Linking whole-system carbon cycling to quantitative food webs in the Colorado River

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Colorado River food web

Altered from changes in physical habitat from GC dam

Invaded by New Zealand mud snail

Changes in productivity and edibility of basal food resources will impact productivity of native and exotic fishes

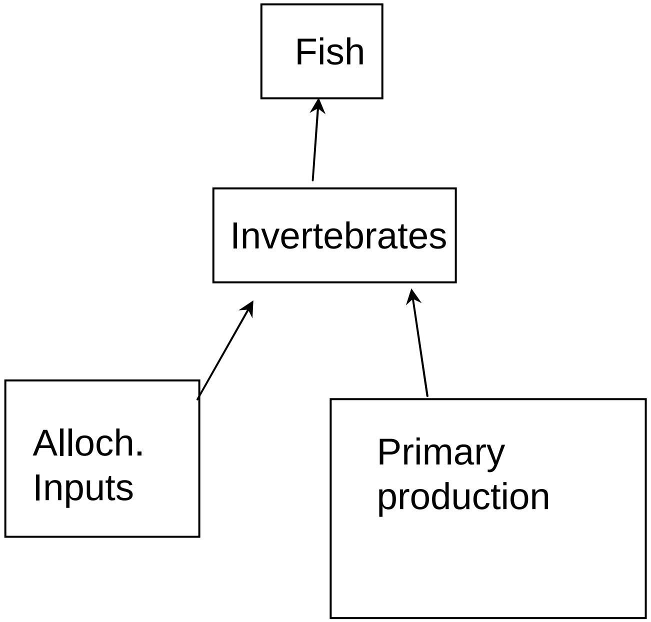
Need to monitor food web flows to assess future changes from invasions or dam management

Questions

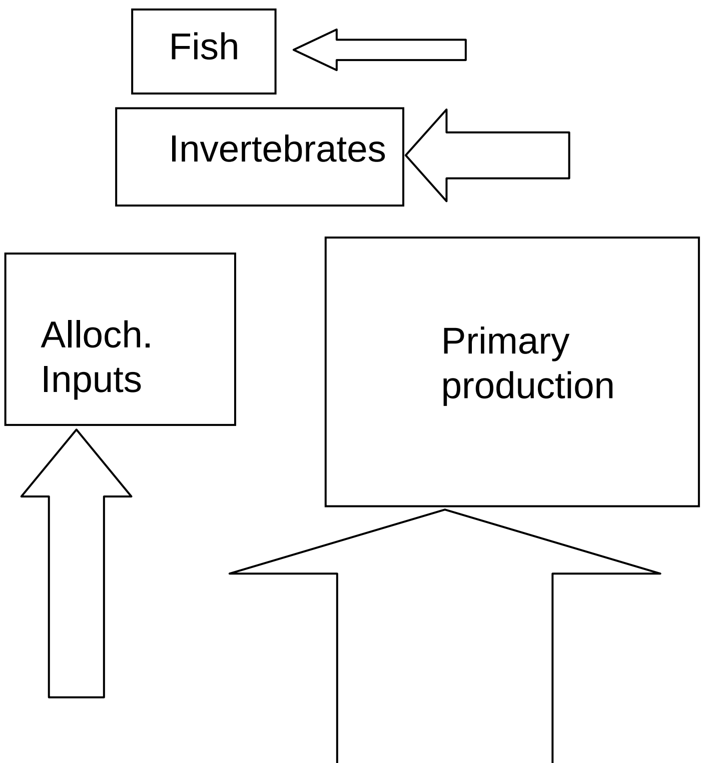
1. To what degree are native fishes food limited? Is there enough energy at the base of the food web to support a large population of fishes?

2. How do patterns of carbon flow through the food web affect native fishes? That is, how much carbon is flowing through exotic (and possibly unedible) snails, and how much carbon flows to exotic trout?

