Ted Melis

Physical Sciences Program Manager, USGS

And

Randall Peterson

Program Manager, USBR

Adaptive Management of the Colorado River Ecosystem Below Glen Canyon Dam:

An Overview of Science & Stakeholder Based River Management in the Colorado River Basin

Presented at

The Aspen Global Change Institute

June 5 - 10, 2003 Summer Science Session I

"Learning from Regions: A Comparative Appraisal of Climate, Water, and Human Interactions in the Colorado and Columbia River Systems"

Glen Canyon Dam
Adaptive Management Program

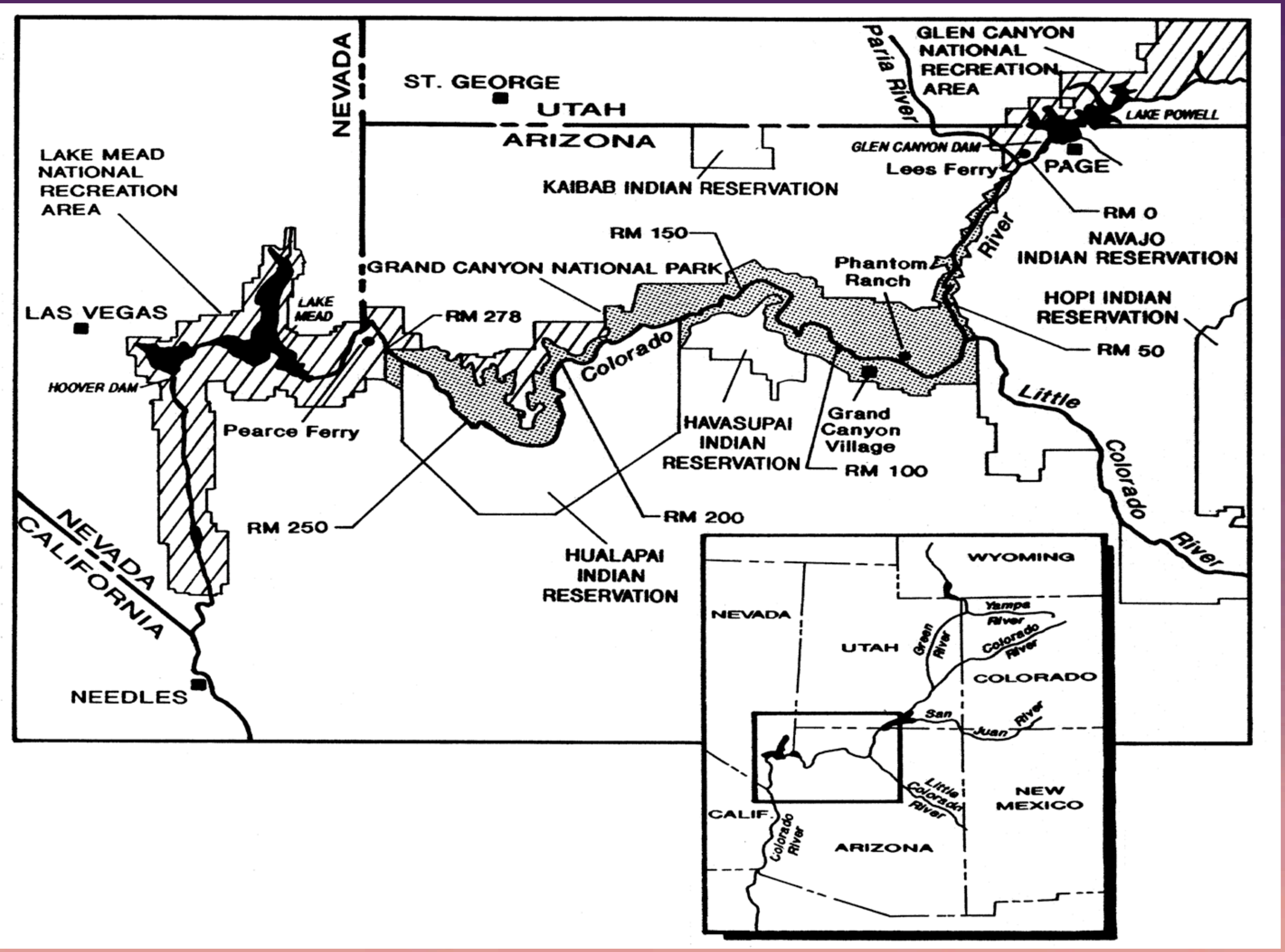
Adaptive Management of the Colorado River Ecosystem Below Glen Canyon Dam:

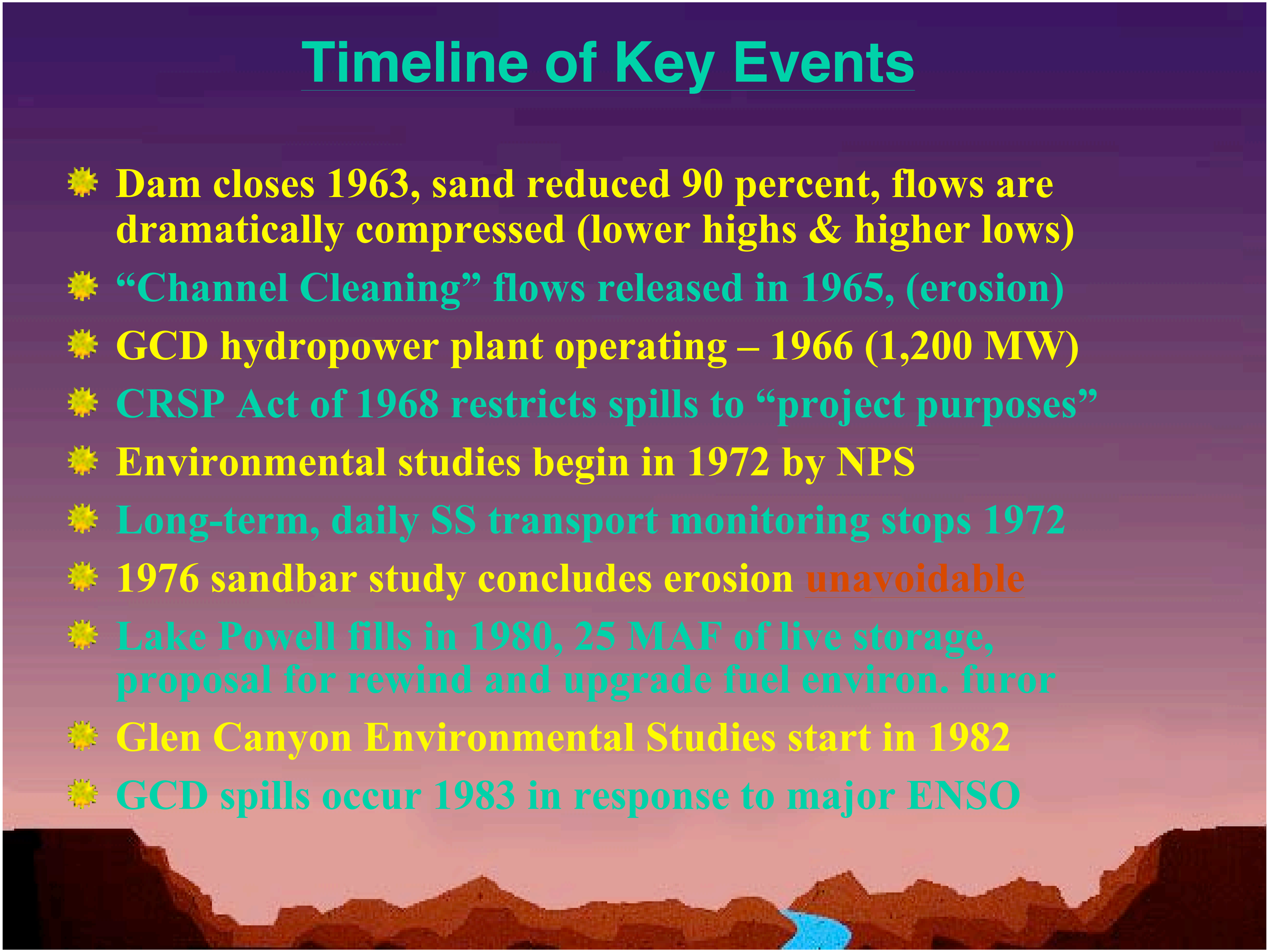
An Overview of Science & Stakeholder Based River Management in the Colorado River Basin

Ted Melis,
Physical Science Program Manager, USGS

Randall Peterson,
Program Manager, USBR

The Colorado River Ecosystem




Timeline of Key Events
Dam closes 1963, sand reduced 90 percent, flows are dramatically compressed (lower highs & higher lows)
“Channel Cleaning” flows released in 1965, (erosion)
GCD hydropower plant operating – 1966 (1,200 MW)
CRSP Act of 1968 restricts spills to “project purposes”
Environmental studies begin in 1972 by NPS
Long-term, daily SS transport monitoring stops 1972
1976 sandbar study concludes erosion unavoidable
Lake Powell fills in 1980, 25 MAF of live storage, proposal for rewind and upgrade fuel environ. furor
Glen Canyon Environmental Studies start in 1982
GCD spills occur 1983 in response to major ENSO

Timeline of Key Events (con't)

- Studies aimed at diurnal fluctuations are confounded
- GCES Phase I documents downstream impacts - 1987
- DOI Secretary orders GCD operations EIS - 1989
- Grand Canyon Protection Act passed - 1992
- EIS evaluation of 9 flow alternatives completed – 1995
- GCMRC established in Flagstaff, AZ - 1995
- First "controlled flood" experiment released - 1996
- DOI Secretary signs ROD – 1996 (MLFF)
- Adaptive management working group est. – 1997
- Hydrologic triggering criteria for BHBF's – 1997
- BOR implements alternative releases Jan. – Mar. of 1998 that avoid a major spill forced by ENSO in July

