Lake Mead Science Symposium 2014

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Details at a Glance

February 4, 2014 • 8:00 am - 6:00 pm
Southern Nevada Water Authority Colorado River Room
Molasky Corporate Center • Seventh Floor
100 North City Parkway Las Vegas, NV 89106

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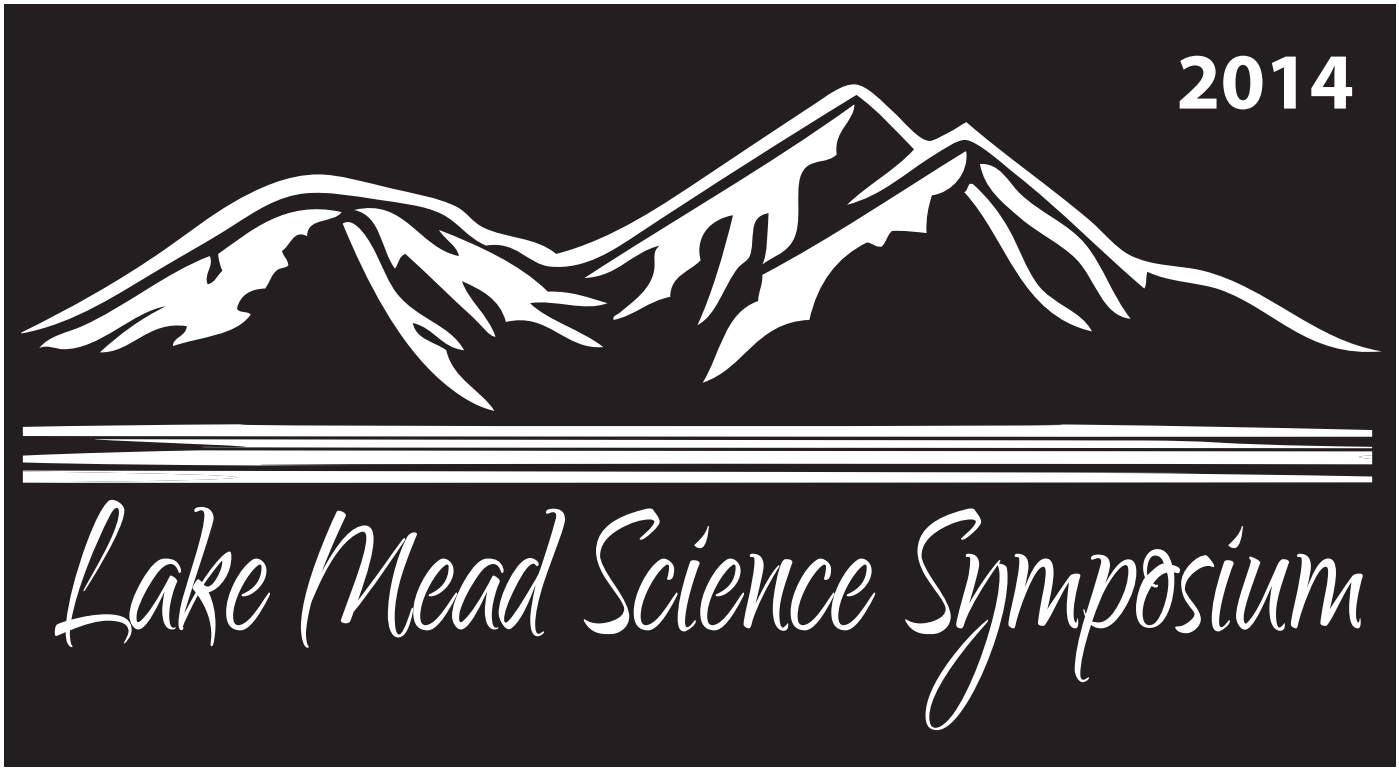
Cover photo by Michael R. Rosen, U.S. Geological Survey



Welcome

Welcome to the third biennial Lake Mead Science Symposium. This event serves as a point of convergence for multi-agency/multi-organization staff, scientists, partners, students, and stakeholders to discuss their latest results and findings related to the waters of Lakes Mead and Mohave, their tributaries, and shorelines. Our combined effort in research and monitoring helps in the collective endeavor to protect water quality for public and municipal water supply, aquatic life, wildlife, recreation, and other beneficial uses. Aquatic life and wildlife includes all components of the food web, which maintain healthy native and sport fisheries and support aquatic dependent wildlife (e.g., avian species), and extends to sediments and riparian and shoreline-dependent native vegetation. Physical and biological stressors with the potential to disturb the health of the ecosystem are of interest as are activities related to wastewater reclamation for return to the Colorado River System through Nevada's return flow credit system. With generous support from the Nevada Division of Environmental Protection and the work of the symposium chair and co-chairs to create a streamlined program focused entirely on presentations, registration for the 2014 Lake Mead Science Symposium is free.

2014 Lake Mead Science Symposium Committee

CHAIR

Peggy Roefer, Southern Nevada Water Authority

CO-CHAIRS

Kumud Acharya | Desert Research Institute
Chris Holdren | Bureau of Reclamation
Jennell M. Miller | University of Nevada, Las Vegas • Public Lands Institute
Michael R. Rosen | U.S. Geological Survey
Roslyn Ryan | Southern Nevada Water Authority
Todd E. Tietjen | Southern Nevada Water Authority
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Xiaoping Zhou |Southern Nevada Water Authority

Symposium Address

William K. Dickinson, Superintendent
Lake Mead National Recreation Area

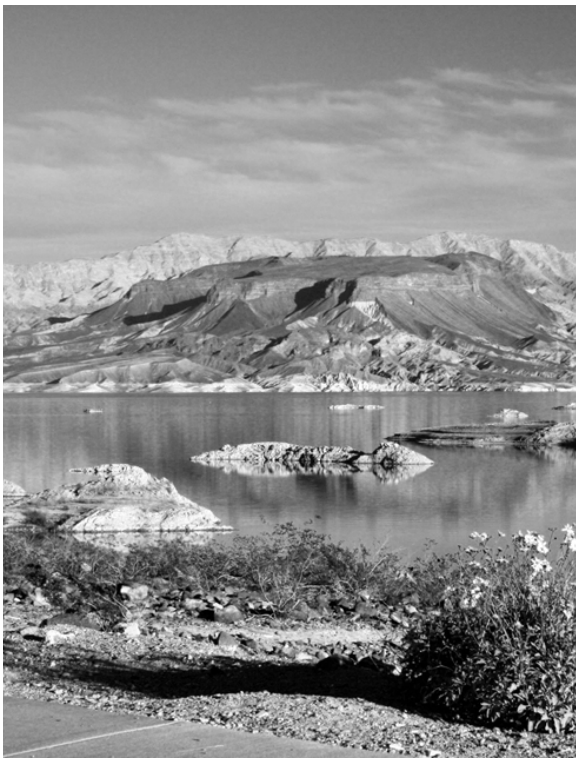

Photo courtesy of National Park Service

A broad purpose of the Lake Mead Science Symposium, now in its third season, is to sustain our partnership for monitoring and research in service to a variety of mutual interagency goals focused on maintaining the health of the resources of Lake Mead and Mohave. This address will briefly outline the importance of those resources and ecosystems, the interagency efforts that have occurred over the last decade, the challenges that we face, and the strength of our existing partnership.

