Surprise and opportunity in Grand Canyon adaptive management

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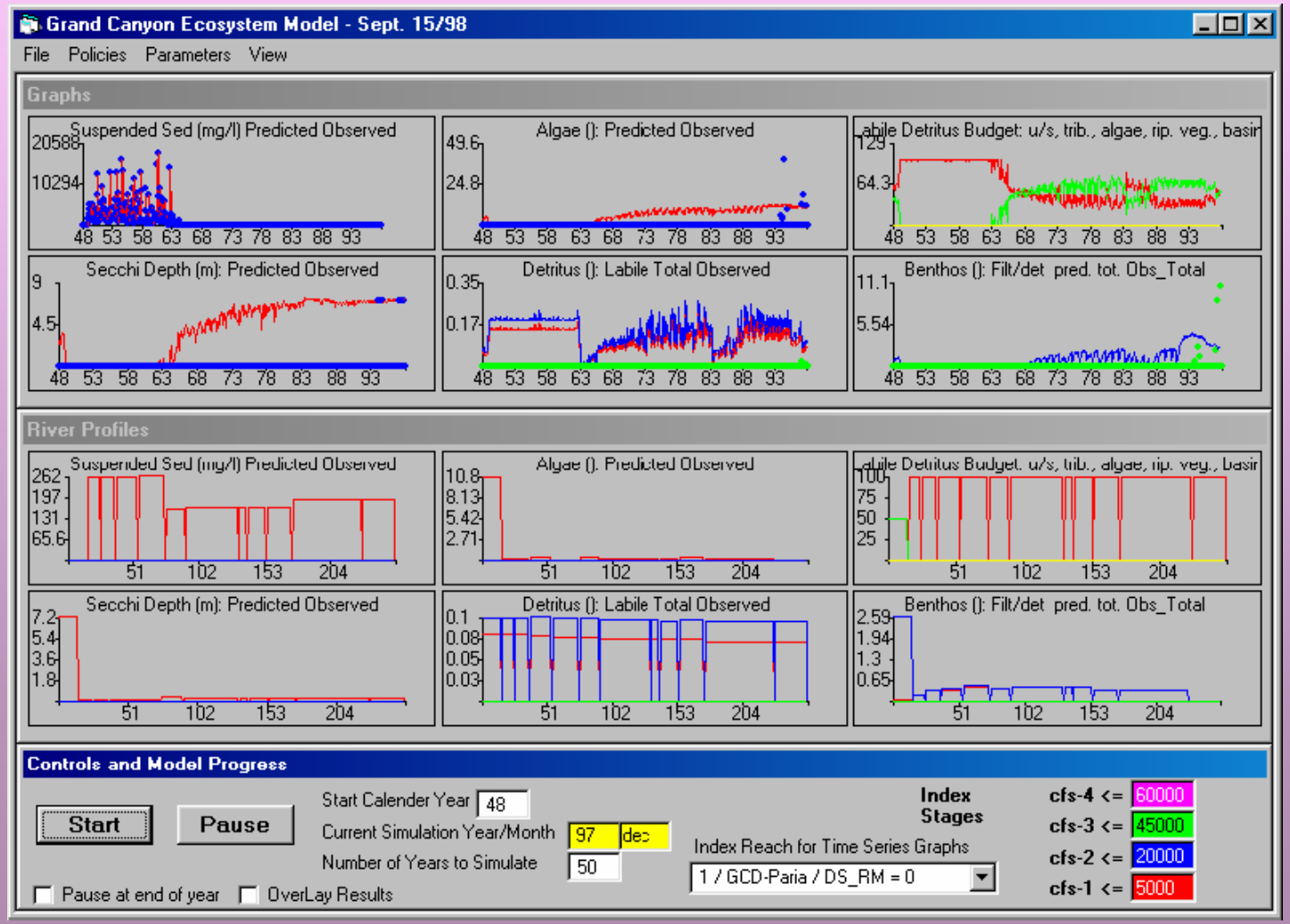
Adaptive management process

- **Ecosystem modeling (1997-99) to**:
  - Clarify key policy options and performance indicators
  - Identify causal linkages from options to indicators
  - Specify clearly why policy predictions based on synthesis of past data might fail, ie to “embrace uncertainty” by highlighting particular science gaps
- **Design of diagnostic policy tests and monitoring program (2000-2005)**
- **Implementation and “learning by doing” (now)**

