

Where are Concentrations of Hydrocarbons and Inorganic Constituents Found in Lake Powell?

“Recent Findings and Future Assessment and Monitoring”



*National Monitoring Conference
Tampa, Florida, May 2-6, 2016
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Today's Presentation

Lake Powell the Reservoir

Why USGS is monitoring

Assessments and Monitoring *(all done in cooperation with Glen Canyon National Recreation Area)*

Where we have been and where we are going with monitoring



Lake Powell...

- is a Reservoir, formed by Glen Canyon Dam and is the 2nd largest reservoir in the nation
- is used for power generation, water delivery/supply to the Lower Colorado River Basin, recreation, and for managing the ecosystem of the Colorado River, Grand Canyon
- Water is released 3 ways and stores about 27 million acre feet of water



Lake Powell *cont...*

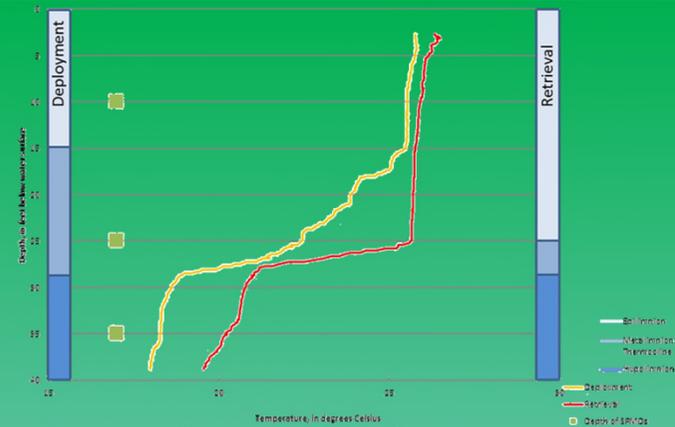
- The lake encompasses 13% of the 1.25 million acre Glen Canyon National Recreation Area, and has 1,960 miles of shoreline and extends 186 miles from the dam into Utah
- It is unique with its 96 major side canyons including Bridge Creek canyon, home to Rainbow Bridge National Monument
- Time zone(s)
 - Arizona – No Daylight Savings Time
 - Utah – Daylight Savings Time
 - Navajo – Daylight Savings Time
 - Hopi – No Daylight Savings Time
 - Dangling Rope – No Daylight Savings Time



Lake Powell

Physiochemical characteristics

- The Lake's chemistry is influenced by the hydrologic regime of the Colorado River, the San Juan River, and numerous smaller watersheds
- The reservoir undergoes seasonal changes,
 - Winter underflow (cold, sediment-laden, saline water enters the reservoir),
 - Spring overflow (warmer less saline enters the reservoir),
 - Summer interflow (warm, clear, saline waters enter the reservoir)
- Well defined thermocline and chemocline mid-spring to late fall
- Mixing in the forebay is incomplete due to the small surface area to volume ratio



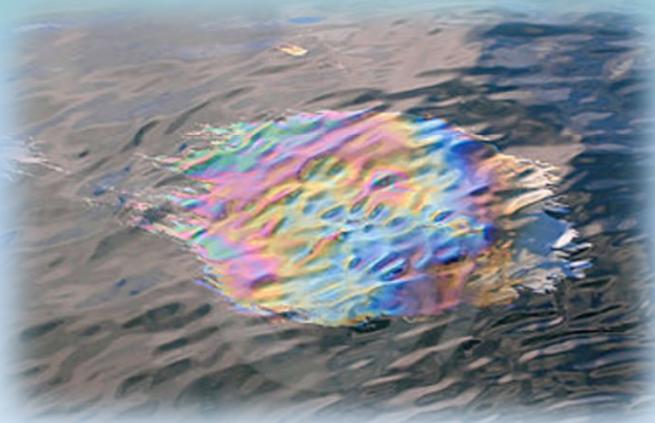
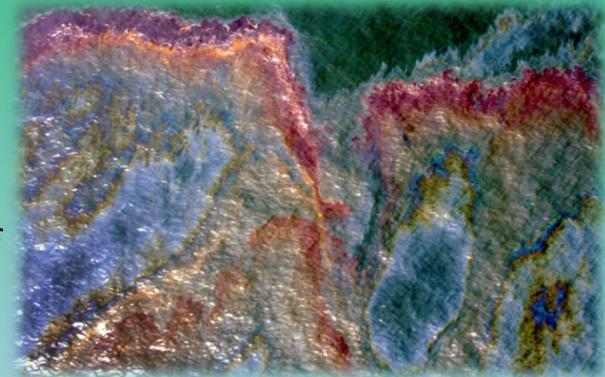
Stresses on Lake Powell and the Recreation Area

