Aquatic food base research and monitoring—what do we know, and what don't we know?

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Outline

- What do we know?
  - Why conduct research/monitoring of aquatic food base?
  - What is the aquatic food base?
  - Downstream and seasonal patterns of important food base components
  - Effects of fluctuations, MLFF, BHBF, and monthly volume shifts on food base components
- What don’t we know?
  - Problems/Limitations of past approach
  - PEP & SA recommendations

What do we know?

- Why should we study the aquatic food base?
- What is the aquatic food base?
- Downstream and seasonal patterns of important food base components
- Effects of fluctuations, MLFF, BHBF, and monthly volume shifts on food base components

Why should we study the aquatic foodbase?

"…food is almost always the critical factor that ultimately limits [animal] population density in a given habitat." (Krebs 1994)

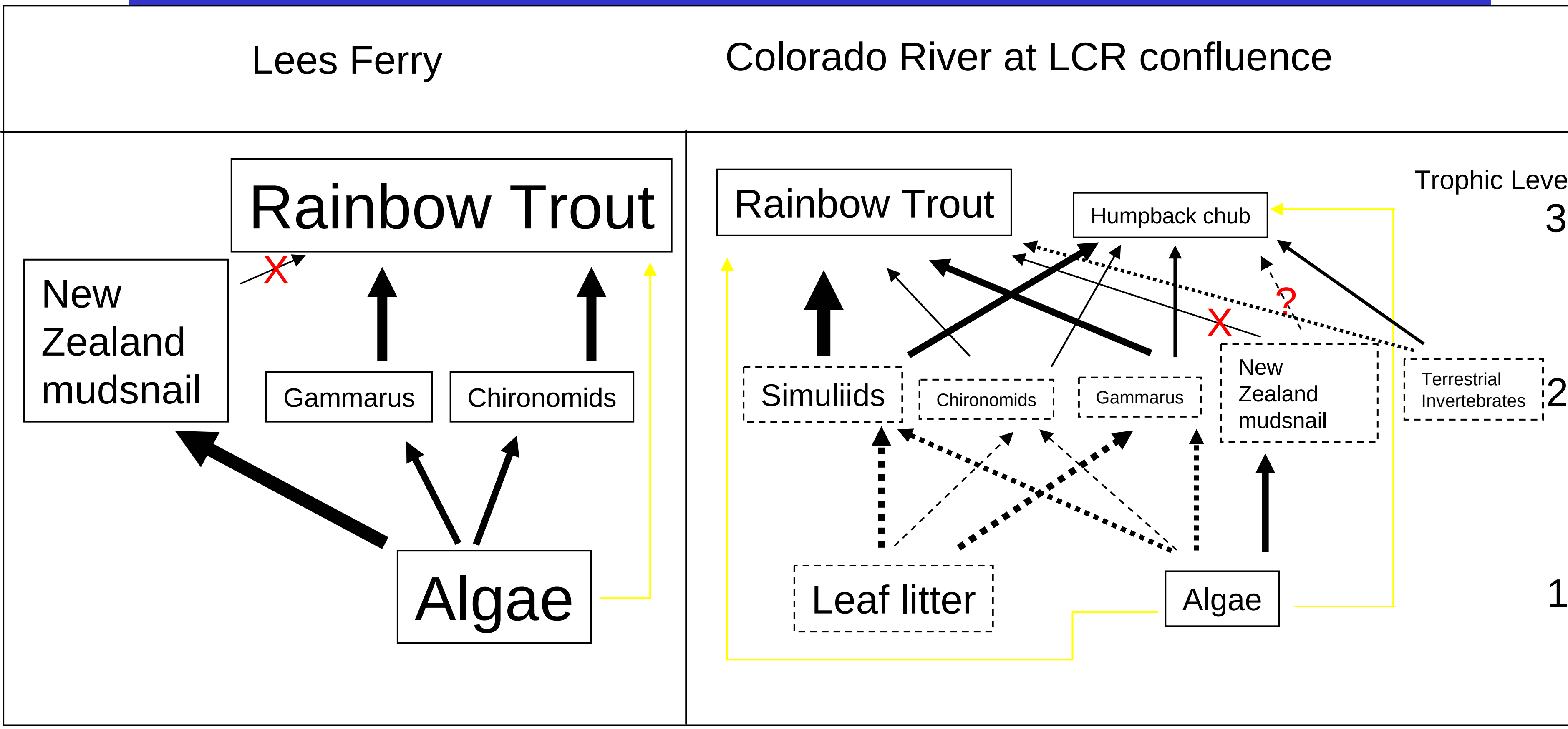
Why should we study the aquatic food base?

