Lake Mead Ecosystem Monitoring Workgroup

Date: May 24, 2012
Location: SNWA, Molasky Corporate Center
Suite 700, Colorado River Room #2
100 City Parkway, Las Vegas NV 89106

Participants

Becky Blasius (Reclamation), **Doug Drury** (CCWRD), **Jason Eckberg** (SNWA), **Dan Fischer** (Las Vegas), **Debora Herndon** (NDOW), **Ron Kegerries** (Bio-West), *__Janet Kirsch__ (Reclamation), **Dana LaRance** (Henderson), *__Maria Lopez__ (MWD), **Kim Maloy** (CRC), **Jennell Miller** (UNLV), **Peggy Roefer** (SNWA), *__Michael Rosen__ (USGS), **Scott Schiefer** (Las Vegas), **Jon Sjöberg** (NDOW), *__Bill Taylor__ (MWD), **Todd Tietjen** (SNWA), **Warren Turkett** (SNWA), **Ron Veley** (USGS), **Ashlie Watters** (NPS and UNLV), **Doyle Wilson** (Lake Havasu), **David Wong** (UNLV), **Xiaoping Zhou** (SNWA), **Ron Zegers** (SNWA).

* via conference call.

Action Items

- Jennell will revise the LaMEM purpose statement based on today's discussion and re-circulate. Participants are asked to review the document and send links/or files associated with "Documents of Interest" to Jennell.miller@unlv.edu.
- Jennell will work with members to finalize the speakers' calendar for year-2 meetings.
- Michael Rosen will speak with NWRA to discuss ideas about future Lake Mead Science Symposium activities and get additional cost estimates for the plans discussed today.
- Next meeting: **August 23, 2012 • 1:00 pm • SNWA Molasky Corporate Center, Colorado River Room-2**. **PLEASE NOTE TIME CHANGE**

Summary

1. Welcome and Introductions (Peggy Roefer, SNWA)

Peggy opened the meeting and participants introduced themselves. The agenda, which was developed and circulated prior to the meeting and is represented in the headings below, was reviewed.

Question: Would participants like to start the meeting earlier? Yes. Participants agreed on **1:00 pm** as the start time for all future meetings.

2. Review and Approval of Lake Mead Monitoring Workgroup Purpose Statement

Group Name

Peggy asked the group to (1) finalize or change the group's name, "Lake Mead Ecosystems Monitoring Workgroup" with consideration to the fact that the group's area of interest extends beyond Lake Mead and (2) finalize the acronym that the group will use.

Following discussion, participants agreed to keep the name "Lake Mead Ecosystems Monitoring Workgroup" and to use the acronym, **LaMEM Workgroup**, as proposed by Ron Veley.

Review and Approval of LaMEM Workgroup Purpose Statement

At the February meeting, participants agreed that a mission statement and administrative objectives should be developed, and they discussed concepts that should be included. Accordingly, Jennell and Kent drafted a "Purpose Statement" document and distributed it to volunteers for review. The edited version was then distributed to the full e-mail list and provided in hard copy at today's meeting. Participants reviewed the document paragraph by paragraph. Several edits were suggested that Jennell will incorporate, and then redistribute the document to the group for final review. Following final review, the text will be posted on the new LaMEM Workgroup web page to be hosted by NDEP.

Comments included:

- (a) Update the acronym throughout the document; (b) in the purpose statement section, add language that states that the LaMEM Workgroup is not funded; (c) add more locations of interest to the Scope of Interest section.
- The full purpose statement text should be posted in the body of the web page; links to (or the files associated with) the LaMEM Workgroup documents of interest should be provided.

3. Special Topic: Colorado River Regional Sewer Coalition Update

Doyle Wilson, Ph.D., Lake Havasu City • See presentation file: CRRSCo_LaMEM_2012-05-24.pdf

Doyle updated the group on the Colorado River Regional Sewer Coalition's (CRRSCo) pending mission change, which its Board is currently considering.

Historical Overview

Formed in the late 1990s, CRRSCo is a non-profit corporation with membership from Arizona, California, and Nevada river communities; local governments; Indian tribes; and regional water providers in the Lower Colorado River Basin. More recently, SNWA, MWD, and CAP have been added.

CRRSCo's original mission was "to protect and enhance the Colorado River through the improvement of wastewater management practices to ensure a high quality of waters for all users. The impetus for its formation was water quality issues (especially nitrates) related to septic tank systems plaguing the Colorado River south of Davis Dam. In the early 2000s, significant sewer construction projects were underway and CRRSCo sought to create a congressionally designated water-quality foundation for the Lower Colorado River similar to those developed in the Chesapeake Bay and Great Lakes regions. A Congressional Bill was drafted; but, unfortunately, it did not pass.

