanobacteria have long been recognized as negative attributes of water bodies because they form unsightly surface scums, produce taste and odor problems in drinking water supplies, and produce a suite of potent hepato- and neurotoxins. Given the cost of toxicity testing of cyanobacteria, many health agencies post advisories restricting human contact and consumption of fish when blooms form. Although scientists have gained insights to the toxins and their potential negative health consequences to livestock, pets and humans, it is less clear how postings/closures and in-lake mitigation measures are perceived and received by the general public. Willow Creek Reservoir in northeastern Oregon is a popular recreation site because it is the only 'lake' in a large geographic area. However, it suffers annual blooms of toxic cyanobacteria and is often closed during the summer. To control cyanobacteria blooms in the reservoir, remediation via solar powered circulators started in 2008. During 2009, we interviewed recreationalists at the reservoir to i) understand the public's perspective of cyanobacteria blooms and ii) examine the potential impact the cyanobacteria control method used may have on recreational activities. Results showed an aversion to surface scums by swimmers but not fishers. The circulators had no negative impact on the swimmers, fishers, or boaters. The majority of recreationists preferred circulators over algae, but questioned the effectiveness of the machines. These findings are placed in context by comparing them to findings of a literature review of water recreation specifically focused on cyanobacteria and control methods.

The Role of Sediments and Aquatic Plants in the Nutrient Budget of Spirit Lake, Washington

★Laura Alskog, Jim Gawel and Terri Hurlbut
Univ. of Washington Tacoma, Tacoma, Wash.

Abstract
The 1980 eruption of Mount Saint Helens caused the bathymetry of Spirit Lake to change drastically resulting in an increase in surface area and a decrease in average depth. Subsequently, Spirit Lake is experiencing an increase in productivity. This study measures concentrations of nitrogen, carbon and phosphorus in sediments and aquatic plants in order to understand the source of the lake's increasing productivity. Over the summer of 2010, we collected surface sediment samples and a short sediment core. The results of these analyses, together with aquatic plant data obtained by Bellarmine High School students and Portland State University, will be used to estimate the role of sediments and aquatic plants in nutrient cycling in Spirit Lake.

Nutrient Loading to Wapato Lake from Park Sheet Flow

★Steve Ayers and Jim Gawel
Univ. of Washington Tacoma, Tacoma, Wash.

Abstract
Nutrients are required for lake productivity, however an excess of nutrients can lead to eutrophication and loss of recreational access for the public. Wapato Lake in Tacoma, Washington has been severely impaired by an overload of nutrients from stormwater and other sources resulting in eutrophication and lake closures. This study examines nutrient fluxes from sheet flow from the surrounding Wapato Park, where pet waste, waterfowl, and fertilizer use may be significant sources. Samples of sheet flow were collected from locations around the lake during storms in 2010-2011 and total phosphorus and total nitrogen were measured. These data will be used to construct a comprehensive nutrient model for the future management of Wapato Lake.

Secchi Disc Transparencies in Waters of the United States

★Dana Bigham, Roger Bachmann, Robert Carlson, Christine Horsburgh, Mark Hoyer and Daniel Canfield Jr.
Univ. of Florida, Gainesville, Fla.

Abstract
Limnologists, fisheries biologists, and other aquatic sciences have long used the Secchi disc to measure water transparency and to assess the trophic status of surface waters, system productivity, and fisheries potential. Despite the thousands of water clarity measurements collected over the years, there are few comprehensive assessments of transparency across the United States. The goal of this study was to assemble Secchi disc measurements from each of the 50 states. There were 972,372 individual Secchi readings gathered from 14,815 water bodies across the United States. The mean of the individual Secchi readings was 2.5 m and ranged from less than 0.1 m to 41.2 m. The mean Secchi readings were less than 1.1 m for 25% of the water bodies and less than 3.4 m for 75% of the waters; only 10% of the water bodies had mean Secchi readings exceeding 4.9 m. Based on median Secchi estimates, the five states with the greatest water clarity were Alaska, Maine, Montana, Vermont, and New Hampshire. The five states with the lowest median water clarity measurements were Texas, South Dakota, Oklahoma, Nebraska, and Mississippi/Louisiana. These results offer one of the best comprehensive assessments of water body transparency in the United States. To continue this effort, there should be not only a national effort to assemble other available Secchi data, but also an international effort to include other North American countries.

Assessing the Role of Zooplankton Grazing on the Development and Decline of Cyanobacteria Blooms in Vancouver Lake, Washington, USA

Gretchen Rollwagen-Bollens, Stephen Bollens, Jennifer Boyer, Julie Zimmerman, Alejandro Gonzalez and Josh Emerson
Washington State Univ., Vancouver, Wash.

Abstract
Harmful cyanobacteria blooms in freshwater are an increasing problem. Since 2007 we have been investigating the factors that influence seasonal cyanobacteria blooms in Vancouver Lake – a large, tidally-influenced shallow lake in the lower Columbia River floodplain. We are interested in how zooplankton grazing may modulate and/or control the magnitude and timing of these blooms. Over two complete bloom cycles (May – October) in 2008 and 2009, we conducted bi-weekly dilution experiments and grazer incubation experiments to make concurrent measurements of cyanobacteria/algal growth rates, microzooplankton (ciliates, dinoflagellates) community grazing rates, and mesozooplankton (copepod and cladoceran) ingestion rates. From April to June of both years, algal growth rates were maximal and microzooplankton grazing rates were relatively low. By contrast, from mid-June to mid-July (immediately preceding large cyanobacteria blooms in both years), algal growth rates were strongly negative. Algal growth rates rapidly increased back to maximal rates at the beginning of the cyanobacteria bloom, and remained high during the bloom from late July to September. However, by the end of the bloom grazing rates were approximately equal to algal growth rates, suggesting grazers contributed to the rapid decline in cyanobacteria abundance by October of 2008 and 2009. These experimental results demonstrate that zooplankton grazing may play an important role in the development and decline of a cyanobacteria bloom, and that the approach of conducting concurrent dilution and incubation experiments may also provide insights into grazer trophic interactions.

*Growth and Developmental Performance of the Milfoil Weevil (*Euhrychiopsis lecontei*) on Various Ecotypes and Hybrids of Eurasian Watermilfoil (*Myriophyllum spicatum*) Present in Ontario, Canada*

★Kyle Borrowman[1], Eric Sager[2] and Ryan Thum[3]
[1]Trent Univ., Peterborough, Ont., Canada [2]Fleming College, Lindsay, Ont., Canada [3]Grand Valley State Univ., Muskegon, Mich.

Abstract
Growing interest in the use of the milfoil weevil (*Euhrychiopsis lecontei*) as a of biological control of Eurasian watermilfoil (*Myriophyllum spicatum*) within Ontario, Canada has led to several pilot projects across lakes in central and northeastern regions of the province including stocking of an *M. spicatum* x *M. sibiricum* hybrid population in Lake Scugog, ON. Recently, two genetically different ecotypes of *M. spicatum* and hybrid *M. spicatum* x *M. sibiricum* populations have been identified throughout Central and Northeastern Ontario. Efficacy of biological control projects may differ due to genetic variation of the intended target and is an important consideration for management practitioners. Previous research into growth and development of *E. lecontei* on *M. spicatum*, *M. sibiricum* and hybrid *M. spicatum* expressed higher survival throughout all life stages on *M. spicatum* in comparison to *M. sibiricum* with an intermediate performance on *M. spicatum* x *M. sibiricum* hybrids. Expanding on previous research, our objective is to determine the growth and developmental performance of *E. lecontei* source populations used for biological control of *M. spicatum* ecotypes and hybrids present in Ontario. This experiment will be conducted in a climate controlled growth chamber over the summer of 2011 to compare the growth and developmental performance of *E. lecontei* on each of these ecotypes and hybrids. In addition to survival and development rates, concentrations of C, N, P, and total phenolics will also be compared across ecotypes and hybrids to determine if any biochemical differences occur across milfoil type.

Pleistocene Groundwater Emplacement into Basalt Aquifers from Glacial Lake Columbia in Northeast Washington State

Lindsay Chutas and Rick Noll
Spokane Conservation District, Spokane, Wash.

Abstract
Flooding from the ice-dammed glacial Lake Missoula has been well documented and catastrophically altered the landscape of Eastern Washington in the Late Pleistocene. Another lesser known glacial lake, glacial Lake Columbia, may have provided a mechanism for recharge of the Columbia River Basalt Aquifers (CRBA). Glacial Lake Columbia surface elevations provided sufficient hydraulic head to have recharged the deep CRBA now being tapped for domestic water use. This increased hydraulic head may have provided some fracturing of the basalt flow tops, temporarily increasing the local hydraulic conductivities allowing increased recharge and over pressurizing the aquifers. This over-pressuring is observed today in some of the local aquifers that are artesian. Varved beds with interbedded cobble deposits, similar to those found in backflood deposits in southern Washington, are present in the Hangman Creek Watershed, indicating inundation by glacial Lake Columbia. Deep groundwater wells were drilled to study the flow of the groundwater in the Hangman Creek Watershed and a number of the wells were found to be over-pressurized. Samples from deep groundwater revealed age dates that range from 5.9 ka to 16.9 ka. Maximum elevation of glacial Lake Columbia was 2,400 feet based on highest strandlines observed near Grand Coulee Dam, indicating a lake depth of up to 700 feet in the Hangman Creek Watershed. Present day recharge of deep groundwater in the CRBA may require new strategies and management.

Rapid Assessment, Monitoring and Aesthetic Evaluation of Lake Shorelines Using Geospatial Techniques

David Cordner, Anthony Gabriel and Jeremy Murray
Dept. of Geography, Central Washington Univ., Ellensburg, Wash.

Abstract
This project developed and compared three methods to rapidly collect geo-referenced field data and integrate it with geospatial techniques to address a wide variety of shoreline management issues. Data collection focused on filling "white holes" often identified in geospatial data sets, including information on shore protection structures, docks, condition of riparian vegetation, ecological health, and scenic resources. Shoreline features were mapped at representative shorelines on Moses Lake, Washington, using a combination of GPS mapping, offset mapping, and videomapping. The accuracy and location of shoreline features mapped by each method were analyzed related to aerial photography and each set of results. A variety of open source software was used to develop a web interface to view the videomapping output. Videos were converted to flash video format, and are displayed in a web browser along with a corresponding route map displaying the second-by-second location of the video scene on a map. A slider evaluation bar allows users to rate the scene they are viewing by a Likert-based scale of attractiveness or apply rapid natural assessment criteria to reach segments. The results of the surveys are automatically georeferenced, and can be used to rank-order views on the basis of scenic preference or ecological criteria. The shoreline images are also broken into reach segments that can be tied to digital field data forms to input professional assessments of ecological conditions. Finally, the survey results can be analyzed in conjunction with physical, biological, and cultural characteristics for each shoreline segment obtained from existing GIS databases.

The Role of Surface and Ground Waters in the Nutrient Budget of Spirit Lake, Washington

★Danielle Dahlquist, Jim Gawel and Amy Leslie
Univ. of Washington Tacoma, Tacoma, Wash.

Abstract
Following the eruption of Mount St. Helens on May 18th 1980, the ecosystem of Sprit Lake was dramatically altered. The blast created a shallower basin with a larger surface area, which has allowed for a significant amount of primary productivity in the south end of the lake. This research focuses on identifying nutrient loads from ground and surface waters entering the lake as a part of a larger nutrient model in an effort to understand the enhanced productivity of the system. Over the summer of 2010, flow rates and water samples were collected from accessible streams and well head measurements and samples were collected across the southern shoreline. Samples were analyzed for nitrogen and phosphorus which will be used to create an estimated nutrient budget for the contributing ground and surface waters.

Prioritizing State-Owned Aquatic Lands in Washington State Lakes for Conservation and Study

Lowell Dickson, Carol Cloen, Melissa Whitman, Kevin Kozak, Ginger Shoemaker and David Palazzi
Washington Dept. of Natural Resources, Olympia, Wash.

Abstract
If you were managing 260,000 acres of lacustrine aquatic lands across 37 Counties in Washington State, how would you prioritize which areas to conserve and protect? Washington Department of Natural Resources (DNR) has developed a Landscape Prioritization Decision Tool to assess potential habitat based on 1) development intensity in the nearshore environment, and 2) the occurrence and distribution of state and federally listed species. The Tool uses a 1-km^2 grid cell resolution of all locations intersecting state-owned shorelands or bedlands. Development inputs for each grid cell include overwater structure area and count, and the amount and type of impermeable surface area on adjacent uplands. DNR's overwater structures dataset was developed specifically for such assessments. Species inputs include both occurrence data and potential habitat distributions (*e.g.*, Washington GAP Analysis). Based on these inputs, a habitat quality rank for each cell is assigned with the highest ranking cells used to define DNR's priority conservation landscapes. Any state-owned aquatic lands proposed for new uses in these priority landscapes will require additional biological assessments on a site-by-site basis, and managed based on the type of use and anticipated impacts. While the Tool was built in support of DNR's future management direction, it was built using publicly available state-wide datasets and, once final, the results should prove useful for many entities; including local, state, tribal, and federal. However, it must be emphasized that Tool results are not meant for site-specific decisions. Rather, they can provide an excellent initial filter for further site-specific assessments.

Paradox of the Paradox: Linking Climatic Extremes to Episodes of Small-cell Phytoplankton Dominance in a Large Southeastern Reservoir

Joseph Dirnberger
Kennesaw State Univ., Kennesaw, Ga.

Abstract
Typically, phytoplankton communities are diverse (so unexpectedly so, based on ecological theory, that G. Evelyn Hutchinson referred to this diversity as the "Paradox of the Plankton"). In the late summers of 1993 and 2007, phytoplankton communities in Allatoona Lake (Georgia, USA) shifted from normally diverse assemblages to near monospecific blooms of small cell-size species (one 0.5 × 2 μm cyanobacterium and one 2.5 × 15 μm diatom, respectively, comprising up to 99% of all cells). Water temperatures in the epilimnion during the late summer in each of these years were the highest measured in these two decades, and were associated with very low inflows into the reservoir. An atypical shift to nitrogen limitation coincided with these blooms, indicating that nutrient quality rather than quantity contributed to the "blooms" (also unlike typical algal blooms, biomass did not change appreciably). Literature based on physiological studies suggests that small cells (having relatively less surface areas) may have an advantage when the limiting nutrient shifts and temperature increases, providing an explanation for these blooms of small cells consistent with the meteorological and limnological changes observed during the blooms. Other studies in recent years have attributed shifts toward smaller cell size of phytoplankton to climate change, and the nature of such an anthropogenic variation can explain episodic declines in phytoplankton diversity and cell size observed here.

Developing a Habitat Monitoring Program to Inform Design and Placement of Over-water Structures on Washington State Owned Aquatic Lake Shore and Bedlands

Cinde Donoghue[1], Anthony Gabriel[2] and Joy Polston-Barnes[1]
[1]Washington Dept. of Natural Resources, Olympia, Wash.
[2]Central Washington Univ., Ellensburg, Wash.

Abstract
The Washington Department of Natural Resources (DNR) is steward to over 170,000 acres of lake shore- and bedlands. In an effort to protect native sensitive, threatened, and endangered species that depend on this lake habitat, the DNR has developed stewardship conditions for the placement and design of over-water structures on these lakes. These conditions, such as percentage of unobstructed grating on ramps and docks, and buffer distances from submerged aquatic vegetation must be complied with if a project is to be authorized for lease of state shore or bedlands. Acknowledging the diversity of lake types and uncertainty regarding the effectiveness of the stewardship conditions, and long term impacts to habitat, the DNR is taking an adaptive management approach to implementation. Long term monitoring to measure change to the distribution and diversity of submerged aquatic vegetation, benthic communities, sediment characteristics and bathymetry in areas beneath and adjacent to new overwater structures in comparison to reference sites will provide information on the effectiveness of the stewardship conditions. In cooperation with Central Washington University's Resource Management Program, a pilot lake habitat monitoring program has been initiated spring of 2011. The overall monitoring program structure, process of prioritization for sampling and reference site selection and initial monitoring results will be presented. Target studies that assess various specific questions (such as maximum light penetration to lake bed and available light for aquatic vegetation in shade cast areas using various types of deck grating) will be integrated into long term monitoring to refine specificity of the stewardship conditions.

Soft Armoring to Improve Essential Salmonid Fish Habitat: A Drift Cell Success Story

Judy Dudley[1] and Tom Slocum[2]
[1]AMEC E&I, Inc., Bellingham, Wash. [2]Washington Conservation Districts, Northwest Region, Mount Vernon, Wash.

Abstract
Salmon populations in the Pacific Northwest have been in decline for more than a century. Federal protection under the Endangered Species Act has been extended to several salmon species and associated Essential Fish Habitat. Fidalgo Bay, Washington is an important nursery area for salmon and is known to support substantial populations of forage fish (sand lance, surf smelt and herring). Hard armoring for the development of shoreline properties in Fidalgo Bay has severely disrupted natural transport of sediments, thereby negatively impacting the spawning habitat of surf smelt and sand lance. A site located within a highly disrupted drift cell and with substantial shoreline erosion problems on Fidalgo Bay was selected for a soft armoring demonstration project. This site was selected because it had historically supported forage fish spawning, but it generated added interest from stakeholders because of the presence of a prehistoric shell midden and a popular shoreline trail, both of which were being damaged by shoreline erosion. Project design included: importing rounded gravel and coarse sand; using native woody debris as short groins to reduce longshore transport of the placed gravels; recycling larger rocks already on the beach to create areas of energy dissipation; and post-construction planting at the landward edge of the project. Two years of post-construction monitoring have indicated that drift does occur but that spawning sized gravels remain distributed throughout the site, surf smelt are spawning at the site, and areal extent of surf smelt spawning habitat has increased significantly.

Past Performance Can Predict Future Returns

Roger Edwards
Oregon Lakes Association, Oreg.

Abstract
Historic USGS stage data for about 60 Oregon lakes and reservoirs were formatted into monthly means and standard deviations to characterize drawdown and refill during the water year. Just making these simple calculations is a worthwhile exercise because drawdown is a feature of lakes just as much as maximum depth or surface area. There is additional value to charting these statistics in order to visualize how much stage levels can vary within a given month. Comparing these charts of historic data to current stage readings show that drawdown and refill rarely varies from historical precedents.

Cumulative Impacts of Lake Level Drawdown and Shore Protection to Nearshore Habitats, Moses Lake, Washington

Anthony Gabriel and Dave Burgess
Dept. of Geography, Central Washington Univ., Ellensburg, Wash.

Abstract
Annual drawdowns of 1.5 m alter the nearshore habitat in Moses Lake, a 6,800 acre, eutrophic lake in the Columbia Plateau region of Washington. The shoreline was classified into 13 habitat types based on upland land cover, substrate, and presence of shore protection. Annual nearshore exposure was quantified for each shoreline type using aerial photographs, and reference sites were established to characterize the aquatic vegetation, substrate, and fish communities impacted by drawdown. The annual exposure of nearshore habitat totals over 1.5 million m^2. Exposure widths vary considerably between shoreline types along the 118 km shoreline, ranging between less than 10 m to more than 85 m at wetland and emergent island shorelines. The type of vegetation impacted also varied by shoreline type, with the greatest diversity of affected vegetation species found at unprotected residential sites with sandy substrates, and the least diversity at unprotected residential sites with boulder substrates. Vegetation species composition also varied greatly between the drawdown zone and permanently wetted offshore locations at all the shoreline types, with a greater number of species found at locations with water depths less than 1.5 m, primarily a result of emergent species found close to shore, particularly along unprotected shorelines. The diversity of submergent vegetation tended to be similar between the drawdown zone and permanently wetted locations offshore, though a greater proportion of bare sample sites were found at offshore locations. The distribution of 14 fish species was found to be associated with habitat types, resulting in differing drawdown impacts.

Modeling Bioavailable Phosphorus as a Function of Total Phosphorus to Estimate Watershed Soil Phosphorus Loading

★Scott Groce and Robin Matthews
Western Washington Univ., Bellingham, Wash.

Abstract
Lake Whatcom is a warm monomictic lake located east of Bellingham, WA (USA), and serves as the primary drinking water source for approximately 100,000 residents in Bellingham and Whatcom County. Matthews *et al.* (2004) noted indicators of increasing algal productivity in the lake. We quantified the amount of soluble, bioavailable and total phosphorus from soils in the Lake Whatcom watershed to help quantify the major sources of phosphorus entering the lake. In addition, we assessed the influence of soil factors (soil series, size faction, aspect, elevation, pH, slope, percent organic matter, median particle size, and percent by volume sand, silt, and clay) on bioavailable phosphorus concentrations. Organic matter, slope, and elevation were positively correlated with bioavailable phosphorus ($\log_{10}$bap = 1.39$\log_{10}$tp - 1.38; Adj. R^2 = 0.79; p-value < 0.001). Total suspended solids data from tributary streams were used to predict concentrations of total and bioavailable phosphorus contributed by watershed soils; the results were compared to actual total phosphorus concentrations measured in the streams. The predicted phosphorus values were consistently lower than actual stream phosphorus values, indicating that there were additional sources of phosphorus (*e.g.*, residential runoff) that supplement what was contributed by watershed soils. The predicted and measured phosphorus values were closest during peak storm flows, suggesting that during high flow events, most of the phosphorus transported into the lake comes from watershed soils.

Sediment Role in Wapato Lake Nutrient Budget

★Cierra Hancock and Jim Gawel
Univ. of Washington Tacoma, Tacoma, Wash.

Abstract
Wapato Lake is a shallow, hyper-eutrophic lake located in Tacoma, Washington. The lake has been affected by urbanization and pollution runoff throughout its history as a park; the City of Tacoma is therefore interested in constructing a nutrient budget for the lake to identify sources of nutrient input and effective mitigation methods. Sediment contribution to the nutrient budget was determined by analyzing surface samples and core samples for phosphorus, nitrogen, and carbon concentrations. Phosphorus concentrations in lake sediments averaged over 1000 mg/kg. A surface sediment concentration map was created to visualize the locations of high and low nutrient levels in order to identify possible localized sources.

Assessment of Bottom Sediment Quantity and Quality in Noxon Rapids Reservoir Prior to the Removal of Milltown Dam

Gary Ingman[1], Taylor Greenup[1,2] and Joe DosSantos[1,3]
[1]Atkins North America, Inc., Helena, Mont. [2]Lolo National Forest, Missoula, Mont. [3]Avista Corporation, Noxon, Mont.

Abstract
Avista Corporation and Atkins N.A. conducted studies in 2005 to characterize quality and volume of deposited sediment in Noxon Reservoir, a hydroelectric impoundment on the lower Clark Fork. The study was prompted by planned removal of Milltown Dam, a Superfund site near Missoula, Montana, that was projected to release large volumes of metals-contaminated sediments to downstream river segments. U.S. EPA agreed to grant Avista a liability waiver resulting from sediment deposition if baseline studies were completed establishing existing sediment quality and quantity within the reservoir. The reservoir sediment study included: 1) collection of bottom sediment core samples for analysis of metals concentrations, and 2) measurement of sediment deposits. Sediment cores were collected at pre-determined locations throughout the reservoir. Deposited sediment was mapped from reservoir transects using a multi-frequency acoustic profiling system coupled to GPS. The acoustic data were interpreted to identify pre- and post-impoundment bottom surfaces and associated sediment thicknesses. GIS modeling was performed to estimate reservoir sediment volumes, post-impoundment deposition rates, and distribution patterns. Concentrations of total Cu, Zn, and As in reservoir bottom sediments averaged 4.40, 39.9, and 90.2 mg/kg, respectively, and were highest in the middle reservoir and in areas with thicker deposits. Metals concentrations were lower than those measured in a 1987 study. Sediment thickness in more than 50% of the reservoir ranged from 0.1 to 3.0 feet, with some areas exceeding 15 feet. Sediment volume was computed at 31,088 acre-feet, with average annual flux of 661 acre-feet/year and a weighted average accumulation of 0.15 feet/year.

Polymer Enhanced Technologies Used to Reduce Eutrophication by Controlling Sediment and Nutrients

Seva Iwinski
Applied Polymer Systems, Woodstock, Ga.

Abstract
Eutrophication is caused by sources such as agricultural runoff, land disturbing activities, sewer overflows, and urban runoff. Runoff coming from sources such as sedimentation and excess nutrient loads contributes to algal blooms and water quality impairment. Negative effects of turbidity include fine particulates that are a point of attachment for nutrients, bacteria, heavy metals, pesticides, and endocrine disruptors. These particulates make up turbidity which we measure in nephelometric turbidity units (NTUs). Various studies have found that at as low as 10-100 NTUs, aquatic organisms begin to show signs of stress. This happens through decreased light, food and oxygen, mechanical effects, and temperature increases due to darker water. If algae grow exponentially due to eutrophication and algae blooms occur, it can threaten the health of the pond and the organisms within it. High nutrient levels, such as phosphorus, produce algae blooms and eventually lead to vegetation that die and decay, which in turn uses up available dissolved oxygen that can cause fish kills. Polymer enhanced technologies reduce sediment and nutrients from entering a water body, as well as reduce sediment and nutrients within a water body. Two solutions are to stop the sediment and nutrients from washing into a water body, or use polymer enhancement in conjunction with aeration systems, fountains, waterfalls, etc., to remove sediment and nutrients from contaminated waters. Through tests and case studies, polymer enhanced technologies have shown a 75-90 percent reduction in phosphorous and a 95 percent reduction in total suspended solids (TSS) and NTUs.

A Eurasian Milfoil Invasion – Lessons Learned: Seattle Public Utilities Aquatic Nuisance Species Plan

Elizabeth Johnson
Seattle Public Utilities, Seattle, Wash.

Abstract
In 1992, 7 acres of Eurasian watermilfoil were discovered in Lake Youngs, a drinking water source for Seattle Public Utilities (SPU). Since this lake is highly protected with absolutely no public access or development, it was determined that the infestation resulted from using the Lake Youngs designated boat in a lake outside our watershed. Annual pipeline maintenance required that the boat be used in Lake Washington only once per year and the boat was 'decontaminated' before it was allowed back in Lake Youngs. Half a million dollars and five years later, the milfoil was eradicated and SPU had learned a valuable lesson: we must protect our watersheds from the introduction of aquatic nuisance species. The SPU Aquatic Nuisance Species Plan was developed and implemented. The plan has four elements: 1) Prevention; 2) Early Detection and Monitoring; 3) Rapid Response; 4) Control and Eradication. This presentation concentrates on the first two elements of the plan. Prevention entails strict adherence to decontamination procedures for both contractors and SPU personnel working in our watersheds. In addition, we encourage the use of designated equipment for watershed sections when it is feasible. Early detection and monitoring necessitates training SPU employees to be the "eyes on the watershed", with emphasis on impacts of ANS, decontamination procedures, and identification. The invasion of aquatic nuisance species may be just around the corner however awareness, prevention, and an action plan may be able to stave off the inevitable indefinitely.

The Role of the Water Column in the Nutrient Budget of Spirit Lake, Washington

★Erika Klein, Jim Gawel and Chelsie Strowbridge
Univ. of Washington Tacoma, Tacoma, Wash.

Abstract
The 1980 Mount Saint Helens eruption greatly impacted the health of the surrounding ecosystem, especially Spirit Lake -northeast of the mountain and in the direct path of the blast. 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.

Methods for Monitoring Vertical Trout Movement and Distribution in Natural Lakes

★Brian Lanouette[1], Barry Moore[1] and Ed Shallenberger[2]
[1]Washington State Univ., Pullman, Wash. [2]Confederated Colville Tribes, Nespelem, Wash.

Abstract
In fisheries management, it is often necessary to monitor fish movement in lakes in order to effectively make management decisions. Managers have a plethora of monitoring tools at their disposal. This study aims to examine the effectiveness of four means to monitor salmonid vertical movement and distribution in Twin Lakes on the Confederated Colville Tribal Reservation in northeastern Washington. Methods included the use of hydroacoustic analysis, gill netting, ultrasonic telemetry tracking, and archival tagging of salmonids. The insights gained through analyzing the strengths and weaknesses of these methods allowed managers to formulate decisions regarding the most appropriate monitoring techniques and tools used at Twin Lakes. Once compared, it became evident that each technique had its positive and negative characteristics. Due to such traits, each one would have been best suited to specific applications when issues such as sampling cost, time, and effort were of concern. It was also evident that some of the four techniques were effective when used by themselves. Some aided in supplementing other methods. However, because the methods had their inadequacies, it was determined that each method alone was not better suited over others for the overall evaluation of vertical movement and distribution. Rather, when used in conjunction, all four methods effectively provided checks over the inadequacies and traits of the others. Therefore, through using a combination of methods, a more complete understanding of the distribution was gained.

Short-term Biological Response to Hypolimnetic Oxygenation in North Twin Lake on the Colville Reservation

★Brian Lanouette[1], Barry Moore[1], Marc Beutel[1] and Ed Shallenberger[2]
[1]Washington State Univ., Pullman, Wash. [2]Confederated Colville Tribes, Nespelem, Wash.

Abstract
Summer dissolved oxygen (DO) depletion in deep waters (hypolimnia) of thermally stratified lakes is widely recognized as one of the most significant and intractable problems associated with water pollution. Oxygen depletion has severe consequences, especially enhanced internal nutrient cycling, driving cascading ecologic impacts such as increased primary productivity, shifts to cyanobacteria dominance of the phytoplankton, reduced transparency, and reduced fish habitat. Line-diffuser oxygenation was implemented in 2009 for trout habitat enhancement in North Twin on the Colville Confederated Tribal (CCT) Reservation, near Inchelium, WA. This is the first application of this technology to a natural lake. In the short-term, we have documented increased fish utilization of summer hypolimnetic habitats through net captures, hydroacoustic monitoring, and active fish tracking. Changes in zooplankton and benthic invertebrate populations were also quantified. Responses of the diurnal-migratory phantom midge (*Chaoborus*) are particularly interesting. Overall, the technology shows great promise, and the CCT plans to extend the oxygenation system to South Twin Lake. Long-term fish community responses, such as improved growth and survival, will be key to evaluating the ultimate success of oxygenation.

A Water Balance Model for a Complex Shallow Floridian Lake

Scott Lowe
Manhattan College, Riverdale, N.Y. and HDR Engineering, New York, N.Y.

Abstract
Lake Jesup is a 12,000 acre lake 30 miles north of Orlando. It is the largest lake in Seminole County. The lake is the subject of intense interest as part of an ongoing nutrient TMDL. One of the challenges in attempting to analyze the lake from a water quality perspective has been getting the water balance correct. A complicating factor is the lake outlet to the St. Johns River, which can also feed water into the lake depending on lake and river stage. Recent seepage studies indicate significant flow from shallow groundwater. Tributary measurements often indicate no flow, or flow out of the lake, in dry weather. To try and piece the system together a 3-D, time-variable hydrodynamic model was used. The results are described in the poster.

The Atlas of Oregon Lakes

Richard Lycan and Rich Miller
Portland State Univ, Portland, Oreg.

Abstract
The web based Atlas of Oregon Lakes was developed to facilitate sharing of water quality data and other lakes information with scientists and the general public. The atlas was a joint effort of several programs at Portland State University and was funded by the Oregon Department of Environmental Quality through a grant from EPA. There were two parts to the project: (1) making data from the Pacific Northwest Water Quality Exchange Database available to the scientific community and (2) providing a "lakes atlas" context for viewing these data and reaching the broader public. One aspect of the project involved the development of the background cartography for the atlas. Rather than relying on existing maps, custom cartography was developed based on data in the National Hydro Database (NHD), road data from best sources for Oregon, and other layers optimized for the region and the purpose of the project. Developing these data layers required coordination. For example, we worked with USGS, Oregon Water Resources, and the PNW Hydro Framework Committee to improve the cartographic representation of lakes and their GNIS names, a serious deficiency in the NHD. A feature that will have broad public appeal is the publication of 200 bathymetric maps for Oregon lakes. This involved finding the best existing bathymetry and conversion of the data into a common form for display. Efforts are underway to make the bathymetry available through Oregon's Geospatial Enterprise Office. The project also served as a pilot effort in utilizing ESRI's ArcGIS Server software.