- Recent trends for fish in the Colorado River may be due in part to changes in food availability and/or quality
  - Decline in condition of humpback chub (Meretsky and others 2000)
  - Decline in condition of LF rainbow trout (McKinney and others 2001)

Why should we study the aquatic food base?

- Understanding spatial and temporal variability, and what controls/limits the availability, of food is critical to determining what controls native and non-native fish density in the Colorado River

What is the Aquatic Food base?



Angradi 1994, McKinney and others 2001, Shannon and others 1994,

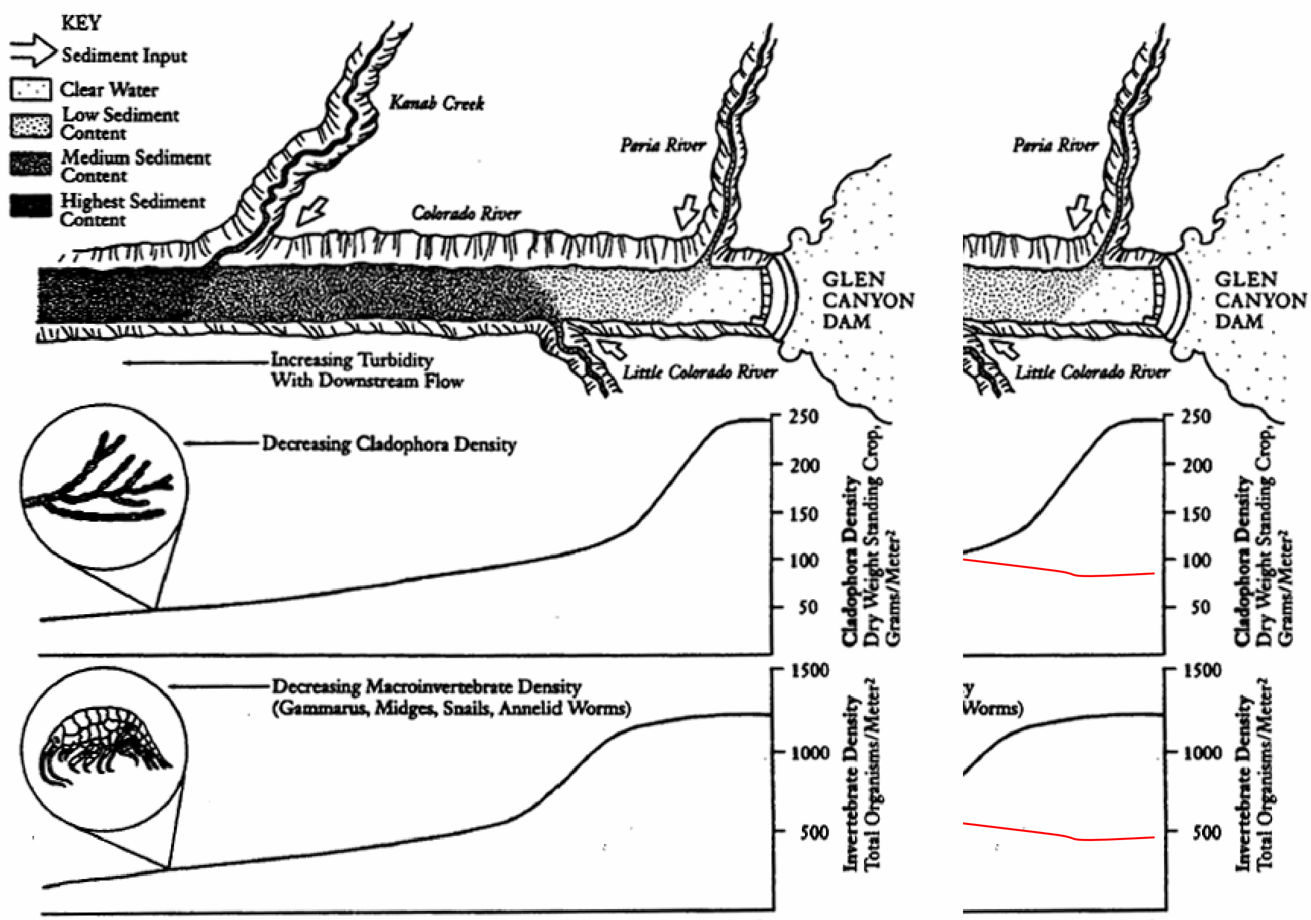
Valdez and Ryel 1995, Stevens and others 1997, Haden and others 1999, Yard and Coggins forthcoming