In 2005, The Clean Colorado River Alliance (within the Water Quality Division of the Arizona Department of Environmental Quality) developed recommendations in the form of an action plan to ensure Colorado River water quality could address the needs of Arizona into the future. Many of the water-quality concerns documented in 2006 by the Clean Colorado River Alliance are still valid today, and new issues have emerged in the interim. The report is available online at: http://www.azdeq.gov/environ/water/download/ccra06.pdf

Doyle also covered a listing of these threats and additional unusual/first-time events that have occurred following quagga mussel introduction (see PowerPoint for details). Specifically, Doyle mentioned that *microcystis* was identified at Lake Havasu last year; an evenly dispersed *microcystis* bloom formed approximately 3-4 weeks ago (very early in the year) throughout the lake.

Rationale for Mission Change

CRRSCo has always had broad interest in water quality in general, but sewer and wastewater management-related activities were its primary focus. As of 2011, the largest sewer construction projects in Lake Havasu and Bullhead cities were completed; thus, CRRSCo Board Members decided to re-evaluate and redirect the group's existing focus. Water quality is proposed as the new primary mission in assistance to a system that serves approximately 25 million people. This change would require modifications to the organization's by-laws and a proposed name change to "Clean Colorado River Sustainability Coalition" (if this name is selected, the acronym "CCRSCo" would have the same pronunciation as the original "CRRSCo"). A new water-quality focus for the organization is timely considering quagga mussel infestation, and the changing aquatic ecosystem that the species brings about.

Partnership and Collaboration Building

CRRSCo's overall intent in its desire to communicate and collaborate is to keep a sustainable level of water quality to benefit all water uses on the river. CRRSCo is open to potential partnerships with all interested groups (such as LaMEM) to further mutual goals and missions related to Lower Colorado River water quality. At the very minimum, a Lower Colorado regional communication system is very important to develop (e.g., when a tentative identification was made for Lake Havasu leeches, Doyle and his group were not aware of this finding, and other events have taken place that would have been helpful to know about).

CRRSCo has partnered with the U.S. Bureau of Reclamation to populate a water-quality database for lower Colorado River communities; this database piggybacks on SNWA's extensive database for Lakes Mead and Mohave. Surface water and groundwater quality data are included. The primary near term effort of CRRSCo will be to continue help to develop the database through 2016. The group would also like to develop a coordinated, regional, water-quality monitoring effort for surface water and groundwater.

Question: Is anyone quantitating the *microcystis* you mentioned?

Response: The location of *microcystis* really depends on wind; there have been reports of temporary accumulation in coves, followed by dispersal across the open water when the wind comes up. Striation accumulations have also been found in various places. Samples have been sent to Dr. David

Walker (University of Arizona) for analysis. Water chemistry analyses for ortho-phosphate and total phosphorus (along with other parameters) have been done. Doyle is also working with BLM (Lake Havasu City Field Office) to test runoff, ground water, and near shore samples; all samples are showing higher than expected phosphorus levels.
Comment: MWD has someone collecting samples on Lake Havasu right now, and is more than willing to cooperate. This is very interesting: Historically, there has not been enough phosphorus for a major *microcystis* outbreak.

5. Topic Presentations:

LAKE MEAD MONITORING: 2011 • Todd Tietjen, Ph.D., SNWA

See presentation file: Tietjen_LaMEM_2012-05-24.pdf

Todd provided an overview of the 2011 end-of-year monitoring data that will be summarized in SNWA's 2011 annual report (in preparation); when complete, the report will be posted online at www.snwa.com. For the overview, Todd focused primarily on data collected at **CR346.4**, a site for which a long-term dataset exists and that, historically, has not varied significantly depending on changes in the wash or other areas. It is well suited for determining long-term trends. Some data from Inner Las Vegas Bay were also discussed.

Increase in Surface Elevation

See presentation file for a graph of Lake Mead Surface Elevation (1970-2011).

During the latter half of 2011, a significant rise in Lake Mead surface elevation resulted from the melting of a relatively increased level of winter snowpack in Colorado, Wyoming, and eastern Utah mountains. This rise in water level became a common theme in explaining the trends that SNWA documented for 2011. Re-inundation of dry areas and an additional contribution of Colorado River water shifted many of Lake Mead's water-quality parameters. In general, the following shifts were detected: cooler water at the Intakes, lower specific conductance, and higher dissolved oxygen (compared to previous years). Todd noted that although some parameters had changed, water quality was not degraded.

Temperature:

See presentation file for a graph of temperature across all elevations by year for the past eleven years at CR346.4.