Timeline of Key Events (con't)

- CR-Ecosystem Model Constructed, EA begins 1998
- Surplus Criteria ROD signed by Secretary – 2000
- Assumptions on effectiveness of ROD upended – 2001
- AMP recommends new experiments to DOI – 2002
- GCMRC recommends 16-yr blocked experiment
- Integrated experiment for both sand and fishes
- AMP rejects adoption of full experimental design
- Alternative 2-year design recommended to DOI
- Experimental design approved by DOI – Dec. 2002
- 2-year experiment implemented (2002-Present)
- No sediment trigger year-1, fish removed & exp. flows

GCD EIS Conclusions

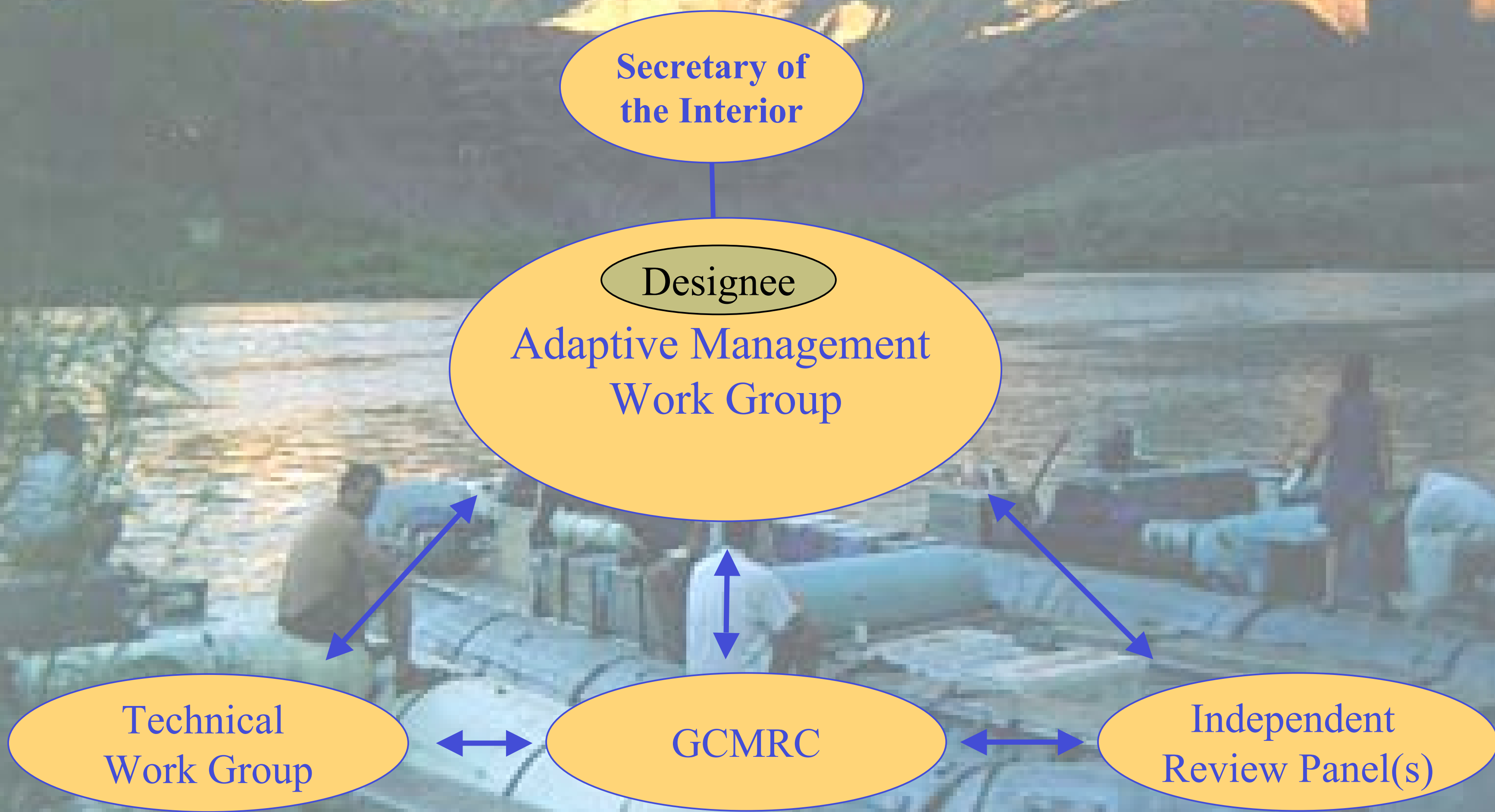
- Sand conservation is a key objective
- Constrained power plant releases will force multi-year accumulation of downstream sand inputs
- Periodic release of controlled floods will move accumulated sand to higher shoreline deposits

- Native fish recruitment depends upon critical habitats related to sand-bar morphology (backwaters)
- Mortality of juvenile chub is linked to altered thermal regime (colder)
- Backwaters provide key refuge for early growth

Ex Post Facto of EIS Studies

- Sand studies focused almost exclusively on post-dam era transport data that were highly biased by 1965-1986 high-flows
- Main channel sand-transport data discontinuous after 1972
- Intensive studies during anomalous period of consecutive ENSO events (1990-1995), lead to some biased conclusions
- Period of unusual climate forcing is not fully recognized as element of EIS until after compliance is completed
- Inflexibility in policy alternatives is magnified by dramatic natural variability of tributary sand inputs

Structure of the GCDAMP



Grand Canyon Monitoring and Research Center

GCMRC Mission

To provide credible, objective scientific information to the Adaptive Management Program on the effects of operating Glen Canyon Dam on the downstream resources of the Colorado River ecosystem, utilizing an ecosystem science approach

Independent Review

The Role of the Science Advisors

Eleven scientists with expertise in different areas. They are convened 2-4 times per year to review and comment on annual work plans, experimental designs, specific proposed management actions, etc.

Who are the Stakeholders?

26 Federal Advisory Committee Members

- *Federal Agencies (BOR, NPS, USFWS, WAPA, BIA)*
- *State Agencies (AZGF, UCC)*
- *Tribes (Hopi, Zuni, Navajo, Hualapai, Paiute consortium)*
- *NGO's (GCRG, GCT, TU, SWR, CREDA, UAMP)*
- *Basin States (AZ, NV, CA, UT, NM, WY, CO)*

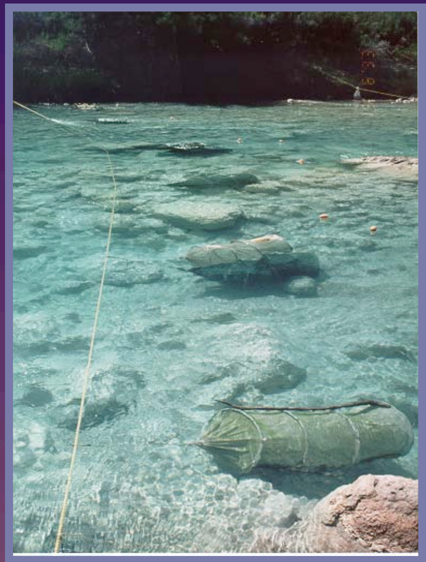
Adaptive Management within the GCDAMP

- New Paradigm - process of "governing with people"
- Uncertainty – is recognized in all agency decisions
- Recommendations – are made directly to the Secretary
- Vision – target measurable & achievable objectives
- Scope - values placed in legal & policy boundaries

Expected Benefits of ROD Operations

- **Improve aquatic food base system-wide**
- **Protect endangered species**
- **Conserve sand and improve beaches**
- **Modest improvement in sport fisheries**

- **Protection of tribal cultural resources**
- **Recreation – increased safety and improved experience**
- **Improved riparian vegetation**
- **Acceptable cost to power customers**

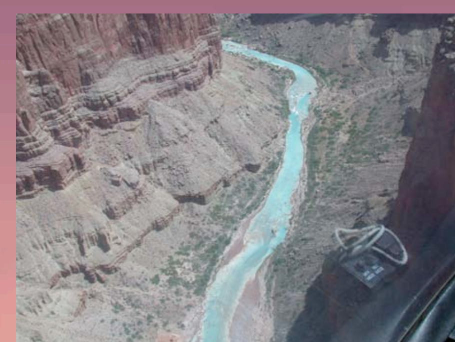


Current Resource Status

- Increased aquatic productivity in the Lees Ferry reach
- Increased numbers of exotic fishes (rainbow trout)
- Decreased populations of humpback chub
- Decreased abundance of channel-margin sand bars
- Water compact requirements continue to be met
- Reduced flexibility has increased power costs

Outline: Case Study on Sand Resources

- Vivid Historical Perspective from the Pre-Dam Era
- Current Monitoring & Research Data from Post-Dam
- Conclusions from Historical Syntheses (pre- vs. post)
- Post-EIS Recommendations from Sediment Experts
- Variability in Delivery of “Renewable” Sand Inputs
- Experimental Design for Testing Sand Hypotheses



THE CAMPING BEACH DOWNSTREAM FROM TAPEATS CREEK

1952 (Kent Frost). Everyone would want to camp here now.