From Ambivalent to Engaged: Getting Adult Audiences to Participate in Voluntary Behavior Change with Beaver LakeSmart

Jane Maginot[1], Trish Ouei[1] and Robert Morgan[2]
[1]Univ. of Arkansas-Cooperative Extension Service, Fayetteville, Ark. [2]Beaver Water District, Lowell, Ark.

Abstract
Engaging adult audiences in voluntary behavior change can be difficult yet once achieved, is proven to be an effective method to long term environmental reform. LakeSmart is a free confidential, self-assessment program that helps lake area residents evaluate their home and property for potential pollution risks. Beaver LakeSmart challenges lake area residents to see themselves not only as stakeholders, but as environmental stewards. By educating adults in methods that are practical, useful, and easy to follow, LakeSmart lets lakeside residents make their own changes to behaviors as they seem necessary or applicable to better the water quality of Beaver Lake in Northwest Arkansas. Successes are measured through self-reporting by lake areas residents on behaviors and activities done before going through the LakeSmart program and after. The results have been successful due to three key elements of the LakeSmart program: it is voluntary, interactive, and informative. Because the program is voluntary, residents are more likely to engage in best management practices freely without feeling forced. The interactive component an anonymous self-evaluation that illustrates their behavior compared to their peers. Through education, lake area residents have been empowered with the knowledge to make better decisions on their behavior.

Sediment Gas Production, Composition, and Ebullition in Lake Elsinore, California

★Denise Martinez and Michael Anderson
Univ. of California, Riverside, Riverside, Calif.

Abstract
The production and composition of gas formed in the sediments of lakes provides important information about sediment biogeochemistry and rates of transformations there. Gas ebullition from bottom sediments is an important process because it has the ability to increase sediment nutrient flux rates into the water column by enhancing diffusive transport. Gas ebullition and release of methane (CH_4) and carbon

dioxide (CO_2) to the atmosphere also results in emission of harmful greenhouse gases. Measurements of volumes of gas in sediments have been made over the past year at 7 sampling sites on Lake Elsinore, a shallow, highly eutrophic lake in southern California. Composition of gas samples were determined using gas chromatography with a flame ionization detector and a CO_2 gas analyzer. Sampling of the gas volumes in sediments during cool winter months resulted in very low or undetectable amounts of gas levels in the sediments. This reflects the decreased rates of microbial activity at low temperatures. During summer months there was a great increase in sediment gas production, with volume exceeding 5 L m^{-2} at one site, indicating rapid rates of microbial activity in the sediments. Analyses indicate large concentrations of CH_4 and CO_2 gas present, suggesting a benthic microbial environment suited for large amounts of methane production via methanogenesis.

Residential Build-out Assessment of the Upper Saint Croix Watershed

Dan McFarlane and Nancy Turyk
Univ. of Wisconsin-Stevens Point, Stevens Point, Wis.

Abstract
As part of a lake and watershed management planning process, a build-out analysis was conducted for the Upper Saint Croix River watershed in Douglas County, Wisconsin to identify residential development potential in accordance with current land regulations. Recent advances in GIS have made the development of alternative policy scenarios easy to document and analyze. Parallel advances in watershed modeling have produced more accurate results in estimating the land use effects on surface water quality. Bringing these developments together, we evaluate the likely impacts of potential residential development on lake water quality in the Upper Saint Croix Watershed. The build-out analysis is a tool used to project all possible growth potential in a community given environmental and physical constraints, including land use regulations such as zoning. To accomplish this, we used GIS, land information data, and Community Viz™ to identify development constraints and simulate potential development in the watershed. We then estimated the amount of land use change from the build-out results and based on existing residential development patterns. Our analysis shows that the current zoning in the watershed aims to concentrate residential development near surface water features. Residents of the watershed are using the build-out results to implement both regulatory and non-regulatory strategies for protecting key lands from development in an effort to minimize the negative effects of development on lake water quality.

Algae Identification Projects and Outreach Workshops

Raymond Murrell and Erin Zoski
Agriculture & Agri-Food Canada, Regina, Sask., Canada

Abstract
Algae, especially the toxic species (blue green algae or cyanobacteria) are an increasing issue across North America. The toxicity of blue green algae is of major concern for water quality, recreation and agriculture production. As such, the Water Quality Unit of the Agri-Environment Services Branch (AESB) in partnership with Saskatchewan Ministry of Agriculture and the University of Alberta have conducted a variety of algae identification projects to increase the management practices and awareness of algae. Algae Identification workshops showcasing an algae field identification guide have been conducted in various locations across Saskatchewan. A Cyanobacteria Decision Support tool has been developed which enables producers to assess the form of algae in their water source and determine the steps they can take to decrease the risk of toxicity to their livestock. The decision support tool and algae workshops deliver tools and practices which enable producers to implement strategies for algae management, risk and control. The algae probe project develops a scientific way to correlate probe findings with actual blue green algae toxicity results while determining the accuracy and robustness of the algae probes. Different probes for identifying algae have been studied for accuracy and ease of use as a front line of defence for toxic algae.

Recreational Boating and Shoreline Erosion; Is There A Compromise?

Charlie Peterson
Spokane Conservation District, Spokane, Wash.

Abstract
Shoreline erosion is a naturally occurring process along all water bodies. Although extremely variable, boat waves have been shown to increase this process. The destructive force of a wave is directly dependent on its size. Many different factors influence wave size including boat speed, ballast, hull shape, water depth, and the boats proximity to the shoreline. The variances in erosion are also closely linked to the shoreline's vegetative community and substratum composition. Observations made by the Minnesota Department of Natural Resources have shown that a wave of 12.5 cm height does not cause significant shoreline damage. Waves of this height are generally created by boats at planing speed. Boats that are designed to create large waves, such as Wake Board or Bladder Boats, generate waves in excess of 60 cm and are 30 times more destructive. Although shoreline erosion has many contributing factors, can reducing the effects of the major contributors in-turn significantly reduce shoreline degradation? Outreach programs can be implemented to educate boaters on the destructive forces of large boat waves and what they can do to reduce wave size. Unfortunately, there is no one-size-fits-all approach to wave size reduction. Every lake will have its own set of challenges but through more intensive lake management, shoreline protection and recreation boating can co-exist.

Allelopathic Chemicals Isolated From Reed Canary Grass Roots

Beth Proctor
Minnesota State Univ.-Mankato, Mankato, Minn.

Abstract
Allelopathy has been defined as the direct or indirect harmful effect of one organism on another through the production of chemicals released into the environment (Fay and Duke, 1977). Methanol extracts of macerated and whole Reed Canary Grass (RC) roots grown alone, with another RC plant or with Tussock Sedge (CS) have been found to reduce the germination and growth of lettuce, radish and the aquatic plant, Reed Manna Grass seeds (Veit and Proctor 2009; Pradhan and Proctor 2009). The purpose of this research was to identify compounds in these methanol extracts. Methanol extracts were analyzed by Gas Chromatography (GC) - Mass Spectrometry (MS). The methyl esters of hexadecanoic acid (retention time (RT) 24.19 minutes), linoleic acid ((RT) 26.26 minutes), and linolenic acid (RT 26.36 minutes) were found in both macerated and whole Reed Canary Grass roots. Several macrophytes (*Pistia stratiotes*, *Eichornia crassipes*, and

Potomogeton malaians) produce linoleic acid and/ or linolenic acid which inhibit the growth of several algae including *Microcystis aeruginosa* (Nakai *et al.* 2006; Hu and Hong 2008; Wu *et al.* 2007).

Field Measurements of Blue-green Algae Blooms in Taihu Lake, China

Xin Qian, Rui Ye and Wen Xiong
Nanjing University, Nanjing, China

Abstract
Lake Tahu is a typical shallow lake situated at downstream of Yangtze River Catchment in southeastern China. Due to the nutrient inflow from basin, the lake has suffered from eutrophication since 1980s and the algae blooms each summer damage tourism, fisheries, and water resources. Nutrients and algae biomass in the lake have been investigated each month since 2009. Measurements show that cyanobacteria, green algae, diatoms, Euglena and Cryptophyta are main algae in the lake. The biomass of cyanobacteria, green algae, and diatoms represent more than 99% of the biomass over the year and exhibit no significant succession of the algae community. Microcystis is the dominant genus of cyanobacteria in the lake. During the spring, concentrations of dissolved inorganic nutrients (SRP, NO_3-N, NO_2-N and NH_3-N) were quite high and provided the potential for algae growth. In the summer, algae aggregated at the northwestern bank by dominant winds, and resulted in high TP and TN concentrations at the same stations. Algae density was lower in the eastern part of the lake due to summer winds. Algae bloomed at a different time with different peak values in 2009 and 2010, which may have been related to the timing of the annual rainy season and the intensity of rainfall that resulted in differences in water level, concentrations of nutrients, and the availability of solar radiation for the algae in the shallow lake.

Saltese Flats Wetland Restoration, Spokane, Washington

Mike Rotar[1], Ben Brattebo[2] and Gary Andres[3]
[1]Atkins North America, Bozeman, Mont. [2]Spokane County Division of Utilities, Spokane Wash. [3]Atkins North America, Spokane, Wash.

Abstract
A wetland restoration project is in the design stage for Saltese Flats. Saltese Flats lies at the southern edge of the Spokane Valley Rathdrum Prairie (SVRP) aquifer near Liberty Lake. Water flowing through the Flats discharges to nearby Shelley Lake where it infiltrates into the SVRP, eventually entering the Spokane River. The hydrology of the portion of Saltese Flats targeted for restoration has been artificially managed for over a century to facilitate agriculture. Historically the location featured a seasonal lake and wetland environment. In 2008, a study was conducted by Atkins for Spokane County Division of Utilities to determine the feasibility of restoring the northern portion of Saltese Flats to a wetland environment. The study was undertaken in part as one of several watershed management efforts to identify actions to increase summer flows in the Spokane River. The feasibility study included the installation of wells and staff gages to collect data on the hydrologic system, along with detailed survey work and a water budget analysis. While the flow dynamics of the system are complex and continue to be discerned, the study concluded that wetland restoration is feasible. Since that initial study was completed the monitoring sites have been updated with dataloggers and baseline data collection continues to better understand the hydrology. The wet conditions of 2011 have provided very interesting data that illustrate how the system behaves under high water conditions. Design of the restored wetlands is scheduled to begin this year and be completed in 2012.

The Spatial Relationship Between the Lakes of the Cascade Lakes Region, Oregon

★Arick Rouhe and John Rueter
Portland State Univ., Portland, Oreg.

Abstract
Wetlands directly adjacent to lakes and wetland areas in a watershed can have a large impact on lake ecology. Major influences include uptake and release of nutrients and dissolved organic compound (DOC, temperature alterations, and species habitat alterations. This proposed study focuses on DOC because it is considered the main ecological driver in a wetland dominated system. The goal is to better understand the influence of wetlands on lake ecology and the relationship between wetlands and the trophic status of lakes in the central and southern Cascade Range of Oregon. To achieve this goal, the study has four objectives: 1) create up-to-date GIS maps of wetland areas in the entire study area and in each lake watershed, 2) conduct DOC transects near marshes, and measure nitrogen, phosphorus, and chlorophyll concentrations from each lake in the study at roughly that same time, 3) compare the water chemistry with the wetland area of each lake and watershed to determine how much DOC variability in the study lakes can be attributed to and explained by wetlands, and 4) use spatial statistics to determine the influence of wetland area and proximity on trophic status. We will determine which type of wetland explains the most variability in water chemistry parameters: local wetlands or regional wetlands. Based on a literature review, it is expected that regional wetland area will explain more variability than local wetland area for each lake.

The Role of Insects in the Nutrient Budget of Spirit Lake, Mount Saint Helens, Washington

★Katie Royer and Jim Gawel
Univ. of Washington Tacoma, Tacoma, Wash.

Abstract
The effects of the May 18, 1980 eruption of Mount Saint Helens on nearby Spirit Lake have created a unique opportunity to study a highly disturbed environment. One way to examine the functioning of this ecosystem over time is through the creation of a nutrient budget for Spirit Lake. Nutrients leave and enter the lake through the emergence and deposition of insects. Insect emergence and deposition may have a significant impact on the nutrient budget of Spirit Lake. This research builds off of previous insect emergence and deposition studies at Mount Saint Helens to help model the role of insects in the nutrient budget of Spirit Lake.

Development of a State-wide Conservation Strategy for Aquatic Vegetation in Lakes

Ginger Shoemaker and Carol Cloen
Washington Dept. of Natural Resources, Olympia, Wash.

Abstract
Submerged and emergent native aquatic vegetation provides crucial lacustrine habitat for threatened and endangered amphibians, birds, and fish in the State of Washington. An aquatic vegetation strategy will be incorporated into the

Washington State Department of Natural Resources' Aquatic Lands Habitat Conservation Plan (HCP). This strategy is designed to protect vegetative habitats important to listed species through siting criteria and the implementation of buffers between structures and aquatic vegetation, and will be applied to all authorized uses of state-owned aquatic land as part of the implementation of the HCP. Buffer distances will be based on the expected impacts of the authorized use including, shade, propeller scour and the elevation of sediment free sulfide concentrations. Under the HCP a formal Adaptive Management Plan will be used to explore the data gaps related to impacts on vegetation associated with nearshore buildings, mooring buoys, dock height and vessel traffic.

Effects of Water and Methanol Extracts of Common Buckthorn Berries on the Germination and Growth of Lettuce

⋆Jordy Veit and Beth Proctor
Minnesota State Univ.-Mankato, Mankato, Minn.

Abstract
The Common Buckthorn (*Rhamnus cathartica*) is an invasive species and a major threat to natural areas. The purpose of this research was to determine if water and methanol extracts of berries of the Common Buckthorn will reduce the germination and growth of lettuce. Berries were collected fall 2010 and refrigerated until processed. One, 2, and 4 berries were placed in separate vials. The berries were macerated, extracted with water and centrifuged at 2,500 rpm. Water extracts (10 ml) were added to Petri dishes lined with filter paper and then 10 lettuce seeds were added. Methanol was added to the berries and the processes repeated. Methanol extracts were allowed to evaporate before adding 10 lettuce seeds and 10 ml of distilled water. Seeds were incubated at 25 °C under a 14 hour light/10 hour dark cycle. Germination of seeds was monitored daily and at the end of incubation period the root length of the lettuce was measured. Multiple replicates (3-10) were run. Seeds treated with water extracts from 4 berries (1 gram) or 2 berries (0.5 grams) did not germinate. Seeds treated with water extracts from 1 berry (0.2 gram) had an 84% germination rate, but had significantly shorter root length than the water controls. Seeds treated with the methanol extracts from 4 berries had the highest germination rate but their root length was significantly less than the methanol controls. Percent water of the berries averaged 51.6%. One gram wet weight equaled 0.48 grams dry weight.

*Zebra and Quagga Mussel (*Dreissena polymorpha *and* D. rostriformis bugensis*) Early Detection Monitoring Efforts Throughout the Western United States*

Steve Wells[1], Mark Sytsma[1], Jesse Schultz[2], Amy Ferriter[3], Rick Boatner[4], Martha Volkoff[5], Stephen Phillips[6], Denise Hosler[7], Larry Dalton[8], Tom McMahon[9], Rebecca Weiss[10], Dan Jackson[11], Rod Jung[11], Barbara Coulter[12], Jason Goeckler[13], Steve Schainost[14] and Angel Pletka[15]
[1]Portland State Univ., Portland, Oreg. [2]Washington Dept. of Fish and Wildlife, Olympia, Wash. [3]Idaho State Dept. of Agriculture, Boise, Id. [4]Oregon Dept. of Fish and Wildlife, Salem, Oreg. [5]California Dept. of Fish and Game, Sacramento, Calif. [6]Pacific States Marine Fisheries Commission, Portland, Oreg. [7]Bureau of Reclamation, Denver, Colo. [8]Utah Division of Wildlife Resources, Salt Lake City, Ut. [9]Arizona Game and Fish Dept., Phoenix, Ariz. [10]US Army Corps of Engineers, Portland, Oreg. [11]East Bay Municipal Utility District, Oakland, Calif. [12]New Mexico Dept. of Game and Fish, Santa Fe, N.M. [13]Kansas Dept. of Wildlife, Parks and Tourism, Pratt, Kans. [14]Nebraska Game and Parks Commission, Lincoln, Nebr. [15]US Army Corps of Engineers, Omaha, Nebr.

Abstract
Monitoring and early detection of zebra and quagga mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*) are key to early detection and management of the invasion of western water bodies. Zebra and quagga mussels cause damage to water structures and native ecosystems. Since initial discovery in the Great Lakes region, these species have spread to more than 25 states. Their continued spread has been facilitated by transport of adult mussels on boats and larvae movement by water current from infested to uninfested portions of watersheds. The continued spread into western water bodies can be prevented but risk of introduction, establishment and spread has increased. Prevention and containment efforts are dependent on effective monitoring, early detection, and efficient information dissemination. Early detection monitoring is difficult. The inherent rarity of newly established populations, clumped distribution, environmental influences on spawning, and difficulty of observing underwater habitats complicates early detection. There are many agencies and volunteers involved with these efforts, and there are multiple methods used for early detection monitoring including artificial settlement substrates, visual inspections of shorelines and natural substrates, surface scrapings, SCUBA, and analysis of plankton for larvae. There is no best method for early detection monitoring. Increased efficacy requires focus of effort on high-risk water bodies, increased sampling intensity targeting both larvae and adults using multiple methods, and both volunteer networks and trained biologists. Identification of gaps in the monitoring network and good regional communication and coordination is critical to the efficacy of early detection and rapid response efforts in the West.

Ultrasonic Algae Control – How it works

Kirk Whatley
SonicSolutions LLC, West Hatfield, Mass.

Abstract
Ultrasonic sound waves have been proven to kill and prevent algal growth. There are thousands of installations around the world. Ultrasonic sound waves kill bluegreen algae without releasing any toxins into the water. The frequencies and power used to emit the ultrasonic sound waves are safe for fish, frogs, turtles, snakes, alligators, otters, and all other forms of aquatic life (with the only exception being bluegreen algae/cyanobacteria). Ultrasonic technology also works on vast majority of green and filamentous algae, along with bluegreen algae. Ultrasonic sound waves affect the algae in a manner that it becomes difficult to impossible for the algal cells to consume food or get rid of waste. The end result is that the algal cells end up starving to death. Ultrasonic devices are installed and successfully working in lakes, ponds, irrigation ponds, and stormwater retention ponds, as well as wastewater and drinking water applications.

Lake Eutrophication and Criteria and Control Standard of Total Phosphorus in China

Liuyan Yang and Xiaoming Chuai
Nanjing Univ., Nanjing, China

Abstract
Lake eutrophication is of great concern to the Chinese government and limnologists. By comparing 28 lakes located in China, the relationship between TP and the primary

productivities in the lake ecosystems can be simulated by the equation $R_{max} = e^{0.000728*Tem}$ used to describe the relationship between R_{max}, which represents the capacity of transforming TP into the actual primary productivity (Chl *a*), and the accumulated temperature (Tem) with a threshold for Tem between 3,400 °C·d and 4,730 °C·d. The phosphorus flows slowly in aquatic ecosystems when the temperature is lower than 3,400 °C·d, and flows fast when Tem is above 4,730 °C·d. The 28 lakes are geographically categorized into several groups as Xinjiang lake regions, Inner Mongolia lake regions, northeast plain/mountainous lake regions, eastern plain lake regions, and Yun-Gui plateau lake regions in China. These lakes could further be classified as fast, intermediate, and low speed ecosystems based on their phosphorus flow rates. Based on the categorization of the 28 lakes, the TP criteria and the corresponding control standards were formulated with the combination of probability statistics and Carlson models. Accordingly, the TP criterion and control standard were 0.08 and 0.20 $mg \cdot L^{-1}$ in Lake Hulun, 0.03 and 0.06 $mg \cdot L^{-1}$ in Lake Taihu, and 0.08 and 0.15 $mg \cdot L^{-1}$ in Lake Dianchi, respectively.

Session D-1: Cyanobacteria Analysis

Thursday, October 27
8:30 am – 10:00 am
Room 205

Analysis of Cyanobacterial Toxins from Washington Lakes

Gabriela Hannach and James Buckley
King County Dept. of Natural Resources and Parks, Environmental Lab, Seattle, Wash.

Abstract
There is true concern over the increased occurrence of toxic cyanobacteria in Pacific Northwest lakes; nonetheless, our current understanding of the dynamics and health risks of cyanobacterial blooms in this region remains quite limited. Greater awareness of this public safety issue has seen an emergence of new programs through diverse funding sources, all aimed at assessing the severity and impact of toxic cyanobacterial blooms in our state. While the various programs may differ with respect to priorities and goals, it is imperative that all information gained from these efforts remains comparable and of consistent quality so that data may ultimately be combined to generate a meaningful regional dataset. In 2002, King County launched the only long term monitoring program for the detection of cyanobacterial toxins in this region. The County's Environmental Lab has since expanded its analytical capabilities, becoming a regional resource for the analysis of four major freshwater cyanotoxins: microcystins, anatoxin-a, saxitoxin and cylindrospermopsin. Methodology follows rigorous standard operating and quality control procedures, and data are then loaded into an oracle database via customized software to protect data integrity and consistency. As cyanotoxin analytical procedures are rapidly evolving our laboratory methods are continually revised and updated to reflect developments in the field. Future advances may include extensive use of passive samplers containing selective resins as well as gene microarray analysis to identify the presence of toxigenic species in the field.

Variations in the Microcystin Congener Composition Among Temperate Lakes

Frances Pick[1], Arthur Zastepa[1], Marie-Eve Monchamp[2], Jillian Kingston[3], Roxanne Maranger[2], Jules Blais[1] and Claudia Wiedner[4]
[1]Center for Advanced Research in Environmental Genomics, Univ. of Ottawa, Ottawa, Ont., Canada [2]Dept. de Biologie, U. de Montreal, Montreal, Que., Canada [3]Ontario Ministry of Environment, Toronto, Ont., Canada [4]Dept. of Freshwater Conservation, Brandenburg Technical Univ., Cottbus, Germany

Abstract
Cyanobacteria can produce a wide range of compounds several of which are toxic to other organisms including humans. The microcystins appear to be the most widely encountered cyanotoxins in freshwater: over 80 different types of congeners have been described. The drinking water standards are based on microcystin LR and less attention has been given to other congeners as a result. However, other microcystins and the actual composition observed in lakes should also be of interest since some microcystins are much more toxic than others. Unfortunately, only about half a dozen microcystins are available commercially and can thus be reliably measured. At present, the factors that regulate the composition of microcystins in the environment are largely unknown. Culture work and empirical observations of European lakes has suggested that light and nitrogen availability may influence the observed microcystin profiles in lakes. Using literature data and ongoing water intake and lake monitoring data, we examine the potential role of environmental factors and lake trophic state in regulating the relative abundance of microcystin congeners. Preliminary observations from Canadian lakes suggest some congeners such as microcystin LA may be more commonly encountered than in European lakes where it appears to be relatively rare.

High Throughput Sequencing Analysis of Cyanobacterial Bloom Populations

Connie Bozarth and Theo Dreher
Dept. of Microbiology Oregon State Univ., Corvallis, Oreg.

Abstract
Cyanobacterial blooms in lakes and reservoirs are of continually increasing concern for recreational contact and drinking water supplies. Despite their widespread occurrence and the impact of their toxicity, there is a general dearth of knowledge of the genetic identity of major blooms and of the relationships between different blooms. Genetic identifications of cyanobacterial taxa are more reliable than visual identification, and are more comparable between investigators and across time. The very large capacity of 454 pyrosequencing allows DNA targets of many cells in each of several samples to be simultaneously sequenced. We have applied 454 sequencing to analyze the ITS and CPC loci of cyanobacteria present in blooms in the U.S. Pacific Northwest. We discuss the applicability of this technique for the genetic cataloguing of blooms.

Genetic and Toxin Analysis of Blooms and Single Colonies to Catalogue the Toxigenicity of Pacific Northwest Bloom-forming Cyanobacteria

Theo Dreher, Connie Bozarth, Dave Stone and Claudia Maier
Oregon State Univ., Corvallis, Oreg.

Abstract
Although many bloom-forming cyanobacterial genera have been reported to be capable of producing toxins, the toxigenicity of natural blooms and the toxins associated with them have not been well documented. It is well known that *Aphanizomenon* blooms in Upper Klamath Lake, Oregon, are non-toxic, although *Aphanizomenon* from other parts of the world have been associated with the production of toxins, including microcystin and anatoxin-a. It is not known whether this is an isolated case, or whether variations in toxigenicity are more widespread. To address this question, we are analyzing the toxins associated with Oregon cyanobacterial blooms. Bloom samples are being analyzed by DNA sequencing to determine the genotypes present, and by LC/MS/MS to identify the presence of microcystins and anatoxin-a. These analyses are also being applied to individual colonies picked from mixed blooms. By determining the association or lack thereof of toxins with particular cyanobacteria, this study should allow the development of evidence-based responses to blooms. Current guidance treats all blooms consisting of cyanobacteria that have at some point been reported to be toxic as equally toxic health risks.

Session D-2: Lake Management

Thursday, October 27
8:30 am – 10:00 am
Room 206A

Phosphorus, Algae, and Water Quality: Interrelationships and Management Implications

West Bishop[1], Scott Shuler[2] and Shaun Hyde[2]
[1]SePRO Corporation, Whitakers, N.C. [2]SePRO Corporation Carmel, Ind.

Abstract
Increased demand on our freshwaters and factors that threaten water quality can elicit harmful ecological and economic consequences. Nutrient enrichment of water resources can impact aquatic diversity, drinking water supplies, recreation and compliance of water quality standards. Phosphorus is highly correlative to algae productivity, algal assemblage composition, and is typically the primary component governing eutrophication. Years of phosphorus accumulation has resulted in the need for innovative *in situ* management strategies that effectively remove bio-available phosphorus and restore water quality. The objectives of this presentation are 1) to correlate phosphorus levels to algae densities and classification; 2) to illustrate water quality impacts of increased phosphorus levels; and 3) to highlight new solutions for management of algae, phosphorus and/or water quality. Laboratory and field research data on the efficiency of these new solutions at mitigating nuisance algae and undesirable phosphorus levels will be reviewed. SeClear* (pending registration) is an algaecide and water quality enhancer that can control toxin and taste/odor compound producing cyanobacteria and decrease phosphorus levels. Experimental results showed significant decreases in algae response parameters (*i.e.*, chlorophyll, cell densities) following one treatment and significant decreases in phosphorus concentrations throughout a treatment program. Phoslock® is a lanthanum-based phosphorus locking technology that provides an effective approach to combat the eutrophication process and restore water quality. Laboratory and field research studies documented significant decreases in both total and free reactive phosphorus at all treatment sites within 24 hours and continually decreased throughout the studies.

An Ecologically-Based, Systems-Approach to Freshwater Management

H Kenneth Hudnell
SolarBee, Inc., Chapel Hill, N.C. and Univ. of North Carolina, Chapel Hill, N.C.

Abstract
Will we have a sustainable supply of usable freshwater? Whereas the U.S. EPA estimated in 1972 that 10-20% of lakes and reservoirs were impaired due to eutrophication, approximately 50% are now eutrophic or hypereutrophic. These data indicate that watershed-management policy is insufficient for preventing eutrophication. A complementary policy of within-water-body management is needed to address the primary stressor of eutrophication, freshwater harmful algal blooms (FHABs), and to reduce nutrient levels in the near term. An impaired water body is analogous to an ill person in need of supportive therapy to reduce stress on biochemical processes. Eutrophic water bodies need enhanced circulation, such as solar-powered, long-distance circulation, to suppress FHABs. The suppression of FHABs enables nutrients to ascend the trophic levels of the food web. Additional nutrient reduction can be achieved using other technologies such as floating islands and side-stream floways for chlorophyte culture, harvest and reuse. Satellite monitoring of FHAB intensities and phosphorus concentrations in the past and into the future assists treatment-plan development and results evaluation. U.S. regulations require prioritization of CWA Section 303(d) impaired waters for development of total-maximum-daily-loads (TMDLs). Water bodies can be delisted from Section 303(d) when TMDLs are developed or when they exhibit sufficient water quality improvement. Successful application of within-water-body management obviates the need to develop TMDLs. Less rigorous applications of watershed management reduce the overall cost of freshwater management. This ecologically-based, systems-approach to freshwater management can reverse the trend of increasing eutrophication and FHAB occurrence, and ensure a sustainable supply of useable freshwater.

Lake Management Needs to Rediscover its Limnology Roots

Bob Kortmann
Ecosystem Consulting Service, Inc., Coventry, Conn.

Abstract
In the opinion of someone who has been involved in the "NALMS mission" since before there was a NALMS: limnology needs to become the guiding science of lake management again. Lake ecosystems, like organisms, can be more autotrophic (driven by autochthonous organics from internal primary productivity) or more heterotrophic (driven by inputs of allochthonous organics - photosynthesis happens in the watershed too!). Most lake assessment and management methods focus almost exclusively on the autotrophic nature of lake ecosystems. For example, TSI uses chlorophyll *a*, Secchi transparency, and total phosphorus to characterize trophic state. These parameters relate to pelagic phytoplanktonic autotrophy and do not account for littoral or allochthonous

organic inputs. Anoxic factor, AHOD, Dissolved Inorganic Carbon Increments, Respiratory Quotients, and similar methods diagnose the whole "ecosystem organism". By viewing lakes as "land-water ecosystem organisms" with unique chemical, physical, and biological attributes, new management strategies emerge that are inexpensive and "naturalistic". Diagnostic and management methods which you've probably not heard about include: RTRM, RVG, RQ, AHOD, AF, Flow Routing, Winter Thermal Treatment, Iron Cycle Manipulation and Enhancement, Chemical Nutrient Inactivation without adding any chemicals, Alum Surrogates, Layer Aeration Strategies, Reservoir Reach Partitioning, and Wind and Solar Driven methods. Do you remember: RIPLOX Cyanophage Bactivory and the Microbial Loop, and Benthic Detrital Electron Flux? Many effective lake management methods remain to be discovered and developed. As we learn more about the operation of lake ecosystems, we will learn more about how to effectively manage them. Limnology must return to a prominent basis for lake management decisions.

Stocking the Tool Box: Understanding Lesser Known Options

Kenneth Wagner
Water Resource Services, Wilbraham, Mass.

Abstract
When managing for desirable lake attributes, there is no one size that fits all and it is rare for one technique to meet all needs. Applying a building trade analogy, we need a well-stocked toolbox, we need to understand how to use each tool, and we need to use the right tool for the right job. Two examples of tools that are not well enough understood and are therefore left in the box or misused are sonication and bacterial additives. Sonication uses sound waves to disrupt cellular structure, killing susceptible algae, but not all algae are equally susceptible. Sonication depends on "line of sight" mechanics. Applications have to be mindful of these constraints. Bacterial additives are intended to work with oxygen to tie up nutrients and compete with algae, and potentially to reduce sediment build up through decay processes. Oxygen is the key need, but as with any sludge management, getting the right balance of nutrients to maximize bacterial effects is tricky. Without detailed site specific data and bench testing, products are developed to allow non-hazardous application, hopefully favorably. Despite documented successes and failures, there is virtually no peer reviewed literature for either technique, leaving lake managers to evaluate for themselves with influence from marketing campaigns. It is appropriate for lake managers to be skeptical of lesser known techniques and to ask questions and expect answers, but it is not helpful to either denigrate techniques without complete understanding or to market products with unsubstantiated claims.

Session D-3: Coeur d'Alene Lake

Thursday, October 27
8:30 am – 10:00 am
Room 206B

Historical Perspective of the Coeur d'Alene Tribe's Management of Coeur d'Alene Lake

Phillip Cernera
Coeur d'Alene Tribe, Plummer, Id.