There is still much misunderstanding about the reasons for adaptive management

- Adaptive management is NOT about gaining better “scientific understanding” through modeling and management experiments
- Rather, it is about using the experimental methods of science to directly compare policy options, whether or not that comparison results in any improvement in understanding about causes of differences in performance among policy “treatments”

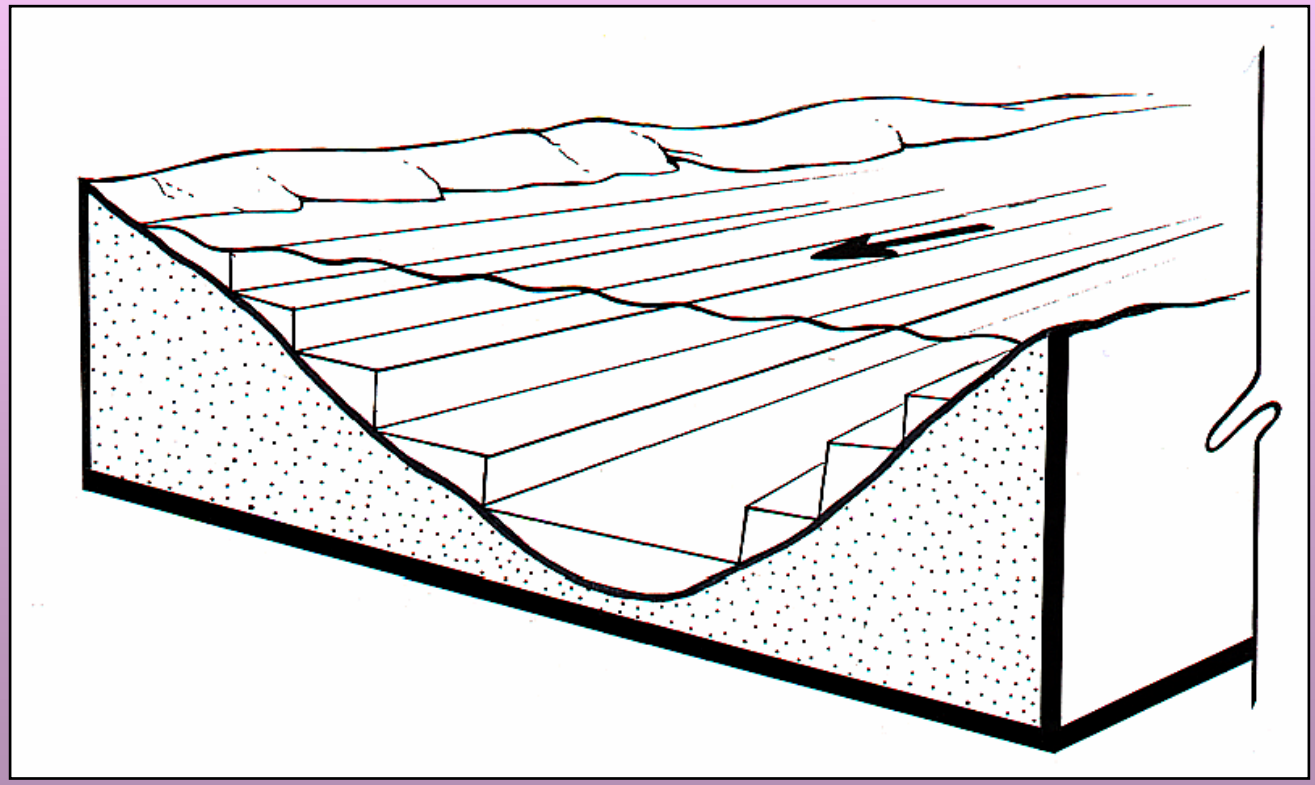
We produced a wonderfully complex model that represents biophysical dynamics on multiple space-time scales