- Visitor use to Lake Powell
 - *> 3 million visitors to Glen Canyon National Recreation area*
 - *Water sports – house boating, PWC, ski and sport boats, fishing*
 - *> 400 boat launches every year*
 - *3.2m gallons of fuel sold at the recreation area in 2015*
- Sources of Contaminants
 - *Visitor use – PWCs, other motor craft, camping*
 - *Contaminants in the watershed*
 - *Coal Powered Power Plants*
- Invasive species
 - *Quagga mussels*
- Climate and Drought
 - *Decrease in annual runoff*
- Water demands
 - *Colorado River is over allocated (more than 40 million people)*

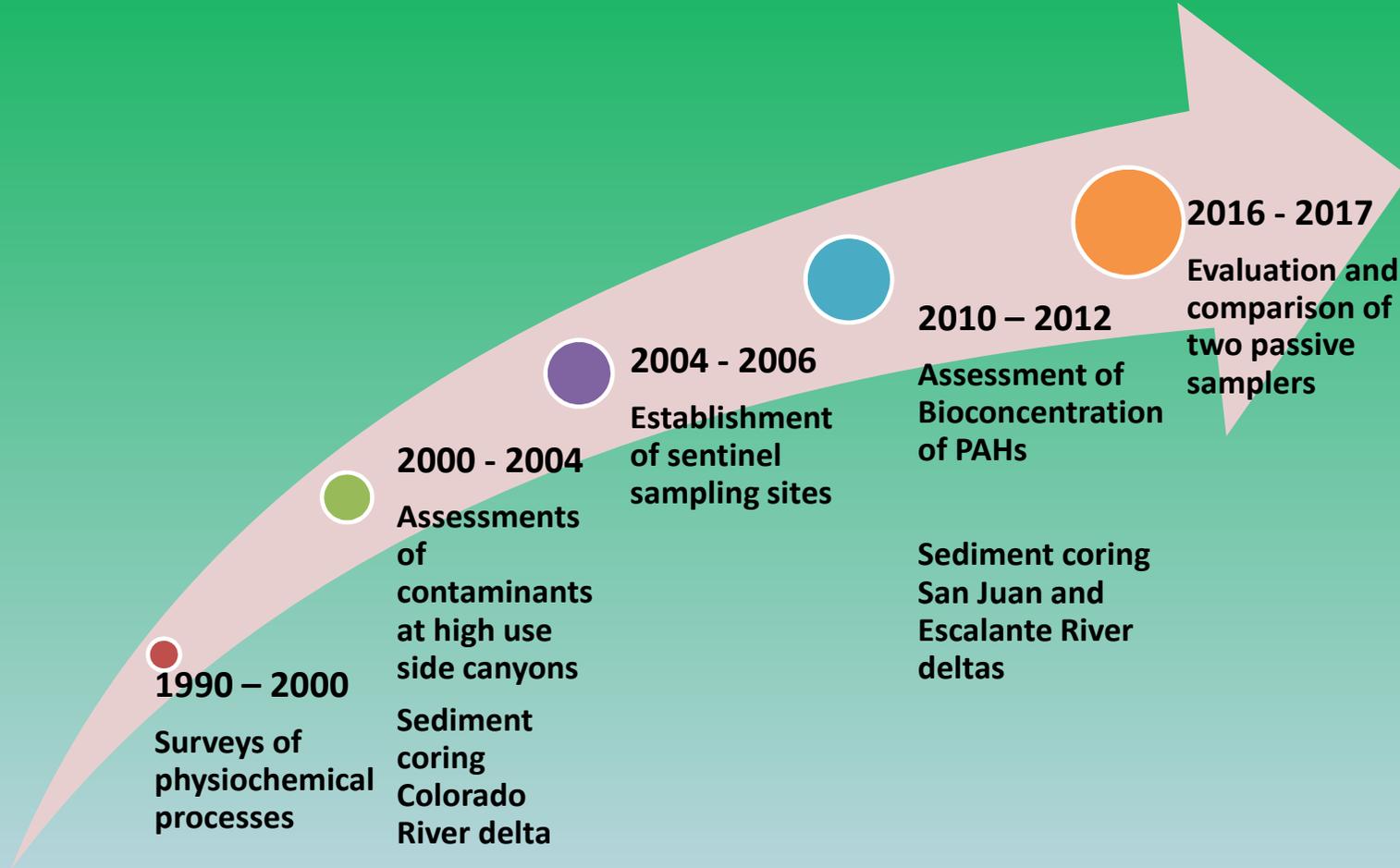


Rules and Regulations

- 2003 Record of Decision for the Environmental Impact Statement
- [Code of Federal Regulations Title 36, 7.70\(e\)\(3\)](#)
 - *After December 31, 2012, **no one** may operate a PWC that does not meet the 2006 emission standards set by EPA for the manufacturing of two-stroke engines. Requires the use of only direct injection 2- or 4-stroke engines (not carbureted, and fuel and oil are not mixed)*



