Lake Mead Endocrine Disruption Studies

Environmental Assessment of Chemical Stressors and Effects on Fish Health within Lake Mead National Recreation Area

Collaborative effort between:

US Geological Survey, US Fish and Wildlife Service, National Park Service, Texas Tech University, University of Nevada, Desert Research Institute
Research Contacts

USGS personnel

Project coordinator: Michael R. Rosen
mrosen@usgs.gov
775-887-7683
(Chemist)

Fish Biologist: Reynaldo Patiño
r.patiño@usgs.gov
806-742-2851

Risk analyst: Greg Linder
glinder2@usgs.gov
573-876-1838

Fish microbiologist: Jill Jenkins
jenkinsji@usgs.gov
503-590-3916

Chemist: Kathy Echols
kechols@usgs.gov
775-354-4849

Toxicologist: Steven Goodbred
goodbred@usgs.gov
702-515-5243

USFWS

Toxicologist (Sed.-Hydro.): Erik Orsak
Erik.orsak@fws.gov
775-887-7683

Foodweb biologist: Sudeep Chandra
sudeep@cabnr.unr.edu
702-378-7639

Microbiologist: Duane Moser
duane.moser@dri.edu
775-354-4849

Risk analyst: Greg Linder
glinder2@usgs.gov
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mrosen@usgs.gov
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Partners

Las Vegas skyline

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Partners

Las Vegas skyline
How it all began

• In Cycle I NAWQA, NVBR Study Unit collaborated with Steve Goodbred (BRD) in an assessment of fish health in Lake Mead and Las Vegas Wash using new techniques (SPMDs)

• Sampled water, fish and bed sediment

• Results published in: Bevans and others, 1996 WRIR 96-4266
What Happened next

- Senator Reid took an interest in what was happening in Lake Mead
- Funded study in 1999-2000 to do a seasonal assessment of fish health
- Results published in Patiño and others 2003 and Goodbred and others 2007
- SNPLMA funding becomes available in mid 2000s
What is happening now?

• Third year of 4-year Round 6 work is almost completed
• Project team sampling has been completed
• Involvement of UNR and DRI welcomed
• Well balanced study
• New publications are available
What is happening now?

• AP article on pharmaceuticals in water supplies and their effect on aquatic organisms has created quite a bit of interest in our work

• Senate hearing April 2008

Many of those studies refer to the heralded research at Lake Mead. There, on a recent trip, Steven Goodbread and colleagues scooped up large, ashen fish from the bottom of Lake Mead and removed parts of their bodies, including their gonads and skin. The specimens will be flown across the country to laboratories where aquatic toxicologists are studying what happens to fish that live in water contaminated with at least 13 different medications—three over-the-counter painkillers, three antidepressants, and mood stabilizers. More often than not these days, the legislators, too, have tested the same species.

A five-month Associated Press investigation has determined that trace amounts of many of the pharmaceuticals we take to stay healthy are slipping into drinking water systems, in some cases contaminating fish and other aquatic sources that could harm humans but aren’t the only ones who consume that water. There is more and more evidence that some animals that live in or drink from streams and lakes are seriously affected. Pharmaceuticals in the water are being blamed for severe reproductive problems in many types of fish. The endangered razorback sucker and male fathead minnow have been found with lower sperm counts and damaged spines; some walleyes and male carp have become what are called feminized fish, producing eggs that procreate inferior males and females.

Meanwhile, female fish have developed male genital organs. There are problems with other wildlife as well. A factory worker’s reaction to a man-made compound has caused a strange kind of malformation that affects the liver and kidneys. "We have no reason to think that this is a unique situation," said Erick Ovask, an environmental contaminant specialist with the U.S. Fish and Wildlife Service, "We have reason to think that this is a unique situation."
Process by which external chemical causes adverse health effects after changes in endocrine function

For more about endocrine disruption:

http://www.tmc.tulane.edu/ecme/eehome/
Lake Mead Study - Overview & Update

- Study Area
- Environmental Issues
- Current Study
  - Goals
  - Progress
- Next Steps
Study Area – Lake Mead National Recreation Area

EXPLANATION

- Sampling locations (all types of data)
Environmental Issues

- Las Vegas Wash - Multiple potential sources of environmental contaminants
- Elevated levels of synthetic chemicals in water, sediment and fish in Las Vegas Bay
- Carp in Las Vegas Bay show signs of reproductive or endocrine disruption
Study Goals

- Evaluate evidence of reproductive- or endocrine-disrupting effects in multiple species, particularly trust species
- Examine evidence for trends of adverse effects in fish
- Determine if emerging contaminants are increasing over time
- Assess flux of contaminants from or to sediments
- Assess risk of contaminant exposure to multiple species
Study Approach

- Use multiple lines of evidence (passive samplers, sediment, and fish tissue) to document if fish in Lake Mead are exposed to EDCs
- Employ multiple endocrine and reproductive biomarkers to determine if exposure in fish has disrupted the endocrine system
- Conduct tests on fish using treated effluent to see how various levels of treatment reduces endocrine effects
Study Progress - Overview

Chemistry
1. Distribution of contaminants
2. Contaminants in fish

Biology
1. Sperm quality
2. GSI

Significance
1. Exposure is occurring
2. Over time effects are consistent
3. We are now evaluating the risks
Deployment and Retrieval of SPMDs
Distribution of Contaminants

37 ng = Total EDC
(2) = Number of EDCs
Study Progress – Water Chemistry

Is there a flux of contaminants from the sediment or are contaminants moved seasonally from LV Wash to LV Bay
New Flux Experiment

- Was conducted summer 2008 (when plume was at the surface)
- New application of SPMDs
- Planned and executed with Dave Alvarez (CERC) and Steve Goodbred (SAC)
Sediment