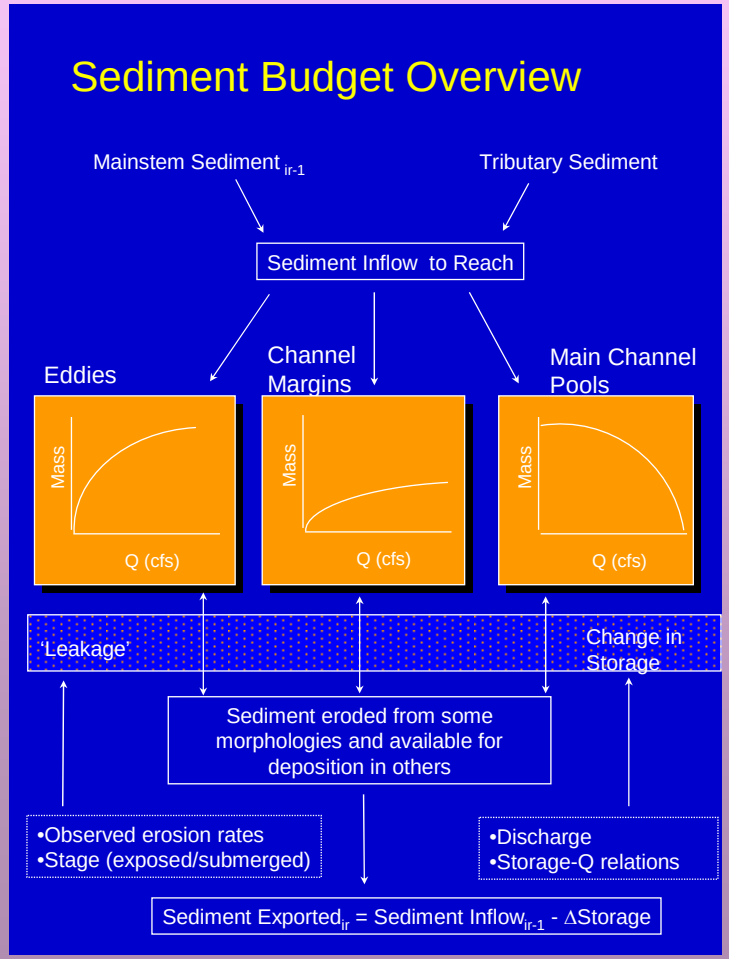
Two main submodels emerged as problem areas for prediction

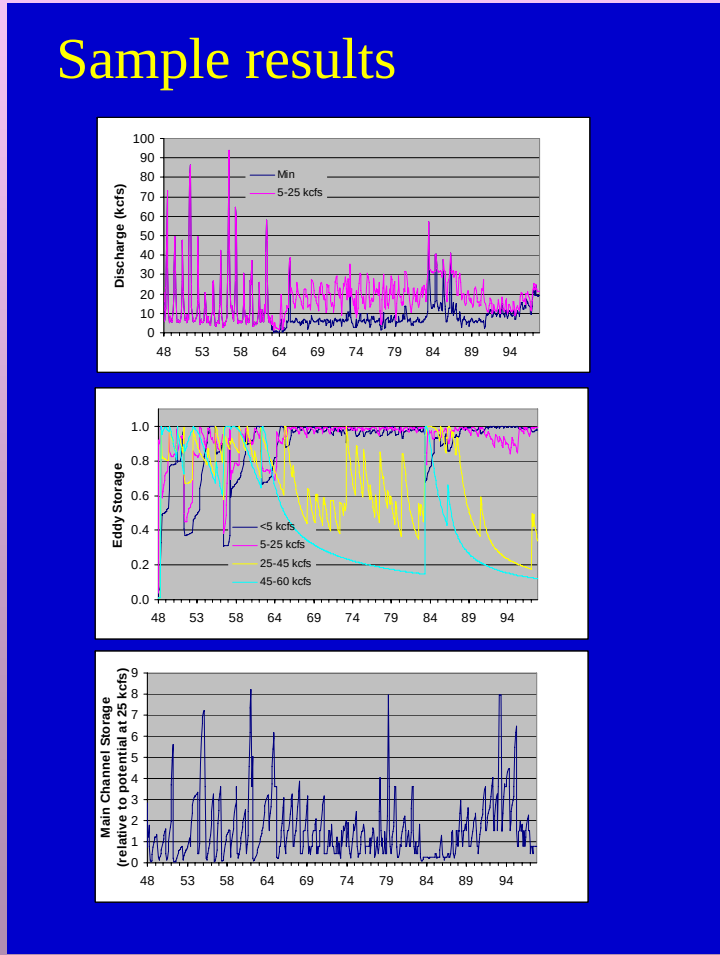
- **Food web structure and trophic interactions involving exotic species**: model predicted that physical habitat restoration could create a warm, muddy river full of carp and catfish rather than a restored ecosystem
- **Sand input, transport, and storage**: model predicted that sand inputs from tributaries below Powell might not be sufficient to maintain camping beaches, even with careful conservation through flow/storage management