As evidenced by the results of extensive monitoring over the past 20 years, Lakes Mead and Mohave currently exhibit high water quality. This high quality is due in large part to enhancements in flood and wastewater management in the Las Vegas Wash. The development of a whole lake water quality model for Lake Mead, and the extensive data sets that support it, comprise an outstanding set of tools for the continued evaluation of conditions and trends. Temporary funding sources, which supported these efforts are not likely to be available into the future. Meanwhile, lowering water levels, from both drought and climate change; quagga mussels and other potential invasives; changes in flood frequencies; urbanization of tributary watersheds—all have potential to negatively influence water quality. The conditions that influence the lakes are dynamic, and if the existing high water quality is to be sustained, a number of monitoring and management activities need support for their continuation or enhancement.

Fortunately, an impressive array of interagency partnerships exist with a proven track record for evaluation and management of water resources and quality within Lakes Mead and Mohave. In an uncertain future, these partnerships are essential for the continuation of the essential suite of services these lakes provide to the nation's Southwest. Local agencies with active monitoring or regulatory interests in Lakes Mead and Mohave include: Nevada Department of Environmental Protection, Arizona Department of Environmental Quality, Southern Nevada Water Authority, the four urban wastewater treatment districts of Las Vegas Valley (Clark County, City of Las Vegas, City of Henderson, and City of North Las Vegas), Nevada Division of Wildlife, and Arizona Game and Fish Department. The US Department of the Interior agencies with an interest in Lakes Mead and Mohave include the National Park Service, the Bureau of Reclamation, US Geological Survey, and the US Fish and Wildlife Service. For more than a decade, the agencies with responsibilities on Lakes Mead and Mohave have also benefited from partnerships with research institutions, including the University of Nevada, Las Vegas, University of Nevada, Reno, and Desert Research Institute.

William K. Dickinson is the 12th Superintendent of Lake Mead National Recreation Area (Lake Mead NRA). He assumed the role on December12, 2000 following service as Assistant Superintendent of the same unit between 1994 and December 2000. Lake Mead NRA includes 1.5 million acres and receives approximately 8 million visitors per year. It is the fifth most visited unit of the National Park System. Previous assignments during Superintendent Dickinson's 39-year career include:

- Superintendent of the Big South Fork National River and Recreation Area and the Obed Wild and Scenic River. The Big South Fork includes over 100,000 acres in northeast Tennessee and southern Kentucky, rich in natural, cultural and recreational resources and facilities. The Obed, located in Tennessee, includes a 45-mile wild and scenic river corridor.
- Superintendent of the USS Arizona Memorial in Pearl Harbor, Hawaii
- Management Assistant to the Superintendent of Grand Canyon National Park in northern Arizona.
- Outdoor Recreation Planner in the Western Regional Offices of the National Park Service, Heritage Conservation and Recreation Service, and the Bureau of Outdoor Recreation.

Dickinson graduated from the University of Illinois with a degree in Landscape Architecture.

Agenda

8:00 - 8:15	Registration
8:15 - 8:20	**Welcome • Peggy Roefer, Lake Mead Science Symposium 2014 Chair** Southern Nevada Water Authority
8:20 - 8:35	**Symposium Address • William K. Dickinson, Superintendent** Lake Mead National Recreation Area
8:35 - 8:45	**Opening Remarks • David Gaskin, P.E., Deputy Administrator, Water and Mining Programs** Nevada Department of Environmental Protection
8:45 - 10:05	**Morning Session • Chair: Michael Rosen**
8:45 - 9:05	**Climate Change: Explaining the problem and its solution to non-scientists** **George Rhee** (Physics and Astronomy Department, University of Nevada, Las Vegas)
9:05 - 9:25	**Lake Mead striped bass sonic telemetry study** **Debora Y. Herndon** (Nevada Department of Wildlife)
9:25 - 9:45	**Status update of the Lake Mohave fishery and Lake Mohave habitat enhancement project** **Mitch A. Urban** (Nevada Department of Wildlife)
9:45 - 10:05	**Lower portal road at spring habitat improvement project** **Heidi A. McMaster**[1] and Marc Maynard[1] [1]U.S. Bureau of Reclamation
10:05 - 10:20	15-minute Break
10:20 - 11:40	**Mid-Morning Session • Chair: Kumud Acharya**
10:20 - 10:40	**Evidence of endocrine disruption of common carp at Willow Beach: Do we have an answer?** **Michael R. Rosen**[1], Reynaldo Patiño[2], David Alvarez[3], Steven Goodbred[4], and Kathy Echols[3] [1]Water Science Field Team, U.S. Geological Survey; [2]U.S. Geological Survey, Texas Cooperative Fish & Wildlife Research Unit, Texas Tech University; [3]Columbia Environmental Research Center, U.S. Geological Survey; [4]U.S. Geological Survey
10:40 - 11:00	**Changes in thermal structure and water quality of Lake Mead due to lower lake levels** **Al Preston**[1], Todd Tietjen[2], Peggy Roefer[2], and John E. List[1] [1]Flow Science Incorporated; [2]Southern Nevada Water Authority
11:00 - 11:20	**Real-time water quality data and applications in the Las Vegas wash during storm events** **Xiaoping Zhou** (Southern Nevada Water Authority)
11:20 - 11:40	**Understanding selenium distribution in Lake Mead using a hydrodynamic based water quality model** **Xiaolu Wei**[1], Kumud Acharya[1], and Zhongbo Yu[2] [1]Division of Hydrologic Sciences, Desert Research Institute; [2]Department of Geoscience, University of Nevada, Las Vegas
11:40 - 12:40	Lunch Hour
12:40 - 3:20	**Early Afternoon Session • Chair: Ashlie Watters**
12:40 - 1:00	**Assessing the impact of high flow experiments in Grand Canyon on the water quality of Lake Mead** **Roslyn Ryan**[1] and Todd E. Tietjen[1] [1]Southern Nevada Water Authority
1:00 - 1:20	**Initial Assessments of Lake Mohave water quality** **Todd E. Tietjen**[1] and Roslyn Ryan[1] [1]Southern Nevada Water Authority