Chronology and process of USGS Studies



Constituents analyzed

2000 to 2012

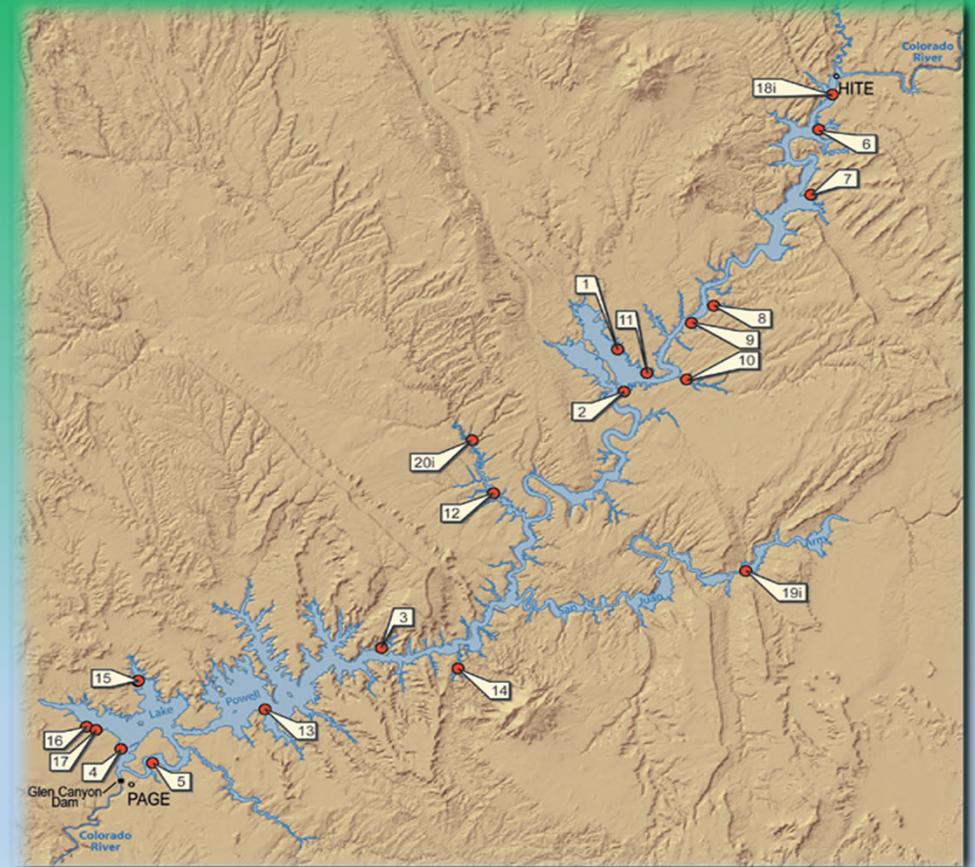
- **2000 – 2004 - Assessment of 3-high use side canyons**
 - Organic and inorganic constituents in water and lakebed material
 - Hydrocarbons, volatile and semi-volatile compounds
 - oil and grease
 - CECs – industrial compounds, pharmaceutical compounds, hormones and steroids, and household products
 - Trace and rare-earth elements
 - Major elements and nutrients
 - Bacteria
- **2004 – 2006 - Establishment of 20 sentinel sampling sites**
 - Sampled for organic and inorganic compounds in water and lakebed materials
- **2010 – 2012 – Repeat sampling at sentinel sites**
 - Repeat sampling plus deployment of passive samplers (SPMDs)



Sentinel Sampling Sites on Lake Powell

For repeat water and lakebed-material sampling

- 11 High-use side canyons and bays
- 6 Marinas
- 3 major inflow sites
- Established during 2004 – 2006
- Last visited during 2010 and 2011



Contaminants found in Lake Powell so far...

