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Lessons from 10 years of adaptive management in Grand Canyon

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Objective

- Summarize findings of SCORE report
- Evaluate accuracy of predictions in 1995 EIS with current research and monitoring data
- Identify critical issues for future research

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Environmental impact statement (1995)

- Table II-7
- 30 resource predictions* under Modified Low Fluctuating Flows (preferred alternative)
- In this presentation:

  “+” = prediction correct or exceeded expectations

  “-” = prediction incorrect or desired outcome not achieved
- “+/-”= prediction with mixed outcome
- “?” = unknown, data and/or analyses not available

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** Using best data available*

Resource: fine sediment (riverbed and sandbars)

- **PREDICTION:** Modest improvement by constraining daily power plant operations and periodic implementation of Beach/Habitat-Building Flows following accumulation of new tributary sand supplies
- **OUTCOME:** -
- **COMMENT:** Sandbars continue to erode under sediment deficit

Resource: coarse sediment*

- **PREDICTION:** Continued accumulation
- **OUTCOME:** +
- **COMMENT:** Continued “coarsening” of system partially mitigated by high flow releases

* *Not in EIS*

Resource: aquatic food web

- **PREDICTION:** “Potential major increase”
- **OUTCOME: +/-**
- **COMMENT:** Increases in Lees Ferry reach, not canyon-wide

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Resource: native fish

- **PREDICTION:** “Potential minor increase”
- **OUTCOME: +/-**
- **COMMENT:** HBC decreased, native suckers may be stable or slightly increasing

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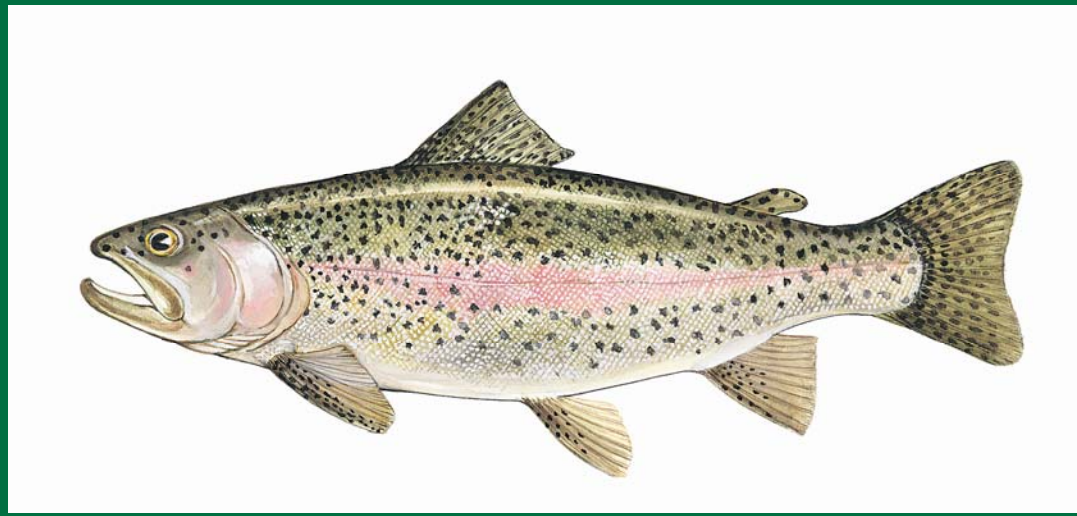
Resource: nonnative fish

- **PREDICTION:** “Potential minor increase”
- **OUTCOME: +**
- **COMMENT:** rainbow trout population increased substantially in Lees Ferry reach and Marble Canyon



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Resource: interactions between native and nonnative fish

- **PREDICTION: "**Potential minor increase in warm, stable microhabitats"
- **OUTCOME: -**
- **COMMENT:** Drought-induced warmer releases not related to dam operations

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Resource: trout

- **PREDICTION: “I**ncreased growth potential, stocking-dependent”
- **OUTCOME: -**
- **COMMENT:** Trout numbers up, condition factor down in Lees Ferry reach. Stocking not required

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Resource: woody plants

- **PREDICTION: “**Modest increase”
- **OUTCOME: +**
- **COMMENT:** Especially nonnative tamarisk and arrowweed.