1995. The beach reappeared briefly after the 1996 flood.

Grand Canyon Monitoring and Research Center

Preliminary Estimates of Reach Sand Export 01/01/02 through 07/01/02

MASS-BALANCE "Efflux"

Lees Ferry to Phantom Ranch: rm 0-87

-160,000 ($\pm$ 20,000) metric tons lost downstream (~93,000 m^3)

Phantom Ranch to Diamond Creek: rm 87-226

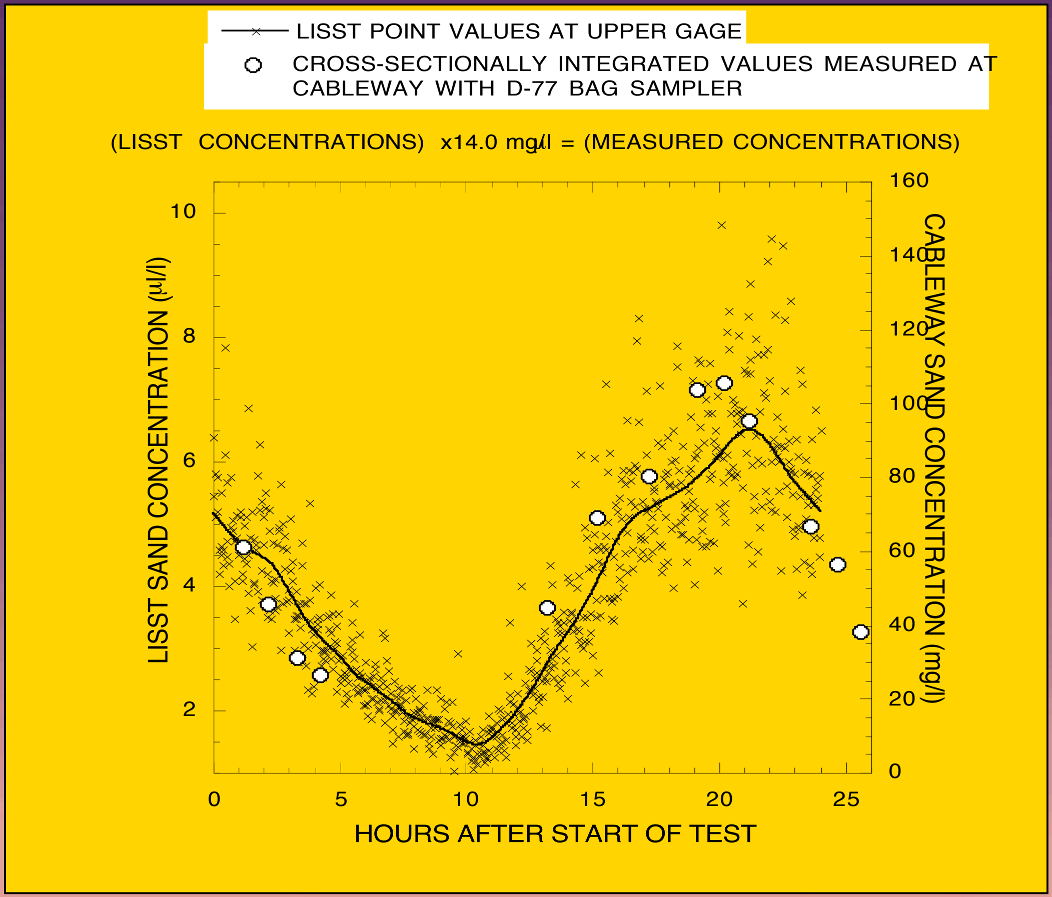
-99,000 ($\pm$ 11,000) metric tons lost downstream (~57,000 m^3)

Perhaps More and Better Data Will Lead to a Solution?

(Maybe, But Policy Constraints Still Rule Outcomes)

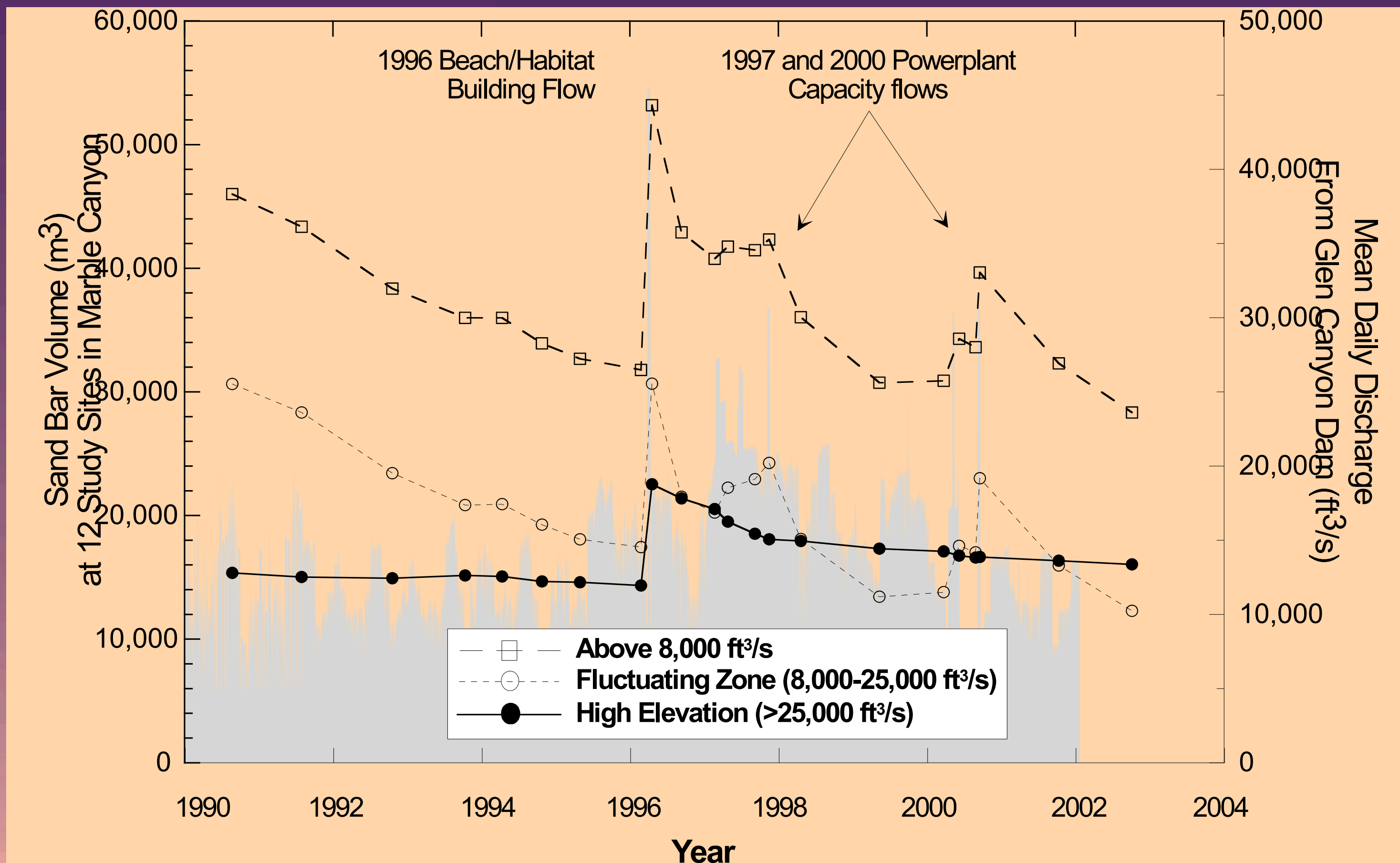
"LISST Technology"

RESULTS FOR MONITORING SAND CONCENTRATION



Cumulative Sand Bar Volume in Marble Canyon
Jun. 1990 – Sep. 2002

(Data from Northern Arizona University, Geology Dept.)



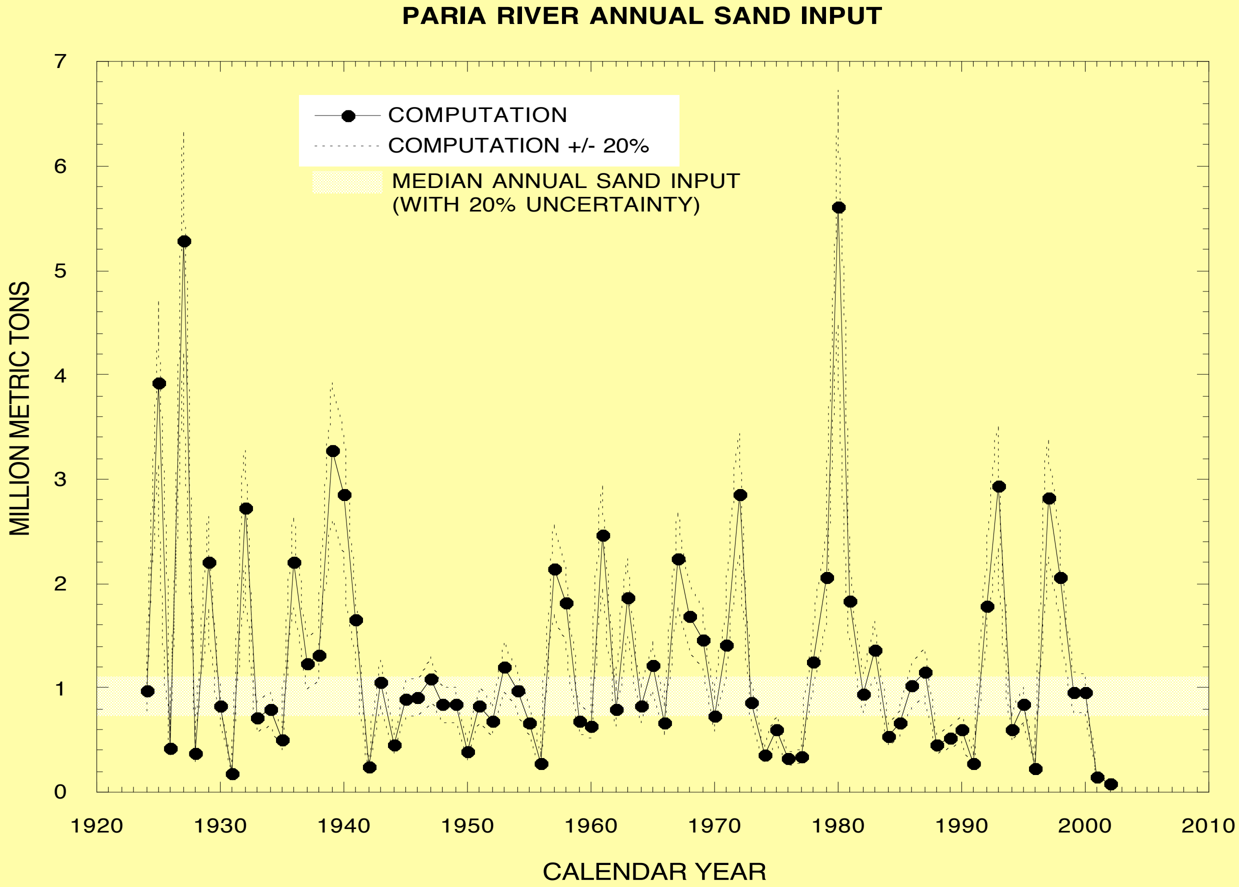
SUMMARY OF SAND BAR DATA (1963-2002)