1:20 - 1:40	**Lake Mead Water Quality Forum Algae Task Force update: What a difference 10 years makes** **Douglas D. Drury** (Clark County Water Reclamation District)
1:40 - 2:00	**Response of the algal community in Boulder Basin, Lake Mead to the introduction of quagga mussels and reduced water levels** **Ann L. St. Amand**[1], Todd E. Tietjen[2], Peggy Roefer[2], Jim Labounty[2], and Joel Gerweck[1] [1]PhycoTech; [2]Southern Nevada Water Authority
2:00 - 2:20	**Quagga mussels have limited impact on phytoplankton and zooplankton phenology and composition in Lake Mead, NV (2007-2013)** **John R. Beaver**[1], Claudia E. Tausz[1], Becky J. Blasius-Wert[2], Janet E. Kirsch[2], Thomas R. Renicker[1], Derrick D. Cooper[1], Erin E. Manis[1], and Lauren M. Baldarelli[1] [1]BSA Environmental Services; [2]U.S. Bureau of Reclamation
2:20 - 2:40	**Decadal changes to zoobenthos in a subtropical reservoir: Establishment of non-native invertebrates shift assemblage structure** Clinton J. Davis[1], **Timothy J. Caldwell**[1], Annie Caires[1], and Sudeep Chandra[1] [1] University of Nevada, Reno
2:40 - 3:00	**Temporal and basin-specific population dynamics of quagga mussels in the soft sediment of a multi-basin reservoir** **Timothy J. Caldwell**[1], Michael R. Rosen[2], Sudeep Chandra[1], Kumud Acharya[3], Andrea M. Caires[1], Clinton J. Davis[1], Melissa Thaw[3], Daniel Webster[2] [1]University of Nevada – Reno, Aquatic Ecosystems Analysis Laboratory; [2]U.S. Geological Survey; [3]Division of Hydrological Sciences, Desert Research Institute, Las Vegas
3:00 - 3:20	**Adult quagga mussel survival, growth, and reproduction potential in a large oligotrophic lake (Lake Tahoe, USA)** Clinton J. Davis[1], **Sudeep Chandra**[1], Emma K. Ruhmann[2], and Kumud Acharya[2] [1]University of Nevada, Reno; [2]Desert Research Institute, Las Vegas
3:20 - 3:40	20-minute Break
3:40 - 6:00	**Late Afternoon Session • Chair: Kent Turner**
3:40 - 4:00	**Can *Dreissena rostriformis bugensis* veligers survive in Lake Tahoe water? A comparison of growth, survival, and settlement in Lake Mead and Lake Tahoe** **Emma K. Ruhmann**[1], Kumud Acharya[2], Clinton J. Davis[3], and Sudeep Chandra[3] [1]Desert Research Institute/University of Nevada, Las Vegas; [2]Desert Research Institute; [3]University of Nevada, Reno
4:00 - 4:20	**Lake Havasu quagga mussel monitoring program update** **Heidi A. McMaster**[1], Dana Anat[1], Janet E. Kirsch[1], Jessica Stegmeier[1], and Marc Maynard[1] [1]U.S. Bureau of Reclamation
4:20 - 4:40	**Susceptibility of *Dreissena bugensis* (quagga mussel) to UVB radiation throughout the lifecycle** Melissa Thaw[1], Kumud Acharya[1], and **Michael J. Nicholl**[2] [1]Division of Hydrologic Science, Desert Research Institute; [2]Department of Geoscience, University of Nevada, Las Vegas
4:40 - 5:00	**Evaluating the efficacy of quaternary ammonium compounds for wildland firefighting equipment exposed to Dreissenid adults and veligers** **Ashlie Watters**[1], Shawn Gerstenberger[1], and Wai Hing Wong[1] [1]University of Nevada, Las Vegas
5:00 - 5:20	**Results of boater survey answers versus actual observations of boaters pulling their plugs** **Kami Silverwood**[1] and Tom McMahon[1] [1]Arizona Game and Fish Department
5:20 - 5:40	**Watercraft inspection and decontamination training updates** **"Quagga D" Davis** (Pacific States Marine Fisheries Commission)
5:40 - 6:00	**Conclusion and Adjournment**

Abstracts

Morning Session • Chair: Michael R. Rosen

8:45 – 9:05

Climate change: explaining the problem and its solution to non-scientists

George Rhee (Physics and Astronomy Department, University of Nevada, Las Vegas)

The cause of the problems facing Lake Mead is climate change. The causes of climate change and the proposed solution to the problem are well understood but require a quantitative understanding of the laws of physics and a familiarity with large numbers. I have taught a class on energy usage for non-science majors at the University of Nevada, Las Vegas (UNLV) for several years. How can one explain in simple terms the problems caused by fossil fuels to an audience of non-scientists? I will present the approach that I have adopted in the classroom. We choose to use numbers but on a personal scale such that all the numbers lie roughly between one and one hundred. By using a unit of kWh/d for a measure of power, the whole problem of energy can be understood in a quantitative manner. With a proper grasp of the numbers one can have a better discussion of the choices that are available to us to avert further climate change.

One way forward to solving the problems facing Lake Mead is to have a public debate about energy usage that is quantitative. I will present one approach to teaching science to non-scientists that may be helpful in promoting such a debate.

9:05 – 9:25

Lake Mead striped bass sonic telemetry study

Debora Y. Herndon (Nevada Department of Wildlife)

Striped bass (*Morone saxatilis*) are the most harvested and sought after sport fish in Lake Mead. Because of changes to habitat distribution and quality from long-term lake level declines and recent introduction of invasive species, information regarding seasonal movement and habitat use of this important species is needed to better identify habitat needs. Sonic-tagged fish were released to Boulder Basin and Overton Arm in December 2011. Active and passive tracking found the fish to travel large expanses of the lake in a relatively short period of time. These fish were utilizing the inflow areas of the Las Vegas Bay, the Virgin/Muddy River, and the Colorado River after release. By February 2012, many of the tagged striped bass moved to the Colorado River inflow area some 40 miles upstream. By late spring and summer, striped bass had returned to Las Vegas Bay and Boulder Basin, and one fish returned to Overton Arm. During this period, striped bass in the Las Vegas Bay were found in deeper waters from 17-37 m deep, while two fish found in Boulder Basin were in much shallower water of 8-12 m deep. Striped bass movements indicate the importance of the nutrient rich inflow areas and the abundant prey associated with these areas, the likely use of the Colorado River inflow area for spawning, and the need for deep water thermal refuge in the summer.

9:25 – 9:45

Status update of the Lake Mohave fishery and Lake Mohave habitat enhancement project

Mitch A. Urban (Nevada Department of Wildlife)

A cooperative effort among federal and state agencies has occurred for several decades to monitor the Lake Mohave fishery through gill netting, electro-fishing, and creel surveys. Utilizing standard sampling methods, trends of fish species can be seen over time. Looking at these trends in recent years, striped bass capture rates and biomass are below the long-term average. Despite the recent decline in the striped bass fishery, the black bass fishery continues to improve.