The statistical dynamics of secondary production and sediment transport/storage have proven to be extremely complex, especially given that we need to predict outcomes along the edges of the system

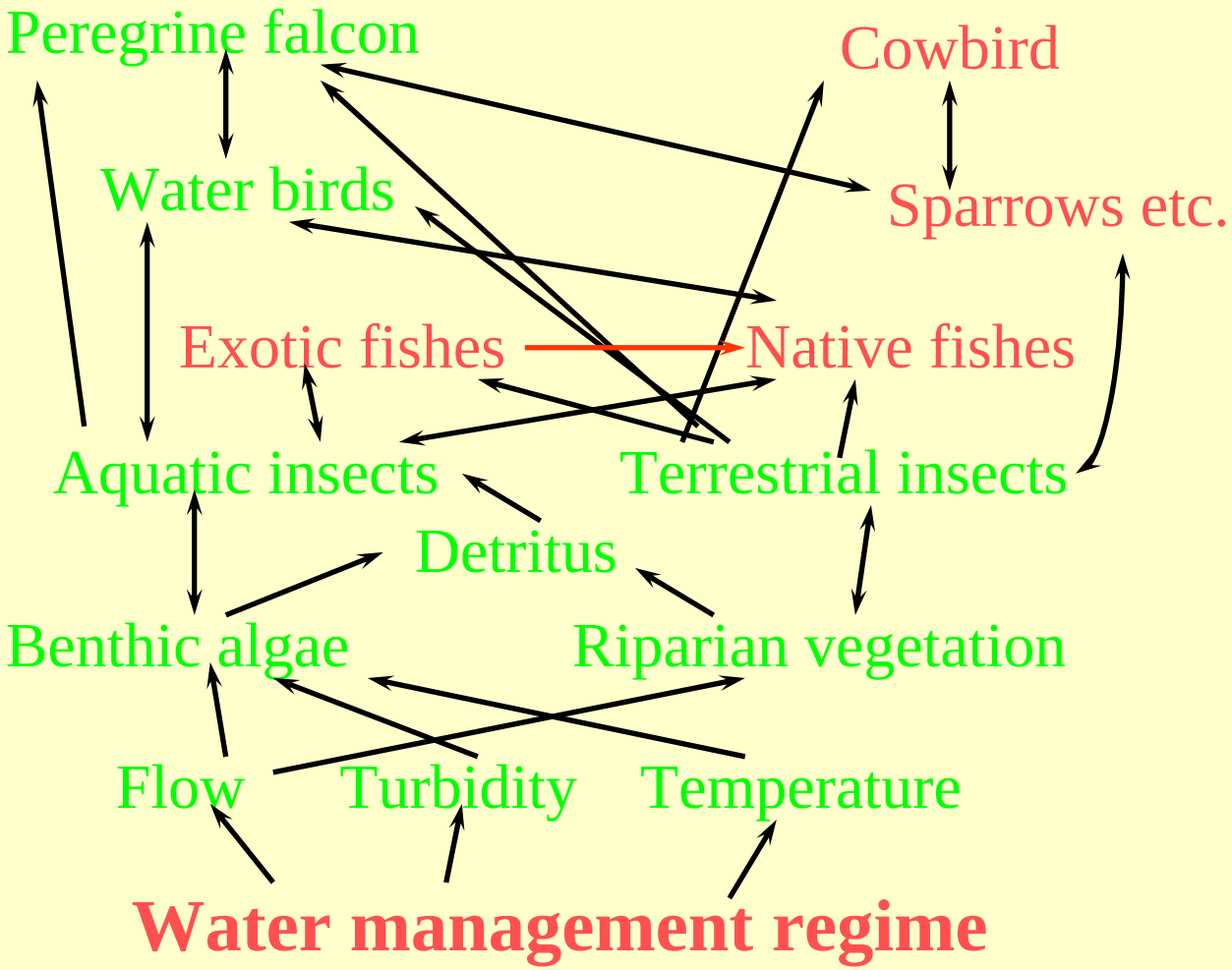


It is not enough to just monitor sediment loads and total outputs (mass budgets), because of very complex storage dynamics created by bank and channel storage structure





We can predict lower trophic level responses fairly well; the troubles start with recruitment predictions for interacting fish populations