Sand Supply – about 90 percent of the pre-dam sand supply is now trapped in Lake Powell

Cause & Effect – downstream supply of sand is fine-grained + flood frequency is compressed (loss of both low & high flows)

Ecosystem Response – about a 25% decrease in sand bars in the upper third of the system since 1984

Annual Paria River Sand Inputs
May 1924 – Sep. 2002



Current Recommendations of the Sediment Group

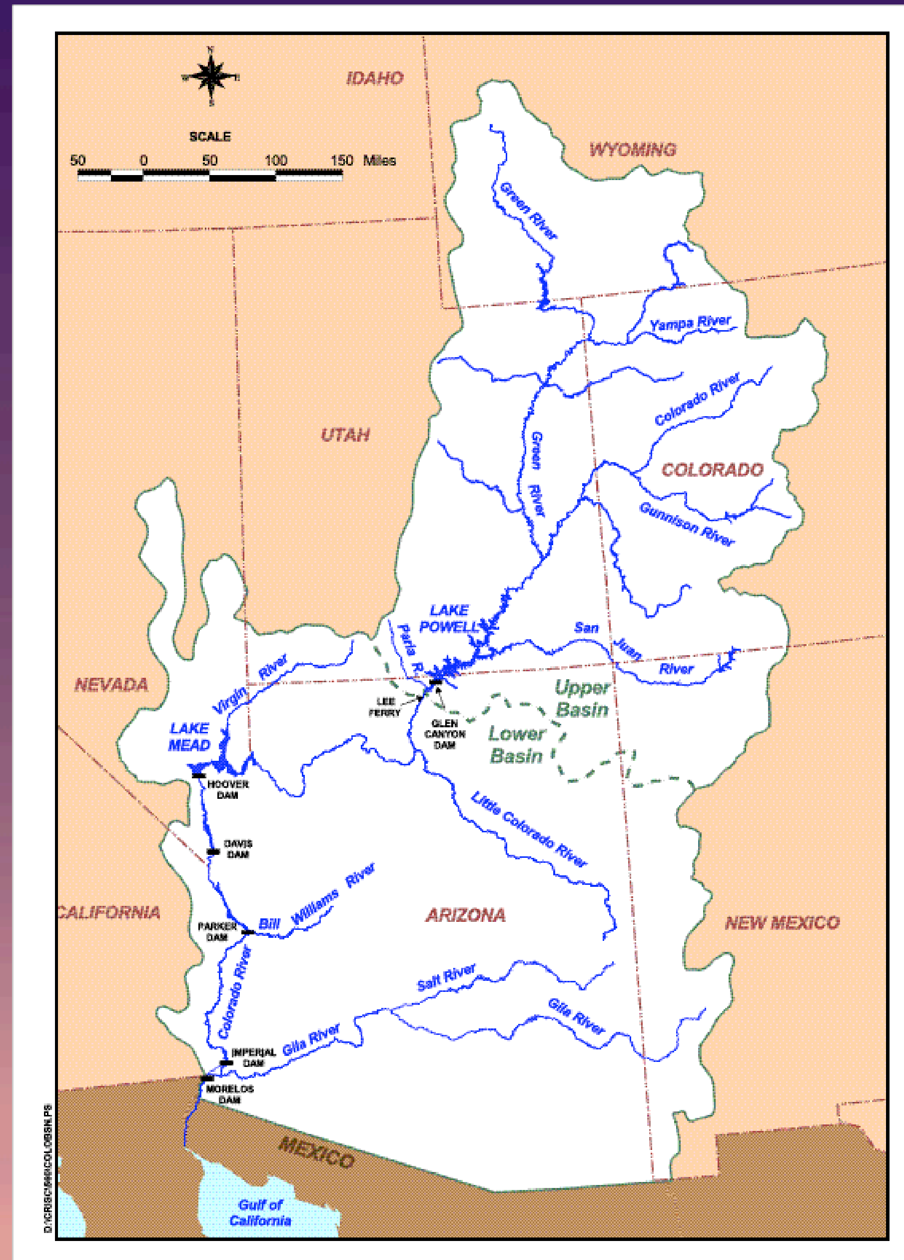
July – October BHBF's – put new sand up on banks during input season, before it gets exported to Lake Mead

Force Short-Term Sand Retention (Flows less than 9,000 cfs) following inputs, reduce flows dramatically to retain new sand until a BHBF can be released (Jan. – May)

Sediment Augmentation – following experimental testing of above alternatives, results may indicate that supplementing downstream supplies may be the only means of achieving restoration and maintenance of sand resources in a sustainable manner

Colorado River Basin

Glen Canyon Dam is located at the dividing line between the Upper and Lower Basins, serving as an exchange agreement mechanism that allows the Upper Basin to deplete water for consumptive use while making Compact deliveries to the Lower Basin.



Colorado River Storage Project Financing

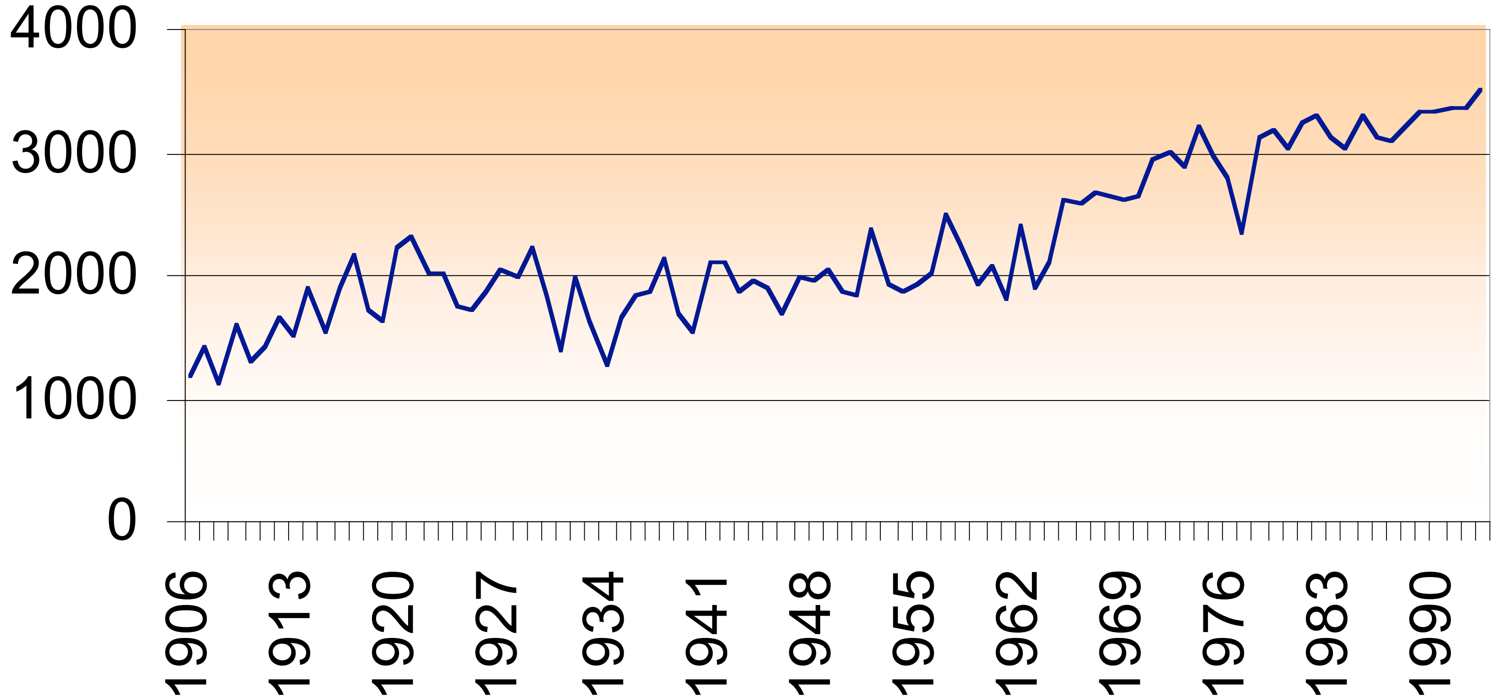
- Power revenues would not only repay dam construction costs, but also subsidize irrigation development.

- Modification of this power economics cycle is viewed as a threat to the States' economic/water development strategies.