Downstream and Seasonal Patterns—Benthos

What's missir

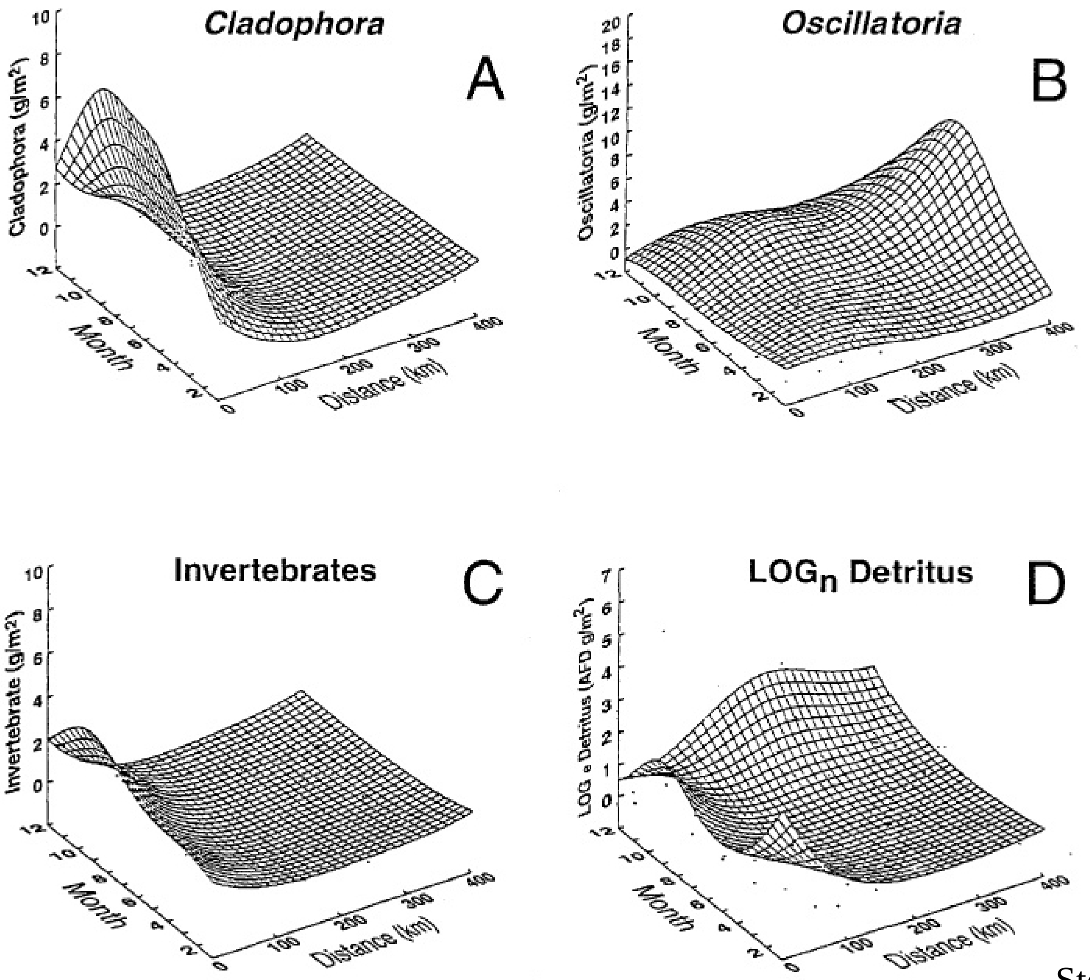
Allochthonous ı
Particulate Orga

Simuliids



Carothers & Brown, 1991

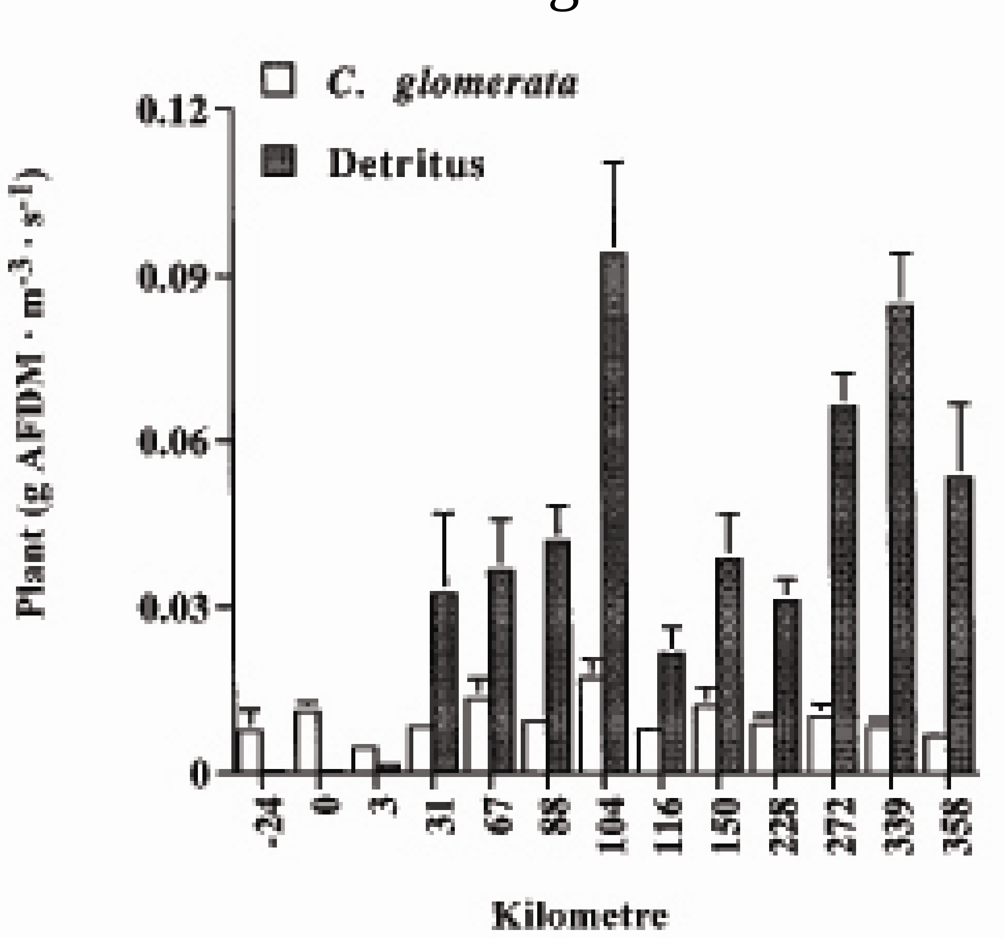
Downstream and Seasonal Patterns—Benthos



Stevens and others 1997

Downstream and Seasonal Patterns—Drift

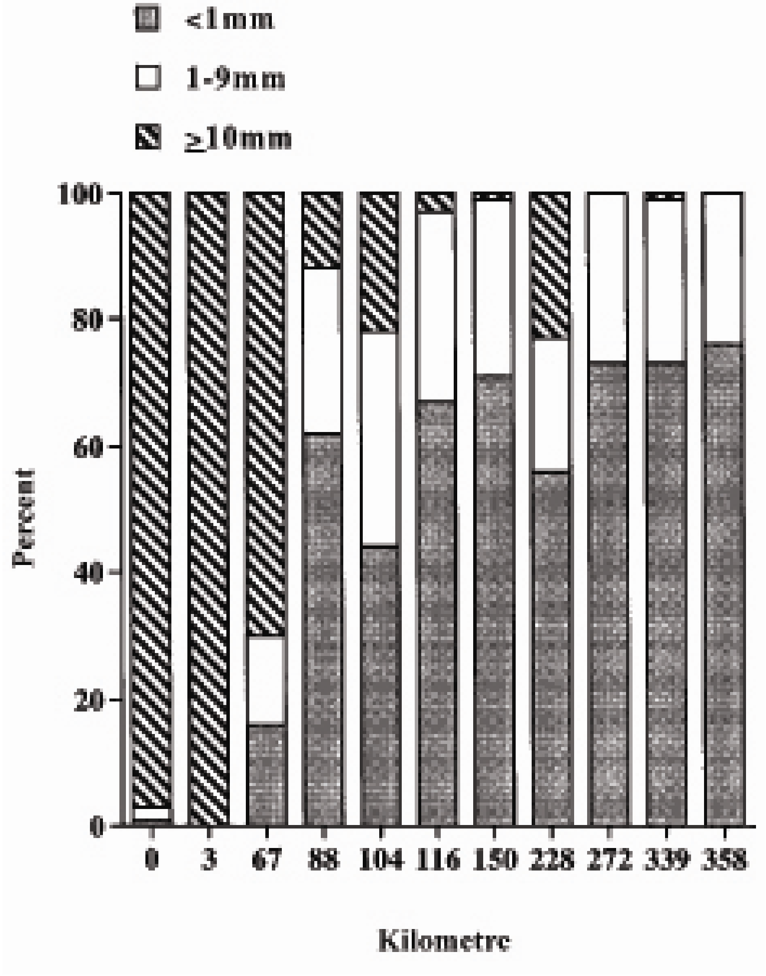
Composition of drift shifts from algae to terrestrial detritus downstream



Shannon and others 1996

Downstream and Seasonal Patterns—Drift

Downstream increase in Fine POM (food for black fly larvae)



Shannon and others 1996

Downstream and Seasonal Patterns—Drift

- Unclear whether/what seasonal patterns exist in invertebrate drift
  - Some found drift density of inverts greatest in spring (McKinney and others 1999)
  - Others found invert drift density was greatest in summer and lowest in winter and spring (Leibfried and Blinn 1987, Blinn and others 1994, Shannon and others 1996)