The habitat enhancement project is another joint effort that started in 2007. This interagency effort places artificial habitat into coves that are void of natural habitat for the purpose of increasing fish abundance and angler success. Three types of habitat structures have been used: PVC structures, brush bundles (made with shoreline tamarisk), and pallet structures. For the first five years of the project, habitat was put into four coves but now has expanded to include an additional four target coves. Surveys completed show that there is an increase in fish abundance in coves with habitat structures compared to coves without habitat structures.

9:45 – 10:05

Lower portal road at spring habitat improvement project

Heidi A. McMaster[1] and Marc Maynard[1]

[1]U.S. Bureau of Reclamation

In 2009, in an effort to reduce fire fuel loads and improve habitat along the Colorado River, the U.S. Bureau of Reclamation began mechanical removal of invasive tamarisk (*Tamarix spp.*) along the Lower Portal Road. A pupfish refuge was constructed in 1974 to create a secondary refuge for the Devil's Hole Pupfish, a species listed under the Endangered Species Act (ESA) of 1973, as amended. The Lower Portal Road has a natural warm spring that seeps from the canyon wall above the river. The year round access to water created ideal habitat for the relict leopard frog (*Rana onca*). A total of 541 relict leopard frogs were introduced between 2003 and 2008. With the assistance of the National Park Service (NPS) Exotic Plant Removal Team, in the first two years of tamarisk removal, 160 cubic yard of tamarisk was removed. To date, approximately 2.15 acres of tamarisk have been cleared. With the tamarisk removed, honey and screwbean mesquite trees (*Prosopis glandulosa* and *P. pubescens*) were planted in March 2012. Coyote willow (*Salix exigua*) was planted in the stream channel in 2010, 2011 and 2012. In 2012, 200 coyote willow were planted and tubes were placed around the young trees to encourage growth and establishment before predation by desert bighorn sheep (*Ovis Canadensis nelsoni*). Future plans for the site include maintaining areas for relict leopard frog habitat, planting of additional native trees, and treatment of tamarisk regrowth as needed.

Mid-Morning Session • Chair: Kumud Acharya

10:20 - 10:40

Evidence of endocrine disruption of common carp at Willow Beach: Do we have an answer?

Michael R. Rosen[1], Reynaldo Patiño[2], David Alvarez[3], Steven Goodbred[4], and Kathy Echols[3]

[1]Water Science Field Team, U.S. Geological Survey; [2]U.S. Geological Survey, Texas Cooperative Fish & Wildlife Research Unit, Texas Tech University; [3]Columbia Environmental Research Center, U.S. Geological Survey; [4]U.S. Geological Survey

Endocrine disruption in common carp (*Cyprinus carpio*) at Willow Beach downstream of Hoover Dam was first documented in 2003. Male and female fish in subsequent collections in 2005, 2007-2008 and 2010 showed some evidence of endocrine disruption and histological abnormalities. In 2007-2008, male carp from Willow Beach showed greater impairment of reproductive health than males from Las Vegas Wash or Las Vegas Bay. Chemical results indicate that Willow Beach common carp sampled in 2005 and 2007-2008 had relatively high (average of 458 ng/g wet weight (ww); maximum 2052 ng/g ww) concentrations of polychlorinated biphenyls (PCBs) compared to fish sampled at Overton Arm (average of 16 ng/g ww; maximum 132 ng/g ww); however, PCB concentrations in carp at Willow Beach were comparable to concentrations found in carp from Las Vegas Bay and Las Vegas Wash. Triclosan and methyl-triclosan were also detected at low concentrations in fish at Willow Beach in 2007-2008. In 2010, samples of bed sediment and algae were collected and passive samplers deployed at sites upstream, at, and downstream of the Willow Beach fish hatchery. Samples of caulk, rubber, and food from the fish hatchery were also collected. PCBs weren't found in the water near Willow Beach, but were found at low concentrations in sediment in 2005 (14.6 ng/g) and 2010 (maximum of 2.5 ng/g) and in the rubber, caulk, and food at the fish hatchery (maximum concentration of 84 ng/g in the raceway rubber). Triclosan and methyl-triclosan were found in water at concentrations similar to Las Vegas Bay. Concentrations of triclosan at the five sites at Willow Beach increased downstream, suggesting that the source of triclosan does not likely originate from upstream. Currently, the source(s) of PCBs and triclosan are unknown and the cause of endocrine disruption in carp at Willow Beach remains unclear.

10:40 - 11:00

Changes in thermal structure and water quality of Lake Mead due to lower lake levels

Al Preston[1], Todd Tietjen[2], Peggy Roefer[2], and John E. List[1]
[1]Flow Science Incorporated; [2]Southern Nevada Water Authority

Recent 24-month flow projections by Reclamation indicate low inflow conditions and continuing decreasing water levels for Lake Mead. Several more years of low inflows and decreases in water surface elevation may lead to the Hoover Dam upper outlets becoming inoperable, potentially affecting the limnology and water quality within Lake Mead. As part of research funded by a Reclamation WaterSMART grant to investigate the effects of climate change on Lake Mead we used the three-dimensional Estuary, Lake and Computer Ocean Model (ELCOM) in conjunction with the Computational Aquatic Ecosystem DYnamic Model (CAEDYM) to predict water quality changes in Lake Mead due to variable inflows from the Colorado River and lower water volumes in the lake. Simulation parameters included temperature, salinity, bromide, total organic carbon (TOC), nutrients, chlorophyll (algae), dissolved oxygen, pH, and suspended-solids. Simulations indicate that decreasing lake levels will lead to changes in the thermal structure of Lake Mead once the Hoover Dam upper outlets are inoperable, and that these changes will affect the water quality in the epilimnion of Boulder Basin and at the SNWA's intakes. For example, the concentrations of constituents (i.e., bromide, TOC, phosphorus, nitrogen, and suspended-solids) in the epilimnion of Boulder Basin are predicted to increase by approximately 10 to 20 percent when the Hoover Dam upper outlets are out of operation. These findings may have near-term implications if the recent low-inflow conditions persist, as well as longer-term relevance, since climate change models predict higher probabilities of low future water levels in Lake Mead.