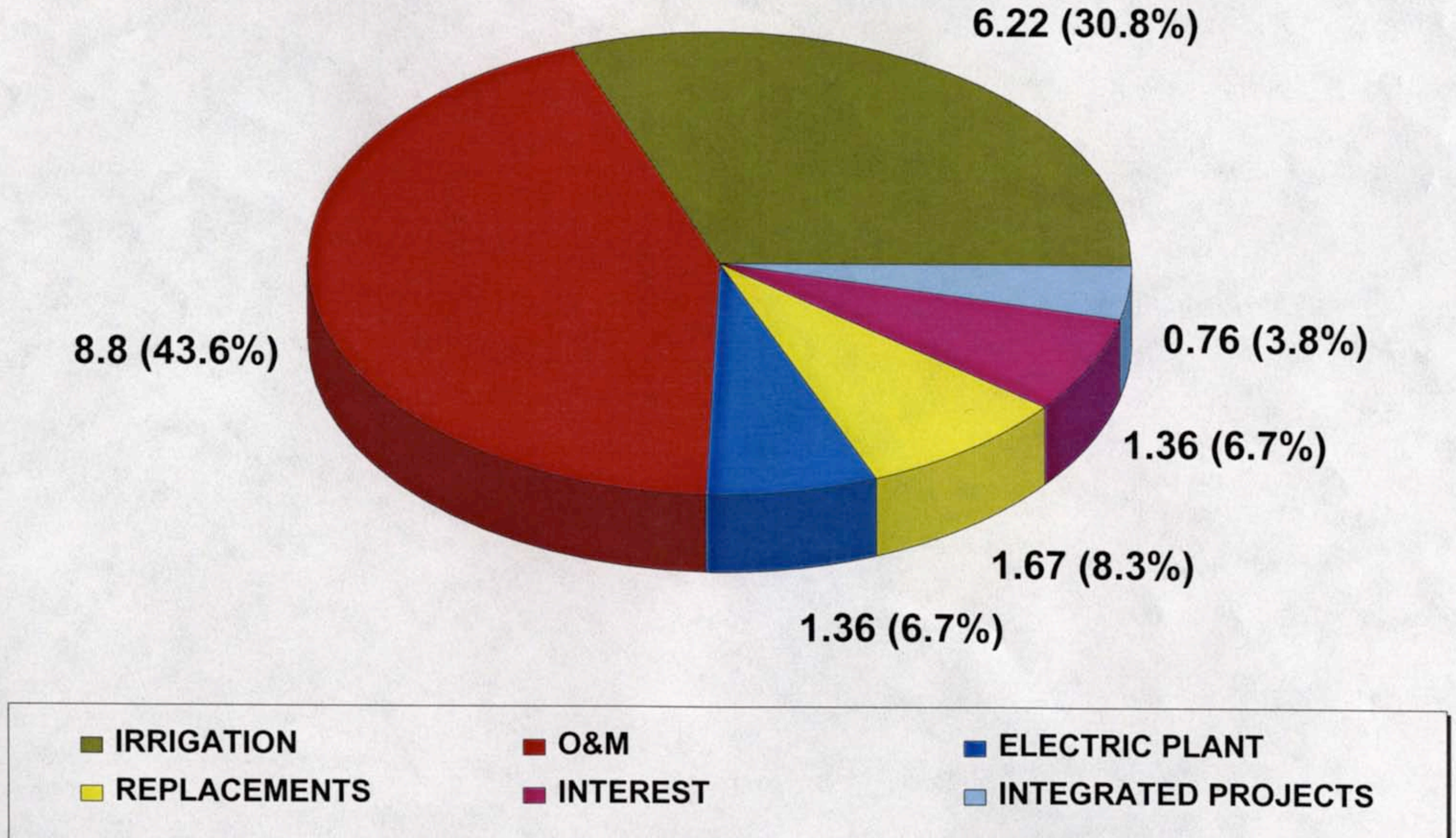
- Power revenues have repaid most of the dam construction costs, but repayment of the irrigation subsidies will continue through 2060, requiring continued power generation.

Upper Basin Depletions

(source California Water Board)



COMPOSITE POWER RATE COMPONENTS
20.17mills/Kwh(percent of total)



Lake Powell - Traditional Controls

Division between Basins of:

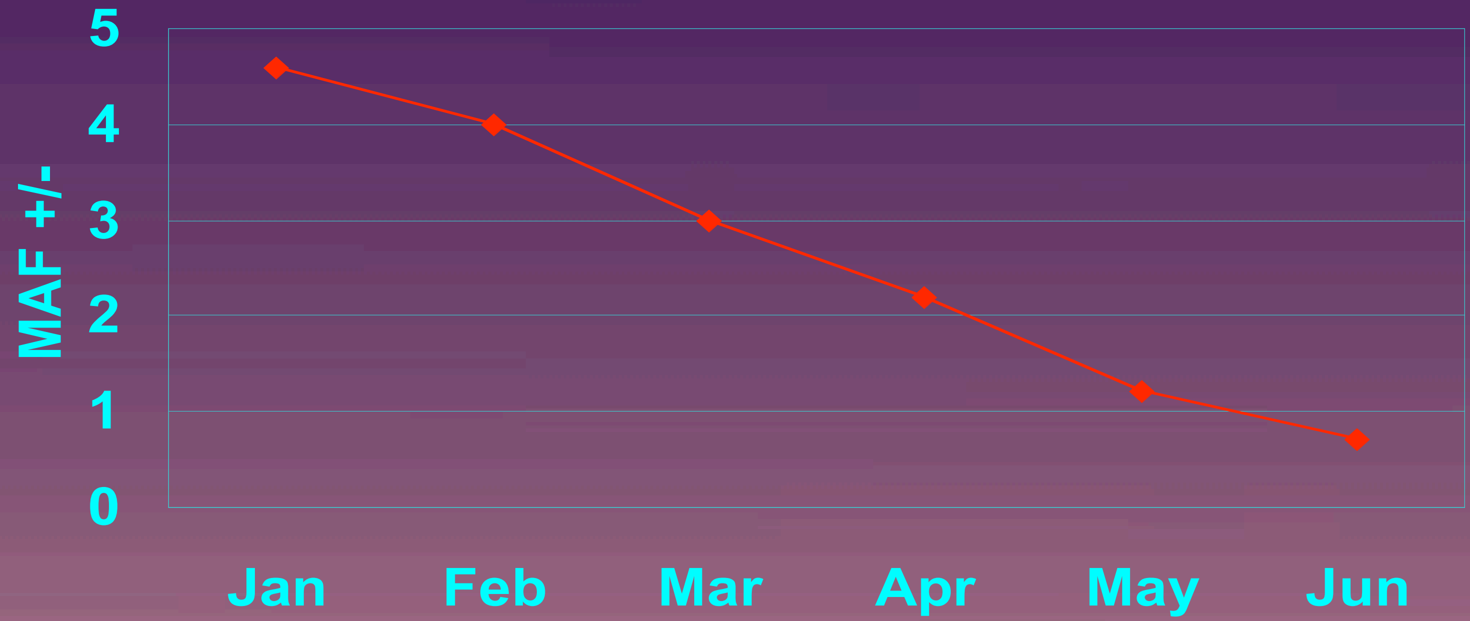
- Consumptive use yield
- Power generation benefit

Accomplished at Lake Powell through:

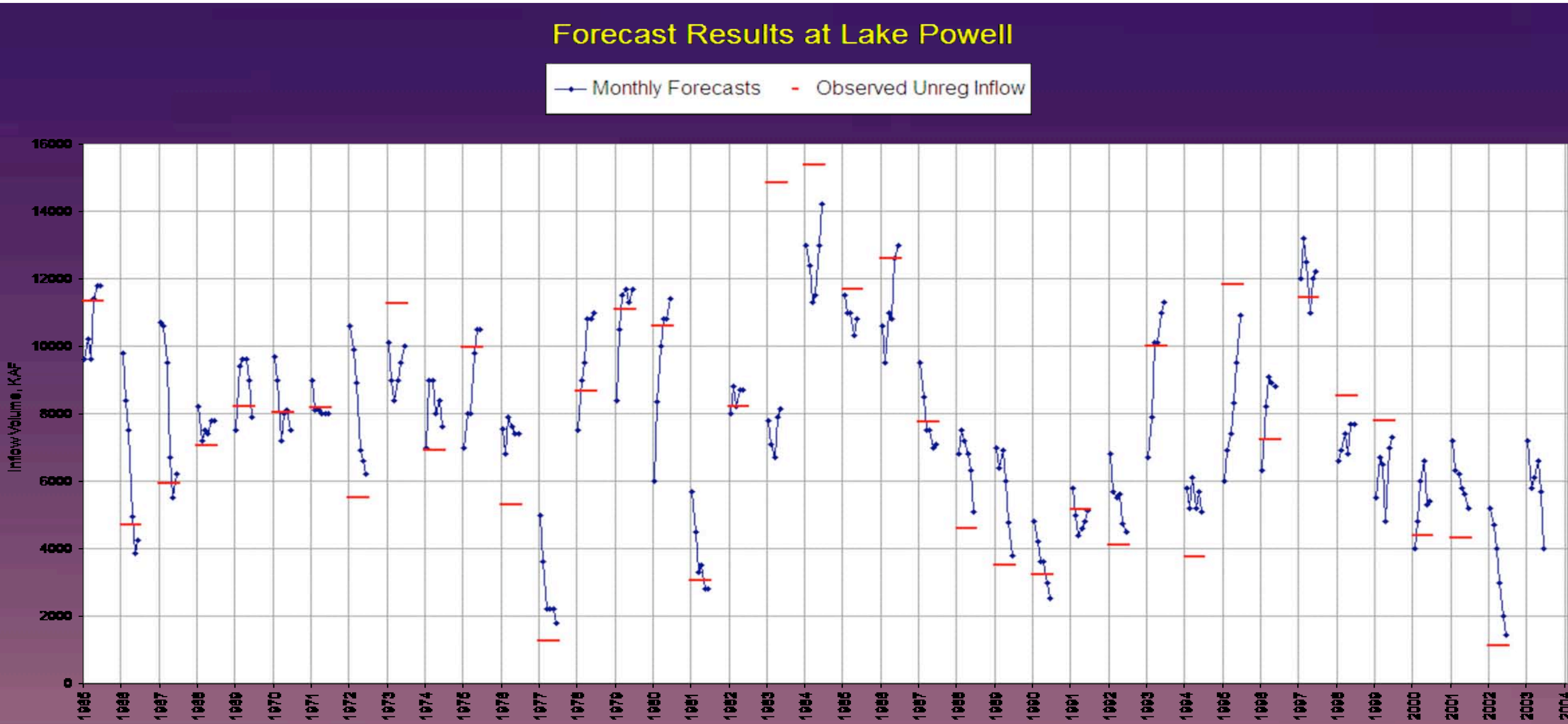
- Minimum annual release (8.23 MAF)
- Storage equalization between
  Lakes Powell and Mead
- Elimination of spills from Lake Powell
  (defined as releases in excess of
  powerplant capacity)

Lake Powell Inflow Forecast Error

5 / 95 % Confidence Intervals



Forecast error is used as a measure of risk that is considered along with runoff estimates in determining when a powerplant bypass would be allowed under the constraints of the 1968 Colorado River Basin Project Act.