- In water
 - Hydrocarbons, volatile (BTEX compounds) and semi-volatile (PAHs)
 - Trace elements
 - Organic wastewater compounds
 - *Steroids, hormones, plastics, disinfectants, solvents*
 - Bacteria, *E Coli*
- In lakebed material
 - Hydrocarbons, semi-volatile (PAHs)
 - Trace metals
 - Radionuclides



Most recent monitoring results, 2010 – 2012

Schonauer and others, 2013



Observations of PAHs in Water (using SPMDs)

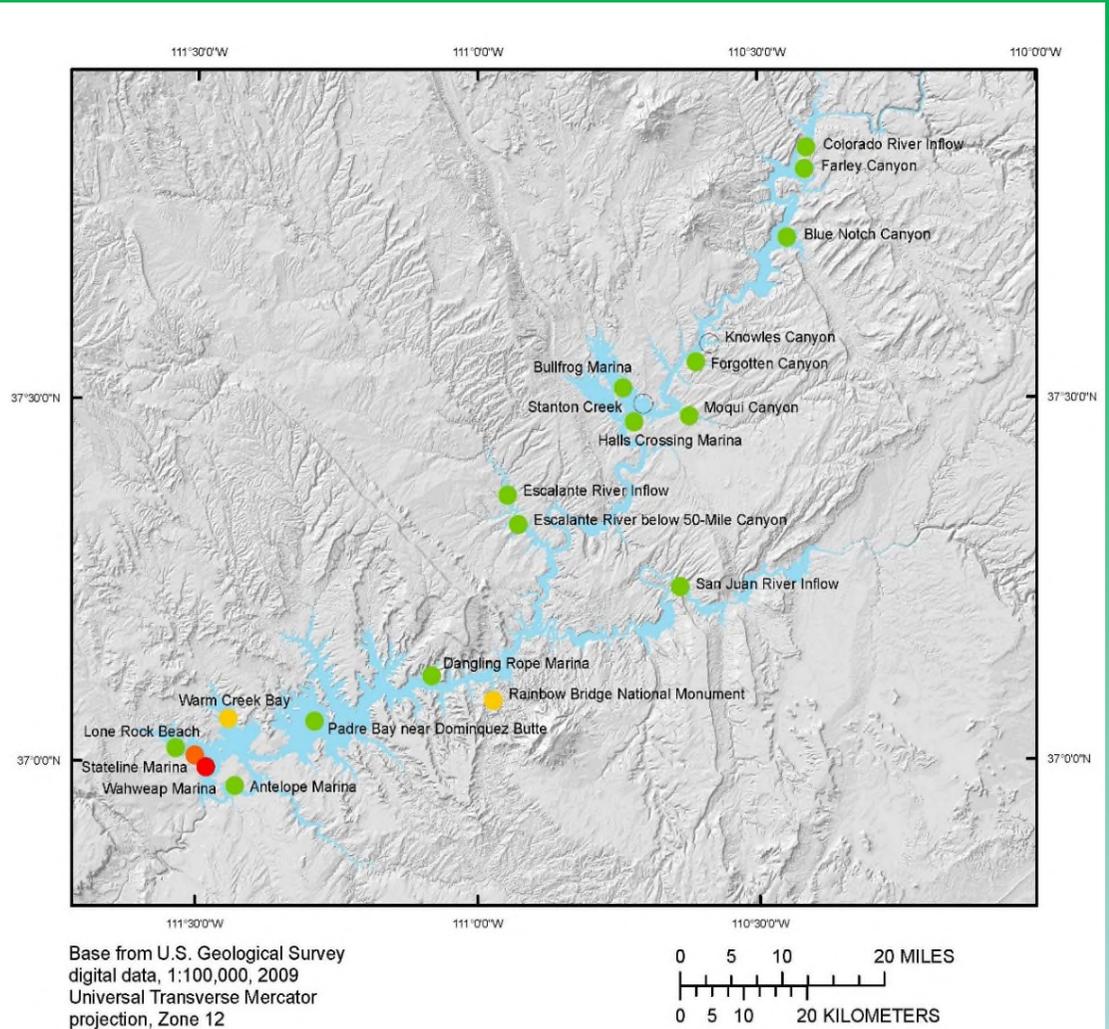
- Southern sites have the greatest concentration of PAHs
 - 4,801 to 6,000 ng/L
- Northern sites have the least concentration of PAHs
 - 0 to 1,200 ng/L
- Between 2 and 21 PAHs out of 44 analyzed were present at all sites except at Farley Canyon



EXPLANATION

Sum of PAH concentrations found in SPMDs (ng/L)

- No sample collected
- 0 - 1,200
- 1,201 - 2,400
- 2,401 - 3,600
- 3,601 - 4,800
- 4,801 - 6,000