Effects of Fluctuations on Food Base Components

Effects of Fluctuations on Food Base Components—Algae and Invertebrates

- Even short periods of exposure lead to reductions in algae and invertebrate mass/density
- Recovery of snails following exposure occurs quickly (~1week), but algae and other invertebrates take considerably longer to recover (>4months)

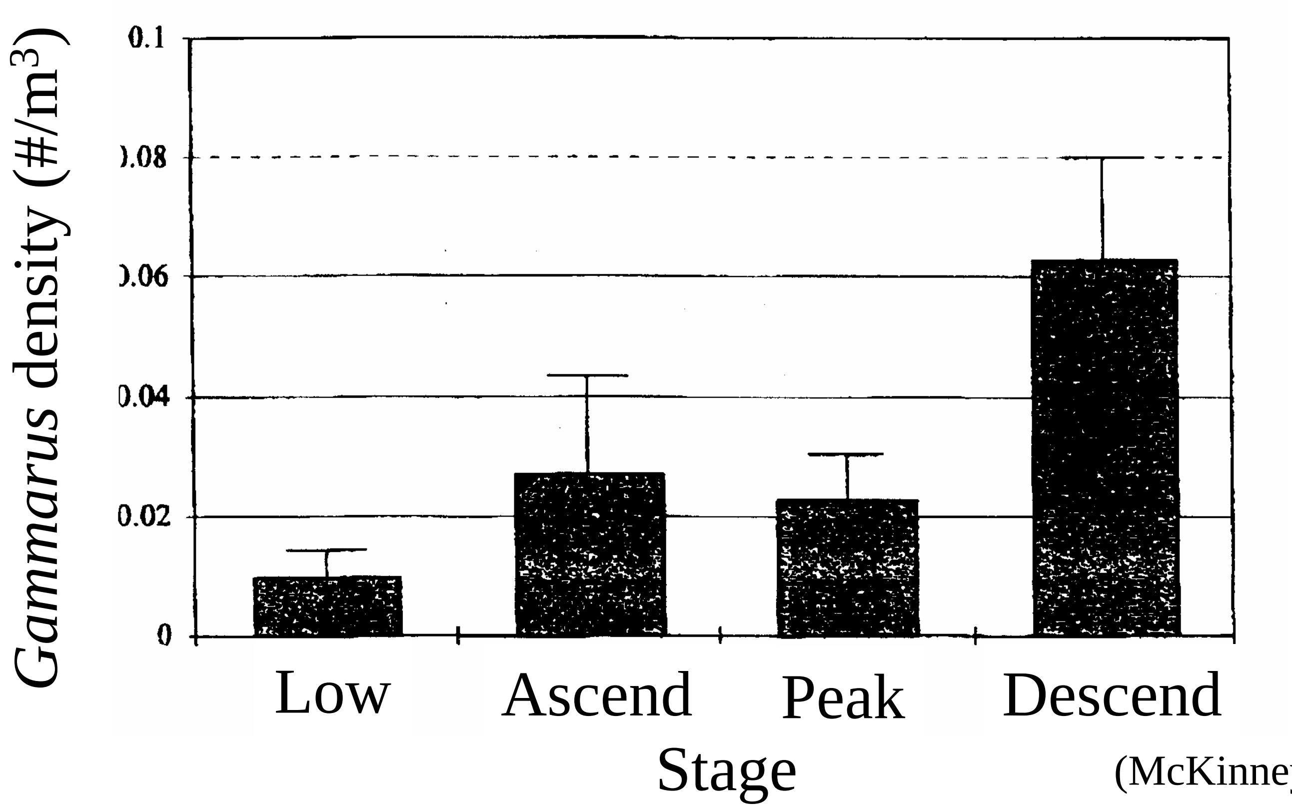
Blinn and others 1995

Effects of Fluctuations on Food Base Components—Drift

- Particulate Organic Matter (POM)
  - Mass flux of POM increases w/ discharge, but concentration unrelated to discharge (Angradi & Kubly 1994, Benenati and others 2001)
  - Ramping rate has no effect on drift mass (Shannon and others 1996)