ENSO signals were used in 1997-1998 by Reclamation in making higher than normal winter releases from Lake Powell, avoiding spills later in the spring. Such climate information could be used in the future in combination with Paria River sediment input data as dam releases decisions are made.

Development of Spill Triggering Criteria

Allows ecologically beneficial spills :

- During runoff forecast period of Jan – Jul
- When high likelihood that spills would occur naturally
- With minimal power loss

Results from new research information :

- Spills should be timed with sediment inputs (annually and seasonally)
- Stakeholders have agreed to some limited experimentation

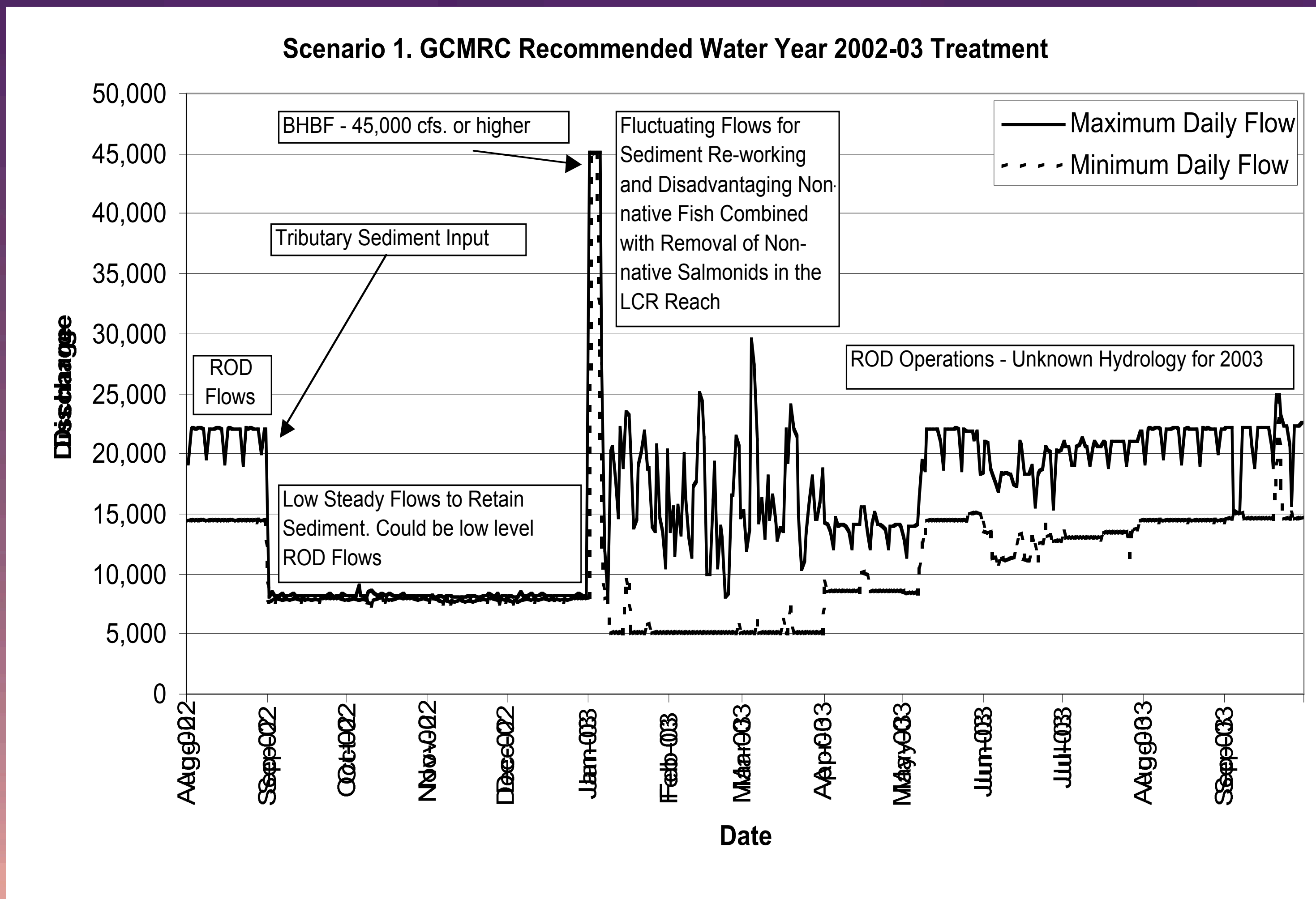
Testing a New Paradigm

Scientists - have the obligation to inform managers about what the best options are for preventing continued decline of downstream resources, on the basis of new information obtained since the EIS was completed (including climate)

Adaptive Management – is designed to allow stakeholders to embrace uncertainty, as well as new information, to formulate course-corrections for strategies aimed at achieving restoration and sustainability in Grand Canyon

Ongoing Experimentation – is the key to finding workable solutions that can be implemented over the lifespan of major projects (simply call it "learning-by-doing" if the term experiment triggers stakeholder doubts)

Treatment #1 of Proposed Experimental Flow Design



Some Take-Home Messages

Paria River Sand-Input Trigger:

We needed 1,500,000 metric tons by Dec. 2002

We received ~50,000 metric tons (or less)

Chances of Major Paria River Floods Nov.-May:

Significantly less than Jul. – Oct.

Currently, a January 2004 EHF is tied to Summer PPT!

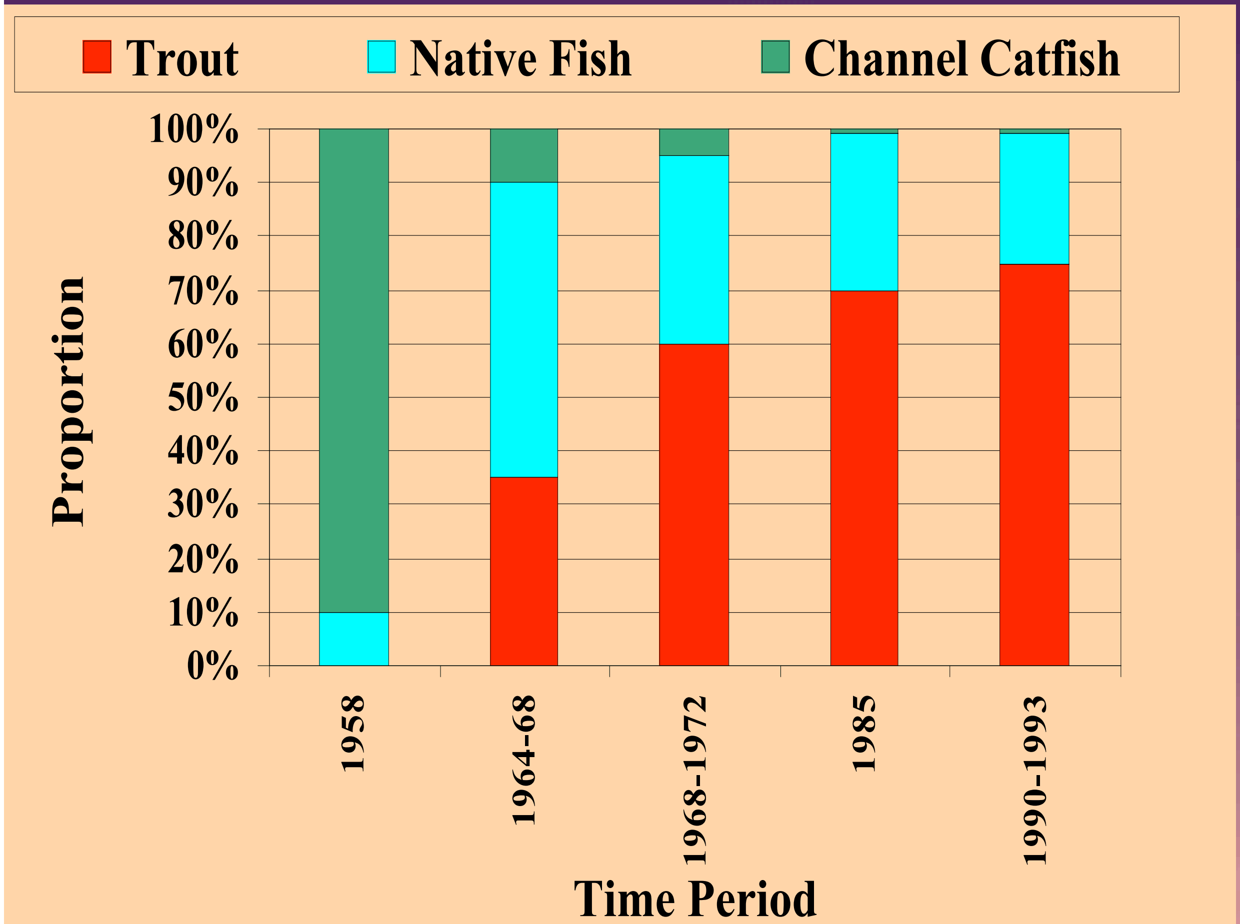
Continued Export & Erosion Very Likely under Higher Flows this Summer

What About the Fisheries?