Abstract
From time immemorial, the Tribe has been the original Natural Resource Manager. With the advent of white settlement arrived many activities that changed the Tribes homeland. This included the creation of the 1873 reservation, mining, logging, development of illegal hydropower operations, all of which had a negative effect on Tribal natural resources. This resulted in the tireless fight of the Coeur d'Alene's to maintain their sovereignty and 100 years of environmental injustices. For the last 30 years the Tribe has fought for environmental injuries in their homeland. In 1991, the Tribe filed two lawsuits (one to affirm their ownership to Coeur d'Alene Lake and the other an NRDA claim against the mining industry). Since then the Tribe has been demanding the U.S. join the Tribe by using their CERCLA authorities to remediate and restore the basin and Lake. In 1996, the USA joined the Tribe in both cases. After nearly 20 years of litigation much clean-up has occurred, mining companies have settled their claims and the Tribe has continued to be a leader in natural resource protection. Currently the Tribe has both a Natural Resource and Lake Management Department with over 75 staff. Staff is dedicated to protecting the waters of the lake, management of native fisheries, invasive species, and encroachments, and keeping shorelines open to the public. This requires a combination of conducting sound science, providing the public access to the process, and engaging with Idaho in the implementation of a unique Lake Management Plan.

Limnology of Coeur d'Alene Lake as Impacted by Two Major Rivers

Rebecca Witherow[1], Dale Chess[2], Glen Rothrock[1], Glen Pettit[1] and Scott Fields[2]
[1]Idaho Dept. of Environmental Quality, Coeur d'Alene, Id.
[2]Coeur d'Alene Tribe, Plummer, Id.

Abstract
Coeur d'Alene Lake water quality is highly influenced by two major rivers, the Coeur d'Alene and the St. Joe. Both rivers deliver sediments and nutrients to the system, and the Coeur d'Alene River, which drains the Bunker Hill Superfund Site, delivers large amounts of metals such as zinc, lead, cadmium, and arsenic. Much of this contamination becomes entrained in lake sediments. A primary concern for the lake is the potential release of metals to the water column due to oxygen depletion in the bottom waters caused by nutrient enrichment and organic matter decomposition. The ensure optimal oxygen levels, the Coeur d'Alene Lake Management Plan focuses on long-term monitoring of basin-wide nutrient inputs and trace metal concentrations in the lake. The southern waters fed by the St. Joe River are generally higher in nutrients than the northern waters. The northern pool is more enriched in metals from the Coeur d'Alene River than the southern pool. Combined with USGS data, our results suggest an increasing trend in phosphorus and chlorophyll *a* concentrations throughout the entire lake. Phosphorus release from the sediments has been exhibited following a prolonged

period of anoxia in the hypolimnetic waters of the southern pool. Dissolved oxygen conditions in the northern pool remain above critical levels for the release of nutrients and metals from the sediments, however given the increasing nutrient concentrations throughout the lake, it is critical that these processes be monitored and managed to prevent the release of metals from the sediments to the water column.

Education and Outreach Needs Assessment for the Coeur d'Alene Lake Management Plan (LMP)

Rebecca Stevens[1] and Glen Rothrock[2]
[1]Coeur d'Alene Tribe, Coeur d'Alene, Id. [2]Idaho Dept. of Environmental Quality, Coeur d'Alene, Id.

Abstract
The Coeur d'Alene Lake Management Plan (LMP) is a joint effort between Idaho DEQ and the Coeur d'Alene Tribe which was finalized in March 2009. The stated goal of the plan is "to protect and improve lake water quality by limiting basin-wide nutrient inputs that impair lake water quality conditions, which in turn influence the solubility of mining-related metals contamination contained in lake sediments." One core objective of the LMP is to increase public awareness of lake conditions. The first step of this objective was to conduct a Public Education/ Outreach Needs Assessment (polling survey). In 2010, an assessment was conducted by Robinson Research (Spokane). The purpose of the assessment was to "evaluate the public's attitudes and perceptions regarding the water quality of CDA Lake as well as their perception of agencies involved". Four methods were used: telephone and internet questionnaires, community opinion leader interviews, and focus group discussions. Some significant results are: 1) there is a general lack of understanding of governmental involvement in water quality protection, 2) overall misunderstanding of metal pollution in the lake, and 3) consensus that invasive aquatic plants pose the biggest threat to water quality. Assessment conclusions include: there needs to be more collaboration amongst agencies, the current status of water quality needs to reach the public, and there is an overall need for an education/ outreach program.

Chinook Salmon and Kokanee Fisheries in Coeur d'Alene Lake, Idaho

Jim Fredericks and Melo A. Maiolie
Idaho Dept. of Fish and Game, Coeur d'Alene, Id.

Abstract
For nearly three decades, Coeur d'Alene Lake, Idaho, has provided important fisheries for both kokanee and Chinook salmon. These two fisheries have made the lake one of the most valued fisheries in the State and provided about 250,000 angler hours in some years. The balance between the two species has been dynamic with both species going through wide cycles in abundance as managers regulated Chinook salmon stocking to match the kokanee population. Prior to stocking Chinook salmon in 1982, kokanee harvest was estimated at 465,000 and 578,000 kokanee annually, but their size was small with adults reaching about 250 mm in total length. Chinook salmon were introduced in 1982 mainly to reduce kokanee densities and increase their size. Fishing effort remained fairly constant for the next 14 years at about 250,000 angler hours/year after the introduction of Chinook salmon. Chinook salmon contributed 2,200 to 3,300 fish to the harvest with an added trophy component. However, high water in 1996 and 1997 caused a decline in kokanee abundance, and an imbalance in the predator/prey relationship. To rebalance predator and prey, managers reduced the numbers of Chinook salmon stocked, limited the number of wild-spawn Chinook salmon redds, closed the fall fishery for kokanee to protect spawning adults, and adjusted the harvest limit on kokanee. Kokanee numbers rebounded, affording the opportunity to resume trophy Chinook management. Although the current fishery appears to be on target to achieve management objectives, a retrospective look at thirty years of management history demonstrates the difficulty in consistently maintaining a balance between these two populations. As fishery managers develop the multi-year fishery management plan for 2012 and beyond, the expectations of a balanced fishery as well as management alternatives will be primary topics of discussion with anglers and other stakeholders.

Session D-4: Fish Studies 1

Thursday, October 27
8:30 am – 10:00 am
Room 206C

Lake Habitat Improvements for the Machado Lake Ecosystem Rehabilitation Project

Brian Murphy[1], Matt Petty[1], Alfred Mata[2] and Stephanie Bache[3]
[1]CDM, Denver, Colo. [2]City of Los Angeles, Los Angeles, Calif. [3]Parsons, Dallas, Tex.

Abstract
Ken Malloy Harbor Regional Park (KMHRP) is located in the Wilmington community of the City of Los Angeles. KMHRP has one of the most diverse habitats in the region and features a 40-acre lake (Machado Lake). However, water quality in Machado Lake has deteriorated through excessive external and internal loading of organic matter, nutrients, sediment, and trash. Results of excessive loading include seasonal algal blooms, nuisance aquatic plant species, increased water temperatures, and decreased lake volume. The eutrophic conditions deteriorate the lake's aesthetic quality, attractiveness for recreation, and usefulness as aquatic habitat. Machado Lake is listed on the EPA 303(d) list of impaired water bodies. Residents of Los Angeles approved Proposition O, a $500-million bond measure, in 2004 to improve water quality for impaired water bodies such as Machado Lake. The broad goal of the Machado Lake Ecosystem Rehabilitation Project is to improve the water quality conditions, visual aesthetics, and the biological diversity of the ecosystem. The lake currently lacks biological diversity necessary to support and sustain aquatic species. Therefore, the goal of lake habitat improvements is to re-establish important missing or altered aquatic habitat. The general approach taken is to identify fish habitat needs for selected species likely to be utilized for a Machado Lake recreational fishery, such as crappie, bluegill, and largemouth bass. Habitat improvements considered appropriate to Machado Lake include natural and artificial structures; spawning beds, rock piles, trees, brush piles, large woody debris, lake bottom relief, vegetation (emergent and submerged), floating islands, and littoral zone enhancements.

Our Resilient Reservoirs: Assessing the Robustness of a Fish Community after a Major Environmental Event

Jason Yarbrough, Tyler Baker, Kurt Lakin, Donny Lowery and John Justice
Tennessee Valley Authority, Chattanooga, Tenn.

Abstract
On December 22, 2008, a dike retaining fly ash and bottom ash in an 84-acre cell complex from Tennessee Valley Authority's Kingston Steam Plant failed. An estimated 5.4 million cubic yards of ash was released into the adjacent Emory River, with some of the ash deposits extending as far as 3.5 miles upstream of the Plant and as far as 5.8 miles downstream of the Tennessee River confluence with the Clinch River. A comprehensive assessment of the ecological consequences from the ash spill was initiated soon after the incident. Included in this assessment were studies of both fish communities and the sport fish populations. The fish community was examined at 3 sites in the fall of 2009 and 2010. Two of those sites (Clinch River Miles 1.5 and 4.4) also were sampled in 2001, 2003, 2005 and 2007. An additional fish community study site was established on the Emory River at mile 2.5 in 2009 to evaluate immediate near-field effects of the spill. Sport fish populations (*i.e.*, largemouth bass) were examined at 2 sites in the spring of 2009, 2010 and 2011. One of those sites (Clinch River Mile 2.5) was sampled as part of TVA's Valley-wide Monitoring Program in 2002, 2003, 2004, and 2005. An additional site was established on the Emory River at mile 2.5 in 2009 to evaluate immediate near-field effects of the spill. Fish community and sport fish population results indicate post spill abundances, species richness, and condition of fish are similar to those observed prior to the spill.

*The Role of the Opossum Shrimp (*Mysis diluviana*) in the Food Web of Lake Pend Oreille, a Large (380 km^2) and Deep (>350 m) Oligotrophic Lake in Northern Idaho, USA*

Timothy Caldwell and Frank Wilhelm
Univ. of Idaho, Moscow, Id.

Abstract
It is well known that invertebrate predators can structure the size and species composition of aquatic food webs via predation. In the Pacific Northwest, the opossum shrimp, *Mysis diluviana*, was widely introduced into lakes in the late 1960s as supplemental fish food. However, because of their omnivorous diet they often disrupted the food web of the lakes into which they were stocked because they competed with fish fry for zooplankton prey. We used gut content analysis to examine the seasonal diet of *M. diluviana* to quantify predation rates, estimate effects on kokanee salmon (*Oncorhynchus nerka*), and compare the diet of mysids between the deep and shallower basins in Lake Pend Oreille. A prey-specific index was used to describe mysid feeding habits and plotted against time to examine seasonal trends. While the lake was isothermal, mysids selected food opportunistically and consumed copepods, diatoms, and rotifers. However, when the lake was stratified, mysids overwhelmingly selected cladocerans. During late spring and early autumn, the ratio of mysid consumption to production of cladocerans was < 1, providing evidence that mysids probably regulate the abundance of cladocerans when the lake is not stratified. The suppression of cladocerans coincides with the appearance of kokanee fry which likely affects their growth and survival. Our data suggest that to increase kokanee survival, the release of hatchery-reared kokanee fry should be delayed until after the lake is well-stratified and cladoceran densities are high.

Tackling Total Dissolved Gas in the Lower Clark Fork River - Lake Pend Oreille System, Idaho

Joseph M. DosSantos, Timothy J. Swant and Guy E. Paul
Avista Corporation, Noxon, Mont.

Abstract
Avista Corporation (Avista) owns and operates the Cabinet Gorge Hydroelectric Development located in Idaho approximately one-half mile downstream of the Montana border and eight miles upstream of Lake Pend Oreille, a large, deep, freshwater lake. Other hydroelectric developments exist both upstream of Cabinet Gorge in Montana, and downstream in Idaho and Washington. After a successful collaborative relicensing process, FERC issued a new 45-year operating license in 2000. As part of this new license, Avista is required to address, through an adaptive management approach, the issue of elevated levels of total dissolved gas (TDG) downstream of Cabinet Gorge during periods of high flows and spill. With the assistance of interested stakeholders, Avista finalized a comprehensive Gas Supersaturation Control Program (GSCP) in 2004. Implementation of the GSCP has resulted in changes to spill gate operating procedures in order to avoid and minimize any increase in TDG, an annual TDG monitoring and reporting program, and the evaluation of over twenty structural modifications to control gas supersaturation downstream of Cabinet Gorge. The first of these modifications could be in place as early as 2013. Another important component of the GSCP is its ongoing annual mitigation program, which has allowed for aggressive fisheries management activities on Lake Pend Oreille in order to preserve important native fish populations.

Session E-1: Cyanobacteria Toxin Accumulation

Thursday, October 27
10:30 am – 12:00 pm
Room 205

Efforts to Screen Microcystins in Fish from Western Washington Lakes with Toxic Cyanobacteria Blooms

Joan Hardy[1], Art Johnson[2] and Kathy Hamel[2]
[1]Washington Dept. of Health, Olympia, Wash. [2]Washington Dept. of Ecology, Olympia, Wash.

Abstract
Recent reports of microcystins detected in fish muscle tissue raised concerns regarding potential human health impacts from anglers consuming fish caught in regional lakes. Western Washington has documented toxic blooms in numerous lakes that contain various recreational fish species. In 2008, Ecology investigated microcystin and anatoxin-a levels in fish collected from six lakes. No anatoxin-a was detected. Microcystin from homogenized tissue was analyzed using an ELISA test; every sample tested contained microcystin. Highest muscle concentration was 73 μg/kg in yellow perch from Ketchum Lake. Because results were highly variable, the microcystin tests were repeated in 2009 and expanded to include an analysis by liquid chromatography/mass spectrometry (LC/MS). Lake bottom sediments were also analyzed by LC/MS.

Currently, partners from Florida, California, Washington, and Georgia are working together to determine what results from various methods represent and recommend the best chemical methods to use in the future.

Cylindrospermopsis raciborskii*: Abundance and Toxin Accumulation in Harvested Food Products*

Laura Dávalos-Lind[1,2], Owen Lind[1,2], John Berry[3] and A. Jaja[3]
[1]Baylor Univ., Waco, Tex. [2]Universidad Veracruzana, Xalapa, Veracruz, Mexico [3]Florida International Univ., Miami, Fla.

Abstract
The purpose of this presentation is to report on the effects of a toxin-producing cyanobacterium in a lake whose fishery is an important component of the local economy. *Cylindrospermopsis raciborskii* is a tropical, toxin-producing, cyanobacterium that is presently extending its range across temperate regions of the earth. In tropical Lake Catemaco, Mexico it is present as a near-monoculture year-round. Abundance (annual mean = 4.4 $\times$ 10^8 trichomes l^{-1}) exceeds any reported in the literature. The individual trichomes are exceptionally small and polymorphic, both factors being determined by ambient nitrogen. In this presentation we present data from a food-web study of toxins. Two toxins, cylindrospermopsin, and SXT/PST, are present in fishes and snails. Both of these are harvested for sale and consumed locally. Toxins are below detection limits without concentration in the laboratory, but have SXT/PST bioaccumulation factors (BAF) of 78 in snails, up to 134 in one fish species, and 391 in copepods. Several fish species assumed to be planktivores have been found with snails in the stomach, suggesting an alternate pathway for toxin transfer.

Cyanobacteria and Fish: A Toxic Health Threat to Tribal Communities?

★Ellen P. Preece and Barry C. Moore
Washington State Univ., Pullman, Wash.

Abstract
Noxious cyanobacteria (blue green algae) blooms have become a serious environmental problem worldwide. There is indication that the prevalence and toxicity of cyanobacteria are increasing throughout the United States. Direct exposure or consumption of water with cyanotoxins is a known health hazard, but there is a fundamental gap in understanding trophic transfers of these toxins and their potential accumulation in aquatic animals such as fish. For individuals in tribal and other communities that depend on local fish sources as a substantial part of their diet, toxin accumulation in fish may be of particular concern. Our study addresses the most common cyanotoxin, the hepatotoxin microcystin (MYCYST), known to cause fatalities in humans, fish and domestic livestock. We collected brook trout (*Salvelinus fontanels*) and rainbow trout (*Oncorhynchus mykiss*) from four lakes on the Colville Confederated Tribal reservation in northeastern Washington, where recent increases in cyanobacteria blooms have been noted. Based on sound analytical procedures, preliminary studies have shown some accumulation of MYCYST in fish muscle and that common cooking methods may enhance biological availability of the toxin.

The Calculus of Risk: How Do We Weigh Lake Recreational Benefits Against Potential Exposures to HABs?

Curtis Cude
Oregon Health Authority, Portland, Oreg.

Abstract
Lakes and reservoirs provide recreational opportunities, public and private sources of drinking water, aesthetic qualities and other societal needs. At the same time, these water bodies harbor a variety of microorganisms, including cyanobacteria, which can lead to illness, injury and death to humans, domestic animals and wildlife. Given continued nutrient loading and environmental changes, we expect the occurrence of harmful algae blooms (HABs) to increase leading to increased risk of cyanotoxin exposure. A variety of federal, tribal, state and local agencies manage these aquatic resources and surrounding lands with overlapping and sometimes competing missions. Local economies depend on the attraction of recreational dollars provided by these resources. The emergence of HABs as a public health concern threatens the current balance of resource management and economic benefit. Posting a public health advisory for HABs leads to dramatic decreases in recreational visits and revenue regardless of whether public health action included closing the lake or beach to recreational use. Our challenge is to establish a new balance between public health protection and economic benefit. How can we work together to improve and economize environmental assessment? How might we predict when blooms will become toxic and improve advisory precision? How might we improve our understanding of the risk of exposure to contaminated water, fish, and produce? How do we calculate the new balance of risk to benefit? This session will not provide those answers, but will begin the dialog to establish this calculus of risk.

Session E-2: Floating Wetlands and Streambeds

Thursday, October 27
10:30 am – 12:00 pm
Room 206A

Floating Treatment Streambeds to Enhance Fisheries and Mitigate Lake Eutrophication

Mark Reinsel[1], Bruce Kania[2] and Frank Stewart[3]
[1]Apex Engineering, PLLC, Missoula, Mont. [2]Floating Island International, Inc., Shepherd, Mont. [3]Stewart Engineering, Bozeman, Mont.

Abstract
In a novel approach to address nutrient loading, a simple, cost-effective floating treatment streambed (FTS) shows the ability to transform agricultural effluent into world-class fish habitat. An ongoing experiment to monitor efficacy of the FTS is being conducted at a research lake near Shepherd, Montana, with the objective to determine whether biofilm-based microbes can enhance fish productivity along with providing nutrient removal. Water is aerated and pumped through the FTS while being exposed to sunlight and air, infiltrates through a matrix constructed of post-consumer polymer fibers and discharges at the FTS outlet. After 17 months, water clarity in the lake had improved from 14 inches of visibility to as much as 131 inches. The water temperature gradient was simultaneously reduced, creating a larger "livable" zone for fish. Throughout 2010, a favorable temperature/dissolved oxygen zone from

the water surface to at least 12 feet deep was maintained as potential Yellowstone cutthroat trout habitat. Cutthroat trout, crappie and perch have all flourished, with this being near the eastern edge of the cutthroat's range. The new aeration scheme improves lake water quality by incorporating dissolved phosphorus and nitrogen into the aquatic food web, in the form of periphyton, while limiting the growth of deleterious algae. Total phosphorus concentrations are reduced from about 0.6 mg/L to 0.2 mg/L, while total nitrogen concentrations decrease from about 0.5 mg/L to less than 0.1 mg/L.

Floating Islands Provide Fish Spawning Habitat

Bruce Kania[1], Laddie Flock[2] and Mark Reinsel[3]
[1]Floating Island International, Inc., Shepherd, Mont. [2]Floating Islands West, LLC, Lockeford, Calif. [3]Apex Engineering, PLLC, Missoula, Mont.

Abstract
Four floating islands were evaluated recently for enhancing fish spawning habitat in Montana and New Mexico. In the most recent project, at Floating Island International's research lake near Shepherd, Montana, Yellowstone cutthroat trout eggs were introduced to a floating treatment streambed in April 2011; the eggs have hatched and the trout fry appear to be thriving. This is significant because Montana officials have made two unsuccessful attempts to sustain cutthroat populations in a nearby stretch of the Yellowstone River. This project demonstrates the potential ability to develop self-sustaining salmonid populations in land-locked waterways. In the second project, a subgroup of the New Mexico Bass Fishing Association undertook a project in 2009 to increase the bass population in Elephant Butte Lake. A floating island was of particular interest because lakes in this area are used for irrigation, with bass often losing their land-based spawning grounds when lake levels drop. The youth group partnered with the New Mexico Game and Fish Department, marina owners, and other local interested parties by working with Floating Islands West (FIW), which has developed floating botanical gardens to increase fish and other wildlife habitat, along with improving water quality. FIW designed a portable spawning bed for fish that includes a cover and protection for the fry. The other locations where floating islands were deployed for spawning habitat are Lake Elmo in Billings, Montana and Tingley Lake in Roswell, New Mexico. Data and photographs from all four case studies will be presented.

Canal Restoration Using Wetland and Stormwater Treatment Systems in Ningbo, China

Rob Zisette[1], Mark Merkelbach[1], Rebecca Dugopolski[1] and Galen Fulford[2]
[1]Herrera Environmental Consultants, Seattle, Wash. [2]Organica Water, Forres, Scotland, UK

Abstract
The City of Ningbo, China is building a New Town in a 16-km^2 agricultural/industrial area that drains to the sea by a network of polluted canals. The design of this new metropolis emphasizes sustainability with an eco-corridor located along 3.3 km of the canal system. One of the biggest challenges is how to improve canal water quality within the New Town without having any control over upstream pollution sources or the canal hydraulics that vary greatly with irrigation/industrial withdrawals and tide gate operations. Restoration of water quality in the eco-corridor canals requires an integrated approach to reduce noxious algae blooms caused by high nutrients (>1 mg/L TP and >15 mg/L TN), and resulting in anoxic conditions, high BOD (>5 mg/L), and ammonia toxicity (>5 mg/L). The primary treatment approach is the installation of 70 floating wetland systems that pump aerated canal water over an extensive synthetic root system to both enhance nutrient/BOD removal by microbial growth on the root system and reduce internal phosphorus loading from anoxia. Additional nutrient removal is achieved by pumping canal water to cascading wetland systems constructed along the canal shoreline. Bioswales and rain gardens are used to reduce stormwater nutrient loadings from the New Town. This presentation will focus on how these canal restoration components were designed to meet water quality standards and provide a high quality eco-corridor for the New Town.

Evaluation of Small-Scale In-Lake Management Techniques for Westtown Lake, a Shallow Impoundment in Chester County, Pennsylvania

Fred Lubnow
Princeton Hydro, LLC, Exton, Pa.

Abstract
Westtown Lake is a 5.9 ha lake located on the Campus of the Westtown School located in the Township of Westtown, Chester County, Pennsylvania. The lake serves as one of the main features of the campus and historically has been the site of various recreational activities ranging from fishing to ice skating and boating. In addition to recreational activities that take place in and around the lake, it serves as an educational tool for the several departments of the school. Westtown School was awarded grant from the Pennsylvania Lake Management Society to implement an evaluation some innovative in-lake management techniques, specifically designed for shallow ecosystems such as Westtown Lake. The first technique was the use of an amphibious harvester called a Truxor DM 5000, designed to harvest nuisance submerged vegetation from lakes were water depths are less than a 1meter. The second technique was to install a series of Floating Wetland Islands to provide a means of assimilating nutrients directly from the water column. Both techniques were implemented over the 2011 growing season and included quantifying their nutrient (phosphorus and nitrogen) removal capacities. This presentation will review the results for these in-lake management techniques.

Session E-3: Lake Mead

Thursday, October 27
10:30 am – 12:00 pm
Room 206B

Long Term Aquatic Resources Monitoring and Research Plan for Lakes Mead and Mohave, Lake Mead National Recreation Area

Kent Turner
Lake Mead National Recreation Area, Boulder City, Nev.

Abstract
Lakes Mead and Mohave, Nevada and Arizona, are critically important to overall management of the Colorado River and to life within the Southwestern United States. Lake Mead alone can store approximately two years average runoff of the Colorado River, and this storage is critical to beneficial uses within the lower Colorado River region, including drinking water storage for over 23 million people, water storage for over 2.5 million acres of irrigated croplands, electricity generation of over 4 billion kilowatt hours annually, and provision of

a diversity of high quality water based recreation for over 8 million visitors annually. Lakes Mead and Mohave face a number of threats to overall water quality and water resources, from increasing urbanization along tributaries, to invasion by the invasive quagga mussel, to uncertainties related to water availability from drought and climate change. This presentation will provide an overview of an over six year interagency monitoring effort that resulted in development of mutual monitoring objectives and articulation in 2010 of a Long Term Limnological and Aquatic Resources Monitoring and Research Plan for Lakes Mead and Mohave. The paper will summarize the monitoring objectives and summarize the content of the plan. The presentation will summarize recent events in overall interagency management of Lake Mead, and present potential for moving forward with the long term plan in the face of an uncertain funding climate.

A Detailed Phosphorus Budget for Lake Mead

Imad Hannoun[1], Li Ding[1], Todd Tietjen[2], Peggy Roefer[2], E. John List[1] and Jim Devlin[3]
[1]Flow Science Incorporated, Harrisonburg, Va. [2]Southern Nevada Water Authority, Las Vegas, Nev. [3]Clean Water Coalition, Henderson, Nev.

Abstract
Total and dissolved phosphorus annual budgets were developed for Lake Mead for 2007 and 2008. Lake Mead is the largest fresh water reservoir in the United States and has multiple uses, including recreation, water supply, water-reuse, and providing a habitat for wild-life. Previous studies have indicated that phosphorus is the growth-limiting nutrient for phytoplankton and extensive efforts have been undertaken to reduce phosphorus loading by regional wastewater treatment facilities. The development of a phosphorus budget for the lake is a natural step for understanding the spatial and temporal distributions of the loadings, and their potential to impact water quality throughout the lake. The presentation will show detailed calculations for the amount of phosphorus (particulate and dissolved) entering and leaving individual basins and the lake overall, as well as the mass contained in the water column and the amount retained within the sediments. The results show a significant seasonal pattern in the amount of ortho-phosphorus retained in the lake. In summer, most of the phosphorus is used by algae, and eventually settles into the sediments. In winter, a smaller fraction of phosphorus is retained in the lake. Overall the lake is a sink for phosphorus with the majority of the phosphorus entering through the Colorado River being retained within the reservoir, mostly in the upstream basin. The results of this study proved to be a valuable resource for understanding the interactions between the various sources of phosphorus and provide insights into how the existing extensive field monitoring program could be optimized.

Determining the Chlorophyll Yield of Phosphorus Additions to Lake Mead Phytoplankton

Todd Tietjen
Southern Nevada Water Authority, Las Vegas, Nev.

Abstract
Phytoplankton in Lake Mead are primarily controlled by the availability of phosphorus. Nitrogen to phosphorus ratios in the lake are ~250:1 with soluble phosphorus concentrations below 2 μg P L^{-1} in the open waters of the lake and below 10 μg P L^{-1} near the downstream tributaries. Chlorophyll concentrations follow a similar pattern with values below 2 μg L^{-1} in the open waters and between 5 and 20 μg L^{-1} near the downstream tributaries. During the past decade, water quality has generally improved as wastewater treatment in the Las Vegas Valley has reduced the loading of phosphorus to the Las Vegas Wash. Simultaneously, drought has reduced water levels in Lake Mead, reducing the in-lake dilution of anthropogenic nutrients. In an attempt to quantify the impact of future phosphorus conditions, a series of algal growth assays were conducted to determine the chlorophyll yield per unit phosphorus. Water samples were collected from three locations in the lake at monthly intervals and supplemented with phosphorus at concentrations sufficient to overcome nutrient limitation. The accumulation of chlorophyll and the decrease in phosphorus concentrations were measured daily for 5 days to determine rates of chlorophyll production and phosphorus uptake. In general, the rates of chlorophyll production and phosphorus uptake were higher at the location nearer the Las Vegas Wash and lowest in the open waters of the lake. Information from these experiments will be used to update simulation modeling of the lake in order to determine the potential impact of changes in phosphorus loading.

Phytoplankton Community Dynamics in Lake Mead, Nevada (2007–2011): A Multivariate Analysis

John Beaver[1], Kyle Scotese[1], Catherine Teacher[1], Becky Blasius-Wert[2], Janet Kirsch[2], Claudia Tausz[1] and Chris Holdren[3]
[1]BSA Environmental Services, Beachwood, Oh. [2]US Bureau of Reclamation, Boulder City, Nev. [3]US Bureau of Reclamation, Denver, Colo.

Abstract
We investigated the phytoplankton community composition in all three basins of Lake Mead using quarterly data from approximately 250 samples collected from winter 2007 through winter 2011. The phytoplankton data set was initially reduced to 67 taxonomic groupings based on at least one occurrence constituting 5 percent of the total biovolume of a sample. Groupings of similar algal composition were identified using both hierarchical cluster analysis and principal component analysis (PCA) followed by canonical correlation analysis (CCA) on the proportions of 67 taxonomic groupings. The hierarchical cluster analysis and the PCA/CCA analysis produced similar results. Characteristic phytoplankton communities during winter and spring periods were identified with relatively low diversity and biovolume, dominated by small diatoms and cryptomonads, and corresponded to the largest *Daphnia* biomass. Phytoplankton community biovolume was generally higher in summer and fall periods with higher proportions of cyanobacteria and dinoflagellates. Canonical correlation analysis indicated that the taxonomic composition of the phytoplankton community during the winter and spring was strongly associated with phosphorus and nitrogen inputs near shallow inflow stations, and elevated temperature during the summer and fall. Our approach allows for data reduction to a more understandable graphic format and overcomes the problems of analyzing unwieldy large phytoplankton data sets. Although Lake Mead has experienced drought conditions since 2000 and quagga mussel invasion since *ca.* 2003, our data suggest historic patterns in phytoplankton succession remained intact for the study period.

Session E-4: Fish Studies 2

Thursday, October 27
10:30 am – 12:00 pm
Room 206C

Using Chemical and Isotopic Tracers to Track Biogeochemical Processes Under Ice Cover at Georgetown Lake, Montana

★William Henne[1], Chris Gammons[1] and Simon Poulson[2]
[1]Montana Tech of the Univ. of Montana, Butte, Mont. [2]Univ. of Nevada, Reno, Reno, Nev.

Abstract
Georgetown Lake is a shallow (5 to 10 meter), man-made lake and prodigious trout fishery in southwestern Montana. Previous studies have shown that severe DO depletion occurs throughout the lake each winter under ice cover. Here we report the results of monthly chemistry and stable isotope sampling at two sites through the winter of 2010-2011. By mid-winter, both sampling sites had established a robust vertical profile with the following characteristics: a) a rapid lowering of dissolved oxygen (DO) concentration to values near zero about 1 meter above the bottom, with a simultaneous increase in δ^{18}O-DO; b) an increase in alkalinity, CO_2 partial pressure, and dissolved inorganic carbon (DIC) with depth, with a decrease in δ^{13}C-DIC; and c) an increase in ammonium, H_2S, silica, phosphate, Ca^{2+}, Mn^{2+} and Fe^{2+} towards the lake bottom. These trends are consistent with a combination of aerobic and anaerobic respiration, coupled with dissolution of calcite in lake sediment. However, the shallower of the two sites investigated had a lower slope of δ^{18}O-DO versus DO concentration, suggesting that below-ice photosynthesis was partly offsetting consumption of DO by respiration. Photosynthetic, purple, H_2S-oxidizing bacteria were observed at the shallow site, but not at the deeper site. The ability of photosynthesis to continue during the 6+ months of ice cover could well be a critical reason why fish survive the winter season in Georgetown Lake. However, the lake is near an ecological tipping-point, and is vulnerable to increased residential development and associated nutrient loads.

Evaluating Lake Oxygenation Using Changes in Salmonid Movement

★Brian Lanouette[1], Barry Moore[1] and Ed Shallenberger[2]
[1]Washington State Univ., Pullman, Wash. [2]Confederated Colville Tribes, Nespelem, Wash.