Effects of Fluctuations on Food Base Components—Drift

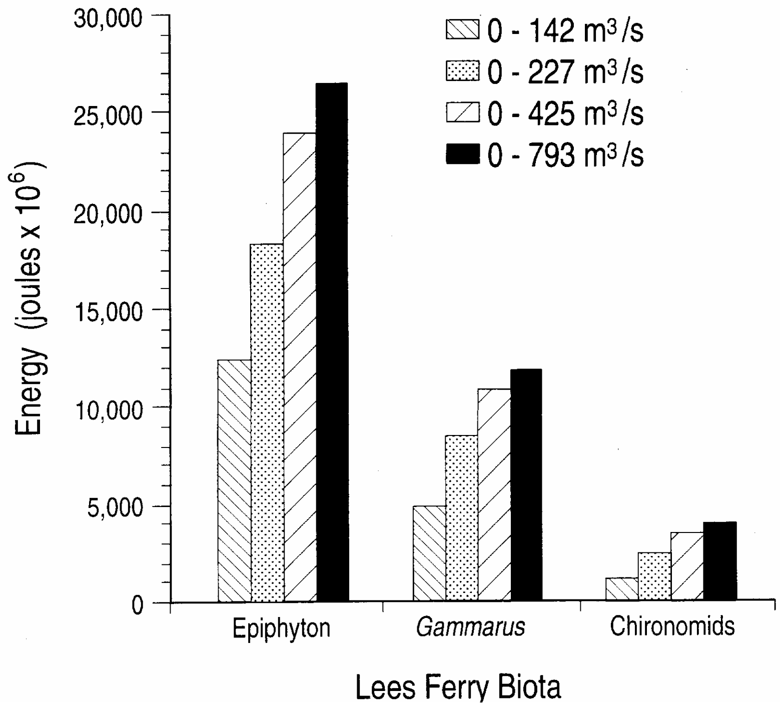
Density of *Gammarus* in drift increases during the descending limb of hydrograph



(McKinney and others 1999)

Effects of MLFF on Food Base Components

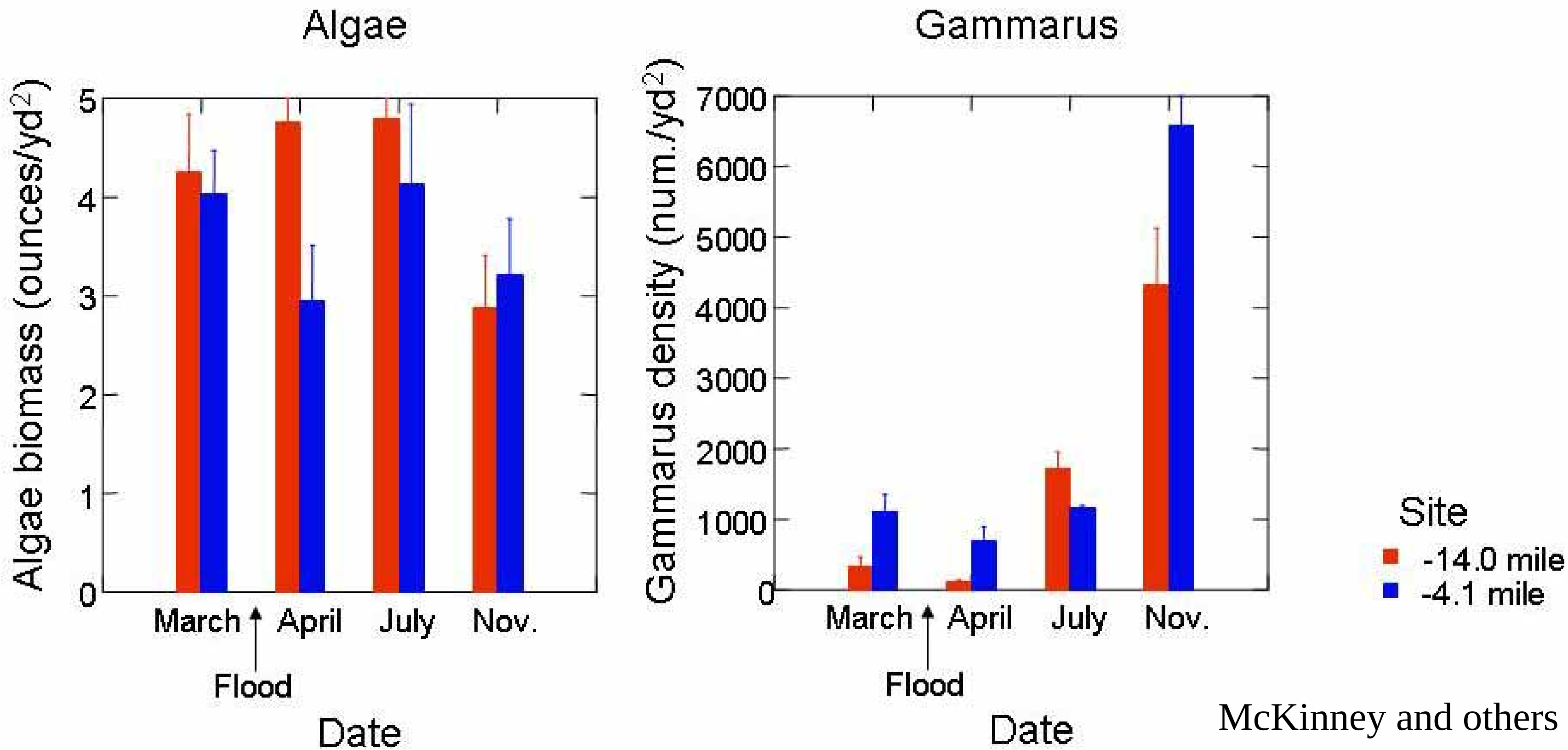
By increasing minimum discharge and restricting daily fluctuations, MLFF most likely increased standing mass of algae and invertebrates