We Were Suppose to Get Higher Recruitment of Natives with the “preferred alternative” ROD

Instead, We Got . . . .

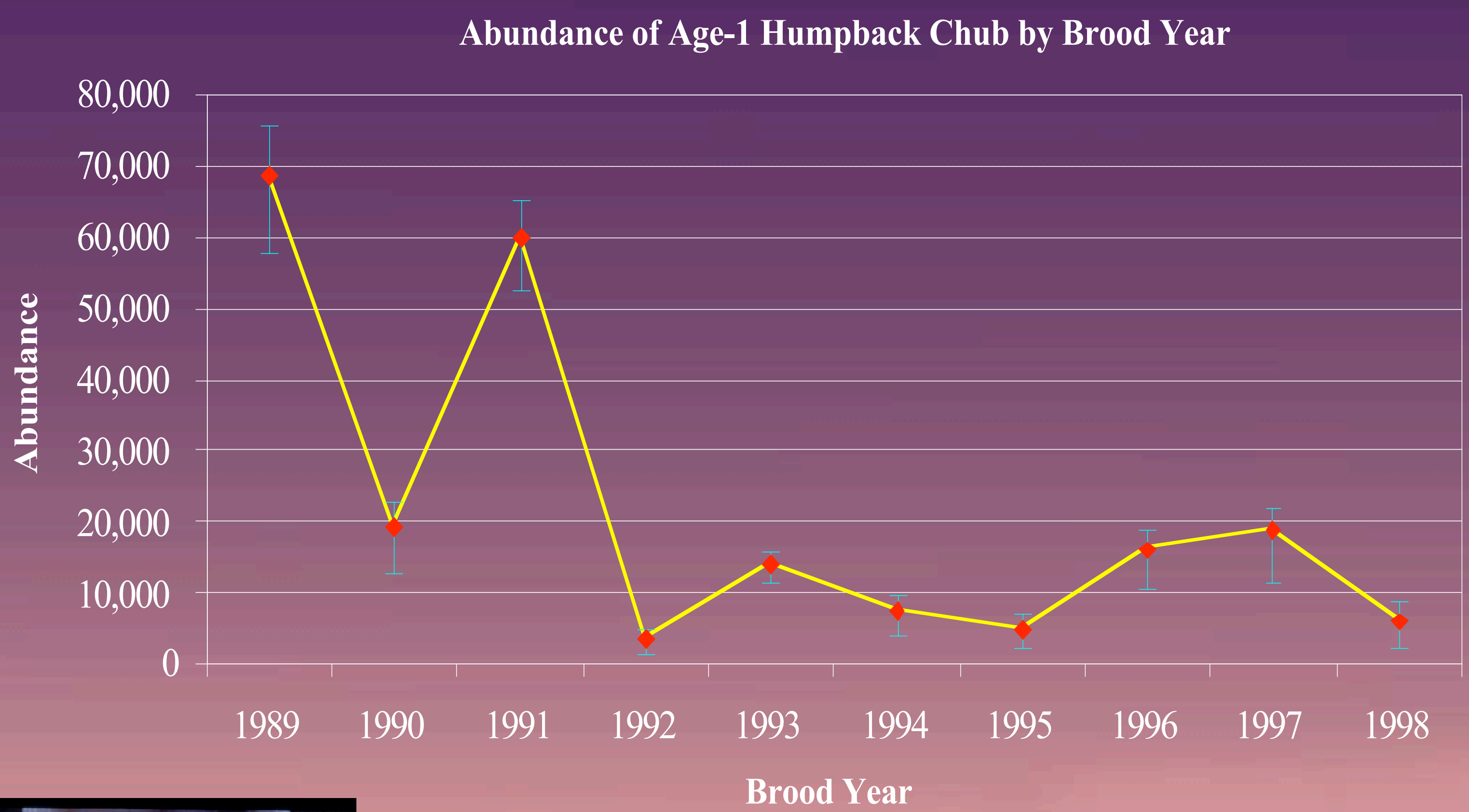
Fish Community Composition Change



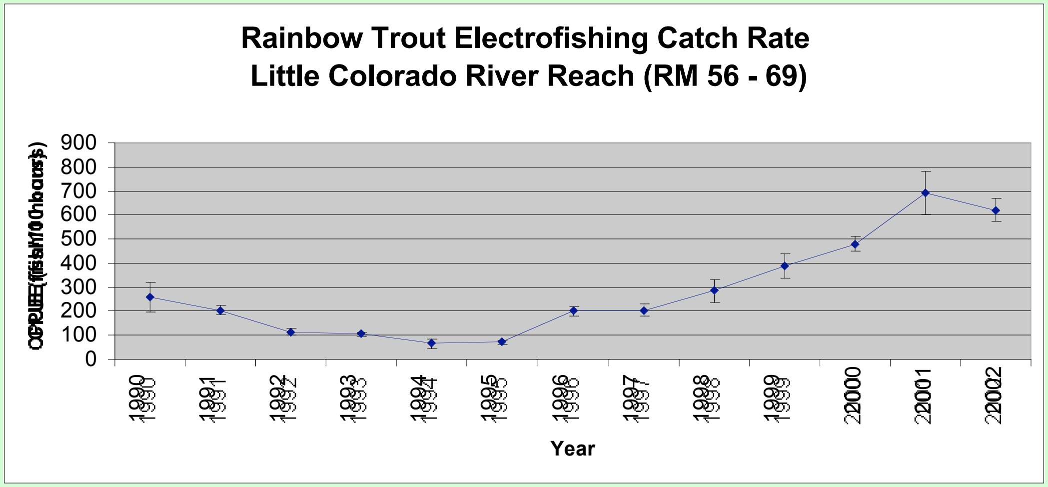
- Following dam closure in 1963, cold dam release temperatures have reduced native fish abundance and increased predatory trout. However, predatory catfish have decreased.

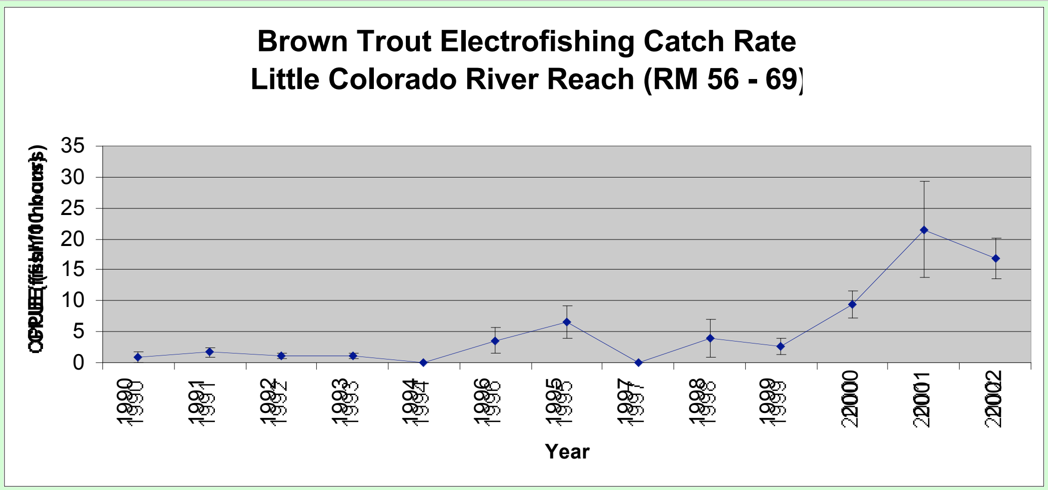
- Increasing dam release temperatures have uncertain outcomes, including mainstem recruitment of native fish but expansion of catfish.

Recent Recruitment Trends in the Little Colorado River Population of Humpback Chub



Recent Trends in Salmonid Abundance





- Stable dam releases 1991 – 2002 during trout spawning periods increased number and decreased size and condition of trout. Probable increase in predation on HBC.

- Decline in HBC population coincident with stabilizing of dam releases and trout population increase, but decline could also be tied to Asian tapeworm and death of senescent pre-dam mainstem HBC.

Restoration Actions for Protecting Humpback Chub

Pre-TCD

- non-native fish control
- translocate YOY HBC
- baseline for fish parasites and diseases
- design habitat / flow experiments
- captive population

Post-TCD

- increase non-native control - monitor
- monitor parasites / diseases
- implement flow testing program
- augment if necessary

Adaptive Management Progression since 1994 Biological Opinion

2nd Spawning Aggregation -> Meta-population
Translocation and "grow-out" of HBC
Warming of mainstem through temperature control device

Stable "natural hydrograph" -> non-native reduction, flows to target specific HBC requirements

Flow constraints only in minimum release years -> more frequent HBC benefit from comprehensive strategy actions

Defining Success in Adaptive Management

We should give broader consideration on how we define success, perhaps developing criteria that can be used by stakeholders to evaluate progress.

- Resource Protection – Legal requirements require protection of listed species.
  Numeric population estimates measure improvement.
- Experimentation – Scope and approach to experimentation are key factors.
  Active adaptive management may be occurring in subbasins even though system-wide experiments are not yet implemented.

Incremental learning may be the only possibility in large, complex systems where large economic impacts may result from experimentation.

- Stakeholder collaboration – Long-term success depends on successful collaboration. Collaboration goals and measurements may be essential to improvement of stakeholder interactions.
- Economic value – It may be possible that implementation of adaptive management would result in increased value of system operation.
  Broad economic analysis would be key.

Transferable Knowledge

Perhaps Salmonid Restoration Programs Could Take a Lesson from the GCD ROD?

Nearly Continuous "Channel-Cleaning" Flows combined with Annual Gravel Injections from Tributaries (albeit, natural) Appear to Work for Rainbow Trout

And What About That Climate Stuff Anyway?