Observations of PAHs in Lakebed Material

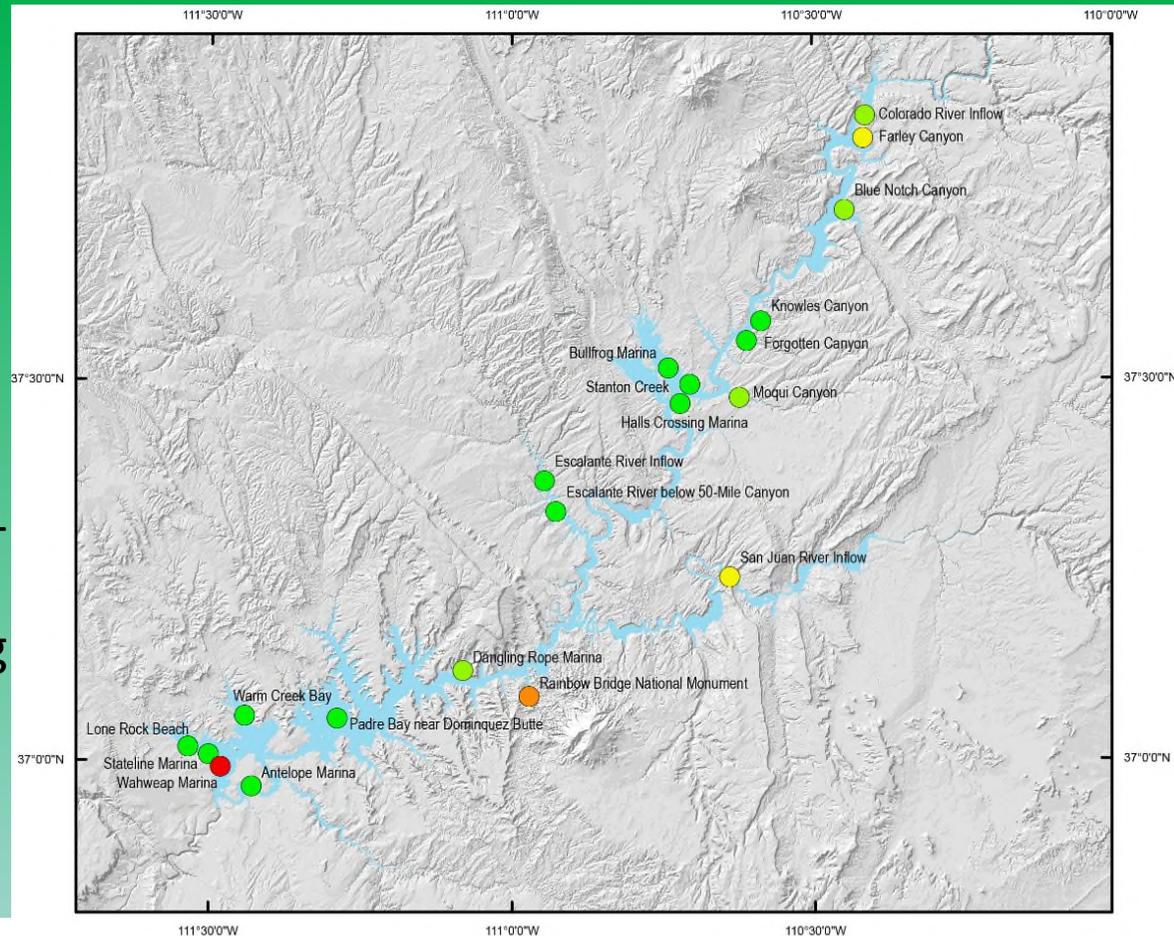
- Wahweap Marina has the highest concentrations of PAHs
- Rainbow Bridge, San Juan River, and Farley Canyon have concentrations from 59 to 591 ug/kg
- Detected at all sites except at Halls Crossing and Forgotten Canyon
- 24 of 44 PAHs analyzed were detected
 - *Perylene* most prevalent



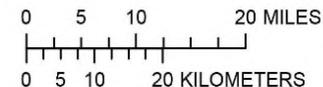
EXPLANATION

Sum of PAHs in lakebed material (ug/kg)