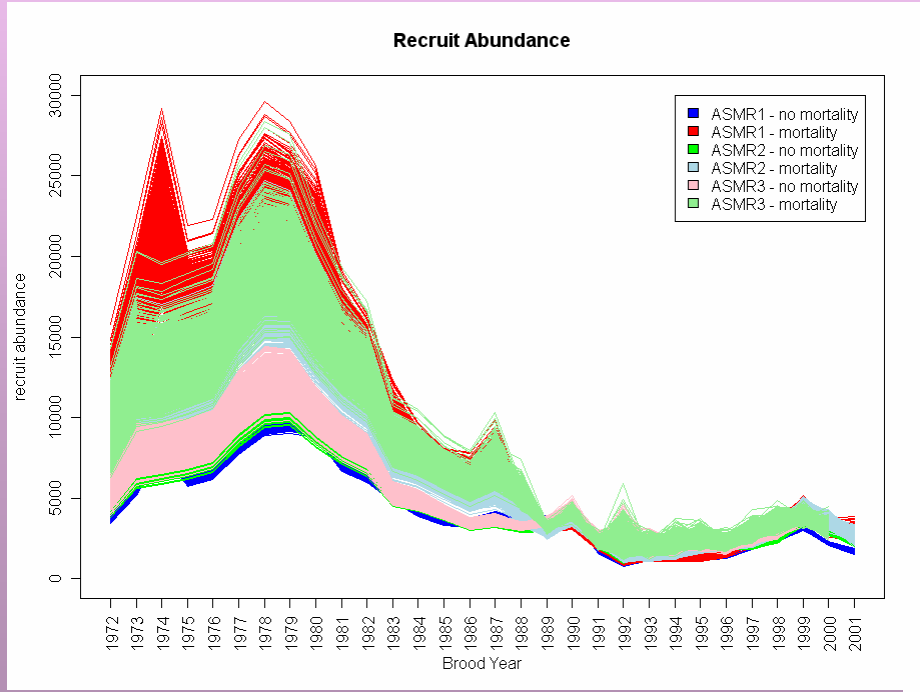
As of 1997, two years after the EIS, the GCM conceptual model was predicting most of Jeff Lovich's ROD responses correctly

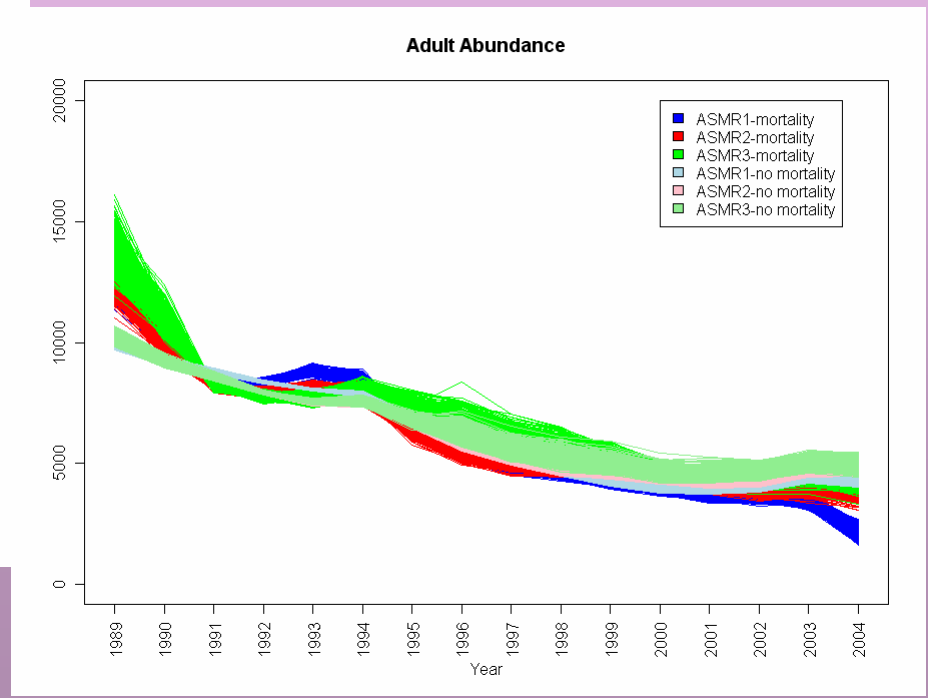
- It did "see" the emerging problem with sand storage and camping beaches
- It predicted strong salmonid responses to reduced flow fluctuation (it fit the data already becoming available)
- It did calculate changes in economic performance indices for power production
- But none of us were willing to trust it except as an aid to identifying key uncertainties