In 2011, there was no real change to surface water temperatures, which peaked at 30° C as expected. However, the influx of cold Colorado River water and the increase in surface elevation, combined, kept temperatures at the depth of Intakes 1 and 2 cooler (deep metalimnetic) for a longer period of time (i.e., 19-20° C temperatures were reached only at the very end of the stratified period) compared to the past four to five years. Less deepening of the epilimnion was also observed late in the year; this finding could possibly be attributed to a combination of the atmospheric environment (air temperatures) combined with inflowing cold water. The lake completely mixed (not shown; mixing appears in early 2012).

Specific Conductance (SC):

See presentation file for a graph of Specific Conductance across all elevations by year for the past eleven years at CR346.4.

While, the salinity of the Colorado River might not be considered "low" in comparison to other U.S. water bodies outside of the West, it is the lowest source of salinity input into Lake Mead. SC increased throughout 2005 and decreased thereafter. With the influx of Colorado River water in 2011, levels declined further. The declining salinity since 2006 reflects Lake Powell releases. Todd noted that even under drought conditions, lowered conductivity is expected until Lake Powell operations change the conductance of Colorado River input.

Dissolved Oxygen (DO):

See presentation file for a graph of DO Percent Saturation across all elevations by year for the past eleven years at CR346.4.

2011, which started with complete mixing, was a good DO year. At the beginning of the year DO was 9-10mg/L (90% saturation) with a supersaturated oxygen maxima in the metalimnion early in the growing season. DO conditions were especially good at the bottom of the lake; this finding was attributed to the Colorado River underflow that brought oxygen with it.

Todd also noted (data not shown) that low oxygen (approximately 4-5 µg/L) conditions were observed at the back of Las Vegas Bay (LV4.15 site) for a short period in late summer. This finding could reflect decomposition driven by algal production and death exacerbated by another factor (e.g., temperature, excessive feeding by *Daphnia*, and/or Las Vegas Wash Loading) that increased algal die-off over the month in question. During the period immediately prior to the low DO occurances, Chl-*a* concentrations had increased.

Nutrients

Phosphorus - Total Phosphorus and Ortho-Phosphate:

See presentation file for graphs of total phosphorus at CR346.4 and ortho-phosphate concentrations near the Las Vegas Wash/Bay interface across all elevations by year for the past eleven years.

For the most part, total phosphorus concentrations remained low (below 6-10 µg/L), as expected for a large reservoir with heavy settling at the inflows. On occasion, relatively higher values were observed at the lake bottom; these results might be due to sampling errors (e.g., collecting sediment instead of water). The small peak observed at the end of the year may reflect mixing. The low levels observed are representative of what is delivered downstream through the dam.

The bulk of phosphorus in Lake Mead enters through Las Vegas Wash. Through the middle of 2011, ortho-phosphate concentration increased near Las Vegas Wash, but did not make it to the surface (possibly taken up and used by algae). Levels dissipate further out into Boulder Basin. The observed phosphorus increase was sustained longer than what was seen in the past two years, but it did not reach levels higher than what had been observed in the past.

Nitrogen:

See presentation file for a graph of total nitrogen concentrations across all elevations by year for the past eleven years at CR346.4.

Total nitrogen has been very stable for the last decade, with plenty for algal production; phosphorus continues to be the limiting nutrient. In 2011, there were slightly higher concentrations at the lake bottom; this finding is consistent with the influx of the Colorado River.

Phytoplankton

See presentation file for graphs of Chl-a concentrations across a series of sites from Las Vegas Bay to Hoover Dam and Phytoplankton abundances for the past eleven years at CR346.4.

Chl-*a* sampling is conducted only in the top 6 meters of Lake Mead. Although 2011 Secchi disk depths were very deep, Chl-*a* concentrations were slightly higher than recent trends, reaching 30 µg/L at sites nearest Las Vegas Wash. Las Vegas Wash water input provides a level of phosphorus loading that contributes to algal increase, but with the rise in lake level, shoreline sediments could also have released phosphorus.

The phytoplankton community continued to be dominated by Cyanobacteria (abundance) and by Diatoms (biovolume/biomass).

Total Organic Carbon (TOC)

See presentation file for a graph of TOC concentrations for the past eleven years at CR346.4.

2011 was unremarkable in terms of TOC. Overall, levels were good and improving. In Lake Mead, algae drive TOC concentrations; TOC levels are also influenced by recalcitrant input from the Colorado River and other tributaries in the form of material that bacteria just can't break down.

Zooplankton

See presentation file for graphs of zooplankton taxa percent composition and abundances since 2007.

Lake Mead zooplankton trends have remained stable since 2007, with predictable seasonal changes. Each year, Copepods persist throughout, and Cladocerans are detected at their highest levels early in the year. Rotifers do not play much of role in the open water.