11:00 - 11:20

Real-time water quality data and applications in the Las Vegas wash during storm events

Xiaoping Zhou (Southern Nevada Water Authority)

The Las Vegas Wash (Wash) serves as the sole drainage of runoff from the Las Vegas Valley watershed to Lake Mead during storm events. Besides grab sample collection and analysis, water quality in the Wash during storm events has been monitored by Southern Nevada Water Authority (SNWA) at several real-time water quality stations. A multiple-probe instrument (Hydrolab) is used at each station to monitor and record real-time water quality data at 15-minute intervals. The measurements include temperature, pH, electrical conductance (EC), and dissolved oxygen (DO). Data collected during storm events in the past several years has shown good correlations between the storm intensity-duration-frequency (IDF) and water quality changes. Runoffs that entered the Wash during storm events dramatically diluted total dissolved solid (TDS) concentrations (or EC concentrations) and changed the temperature, pH, and DO of the pre-storm Wash water. Dilution and change of Wash water quality was directly controlled by different storm IDF in the valley. In addition, with SNWA real-time water quality data and flow data from USGS gages in the Wash, extra TDS mass loading to Lake Mead from each storm event can be quantified. The results from the real-time water quality monitoring program conducted by SNWA provide firsthand information on storm-water quality and potential impacts on water quality in the Las Vegas Bay and Lake Mead after storm events.

11:20 - 11:40

Understanding selenium distribution in Lake Mead using hydrodynamic based water quality model

Xiaolu Wei[1], Kumud Acharya[1], and Zhongbo Yu[2]
[1]Division of Hydrologic Sciences, Desert Research Institute;
[2]Department of Geoscience, University of Nevada, Las Vegas

Shallow groundwater in Las Vegas Wash are known to have elevated level of selenium (Se) which mainly comes from the naturally occurring geological hotspots on the southeast side of the Las Vegas Valley. Se fate and transport after it enters into Lake Mead from the Las Vegas Wash are not clearly understood. A three-dimensional Environmental Fluid Dynamic Code model (EFDC) was used to model movement of Se in the Boulder Basin, Lake Mead. The concept of Lagrangian particle tracking and water age were respectively applied to understand the specific motion trail of Se and to simulate the horizontal and vertical Se distribution influenced by different wind and water level conditions. The model results showed that it takes approximately 300 days for Se particles to be transported to the Hoover Dam. The highest depth-averaged Se concentration near the Hoover dam was 0.085 µg/L. Average Se concentration in the Boulder Basin was estimated to be 0.087 µg/L and 0.057 µg/L for the shallow (< 20 m) and deep (> 70 m) regions, respectively based on 3.5 µg/L

average inflow from the Las Vegas Wash. The results showed that the transport of Se in the lake is strongly influenced by hydrodynamic conditions induced by wind intensity and directions and various water levels. The wind magnitude and directions in Lake Mead are highly variable, especially in springs and summers. The model results imply that stronger winds impact Se dispersal in both the horizontal and vertical directions by changing water age in the Boulder Basin.

Early Afternoon Session • Chair: Ashlie Watters

12:40 - 1:00

Assessing the impact of high flow experiments in Grand Canyon on the water quality of Lake Mead

Roslyn Ryan[1] and Todd E. Tietjen[1]

[1]Southern Nevada Water Authority

Current plans call for the Department of Interior to continue High Flow Experiments (HFEs) for years to come in order to continue evaluating their feasibility in building critical habitat and beaches. The impacts on Lake Mead were investigated during the 2012 flows and again sampled during the 2013 event. In 2012 the experimental waters carried significant turbidity into Lake Mead and were identifiable by their conductivity signature for many miles into the lake, eventually becoming mixed with lake water downstream of the confluence with the Overton Arm. Preliminary results from the 2013 experiment suggest a similar path. Overall the impacts on water quality from these events have not been significant, but based on these results we have identified scenarios that could have a measurable impacts. As long as the HFEs continue to be carried out following the onset of epilimnetic cooling and the floods deliver high density (cold) water with low concentrations of very fine particles, impacts should be limited to Gregg's Basin and not cause significant harm. If changes in Lake Powell shift the quality of the water available for HFEs, this prediction would change. Warmer experimental water would be more likely to enter Lake Mead at the surface, potentially altering stratification patterns, limiting mixing and advective oxygen additions and shifting the progression of biogeochemical cycling of nutrients in the sediments. Understanding these potential impacts will rely on predicting and understanding the future conditions in both Lakes Mead and Powell.

1:00 - 1:20

Initial assessments of Lake Mohave water quality

Todd E. Tietjen[1] and Roslyn Ryan[1]

[1]Southern Nevada Water Authority

Lake Mohave has been sampled monthly throughout 2013 in order to provide a comprehensive assessment of water quality. Five locations between Willow Beach and Davis Dam were sampled for routine limnological parameters throughout the water column. These parameters included temperature, specific conductance, pH and dissolved oxygen profiles as well as epilimnetic, metalimnetic, and hypolimnetic nutrient concentrations. Biological samples include zooplankton and phytoplankton as well as concentrations of chlorophyll a and algal toxins. Overall the results of this preliminary investigation reveal that water quality in Lake Mohave was generally good during 2013, and that releases from Lake Mead determine much of what occurs in Lake Mohave. Cold releases from Hoover Dam flow to the bottom of Lake Mohave throughout the stratified period, isolating the epilimnetic waters while maintaining a very short retention time in the hypolimnion. Chlorophyll accumulation in the epilimnion is mainly controlled by the availability of nutrients at the onset of stratification and occasional supplements when there are inflows from tributaries downstream of Lake Mead during rain events. Lake Mohave water quality in 2013 appeared to be better than anecdotal reports from previous years. In the past there have been reports of the toxin producing cyanobacteria Microcystis occurring in significant concentrations in Lake Mohave. While Microcystis was found in Lake Mohave samples, the toxin was never detected and concentrations were below those that would be recognized by general lake users. Sampling is planned to continue into 2014 in order to continue the expansion of our understanding of Lake Mohave.

1:20 - 1:40

Lake Mead Water Quality Forum Algae Task Force update: What a difference 10 years makes

Douglas D. Drury (Clark County Water Reclamation District)

The 2010 Algae Task Force has recently completed its review of the 2010 bloom in Lake Las Vegas. The task force also reviewed the work of the 2001 algae task force and the data collected since 2001. The 2010 Algae Task Force compiled as much data, reports and records it could find on the water quality concerns for the Las

Vegas Bay of Lake Mead. The Chlorophyll-a data for the Las Vegas Bay is summarized for each sampling station. Substantial reduction in Chlorophyll-a have been observed since 2005 when the wastewater dischargers optimized their plants for phosphorus removal. The existing Chlorophyll-a data is analyzed with respect to the lowering lake levels. It is clear that many of the sampling stations in the Las Vegas Bay will move out into the Boulder Basin as lake levels decrease. The question is which Water Quality Standard will apply at that time. It is also clear that the lowering lake levels will bring the Las Vegas Wash delta closer to the drinking water intakes.