Abstract
Hypolimnetic anoxia and warm surface temperatures during summer stratification can significantly reduce cold-water fish habitat. The resulting "habitat squeeze" can increase fish stress, susceptibility to infection, reduce growth rates, and can cause summer mortality. Such a reduction in optimal habitat has been noted in North and South Twin Lakes in northeastern Washington. In 2008, a diffused line oxygenation system was installed in North Twin Lake to eliminate hypolimnetic anoxia and enhance cold-water salmonid habitat. The system was operational during summer stratification season in 2009 and 2010. We evaluated post-oxygen temperature and dissolved oxygen (DO) in North Twin; South Twin provided an un-oxygenated "reference." Biologic responses, including changes in *Chaoborus* distribution and salmonid habitat utilization were evaluated. Habitat usage was estimated using a combination of archival tags, gillnetting, and hydroacoustic methods. The oxygen system eliminated summer hypolimnetic anoxia in North Twin for 2009 and 2010. Archival tag results ($p = 0.0308$) indicated increased use of the hypolimnion by salmonids in North Twin during oxygenation. Gillnetting and hydroacoustic analysis also revealed salmonids occupying deeper depths in North Twin during summer stratification. More *Chaoborus* were found in the benthic sediments ($p = 0.022$) and less in the water column ($p = 0.035$) of oxygenated North Twin compared to un-oxygenated South Twin. This change indicated that *Chaoborus* in North Twin Lake potentially exhibit altered diel migration patterns in response to increased salmonid presence and predation in the hypolimnion. Increased use of hypolimnetic cold-water habitat demonstrated that salmonids utilize the hypolimnion when oxygenated.

The Influence of Hypolimnetic Oxygen Depletion on Diet Patterns of Brook Trout Using Stable Isotope Analysis in Dimictic Owhi Lake

★Amy A. Martin[1], Barry C. Moore[1], Benjamin K. Cross[1], Ellen P. Preece[1], Andrew W. Child[1] and Edward Shallenberger[2]
[1]Washington State Univ., Pullman, Wash. [2]Confederated Tribes of the Colville Reservation, Nespelem, Wash.

Abstract
Owhi Lake is a dimictic lake located in north central Washington on the Colville Confederated Tribes' reservation. Owhi provides recreational opportunities for tribal members and serves as the hatchery brood stock source for eastern brook trout. However, these resources are threatened by recent severe cyanobacteria blooms and low dissolved oxygen in the summer hypolimnion. Indications are that mortality rates in Owhi fish are high. In response to concerns about water quality and fish health in Owhi, we are conducting a study of summer habitat conditions using stable isotope analysis (SIA) to assess how low hypolimnetic DO and high epilimnetic temperatures may influence fish diets. We are using isotopic signatures from both muscle and liver fish tissues to determine long term vs. short term dietary trends. SIA data is applied to the IsoSource model to quantify ranges of dietary importance for up to ten potential food sources. Stomach content analysis will be used to support SIA findings. Recommendations for future fish and water quality management options are also discussed.

Monitoring of Freshwater Fish in Florida Lakes Using Electrofishing: Lessons Learned

Mark Hoyer, Jason Bennett and Dan Canfield
Fisheries and Aquatic Sciences, School of Forest Resources and Conservation, Univ. of Florida/IFAS, Gainesville, Fla.

Abstract
Electrofishing was used in 30 Florida lakes to monitor fish communities over an eight-year period. Six 10-minute electrofishing transects were used annually per lake to estimate the catch per unit effort (CPUE gm/hr) of total fish, sport fish, and each individual fish species. A variance components analysis using CPUE as the dependent variable and lake, year within lake, and transect within year and lake as independent variables showed that in almost every case transect accounted for over 50% of the variance in CPUE. The estimated variance from this sampling effort showed that the average number of electrofishing transects needed to estimate total fish and sport fish CPUE within 20% of the mean at a confidence of 95% would have to double and triple the current effort, respectively. Lake trophic status, estimated with chlorophyll concentrations, was also monitored showing a direct positive relation with total and sport fish even with low sampling effort, giving a general ability to estimate CPUE in Florida lakes.

After accounting for lake trophic status, estimates of aquatic plant abundance did not account for more variance in CPUE estimates because the sampling effort was not rigorous enough for multivariate analyses. Eight years of repeated sampling yielded an asymptote for cumulative species richness. Lake surface area and altitude were directly and inversely related to species richness, together accounting for 43% of the variance in species richness. Lake managers interested in monitoring fish populations should conduct a pilot study to estimate sampling frequency needed to answer stated objectives.

Session E-5: Zebra / Quagga Mussels

Thursday, October 27
10:30 am – 12:00 pm
Room 206D

Quagga Mussels in the West: The Promises, Perils, and Politics of Early Detection

Chris Holdren and Denise Hosler
Bureau of Reclamation, Denver, Colo.

Abstract
Since the discovery of adult quagga mussels in Lake Mead in January 2007 there has been a great deal of concern about the spread of these organisms. Considerable effort has been made to improve early detection methods to give affected areas more time to prepare for a mussel invasion. Early detection can theoretically give water districts and planning agencies up to three years to prepare budgets and action plans for dealing with mussels. Unfortunately, the knowledge that mussels may be present may also bring additional requirements or lead to changes in existing programs that are not always welcome. The issue is further complicated because each state has different ideas as to what constitutes a positive detection and the western quagga mussels do not appear to have the same environmental constraints as quagga and zebra mussels in the east. It is likely that important information about conditions required for a successful invasion and what constitutes suitable mussel habitat are being lost as a result of these inconsistencies. We will use the Bureau of Reclamation's experience and extensive data set to provide examples of these issues.

*The Use of Whole Lake Manipulations to Manage Quagga Mussels (*Dreissena bugensis*) in Western U.S. Drinking Water Reservoirs*

William Taylor, Ricardo De Leon and Richard Losee
Metropolitan Water District of Southern California, La Verne, Calif.

Abstract
Since reporting of quagga mussels (*Dreissena bugensis*) in Lake Mead January 2007, they have spread down the Colorado River, and been carried about 350 miles via the MWDSC conveyance and storage system designed to deliver water to about 19 million people in southern California. Maintenance chlorination of the Colorado River Aqueduct on a 24/7 basis and desiccation during shutdowns achieved reasonable control of adult mussel populations along 240 miles of open aqueducts, cut and cover tunnels and pipelines, and has significantly reduced adults in three of five pumping plants. Four source water reservoirs, not protected by chlorination, have become infested with large breeding populations. Successful attempts to exterminate or manage invasive mussels in lakes and reservoirs are rare. In this project, two reservoirs, Lake Mathews (180,000 a-f) in 2008 and Lake Skinner (40,000 a-f) in 2008 and 2010, were operated to enhance stratification and the development of anoxia to take advantage of natural processes to kill mussels in the anoxic zone and thus reduce breeding populations. The second phase was to reduce lake elevation to kill mussels via desiccation, successful only in Lake Mathews due to operational constraints at Lake Skinner. Both reservoirs had to remain operational during the studies. All mussels exposed to anoxia for 2-3 weeks were killed in both lakes. Mussels exposed to ever decreasing concentrations of oxygen had the highest survival rates in the water column just above the anoxic zone. The limitations and benefits of this approach in water supply reservoirs will be discussed.

*Using Shell Morphology to Quantitatively Identify Freshwater Planktonic Mussel Larvae in Early Detection Monitoring Efforts for Zebra and Quagga Mussels (*Dreissena polymorpha *and* D. rostriformis bugensis*)*

Steve Wells and Mark Sytsma
Portland State Univ., Portland, Oreg.

Abstract
Accurate larvae identification is important for early detection monitoring for zebra and quagga mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*). Incorrect and ambiguous results confuse policy makers and managers, and complicate other agency efforts. Plankton monitoring targets mussel larvae and samples are analyzed using cross-polarized light microscopy, polymerase chain reaction assays (PCR), and image recognition software. Plankton analysis, regardless of analytical technique, is difficult. Plankton analysis is confounded by dense matrices, degraded specimens, and confusion with morphologically similar species such as corbicula (*Corbicula fluminea*) and dark false mussels (*Mytilopsis leucophaeata*). Larvae from five populations were compared to determine the efficacy of using shell morphology to quantitatively differentiate corbicula, dark false, zebra and quagga mussels. Larvae were collected from lakes with known populations, and identification was verified using PCR. A combination of plots, contingency tables and regression trees were used to identify morphological features, or combinations of features, used to separate the species at various larval stages. Based on sampled populations, corbicula can be readily separated using shell morphology. Distinct differences in morphology are lacking between dark false, zebra and quagga mussels, although, combinations such as shell length and hinge length can be used, in most cases, to differentiate dark false mussels. Zebra and quagga mussels were not readily separated using shell morphology. These results suggest that shell morphology can be used to separate most bivalve larvae encountered in North American freshwater plankton samples, but that molecular techniques are required to identify *Dreissena* spp. larvae to the species level.

Dreissenid Veliger Detection and Enumeration Technology Enhanced to Improve Reliability and Sample Processing Using a Continuous Imaging Particle Analyzer (FlowCAM)

Harry Nelson, Matthew Duplisea and Robert Grimm
Fluid Imaging Technologies, Yarmouth, Me.

Abstract
In 2008 Fluid Imaging Technologies adapted their imaging particle analyzer FlowCAM for use in the detection and identification of zebra and quagga mussel veligers by offering a version of the FlowCAM equipped with Cross Polarizing optical filters for the purpose of detecting the natural birefringence seen on veligers. A number of organizations in the Western U.S. have since been using the FlowCAM in their veliger monitoring activities. Included among these organizations is the Bureau of Reclamation (BOR) who have recently entered into a "Cooperative Research and Development Agreement" (CRADA) with Fluid Imaging Technologies to further enhance the technology for the express purpose of detecting, identifying, and enumerating Dreissenid veligers. With input from BOR, engineers at Fluid Imaging have taken the proven FlowCAM technology and improved its ability to detect and identify veligers while at the same time increase its sample volume processing capability. A review of the technological improvements along with supporting data will be discussed.

Session F-1: Cyanobacteria in Washington

Thursday, October 27
1:30 pm – 3:00 pm
Room 205

Evaluating Toxic Cyanobacteria in Washington State

Joan Hardy[1], Kathy Hamel[2] and Beth leDoux[3]
[1]Washington Dept. of Health, Olympia, Wash. [2]Washington Dept. of Ecology, Olympia, Wash. [3]King County Dept. of Natural Resources, Seattle, Wash.

Abstract
Toxic blue-green algae (cyanobacteria) are an emerging public health concern in Washington's recreational waters, causing illnesses to humans, pets, and wildlife. Washington Departments of Health (DOH) and Ecology works with local health partners and lake managers to track toxic blooms and related animal and human health incidents throughout the state. To evaluate toxic blooms, DOH developed provisional human health guidance values for microcystins (6 μg/L) and anatoxin-a (1 μg/L), and is in the process of guidance development for cylindrospermopsins and saxitoxins. Guidance values have been incorporated into a protocol for lake managers to provide a consistent approach to toxic blooms. Microcystins were observed above the guidance value in 18 lakes in 2008, 19 lakes in 2009, and 14 lakes in 2010 (maximum = 18,700 μg/L). During the same period, anatoxin-a was observed above the guidance value in 8 lakes in 2008, 4 lakes in 2009, and 5 lakes in 2010 (maximum 172,640 μg/L). Cylindrospermopsin (maximum = 0.106 μg/L) and saxitoxin (maximum = 193 μg/L) have each been observed in two Washington lakes. As part of a cooperative agreement with Centers for Disease Control and Prevention entitled "Harmful Algae Bloom-related Illness and Surveillance System" (HABISS), a third season of monitoring 30 Puget Sound lowland lakes for the four cyanotoxins began in June 2011. Outreach efforts in 2011 regarding dangers of exposure to toxic blooms are focused on animal owners and veterinarians.

Regional Examination of Harmful Algal Blooms: Findings at the Half Way Point

Beth leDoux[1], Marisa Burghdoff[2], Gene Williams[2], Lindsay Tuttle[3], Ray Hanowell[3] and Joan Hardy[4]
[1]King County WLRD, Seattle, Wash. [2]Snohomish County SWM, Everett, Wash. [3]Tacoma Pierce County Health Dept., Tacoma, Wash. [4]Washington Dept. of Health, Lacey, Wash.

Abstract
Toxic cyanobacterial blooms have been documented in numerous Washington State lakes during the past 30 years, and the rate of occurrence appears to be increasing over time. In response to increased toxic blooms, a partnership was formed between Washington Departments of Health and Ecology, King, Pierce, and Snohomish Counties, and Seattle University to address associated environmental and public health issues. The partnership is in the third year of a five-year cooperative agreement with the Centers for Disease Control. One goal of the agreement, entitled "Regional Examination of Harmful Algal Blooms" (REHAB), is for partners and volunteers to monitor 30 lakes for four freshwater toxins (microcystin, anatoxin-a, cylindrospermopsin and saxitoxin) on a routine basis. Other parameters measured include phytoplankton, weather, clarity, and public use. This effort has improved our understanding of HAB frequency and associated risks, initiated investigations of freshwater saxitoxin and cylindrospermopsin blooms, and increased public outreach to improve awareness of HABs. An important aspect of REHAB is the participation of 25 volunteers who routinely collect water samples for toxicity tests. Results show that microcystins are the most frequent cyanotoxins in the Puget Sound region, followed by anatoxin-a, with few occurrences of saxitoxin and cylindrospermopsin. Another goal of REHAB is to provide effective methods for public health notification and prevention activities. By the end of REHAB, we hope to have more information about the variability, toxicity, and frequency of blooms as well as outreach and education methods for lake managers.

Progress Report on the Phytoplankton Analyses Associated with the Regional Harmful Algal Blooms (REHAB) Project in the Puget Sound Lowlands

Sally Abella
King County, Seattle, Wash.

Abstract
Currently, a collaborative effort is in the third year of a study of 30 lakes in the Puget lowlands that is aimed at measuring the rate of incidence of cyanobacterial toxicities and the associated cyanobacterial species present. Collaborators include staff from two counties, two state agencies and Seattle University. Data on the phytoplankton assemblages for the first two years show some interesting patterns beginning to emerge. This presentation will focus on what has been found to date and will include some speculation on the relationships between physical conditions, species distributions, and measured toxicities between years and among the lakes.

Rapid Detection and Public Notification of Toxic Cyanobacterial Blooms at Three Lakes in Snohomish County, Washington

Marisa Burghdoff and Gene Williams
Snohomish County - Public Works Surface Water Management, Everett, Wash.

Abstract
From 2007-2010, three lakes located in Snohomish County, Washington were intensively monitored for the presence of toxic blooms of cyanobacteria. The purpose of the monitoring program was to improve the speed of toxic bloom detection and public notification and evaluate potential indicators for predicting toxic events. The monitoring program was paired with a public outreach campaign to increase the awareness of toxic algal blooms and nutrient pollution. Weekly monitoring at multiple locations on the lakes was conducted to determine the presence of algal scums and to test for the cyanotoxins, microcystin, and anatoxin-a. Environmental parameters, including *in situ* chlorophyll *a*, *in situ* phycocyanin, water transparency, and temperature/dissolved oxygen were also measured at multiple sites. All three lakes experienced one or more cyanobacterial blooms with toxin levels exceeding the recreational standards set by the Washington State Department of Health. Monitoring results indicated that *in situ* phycocyanin measurements are an inexpensive and rapid method for assessing levels of cyanobacteria and scum presence, but are less strongly correlated with the presence of algal toxins. The presence of algal scums was also strongly correlated with a higher risk of algal toxins, validating scum presence as a useful warning indicator for the public. Finally, no environmental factors were identified that could improve the ability to predict future bloom occurrences or toxin production. The findings of the monitoring program coupled with public outreach efforts helped to shape a long-term, low-budget strategy for toxic bloom monitoring and public outreach/notification.

Session F-2: Sediment Management

Thursday, October 27
1:30 pm – 3:00 pm
Room 206A

Sediment Quality of the Lower Snake River, 2011

Russell Heaton
US Army Corps of Engineers, Walla Walla, Wash.

Abstract
As part of the U.S. Army Corps of Engineers (USACE) Walla Walla District Programmatic Sediment Management Plan, the development of this sediment quality report was initiated on November 16, 2010. A total of 197 chemicals were evaluated over a 150 mile stretch of river for their potential to contaminate sediments and pose a risk to aquatic life; the following factors were considered in this evaluation: registration status, toxicity to invertebrates, toxicity to fish, potential to bio-concentrate, presence or absence in the sediment, persistence, and use patterns in the Pacific Northwest. A total of 197 chemicals were evaluated: 23 inorganics, 67 herbicides, 17 fungicides, 74 insecticides, and 16 PAHs. Of these chemicals, 27,537 individual data points were evaluated. Results were pooled using GIS techniques to cluster and further analyze the data. Specific biological endpoints from the literature were used for native species and bioaccumulation literature was used for all available species in the literature. The results were written in a 774 page report with extensive background information on all the chemicals evaluated during this study. Over 3,500 literature citations were used in this study. The report is to be released to the public in October 2011.

Lake Aeration and Sediment Sampling Systems

Dennis Haag and Greg Howick
Burns & McDonnell, Kansas City, Mo.

Abstract
This paper provides current study findings concerning "air dredging" equipment and bacteria applications in a small lake located in DuPage County, Illinois. Burns & McDonnell has used several methods to restore lakes and manage lake sediment that are alternatives to building new dams. This project was implemented in 2007 and has been monitored annually. Current findings indicate that the air dredging and bacteria treatments have continued to protect the lake from accumulated sediments; and also indicate a slight increase in the average lake depth. Similar systems have been installed in two other small lakes. The presentation will also highlight new equipment for obtaining undisturbed sediment cores.

Passive Dosing Methods of Water Clarifying Polymers for Dredging Projects

⋆Kyla Iwinski and Steve Iwinski
Northern Michigan Univ., Marquette, Mich.

Abstract
Dredging practices produce highly turbid water that usually cannot meet EPA effluent limitation guidelines (ELGs) or various state discharge requirements. Historically, liquid polymer flocculants have been used by drip feed or injection systems for water quality control before discharge. These systems are many times unreliable in performance or require power sources, injection pumps, and metering devices that require a significant amount of manpower to operate. Newer methods using polymer logs or blocks using passive dosing methods have shown very high performance results for water quality without personnel oversight and greatly reduced cost. This presentation will describe various methods and assemblies using these low cost, passive dosing systems. Toxicity issues with dredging and polymers will also be addressed.

How Deep to Dredge? Pre-dredge Experimental Tests

Alex Horne
Univ. of California, Berkeley, Calif.

Abstract
Dredging lakes often seems like common sense but initial set-up and disposal costs make dredging expensive - even for small water bodies. Urban lakes usually contain toxic contaminants which increase costs. Sediment cores show the stratigraphy of nutrients and contaminants, but do not show the magnitude of releases from a newly excavated sediment surface. Also how will the new sediment surface react to common lake management practices such as aeration-oxygenation or alum treatment? The 40-acre Machado Lake, Los Angeles, is very shallow (0.5 - 2 m), eutrophic, heavily contaminated, and lies in a blighted urban location near the harbors. Nonetheless, it still is quite beautiful and part of a 250-acre park. Tests were carried out on isolated cores simulating dredging of 0, 2, 4, and 6 feet (~ $0-$60 million). To give a cost perspective, each foot of dredging costs approximately $10 million, so over-dredging is not good. Nutrient fluxes were measured

under aerated, calm (anoxic), and alum additions to simulate management practices for the various depths considered for dredging. No substantial differences were shown at any depth of dredging for this natural lake with its high sedimentation rate (8 ft/100 yrs). The flux tests were most valuable for designing new lake bathymetry. Design can be for other goals such as edge deepening to reduce invasive *Ludwigia* plants and a central hole for oxygenation (see another paper at NALMS 2011) without consideration of altering nutrient-contaminant fluxes from the sediments.

Session F-3: Lake Pend Oreille

Thursday, October 27
1:30 pm – 3:00 pm
Room 206B

An Overview of Large-Scale Predator Suppression Efforts in Lake Pend Oreille, Idaho

Jim Fredericks, Andy Dux, Nicholas Wahl and Charles Corsi
Idaho Dept. of Fish and Game, Coeur d'Alene, Id.

Abstract
Lake Pend Oreille, Idaho's largest and deepest lake, once provided the largest kokanee (*Oncorhynchus nerka*) fishery in the state. Between 1952 and 1966, harvest of kokanee averaged one million fish/yr. In the mid-1960s the kokanee population began a steady decline that resulted in a harvest closure by 2000. Impacts to shoreline spawning habitat associated with winter drawdown is believed to be the initial cause of decline. The introduction and establishment of the zooplanktivorous Mysis shrimp (*Mysis diluviana*) in the 1960s compounded the problem by decreasing cladocerans available to kokanee. Recently, however, predation has become the primary factor limiting recovery of kokanee stocks. Lake trout (*Salvelinus namaycush*) were introduced in 1925, however the population remained at low density for many years. In the late 1990s the population began growing exponentially. The increased abundance of lake trout, combined with existing populations of piscivorous rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*), resulted in unsustainable levels of predation on the depressed kokanee population. In response, a program was initiated in 2006 to reduce rainbow trout abundance over the short-term and permanently suppress or collapse the lake trout population. The program involves both anglers and commercial fishing equipment. Angler harvest of rainbow and lake trout has been incentivized with a $15/fish reward, and commercial fishermen with decades of experience in Lake Michigan have been contracted to fish deepwater trap nets and gill nets to remove lake trout. After five years of predator suppression, the program is showing positive results.

Social Considerations for Implementation of an Intensive Fishery Restoration Program on Lake Pend Oreille, Idaho

Chip Corsi, Jim Fredericks, Andy Dux and Ned Horner
Idaho Dept. of Fish and Game, Coeur d'Alene, Id.

Abstract
Lake Pend Oreille historically supported more angler days than other fishery in Idaho. Kokanee salmon provided the greatest number of angler days, but also served as the forage base for the Kamloops rainbow trout and bull trout fishery. World records for both rainbow and bull trout were taken from Pend Oreille and created a demand for trophy fishing opportunity on the lake. Declines in the fishery due to anthropogenic changes in habitat conditions were exacerbated in the late 1990s and early 2000s by the rapid increase in the non-native lake trout population. By 2001, predation of kokanee by lake trout had been identified as a major threat to the fishery, including the persistence of bull trout, now a federally listed "threatened" species. Biologically it was clear that controlling lake trout would be necessary to meet fishery management goals and to protect listed bull trout. Most anglers agreed that maintaining kokanee and trophy rainbow trout fishing was important, but lake trout angling was increasing in popularity, and implementation of lake trout suppression was controversial. To find common ground on fishery management objectives, and strategies for meeting those objectives, we engaged anglers and other stakeholders through public meetings, information releases, engaging with the media, creation of stakeholder advisory groups, and ultimately rewarding participation by anglers. Angler and other stakeholder buy-in has been an essential and critical component of the success of the recovery program to date.

The Effects of Large-scale Predator Suppression Efforts in Lake Pend Oreille, Idaho

Andy Dux, Jim Fredericks, Nick Wahl and Chip Corsi
Idaho Dept. of Fish and Game, Coeur d'Alene, Id.

Abstract
Predation became the primary factor limiting kokanee *Oncorhynchus nerka* recovery in Lake Pend Oreille, Idaho after an increase in lake trout *Salvelinus namaycush* abundance from 1999-2005. In response, a predator removal program was developed to target long-term suppression of the lake trout population and short-term reduction of rainbow trout *Oncorhynchus mykiss*. These efforts began in 2006, using both anglers and a contract netting operation. Since 2006, anglers have removed 33,351 rainbow trout and 58,161 lake trout, while netting has removed 61,414 lake trout. The combined angling and netting approach has substantially reduced the lake trout population. Mature lake trout (>600 mm) declined most rapidly, including a 74% decrease since 2008. Juvenile (<400 mm) abundance remained high initially, but the netting catch rate declined 56% in the spring of 2011 from the previous year. This suggests that juvenile abundance is also decreasing. A compensatory response by lake trout to increased mortality has not occurred. The rainbow trout population has responded differently than lake trout. This population has remained stable, primarily because annual exploitation rates have been low (<25%) despite incentivized harvest. Kokanee survival rates have improved since 2007, which indicates predation pressure has been reduced. Additionally, adult abundance has steadily increased since reaching an all-time low in 2007. To date, predator removal efforts have effectively allowed a nearly collapsed kokanee population to rebound. Further, results continue to support the hypothesis that suppression of lake trout in a large, deep lake is achievable.

An Evaluation of Bull Trout Salvelinus confluentus *Bycatch From Predator Reduction Netting in Lake Pend Oreille, Idaho*

Nicholas Wahl, Andrew Dux and Robert Ryan
Idaho Dept. of Fish and Game, Coeur d'Alene, Id.

Abstract
Kokanee (*Oncorhynchus nerka*) in Lake Pend Oreille have reached record lows following increased predation during the past decade. To increase kokanee abundance, extensive predator reduction efforts were initiated in 2006 and included contracting a commercial fishing company to remove lake trout (*Salvelinus namaycush*). During 2006-2011, about 62,000 lake trout were removed by gill and trap netting. Incidental bycatch of native bull trout (*Salvelinus confluentus*) was over 4,500 individuals and direct mortality rate was 25%. To minimize bycatch and understand potential effects of netting on the bull trout population, data collected during netting operations were evaluated. Seasonal catch rates by gill net mesh size and panel height were analyzed and used to design nets that maximized the lake trout to bull trout catch ratio. Gill nets with stretch mesh of 5.1-7.0 cm were most effective for targeting juvenile lake trout, while stretch meshes of 11.4 and 12.7 cm were best for targeting mature lake trout. Further, shorter gill net panels reduced bull trout bycatch, especially during the spring. Genetics samples were collected from bull trout and used to assign fish to their stream of origin, which allowed bycatch risk to be assessed for individual tributary stocks. Genetics analyses showed bull trout from all tributaries distributed throughout the lake and should have been equally vulnerable to capture. These analyses have allowed netting operations to most effectively target lake trout while minimizing bull trout bycatch and the lake trout netting has not been detrimental to the Lake Pend Oreille bull trout population.

Session F-4: Regional Assessment of Lake Habitats

Thursday, October 27
1:30 pm – 3:00 pm
Room 206C

Using Innovative Technologies to Access Environmental Data

Won Kim[1], Rich Miller[2] and Mark Sytsma[2]
[1]Oregon Dept. of Environmental Quality, Portland, Oreg.
[2]Portland State Univ., Portland, Oreg.

Abstract
Diverse water quality and Oregon lake information are available from government agencies, academic institutions, volunteer monitoring organizations and private companies. Obtaining and interpreting the data can prove to be a laborious task due to varying sources and complexities of the data. Portland State University and Oregon Department of Environmental Quality developed a 'one stop shop' web based system for the storage, distribution, publishing and interpretation of Oregon's lake data through a single web portal: the Atlas of Oregon Lakes data exchange http://aol.research.pdx.edu/. The Atlas implements data standards across multiple platforms, publishes environmental data on line and provides real time statistical calculations. In addition, the Atlas plots water quality data through map and text based interfaces. The Atlas incorporates new technologies such as Pacific Northwest Water Quality Data exchange, web services and geo databases to achieve this goal. The final results include access to databases from different organizations, real time metric calculations, web services to communicate data efficiently and a map based web site. Merging technologies and creating partnerships maximizes the resources to share ideas, utilize new technologies and merge disparate data systems into a single web based system. This partnership provided a solution for a concept that originated from the data users.

Indexing Fish Habitat: Development of Metrics for Nearshore Littoral Zones of Wisconsin Lakes

★Jessica Orlando[1] and Michael Bozek[1,2]
[1]Wisconsin Cooperative Fishery Research Unit, Stevens Point, Wis. [2]US Geological Survey, Stevens Point, Wis.

Abstract
The complexity and diversity of structural habitats in nearshore littoral zones are highly variable and serve as important spawning, foraging, and nursery sites for many north temperate fish species. The objective of this research is to develop and test metrics that can be used to index structural habitat as it relates to fish community in nearshore littoral zones of these lakes. For each lake, fish assemblage was quantified using electrofishing and habitat was quantified by measuring depth, macrophyte bed structure, substrate, and coarse woody structure. Habitat sampling occurred at 25-30 sites using quadrats along transects. Metrics relating structural habitat to fish species diversity, richness, abundance, and spawning probability were developed using regression analyses. It was found that fish assemblage exhibited a range of relations to different habitat metrics and that response varies among lakes. This may indicate that there are different lake types that vary in terms of limiting habitat. The fish habitat metrics will be used to develop a multimetric habitat quality index to provide within- and among-lake comparisons used to identify habitat management strategies that can protect, restore, or enhance littoral zone habitats.

An Analysis of Landscape Factors Influencing Variation in Lake Phosphorus Levels Across Minnesota for Use in Directing Fish Habitat Protection and Restoration Efforts

Timothy Cross[1] and Peter Jacobson[2]
[1]Minnesota Dept. of Natural Resources, Hutchinson, Minn.
[2]Minnesota Dept. of Natural Resources, Park Rapids, Minn.

Abstract
Lake phosphorus concentrations are known to be a significant factor influencing fish populations in Minnesota lakes. Consequentially, a primary focus in renewed efforts by the Minnesota Department of Natural Resources to address fish habitat deficiencies in lakes across the state has been to determine relationships between phosphorus concentrations and watershed conditions in Minnesota lakes. Since TP concentrations in Minnesota lakes vary widely corresponding to differences in geomorphology, criteria was established by the Minnesota Pollution Control Agency to support fishing and other water recreational uses that matches expectations across Omernik ecoregions. To refine these relationships on Minnesota lakes, we gathered mean summer TP concentrations on 1,330 natural lakes to identify lakes where agricultural and human development has elevated phosphorus levels. Various modeling approaches were used to model spatial variation in lake phosphorus concentrations across Minnesota including generalized additive models, regression tree analysis, and random forest machine learning algorithms. Key landscape variables known to regulate TP

concentrations in lakes, including lake depth and watershed size, were used as explanatory variables in these models along with agricultural and human development quantified for each individual lake watershed from the National Land Cover Dataset (NLCD 2001). Various models could explain close to 70 percent of the variation in TP in lakes across the state and showed critical threshold levels of agricultural and urban development land uses, that once exceeded, could significantly alter fish populations. This information should be useful for fish managers to prioritize conservations efforts and to set appropriate fish population goals.

Modeling Fish Habitat Conditions for Midwest Lakes: A GIS Approach

Patrick Rivers[1], Fritz Boettner[2], Michael Strager[3] and Maureen Gallagher[4]
[1]Minnesota Dept. of Natural Resources, St. Paul, Minn. [2]Downstream Strategies, Morgantown, W.Va. [3]West Virginia Univ., Morgantown, W.Va. [4]USFWS, Maryville, Mo.

Abstract
Natural resource managers use professional judgment to ascertain the primary threats and stressors to sustainable lake habitats. Quantifying those threats and prioritizing management actions based on objective data has been elusive. The Midwest Glacial Lakes Partnership, in cooperation with a private consulting firm, will soon complete a fish habitat condition assessment for natural lakes in the Midwest. This GIS assessment quantifies natural habitat potential as well as anthropogenic stress for several modeling "endpoints" (*e.g.*, coldwater, coolwater, and warmwater fish habitats). The integration of these indices reveals likely locations for conservation actions, including the quantification and ranking of known stressors. Further, decision support tools that are in development will allow "what if" scenario building for changes in land use in a given watershed (*e.g.*, addition or removal of CRP acreage). Social and economic considerations will also be integrated into the support tools. This effort is part of a larger project to assess fish habitat condition for six Midwest fish habitat partnerships, all of which will ultimately lead to more strategic aquatic habitat conservation.

Session G-1: Cyanobacteria in Reservoirs

Thursday, October 27
3:30 pm – 5:00 pm
Room 205

Alteration of Nutrient Regimes in Large-scale In-situ Enclosure Experiments to Reduce Cyanobacterial Biovolume and Toxicity

★Ted Harris[1], Frank Wilhelm[1], Jennifer Graham[2] and Keith Loftin[2]
[1]Univ. of Idaho, Moscow, Id. [2]US Geological Survey, Lawrence, Kans.