Compared to other taxa in Lake Mead's zooplankton community, quagga mussel veligers are quite abundant (in terms of numbers); however, they contribute very little to overall zooplankton biomass. Todd noted that based on data from other areas, there has been concern that Lake Mead zooplankton would decline following quagga mussel infestation from out-competition. To date, no decline in zooplankton has been noted. (See also David Wong's presentation summary, below).

Perchlorate

See presentation file for graphs of zooplankton taxa percent composition and abundances since 2007.

Perchlorate treatment is a success story; levels have continued to decline. At the intersection of Las Vegas Wash and Las Vegas Bay, perchlorate concentration are much lower than in the past. This result is attributed to both dilution and water treatment before water enters Las Vegas Wash.

2011 WATER QUALITY IN LAS VEGAS WASH

Xiaoping Zhou, Ph.D. and Roslyn Ryan, SNWA

See presentation file: Zhou_LaMEM_2012-05-24.pdf

The Las Vegas Wash monitoring program has been ongoing for more than 10 years; data are fully summarized each year in an annual report and data are also stored in a database. When complete, the report will be made available at www.lvwash.org. Xiaoping provided an overview of 2011 data, focusing on variations observed in different parts of the mainstream Wash due to differences among its major inflows. Accordingly, 10 sampling sites were strategically chosen for this purpose and included (*see presentation file for map of sampling locations*):

- **LW11.5** Captures the combined flows of Flamingo Wash and Upper Las Vegas Wash (Las Vegas Creek). This sampling site provides the reference point above the treatment plants.
- **LW11.1** Above the COLV but includes flow from Sloan Channel (now includes CNLV effluent discharge).
- **LW9.3** Includes addition of COLV effluent discharge
- **LW8.85** Includes Clark County effluent discharge.
- **LW7.2** Further downstream of Clark County effluent and Ducks Unlimited Ponds, but just upstream of the confluence with Duck Creek.
- **LW6.85** Includes flow from Duck Creek.
- **LW6.05** Includes addition of COH effluent discharge; last site downstream of a major inflow source.

2011 Average Field Data

See presentation file for a combined graph of DO, pH, Temperature, and Conductance averaged over the year across the 10 selected sampling locations.

Downstream of the Clark County Water Treatment Plant, water quality is very stable. However, some variations can be detected by comparing multiple sites at a very fine scale. Having multiple sites allows for the detection of variations that would otherwise go unnoticed.

<u>Dissolved Oxygen (DO)</u> Variations among sites were small.
<u>pH</u> ....Variations among sites were small.
<u>Temperature</u>.................Variations among sites were small.
<u>Conductance</u>.................Conductance showed the most variation. Unsurprisingly, a significant drop in conductance occurs after LW11.1 due to dilution by wastewater treatment efforts. Conductance rises again after Duck Creek (LW6.85), which is a high salinity input.

Water Quality Variations in the Wash due to Major Inflows

<u>Major Ions:</u>

See presentation file for a combined graph of chloride, sodium, sulfate, and Total Dissolved Solids annual averages for the 10 selected sampling locations and a similar combined graph of alkalinity bicarbonate, bromide, calcium, chlorate, fluoride, magnesium, potassium, silica, and sulfide.

All major ions decrease following the (LW9.3). Most ions are detected at slightly higher levels after Duck Creek. With an average flow rate of 10 cfs, it is unsurprising that Duck Creek demonstrably contributes to this increase. It was noted that homeowners pump groundwater into Duck Creek. Ground water also impacts water quality at the lower reaches of the wash.

<u>Metals:</u>

See presentation file for a combined graph of barium, manganese, zinc, aluminum, and iron annual averages for the 10 selected sampling locations and a similar combined graphs for arsenic, copper, nickel, selenium, antimony, chromium, and lead.

Most metals increase after Duck Creek. Xiaoping reiterated that if these results were viewed at a larger scale, the graph lines would be flat. It takes a very close look to see the variations. As with ions, there is greater contribution to metals by groundwater at the lower part of the wash.

Question: How can selenium increase between LW8.85 and LW7.2 (pre-Ducks Unlimited)?

Response: The slight increase is due to Duck Creek shallow ground water contribution.

Average NH_3 and NO_3

See presentation file for a combined graph of NH_3 and NO_3 yearly averages for the 10 selected sampling locations.

Upstream of the wastewater treatment plants, nutrients are low; downstream they are relatively higher. For the most part, ammonia averages between 0.10 and 0.140 mg/L as N and nitrate between 12.0 and 16.0 mg/L as N.

Question: What is the detection limit for ammonia? It must be quite low.

Response: It used to be .008 mg/L. New technology may be able to detect lower limits.

Phosphorus

See presentation file for a combined bar graph of annual averages of phosphorus (orthophosphate and total phosphorus) for the 10 selected sampling locations.