1:40 - 2:00

Response of the algal community in Boulder Basin, Lake Mead to the introduction of quagga mussels and reduced water levels

Ann L. St. Amand[1], Todd E. Tietjen[2], Peggy Roefer[2], Jim Labounty[2], and Joel Gerweck[1]

[1]PhycoTech; [2]Southern Nevada Water Authority

Algal data were analyzed at several surface stations in Boulder Basin, Lake Mead from 2002-2013. Stations ranged from the Las Vegas Bay to just upstream of the Hoover Dam and included a variety sites, including the intake for the drinking water treatment plant at depth. The volume of the reservoir has been declining in recent years, although water treatment efforts have substantially decreased input nutrients, especially phosphorus (1994 and 2006 forward). Quagga mussels (*Dreissena rostriformis bugensis*) were first detected in Lake Mead in January 2007, but archival samples indicated that the mussels had been present at low levels since potentially 2006. Quagga and zebra mussels have been associated with a shift towards toxin producing Cyanophytes in other systems, including the Great Lakes, and have also been associated with ecosystem changes relating to zooplankton food supply. Both raw data (density, total biovolume, total area, total volume, GALD) and water quality indices and ratios were analyzed correlating results to several key environmental variables (elevation, surface temperature, conductivity), and the invasion of quagga mussels. In addition to total community indicators, several species/genera were also used in the analysis including *Cyclotella spp*, *Pyramichlamys cordiformis* (*Tetraselmis*), *Fragillaria crotonensis, Cylindrospermopsis raciborskii, Aphanizomenon flos-aquae, Microcystis aeruginosa,* and toxin-producing cyanophytes, and several key species of picoplankton (*Cyanogranis ferruginea* and *Cyanocatena plantonica*). Both time series analysis and multidimensional scaling analysis (Primer 6) were used to explore ecological relationships among algal indicators and environmental variables in the inner and outer basins.

2:00 - 2:20

Quagga mussels have limited impact on phytoplankton and zooplankton phenology and composition in Lake Mead, NV (2007-2013)

John R. Beaver[1], Claudia E. Tausz[1], Becky J. Blasius-Wert[2], Janet E. Kirsch[2], Thomas R. Renicker[1], Derrick D. Cooper[1], Erin E. Manis[1], and Lauren M. Baldarelli[1]

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Potential invasion of large western U.S reservoirs by quagga mussels has been a major concern for managers since these bivalves have demonstrated significant disturbances to plankton food webs in large natural lakes of the Great Lakes region. We investigated whether the phytoplankton and zooplankton community composition in Lake Mead displayed any evidence of change from the ca. 2003 invasion of quagga mussels using quarterly data from approximately 372 paired phytoplankton and zooplankton samples collected from winter 2007 through fall 2012. Principal component analysis indicated that more than 50% of the variance in phytoplankton community structure was explained by two small taxa (*Cyclotella* and *Rhodomonas*) which are excellent food for the dominant zooplankton grazers (*Daphnia spp.*). Canonical correlation analysis demonstrated the overriding importance of the thermal regime of the system for seasonal initiation and maintenance of the long-established trophic coupling of these small phytoplankton taxa with the major planktonic herbivores despite the invasion of quagga mussels. The largest zooplankton biomass occurred in open waters not influenced by quagga mussel grazing. Habitat separation and the large depth of Lake Mead likely mitigated the grazing competition between daphnids and quagga mussels. Although Lake Mead has experienced quaqqa mussel invasion and impacts for nearly 10 years, our data provide little evidence of catastrophic regime change in plankton dynamics and composition in large western U.S. reservoirs as has been observed in natural lakes the Great Lakes region.

2:20 - 2:40

Decadal changes to zoobenthos in a subtropical reservoir: establishment of non-native invertebrates shift assemblage structure

Clinton J. Davis[1], **Timothy J. Caldwell**[1], Annie Caires[1], and Sudeep Chandra[1]

[1] University of Nevada, Reno

Lakes and reservoirs are ecosystems that are among the most impacted by the spread of invasive species, with many systems experiencing the introduction and establishment of multiple species within a relatively short time frame (<30 years). Three species of benthic invertebrates have demonstrated their potential as ecological problematic in many freshwater systems: Asian clams (*Corbicula fluminea*), quagga mussels (*Dreissena rostriformis bugensis*), and New Zealand mudsnails (*Potamopyrgus antipodarum*). We assessed density and composition changes in benthic macroinvertebrate assemblages during the establishment of these three invasive invertebrate species in a large, multi-basin reservoir (Lake Mead, USA). The primary objective was to evaluate shifts in Lake Mead's zoobenthos structure by comparing assemblages collected in 1986-1987 to recently collected assemblages (2008-2011). Decadal changes in the overall structure of zoobenthos in Lake Mead are both depth and basin specific. Increased densities of quagga mussels, mudsnails and native snails, as well as declines in chironomids and invasive clams drive the observed shifts in structure. Attributing shifts in native assemblage structure to non-native introductions is complicated by the multitude of other potential factors that have impacted the reservoir system (e.g., lake level declines, reduced algal productivity) over the past decade.

2:40 - 3:00

Temporal and basin-specific population dynamics of quagga mussels in the soft sediment of a multi-basin reservoir

Timothy J. Caldwell[1], Michael R. Rosen[2], Sudeep Chandra[1], Kumud Acharya[3], Andrea M. Caires[1], Clinton J. Davis[1], Melissa Thaw[3], and Daniel Webster[2]

[1]University of Nevada – Reno, Aquatic Ecosystems Analysis Laboratory; [2]U.S. Geological Survey; [3]Division of Hydrological Sciences, Desert Research Institute, Las Vegas

Invasive quagga (*Dreissena bugensis*) mussels have rapidly spread throughout North America. Understanding the relationships between environmental variables and quagga mussels during the early stages of invasion will help management strategies and allow researchers to predict patterns of future invasions. Quagga mussels were detected in Lake Mead, NV/AZ in 2007. We monitored early invasion dynamics in 3 basins (Boulder Basin, Las Vegas Bay, Overton Arm) bi-annually from 2008-2011. Mean quagga density increased over time during the first year of monitoring and stabilized for the subsequent two years at the whole-lake scale (8 to 132 individuals•m-2, geometric mean), in Boulder Basin (73 to 875 individuals•m-2), and in Overton Arm(2 to 126 individuals•m-2). In Las Vegas Bay, quagga mussel density was low (9 to 44 individuals•m-2), which was correlated with high sediment metal concentrations and warmer (> 30°C) water temperatures associated with that basin. Sediment carbon content increased with depth in Lake Mead and during some sampling periods quagga density was also positively correlated with depth, but more research is required to determine the significance of this interaction. Laboratory growth experiments suggested quaggas are food limited in Boulder Basin, indicating an opportunity for population expansion in this basin if primary productivity were to increase, but was not the case in Overton Arm. Overall quagga mussel density in Lake Mead is highly variable and patchy, suggesting that temperature, sediment size, and sediment metal concentrations, and sediment carbon content all contribute to mussel distribution patterns.