Water

Metal plate may need to have some holes in it to let water flux through

To float

36 inch SPMD/POCIS

6 inch SPMD/POCIS

These would be spread around the plate (not in a line)
Study Progress – Sediment Chemistry

1998 cores

Lake Mead Stage Height (m)

240 280 320 360 400

Date

Construction of reservoir

Distribution of Contaminants - Different contaminants peak at different times

Construction of reservoir

Discontinued use of most DDT in US

Discontinued use of PCBs

Organic carbon (percent)

DDE (µg/kg)

Total PCBs (µg/Kg)

Lake Powell fills

2000

1990

1980

1970

1960

1950

1940

1930


0.0 0.5 1.0 1.5 2.0

0 10 20 30 40 50 60

0 5 10 15 20

(A)

(B)

(C)

- LVB Shallow
- LVB Deep
- Overton
- Virgin Basin

Discontinued use of most DDT in US

Discontinued use of PCBs
0 – 10 cm depth Sediment results

Low concentrations of the following compounds were detected:

• Tonalide (AHTN), galoxolide (HHCB), methyl salicylate - Fragrances
• Para-cresol - Many sources (wood preservative, combustion product, fragrances, flavoring, etc.)
• BHA (Butylated hydroxyanisole) - Food preservative
• 2,6-dimethylnaphthalene – PAH degradation product
New cores collected in March 2007

- Purpose is to look for emerging contaminants that were not analyzed in the 1998 cores
- Also FWS is interested in Selenium
- No data available yet
Reproductive Biomarkers used

- **Gonadal-Somatic-Index (GSI):** gonads as a percent of body weight.
- **Sex Steroid Hormones:**
  - *Estradiol (E2):* primary sex steroid for female fish, critical to egg growth and development.
  - **11-ketotestosterone (11-KT):** primary male sex steroid for many fish species, critical to spermatogenesis.
  - *Testosterone:* sex steroid precursor for both estradiol and 11-ketotestosterone.
- **Vitellogenin (Vtg):** egg yolk protein produced by the liver in response to estradiol.
- **Sperm Quality:** motility, viability, histology.
Contaminants in Fish - LV Bay (1999/2000 Study)

The bar chart shows the sum of organic contaminants in whole body fish tissue (µg/kg) in Las Vegas Bay and Overton Arm. Las Vegas Bay has a significantly higher concentration of contaminants compared to Overton Arm.
Study Progress – Summary

Contaminants in female whole body (March 2006)

Exposure is still occurring

Graph showing the sum of organic contaminants in whole body fish (µg/kg) for different locations:
- Las Vegas Bay
- Overton Arm
- Gregg Basin (BCAN)
- Willow Beach
Sperm Quality and GSI –
Testicular size is consistently smaller throughout the year for fish in Las Vegas Bay compared to fish in Overton Arm.
Sperm Counts: 2007

- Las Vegas Bay
- Las Vegas Wash
- Willow Beach
- Overton Arm

Sperm/mL Milt

- P = 0.027

[Graph showing sperm counts for different locations in 2007]
Male GSI: Lake Mead 2006

\[ P = 0.0363 \]

- Boulder Basin: 5.1
- Black Canyon: 4.9
- Las Vegas Bay: 5.6
- Willow Beach: 4.6
- Overton Arm: 7.1

(Bar chart showing GSI values for male carp in different areas of Lake Mead, with significant difference indicated by P = 0.0363.)
Testicular tumor in common carp collected from Willow Beach (WB CC-43, Nov 2007)

Willow Beach tumorous testis

Non-tumorous testis

Seminoma
Willow Beach issues

- Could be caused by:
  - Hybrids (goldfish-Carp) present
  - Environmental conditions not conducive to fish reproduction (cold water)
  - EDC chemicals (PCBs) found in fish and sediment
  - Federal hatchery may have an influence
Round 5 Results – Males

Reproductive hormones

Comments

• Highest levels of plasma 11KT and 11KT/E2 ratios found in OA males

• Lowest levels of plasma 11KT and 11KT/E2 ratios found in LVB males
Study Progress – Summary

Exposure and biological effects are consistent over time -

1995 Study - Indicated effects on biomarkers of fish health

1999 - 2000 Study - First yearlong seasonal study of endocrine disruption that also confirmed results of 1995 and 1998 studies

2006 – 2008 Study – Continued effects on biomarkers of fish health, seasonal sampling still being done, effects at Willow beach need to be examined closer
Food web and Microbial work

• Food web – UNR
  – Food web results not yet available

• Microbial work – DRI

HPLC chromatograph displaying 10 ppm (yes 10 ppm!)

Incubation for 2 weeks with sample from Las Vegas Wash.

Large peak from 1 - 2 min derives from media components.
Conclusions

• Contaminant inputs into Lake Mead from Las Vegas Wash have been apparent from 1995 to present
• Distribution of contaminants in water show LVB containing low concentrations throughout the bay
• Fish health has been compromised particularly in Las Vegas Bay, but also possibly at Willow Beach
• Sediments show emerging contaminants are present in upper 10 cm at least
Next Steps

• Expand assessment to include:
  – biomarkers of general health, reproductive, endocrine, and metabolic status
  – contaminant history and fluxes
  – multiple aquatic species
Next Steps

- Perform fish screening assay using:
  - wastewater effluent
  - fathead minnows
- Task in cooperation with SNWA, Clark County wastewater treatment facility, Clean Water Coalition, and FWS
Next Steps

- Perform risk assessments using:
  - Current hydrologic conditions
  - Proposed changes to hydrologic conditions
- Task in cooperation with Clean Water Coalition
- Lake Mead Marina Moved due to drought

Las Vegas Bay Marina

Pre-drought water level

March 2007

March 2008