Xiaoping noted that the phosphorus data in his presentation are averaged data, not continuous data, as was shown earlier by Todd for Lake Mead.

Total Suspended Solids (TSS) and Perchlorate

See presentation file for two graphs of average TSS and Perchlorate over the year across the 10 selected sampling locations. In 2011 there were two sampling frequencies. From January through March sampling was conducted monthly; between April and December sampling was conducted quarterly.

Compared to previous years, 2011 samples contained higher TSS numbers in some locations. Previous results have typically been $\leq$ 10 mg/L; in 2011, the average at LW5.7 was above 30 mg/L (and other sites also had values above 10 mg/L). The increased TSS is likely due to construction activities. Note that results from the lower part of the Wash were relatively low.

Average perchlorate is lower than 70 μg/L at LW0.55 (Northshore Bridge Site).

Question: There seems to be some detection of perchlorate at sites upstream of the treatment plant. What would be the source of this perchlorate?

Response: Unknown; possibly from water use cycles (background perchlorate) in the Valley and evaporation in urban runoff tributaries.

Mass Balance of Key Parameters at LW0.9 (Below Lake Las Vegas)

Flow data from an USGS continuous flow gage and water quality data collected by SNWA were used to compute a mass loading rate of key parameters (perchlorate, selenium, total phosphorus, TSS, and TDS) at LW0.9. *See presentation file for results table.*

Question: Has mass loading of TDS increased over the years?

Response: Analysis of TDS trend over time (e.g., over the past 10 years) is complicated by changes in average flow. It would be fair to say TDS has likely increased because flow has increased.

LAKE MEAD RAZORBACK SUCKER MONITORING AND RESEARCH

Brandon Albrecht, **Ron Kegerries**, and Zach Shattuck, BIO-WEST, Inc.

See presentation file: Albrecht_LaMEM_2012-05-24.pdf

Ron provided a summary of BIO-WEST's recent Lake Mead razorback sucker findings, with a focus on 2011 data. Within Lake Mead, the razorback sucker population is **all wild** and demonstrates annual natural recruitment. Anomalous in the Colorado River Basin, this species has maintained itself in Lake Mead for nearly 100 years in spite of changed habitat conditions and nonnative fish presence. BIO-WEST has been studying razorback suckers in Lake Mead since 1996, following discovery of the species' presence by the Nevada Department of Wildlife. The objectives of the long-term monitoring project have included: (1) determining population size; (2) documenting life history characteristics and Lake Mead habitat use, especially known spawning sites; (3) conducting sampling and analyses for all life stages; and (4) searching for new population concentrations (e.g., Colorado River Inflow area). The search for new populations is a task that was specified by the *Lake Mead Razorback Sucker Management Plan*.

Collaboration and Cooperation

This ongoing razorback sucker monitoring and research effort has relied on the collaboration of numerous entities including the Southern Nevada Water Authority; National Park Service, Lake Mead National Recreation Area; U.S. Bureau of Reclamation's Multi-Species Conservation Program; Arizona Game and Fish; and Nevada Department of Wildlife. Collectively, the group is known as "the Lake Mead Razorback Sucker Workgroup." The Colorado River inflow investigations are funded collectively by the Lower Colorado River MSCP and the Upper Colorado River U.S. Bureau of Reclamation.

Geographic Scope and Methods Overview

See presentation file for a map of the study area.

The original 1996 study area encompassed Las Vegas Bay near Las Vegas Wash and Echo Bay. In 2005, the Overton Arm near the Muddy and Virgin River inflows was added. Still more recently, the Colorado River Inflow (CRI) area was included. The project uses multiple methods for capture, collection, and aging; resulting data provide a collective suite of information. Methods include sonic telemetry (active and passive), trammel netting, larval sampling (via crappie lights at night), nonlethal age determination (via fin-ray sections and microscopy), and population estimates. Ron noted that sonic telemetry to date has mostly involved the use of hatchery fish (8-12 per year) into which sonic and PIT tags are implanted. The sonic tagged individuals are followed to natural populations in close proximity to spawning areas; trammel nets are then used to capture wild fish.

2011 Long-term Monitoring Site Highlights

(Las Vegas Bay, Echo Bay, and Muddy River/Virgin River inflow at the Overton Arm)

- 67 total net-nights (January–April 2011)
- 86 total captures - 14 recaptures (16.3%) = **72 new/wild captures**

- 73 individuals aged
- 72.6% (n = 53) were 7 years old or younger
- Strong year-class for 2005
- Total of 4,288 larval razorback collected from long-term monitoring sites
- **5 wild juveniles**

To date, 600+ Lake Mead razorback suckers have been captured and tagged; 360 have been aged. As of 2011, 107 wild, subadult razorback suckers have been collected (see table below). The continued presence of such young individuals is not observed anywhere else.