Blinn and others 1995

1996 BHBF Effects on Food Base Components

BHBF had short term and minor impact on algae and invert standing mass.
But, trout stomachs actually contained more food after flood!



McKinney and others 1999

2004 BHBF Effects on Food Base Components—Approach

- Quantify organic matter and invertebrate drift at LCR confluence (Yard and others)
- Quantify algae production in Glen Canyon using methods employed by Marzolf and others (1999) during '96 (Kennedy and others)
- Results will be presented at Oct. 2005 Science Symposium

Effects of Shifts in Monthly Volumes on Food Base Components

- Large increase in monthly volume
  - Short-term reduction in algae productivity
    - Nearshore algae and inverts suddenly under several meters of water = less light
  - Long-term increase in algae standing mass
    - More surface area available for algae and inverts
- Large decrease in monthly volume
  - Abrupt decrease in algae and invertebrate mass
  - If new high water is less than old low water (Old low = 10k cfs, new high = 8k cfs), large quantities of food left behind

What do we know—Conclusions

- Algae drives food web in LF. Downstream?
- Gammarus and midges dominant food item in LF, Simuliids dominant food item for both chub and trout downstream
- Algae and invertebrate mass decrease downstream
- Abundance of allochthonous detritus and simuliids increases downstream

What do we know—Conclusions

- MLFF probably led to greater food availability
- 1996 BHBF had short-term negative impacts on food base standing mass, but trout feeding actually increased
- Large shifts in monthly volume probably cause abrupt decreases in food quantity, or short term decreases in algae production, and/or leave significant quantities of food behind

What don’t we know?

- Problems/Limitations of past approach
- PEP & SA recommendations

Recent Research & Monitoring—Problems/Limitations

- Very little statistical power to detect trends
- Algal standing crop is a poor proxy for algal production
  - interpretation of data complicated by across site differences in invertebrate consumption rates
- Algae probably not a good indicator of food availability across the entire CRE considering downstream increase in POM

Recent Research & Monitoring—Problems/Limitations

- We don’t know what the food base is at sites downstream from LF!
  - What is the relative contribution of allochthonous material to HBC and RBT production at downstream sites?
  - How does it vary over space and time?
  - Is it from tributary floods or mainstem riparian vegetation?
  - Is algae locally derived or imported from LF?

- Answers will determine the kinds of management actions we could employ to increase food availability
  - If algae is the most important carbon source at downstream sites, sediment augmentation would reduce already limited algae production
  - If allochthonous material is important at downstream sites, periodic 31k cfs, or greater, flows could be used to capture this material

PEP & SA Recommendations

"The food base program needs to be critically reviewed because the current level of understanding about the linkages between lower trophic levels and food availability of native fishes is not adequate to interpret food base data in relation to the management goal"—PEP 2001

Bottom line—we don't know what the food base is at downstream sites.

PEP & SA Recommendations

“Since there are scientific as well as statistical uncertainties associated with any approach for studying the relation of food base to trends in abundance of fish populations the best approach is likely a fully integrated one, utilizing data on the abundance of prey available to fish in the CRE, the apparent food habits as indicated by stomach content analysis, and indicators from the fish themselves, including isotopes, growth and condition, and body composition”—PEP 2001

Bottom line—don’t just measure trends in lower trophic levels…figure out what foods are available, what fish are actually eating, and whether food availability/quality is affecting fish growth, condition, etc.