Abstract
Previous studies of Midwest U.S. lakes spanning a global range of nutrient concentrations showed that cyanobacterial biovolume and microcystin concentration were highest at nitrogen concentrations between 500 and 4,000 μg/L. In addition, the abundance of cyanobacteria and microcystin was generally low in water bodies where total nitrogen: total phosphorus (TN:TP) ratios were greater than 30:1. These patterns suggest that managing the TN:TP ratio offers a potential in-lake avenue to manage toxic cyanobacterial blooms; however, this concept has not been examined experimentally at large scales. To test the hypothesis that cyanobacterial abundance and microcystin concentrations can be managed by manipulating TN:TP ratios, we experimentally manipulated the TN:TP ratio in large (3 m diameter × 11 m deep) *in situ* lake enclosures between July and October in Willow Creek Reservoir, Oregon. In 2010, ammonium nitrate was added to the enclosures, and in 2011 phosphorus was stripped from the epilimnion to maintain TN:TP ratios of greater than 30. In 2010, Secchi depth was deeper, and the chlorophyll *a* concentration, microcystin concentration, and cyanobacteria biovolume were lower in enclosures with a TN:TP ratio greater than 75 compared to the lake (control); when TN:TP ratios were less than 75 in the enclosures, cyanobacterial biovolume and microcystin concentrations increased. We compare the 2011 results to those from 2010, and discuss the implications of manipulating TN:TP ratios at a whole-lake scale.

Cyanobacteria Abundance and Toxin Production in a Drinking Water Supply Reservoir

★Kari Reynolds[1,2], Todd Brewer[2] and John Havel[1]
[1]Missouri State Univeristy, Springfield, Mo. [2]City Utilities of Springfield, Missouri, Springfield, Mo.

Abstract
Cyanobacteria are well known to cause water quality problems in lakes, and numerous taxa include strains that produce toxins. These toxins target cellular processes and affect a wide range of organisms. Although the effects of toxins on biodiversity have been documented, the main reason why cyanobacteria release their toxins is still unknown. This study examined the co-occurrence of cyanobacteria densities and hepatotoxin concentrations in a local drinking water reservoir using immunoassay. McDaniel Lake is a monomictic, eutrophic reservoir (area 3.0 km^2, average and maximum depths 1.9 and 9.1 m), located near Springfield, Missouri. Two sites on McDaniel Lake (up-lake and near the dam) were sampled weekly from May-September 2011 to determine algal composition and dynamics, and relate cyanobacteria density to concentration of hepatotoxins (microcystin and cylindrospermopsin). Hepatotoxins were measured using enzyme-linked immunosorbant assay (ELISA) kits. We will describe the correspondence between densities of algal genera known to include toxin producers with the concentrations of these hepatotoxins.

Seasonal Microcystin Dynamics in Missouri Reservoirs

Jennifer Graham[1,2], John Jones[2] and Daniel Obrecht[2]
[1]US Geological Survey, Lawrence, Kans. [2]Univ. of Missouri, Columbia, Mo.

Abstract
During January-December 2004, 15 northwestern Missouri reservoirs were sampled weekly at pelagic locations to assess seasonal patterns in total microcystin concentration and relations with environmental factors. Microcystin, measured by enzyme-linked immunosorbant assay, was detected in 8 reservoirs; detection frequencies in individual reservoirs ranged from 14 to 43% of the samples collected (n = 49). Annual maxima occurred in June-December, but peak microcystin concentrations in most (n = 5) reservoirs with detectable microcystin occurred in the fall after destratification. Peak microcystin concentrations ranged from 0.2 to 21 μg/L (median = 0.9 μg/L); multiple peaks in microcystin

concentration occurred in half (n = 4) of the reservoirs with detectable microcystin. In general, mean annual nutrient and chlorophyll concentrations were 2 to 3 times larger in reservoirs with detectable microcystin than in reservoirs without microcystin. Mean annual microcystin concentrations were most strongly correlated with measures of the algal community, including phycocyanin ($r_s = 0.72$, $p < 0.01$, $n = 15$) and net chlorophyll ($r_s = 0.68$, $p < 0.01$, $n = 15$). In individual reservoirs, the environmental factors most strongly correlated with microcystin varied by reservoir and included nutrients, cations, and measures of the algal and zooplankton communities. Seasonal microcystin dynamics and relations with environmental factors were unique to individual reservoirs in Missouri. While microcystin was linked to biological, physicochemical, and hydrologic factors, there was no single relation that was broadly applicable to all reservoirs.

Co-Occurrence of Cyanobacterial Toxins and Taste-and-Odor Compounds in Midwestern Drinking-Water Supply Reservoirs

Lenore Tedesco[1], Jennifer Graham[2], Nicolas Clercin[1], Mark Gray[3] and Emmanuel Soyeux[4]
[1]Center for Earth and Environmental Science, and Dept. of Earth Sciences, Indianapolis, Ind. [2]US Geological Survey, Kansas Water Science Center, Lawrence, Kans. [3]Veolia Water Indianapolis, LLC., Indianapolis, Ind. [4]Veolia Environnement Recherche & Innovation, Paris, France

Abstract
Drinking-water supply reservoirs in the Midwestern United States commonly have cyanobacterial-related taste-and-odor issues that are a major cause of customer complaints and loss of confidence in drinking-water safety by the general public. Increased public awareness of potential health risks associated with cyanobacterial blooms has exacerbated recreational and drinking-water safety concerns. Many cyanobacterial taxa are capable of producing toxins (*e.g.*, microcystins) and taste-and-odor compounds (*e.g.*, 2-methylisoborneol and geosmin), and some produce multiple compounds simultaneously. With multiple potential producers of microcystins, 2-methylisoborneol (MIB), and geosmin, co-occurrence in mixed assemblage cyanobacterial blooms can be expected; however, few studies have characterized mixtures of toxins and taste-and-odor compounds during blooms. Recent (2001-2010) multi-year studies in Midwestern (Indiana and Kansas) drinking-water supply reservoirs (n = 4) have documented frequent co-occurrence of microcystins, MIB, and/or geosmin. Depending on the reservoir, microcystin and MIB co-occurred in about 22 to 53% of samples with detectable MIB. Microcystin and geosmin co-occurred in 22 to 63% of samples with detectable geosmin. Similarly, co-occurrence of MIB and geosmin ranged from 51 to 76%. Co-occurrence of microcystins, MIB, and/or geosmin was most common in blooms dominated by *Aphanizomenon*, *Anabaena*, *Planktothrix*, *Pseudanabaena*, and *Synechococcus*. Cyanobacterial bloom assemblages are a critical determinant of the likelihood of co-occurrence. While some toxin producers are not known taste-and-odor producers, the majority of known taste-and-odor producers also are known toxin producers. While these studies show that co-occurrence of microcystins, MIB, and/or geosmin was relatively common, there were numerous instances of cyanobacterial-related taste-and-odor events that occurred without accompanying microcystins.toxins is still unknown. This study examined the co-occurrence of cyanobacteria densities and hepatotoxin concentrations in a local drinking water reservoir using immunoassay. McDaniel Lake is a monomictic, eutrophic reservoir (area 3.0 km^2, average and maximum depths 1.9 and 9.1 m), located near Springfield, Missouri. Two sites on McDaniel Lake (up-lake and near the dam) were sampled weekly from May-September 2011 to determine algal composition and dynamics, and relate cyanobacteria density to concentration of hepatotoxins (microcystin and cylindrospermopsin). Hepatotoxins were measured using enzyme-linked immunosorbant assay (ELISA) kits. We will describe the correspondence between densities of algal genera known to include toxin producers with the concentrations of these hepatotoxins.

Session G-2: Voice of Experience

Thursday, October 27
3:30 pm – 5:00 pm
Room 206A

Forty Plus Years of Lake Management and NALMS

G. Dennis Cooke
Kent State Univ., Kent, Oh.

Abstract
I have had a great career in lake and reservoir restoration and management. I present a few highlights and "career lessons", and my most sincere "thank you" to all of my colleagues and to NALMS.

Recollections and Observations

Kenneth Reckhow
RTI, Research Triangle Park, N.C.

Abstract
NALMS and I began our professional careers at about the same time. I participated in the pre-NALMS meetings in Madison and East Lansing, along with the early NALMS meetings, giving (with Steve Chapra) the first short course. My research focus has veered away from lakes during the past twenty years, but many of my experiences relate to lake water quality assessment, modeling, and decision making under uncertainty. These include such topics as TMDLs, water quality standard setting, adaptive management, and risk/decision analysis. I will present some comments on NALMS and relevant professional experiences, and then hope to engage in some interesting discussion with the audience.

From Limnologist to Corporate Lackey (aka "Senior Advisor")

Wayne Poppe
Tennessee Valley Authority, Chattanooga, Tenn.

Abstract
I heard a Hindu proverb once that I've never forgotten: "No physician is really good before he has killed one or two patients." I'm happy to say that I haven't killed anyone yet, but I've had a few close encounters with irate lake users, spineless supervisors, disgruntled employees, and other common workplace perils in the course of my 33-year career at TVA, and I've learned from each experience. I've also had the privilege of working with some outstanding managers and scientists who were willing to share their wisdom and experience with me, and help me avoid some mistakes that could have derailed several of the projects and plans that I've worked on over the years. I'm glad to be part of the "Voice of Experience" session (which I prefer to call the "Geezer Gab") and have the opportunity to pass along some of these lessons.

Now, Then and In Between

Bill Funk
Wash State University, Manti, Ut.

Abstract
This presentation will provide a brief history of efforts to clear the lake waters of the Pacific Northwest and elsewhere. Also included will be a tale of education, frustration, and a few failures, followed by successes, hope, and now concern.

Session G-3: Clear Lake, Manitoba

Thursday, October 27
3:30 pm – 5:00 pm
Room 206B

Keeping the Clear in Clear Lake: Managing for Ecological Integrity and Visitor Expectations in Riding Mountain National Park of Canada's Aquatic Ecosystems

Marlow Pellatt[1], Jeff Curtis[2], Heather Gray[2,3], Natasha Neumann[2], Robert Reside[3], Cliff Robinson[1], Ian Walker[2], Carrie White[2] and Ryan Whitehouse[2]
[1]Parks Canada, Western and Northern Service Centre, Vancouver, B.C., Canada [2]Univ. of British Columbia Okanagan, Kelowna, B.C., Canada [3]Riding Mountain National Park of Canada, Wasagaming, Manit., Canada

Abstract
Clear lake is the most important recreational draw for visitors in Riding Mountain National Park; it is also the largest, deepest lake in the park. Clear Lake is experiencing increased nutrient loading and other stressors of ecological integrity (EI). Parks Canada has initiated an "on-the-ground" research and management project designed to maintain the EI of Clear Lake and the national parks' other waterbodies. Parks Canada is working with academics, community stakeholders, and citizen science groups in order to develop a sustainable management regime that can maintain ecological health, as well as aesthetic and recreational values that the ecosystem provides park visitors. We are applying science to real-life community driven issues with "on-the-ground" activities. This work involves the determination of in-lake and catchment scale processes, indicator fish and aquatic plant/algae monitoring, paleolimnology and threshold monitoring, and citizen science. This science has been integrated with the community through outreach and interpretation efforts, lake management advisory boards, and park management plans. Here we present the progress of this research and how we have effectively integrated complex scientific research with community interests to create a successful conservation story.

Catchment Flowpath Distributions and Hydroecological Implications for Clear Lake, Manitoba, Canada

★Natasha Neumann and P. Jeff Curtis
Univ. of British Columbia Okanagan, Kelowna, B.C., Canada

Abstract
Catchment inputs to downstream freshwater ecosystems are heavily influenced by the upstream distribution of water transit times, which in turn are determined by the available surface and subsurface pathways. The chemical and physical properties of water are affected by the materials through which it flows, the rate of flow, biogeochemical reactions that occur along its flowpath, and the chemical composition of precipitation. Different biogeochemical reactions occur along surface and subsurface pathways, which can alter water chemistry in unique and distinguishable ways. Within a relatively uniform geological and meteorological setting, then, surface and groundwaters fall within a predictable geochemical space determined by the cumulative transit time along surface and subsurface flowpaths. The location of a water sample in this space may vary seasonally or daily depending on the distribution of water pathways converging at that point. Clear Lake, Manitoba, is a relatively large deep lake with high nutrient loading, but with no indications of eutrophication. This study was part of a larger project aimed at understanding biogeochemical processes in the Clear Lake catchment and developing management practises that best protect the ecological integrity of the lake. Flowpaths and transit time distributions through this mid-latitude boreal parkland catchment were inferred from natural water chemistry and hydrological analysis. Spatial and seasonal geochemical variations will be discussed in the context of water flow pathways in the catchment.

Biogeochemical Cycling of Phosphorus in Clear Lake, Manitoba

Ryan Whitehouse, Natasha Neumann and P. Jefferson Curtis
Univ. of British Columbia, Okanagan, Kelowna, B.C., Canada

Abstract
Clear Lake represents an economically significant mesotrophic lake located in southwest Manitoba. In an attempt to describe the biogeochemical factors and mechanisms controlling the cycling of phosphorus in this waterbody, various physio-chemical and chemical attributes of the lake water, seston, and sediments were measured. Chemical analysis of the lake indicated the water was alkaline and enriched in Ca^{2+} and Mg^{2+}. During summer stratification in 2008, large concurrent increases in dissolved oxygen, pH and $CaCO_3$ saturation index were observed to occur simultaneously with large reductions in total and dissolved P. This was interpreted as an incidence of biologically-mediated pH shift during an algal bloom leading to a precipitation of $CaCO_3$ in association with occluded organic and inorganic P. Fractional P analysis, conducted on particulate seston and sediment, separated the total P (TP) into organic P (OP), non-apatite inorganic P (NAIP), and apatite P (AP). Significant amounts of AP in the seston and sediment provide support for the interpretation that authigenic $CaCO_3$ scavenged P from the water column. Within the sediment cores, large and increasing amounts of AP indicate that all co-precipitated P is retained long term within the sediment as refractory AP. The combination of efficient scavenging during co-precipitation events and long-term storage of P as AP in the sediments suggests that the calcareous nature of the lake is playing an important role in the biogeochemical cycles.

Aquatic Macrophytes and Algae as Environmental Threshold Indicators for Lakes within Riding Mountain National Park, Manitoba

★Heather Gray[1,2], Marlow Pellatt[1] and Ian Walker[2]
[1]Parks Canada, Vancouver, B.C., Canada [2]Univ. of British Columbia Okanagan, Kelowna, B.C., Canada

Abstract
Riding Mountain National Park (RMNP), Manitoba has hundreds of lakes that support wildlife and attract thousands of visitors every year. It is in the interest of the Government of Canada, the Province of Manitoba, stakeholders, Indigenous peoples,

and tourists that the highly utilized lakes remain in pristine condition. Fifty lakes within and surrounding RMNP were sampled for aquatic macrophytes and algae to determine the relative importance of depth, chemistry, basin morphometry, sediment type, and nutrient concentrations. Preliminary data inspection identified four macrophyte species, *Utricularia vulgaris*, *Potamogeton pectinatus*, *Ceratophyllum demersum* and *Chara* that have the potential to be used as ecological threshold indicators. However, literature suggests that algae species and abundances are more useful as ecological indicators due to their faster response time to environmental changes. Therefore, algal abundances and species types in RMNP lakes will be compared with the four aquatic macrophyte species to determine which indicator is more useful in defining ecological thresholds within lakes. If the relationship between algae and/or aquatic macrophytes and nutrient concentration changes proves to be significant, then an index defining ecological thresholds in the region will be used to predict ecosystems at risk of a state change. This is important because once an ecosystem changes ecological or nutrient states, it is often very difficult to reverse the damage. The results of this research will be incorporated into the Park's Canada ecological integrity monitoring program and applied to the management of RMNP's aquatic ecosystems.

Session G-4: Stream / River Bioassessment

Thursday, October 27
3:30 pm – 5:00 pm
Room 206C

A Review of Stream Biological Assessment Methods in the 50 States of the U.S.

Shannon McMorrow, Ann Shortelle and Judith Dudley
AMEC E&I, Inc., Newberry, Fla.

Abstract
The fish, insects, algae, plants, and other biota in an aquatic system provide direct information about status and condition because the aquatic biota are continuously exposed to various stressors, and thus act as integrators. Therefore, biological assessments and biocriteria are increasingly used by regulators for decision-making. Federal and state agencies have developed biological assessment methods and protocols to standardize biological sampling so direct comparisons can be made between sites. Biological criteria are developed based on metrics characterizing the biological community. Biological metrics generally fall into five distinct categories: richness, abundance, tolerance, feeding group, and habit. There is tremendous variation in bioassessment and biocriteria programs among individual states. For example, Wisconsin's numeric invertebrate biocriteria are calculated using the most metrics, 14, while North Carolina and South Carolina numeric biocriteria are calculated using only one metric which is based on taxa pollution tolerance values. A review of state programs has identified: 27 states utilizing numeric biocriteria for macroinvertebrates, 11 states utilizing numeric biocriteria for fish, 8 states are in the process of developing numeric biocriteria for macroinvertebrates, 2 are in the process of developing numeric biocriteria for fish, 10 states have narrative biocriteria for macroinvertebrates, 3 states have narrative biocriteria for fish, and 4 states have no specified biocriteria. These programs are compared, and the ability to evaluate stream biotic condition across state boundaries is discussed.

Riparian Buffer Decision Support Tool: A Canadian Example

Alan Stewart, Sharon Reedyk, Bill Franz, Kim Fomradas and Clint Hilliard
Agriculture and Agri-Food Canada, Edmonton, Alta., Canada

Abstract
The Riparian Buffer Design Tool is a decision support tool that was created for non-regulatory adoption of stream buffers in the Canadian prairies. Although the tool was initially designed for use in a non-regulatory framework, it was found to be useful as a means of granting exemptions for buffers in other regions of Canada that had adopted a regulatory approach to riparian area management. As such, the tool was modified for application in eastern Canada where both the physical and regulatory environments differ from the prairies. The Tool allows users to determine critical areas for locating buffers along stream systems adjacent to cropland. The tool also identifies alternative land best management practices (BMPs) in instances where a riparian buffer is not the appropriate practice. The approach includes both landscape scale assessment and on-site assessment and the application of the tool benefits with participation by the landowner. Thus under non-regulatory environments it is targeted to those farmers who have requested assistance in understanding the role that a buffer may play on their land. Under regulatory environments, the tool can help bridge the gap between regulators and land owners by providing a rational decision process for the assessment of the need for a buffer. The Riparian Buffer Design Tool incorporates a series of decision steps and is available as a Field Manual for technical experts to use in decision making.

Instream Assessment of Biota and Migration Patterns of the South Fork Palouse River Watershed

Shannon Brattebo[1], Chris Millard[2], Robert Plotnikoff[3] and Blaine Snyder[2]
[1]Tetra Tech, Inc. Surface Water Group, Spokane, Wash. [2]Tetra Tech, Inc. Center for Ecological Science, Owings Mills, Md. [3]Tetra Tech, Inc. Surface Water Group, Seattle, Wash.

Abstract
Historical and current environmental information was collected to describe aquatic life uses in the South Fork Palouse River watershed. Comparison of historic life uses against current aquatic conditions was used to determine potential for restoration of water quality and physical habitat characteristics that resemble natural conditions. The South Fork Palouse River in southeast Washington State has experienced significant changes to water quality over the past 140 years of settlement. Changes to the original landscape from a native bunchgrass vegetative cover to cultivated wheat crops has increased erosion of loess soils that serve as means for conveyance of pollutants (bacteriological, nutrients) to the aquatic ecosystem. The fish community has never hosted a dominant salmonid community, but has endemic cyprinids and other warmwater species that currently dominate the mainstem and most tributaries. Changes in habitat and location of water quality impacts have resulted in reduction of the endemic warmwater fish populations. Factors that were significantly altered following European settlement of the area include flow availability, augmentation of flow, and changes in flow pattern. Water quality impacts and changes to the physical habitat are identified by the presence of "opportunistic" benthic macroinvertebrate taxa that respond positively to nutrient-enriched stream areas of the watershed. The most identifiable impacts occur in the urbanized stream settings

where nutrient input and habitat alterations were greatest. The original migratory patterns of endemic fish populations in the watershed have become disjunct with establishment of both physical and chemical barriers (*e.g.*, shallow, sandy channels and high water temperatures).

Relations Between Benthic Macroinvertebrates and Vegetative Communities Along an Elevation Gradient in the Southern Andes of Ecuador: Baseline Data for Indigenous Communities and Long-term Resource Management

★Carrie Anderson[1], Emily Shimada[1], Fausto Lopez[2], Cesar Tiwi[3], Rodrigo Cisneros[2], Adrian Leiva[2], Carlos Iñiguez[2], David Roon[1], Alex Fremier[1] and Frank Wilhelm[1]
[1]Univ. of Idaho, Moscow, Id. [2]Universidad Técnica Particular de Loja, Loja, Loja, Ecuador [3]Centro Kiim, Kiim, Loja, Ecuador

Abstract
Elevation gradients and terrestrial ecotones strongly influence biotic and abiotic components of ecosystems, which in aquatic ecosystems constrain the distribution of sensitive macroinvertebrates. Such patterns are not well studied for high elevation, tropical streams of South America. Our objectives were to examine relationships between elevation, terrestrial ecotones and communities of aquatic macroinvertebrates in the Kiim River in the Andes Mountains of Southern Ecuador. The Kiim River drains an area of 25,700 ha and the watershed ranges in elevation from 900 to >3,300 m. It is culturally important and of significance to the Shuar people, an indigenous group of Ecuador, and crosses three separate Shuar protected areas. Thus, an overarching objective of our research is to provide baseline data of this pristine undisturbed system for the indigenous community and land managers. Five stream reaches in distinct terrestrial ecotones along the elevation gradient were sampled and analyzed. Macroinvertebrate richness, abundance, and diversity changed with increasing elevation and were predominantly related to stream temperature and oxygen saturation. Changes in stream pH related to input of organic matter from over-hanging vegetation and surrounding forest soils also influenced macroinvertebrate communities along the gradient. Our results will serve as baseline data for the administration of the Kiim Community to support land management decisions for the region in the future. In addition, these results will serve as a reference for the comparison of impacted streams and provide a start to identify potential indicator species for a future biomonitoring program.

Session H-1: Invasive Species

Friday, October 28
8:30 am – 10:00 am
Room 205

Aquatic Invasive Species Management in Wisconsin: Containment and Prevention

Reesa Evans
Adams County LWCD, Friendship, Wis.

Abstract
In 2007, Viral Hemorrhagic Septicemia, a non-native virus, was discovered in fish at an inland lake in Wisconsin. When the information was covered by the media, the public seemed to "wake up" to the danger that invasive species could contribute. Since this, funding for invasive species programs, especially aquatic invasive species, has nearly tripled. The issue is being attacked from a number of avenues: billboards; a Clean Boats, Clear Waters boater and angler education program staffed by citizen volunteers; training of citizens to monitor for AIS species on waters in their area; distribution of "wildcards", temporary tattoos, bobbers and brochures about AIS; expansion of the law to allow any law enforcement personnel to stop citizens with any aquatic species on their equipment; development of a prohibited & restricted list for non-native species; implementation of an Early AIS Detection Program that includes: looking for non-native snails, clams and mussels, and non-native plants and animals; designation of AIS Coordinators for most of the counties to assist in local management; designation of certain waterbodies as "superspreaders"; development of a containment vs. prevention strategy; and various others.

Aquatics in Idaho: Survey, Treatment and Prevention

Thomas Woolf and Amy Ferriter
Idaho State Dept. of Agriculture, Boise, Id.

Abstract
Invasive aquatic species are a relatively new issue for the state of Idaho. Emerging problems with Eurasian watermilfoil and hydrilla as well as the spread of zebra and quagga mussels into the Western US prompted aggressive action in Idaho beginning in 2006. Legislative action passed laws that facilitated an Early Detection / Rapid Response (EDRR) strategy and created a funding mechanism to support a proactive prevention program. Today aggressive treatment continues for Eurasian watermilfoil and hydrilla populations in the state. Survey state-wide seeks to identify new populations of invasive plants, mussels and other invasive aquatic species. Watercraft inspection stations are operated throughout the state to help stop the transport of invasive aquatic species and to educate the public on what they can do to help protect their waters.

New Zealand Mudsnails in Washington

Allen Pleus
Washington Dept. of Fish and Wildlife, Olympia, Wash.

Abstract
The New Zealand Mudsnail (*Potamopyrgus antipodarum*) is listed as one of the state's top 50 invasive species of concern by the Washington Invasive Species Council with established populations known in three areas of the state. It is a more recent invader in the west with first populations detected in central Idaho in the mid 1980s with current spread to all western states except New Mexico. As with most aquatic invasive species, control and management of established populations is not possible in large open environments and very expensive in isolated situations. Therefore, the best option for water body managers and private citizens is focusing on prevention. Forms of prevention can include education and outreach, voluntary inspection and decontamination, or possible mandatory inspection and decontamination depending upon the local regulatory authorities. As New Zealand Mudsnails are only one of many potential aquatic invaders, any prevention efforts should be broadly applied.

*Asian Clam (*Corbicula fluminea*) Rapid Response Efforts in Lake George, New York*

Meg Modley
Lake Champlain Basin Program, Grand Isle, Vt.

Abstract
Asian clam (*Corbicula fluminea*) were first discovered in Lake George, NY in August 2010. Local, state, and federal partners quickly formed the Lake George Asian Clam Rapid Response Task Force to address the new infestation. The Task Force worked together to review treatment options and supported surveys to delineate the population. The Task Force also coordinated a pilot project to test the effectiveness of a benthic barrier mat treatment in fall 2010. The small size of the known infestation site in southern Lake George and the early detection of this species led to the spring 2011 benthic barrier mat treatment, for which the Task Force worked to raise money and secure all necessary permits.

Session H-2: Drinking Water Assessment

Friday, October 28
8:30 am – 10:00 am
Room 206A

Environmental Factors that Influence Cyanobacteria and Geosmin Occurrence in Two Southeastern United States Reservoirs

Celeste Journey[1], Karen Beaulieu[2], Jane Arrington[3], Jennifer Graham[4] and Paul Bradley[1]
[1]US Geological Survey, Columbia, S.C. [2]US Geological Survey, East Hartford, Conn. [3]Spartanburg Water, Spartanburg, S.C. [4]US Geological Survey, Lawrence, Kans.

Abstract
Occurrence of dissolved geosmin was studied in two reservoirs in Spartanburg County, South Carolina. The reservoirs are relatively shallow, meso-eutrophic, warm monomictic, cascading impoundments. Overall, water-quality conditions and phytoplankton community assemblages were similar between the two reservoirs but differed seasonally. Median dissolved geosmin concentrations in the reservoirs ranged from 4 to 6 nanograms per liter. Annual maximum dissolved geosmin concentrations tended to occur between March and May. In this study, peak dissolved geosmin production occurred in April and May 2008, ranging from 50 to 100 nanograms per liter at the deeper reservoir sites. Peak dissolved geosmin concentrations were not concurrent with maximum cyanobacterial biovolumes, which tended to occur in the summer (June to August). Nonetheless, annual maximum cyanobacterial biovolumes rarely resulted in cyanobacteria dominance of the phytoplankton community. In both reservoirs, elevated dissolved geosmin concentrations were correlated to environmental factors indicative of unstratified conditions, greater light penetration, and reduced algal biomass, but not to nutrient concentrations or ratios. Additionally, elevated geosmin concentrations were correlated to biovolumes of specific geosmin-producing cyanobacteria genera (*Oscillatoria* and *Synechococcus*) but not to actinomycetes concentrations. Conversely, environmental factors that correlated with elevated cyanobacterial biovolumes were indicative of stable water columns (stratified conditions), warm water temperatures, reduced nitrogen concentrations, greater residence times, and greater phosphorus concentrations in the hypolimnion. Related variables were selected as input into a multiple logistic regression model that would serve as a tool to evaluate the likelihood of geosmin concentrations exceeding the threshold level for human detection.

Thermoconvective Mixing as a Possible Mechanism for the Transport of Taste and Odor Compounds

Reed Green[1], Ray Avery[2], Tetsuya Shintani[3] and Robert Morgan[2]
[1]US Geological Survey, Little Rock, Ark. [2]Beaver Water District, Lowell, Ark. [3]Tokyo Metropolitan Univ., Tokyo, Japan

Abstract
Geosmin and 2-methylisoborneol (MIB) are natural compounds found in lakes that lead to taste and odor problems. Geosmin and MIB tend to increase in concentration in Beaver Lake, Arkansas in late summer. During this season, inflows are low, wind mixing is minimal, and air temperatures start to decline, especially at night and cause the shallow littoral zone to cool more rapidly than the pelagic zone. This cooling causes the denser littoral waters to sink and slide down the lake bed until reaching the layer of pelagic water of the same density. If geosmin and MIB compounds are produced in littoral zone sediments and released into the water above, these compounds would be transported into the open water, and ultimately further downstream. During the mornings of September 8 and 13, 2010, close interval temperature depth profiles were measured along five transects, from littoral to pelagic zones in the upper part of Beaver Lake. Geosmin and MIB samples were collected 0.1, 0.5, and 1.1 m above the bottom at the point where water sinking from the littoral waters should separate from the bottom and disperse into the pelagic zone. Geosmin and MIB concentrations ranged from 1.0 to 1.8 ng/L and 15 to 31 ng/L, respectively (means of 1.3 and 22.1 ng/L). In three of the five transects, geosmin and MIB concentrations were higher in one or both the 0.1 and 0.5 m samples than the 1.1 m sample, suggesting that the thermoconvective mixing is a possible mechanism for geosmin and MIB transport.

Unraveling Algal Mysteries Impacting Seattle's Drinking Water – Two Case Studies: Botryococcus *and* Cyclotella

Moya Joubert
Seattle Public Utilities, Seattle, Wash.

Abstract
Seattle Public Utilities (SPU) serves drinking water to 1.4 million people in and around Seattle, Washington. The watersheds providing this drinking water are protected with no development and limited access ensuring that customers receive high quality water. However, even pristine waters can develop algal problems. In 2007, a white material was found floating in several finished drinking water reservoirs during a sanitary survey with the Department of Health. Samples of the material were examined by the SPU laboratory and were sent to several outside laboratories. After considerable effort, the material was identified as the alga, *Botryococcus*. The drinking water treatment process made identification of the material difficult. In 2008, a stringy material began clogging screens in the Cedar Treatment Facility challenging the drinking water treatment process. Once again, samples of the material were examined by the SPU laboratory and were sent to several outside laboratories for identification. Eventually, the stringy material was identified as microfilaments from the diatom *Cyclotella*. This presentation provides an overview of the

impacts of these algae on Seattle's drinking water system, the trials and tribulations of identifying an unknown, and the impact to SPU's limnological monitoring plan.

Filter Clogging and the Continuing Investigation of the Zooplankter Holopedium gibberum *in Lake Chaplain Reservoir*

★Anna Thelen[1] and Michael Brett[2]
[1]City of Everett, Everett, Wash. [2]Univ. of Washington, Seattle, Wash.

Abstract
The City of Everett Water Filtration Plant is located on Lake Chaplain Reservoir in the foothills outside Sultan, Washington. The Filtration Plant intermittently experiences filter clogging due to the zooplankter *Holopedium gibberum*. Plant operability during clogging events is dependent on several factors. These include the number *Holopedium* present, their degree of diel vertical migration, and the potable water demand at the time. When the filters are clogged to a degree that the plant is inoperable, the City switches to using water directly from Spada Reservoir, which feeds Lake Chaplain Reservoir. This requires cooperation with the Snohomish County PUD because operations of the Jackson Hydroelectric Project are constrained in this operating configuration. Monitoring of Lake Chaplain Reservoir was increased after *Holopedium gibberum* was positively identified as the main source of filter clogging for the City of Everett. The parameters currently sampled include zooplankton, phytoplankton, nutrients, and conventionals. Monitoring is conducted once every two weeks when Lake Chaplain Reservoir is stratified and once a quarter during the winter. The City of Everett would like to create a model in order to better understand the population dynamics of *Holopedium gibberum*. Monitoring experience implicates several environmental variables as having an effect on *Holopedium gibberum* bloom onset, development, and magnitude. These include inorganic turbidity, water temperature, food availability, and competition with *Daphnia*. It is anticipated that these factors will be further investigated in Lake Chaplain Reservoir during the summer of 2011 using *in situ* single variable treatments.