The ecological responses that we cannot predict imply a catastrophic divergence of model predictions about habitat restoration

- There are two types of warmwater fishes in the system: native and exotic
- Both may benefit from restoration of more natural flows, temperature, turbidity
- But exotic fishes are not exactly the chub's best friends…

Meanwhile, back at the LCR, the humpback chub has not been doing so well and will stabilize at dangerously low abundance unless recent recruitment increases (for which management was likely not responsible) persist



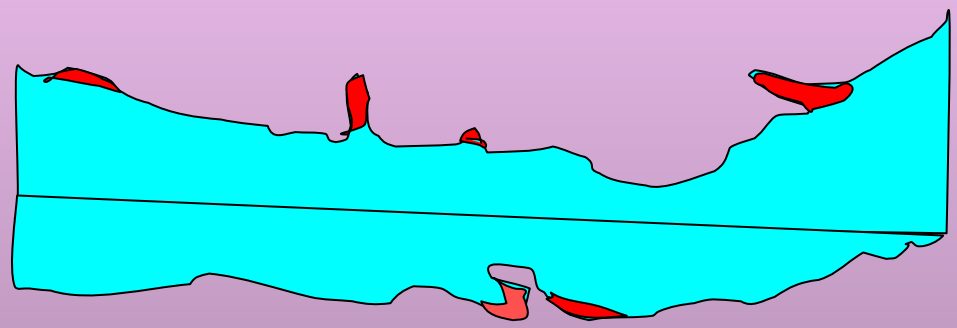


Besides floods for beach restoration, two main adaptive management "treatments" have been tried in the last few years

- **Steady flow regime over summer 2000** (which the modeling told us would not likely have much impact, and which we did not favor)
- **Mechanical removal of salmonids near the LCR** (for which we had great hopes)

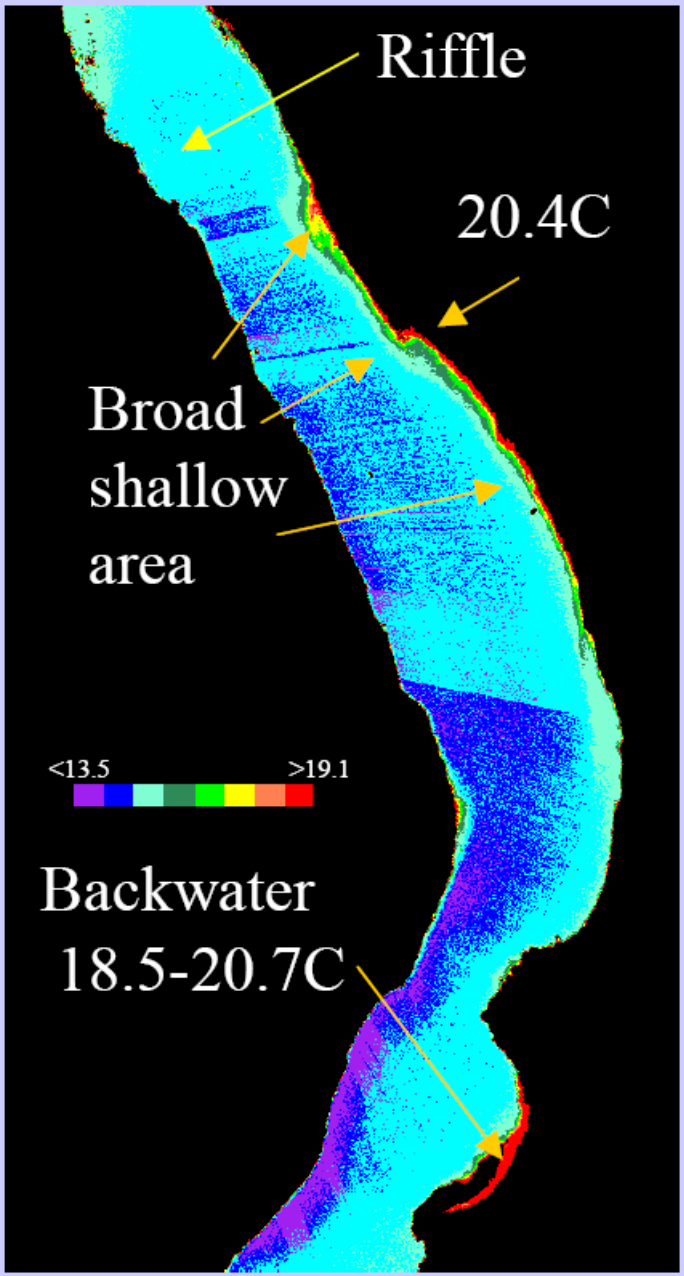
The biggest surprises have come from the treatment that we did not want, i.e. the steady flow regime