- 0–14
- 15–58
- 59–115
- 116–591
- 592–3,477



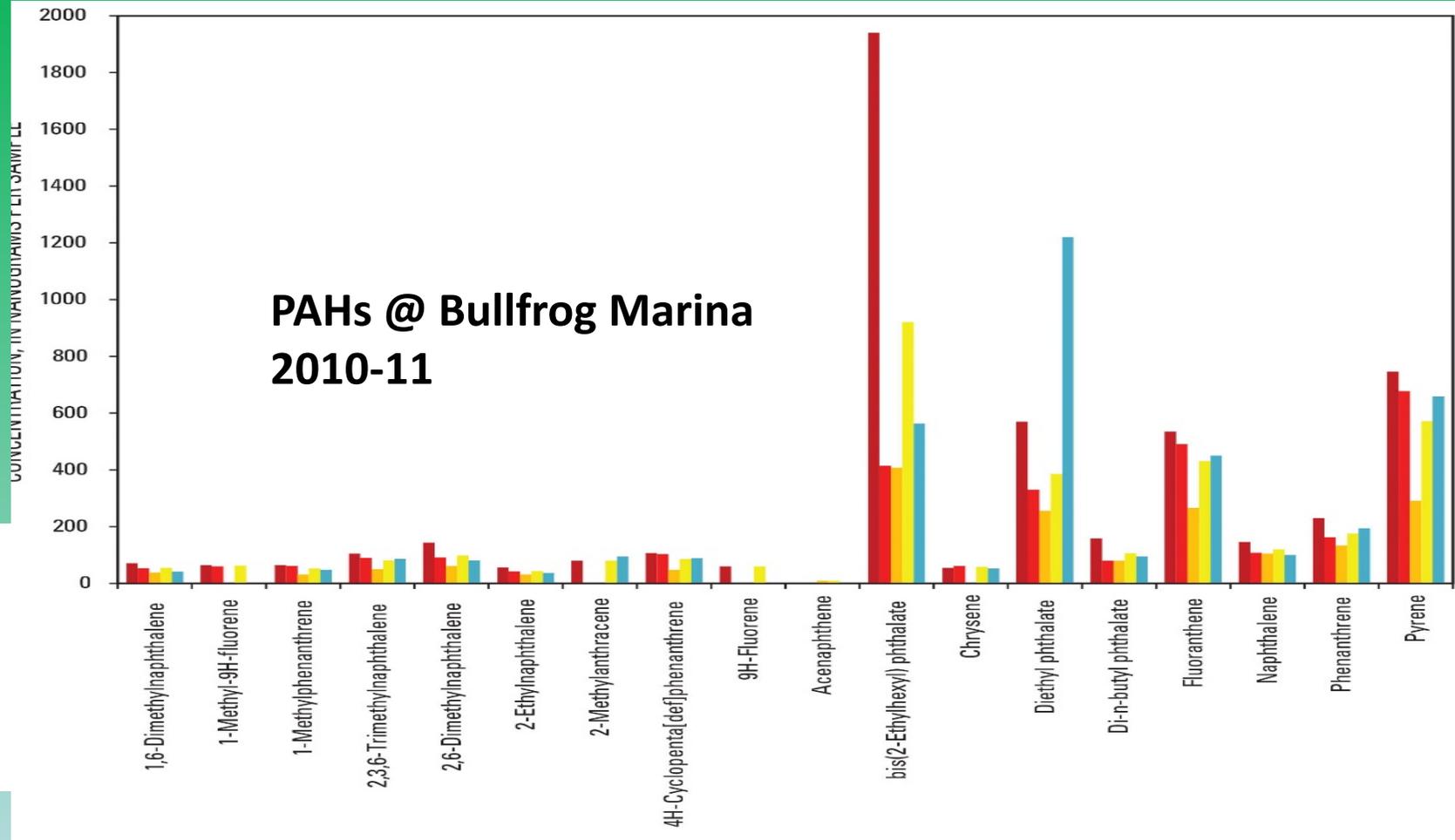
Base from U.S. Geological Survey
digital data, 1:100,000, 2009
Universal Transverse Mercator
projection, Zone 12



Vertical variability of PAHs related to stratification

- Depth samples in each stratified layer
- 3 replicates at each depth
- Replicates composited
- Related to each depth, the composites, and the combined average environmental sample