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Resource: emergent marsh plants

- **PREDICTION:** “Same as or less than no action”
- **OUTCOME: +/-**
- **COMMENT:** Wet marsh species decreased, and dry marsh species increased.

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Resource: wintering waterfowl

- **PREDICTION:** “Potential increase”
- **OUTCOME: +/-**
- **COMMENT:** Trends vary by species. Difficult to distinguish from background variation.

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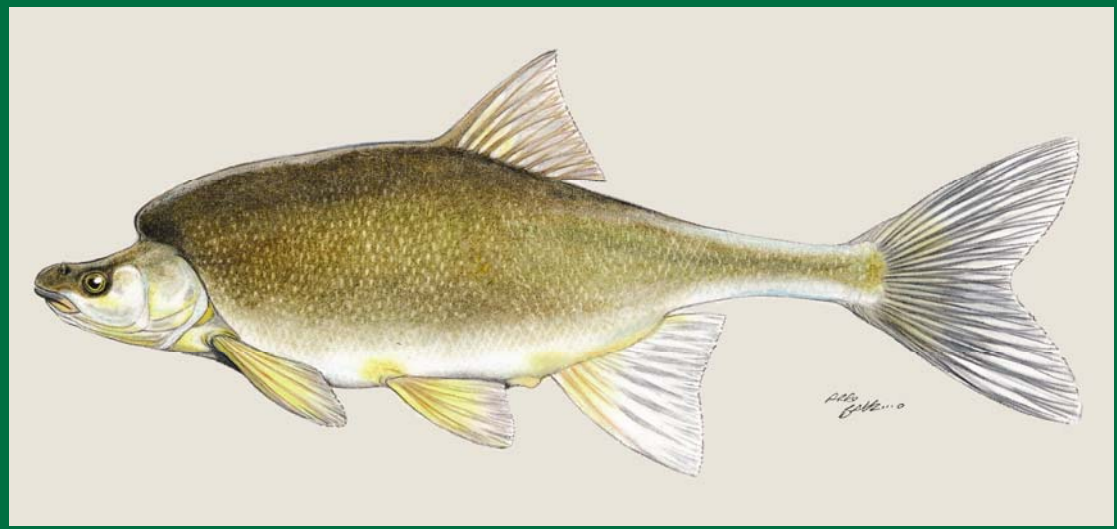
Resource: Native fish (humpback chub, razorback sucker, flannelmouth sucker)

- **PREDICTION: “**Potential minor increase”
- **OUTCOME: +/-**
- **COMMENT:** HBC declined. Native suckers may be stable or slightly increasing.



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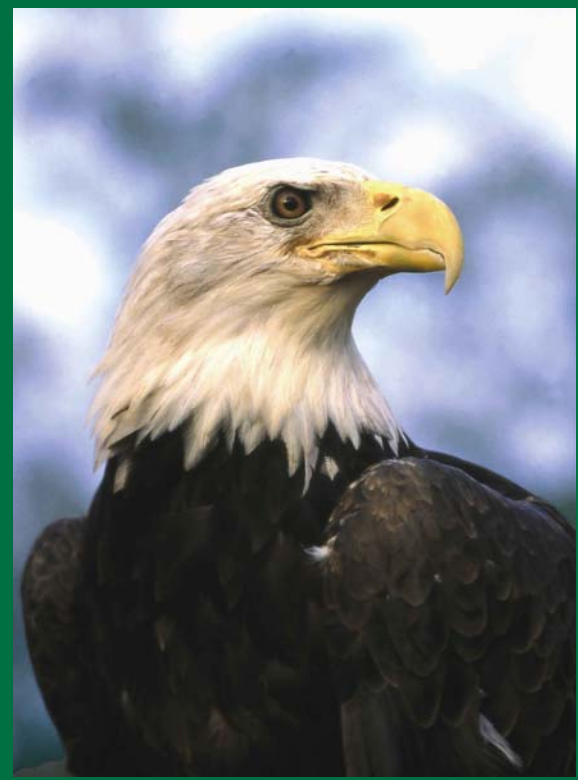
Resource: bald eagle

- **PREDICTION: “**Potential increase”
- **OUTCOME: ?**
- **COMMENT:** Numbers in Arizona have increased overall.