3:00 - 3:20

Adult quagga mussel survival, growth, and reproduction potential in a large oligotrophic lake (Lake Tahoe, USA)

Clinton J. Davis[1], **Sudeep Chandra**[1], Emma K. Ruhmann[2], and Kumud Acharya[2]

[1]University of Nevada, Reno; [2]Desert Research Institute, Las Vegas

Establishment of invasive mussel (*Dreissena spp.*) populations into water-bodies of the western USA has expanded the geographic concern regarding the ecological and economical impacts this invasive species will have in these aquatic ecosystems. Lake Tahoe is a large, deep oligotrophic lake that in the last century has experienced repeated establishment of invasive plants and animals that have altered the system's structure and function. We evaluated the invasion potential of quagga mussels in Lake Tahoe using seminatural laboratory bioassays to compare the survival, growth

and reproductive potential of adult mussels held for an extended time period in ambient (ca. 10 mg Ca L-1) and calcium amended water from Tahoe (20, 24, 32 mg Ca L-1). The amended concentrations (20, 24 mg Ca L-1) were selected since these are concentrations found in patches at the bottom of the lake due to invasion by Asian clams (Corbicula fluminea). Survival was high after 90 days for calcium amended Tahoe water (80-90%) and decreased appreciably in ambient Tahoe water (0-30%). Instantaneous growth rates of adult mussels were positive for calcium amended treatments (0.02 to 0.06 wk-1) and negative for an ambient treatment (-0.01 wk-1). Further analysis of mussel reproductive potential revealed that a high percentage of reproductively viable mussels in calcium amended Tahoe waters (83-100%) compared to relatively low viability in ambient Tahoe water (11%). These results provide compelling evidence for successful establishment of adult quagga mussels in Lake Tahoe. Preliminary evaluation of adult establishment risk appears particularly high in habitats of Lake Tahoe where dissolved calcium is elevated above ambient waters (e.g. sediment porewater, Asian clam-beds).

Late Afternoon Session • Chair: Kent Turner

3:40 - 4:00

Can *Dreissena rostriformis bugensis* veligers survive in Lake Tahoe water? A comparison of growth, survival, and settlement in Lake Mead and Lake Tahoe

Emma K. Ruhmann[1], Kumud Acharya[2], Clinton J. Davis[3], and Sudeep Chandra[3]

[1]Desert Research Institute/University of Nevada, Las Vegas; [2]Desert Research Institute; [3]University of Nevada, Reno

As populations of *Dreissena rostriformis bugensis* (quagga mussels) continue to establish in aquatic systems throughout the western United States, more quagga mussel specific research is needed to determine the physicochemical characteristics of water bodies needed for successful establishment. Currently, the calcium risk assessment is used to determine the risk of quagga mussel establishment in an aquatic system. Under this assessment, Lake Tahoe is considered "low risk" (6-14 ppm Ca) versus the "high risk" waters of Lake Mead. Since 2007, quagga mussels have successfully established in the calcium rich waters (~70 ppm) of Lake Mead. Quagga mussel veligers (larval stage) were observed in a semi-natural laboratory setting to compare the growth, survivability, and settlement potential under Lake Tahoe water conditions with that of Lake Mead. Survivability and settlement were observed over 28 days. Growth rate was measured weekly using digital imagery analysis to measure change in shell area. Survivability after 28 days was lower for Lake Tahoe (~20% versus ~40% for Lake Mead); however, those veligers which survived continued to grow. Both conditions resulted in similar average daily growth rates (0.35 µm2 for Lake Mead versus 0.37 µm2 for Lake Tahoe). Lake Mead conditions also resulted in higher settlement rates compared to Lake Tahoe. However, Lake Tahoe did promote some veliger settlement. Results represent evidence for successful establishment of veliger quagga mussels in Lake Tahoe. These findings will help management agencies should the mussels find their way to the lake, despite prevention efforts.

4:00 - 4:20

Lake Havasu quagga mussel monitoring program update

Heidi A. McMaster[1], Dana Anat[1], Janet E. Kirsch[1], Jessica Stegmeier[1], and Marc Maynard[1]

[1]U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation Lower Colorado Region began a monitoring program on Lake Havasu in 2009. The program began as a "Trophic Study" which included gut content analysis of gizzard shad (*Dorosoma cepedianum*), in addition to zooplankton analysis and Secchi depth transparency. However, due to low occurrence of gizzard shad, the focus of the project became a monitoring study for quagga mussel veligers. Data collection includes zooplankton biomass and abundance (0.64 µL, 12 cm diameter plankton net), ambient water quality (utilizing a Eureka Manta multiprobe to collect pH, specific conductivity, dissolved oxygen, and temperature), and transparency. Chlorophyll, phosphorous, and phytoplankton biovolume and abundance were added to the collection protocol in July 2013. Samples are collected at five sites ranging from the mouth of the Colorado inflow to Lake Havasu south to Parker Dam (CR215.12 to CR192.3). Since sampling began, there has been a steady increase in veliger abundance with seasonal variation demonstrated throughout the year. However, there continues to be a steady population of Cladocerans and Copepods throughout the lake. Total

phosphorous for July 2013 averaged about 0.0053 mg/L, whereas in October 2013, the average total phosphorous for the lake was 0.0096 mg/L indicating some potential seasonal variability although this is a relatively new parameter. Reclamation continues to track potential ecosystem changes that could arise with the increasing abundance of quagga mussel veligers. Unlike Lake Mead, Lake Havasu lacks an abundance of data; therefore, continued sampling of Lake Havasu is needed to ensure ecosystem fluctuations are monitored.

4:20 - 4:40

Susceptibility of *Dreissena bugensis* (quagga mussel) to UVB radiation throughout the lifecycle

Melissa Thaw[1], Kumud Acharya[1], and **Michael J. Nicholl**[2]

[1]Division of Hydrologic Science, Desert Research Institute; [2]Department of Geoscience, University of Nevada, Las Vegas

Predicting, and potentially controlling the spread of *Dreissena bugensis* (quagga mussel) in the western United States requires that we better understand the susceptibility of the species to both environmental and anthropogenic conditions. T he middle portion of the ultraviolet spectrum (UVB radiation) has the potential to damage aquatic organisms through programmed cell death, immune suppression, and carcinogenesis. Understanding how UVB effects quagga mussels is an important step towards characterizing the environmental conditions which lead to their invasive success, and may provide a basis for improved control measures. Ultraviolet radiation does not dilute or create residual byproducts in the same way that chemical treatments do, which means that UVB may be a particularly useful part of engineering solutions to treat Dreissena bugensis mussels within facilities. Here, we quantify the UVB dose required to induce high mortality rates in Dreissena bugensis for three distinctly different life stages (adult, juvenile, veliger). Live samples were collected from Lake Mead, cultured in the laboratory, and then subjected to UVB under controlled conditions while monitoring mortality. Dose-response functions were modeled for all three life-stages, and the lethal dose needed for 50% mortality (LD50) was calculated. All of the dose-response functions reflect a pattern in which low doses of UVB are ineffective and moderate doses lead to high mortality. The mortality rates leveled off at the highest doses, suggesting that resistance to UVB varies between individual specimens at similar stages in the life cycle.