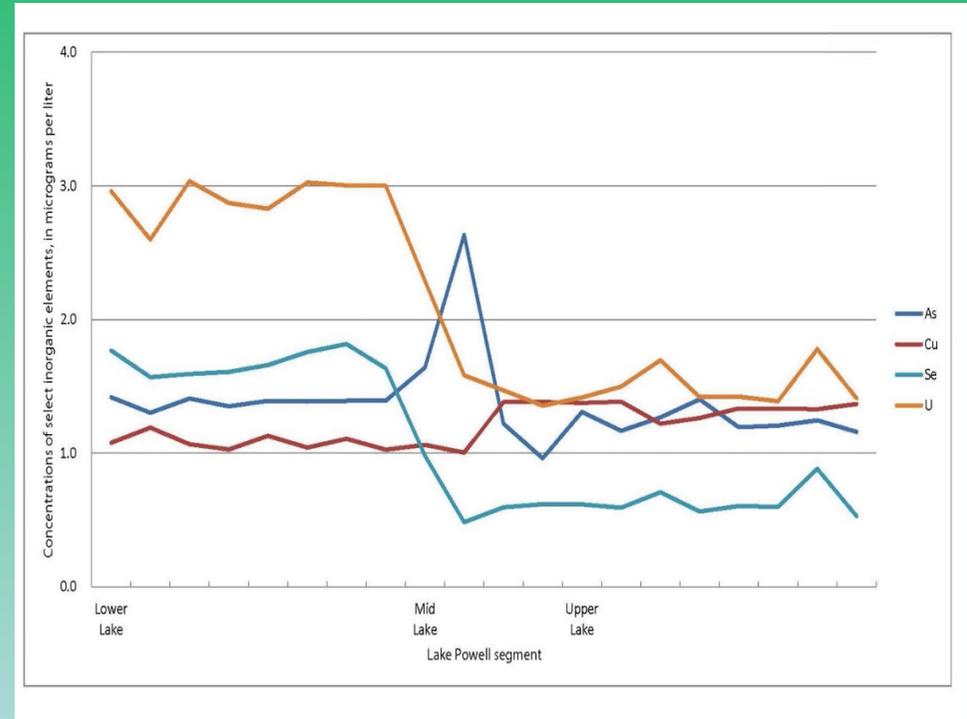
Vertical stratification is apparent



Longitudinal Observations

Dissolved inorganic elements

- Upper lake-more river like up lake from Halls Crossing (~40 miles), concentrations were similar for most elements
- Mid lake-transition area, between Halls Crossing and the mouth of the Escalante River (~32 miles), concentrations varied for most elements
- Lower lake-more lake like (~68 miles) from the Escalante River to the dam concentrations were similar for most elements