Session H-3: Hydroacoustics

Friday, October 28
8:30 am – 10:00 am
Room 206B

Lake Bathymetry: Why You Need It and How It Can Be Cost Effectively Acquired

Mark Reller
Constellation Services, Helena, Mont.

Abstract
Lake managers have many needs for lake bathymetric maps or depth contour maps. Lake volume, surface area, maximum depth and mean average depth can be generated from bathymetric datasets. Modern GPS and sonar technologies can be easily combined and along with robust data collection techniques, cost effective high accuracy bathymetric maps can be produced to serve a wide range of lake management needs. Many lakes have no modern era bathymetric maps. Older depth contour maps are often at a course scale, generally with twenty foot contour intervals and often have no meta-data to reveal data collection density, nor data distribution. Some reservoir contour maps are remnants from pre-impoundment ortho-photo quads. Application of GPS/Sonar technology and robust data collection techniques can quickly achieve bathymetry suitable for lake managers, with contour intervals down to one-foot. With high quality bathymetrics in hand, lake managers can address a wide variety of lake management issues. Habitats vary by depth or stage, slope, fetch exposure, and feature variability. Good bathymetry helps delineate and quantify habitat types and distribution. Bathymetry can help assess fisheries resources, recreation distribution, invasive species risk, current-flow patterns, sediment redistribution or accumulation, research monitoring protocols, shoreline remediation options, and lake level management options. When lake models are to be applied, up-to-date and accurate bathymetric information is especially important. This presentation will provide an overview of a modern GPS-Sonar system along with important considerations regarding data collection and analysis, and final production of useful bathymetric maps.

Amount of Hydroacoustic Survey Effort Required to Accurately Assess Water Body Volume

★Benjamin Cross and Barry Moore
Washington State Univ., Pullman, Wash.

Abstract
Lake volume estimates are an integral aspect of lake and reservoir management. Volume estimates are needed to conduct a variety of important studies and metrics, such volume-weighted concentrations and hydrologic and nutrient modeling. New computational tools have narrowed the uncertainty associated with estimates of volume based on limited data sets, such as simple bathymetric maps. Hydroacoustic technologies, combined with geographic information systems (GIS), also provide an opportunity to gather accurate bathymetric data much more rapidly and with less cost than traditional survey/sounding methods. A key question then is: "How much data are sufficient to provide accurate lake volume estimates?" In this study, we examine how spacing of stratified random transects in a reasonably complex lake affects lake volume estimates. The study was done in 445 ha Loon Lake, in northeastern Washington State. Spatially referenced depth-point data obtained from hydroacoustic transects were converted into a triangulated irregular network (TIN) using GIS to acquire volume estimates. Volume estimates were compared using multiple calculations at variable transect intervals that ranged from about 47 to 470 m. Larger transect spacing intervals produced significantly lower estimates of lake volume with high variability. The relationship between transect interval and volume estimate followed a polynomial function. The study indicates that, at least for irregularly shaped lakes, multiple, closely-spaced transects are required to obtain stable volume estimates with low uncertainty.

Whole-Lake Mapping of Total Phosphorus in Reservoir Bottom Sediments Using Acoustic Echosounder Data

Mark Jakubauskas, Donald Huggins, Frank deNoyelles, Edward Martinko and Ryan Callihan
Kansas Biological Survey, Lawrence, Kans.

Abstract
High nutrient levels, particularly total phosphorus (P) can lead to increased eutrophication in lakes and reservoirs. Phosphorus in sediments contributes to the total phosphorus in the water

column, a process termed internal loading, and thus data on sediment phosphorus levels is critical to modeling and estimation of reservoir total phosphorus loads. The spatial distribution of nutrients within a reservoir can vary widely, and this spatial variability is not easily represented by traditional means of sampling reservoir sediment (*i.e.*, point sampling of bottom sediment using a sediment corer or sampling device). Because phosphorus binds to clay, and the fractal dimension of acoustic signal is affected by bottom type composition (sand, silt, clay), acoustic remote sensing provides an opportunity for intensive non-contact sampling of nutrients in reservoir bottom sediment. We developed an innovative new remote sensing approach to whole-lake quantification of sediment total phosphorus by developing a regression model between the average fractal dimension of the reflected acoustic echo from a 200-kHz echosounder to phosphorus levels from field-sampled point measurements for six Midwestern reservoirs. This regression model was then applied to all acoustic data points within a reservoir to create a map of sediment phosphorus patterns within a given lake.

Hydroacoustic Signatures of Gleotrichia *blooms in Owhi Lake, Washington*

Ed Shallenberger[1], Andrew Child[2], Ben Cross[2], Amy Martin[2], Ellen Preece[2] and Barry Moore[2]
[1]Colville Confederated Tribes, Nespelem, Wash. [2]Dept. of Natural Resource Sciences, Washington State Univ., Pullman, Wash.

Abstract
Located near Nespelem on the Colville Confederated Tribal Reservation in northeastern Washington, Owhi Lake serves as an important recreational resource and a main source of brook trout used in Tribal hatcheries. Cyanobacteria blooms, primarily comprised of *Gloeotrichia echinulata*, have prompted much concern for the lake's continued viability to support these uses. Quantification of *Gloeotrichia* can be complicated as samples typically contain a mix of intact and broken colonies and individual trichomes. Colonies are large enough to be visible without magnification, and have many characteristics that make them good acoustic targets. We have found that whole-lake density results from echo counting at -70db threshold from 420 MHz transducer transects yield good relative correlation with *Gloeotrichia* densities, while echo counts at -50 db exclude all targets that are presumed to be *Gloeotrichia*. Hydroacoustics may provide at least a semi-quantitative means to track bloom development over time. The ability of hydroacoustic counts to quantify *Gloeotrichia* densities in specific strata is being investigated.

Session H-4: Anthropogenic Impact Assessment

Friday, October 28
8:30 am – 10:00 am
Room 206C

Linking Long-term Watershed-based Research with Natural Disturbance and Industrial Landscape Planning in the Canadian Boreal Forest

Ellie E. Prepas[1,2], Gordon Putz[3], Janice M. Burke[1], Daniel W. Smith[2] and Jonathan S. Russell[1]
[1]Lakehead Univ., Thunder Bay, Ont., Canada [2]Univ. of Alberta, Edmonton, Alta., Canada [3]Univ. of Saskatchewan, Saskatoon, Sask., Canada

Abstract
In general, watershed disturbance (*e.g.*, wildfire, forest harvest) is associated with changes to nutrient cycling patterns, increased incidence of peak flow events, and higher water and nutrient yields in streams. Long-term studies are essential to quantify disturbance impacts and construct predictive models, particularly in semi-arid regions where water balances can differ dramatically among years. Limited studies have been carried out on the Canadian Boreal Plain, an area that is 20% of the Canadian boreal forest and six times the area of the state of Washington. The Forest Watershed and Riparian Disturbance (FORWARD) Project is the only long-term watershed disturbance study with emphasis on the Boreal Plain that links empirical data from both terrestrial and aquatic ecosystems to forest management planning. Using extensive field infrastructure in 14 first- to fourth-order watersheds, data are collected on weather, soils, vegetation, stream flow, and surface water quality. The experimental design includes streams draining burned, experimentally harvested, and reference watersheds. In addition to their use for hypothesis testing by researchers and students, these data serve as training, testing and validation sets for the development of two types of predictive models: deterministic (Soil and Water Assessment Tool) and stochastic (Artificial Neural Networks). Research-based contributions from the FORWARD Project were integrated into the Detailed Forest Management Plan of two companies working in western Canada. Work is ongoing to apply this approach to other forested regions in Canada.

Identification of Legacy Pollution Sources and Estimation of Nearshore Habitat Modifications in the Lake Washington Watershed Using Historic Documents and Georeferenced Maps in GIS

Jonathan Frodge
Seattle Public Utilities, Seattle, Wash.

Abstract
Historic maps and documents provide information on past land use activities that have profoundly modified the physical structure and water quality of the present nearshore environment. The Lake Washington watershed and its hydrology were modified by the construction of the Lake Washington Ship Canal and the reversal of the Cedar River from the outlet of the lake to being the primary tributary river. The level of Lake Washington was lowered between nine and sixteen feet and significantly reduced the lake level fluctuation. Georeferencing late 19th and early 20th century maps into the existing GIS projection provide accurate information on shoreline modifications and land use activities

and an accurate method of areal comparison. LIDAR provides accurate topography of recent landforms and modifications in the nearshore area, but was less useful in establishing pre-development shorelines. Data contained on these historic documents allows accurate geographic location of industrial activities that no longer exist, but continue to have impacts on habitat and water quality. Sediment contamination from multiple decommissioned lumber mills, a collapsed coal bunker and long decommissioned munitions loading dock has been identified using this approach. Cultural resources have been located and SEPA response improved. This approach allows an accurate estimation of the modification and areal changes of estuarine and nearshore habitat impossible to obtain from real time sampling.

Anthropogenic Impact on Bangalore Lakes and Prospective on Restoration and Management and Conservation Aspects

★R. Abitha
Indian Institute of Science, Bangalore, India

Abstract
In the recent past the wetlands of Bangalore in India are drawing considerable attention and concern because of their importance realized. Wetlands are among the most important ecosystems that are valuable sources in Bangalore urban area. The present paper attempts to identify some of the major threats, wetland face today and make suitable suggestions to draw the attention of wetland biologists, conservationists, planners and policy makers. In recent years, the wetland values are overlooked resulting due to population pressures and unplanned development. This has threatened the very existence of these vital ecosystems. In order to stem the tide of destruction, especially for wetlands located in urban setup suitable guidelines to assess the ecological integrity and effective monitoring programs are required. Thus the very existence of the wetlands is in danger. These wetlands have often been used as open access resources as easily accessible source of various resources and 'wastelands' as most convenient and costless dumpsites. Various uses have been extracted without making any investment for maintenance and restoration of these wetlands. Water quality assessment and fish diversity of six water bodies located at various places in Bangalore urban district has been monitored for a period of twelve months. Solving the problem at the end point is a temporary measure with more serious repercussions. The solution is to tackle this problem at source points with strict enforcement of our environmental laws and regulations. But until that happens the "City of Lake" will soon be history.

Implication of Bangalore Urban Development on Wetlands and Sustainable Management

Sanna Durgappa and R. Abitha
Indian Institute of Science, Bangalore/Karnataka, India.

Abstract
Bangalore, India is located in a state of many wetlands with rapidly deteriorating water quality as well as diminishing wetland area due to anthropogenic and developmental activities. With rapid urbanization and consequent changes in the demographic structure, particularly during second half of the last century, Bangalore urban wetlands (and especially Hebbal, Ulsoor, and Belandur wetlands) have become subjected to various environmental problems. Wetlands of Bangalore occupy about 4.8% of the city's geographical area (640 sq km) covering both urban and rural areas. Historically, there were 262 lakes located within the green belt area of Bangalore City. Many of these wetlands have been destroyed over the years and all that remains now are artificial water tanks. The number of man-made tanks fell from 379 in 1973, to 246 in 1996, and 81 in 1999, and today only 17 good lakes exist. Nearly 70% of the lakes are suffering from eutrophication due to inflow of sewage. Most wetlands have been severely degraded. Catchment areas have been encroached upon and buffer zones no longer exist. The seriously diminishing quantity and quality of freshwater ecosystems and the unequal availability of quality freshwater ecosystems call for high quality limnological research and expertise to underpin the enhancement of sustainable fisheries and aquaculture development. In regard to national health, agriculture, and economics, the continued over exploitation of finite freshwater resources is directly causal to the progressively deteriorating fish production and general standard of living. The integration of basic understanding of inland ecosystems with applied problems and their solutions should be of fundamental concern to all stakeholders in our freshwater resource.

Session I-1: Milfoil Weevils

Friday, October 28
10:30 am – 12:00 pm
Room 205

Assessment of Genetic Variation in the Milfoil Weevil, Euhrychiopsis lecontei*, a Biocontrol Agent for Eurasian watermilfoil*

★Lara Roketenetz
Univ. of Akron, Akron, Oh. and EnviroScience, Inc., Stow, Oh.

Abstract
The milfoil weevil, *Euhrychiopsis lecontei*, has been used as a management tool for Eurasian watermilfoil, through augmentation programs, where these weevils are reared in mass numbers and purposefully introduced into Eurasian watermilfoil infested waterbodies. Several aspects of the milfoil weevil's ecology and life history make it an ideal candidate for consideration as a biocontrol agent for Eurasian watermilfoil. In addition to North American nativity, the weevil exhibits host specificity for milfoil species, it successfully feeds and oviposits on the invasive Eurasian watermilfoil, it consumes milfoil during all stages of development, and it affects physiological functioning of Eurasian watermilfoil through primary and secondary pathways. By preventing Eurasian watermilfoil from monopolizing resources, the milfoil weevil could play an important role in maintaining community structure and species richness. Geographically-significant genetic variation of the weevils may therefore affect the development of successful and acceptable augmented biocontrol programs for Eurasian watermilfoil. Therefore, the primary purpose of this project is to provide a preliminary assessment of how widespread geographic variation is in the weevil. This will be accomplished through the use of sequence analysis of the cytochrome oxidase I (COI) mitochondrial DNA, and the 18S ribosomal RNA genes. These sequences will represent the first gene-based genetic data collected for this important weevil taxon.

*Survey of Eurasian Watermilfoil (*Myriophyllum spicatum*) Ecotypes and Hybrids and Associated Milfoil Weevil (*Euhrychiopsis lecontei*) Populations in Central Ontario, Canada*

★Kyle Borrowman[1], Eric Sager[2] and Ryan Thum[3]
[1]Trent Univ., Peterborough, Ont., Canada [2]Fleming College, Lindsay, Ont., Canada [3]Grand Valley State Univ., Muskegon, Mich.

Abstract
Ecotypic variation and hybridization of Eurasian watermilfoil (*Myriophyllum spicatum*) and northern watermilfoil (*Myriophyllum sibiricum*) raise new concerns surrounding the potential for heterosis, aggressive colonization, displacement of native macrophyte populations and resistance to herbivory. Growing interest in the use of the milfoil weevil (*Euhrychiopsis lecontei*) as a form of biological control in Ontario, Canada as well as the subsequent identification of hybrid milfoil populations within the province has led to an interest in determining the distribution and relationship of these species within the province. Our objective is to determine the current distribution of *M. spicatum* ecotypes and hybrids throughout Central Ontario and their relationship to natural *E. lecontei* populations. In July and August 2010, we embarked on survey of 21 lakes throughout Central Ontario to identify *M. spicatum* ecotypes and hybrid populations to compare associated *E. lecontei* densities, various lake quality and milfoil patch characteristics (pH, conductivity, alkalinity, species richness, biomass, depth, etc) and plant nutritional content (C, N, P). Two different *M. spicatum* ecotypes and *M. spicatum* x *M. sibiricum* hybrids were identified in the 21 lakes that were surveyed throughout Central Ontario. Hybrid milfoil populations were only identified within lakes with high disturbance pressures and where *M. spicatum* had a historical presence. *Euhrychiopsis lecontei* populations were present across all lakes and all *M. spicatum* ecotypes and hybrid populations. These results provide information that is of importance to management practitioners and future applications of *E. lecontei* as a form of biological control.

Milfoil Weevils: Native Population Densities and Panfish Predation

Martin Hilovsky
EnviroScience, Inc., Stow, Oh.

Abstract
The milfoil weevil, *E. lecontei*, is the only commercially available biological control agent for EWM and the hybrid cross of Eurasian and Northern watermilfoils. The process, Milfoil Solution®, has been implemented in over 150 lakes and ponds in 13 states and one Canadian province over the past twelve years. Long-term, sustainable control has been achieved with multiple year augmentations. Measurements of indigenous weevil densities have been recorded across North America and form a valuable database for assessing weevil distribution and making management decisions. Results of studies conducted for We Energy in Michigan's Upper Peninsula that measured native weevil densities, their effectiveness in controlling hybrid milfoil, and their relationship with panfish populations will be presented.

Milfoil Weevils and Other Potential Milfoil Biocontrol Agents, A Summary of Work from Washington State

Jenifer Parsons and Grace Marx
Washington Dept. of Ecology, Yakima, Wash.

Abstract
The Department of Ecology conducted a milfoil weevil augmentation study on a small lake in central Washington between 2002 and 2007. The milfoil weevils took approximately 5 years to become well established after two years of stocking. Eurasian milfoil declined prior to milfoil weevil populations becoming well established, perhaps a result of grazing by other herbivorous insects. In addition, the Department has monitored the macroinvertebrate and aquatic plant communities in a different small lake since 2004. In that lake, the herbivorous aquatic insect populations fluctuate year to year, and yet Eurasian milfoil comprises less than 30% of the plant community, allowing native aquatic plants to dominate.

Session I-2: Reservoir Management

Friday, October 28
10:30 am – 12:00 pm
Room 206A

Water Quality Management Considerations for Winter Pool Level Drawdown Policies for Hydropower Reservoirs

Richard Ruane
Reservoir Environmental Management, Inc., Chattanooga, Tenn.

Abstract
Relicensing of hydropower reservoirs owned by private sector utilities under the Federal Energy Regulatory Commission has provided opportunity for stakeholders to request that winter pool elevations be raised to enhance aesthetic views and recreational uses of selected lakes. Assessments of several lakes being considered for raising winter pool elevations indicate that significant impacts can occur in site-specific situations. This presentation will present the results of these assessments on issues related to increased sedimentation in shallower areas of lakes, increased internal nutrient cycling, increased macrophytes, possibly increased DO demands on the metalimnion, and increased releases of anoxic products.

Results From the First Four Years of a Nutrient Supplementation Project on Dworshak Reservoir

Sean Wilson[1] and Andrew Dux[2]
[1]Idaho Dept. of Fish and Game, Lewiston, Id. [2]Idaho Dept. of Fish and Game, Coeur d'Alene, Id.

Abstract
In 2007, the Idaho Department of Fish Game and the U.S. Army Corps of Engineers began a nutrient supplementation project designed to restore declining N:P ratios and lost productivity to Dworshak Reservoir. The project resulted in increased densities of picoplankton beginning in the first year. The biovolume of edible phytoplankton has not increased over four years, but the biovolume of inedible phytoplankton has decreased. Mean density, length, and biomass of Daphnia increased in most treatment years. These increases have occurred without violating water quality standards set forth by

the Idaho Department of Environmental Quality. The kokanee population initially responded with increased growth rates, increased length at age, and improved body condition. By 2010, the population size of age 1 and older kokanee had more than tripled from 2007, length at age decreased, but body condition remained better than before. As a result, the biomass of kokanee doubled in the fourth year of the project. These results are similar to what has been observed for reservoirs in British Columbia.

Estimation of Reservoir TP Loading, In-lake Concentrations and Assimilation Capacity in Southern Reservoirs

Mark Ernst and Jennifer Owens
Tarrant Regional Water District, Fort Worth, Tex.

Abstract
The District operates 5 reservoirs in north-central Texas covering 100,000 acres. Eutrophication is a concern, particularly as additional secondary treated effluent is discharged. Annual TP loads were estimated for each reservoir by 6 simple methods involving long term median, mean or flow weighted concentrations for 20 major tributaries constituting at least 86% of each reservoir's watershed. FLUX modeling was used for partial loading estimates on 4 out of 5 reservoirs where daily flow data records were available. In general: median loads < average loads < flow weighted loads. SWAT loading for these reservoirs ranged from 60% higher to 56% lower than calculated loading, but was always within a factor of 2 and there was a significant correlation ($P<.025$, $r=.9012$) between the two approaches . Application of these loading rates in two steady-state, mass-balance equations revealed the sedimentation terms had to be increased by a factor of 1.3 to 2.5 for the models to match observed median TP concentrations. A site specific Chl-*a* - TP regression is presented that demonstrates much less Chl-*a* per unit of TP. A reservoir assimilation capacity estimate is proposed whereby a 20% or 3.7 μg/L increase in ambient Chl-*a* is used as a threshold to evaluate TP loading. The site specific Chl-*a* regression, and to a lesser degree the increased sedimentation terms, suggest these southern reservoirs can assimilate about 40 mgd of secondary treated wastewater. Using published Chl-*a*-TP regressions and sedimentation terms, these reservoirs show no capacity for wastewater assimilation.

Development of a Three-dimensional Hydrodynamic Model to Assess Future Water Quality in San Vicente Reservoir

Imad Hannoun[1], Jeff Pasek[2], Li Ding[1] and E. John List[3]
[1]Flow Science Incorporated, Harrisonburg, Va. [2]City of San Diego Public Utilities Dept., San Diego, Calif. [3]Flow Science Incorporated, Pasadena, Calif.

Abstract
More than 1.3 million San Diegans rely on an uninterrupted source of drinking water from the City of San Diego Public Utilities Department. With a rapidly growing population, continuing drought across the southwest and new constraints on imported water supplies, it is increasingly important that San Diego develop alternative local water supply sources. An option being pursued is the augmentation of drinking water supplies with advanced treated recycled water through the City's Water Purification Demonstration Project (Demonstration Project). The project, the first of its kind in California, will evaluate the feasibility of using advanced water treatment on recycled wastewater to produce supplies that can augment San Vicente Reservoir (SVR). SVR is a key component of the City's drinking source water system; it is currently undergoing an expansion from 90,000 to 247,000 ac-ft. As part of the Demonstration Project, a three-dimensional model of SVR was developed and applied to evaluate the water quality effects on the reservoir under future conditions if the project is implemented. The model was used to assess the ability of the reservoir to assimilate the advanced re-purified water. Impacts on dissolved oxygen (DO) concentrations, nutrient dynamics, and algal production potential were also evaluated. The presentation will discuss the results of this evaluation. The modeling work has been very useful in guiding project decisions for all stakeholders and has proven to be a valuable resource in developing a regulatory structure for this and similar projects.

Session I-3: Remote Sensing

Friday, October 28
10:30 am – 12:00 pm
Room 206B

Using Remote Sensing to Monitor and Assess Geospatial and Temporal Trends of Water Clarity in Minnesota

★Leif Olmanson, Marvin Bauer and Patrick Brezonik
Univ. of Minnesota, St. Paul Minn.

Abstract
Remote sensing is a cost-effective way to gather information on water and land resources needed for effective water planning and management. We recently completed a 33-year (1975–2008) comprehensive water clarity database for over 10,000 Minnesota lakes using Landsat imagery. Analysis of the data was conducted using GIS to investigate geospatial and temporal patterns in relation to land use/land cover and lake morphometric characteristics. Lake clarity in Minnesota has a strong geographic pattern; lakes in the south and southwest generally have low clarity, and lakes in the north and northeast tend to have high clarity. Lake depth is a strong factor in water clarity with deep lakes having higher water clarity than shallow lakes. Land use/cover also is a significant factor with decreasing water clarity associated with increased agricultural and urban areas. These patterns are evident at the catchment, watershed, county, ecoregion, and statewide levels. Soils and slope information significantly improved the relationship between water clarity and land use characteristics. Results of this analysis should be useful to lake managers and policy makers in making informed decisions about land development, and improve the management of lake resources. Our water clarity data can be accessed at http://water.umn.edu.

Comparison and Evaluation of Medium to Low Resolution Satellite Imagery for Regional Lake Water Quality Assessment

★Leif Olmanson, Marvin Bauer and Patrick Brezonik
Univ. of Minnesota, St. Paul, Minn.

Abstract
Remote sensing of water resources has been embraced in Minnesota with state-wide water clarity assessments being conducted on a regular basis for over 10,000 lakes. For these assessments Landsat imagery was used, but the current satellites (Landsat 5 and 7) are both far beyond their expected service lives and could fail at any time. The next Landsat is not scheduled to be launched until late 2012. Two alternative

systems, MODIS and MERIS were investigated. These systems have lower spatial resolution than Landsat, which limits the number of lakes they can assess, but they have improved spectral characteristics which should improve measurement of chlorophyll. To evaluate these systems we used empirical methods. The assessment accuracy for chlorophyll and water clarity (Secchi depth) and the size and number of lakes that could be assessed were determined for calibrated radiance and atmospherically corrected MODIS and MERIS products, and were compared to Landsat. While none of the imagery investigated is ideal for regional water quality assessments, the characteristics of an ideal system have become more apparent. The spatial resolution of Landsat allows all lakes approximately 4 ha or larger to be assessed, but its spectral resolution limits the assessments to water clarity. The MERIS band set was the only system with sufficient spectral and spatial resolution suitable for large (>150 ha) lakes that could be used for regional chlorophyll assessment. The atmospherically corrected MERIS products did not perform as well as the calibrated radiance product.

Use of Satellite Water Quality Imaging and Surface Water Instrumentation for Comprehensive TMDL Compliance Monitoring

Robert Vincent[1], Louis Sanderson[1], Erik Host-Steen[2] and Nick Rendall[2]
[1]Blue Water Satellite, Bowling Green, Oh. [2]Hach Hydromet, Loveland, Colo.

Abstract
Lake and river TMDL compliance is often reported based on taking single or small sample size water measurements and reporting results. The fundamental assumption is that a single point or small sample size data set accurately reflects the state of the entire water body. Recent data based on satellite imaging suggests that water bodies may be non-homogeneous and, therefore, single point or small sample size measurements may not accurately reflect whether the water body is in or out of compliance. This becomes problematic for water managers when pass/fail criteria is used on small sample size data sets and it is often difficult to assess progress toward compliance. This presentation will show comparisons between single point or small sample size measurements compared with satellite sampling that provides five or more samples per acre for the entire water body. Statistical methods will be presented to show the degree to which single or small sample size data accurately represents the status of the water body compared with five or more samples per acre data over the entire water body. Guidelines will be presented suggesting criteria for proper sampling regimen for most accurate TMDL compliance. A methodology will be presented for assessing progress based on data from prior years. The conclusion of the presentation will suggest a methodology for using wide area satellite data to guide spot measurement with water quality sondes for a complete and statistically significant approach to determining TMDL compliance levels.

Aerial Detection of Aquatic Invasive Plants

Alan Cibuzar
A.W. Research Laboratories, Inc., Brainerd, Minn.

Abstract
Remote sensing has become a widely used and accepted method for assessing the health of lakes and rivers. With the increased concern over aquatic invasive species, A.W. Research Laboratories (AWRL) has expanded its remote sensing capabilities to address this emerging problem in lake management - aquatic invasive plants. This type of image collection and processing is accomplished by developing a spectral understanding of the target (*e.g.*, curly-leaf pondweed, Eurasian watermilfoil) which is accomplished with a uniquely designed photon capture and camera system that can precisely view the target in very narrow frequencies. By developing an understanding of the spectral signatures of both the target and the background environment, camera systems can be developed with optics that will maximize the reflective differences from other similar targets and background conditions in the lake. Aerial detection and quantification of aquatic invasive species allows for increased effectiveness in management and provides opportunities to monitor the growth and/or movement of the weed patches over time. The data can also be used by treatment professionals to locate priority sites for treatment and to monitor the effects of treatment methods over time resulting in more efficient and cost effective treatment of these problematic aquatic plants.

Session I-4: Best Management Practices

Friday, October 28
10:30 am – 12:00 pm
Room 206C

Impact of Different Wastewater Treatment Technologies on Bioavailability of Phosphorus

★Bo Li and Michael Brett
Univ. of Washington, Seattle, Wash.

Abstracts
Due to the widespread severity of eutrophication in surface water bodies, there is a big push in the U.S. and internationally to get nutrient levels in municipal wastewater treatment plant discharges down to ultra-low levels. However, currently almost nothing is known about how these treatment processes will affect the speciation and especially the bioavailability of the residual nutrients in these discharges. Our research tests how the percentage of bioavailable phosphorus (%BAP) varies for different treatment plants utilizing alum based removal, as well as alternative WWTPs utilizing ferric, biological, or membrane based systems for advanced phosphorus removal. Also, detailed phosphorus speciation analysis of effluents help determine how BAP varies for different operational categories (*i.e.*, particulate + dissolved; reactive + non-reactive). Moreover, our analyses on the bioavailability of a range of well-defined P forms (*i.e.*, $AlPO_4$, Ca-P, ATP, organic-bounded P, etc.) will directly enhance our understanding on P bioavailability.

Phosphorous-Free Detergent in Hangman Creek; A Squeaky Clean Solution?

Richard Noll and Walt Edelen
Spokane Conservation District, Spokane, Wash.

Abstracts
High phosphorus loads have been a regional water quality issue for the Spokane River and Lake Spokane watersheds, resulting in the development of a Spokane River water quality clean-up plan for nutrients, including phosphorus. In early 2008, The Spokane Conservation District initiated a phosphorus-free detergent study at the Hangman Hills community system of 219 homes in the Hangman Creek Watershed. Residences were asked to switch their automatic dishwashing detergent use to a phosphorus-free brand. The study evaluated changes in total and ortho-phosphorus loads to the local community

wastewater. Weekly sampling occurred at the treatment facility for approximately 18 months. The influent ortho-phosphorus loads at the wastewater treatment facility showed a decrease of approximately 27 percent during the period phosphorus-free detergent was supplied to the community. There was not a significant reduction in total phosphorus or total suspended solids during the regulated period.

Natural Filtration to Treat Runoff from Seasonal Livestock Areas

Sharon Reedyk, Serena McIver and Alan Stewart
Agriculture and Agri-Food Canada, Edmonton, Alta., Canada

Abstracts
Cattle wintering sites and calving grounds are frequently located on dissected terrain where there is a high risk of contamination to stream and lake headwaters from on-site runoff, particularly in the spring. A literature review suggested that adaptation of an intermittent packed bed filtration system may provide a low-cost means for cattle producers to treat this runoff water, providing producers with another tool in managing wastewater from agricultural operations. A two-year bench scale trial was initiated to test the effectiveness of six filter technologies. The technologies were chosen based on several criteria which included: capital and maintenance costs, simplicity, known effectiveness, space requirements, and the ability to scale down the technology. In the bench scale trials the woodchip filter consistently reduced total nitrogen concentrations (27-58%) and sand and bottom ash filters consistently reduced pathogen (67-98%) and phosphorus concentrations (24-55%). Based on these results full-scale systems were constructed in Saskatchewan and Alberta. Results from these trials indicate that the filters are generally meeting performance targets; however variability in the influent water quality is a factor that plays a large role in the performance measures. This presentation will review the results from the bench scale trials and from the first two years of the full scale trials.

Natural Stormwater Treatment System

Dennis Haag[1] and Scott Bingham[2]
[1]Burns & McDonnell, Kansas City, Mo. [2]Bowman Bowman Novick, Kansas City, Mo.

Abstracts
Burns & McDonnell and Bowman Bowman Novik developed a design that included native grasses, wildflowers and wetland plants to treat the polluted stormwater runoff from 11 acres of paved parking at Johnson County Community College, Johnson County, Kansas. The project design incorporated many best management practices including: wetland with forebay and wet detention; bioretention and rain garden cells; bioswales; StormTreat (TM) units; pervious paving; and native plantings. The College is monitoring the success of the project which was completed in 2010. In addition to making Kansas streams cleaner, this project is an example of "green infrastructure" for students and the general public. This system demonstrates stormwater treatment capabilities of natural systems and provides JCCC and its students educational and learning opportunities. The project was funded by a $867,000 grant from the American Recovery Reinvestment Act administered by Kansas Department of Health and Environment, and has won several awards including Mid-America Regional Council 2010 Sustainable Success Story and American Public Works Association Kansas City Chapter 2011 award.