4:40 - 5:00

Evaluating the efficacy of quaternary ammonium compounds for wildland firefighting equipment exposed to Dreissenid adults and veligers

Ashlie Watters[1], Shawn Gerstenberger[1], and Wai Hing Wong[1]

[1]University of Nevada, Las Vegas

The zebra (*Dreissena polymorpha*) and quagga mussel (*Dreissena rostriformis bugensis*) have become arguably the most serious nonindigenous biofouling pests introduced into North American freshwater systems. Control and prevention of fouling caused by dreissenid mussels have been a concern for managers of all types of water delivery systems including the equipment used in delivery waters in fire-suppression. This study investigated the effectiveness of the quaternary

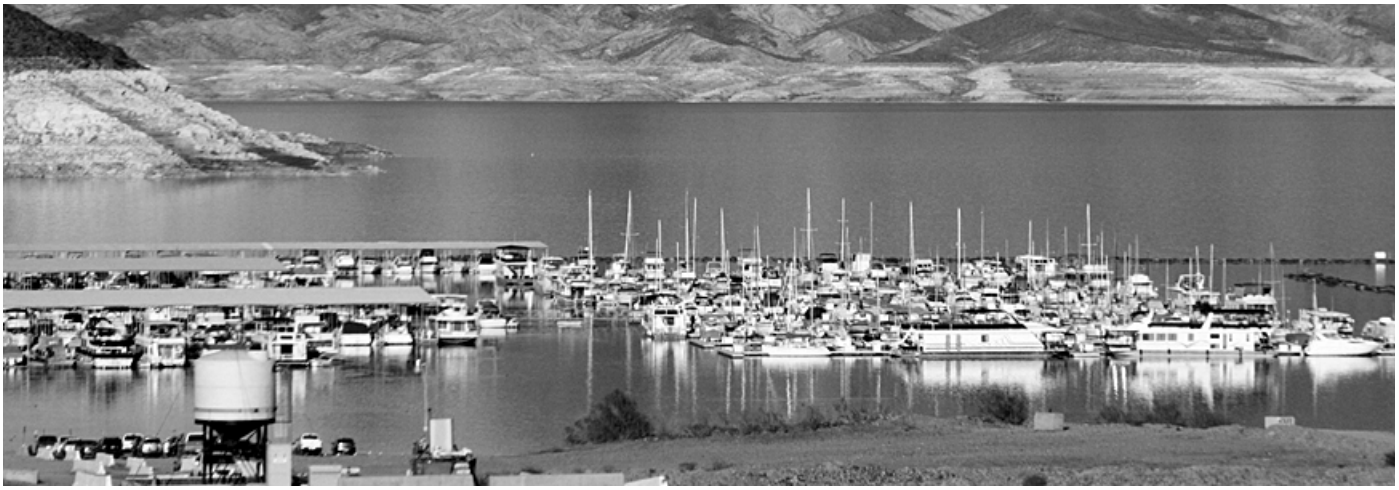

Photo courtesy of National Park Service

ammonium compounds, Quat 128 and Quat 256 on killing dreissenid veligers and adults.
The effectiveness of Quat 128 and Quat 256 on killing adult quagga and zebra mussels was examined over time at four concentrations: 0, 1%, 3%, and 5%. Likewise, the effectiveness of Quat 128 and Quat 256 on killing quagga and zebra mussel veligers was examined over time at different concentrations: 0.25%, 0.5%, and 0.75%; 0.1%, 0.25%, and 0.5%, respectively and at different water temperatures, 35°F, 60°F, and 85°F. The results of the study show that 0.1% Quat 128 is the most effective when killing adult quagga and zebra mussels within 48 hours and 0.25% Quat 256 is most effective when killing quagga and zebra mussel veligers within 5 min at all temperature ranges (35, 60, and 85°F).

This project helps to provide baseline data on the development of a standard and effective decontamination protocol on firefighting equipment exposed to quagga and/or zebra mussels throughout the western United States.

5:00 - 5:20

Results of boater survey answers versus actual observations of boaters pulling their plugs

Kami Silverwood[1] and Tom McMahon[1]
[1]Arizona Game and Fish Department

During the boating seasons of 2012 and 2013 our Aquatic Invasive Species (AIS) Program conducted Boating/Angling Surveys on the boat ramps at Lakes Bartlett, Havasu, and Pleasant. While conducting the surveys, we asked boaters what they did to help prevent the spread of AIS, with a focus on pulling the plug, since in Arizona all watercraft users leaving AIS listed infested lakes are required by law to clean, drain and dry their boats and pull the boat plug when leaving the lake (A.R.S. §17-255). Our results showed that during the boating season of 2012, 88% of boaters said they pulled the plug, but when we "hid behind the bushes" and observed boaters leaving the ramp/park, our results showed that 61% had pulled their plug. During the boating season of 2013, 74% of boaters said they pulled the plug, but when we "hid behind the bushes" and observed boaters leaving the ramp/park, our results showed that 61% had pulled their plug. The gap between what our survey results reflected and what we observed decreased but we recommend future outreach and education to make sure every boater is aware of the potential of transporting AIS and how to prevent the spread while also informing boaters of AZ laws and the clean, drain and dry protocols.

5:20 - 5:40

Watercraft inspection and decontamination training updates

"Quagga D" Davis (Pacific States Marine Fisheries Commission)

Watercraft Inspection and Decontamination Training certification classes have been conducted throughout the western United States. As well, participants from all over the country and Canadian Provinces travel to Lake Mead for training. Certifications include:

Level I – Inspector/Responder Training
Level II – Inspector/Decontamination Training
Level III – Trainer Certification – (In Development)

These courses are designed for those individuals who are or will be active in setting-up or implementing watercraft inspection and decontamination programs for their respective agencies, organizations or businesses. The class size is restricted and the focus is on actual inspections of various types of watercraft and the use of several decontamination systems. It is recognized by 100th Meridian member agencies and successful graduates will be qualified as incident responders, decontaminators, and/or Trainers.

Level I gives a thorough overview of the species and problems caused, and includes information on outreach and education programs, basic mussel biology, distribution, transport vectors, mussel impacts and focuses on how to inspect and educate boaters on how to Clean, Drain, & Dry. **Level II** is delivered over two days (12-14 hours) at Lake Mead, Las Vegas, NV. The focus is on actual inspections and decontamination of various types of watercraft which may or may not be contaminated with Quagga mussels. The instruction includes the use of portable (low-cost) temperature- controlled, power-wash units. **Level III** is scheduled to be added in 2014 to those actively involved in an Inspection/ Decontamination program and can demonstrate the skills and ability to train within their respective agencies or organizations.