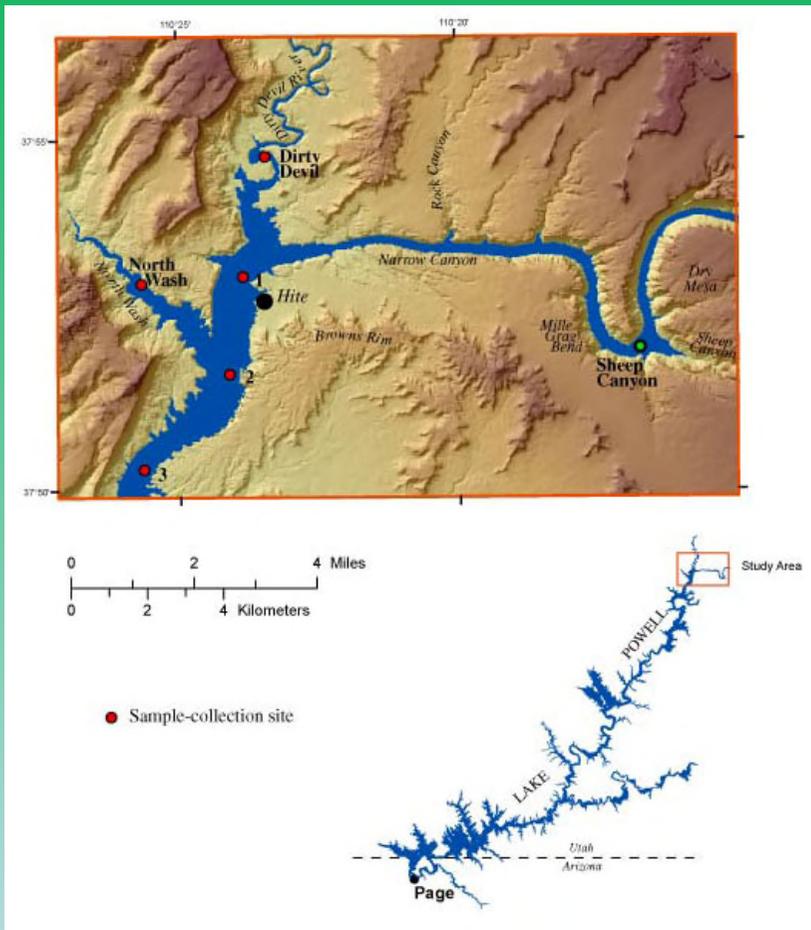


Future Monitoring

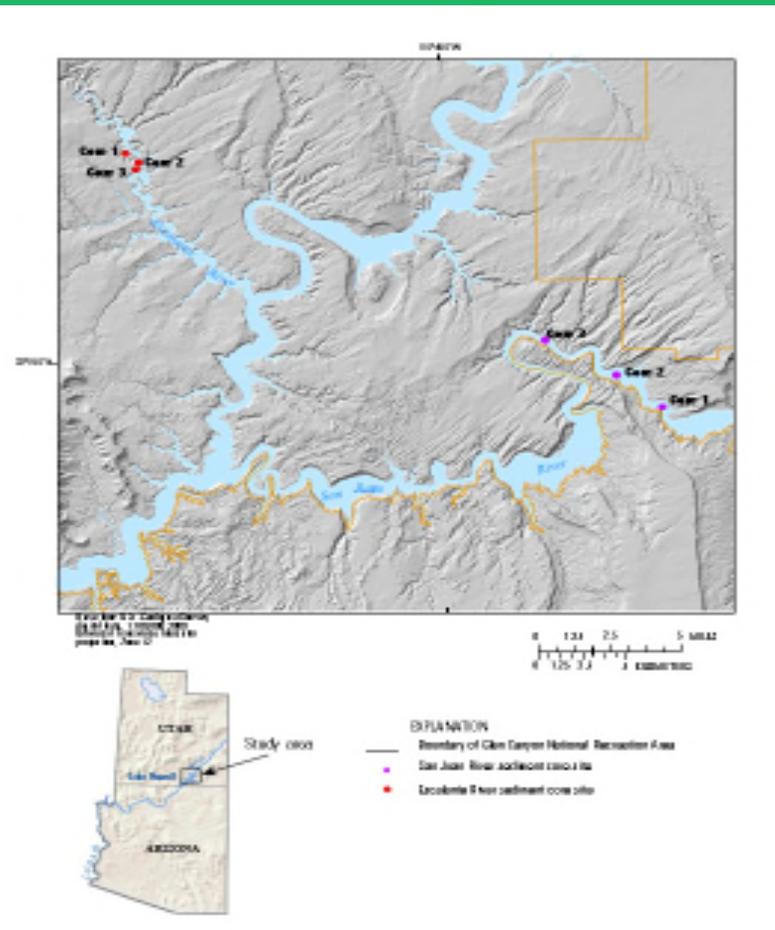
- As part of the Record of Decision, GLCA is required to sample and monitor for PAH concentrations in Lake Powell
 - Previous work has identified areas of greatest concern
 - Future monitoring will focus on those areas
 - Other sites will be periodically sampled
- 2016 - Testing and evaluation of new passive samplers for hydrocarbons
- Reporting on observations, trends, and changes in distribution and concentration of select organic and inorganic contaminants



Repeat sediment coring may occur in the San Juan River Delta



Colorado River Delta
2001



Escalante River and San Juan River Deltas
2010 and 2011



Technology used for monitoring

SPMDs – Semi-permeable membrane devices



Core samplers for sediment-water interface

CLAMS – Continuous low-level aquatic monitoring sampler



SBE25 – CTD profiler



Gravity Piston Coring



Ponar dredge



VOC sampler



USGS Lake Powell Report Products Related to Contaminants

- ❖ Physical and Chemical Characteristics of Knowles, Forgotten, and Moqui Canyons, and Effects of Recreational Use on Water Quality, Lake Powell, Arizona and Utah
<http://pubs.usgs.gov/sir/2004/5120/>
- ❖ Establishment of Sentinel Sampling Sites to Monitor Changes in Water and Sediment Quality and Biota Related to Visitor Use at Lake Powell, Arizona and Utah, 2004–2006;
<http://pubs.usgs.gov/of/2012/1237/>
- ❖ The Presence and Distribution of Polycyclic Aromatic Hydrocarbons and Inorganic Elements in Water and Lakebed Materials and the Potential for Bioconcentration in Biota at Established Sampling Sites on Lake Powell, Utah and Arizona;
<http://pubs.usgs.gov/of/2013/1299/>
- ❖ Sediment Chemistry of the Colorado River Delta of Lake Powell, Utah, 2001; <http://pubs.usgs.gov/of/2005/1178/>
- ❖ Sediment and Water Chemistry of the San Juan River and Escalante River Deltas of Lake Powell, Utah, 2010–2011;
<http://pubs.usgs.gov/of/2014/1096/>



Acknowledgements

- NPS personnel - Barry Long (*deceased*) and GLCA staff including Mark Anderson and their Silver Bullet
- USGS NRP - Howard Taylor (retired) and Ron Antweiler and other NRP staff
- USGS AZWSC - Greg Fisk (retired), Kurt Schonauer, Nancy Hornewer, and Corey Sannes
- Volunteers - Kendra Hart and Austin Smith
- AND the USGS Water Quality Assessment and Monitoring Program