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Resource: peregrine falcon

- **PREDICTION:** “No effect”
- **OUTCOME: +**
- **COMMENT:** Numbers stable in Grand Canyon since 1988.

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Resource: Kanab ambersnail

- **PREDICTION:** “Some incidental take”
- **OUTCOME: +/-**
- **COMMENT:** Snail habitat increased since 1998, but snail numbers are relatively stable.

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Resource: southwestern willow flycatcher

- **PREDICTION:** “Undetermined increase”
- **OUTCOME:** -
- **COMMENT:** Flycatcher is uncommon in Grand Canyon.

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Resource: archaeological sites affected

- **PREDICTION: “**Moderate (less than 157)”
- **OUTCOME: ?**
- **COMMENT:** Subsequent analyses have not been conducted to fully assess.

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Resource: traditional cultural properties affected

- **PREDICTION: “**Moderate”
- **OUTCOME: ?**
- **COMMENT:** Subsequent analyses have not been conducted to fully assess

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Resource: traditional cultural resources affected

- **PREDICTION:** “Increased protection”
- **OUTCOME: ?**
- **COMMENT:** Subsequent analyses have not been conducted to fully assess

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Resource: Effect of emissions on regional air quality

- **PREDICTION:** “Slight reduction”
- **OUTCOME:** ?
- **COMMENT:** Not addressed by Glen Canyon Dam Adaptive Management Program

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Resource: angler safety

- **PREDICTION: “**Moderate improvement”
- **OUTCOME: ?**
- **COMMENT:** No long-term monitoring data.

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Resource: day rafting

- **PREDICTION:** “Major improvement”
- **OUTCOME: ?**
- **COMMENT:** Pre-EIS study suggest that net willingness-to-pay values were insensitive to flows. More studies are needed.

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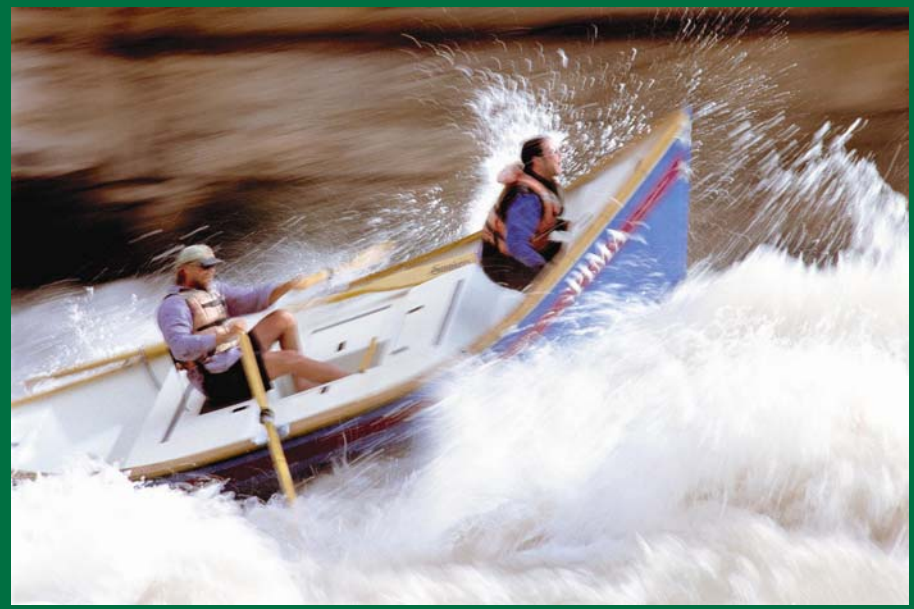
Resource: whitewater boating safety

- **PREDICTION:** “Minor improvement”
- **OUTCOME: ?**
- **COMMENT:** NPS responsibility – not monitored directly as part of Glen Canyon Dam Adaptive Management Program



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Resource: whitewater boating camping beaches (average area at normal peak stage)

- **PREDICTION: “**Minor increase”
- **OUTCOME: -**
- **COMMENT:** Diminishing due to both vegetation encroachment and sandbar erosion.