Need for Better Predictive Skill

- Better long-range forecasts are needed to predict Lake Powell storage changes about 6-12 months in advance (upper basin hydrology and climate forcing)

- Short and long-range forecasts are needed to better anticipate Paria River sand production (days to seasons)

Need for Better Predictive Skill (con't)

- ENSO's of 1983 and 1998 provided rich opportunities for learning about teleconnections and responses in both macro- and micro-scale basins

- Learning has apparently already begun (as shown by the 1997-1998 ENSO scenario), but needs to continue for effective management of the resources

Some Recent Insights

- ENSO conditions appear to force delays in the timing of accumulated upper basin snow pack/runoff

- Shifts in lapse rate above 3,000 m were not previously predicted before 1983 ENSO – is the shift reliable based on the semi-repeat of 1998?

- Despite known teleconnections in the lower CR basin, geographical location of the headwaters may preclude correlation with runoff volume

Some Recent Insights (con't)

- Predicting delays in UB runoff are most critical in periods when Lake Powell storage is high and risk of spills is greatest

- ENP warming increases abundance, magnitude and northward migration of eastern Pacific tropical storms

- Historical flood data from Paria River (1925-2000) correlate positively with dissipating tropical storms (80 percent of bank full or greater flows)

April 1

Mountain Snow pack

Pct of average

1998

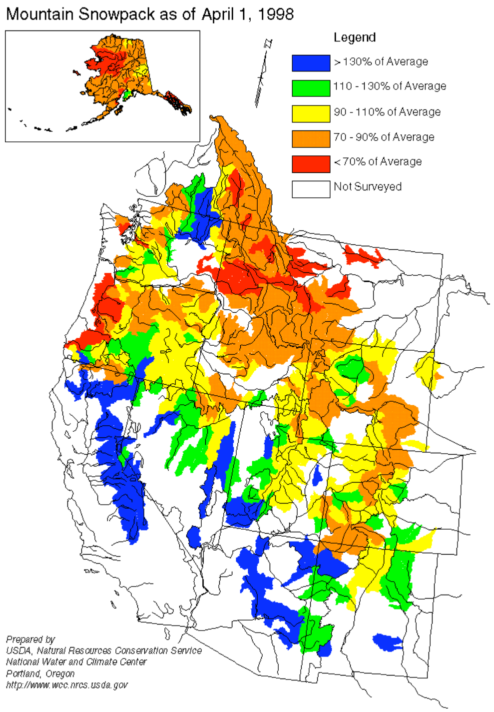
1999

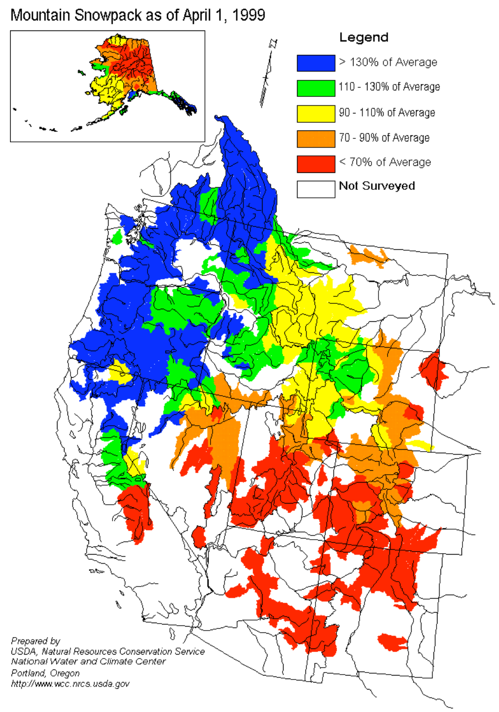
2000

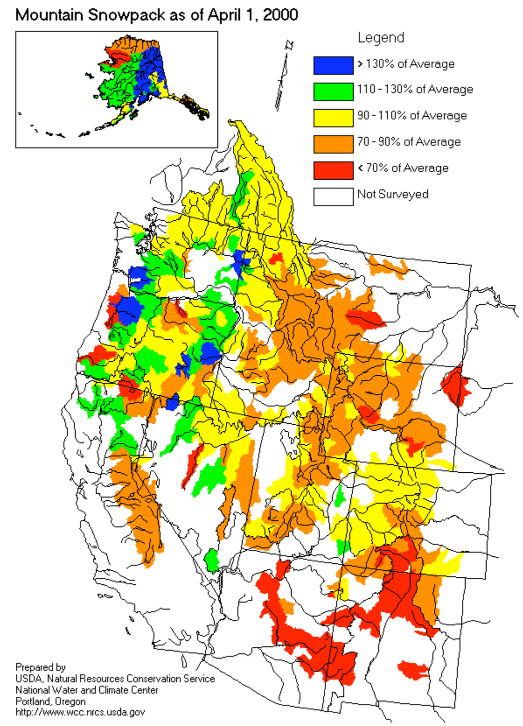
2001

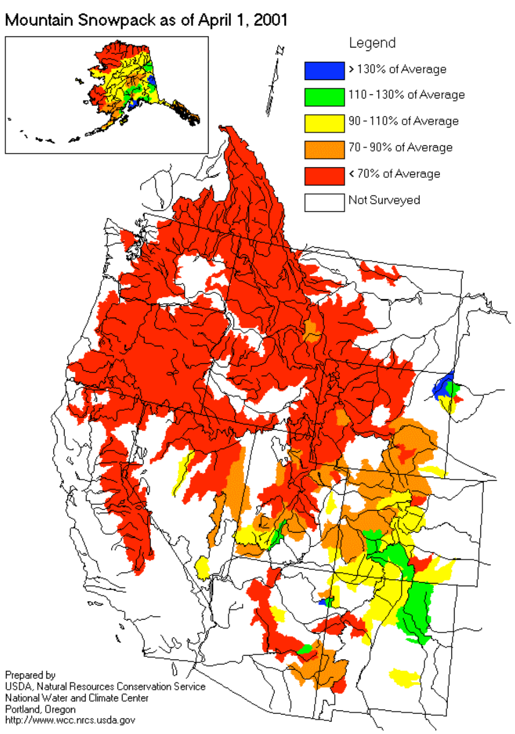
2002

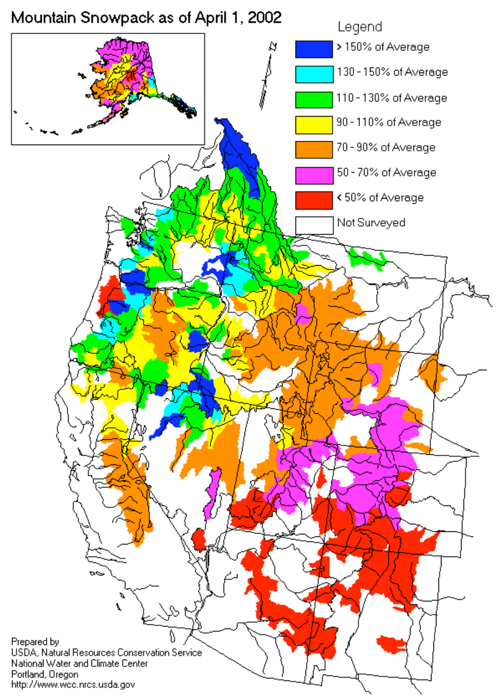
2003

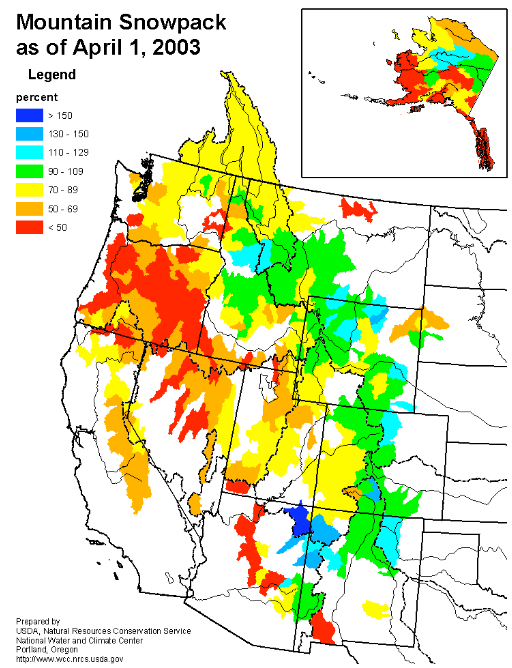












Key Elements of Adaptive Management in Grand Canyon

- For better or worse, we're all in this together. . .
- The path is often narrow, but seldom straight . . .
- Progress is made one tiny step at a time . . .
- Success is ultimately dependant upon cooperation . . .
- There are no short cuts to reaching the goal . . .
- Stakeholders need to trust their "science" wranglers!

Recipe for Fostering Needed Communication in Federal AM Programs

"The Buddy System"

"Management" Buddy

And His . . .

The "Science" Buddy

It worked when we were kids swimming at the lake . . .

The "Buddy System" is A Career Choice

- Scientists interested in supporting AM match themselves with "Adaptive Managers" for extended periods of their careers with focus on major projects

- Goal is to promote better understanding & communication about each others "cultures" w.r.t. AM needs

- Actively "cross-attend" each others meetings annually
- Communicate frequently about critical science/management
- Educate one-another about each others professional cultures
- Maintain continuity between one-another's colleagues
- "Match" activities get supported & rewarded by institutions

"It's The Communication Stupid!" C.W.

- Hearing loss is positively correlated with age . . .
- . . . But, does it really matter if we stop listening carefully as we become senior scientists & managers?

➡ "I understand your AM needs perfectly (I think?). Let me tell you about my latest research (which I am sure you will find interesting and possibly even useful in solving your risk-abhorrent, nearly-intractable, policy-failed, special-interest-infested environmental problems . . . . .)?"

How Do We Remedy Culture Clash?

Scientists are from Mars . . .

. . . Managers are from Venus

Young professionals must figure out "what color their balloon" is, then focus on learning about complimentary colors . . .

THANK YOU FOR YOUR ATTENTION