Session I-5: Climate Change

Friday, October 28
10:30 am – 12:00 pm
Room 206D

Climate Warming and the Onset of Salinization: Rapid changes in the Limnology of Two Northern Plains Lakes

Jeff Sereda, Mathew Bogard, Jeff Hudson, Devin Helps and Tarik Dessouki
Univ. of Saskatchewan, Saskatoon, Sask., Canada

Abstract
Water resources of the interior plains region of North America may be adversely affected by climate warming. The climate records of the Battleford region (west central Saskatchewan) indicate that mean annual temperatures have risen by 0.71 °C and mean annual minimum temperatures have risen by 1.03 °C from 1894 to 2007. Snowfall has also increased but total precipitation has not. Concomitant with periodic declines in precipitation, lake elevation has declined and salinity has increased in Jackfish and Murray lakes from 1938 to 2004. This long term increase in salinity is predicted to have caused an approximate 30% loss in diversity of macrobenthos. Phosphorus concentrations have also increased significantly, and Jackfish and Murray lakes would be classified as eutrophic by freshwater trophic indices. However, despite large increases in nutrients in both lakes, algal biomass has not increased and water transparency has not decreased. Although the total amount of planktonic biomass in Jackfish and Murray's food web is similar to that of freshwater lakes, these lakes contain very low algal biomass (measured as chlorophyll *a*). In fact, such low algal biomass has not been previously observed in such dilute systems. The algal community in these shallow Prairie lakes appears to be very sensitive to slight changes in climate, and future climate driven increases in salinity of prairie lakes may result in large reductions in algal primary productivity.

Statistical Modeling to Assess Potential Climate Change Induced Impacts to Water Quality in Deer Creek Reservoir

★Oliver Obregon, Nicolas A. Gonzalez, Gustavious P. Williams, Everett J. Nelson and Blake D. Buehler
Brigham Young Univ., Civil and Environmental Engineering Dept., Provo, Ut.

Abstract
We evaluated temporal and spatial variations in water quality data collected during five spring-summer seasons (2007-2011) from two different sampling points at three different depths in Deer Creek Reservoir in Utah. Hydrochemical, climatological, and biological (chlorophyll *a*) data were collected. The time window included a period of dam reconstruction that created extremely low reservoir levels as well as normal operational levels. We used multivariate statistical techniques (principal component analysis and factor analysis) to determine the principle parameters associated with water quality and then performed an analysis of variance of the principal components to evaluate temporal variability of the data. We found the best statistical model for each sampling site and used it to predict future water quality impacts produced by various Global Climate Change (GCC) scenarios. We used chlorophyll *a* concentrations as water quality indicators to assess the in-reservoir effects of GCC-induced meteorological and

hydrological changes. We compared our findings with previous results obtained using a computational water quality model and found the statistical techniques produced results that were similar.

Predicted Climate Change Impacts on Lake Ecosystem Dynamics and How This Information is Used for Selecting Effective Restoration Projects and Indicators for Measuring Progress

Robert Plotnikoff[1], Harry, Jr. Gibbons[1] and Toni Pennington[2]
[1]Tetra Tech, Inc. Surface Water Group, Seattle, Wash. [2]Tetra Tech, Inc. Surface Water Group, Portland, Oreg.

Abstract
The conceptual model assembled here integrates shifts in lake ecosystem dynamics as influenced by forces due to climate change (CC) and how these changes influence potential effectiveness of current planned restoration projects. CC is bound to diminish the effectiveness of currently planned projects and requires that implementing agencies re-think the type of project and order for implementation to realize long-term benefits. The CC conceptual model uses best available science to generate predictions about expected changes in lake and tributary ecosystems of the Lake Tahoe, California watershed, and used the California Climate Adaptation Strategy to link hypothetical models to real-time applications. A "Template for Conceptual Model Construction" was developed to initially review how large-scale, climate change forces might affect basin characteristics that alter existing conditions for biota. The organization of this conceptual model provides a broad overview of what and how resources are expected to change in the Lake Tahoe Basin with predictions made for each of the forces (temperature patterns, precipitation patterns, and frequency of extreme hydrologic events). A "two-level" set of diagrams describes the mechanisms behind ecosystem alterations from climate change impacts and how specific stressors (thermal stratification, sediment and pollutant load delivery) appear as limiting factors that affect biological populations (increased productivity, promote aquatic invasive species) in the aquatic ecosystem. Stressors have a direct impact on existing water chemistry and biological communities, and are used as "endpoints" that measure influence of climate change.

Psychology, Perception and Risk Communication through Dialogue: The Climate Change Implications for Lake Management

⋆Albelee Haque, Deepayan Debnath and Xin Yuan
Bangladesh Environment Network, Boxborough, Mass.

Abstract
The purpose of this paper is to improve awareness about climate change, sustainable lake management, and their psychosocial dimensions. The direct outcomes of climate change are: anxiety, environmental toxins, frequent floods/storms, and lake/river pollution. The psychosocial aspects may include loss of life/property and related trauma. Climate change is affecting people's lives in many spheres including moral and cognitive thinking, as well as emotions. A narrow focus on sector driven research may not yield robust solutions, whereas, a planet focus that does not exclude social psychoanalyses may yield resolution. Perception is governed by experience and predisposition. Based on literature review, meditation and spiritual intelligence have neurological basis that can influence perception and cognition. However, meditation is the missing logical link from the current social neuroscience models. Spirituality and neuro-plasticity (brain's ability to change) are related to meditation and can help with our ability to communicate risks associated with climate change. Transmitting the value of dynamic spirituality is indispensable to ameliorate the effects of climate change, for diverse and sustainable lake management (*e.g.*, assure reservoir/drinking water quality, enhance aesthetics/recreational fisheries by shallow lake aeration) or risk reduction to build climate resilience as well as psychological resilience.

Session J-1: Macrophyte Management 1

Friday, October 28
1:30 pm – 3:00 pm
Room 205

A Review of Demonstration and Research Project Activities to Evaluate a Littoral Zone Treatment Technology for the Control of Submerged Aquatic Vegetation

Thomas McNabb and Thomas Moorhouse
Clean Lakes, Inc., Coeur d'Alene, Id.

Abstract
Demonstration and research investigation activities began in 2008 in the Pend Oreille River system in Northern Idaho to evaluate aquatic herbicide efficacy using a Littoral Zone Treatment Technology in run of the river systems. In 2008, research investigations were conducted in the Pend Oreille Lake and River system in Idaho, followed by investigations further upstream in the Clark Fork River system of Montana in 2009-2010. Liquid herbicide formulations of diquat, endothall, and triclopyr were evaluated in 19 plots, and water exchange evaluations to determine Contact and Exposure Time (CET) relationships were performed in a total of 23 plots using rhodamine RWT dye. The 2008-2010 trials were designed to evaluate control efficacy of the various herbicide formulations on Eurasian watermilfoil and curlyleaf pondweed. In addition, applications of endothall were performed in two Florida locations in 2010 (Lake Seminole and Lake Underhill), to evaluate the technology for the control of hydrilla, and 2,4-D applications were performed in Long Lake Wisconsin for the control of Eurasian watermilfoil. A review of the findings will be presented.

The Perfect Storm: Aquatic Vegetation Management in a Hyper-Eutrophic Lake, a Case Study of Eloika Lake

Daniel Ross
Spokane Conservation District, Spokane, Wash.

Abstract
Implementation of the Eloika Lake Integrated Aquatic Vegetation Management Plan (IAVMP) began in 2010, with the first herbicide treatment on 60+ acres of Eurasian watermilfoil. A portion of the project includes monitoring, mapping, and public outreach/education components. The primary goal is to restore the beneficial uses of the lake and return the system to a more natural balance. Due to historic land use practices, the eutrophication process in Eloika Lake has been accelerated over the course of the last century into an unbalanced cycle that generates nutrient rich sediment, reduces lake depth, produces periodic algal blooms, and promotes excessive annual macrophyte populations (native and invasive). The silt composition in the lake consists primarily of organic material

produced over decades of excessive vegetative growth, decay, and deposition. Historic and recent plant composition surveys have documented the presence of five invasive plant species: Eurasian watermilfoil, curly-leafed pondweed, yellow flag iris, reed canary-grass, and purple loosestrife. Through the IAVMP process, it was determined that considerable effort needed to be made in the short-term to target the aquatic invasive species. The challenges leading up to implementing management actions on Eloika Lake have been numerous and varied. Follow along as we re-count this journey.

*Differential Aquatic Herbicide Responses in Eurasian X Northern Watermilfoil Hybrids (*Myriophyllum spicatum *X* M. sibiricum*) and Implications for Future Management*

Mark Heilman[1], Ryan Thum[2], Michael Netherland[3,4], Matthew Zuellig[2], Dustin Wcisel[2] and Sarah Berger[4]
[1]SePRO Corporation, Carmel, Ind. [2]Grand Valley State Univ., Muskegon, Mich. [3]US Army Corps of Engineers, Gainesville, Fla. [4]Univ. of Florida, Gainesville, Fla.

Abstract
Over the last decade, expanded research into the genetics, distribution, and life history patterns of invasive Eurasian and native Northern watermilfoil hybrids (*Myriophyllum spicatum* X *M. sibiricum*) has led resource managers and aquatic scientists to more broadly consider the implications of milfoil hybridism for aquatic habitat management. There have been a growing number of anecdotal reports of hybrid milfoil populations showing reduced response to management with aquatic herbicides. In research presented here, new quantitative data are reviewed showing reduced susceptibility of an isolated number of unique hybrid milfoil lineages to two different aquatic herbicides: the auxin-mimic herbicide 2,4-D and the bleaching herbicide fluridone. Hybrid milfoil lineages from a handful of lakes in several Midwestern states show several times less response in lab and field studies to low use rates (0.5 mg/L or less) of 2,4-D compared to the typical Eurasian milfoil response. A unique hybrid milfoil lineage from a Michigan lake has been determined in multiple lab studies and field treatment to show approximately three times less sensitivity to fluridone compared to classic Eurasian milfoil susceptibility. Early indications are that this population also has reduced response to at least one other bleaching herbicide mode of action. Findings of early research examining these unique hybrid lineages, their atypical herbicide responses, and potential for differential responses in other hybrids with similar genetics and various herbicide use histories will be reviewed, and implications for future assessment and implementation of hybrid milfoil management will be discussed.

Influence of Water Exchange on the Dissipation of Granular Triclopyr and Dye in the Pend Oreille River, Idaho

Toni Pennington[1], Harry Gibbons[2], Mark Heilman[3], Scott Shuler[3], Terry McNabb[4], Dai Thomas[5] and Kevin Pilgrim[5]
[1]Tetra Tech, Inc., Portland, Oreg. [2]Tetra Tech, Inc., Seattle, Wash. [3]SePRO Corp., Carmel, Ind. [4]Aquatechnex, Bellingham, Wash. [5]Tetra Tech, Inc., Fort Collins, Colo.

Abstract
Managing nuisance aquatic plants such as Eurasian watermilfoil (*Myriophyllum spicatum*) under high water exchange can result in reduced herbicide efficacy. Granular formulations of herbicides are used to prolong the effective contact and exposure time (CET) near the target plant. Dissipation rates of concurrent applications of granular triclopyr and liquid inert dye (as a surrogate for a liquid herbicide application) were measured in an impounded section of the Pend Oreille River, Idaho. Two 4 ha plots were treated with 448 kg ha^{-1} triclopyr, resulting in effective concentrations of 752 $\mu g\ L^{-1}$ and 962 $\mu g\ L^{-1}$ in Plots 1 and 2, respectively. Dye was applied to both plots at 10 $\mu g\ L^{-1}$. At 1, 4, 8, 12, 16, 24, 48, and 72 hours after treatment (HAT), 12 water samples were collected from the surface, middle, and bottom of each plot and measured for triclopyr and dye concentration. At the same time, acoustic Doppler current profiler (ADCP) measured continuous three-dimensional velocity. Velocity in Plot 1 was 0.14 m sec^{-1} and 0.12 m sec^{-1} in Plot 2 with eddy currents identified by ADCP in Plot 1. Highest triclopyr concentrations were measured in the bottom of the water column of both plots: 506 ± 134.86 $\mu g\ L^{-1}$ at 8h in Plot 1 and 1573 ± 1384 $\mu g\ L^{-1}$ at 12h in Plot 2. Depending on the mode of action, data suggest liquid formulations may lack sufficient CET, while granular triclopyr likely has moderate to sufficient CET at the bottom of the water column to effectively control Eurasian watermilfoil.

Session J-2: Reservoir Aeration / Oxygenation

Friday, October 28
1:30 pm – 3:00 pm
Room 206A

A 25 Year Study of Source Water Quality Improvement by Layer Aeration

Bob Kortmann
Ecosystem Consulting Service, Inc., Coventry, Conn.

Abstract
Layer aeration is a depth-discrete aeration and circulation technique that adjusts how thermal stratification develops. Layer Aeration redistributes heat and creates thermoclines at design depths. Source water is protected against algae above (taste and odor, cyanotoxins, DBP precursors, TOC) and anaerobic respiration products below (iron, manganese, sulfide). Layer aeration of a 523-acre, 70-feet deep, eutrophic water supply lake has been performed annually since 1987 using two 30 HP rotary screw compressors. Source water has been monitored continually since 1984. The 25-year data record identifies very significant improvements in resource quality, raw water quality, and the cost-effectiveness of water treatment. The reservoir response occurred in several stages. Summer Secchi disk transparency increased from <1.8 m to >4.6 m due to elimination of *Anabaena* sp. and *Aphanizomenon* sp. blooms. Descent of the "compensation depth" into the hypolimnion contributed to restoration of 3,300 acre-ft of cool aerobic habitat. Habitat improvement resulted in the re-establishment of large-bodied Cladocera (*Daphnia* sp.) in 1990, which increased algal biomass reduction by grazing. Deep nitrification increased, and the ecosystem respiratory quotient (ERQ) decreased from 1.51 to 1.14, indicating a shift in respiratory processes from anaerobic to aerobic. No iron, manganese, or sulfide problems have been experienced at the WTP since 1987. Water supply benefits included elimination of prechlorination (reducing DBP formation), extended GAC bed longevity, and avoidance of summer taste and odor episodes. Annual mean TOC of raw water decreased from 7.5 mg/L to 4.3 mg/L, dropping a category in the enhanced coagulation TOC-alkalinity matrix.

Improving Dissolved Oxygen at Long Lake HED by Draft Tube Aeration

John Koreny[1] and Hank Nelson[2]
[1]HDR, Bellevue, Wash. [2]Avista Utilities, Spokane, Wash.

Abstract
Long Lake HED (hydroelectric development) is a 71-megawatt-capacity hydropower generation project on Lake Spokane operated by Avista Utilities. The project includes four Francis turbines with an operating head of about 200 feet. The dissolved oxygen (DO) in the discharge from Long Lake HED decreases to a minimum of 4-5 mg/l during a two to four week period from late August to early October because of stratification and biological processing in the lower layers of Lake Spokane. HDR completed a feasibility study to evaluate and model alternatives to increase the DO in the Long Lake HED discharge up to the regulatory standard of 8 mg/l. Alternatives evaluated included aeration/oxygenation at the reservoir, penstock, draft tube and tailrace. Draft tube aeration is the most-feasible alternative. Draft tube aeration involves admitting air into existing ports on the draft chest utilizing the below atmospheric pressure as the water leaves the turbine and enters the draft tube. A field pilot study was completed during early September 2010. Field testing indicated that draft tube aeration effectively increased DO to 8 mg/l. Air admission rates needed to be controlled so TDG did not exceed 110 percent. Modeling indicates that draft tube aeration will be effective at increasing DO to 8 mg/l for the entire summer except for a few days when the low DO will be 6.5 mg/l. Draft tube aeration is predicted to cause a loss of power in the range of 5 to 10 percent. The technology is simpler and more cost-effective as compared to other alternatives like oxygenation and may be applicable for other reservoir discharges with low DO.

Oxygen Diffuser System to Create Fish Habitat and Enhance Hydropower Water Quality at J Strom Thurmond Reservoir

Mark Mobley[1], Paul Gantzer[2], Gary Hauser[3], Jim Ruane[4] and Jamie Sykes[5]
[1]Mobley Engineering, Inc., Norris, Tenn. [2]Gantzer Water Resources Engineering, LLC, Kirkland, Wash. [3]Loginetics, Inc., Knoxville, Tenn. [4]Reservoir Environmental Management, Inc., Chattanooga, Tenn. [5]US Army Corps of Engineers, Elberton, Ga.

Abstract
An oxygen diffuser system has been installed at the U.S. Army Corps of Engineers' J Strom Thurmond Reservoir on the Savannah River between South Carolina and Georgia to create striped bass fish habitat and improve reservoir releases. This system is part of a court approved agreement to mitigate fish habitat that was impacted by operation of the hydropower pumped storage units at the Richard B. Russell project upstream. After 14-years of efforts to solve fish entrainment issues, the pumped storage units at Richard B Russell were approved for operation in 2002. With this approval, the USACE agreed to limit pump-back operations at 2 units out of 4 until a fish habitat mitigation system was implemented in J Strom Thurmond Lake. The fish habitat system is designed to place oxygen in the reservoir at the specific temperature range suitable for striped bass habitat, as well as enhance dissolved oxygen levels at the dam. Extensive modeling was conducted to determine the best diffuser location and plume strength. Since the elevation and extent of the target temperature range changes during the stratification season, the final design includes a total of 9 diffusers spread over four elevations roughly 50 to 90 feet deep at summertime pool elevations. The diffuser system is located 6 miles upstream of the dam and is capable of distributing up to 200 tons of oxygen per day. This presentation will include field measurements from the first season of operation, comparison of model predictions and field results, and oxygen costs.

Application of Modeling for Developing the Operational Guide for an Oxygen Diffuser System for Striped Bass Habitat in J Strom Thurmond Reservoir

Gary E. Hauser[1], Richard J. Ruane[2], Andy F. Sawyer[2] and Mark M. Mobley[3]
[1]Loginetics, Inc., Knoxville, Tenn. [2]Reservoir Environmental Management, Inc., Chattanooga, Tenn. [3]Mobley Engineering, Inc., Norris, Tenn.

Abstract
An oxygen diffuser system has been installed five miles upstream from J Strom Thurmond Dam on the Savannah River to provide striped bass habitat and DO in the hydropower releases The system will provide oxygen in the 18-24 ºC layer that currently becomes oxygen-depleted in the summer due to thermal stratification in the reservoir. The system is designed to provide 5 mg/L in a one-mile reach and 4 mg/L in a four-mile reach in the lower eight miles of reservoir. The system also will add 3 mg/L to water drawn from the reservoir by the turbine units. The diffuser system has the capacity to add 200 tons/day of oxygen to the reservoir. The system consists of nine 400m porous hose diffusers, each supplied separately from an onshore oxygen source. The full system is scheduled for performance testing during the summer of 2011. This presentation provides an overview of the modeling performed to develop an operation guide for the system to optimize use of oxygen while achieving the design DO goals. The operational guide will involve developing two components:

1. Develop a tool (*i.e.*, a widget) to guide operations for oxygen feed rates and the selection of diffusers to operate.
2. Provide a cost/benefit analysis using the CE-QUAL-W2 model to develop the optimized strategic approach to operations (levels of oxygen feed rates, frequency of adjustments) and assess attainment of the goals considering associated costs.

The development of the guide for optimized use of oxygen will be in concert with development of the widget.

Session J-3: Monitoring Design and Data Analysis

Friday, October 28
1:30 pm – 3:00 pm
Room 206B

QA/QC Programs in Water Quality Monitoring – What They Are and Results They Generate

Erik Host-Steen
Hach Hydromet, Loveland, Colo.

Abstract
Usable data is the lifeblood of any water monitoring program and variation in measurement processes impairs the quality of the data that water resource professionals work so hard

to obtain. Differences in operators, equipment, materials, calibration procedures, test methods, environmental conditions, and other factors can contribute to discrepancies between measurement results. While the "true value" is the ideal output of any measurement system, it's an elusive standard in practice. The best approach to minimizing data discrepancies in measurement results is to employ quality assurance and quality control (QA/QC) programs that minimize variation in the measurement process. This talk will start with a refresher of basic measurement science and the factors that will contribute to variation in measurement results when using field water quality instrumentation. Best practices for QA/QC programs in laboratory and field settings – such as the "10% rule-of thumb" and taking quality control measurements that are spatially and temporally appropriate – will be presented along with data from laboratory and field QA/QC programs that illustrate the lessons that can be learned and applied to any water monitoring program.

Guidelines for Design and Sampling of Water, Sediment, and Biological Quality in Lakes and Reservoirs – A New Chapter in the U.S. Geological Survey National Field Manual for the Collection of Water-Quality Data

Reed Green[1] and Franceska Wilde[2]
[1]US Geological Survey, Little Rock, Ark. [2]US Geological Survey, Reston, Va.

Abstract
The U.S. Geological Survey (USGS) develops sampling procedures and collects data necessary for accurate assessment and management of our nation's surface-water and groundwater resources. Federal and state agencies, water-resource regulators and managers, and many organizations and interested parties in the public and private sectors depend on the reliability, timeliness, and integrity of USGS data and the scientific soundness of USGS data assessments and analyses. The standard data-collection methods used by USGS water-quality personnel are peer reviewed, updated as needed, and published in the National Field Manual for the Collection of Water-Quality Data. A new chapter in this National Field Manual is being drafted to include guidelines for the design of sampling strategies for water, sediment, and biological quality of lakes and reservoirs. Included in this document will be a discussion of the differences between natural lakes and constructed reservoirs that may require different monitoring strategies for specific objectives. General data-collection considerations will include selection of sampling methods, field preparations, safety precautions, and documentation of quality-assurance procedures and onsite practices and observations.

Data Driven Strategies to Guide Shoreland Restoration and Protection

Jennifer McNelly[1], Nancy Turyk[1], Linda Stoll[1], Randy Slagg[2], Steve Bradley[2] and Patrick Sorge[3]
[1]Univ. of Wisconsin-Stevens Point, Stevens Point, Wis.
[2]Portage County Land Conservation Dept., Stevens Point, Wis.
[3]Wisconsin Dept. of Natural Resources, Eau Claire, Wis.

Abstract
In 2002/03, a study of 30 lakes in Portage County was conducted as a means of efficiently collecting data on water quality, algae, aquatic macrophytes, shoreland vegetation, and other parameters. In 2007, the county, WDNR, and UW-Stevens Point (UWSP) staff initiated a three year process to utilize these data in the development of lake management plans. Key objectives of this county-wide planning effort included expanding county staff and departments in lake management education and implementation, empowering citizens through education and dialog in plan development, and involving boards and representatives of local municipalities in lake management and stewardship. The planning process involved more than 300 citizens in the creation of 16 lake management plans. Shoreland management was one of the key elements that citizens were eager to address. Shoreland disturbance ranged from none to over 90%. A variety of approaches and strategies were tailored to the needs and social setting of each lake. Shoreland surveys coupled with GIS analysis helped to identify areas where management strategies should be targeted. Citizen surveys identified motivations for changes in land management and perceptions about shoreland vegetation and issues. The management actions identified in the lake plans were the catalyst for strategies to protect and restore healthy lake shorelands. This presentation will follow three lakes with very different shorelines and explore how they utilized the different tools in the planning process, the management strategies that they created, and the success and challenges that they have met in the process.

Comparing Linear Regression and Time Series Methods to Detect Trends in Lake Water Quality

★Dana Bigham[1], Carlos Duarte[2] and Daniel Canfield Jr.[1]
[1]Univ. of Florida, Gainesville, Fla. [2]CSIC-UIB Instituto Mediterraneo de Estudios Avanzados, Esporles, Mallorca, Spain

Abstract
Many governments and agencies exacerbate the need for identification of trends in lake water quality as developing laws and regulations are contingent on such results. This paper compares two commonly used methods to detect trends in water quality, linear regression analysis and time series analysis. Water quality data were obtained from the well-established Florida LAKEWATCH monitoring program. Average annual total phosphorus, total nitrogen, total chlorophyll, and water clarity data, collected for at least 15 years (N = 193 lakes), were examined. For this population of Florida lakes, linear regression analysis detected about 50% of the lakes had increasing trends in total phosphorus, total nitrogen, and total chlorophyll, and decreasing trends in water clarity Time series analysis detected no trends for each water quality parameter for at least 75% of the lakes; around 10-15% of the lakes showed increasing trends in total phosphorus, total nitrogen, and total chlorophyll, and decreasing trends in water clarity. Overall, the proportion of lakes showing long-term trends as indicated by time series analysis was much smaller than derived from linear regression analysis. Time series analysis better accounted for temporal variance providing a more reliable estimate of lakes showing long-term trends. Both linear regression and time series analysis, however, showed the proportion of Florida lakes with long-term trends was greater than expected by chance.

Session J-4: TMDLs

Friday, October 28
1:30 pm – 3:00 pm
Room 206C

A TMDL-Weighted Approach to Evaluating Project Efficacy

Lance Lumbard[1], Ann Shortelle[1] and Rex Caffey[1]
[1]AMEC E&I, Inc., Orlando, Fla. [2]Louisiana State Univ., Baton Rouge, La.

Abstract
Lake managers are often faced with the challenge of guiding public agencies through the process of selecting the best restoration alternative from a suite of options. Regardless of project type, costs for the various alternatives are often compared using net present value (NPV). Qualitative project benefits must also be considered and, depending on social pressures, can lead to selection of an alternative that does not produce the lake manager's desired results. The need for less subjective methods to determine project efficacy has become apparent with the progressive implementation of TMDLs and load allocations requiring commitment of significant public capital. One performance metric commonly employed is calculated using dollars spent per unit mass of target nutrient removed. This approach, though simple, provides little information about the environmental response generated by the project. To provide this information, a weighting factor for TP mass removal was developed using the ratio of project-specific reduction to the reduction necessary to achieve the TMDL goal. The project-specific TP mass removal was then adjusted by the weight factor and TP removal efficacy was compared for multiple restoration projects using both simple and weighted approaches. Because the TMDL target value already incorporates the desired environmental response necessary for obtaining designated use, the weighted metric provides a more robust method for comparing restoration projects and will increase the probability that the best project alternative is selected.

Como Lake: An Urban Lake TMDL Implementation Success Story

Mark Doneux
Capitol Region Watershed District, St. Paul, Minn.

Abstract
Como Lake is located in the Capitol Region Watershed District (CRWD). Como Lake was listed in 2002 as impaired for excess nutrients. Phosphorus concentrations range from 100 to 400 μg/L, exceeding the ecoregion standard for shallow lakes each year. The watershed load to Como Lake represents approximately 34% of the total load to the lake. A 60% reduction in watershed load is required in the TMDL to meet water quality standards. CRWD began a project in 2003 with a hydrologic analysis of an 830-acre subwatershed draining to Como Lake. The issues addressed were flooding problems in residential areas, runoff volume. and nutrient input reduction, coordination of local stormwater management projects with street and infrastructure reconstruction, as well determining an equitable cost distribution for the partners. Implementation activities included retrofitting existing areas with Best Management Practices (BMPs) and installing new BMPs during street reconstruction. BMPs used included regional ponding, first-of-their-kind under street infiltration trenches, ands rain gardens. Implementation activities met the TMDL goals by reducing phosphorous inputs by 78 pounds to the lake as well as the frequency and duration of flooding. Green infrastructure practices eliminated the need for a costly pipe upgrade in Como Park saving over $1 million. A cost contribution plan fairly distributed the project costs amongst the five partners. Rain gardens now also function as educational tools for stormwater management. While still impaired, water quality trends have improved to meet water quality standards for Secchi disk and chlorophyll *a*.

Spokane River and Lake Spokane Dissolved Oxygen TMDL – Development and Implementation

David Moore
Washington State Dept. of Ecology, Spokane, Wash.

Abstract
Lake Spokane (also known as Long Lake) is a 24 mile long reservoir downstream of Washington's second largest city, Spokane, and several smaller communities. It has experienced a long history of water quality problems. Toxic algae blooms in the 1970s resulted in the court-ordered establishment of a phosphorus TMDL, which has since been shown not to be protective of water quality. In October 2004, Ecology proposed a new DO TMDL. In the summer of 2008, just prior to issuance of a final dissolved oxygen TMDL, EPA directed the Washington Department of Ecology to revise the draft Spokane River TMDL to consider the cumulative impact of nutrient-related pollutants from both Idaho and Washington sources. Since that time, EPA, Ecology, Idaho Department of Quality and the Spokane Tribe of Indians have been developed a TMDL that was approved in May 2010 that not only considers the cumulative impact of pollutants from both states, but considers the decrease in assimilative capacity for nutrients and oxygen demanding pollution caused by Long Lake Dam. A 401 certification of the dam's FERC license requires the operators to comply with water quality responsibilities identified in the TMDL. The Washington State water quality standard requires near-natural conditions, which makes the available loading capacity extremely small. This capacity must be divided between Idaho and Washington. Currently, all river stakeholders are involved in an advisory process, originally focused on nutrient trading, to determine a path to water quality compliance prior to NPDES permit issuance.

Hangman Creek Sediment and Phosphorus Implications to the Lake Spokane Dissolved Oxygen Total Maximum Daily Load Evaluation

Rick Noll
Spokane Conservation District, Spokane, Wash.

Abstract
Hangman Creek, also known as Latah Creek, has been recognized by the Washington State Department of Ecology (WDOE) as a watershed with sediment and turbidity issues. In addition, Hangman Creek phosphorus loading to the Spokane River is being evaluated and modeled to comply with the Spokane River Dissolved Oxygen TMDL phosphorus load allocations. The Hangman Creek watershed total phosphorus loads from soil erosion were estimated both on an annual basis and monthly for the Spokane River TMDL period of interest (April through October). Recent watershed wide soil sampling data collected by the Spokane Conservation District was used in conjunction with a four year suspended sediment study conducted jointly by the Conservation District and the USGS to estimate total and bio-available phosphorus loads from Hangman Creek. On an annualized basis, Hangman Creek sediment phosphorus is a significant load to the Spokane River

system. This is important in understanding how sediment and phosphorus from the Hangman watershed can affect phosphorus management in the Spokane River and Lake Spokane. Using the average annual stream flow from Water Years 1947 to 2007, an estimated annual average load of 3.0 tons and 47 tons of bio-available and total phosphorus, respectively, is delivered from Hangman Creek soils to the Spokane River. For the four years of suspended sediment sampling, the estimated monthly total phosphorus loads ranged from 2 pounds in September 2001 to 26,700 pounds in April 2000.

Session K-1: Macrophyte Management 2

Friday, October 28
3:30 pm – 5:00 pm
Room 205

Aquatic Weed Eradication in Washington – Successes, Attempts, and Lessons Learned

Jenifer Parsons[1], Beth leDoux[2], Tim Miller[3] and Sally Abella[2]
[1]Washington Dept. of Ecology, Yakima, Wash. [2]King County Dept. of Natural Resources, Seattle, Wash. [3]Washington State Univ., Mt. Vernon, Wash.

Abstract
According to Washington State weed law, invasive non-native plants listed on the Class A list must be eradicated. Thus far, the Department of Ecology has focused funding on eradication projects targeting three Class A aquatic weeds – *Hydrilla verticillata* (hydrilla), *Myriophyllum heterophyllum* (variable-leaf milfoil), and *Butomus umbellatus* (flowering rush). The first, Hydrilla, was well established in two small interconnected lakes when discovered in 1994. Eradication efforts began the following summer using a combination of herbicides and hand pulling. Those efforts appear successful after many years of diligent work. Several years of monitoring data from both lakes have produced no new sightings. The second weed, variable-leaf milfoil, was identified in Washington using genetic analysis in 2006. Five lakes have been identified with this species. Control projects started in earnest in each lake in 2008, and data show varying degrees of success. The third weed, flowering rush, was known from one Washington lake for many years, but it was not until reports of its invasiveness in Montana that it was added to the Class A list in 2009. Since then, unfortunately, it has been found in several river systems. We have conducted trials of control methods including herbicides, covering, and diver hand removal. Successful state-wide eradication of this species will be a challenge.

Milfoil Eradication by Hand Pulling in Walsh Lake, Washington

Josh Wozniak and Rob Zisette
Herrera Environmental Consultants, Seattle, Wash.