- Development of warm water microhabitat structure all along the mainstem

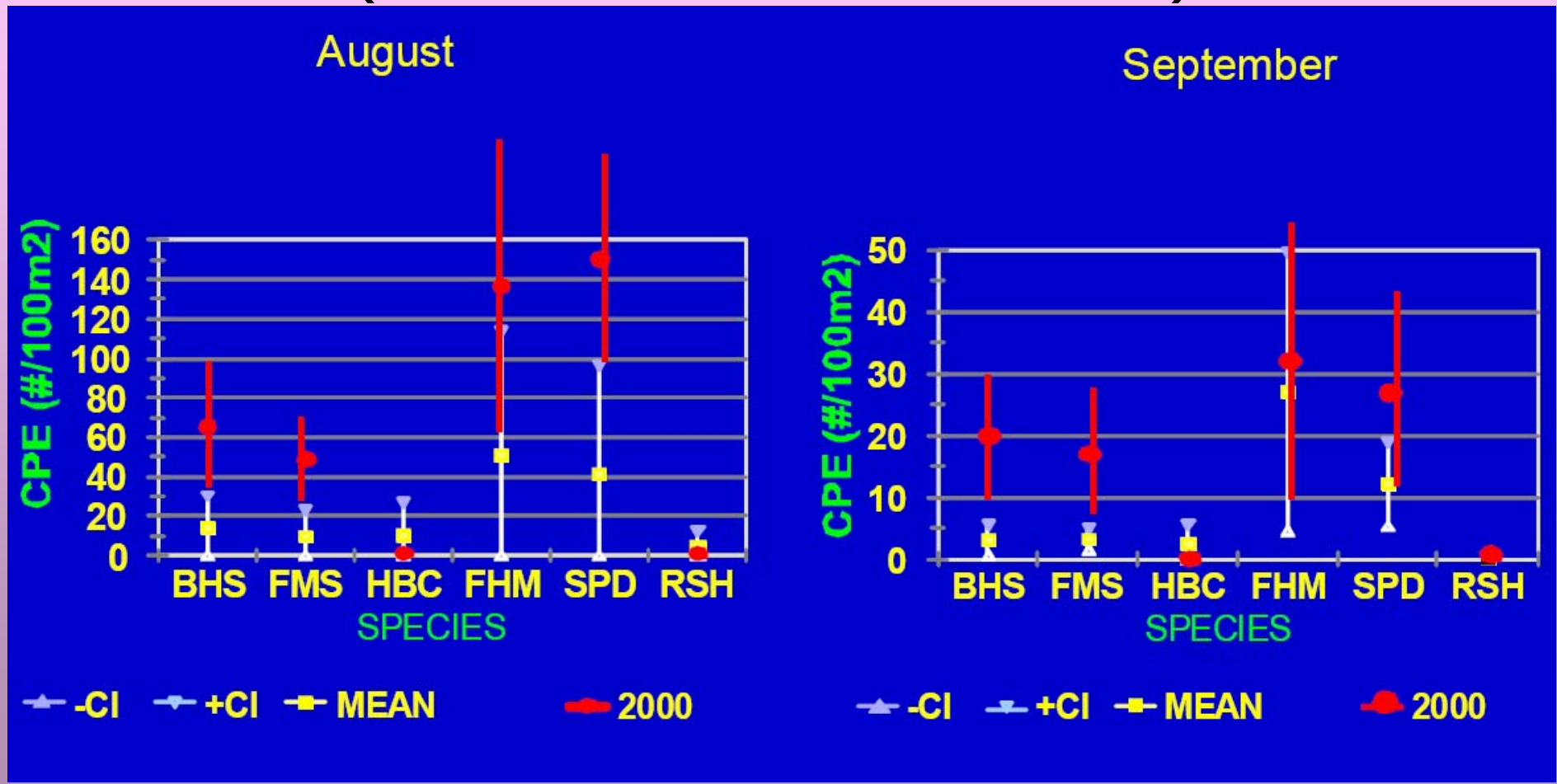


- where juvenile native fishes prospered, until diurnal flow fluctuations were reestablished in September after an experimental flood that had surprisingly large impacts on juvenile fish