Period	Period Length	Number of subadults Collected	
1996-1997	2 years	4	*Sampling methodology had not yet been perfected – low collection.*
1998-2005	8 years	17	*Sampling period where VR/MR Inflow population was found.*
2006-2011	6 years	86	*Sampling period that included all three sites and improved/consistent sampling techniques.*
	Total	**107**	

2011 Colorado River Inflow (CRI) Adult and Larval Sampling Highlights

In 2010, the Razorback Sucker Workgroup recommended a study to determine whether razorback suckers were spawning and recruiting at the CRI area. 2011 data highlights are shown below. This effort confirmed that successful spawning has occurred for the past two field seasons. In addition, wild, adult razorback suckers were captured at two different locations within the CRI.

Adults:

- Total of 187 net nights (600% increase from 2010).
- Total of 15 razorbacks (8 recaptured, 7 new wild fish).
- Total of 7 hybrids [razorback x flannelmouth] (1 recaptured, 6 new wild fish).
- Total of 112 flannelmouth (39 recaptured, 73 new wild fish).
- 0.08 razorback/net night (0.04 new, wild fish/net night).
- Single bluehead sucker also captured.

Larvae:

- Total of 265 sampling events for a total of 146 light hours.
- First larval razorback sucker collected (02/14/2011; 11.5°C).
- Total catch of 65 larval razorback suckers (350% increase from 2010).
- Catch per minute (CPM) value for razorback sucker larvae similar to those observed initially at Muddy River/Virgin River inflow.
- Captured 11 flannelmouth sucker larvae for a CPM of 0.0013.
- CRI is an important spawning location for native suckers.

Within a cove in the CRI area, a line demarcates an area of turbidity that is readily visible; this demarcation is not found anywhere else below Hoover Dam. When BIO-WEST released PIT-tagged fish, they found they would not go too far up the river, but would seek rapids and sit in eddies. They would travel between the rapid and the lake; spending some time in each location.

The CRI work additionally showed that sonic-telemetry techniques can be used as an effective tool to help document razorback sucker habitat use and fund unknown populations of razorback suckers in *some* understudied areas of Lake Mead. Caveat: telemetry is not as effective in deep and turbid waters.

Synthesis

A pattern begins to emerge in combining analyses of annual lake elevation and recruitment (number of individuals spawned based on aging analyses; *see presentation file for graphs*). Initially, it was suspected that recruitment upticks resulted from years when the water levels were high and vegetation was inundated to provide cover. However, in more recent years, large year classes actually resulted when the water level was low. As expected, cover (inundated vegetation) is important; but at lower lake levels turbidity remained and was enhanced. Co-occurrence of turbidity and cover appear to result in the highest levels of recruitment. Because 2011 was a higher or increasing water year, the future 2011 class could be similar in numbers to the 2005 class.

<u>Additional notes on turbidity and cover</u>:

See PowerPoint for a hydrograph of the Virgin River.

Two recent flood events have occurred (2004/2005) and 2010. In 2004/2005 there was a great recruitment year class. The 2010/2011 flood may also have yielded high recruitment, similarly to 2004/2005, the flood provided woody debris, inundated vegetation, and turbidity.

Ron and his BIO-WEST colleagues appreciated the invitation to present; and look forward to continued interactions with the LaMEM Workgroup. Ron noted that the Lake Mead razorback sucker story is positive and the identified sites provide an exceptional and unique opportunity to study wild razorback sucker recruitment. Other unrecognized limnological features of Lake Mead may be important to the success of the species.

LCR MSCP Technical Reports for razorback suckers and other species are posted at:
http://www.lcrmscp.gov/steer_committee/technical_reports_species.html

Question: Why restrict the use of telemetry to hatchery fish? Why not use it on wild fish?

Response: BIO-WEST previously had a USFWS permit to use telemetry on wild razorback suckers. However, the permit limited the numbers of fish that could be caught. It is more convenient to rely on an opportunistic time to catch and tag them. However, we hope to begin using wild fish again to determine if they perform differently than hatchery fish.

Comment: The razorback sucker sites shown in your presentation seem to have different characteristics.

Response: Agreed. There are differences, but there is commonality in turbidity (although Echo Bay is not as turbid). You can't go anywhere in Lake Mead and catch a razorback sucker; but you can consistently find them in the locations discussed today.

Comment: It would seem that the turbidity of the waters discharged through the wash is generally low, but reworking the delta adds turbidity. Would you agree?

Response: Yes, additionally, the lake level, shoreline, wind action all contribute. Turbidity and cover in the form of vegetation have always stood out as unique to the specific sites where razorback suckers occur.