Abstract
Walsh Lake is located in the Cedar River Watershed, which is protected for use as the primary water supply for the City of Seattle. Herbicide use is prohibited within the watershed. Eurasian watermilfoil (milfoil) was first discovered in this natural lake during a botanical inventory in 2001, but a detailed survey and removal plan was not initiated until 2005 when city staff became aware of this discovery. A total of 121 native plant species were identified in the lake and its adjacent wetlands, including 28 native submerged species, adding urgency to the need for milfoil control. Milfoil was primarily confined to a small area where a turbidity curtain was installed to contain fragments during hand removal by divers. Over 580 pounds of milfoil were removed from this site by hand pulling over a two-day period in 2005. In 2007, a new infestation site was detected deep within the cattail marsh near the lake outlet, which is located at a beaver dam 0.5 miles from the original site. Milfoil removal amounts declined each year to only five small plants in 2008. However, removal amounts increased in 2009 at the original infestation site and in 2010 at the outlet site. A bottom barrier was applied at the original infestation site in 2009 and survey intensity increased within the cattail marsh in an effort to achieve eradication. This presentation will explore the challenges of eradicating milfoil in a lake surrounded by a diverse and complex wetland system that is managed by beavers.

What We're Learning from Early Season, Large-scale Herbicide Treatments for Eurasian Watermilfoil in Wisconsin

Timothy Asplund[1], Michelle Nault[1] and John Skogerboe[2]
[1]Wisconsin Dept. of Natural Resources, Madison, Wis. [2]US Army Engineer Research and Development Center, Eau Galle Aquatic Ecology Laboratory, Spring Valley, Wis.

Abstract
Wisconsin has been working with the US Army Engineer Aquatic Plant Control Research Program to evaluate the efficacy and risks of large- to whole-lake scale early season herbicide treatments for the management of Eurasian watermilfoil (EWM). Most projects are funded with state aquatic invasive species grants and involve detailed aquatic plant surveys, spring and fall mapping of the target species, monitoring of residual herbicides, and water quality assessment. Projects were active on 10 lakes in 2009, and increased to include around 25 lakes in 2010 and 2011.

Preliminary findings are surprising:

- Early spring, large scale treatments may result in longer persistence of herbicides than expected, due to colder temperatures and slower degradation rates
- Herbicide dissipation is rapid and large scale treatments often become whole lake treatments
- Effective seasonal control of EWM can be accomplished with initial herbicide concentrations that are well below the suggested application rates
- Multi-year control is possible, but it is unclear how long control will persist and whether it can be accomplished without significant damage to native plant populations
- Residual monitoring is important, both to understand treatment efficacy, as well as ecological risks

This presentation will highlight several case studies from a diverse set of lake types and EWM infestation levels. It is important to note that large scale herbicide treatments in Wisconsin are experimental. While the goal is to restore lakes to a pre-invasion state, it is unclear at this time whether the need for future herbicide treatments would be significantly reduced.

*The Tinmouth Pond Milfoil Project: A Non-chemical Strategy for Controlling Eurasian Watermilfoil (*Myriophyllum spicatum *L.) in Tinmouth Pond, Vermont*

Christopher Knud-Hansen[1] and John Myers[2]
[1]SolarBee, Inc., Westminster, Colo. [2]Tinmouth Pond Association, Tinmouth, Vt.

Abstract
The Tinmouth Pond Milfoil Project (TPMP) is a comprehensive, integrated approach to manage the invasive exotic aquatic weed Eurasian watermilfoil (EWM, *Myriophyllum spicatum* L.) and improve water quality in Tinmouth Pond, VT (78 acres, max depth 11 ft). First noted in 1998, EWM had significantly expanded its coverage by 2002. The TPMP uses two solar-powered circulators as the primary in-lake management tool and includes hand harvesting, benthic barriers (0.03 acres), and EWM fragment retrieval. One circulator was installed in June 2006 and the other in May 2008. Anticipated benefits include cyanobacteria bloom control through epilimnetic circulation, and EWM control through depletion of ammonia-N from enhanced sediment oxidation. There have been no cyanobacteria blooms and water clarity has noticeably improved since the circulators were installed. Because of the lake's shallow depth, the entire lake bottom is within the photic zone. Annual plant surveys conducted since 2005, based on transects using point-intercept frequency and diver observations, document decreases in both frequency of EWM on transects and percent coverage. Many remaining EWM plants look yellowish and unhealthy, consistent with ammonia-N limitation. At the same time, percent coverage by native plant species has steadily increased since 2005. Furthermore, native plant species richness has also increased since 2005, contrary to the typical paradigm in lakes with an EWM infestation. The TPMP's non-chemical strategy has proven effective so far; even with light availability throughout the lake, EWM presence is limited to relatively few scattered plants, and EWM neither dominates nor outcompetes native plants.

Session K-2: Reservoir Hydromodification

Friday, October 28
3:30 pm – 5:00 pm
Room 206A

Effects of Reduced White River Inflow on Lake Tapps Water Quality

Nancy Rapin[1] and Gene Welch[2]
[1]Muckleshoot Indian Tribe Fisheries Division, Auburn, Wash. [2]Tetra Tech Incorporated, Seattle, Wash.

Abstract
Large volumes of water were diverted from the White River to Lake Tapps, Washington, for power generation from 1911 to 2004. During years 2004 through 2006, White River inflows to Lake Tapps were significantly lower (summer average of 159 cfs) compared to the 1982-2003 summer average inflow of 917 cfs. The reduction of river inflows to Lake Tapps raised concerns about maintaining acceptable water quality in the lake. To investigate the effects of reduced White River flows to Lake Tapps water quality, we monitored several sites in Lake Tapps during summer months in 2004 through 2006. Lake Tapps can be classified as an oligotrophic lake, with average summer total phosphorus and chlorophyll values of 8.4 and 2.3 μg/L, respectively. Algae in Lake Tapps are limited by phosphorus and are not light limited. Lower volume flows to Lake Tapps means lower lake phosphorus concentrations because increased water retention time in the lake increases the loss of phosphorus to lake sediments and the inflow phosphorus concentration is lower at lower inflow. Lake Tapps water quality will not benefit from increased White River inflows above those needed to maintain the lake level. The increased water retention time in the lake, however, has increased transparency depths in recent years, which may allow macrophytes (milfoil) to grow in a larger area of the lake.

Flow Routing with Bottom Withdrawal to Improve Water Quality in Walnut Canyon Reservoir, California

Michael Anderson[1], Andy Komor[2] and Keisuke Ikehata[2]
[1]Univ. of California, Riverside, Calif. [2]PACE, Fountain Valley, Calif.

Abstract
Walnut Canyon Reservoir is a small 3,000 acre-ft source water reservoir for the City of Anaheim, California. The reservoir receives untreated water from the Metropolitan Water District of Southern California and is principally used as a raw water storage supply (and emergency storage) for the Lenain Filtration Plant. The reservoir is stratified through the summer, with anoxia and elevated concentrations of dissolved Mn, phosphate, total N, and sulfide present in the hypolimnion. Water quality modeling using DYRESM-CAEDYM was conducted to evaluate different management strategies for the reservoir. Simulations evaluated: (1) diffused aeration, (2) hypolimnetic oxygenation, and (3) flow routing with bottom withdrawal. Meteorological data from nearby CIMIS stations were used to drive the hydrodynamic component of the model, with the model calibrated using available profile measurements and discrete sampling from April-July 2010. Diffused aeration, hypolimnetic oxygenation, and flow routing with bottom withdrawal were all predicted to improve DO conditions and lower concentrations of dissolved Mn, P, and other elements, although flow routing with bottom withdrawal could be implemented by the City without incurring significant capital and operating costs. As a result, this strategy was implemented in the spring of 2011. Results from water column sampling this spring and summer will be compared with conditions last year and with model simulations. Although measurements are ongoing, preliminary findings indicate that flow routing with bottom withdrawal can serve as a practical and effective alternative to other engineered solutions under favorable hydraulic and source water quality conditions.

Will a Shift in Algal Composition in Response to Artificial Whole Lake Mixing Help Achieve the Chlorophyll a *Standard?*

Craig Wolf
GEI Consultants, Inc, Denver, Colo.

Abstract
In 2008, a new management strategy was implemented on Cherry Creek Reservoir, Colorado to help achieve the chlorophyll *a* standard (18 g/L). The destratification system was designed to mix the reservoir and minimize thermal stratification, to reduce the favorable growing conditions for cyanobacteria, and to reduce internal phosphorus loading by oxygenating the bottom sediments. Encouraging patterns in the data indicate the destratification system will be effective in achieving some of the objectives, but achieving water quality standards remains uncertain. The destratification system has

been effective in reducing thermal stratification, although low dissolved oxygen conditions persist at the sediment interface. The low dissolved oxygen conditions promote internal phosphorus loading, and the effective mixing facilitates the upward movement of nutrients into the photic zone which promotes algal growth. The destratification system has greatly reduced the cyanobacteria abundance in the Reservoir. Prior to and in the first year after operation, cyanobacteria comprised between 40% and 80% of the assemblage in terms of density. However, during the past few years, cyanobacteria only comprised 1% and 7% of the assemblage. In response, many flagellated species (cryptomonads, dinoflagellates, and chlorophytes) have increased their abundance. Historically, peak summer chlorophyll *a* levels of approximately 30 μg/L were associated with cyanobacteria. However, during the past few summers, peak chlorophyll *a* levels of approximately 45 μg/L have been associated with the more abundant flagellated species. The new management strategy combined with a shift in algal composition has raised additional questions regarding the appropriate chlorophyll *a* standard for the Reservoir and its beneficial uses.

A Tale of Two Reservoirs: The Spokane Lake and Tenkiller Reservoir Case Studies

Mike Brett
Univ. of Washington, Seattle, Wash.

Abstract
Lake Tenkiller in Oklahoma State and Long (Spokane) Lake in Washington State are both the focus of intensive limnological investigations. Both reservoirs were or currently are extremely eutrophic due to external nutrient inputs. Both are also the focus of intense public interest involving environmental advocacy groups, public utilities, local, state, and federal agencies, cross-state issues, and private corporations. These systems provide a very interesting opportunity to examine how limnological data influences the management and restoration of aquatic systems. This presentation will present a comparative analysis of the history, science, management, legal issues, and future prognosis for these important case studies.

Session K-3: Phosphorus Loading

Friday, October 28
3:30 pm – 5:00 pm
Room 206B

The Quest for Adequate Phosphorus Measurements in Lakes

Gertrud Nürnberg
Freshwater Research, Baysville, Ont., Canada

Abstract
Phosphorus (P) determines whether a water body is eutrophic, and routine assessment is mainly based on the average summer total P (TP) of the photogenic (light-exposed) layer. Not all of TP is available to phytoplankton, and (expensive, high tech) fractionation can be used to determine the part that is. This presentation investigates whether routine TP analysis is adequate or whether fractionation has to be applied. Most important is the context and aim for measuring P:

(A) To determine the trophic state of lakes, it is sufficient to analyze mixed water TP throughout the growing season. But if it is important to determine internal P fluxes, like those from anoxic bottom sediments, TP analysis methods specific to the characteristics of the bottom water samples are required (*e.g.*, whether the water is anoxic or not).

(B) To quantify the immediately bioavailable P fraction, the controversial fractionation of soluble or dissolved reactive P (SRP) after filtration and molybdenum-blue spectroscopy has been routinely used. Whether this method "really" analyzes quantitatively for phosphate depends mainly on the amount of phosphate in the sample. At trace amounts the sample characteristics, such as redox potential, organic acids, quantity and nutrient status of phyto- and bacteria plankton, certain metals and hydrogen sulfide gas and handling (lag-time, sample containers) influence the ability to detect P.

In these cases different pre-analysis treatment is necessary, and the sampling preparation and handling has a much larger influence on analytical detection limits and precision than the actual low-level, high-tech analysis.

Internal Phosphorus Loading and Vertical Transport Drives Algal Blooms in Cedar Lake, Wisconsin

William James
ERDC Eau Galle Aquatic Ecology Laboratory, Spring Valley, Wis.

Abstract
Cedar Lake, WI, is susceptible to vertical transport of soluble phosphorus (SP) from the hypolimnion due to its large surface area (450 ha) in relation to mean depth (5.8 m) and a maximum fetch of 3.5 km along the north-south axis. SP concentrations increase to > 1.0 mg/L in the hypolimnion in conjunction with summer anoxia. Net internal P loading ranges between 6 and 9 mg/m^{2}d. Wind-generated mixing during the summer and fall result in both partial and complete water column mixing and reoxygenation, with accompanying transport of substantial soluble P (SP) to the euphotic zone. The susceptibility of the lake to vertical P transport may be indirectly exacerbated by the lack of significant dissolved iron (DFe) accumulation in the anoxic hypolimnion. The hypolimnetic DFe:SP ratios are very low (<1:1), implying poor binding potential and precipitation of SP back to the sediment during mixing and reoxygenation events. As a result, SP concentrations are elevated in the epilimnion and available for algal uptake. Algal blooms in excess of 100-400 mg/m^3 are sustained from late August through October. In contrast, the sediment Fe:P ratio is >10. Reduction of sulfate and reaction with reduced Fe to form FeS may explain the low DFe concentrations in the hypolimnion during the summer.

Developing a Data-intensive Nutrient Budget for Wapato Lake, Tacoma, Washington, With an Eye Towards Future Management

James Gawel[1], Heather Jennings[1], Anna Sonoqui[1], Steve Ayers[1], Cierra Hancock[1] and Sonya Remington[2]
[1]Univ. of Washington Tacoma, Tacoma, Wash. [2]Arizona State Univ., Tempe, Ariz.

Abstract
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.

The Use of a "Mobile Alum Injection Dosing" (MAID) System to Improve Treatment Efficiencies of Existing Stormwater Ponds

Ronald Novy[1] and Matt Rayl[1,2]
[1]Orange County Lake Management, Orlando, Fla. [2]Aquatic Ecosystem, Inc., Orlando, Fla.

Abstract
Today's TMDL and BMAP requirements and the nation's economic condition are a large challenge for today's lake managers. One avenue to meeting reduction goals is to improve what is currently in place. Many basins have stormwater treatment ponds scatter throughout them; improving the pollutant removal efficiency of these ponds can be a cost effective method of meeting removal goals. One such methodology is the use of alum injection to improve pond removal efficiencies. For this reason a simple, portable, self-contained system with solar powered capabilities is highly desirable. Orange County Lake Management Section together with Aquatic Ecosystems, Inc. began configuring the Mobile Alum Injection Dosing (MAID) system. The system is entirely portable by utilizing a metal cargo shipping container(s) to house all the essential mechanical, electronic control devices and alum product. The MAID system monitors the stormwater inflow rate and injects flow proportional alum doses. The dosed stormwater is effectively mixed using an aeration mixing system and the floc is allowed to form and settle within the existing treatment pond system. The system continuously monitors pH and turbidity levels near the ponds outfall as safeguards to dosing. The system is controlled by a Programmable Logic Controller (PLC) with web-based monitoring of such parameters as total volume treated, rainfall, pond stage, pH, turbidity, and alum supply levels. The site manager user can log-in remotely and review and adjust the setting on any or all of these MAID systems. Estimated removal efficiencies of up to 90% can be achieved for phosphorus.

Session K-4: Combined Sewer Overflow

Friday, October 28
3:30 pm – 5:00 pm
Room 206C

Use of Spatial Rainfall Variability for CSO Facility Design at Spokane, Washington

Duane Studer, Kiana Eller and Lars Hendron
AECOM, Spokane, Wash.

Abstract
The City of Spokane and its Combined Sewer Overflow Program Management Office has developed a long-term plan for the management of their combined sewer system. A significant part of this planning process is the design and sizing of combined sewer overflow (CSO) facilities to control rainfall runoff. Applying an appropriate design event for CSO system analysis is an essential step to assure that these CSO facilities meet regulatory requirements. Published isopluvials for rainfall spatial variability are generalized for the Spokane region, and are not specific enough for the desired level of confidence to meet CSO regulatory compliance. To this end, a specific analysis of Spokane rain data was needed for future CSO control facilities planned in various parts of the wastewater collection system across Spokane. This analysis reviews the process used to define the design event for designing CSO facilities and presents an update to spatial variability from additional years of rainfall data and resulting size impacts to planned CSO facilities.

Challenges of Continuous Simulations to Validate Compliance for CSO Facility Design

Duane Studer[1], Beryl Childs[1], Lars Hendron[2] and Gerry Shrope[1]
[1]AECOM, Spokane, Wash. [2]City of Spokane, Spokane, Wash.

Abstract
As part of the City of Spokane's Combined Sewer Overflow (CSO) Reduction Program, the CSO Program Management Office is conducting the preliminary design phase. A critical part of this process is selecting the size of combined sewer overflow (CSO) facilities to control rainfall runoff and meet regulatory goals. Although design of facilities using a synthetic design event provides a level of confidence against certain rainfall events exceeding the intended design, regulatory guidelines (WAC 173-245) also provides for continuous simulation of historical rainfall as a means of predicting CSO reduction facility performance. Selecting the appropriate historical rainfall record to provide a meaningful evaluation of proposed CSO facilities can be a challenge given the limited rainfall data sets available (< 100 years). In addition, precipitation recording intervals have varied over the years and different gages. An analysis of rainfall data time increment impact on resulting runoff rates and CSO peak flows is presented. A summary is also given for the anticipated ability of designed CSO facilities to meet regulatory requirements.

Combined Sewer System Management: Hydraulic Flow Control Structure Performance Testing and CTI Channel Design for the City of Spokane, Washington

Alex Sylvain and Beryl Childs
AECOM, Spokane, Wash.

Abstract
The City of Spokane has been implementing its comprehensive and integrated program of combined sewer overflow (CSO) reduction planning, analyses, and capital improvements. During the past 12 years, numerous facilities have been constructed and tested with each presenting new lessons learned regarding hydraulic structures and storage design. An integral part of some CSO storage facilities is the in-line combined trunk inflow (CTI) channel. As a strategic part of the design, the CTI can reduce the number of smaller storms diverted to the main (off-line) storage. By maximizing CTI channel flow control and in-line storage, the frequency of use and size of the main storage can ultimately be reduced, thereby decreasing maintenance and cleaning efforts as consequence. The key lies in self-cleaning CTI channels, which require specific dimensions and flow velocities. Management of flow control, detention volume, and water levels are achieved within the CTI channel through flow control devices and adjustable weirs should future level adjustments be necessary. The downstream portion of CTI channel is an integral interceptor inlet vault which contains the flow control device. After construction is complete, CTI channel, flow controls, and weirs are tested for adequate performance in conveying and retaining the correct volumes and flow rates. This presentation highlights the issues and challenges of the installation and testing procedures, and operational considerations including system calibration and lessons learned.

Cochran Basin I&I Reduction Effectiveness for the City of Spokane Combined Sewer Overflow Program

Beryl Childs[1], Duane Studer[1] and Lars Hendron[2]
[1]AECOM, Spokane, Wash. [2]City of Spokane, Spokane, Wash.

Abstract
The City of Spokane's Combined Sewer Overflow (CSO) Program Management Office is evaluating the combined sewer system and assisting the City in implementing a Long-Term Control Plan for CSO reduction improvements. A key part of the program is evaluation of uncontrolled wet weather flows to the interceptor system. A specific area of focus of the evaluation was a 7,900 acre basin area tributary to Interceptor Segment I03 which has unregulated wet weather inflows ranging up to 10 mgd. In order to manage I03 unregulated flows, sources of inflow were identified, quantified, and evaluated for alternative solutions. In conjunction with the City of Spokane Wastewater Management Department, inflow points were identified from various field investigative methods such as smoke testing and dye tracing. Flow monitoring and computer model simulation were utilized to determine the impact of the wet weather influence on I03. Alternatives for inflow mitigation were reviewed and selected. Over a period of 5 years, City staff removed identified inflow points in the sewer system. After construction repairs, a second level of flow monitoring and model simulation was continued to establish the extent of I&I reduction throughout the basin and to quantify the remaining inflow. The remaining inflow is planned to be controlled with detention storage facilities. This analysis reviews the effectiveness of I&I reduction efforts on the collection system capacity and its indirect benefit to combined sewer systems which can have a direct impact on surface water bodies.

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Beth leDoux: *Session F-1*, Session K-1*
Adrian Leiva: *Session G-4*
Amy Leslie: *Poster Session*
Bo Li: *Session I-4**
Qian Liang: *Session B-2*
Hebin Lin: *Session A-1**
Owen Lind: *Session E-1*
E. John List: *Session E-3, Session I-2*
Keith Loftin: *Session G-1*
Fausto Lopez: *Session G-4*
Richard Losee: *Session E-5*
Scott Lowe: *Poster Session**
Donny Lowery: *Session D-4*
Fred Lubnow: *Session B-3*, Session E-2**
Lance Lumbard: *Session J-4**
Richard Lycan: *Poster Session**

Arin MacFarlane-Dyer: *Session B-1**
Jane Maginot: *Poster Session**
Claudia Maier: *Session D-1*
Melo A. Maiolie: *Session D-3*
Roxanne Maranger: *Session D-1*
Piper Marshall: *Session B-4**
Amy Martin: *Session E-4*, Session H-3*
Denise Martinez: *Poster Session**
Edward Martinko: *Session H-3*
Grace Marx: *Session I-1*
Alfred Mata: *Session D-4*
Robin Matthews: *Poster Session*
Dennis McCauley: *Session A-3**
Ashley McFarland: *Session B-1**
Dan McFarlane: *Session A-5, Poster Session**
Paul McGinley: *Session A-5*
Serena McIver: *Session I-4*
Tom McMahon: *Poster Session*
Shannon McMorrow: *Session G-4*
Terry McNabb: *Session J-1*
Thomas McNabb: *Session J-1**
Jennifer McNelly: *Session J-3**
Mark Merkelbach: *Session E-2*
Chris Millard: *Session G-4*
Rich Miller: *Session C-3*, Poster Session, Session F-4*
Stanley Miller: *Session A-5**
Tim Miller: *Session K-1*
Mark Mobley: *Session J-2**
Margaret Modley: *Session C-1, Session H-1**
Marie-Eve Monchamp: *Session D-1*
Barry Moore: *Session A-2*, Session B-4, Poster Session, Session E-1, Session E-4, Session H-3*
David Moore: *Session J-4**
Thomas Moorhouse: *Session J-1*
Robert Morgan: *Poster Session, Session H-2*
Andrew Morley: *Session B-3*
Nancy Mueller: *Session C-1**
Brian Murphy: *Session B-2, Session D-4**
Jeremy Murray: *Poster Session*
Raymond Murrell: *Poster Session**
John Myers: *Session K-1*

Lynda Nakamoto: *Session B-3*
Michelle Nault: *Session K-1*
Everett J. Nelson: *Session I-5*
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Harry Nelson: *Session E-5**
Michael Netherland: *Session J-1*
Steph Neufeld: *Session B-1**
Natasha Neumann: *Session G-3**
John Nolan: *Session B-2*, Session C-4**
Rick Noll: *Poster Session, Session I-4, Session J-4**
Rick Nordin: *Session B-1*
Ronald Novy: *Session K-3**
Gertrud Nürnberg: *Session K-3**

Dan Obrecht: *Session B-3, Session G-1*
Oliver Obregon: *Session I-5**
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Jennifer Owens: *Session I-2*

David Palazzi: *Poster Session*
Jenifer Parsons: *Session I-1*, Session K-1**
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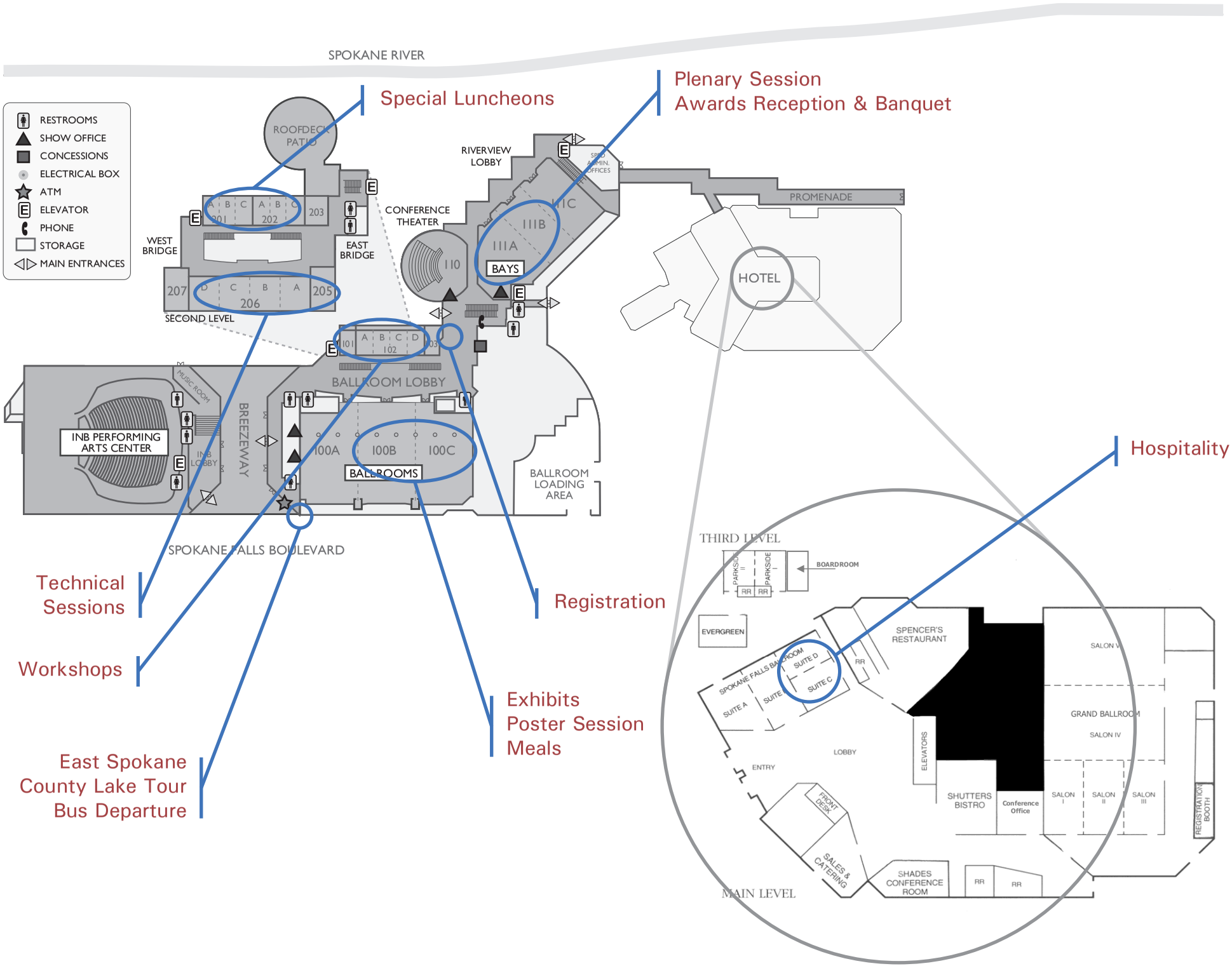
Marlow Pellatt: *Session A-4, Session G-3*
Toni Pennington: *Session I-5, Session J-1**
Mary Gail Perkins: *Session C-1*
Charlie Peterson: *Poster Session**
Glen Pettit: *Session D-3*
Matt Petty: *Session D-4*
Stephen Phillips: *Poster Session*
Frances Pick: *Session D-1**
Kevin Pilgrim: *Session J-1*
Angel Pletka: *Poster Session*
Allen Pleus: *Session H-1**
Robert Plotnikoff: *Session G-4, Session I-5**
Amina Pollard: *Session A-3**
Joy Polston-Barnes: *Poster Session*
Wayne Poppe: *Session G-2**
Simon Poulson: *Session E-4*
Ellen Preece: *Session E-1*, Session E-4, Session H-3*
Ellie E. Prepas: *Session H-4**
Beth Proctor: *Poster Session**
Heather Proctor: *Session C-3*
Gordon Putz: *Session H-4*

Jennifer Winter: *Session B-3**
Rebecca Witherow: *Session D-3**
Craig Wolf: *Session K-2**
Thomas Woolf: *Session H-1**
Josh Wozniak: *Session K-1**
Wayne Wright: *Session A-1**

Wen Xiong: *Poster Session*

Liuyan Yang: *Poster Session**
Jason Yarbrough: *Session D-4**
Rui Ye: *Poster Session*
Xin Yuan: *Session I-5*

Arthur Zastepa: *Session D-1*
Xiaoju Zhang: *Session B-2**
Sami Ziara: *Session C-4*
Julie Zimmerman: *Poster Session*
Norm Zirnhelt: *Session B-1*
Rob Zisette: *Session E-2*, Session K-1*
Erin Zoski: *Poster Session*
Matthew Zuellig: *Session J-1*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SHOW OFFICE
CONCESSIONS
ELECTRICAL BOX
ATM
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PHONE
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MAIN ENTRANCES
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SPOKANE FALLS BOULEVARD
Special Luncheons
Plenary Session
Awards Reception & Banquet
Hospitality
Technical Sessions
Workshops
Registration
Exhibits
Poster Session
Meals
East Spokane County Lake Tour Bus Departure
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SPOKANE FALLS BALLROOM
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SUITE B
SUITE C
SUITE D
GRAND BALLROOM
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32nd International Symposium of the North American Lake Management Society

Lakes in the Landscape: Values > Visions > Actions

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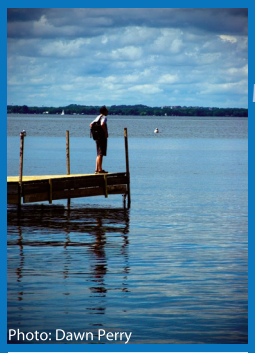
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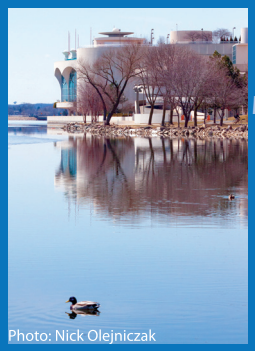
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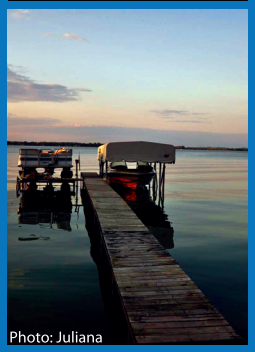
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Kegonsa

Our Values in these tough economic times, the values we place on our natural resources, including lakes, becomes more important than ever. These lake values are brought into focus by,

Our Vision of what we want as an outcome of successful management. Turning these visions into,

Our Actions require partnerships, good science, and perseverance!

Because lakes respond to stressors at a variety of scales, we will emphasize the science of lakes in the landscape, ranging from in-lake to watershed to global, as well as approaches that facilitate lake management… from satellites to shorelines.

The 2012 Madison conference will again feature a special Friday session on the Yahara River watershed and its more than 22,000 acres of lakes and streams that are so important to the region's economy and quality of life, which will be open to all conference attendees and Madison area residents.

Special Sessions and Plenaries

- Landscape Limnology
- Lake Value$ and Ecosystem Services
- Adapting to a Changing Climate
- New Technologies for Lake Monitoring
- Great Lakes Restoration Initiative
- Harmful Algal Blooms
- Yahara Lakes: Implementing a Vision
- Wisconsin Lakes Partnership
- Lake Assessment / Nutrient Criteria
- Lakes on the Shield
- Invasive Species Investigations (Landscape-scale and Case Studies)

Special Events include an election night pub crawl on State Street, an "insider" tour of the State Capitol, field trips to Devil's Lake and the Yahara Watershed, and Frank Lloyd Wright's Taliesin.

Conference Co-chairs: Jeffrey Thornton (jthornton@sewrpc.org) and Tom Slawski (tslawski@sewrpc.org)

Program Co-chairs: Tim Asplund (Tim.Asplund@wi.gov) and Jennifer Hauxwell (Jennifer.Hauxwell@wi.gov)

For sponsorship or general conference information contact NALMS (www.nalms.org, 608-233-2836)