PEP & SA Recommendations

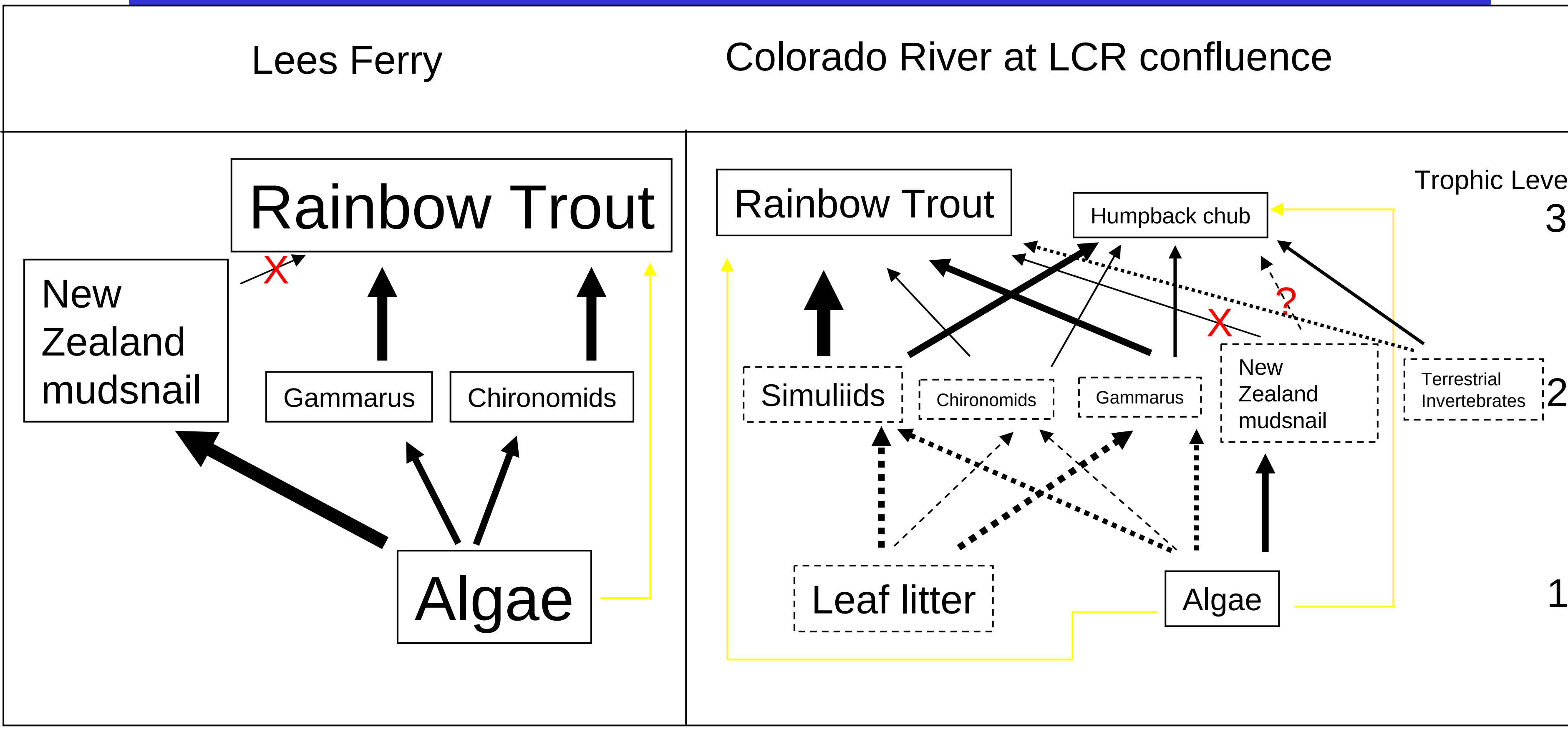
"3.c. It is recommended that GCMRC draft an RFP for release for FY 2005 on aquatic food base science activity. The open RFP should identify a specific research effort for immediate startup that determines most efficient and useful approaches for long-term monitoring/trends of the aquatic food base. This effort should involve stable isotope analysis of food web [linkages] from the trophic base (detritus, algae) to invertebrates, to fish, i.e. HBC, that would help identify the energetic base in this system for production at higher trophic levels"—SA Review of Food Base Program 2004.

Bottom line—Determine what the aquatic food base is, then determine what the most appropriate monitoring metrics are.

Conclusions

- Previous research
  - Documented downstream and seasonal patterns in some foodbase components
  - Documented impacts of fluctuations and BHBF, which provides basis for speculations on MLFF and monthly volumes
  - Resolved trophic linkages at LF
- Future directions
  - Integrated research that will clarify trophic linkages in LF and downstream locations
  - Will provide the basis for developing new monitoring protocols that accurately characterize availability of food for both native and non-native fish in the CRE

What is the Aquatic Food base?



PEP & SA Recommendations

"3.f. These new proposed [research directions] (food web analysis using multiple stable isotope signatures) are significantly complex, especially when combined with the vagaries of the research environment. The SAs strongly believe that input from a mid-career to senior level ecosystem ecologist needs to be available to the GCMRC staff, either through the RFP process or possibly as a staff position."—SA Review of Food Base Program 2004.

Bottom line—Conducting this research via a competitive RFP process will allow us to get high quality research *and* substantial input from experts in the field.