Question: Is anything in the Las Vegas Wash detrimental to razorback suckers?

Response: The Las Vegas Wash seems like it would provide great habitat for the species. Regarding tests for ECCs, razorback suckers are not dissected; but blood tests might have been conducted. Jill Jenkins, Ph.D. (USGS) has compared razorback sucker milt samples from the Las Vegas Wash to samples from other areas. Additional studies (and additional funds) are definitely needed because the sample size was quite small. Also, carp has been used as a surrogate in the study of ECCs in Las Vegas Wash.

Question: You have presented positive results about razorback sucker levels in Lake Mead. Do these numbers impact its status as an endangered species?

Response (Jon Sjöberg)**:** Unfortunately, although robust recruitment has occurred at Lake Mead, it does not affect the range-wide status of the species. We are not near declassifying the razorback sucker from its Endangered listing under the Endangered Species Act. Historically, the species' distribution was widespread throughout the Colorado River System and the Lake Mead population is only one of several recovery populations that have to meet specific size and demographic criteria before the species could be de-listed or downlisted to Threatened. Additionally, Lake Mead was not a recovery population in the original Razorback Sucker Recovery Plan (USFWS 1998). Lake Mead is being added to the revised recovery goals but de-listing or conversion to Threatened status would require meeting the recovery criteria for multiple populations throughout multiple sites; to date, this has not been observed.

QUAGGA MUSSEL MONITORING

David Wong, UNLV and Ashlie Watters, NPS and UNLV

See presentation file: Wong_LaMEM_2012-05-24.pdf

Background and History

Ashlie introduced the Lake Mead NRA emergency response to quagga mussels at Lake Mead followed by the development of an interagency monitoring effort. The invasive quagga mussel was discovered in Lake Mead's Boulder Basin in January 2007; by the end of 2007, the species had spread throughout the lake. Following their discovery in Lake Mead, the NPS initiated an emergency response process and plan. Preliminary data were collected through dives and PONAR grabs to begin to estimate the densities of settled quagga mussels at different areas. In addition, an interagency partnership was formed to develop a standardized, long-term, cost-effective, and consistent monitoring plan for quagga mussels in Lake Mead. The document was titled, "Interagency Monitoring Action Plan (**I-MAP**) for Quagga Mussels." The purpose of the plan was to identify mutual agency goals related to quagga mussel management and information needs, and coordinate activities to gain efficiencies from shared operations and information.

I-MAP Results

Sampling Design and Methods Overview:
David provided a summary of the results from the first comprehensive I-MAP monitoring period, which began in fall 2009 and concluded in fall 2010. For adult/juvenile monitoring, 12 transects were established at different locations across the lake from which a total of 152 samples were collected. There are two types of adult/juvenile sampling sites: hard substrates and soft sediments sampled in proportions calculated through a stratified sampling design based on preliminary NPS data. Adult/juvenile sampling was conducted in a collaboration between NPS Lake Mead NRA staff and UNLV students and investigators. Hard substrates were sampled by divers; soft sediments were collected by Ponar grab. All adult/juvenile samples were analyzed at UNLV. Veliger monitoring and analysis was conducted at 29 stations by SNWA and Reclamation; UNLV conducted sampling and analysis from one veliger monitoring station. Specific sampling locations and frequency were presented (*see PowerPoint for details*).

Adult/Juvenile:
Quagga mussel trends in Lake Mead are not as clear or straightforward as they are in the Great Lakes. Looking at a graph of mussel density (all 152 sampling points combined) by depth, there is no clear trend. Many mussels are present in the shallow areas, but large densities have also occurred at relatively deeper locations, and the data are not normally distributed. Furthermore, no difference was observed among seasons, thermal lake layer, or basins based on analysis of variance. A significant difference **was** found, however, between densities of mussels on different substrate type (i.e., approximately 8K mussels/m^2 on hard substrate vs. 3K mussels/m^2 on soft substrates in 2010). Overall, approximately 1.5 trillion adult/juvenile quagga mussels were calculated to be present in Lake Mead in 2010. For soft sediments, quagga mussel abundance peaked at depths near 200 ft and declined at deeper depths. Looking at individual soft sediment sampling sites, **Callville Bay** most closely matches the soft substrate average or trend. For hard substrates, mussels presented at all depths, and the **Sentinel Island** sampling site most closely matches the overall hard substrate trend. Therefore, the Callville Bay and Sentinel Island sites could be chosen as representative minimal monitoring sites. For greater scientific precision, the stratified random sampling design is recommended. This method would require the following:

Confidence Interval	# Hard Substrate Sites	# Soft Sediment Sites
95%	11	245
98%	15	348
99%	18	429

The vast difference between the numbers of sampling sites needed for hard and soft substrates is explained by the fact that hard substrates are relatively consistent in the number of mussels found whereas there is a great deal of variability on soft sediments. Sampling across the transect at each site requires up to six samples.