A snapshot from Bill Vernieu's temperature data (near Tanner rapid)



Little fishes did well until the experimental flood in September 2000 (Melissa Trammell data)



It is too early to evaluate impacts of mechanical removal treatment

- Little chubs washed into the mainstem by fall LCR freshets appear to survive better
- But surviving for a few months does not imply recruitment to adult population; it will take a minimum of 4 years to see that (2007-2009)
- A winning policy combination may be to combine removal with fall steady flows

So the adaptive management program is showing progress, but it is running on serendipitous results rather than a planned experimental design

- There are two choices for the future:
  - Keep trying options, hope for lucky results;
  - Use a long-term, designed treatment plan.
- There are three basic options for a long-term plan:
  - Titration: progressively more expensive options
  - Reverse titration: invest heavily, back off to see what worked
  - Factorial comparison of treatment combinations

It may be that planning/implementation lead times will leave little choice but a titration design

- In that case, we need to think carefully about how to deal with confounding of treatment effects with effects of uncontrollable changes such as low flows and warm water.
- For endangered fish treatments, we desperately need to find ways to reduce the lag time from treatment to recruitment response measurement

But what is a “good” experiment?

- Is it just one that allows us to quantify uncertain treatment effects?
- Or is it one that surprises us, producing results that we really did not expect?
- Indeed, why even do “experiments” for situations where we already know the answer?
- Surprises represent opportunities!

With low Powell levels, we have just been handed a wonderful opportunity to look ahead at temperature management options

- But are we capitalizing on that opportunity, i.e. making a major emergency investment in monitoring ecological responses?
- Have we reached clear consensus on just what other treatment options should be tested in combination with the warm water, i.e. fluctuating vs steady flows?

Warm water+flow=nasty tradeoffs

- **Current flow regime (MLFF)**
  - The easy option (ROD, stakeholder compromise)
  - Simpler scientific comparisons
  - Least impact on recreation
- **Load following regime (5-25)**
  - Reduce losses in power production at expense of increased sand loss, inconvenience for recreation
  - Look ahead to relaxed restrictions if TCD built
  - Prevent exotic fishes from prospering
  - Favored in stakeholder multiattribute utility exercise
- **Seasonally adjusted steady flows**
  - Most “natural” conditions for survival of juvenile native fish (**?**)
  - Maximize sediment retention and recreation

And a wonderous vampire has just come up from the basement (or the lower epilimnion as it were)

- A massive die-off of trout in the Lee's Ferry reach could be bad for recreational fishing guides.
- But now we have a great opportunity to measure the resilience of the trout population, and to determine whether it has been over-cropping key food resource species like amphipods.
- Will we capitalize on this opportunity?

Carl's predictions about what we will see over the next decade

- Mechanical removal will not enhance humpback chub recruitment, and population will stabilize at adult population of 2000-3000, below minimum needed for ESA delisting. There will be fierce debate about whether to change the target population size for delisting…
- Camping beaches will continue to disappear, with little impact on net loss rate by management of tributary inputs. Other options for maintaining campsites will be debated, e.g. tent platforms.

Carl's predictions about what we will see over the next decade

- Warmwater exotic fishes will flourish briefly while Powell remains low, then will continue to decline toward near extinction in the mainstem above rm 160 or so.
- There will be a move back toward load-following diurnal flows, which will result in a lower population size of larger trout in the Lee's Ferry reach as the population rebounds from impacts of high temperatures and low O_2.
- Riparian vegetation communities will show succession toward fewer, larger trees and shade tolerant ground cover species, with lower secondary productivity.

If we do not want to see those outcomes, we will have to start thinking about much more radical policies

- Temperature control devices
- Transport of sediment from the upper basin or other sources, perhaps along with warm water
- Severe alteration in the seasonal hydrograph to reverse successional processes and restore backwater structures
- A clear and explicit decision to accept the new Colorado River ecosystem as a marvel in its own right, and learn to live with its changes

Can we learn to view change as opportunity rather than threat?

- Treating change as threat is the worst kind of command-and-control mentality, as Meffe has warned us
- Weed-whackers could turn those nasty tamarisk stands into better, sand-retaining camping areas
- Cold water can protect the humpback chub from mainstem exotics
- Variable flows can be used to manage foodbase succession and rainbow trout growth