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Resource: whitewater boating wilderness values

- **PREDICTION: “**Moderate to potential to become major increase”
- **OUTCOME: ?**
- **COMMENT:** Potential decrease and decline in campable areas.

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Resource: Economic benefits (not related to hydropower revenue)

- **PREDICTION: Positive**
- **OUTCOME: +**
- **COMMENT:** Increase both locally and regionally

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Resource: annual economic cost (power)

- **PREDICTION:** “Acceptable costs relative to other alternatives”
- **OUTCOME: ?**
- **COMMENT:** Subsequent studies are not available to fully assess

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Resource: wholesale rate of power

- **PREDICTION: “**Acceptable costs relative to other alternatives”
- **OUTCOME: ?**
- **COMMENT:** Not monitored as part of the Glen Canyon Dam Adaptive Management Program except as done by the Western Area Power Administration

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Resource: retail rate of power (70% of end users)

- **PREDICTION:** “No change to slight decrease”
- **OUTCOME:** **?**
- **COMMENT:** Not monitored as part of the Glen Canyon Dam Adaptive Management Program except as done by the Western Area Power Administration

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Resource: retail rate of power (23% of end users)

- **PREDICTION:** “Slight decrease to moderate increase”
- **OUTCOME:** **?**
- **COMMENT:** Not monitored as part of the Glen Canyon Dam Adaptive Management Program except as done by the Western Area Power Administration

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Resource: retail rate of power (7% of end users)

- **PREDICTION:** Acceptable costs relative to other alternatives
- **OUTCOME:** ?
- **COMMENT:** Not monitored as part of the Glen Canyon Dam Adaptive Management Program except as done by the Western Area Power Administration

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Resource: nonuse value

- **PREDICTION:** “No data”
- **OUTCOME: +**
- **COMMENT:** Substantial nonuse value, $3 - $4 **billion**, has been demonstrated as willingness to pay for flows to protect fish.

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“Report Card” or outcome of EIS predictions

✓ ++	5*	(17%)
✓ - -	5	(17%)
✓ +/-	6	(20%)
✓ ??	14	(46%)

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** not inc. coarse sediment*

How did the EIS writers do statistically?

Assumptions

1. Eliminate unknown categories (?)
2. Assume that there are only three outcomes (+, -, or +/-)
3. Assume that the probability of each outcome is the same

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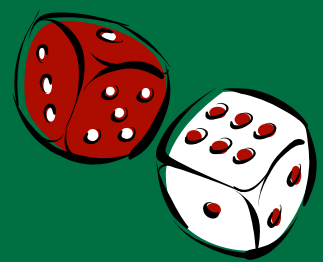
	-	+	+/-	**Total**
Observed	5	5	6	16
Expected	5.33	5.33	5.33	16

Chi-square = 0.125, *P* = 0.94



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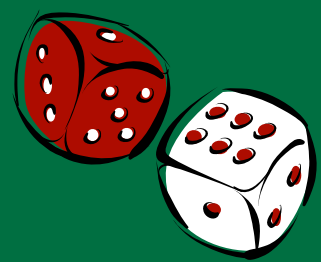
	-	+ or +/-	Total
Observed	5	11	16
Expected	8	8	16

Chi-square* = 2.25, *P* = 0.13



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** Yate's correction for continuity*

Does this mean that Adaptive Management is a failure?

ABSOLUTELY NOT!

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Why didn’t they get more predictions right?

- **Vastness of system**
- **Complexity of system**
  - Geological context is many millions of years old
  - Shaped by processes that occur in cycles of thousands (glacial periods) or hundreds of years (climate cycles, e.g., drought)
  - Inhabited by fish with life spans of decades
  - We have knowledge based on about one decade of focused research and monitoring
- **Need for sustained long-term monitoring and more experimentation**

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Future research questions

- Why are humpback chub declining?
- What is the linkages between native and nonnative fish, food base (aquatic and terrestrial) and dam operations?
- If the drought continues, what are the impacts of warmwater discharge?
- Is sediment augmentation a viable option?
- What are the linkages between dam operations and archaeological site erosion?

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