Veliger Results:

David presented zooplankton and veliger abundance data collected and analyzed by the U.S. Bureau of Reclamation (Reclamation; Chris Holdren, Ph.D.). Since 2007, Reclamation has carried out two monitoring programs that assessed veliger abundance: (1) veliger monitoring using microscopy that was incorporated into existing water-quality monitoring program (established in the 1990s) at 21 sites and (2) the addition of four new veliger-monitoring sites that used both polymerase chain reaction (PCR) and microscopy to detect veligers. See PowerPoint for a map of veliger sampling locations and a series of graphs plotting veliger abundance over time (2007-2012) for each basin and estuarine region. Based on statistical analysis, highest veliger abundances were observed in the Overton Arm, Virgin Basin, and Temple Basin; lowest were in Las Vegas Bay and the estuaries, which are more turbid and have a higher flow rate. Overall, veligers in Lake Mead have increased from 18 trillion to 320 trillion at an assumed lake level of 1,100 ft.

Also shown was a combined graph of zooplankton abundance over time for three zooplankton taxa and veligers. The results are the complete opposite of what was observed at other locations such as the Hudson River. In these locations, zooplankton abundance declined significantly after the introduction and infestation of quagga mussels. However, no significance difference was seen for cladocerans, and copepods and rotifers increased after 2007 as quagga mussels increased and spread throughout Lake Mead. This is especially curious considering that Lake Mead is and was an oligotrophic lake even before the introduction of quagga mussels.

The differences in veliger abundances between Lake Mead and Lake Mohave were discussed. An increasing trend is clear for both lakes. Differences in numbers are likely due to the differences in environmental conditions at the monitoring stations chosen.

Next Steps:

The level of sampling required for a statistical analysis exceeds current resources of the participating entities. Therefore an *ad hoc* meeting was recently held to discuss and to agree to a minimal sampling regime that can be executed with available resources and staffing. Following the meeting, a plan was drafted that is currently under review and finalization.

Question: You mentioned that quagga mussels prefer to settle on hard substrates, yet soft sediments are abundant in Lake Mead. Can soft sediments turn into hard substrates over time due to quagga mussel colonization?

Response: Yes, in fact, this did happen in Lake Erie. When mussels have fully colonized hard substrate, they begin to settle on soft substrate. Over time, these individuals provide habitat to future mussels (creating a blanket of hard substrate made of their bodies).

End of Presentations

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6. Lake Mead Science Symposium 2014? (Peggy Roefer, SNWA)

Participants discussed Questions 1-3 below; summarized responses follow each question.

(1) Should the Lake Mead Science Symposium continue to occur in partnership with National Water Resources Association (NWRA)?

Response: The group agreed that the partnership should continue if possible.

(2) What should be the frequency of the Lake Mead Science Symposium? The original plan was to conduct the event every three years. The larger NWRA conference is held in Southern Nevada every other year. That means our symposium would have to be held every other year or every four years.

Response: The group agreed that every other year would be too frequent for a full Lake Mead Science Symposium; every fourth year would allow for more data and findings to be developed and shared. Additionally, the group felt it likely that more people would be able to attend every four years. To keep momentum going, perhaps a single Lake Mead Science special session (e.g., a half-day mini symposium) could be incorporated into the NWRA conference on alternate years. Additional discussion with NWRA organizers will be necessary.

(3) The 2011 Lake Mead Science Symposium required $18,000 in sponsorships, including sponsorship by NDEP and NPS, from one-time funding sources. Do participants feel that their agencies will be amenable to contributing at a $3,000 sponsorship level? In this way, only six contributions would be needed to cover the sponsorship cost.

Response: More information is needed from NWRA to determine costs for an every-other-year special session and an every-fourth-year Lake Mead Science Symposium. Once cost information is provided by NWRA, participants will feel comfortable inquiring about the possibility of contributions by their agencies. Michael Rosen will speak with NWRA and report back to the group at the next meeting.

6. Announcements, Assignments, and Next Meeting Reminder

Announcement: In 2014, the North American Lake Management Society Conference will be held in San Diego. Specific dates are not yet set, but will be in the fall around Halloween.

Assignments: See **Action Items** listed on the first page of this summary.

Next Meeting: **August 23, 2012 • 1:00 pm** • SNWA Molasky Corporate Center, CO River Room-2. Please note that the previously agreed upon start time of 2:00 pm for this and all future meetings has been changed to 1:00 pm.

Future Meeting Dates:
11-15-2012
02-13-2013
05-23-2013
08-22-2013
11-21-2013