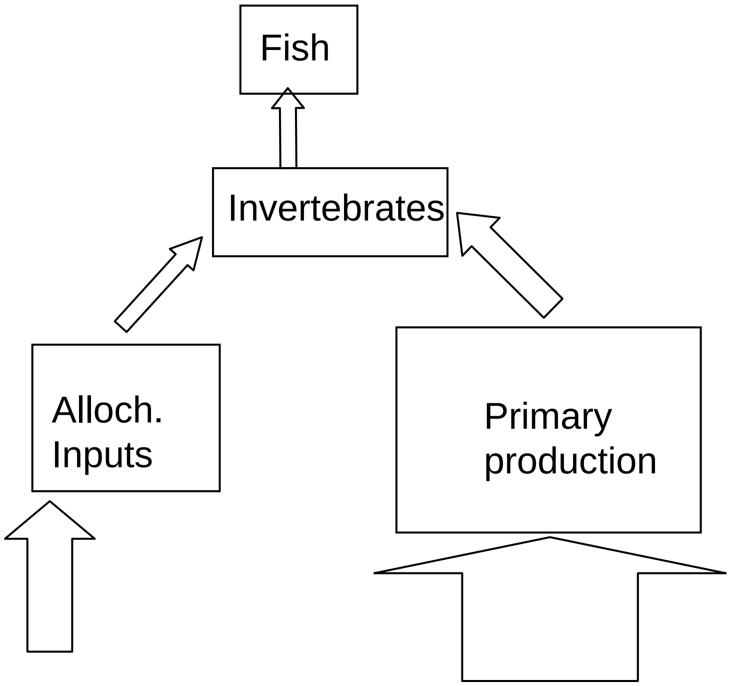
Both of these questions require an energetic approach.



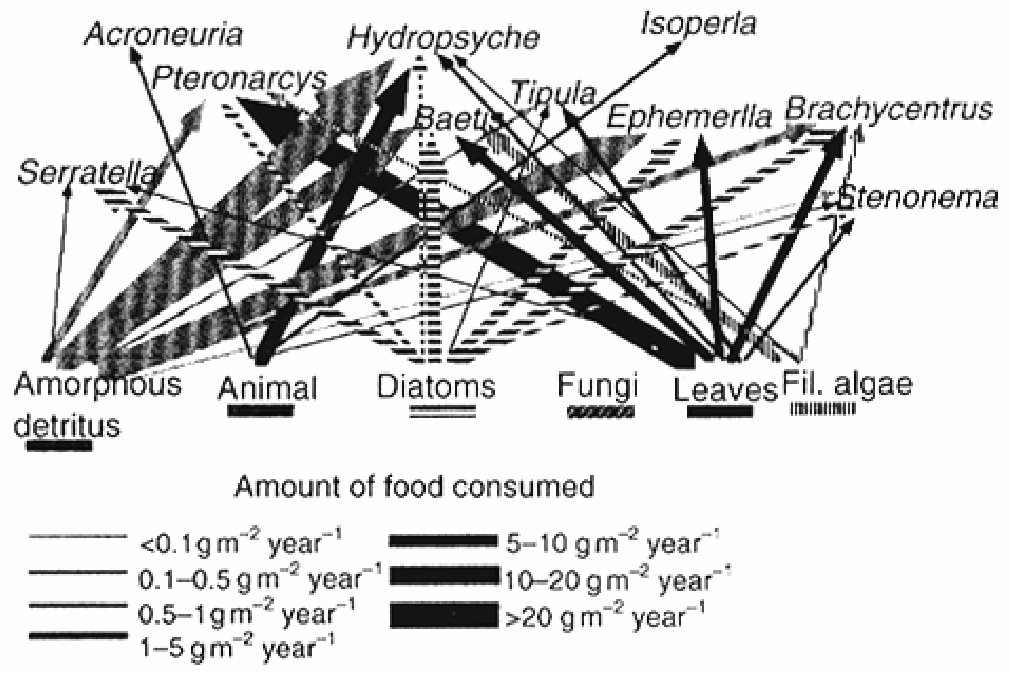
Linkage-based web. This food web is based on diet and/or isotopes to evaluate food sources. Both of these approaches can estimate the relative use of one food source vs. another (e.g. percent autochthonous vs. allochthonous contribution), but they do not measure flows.



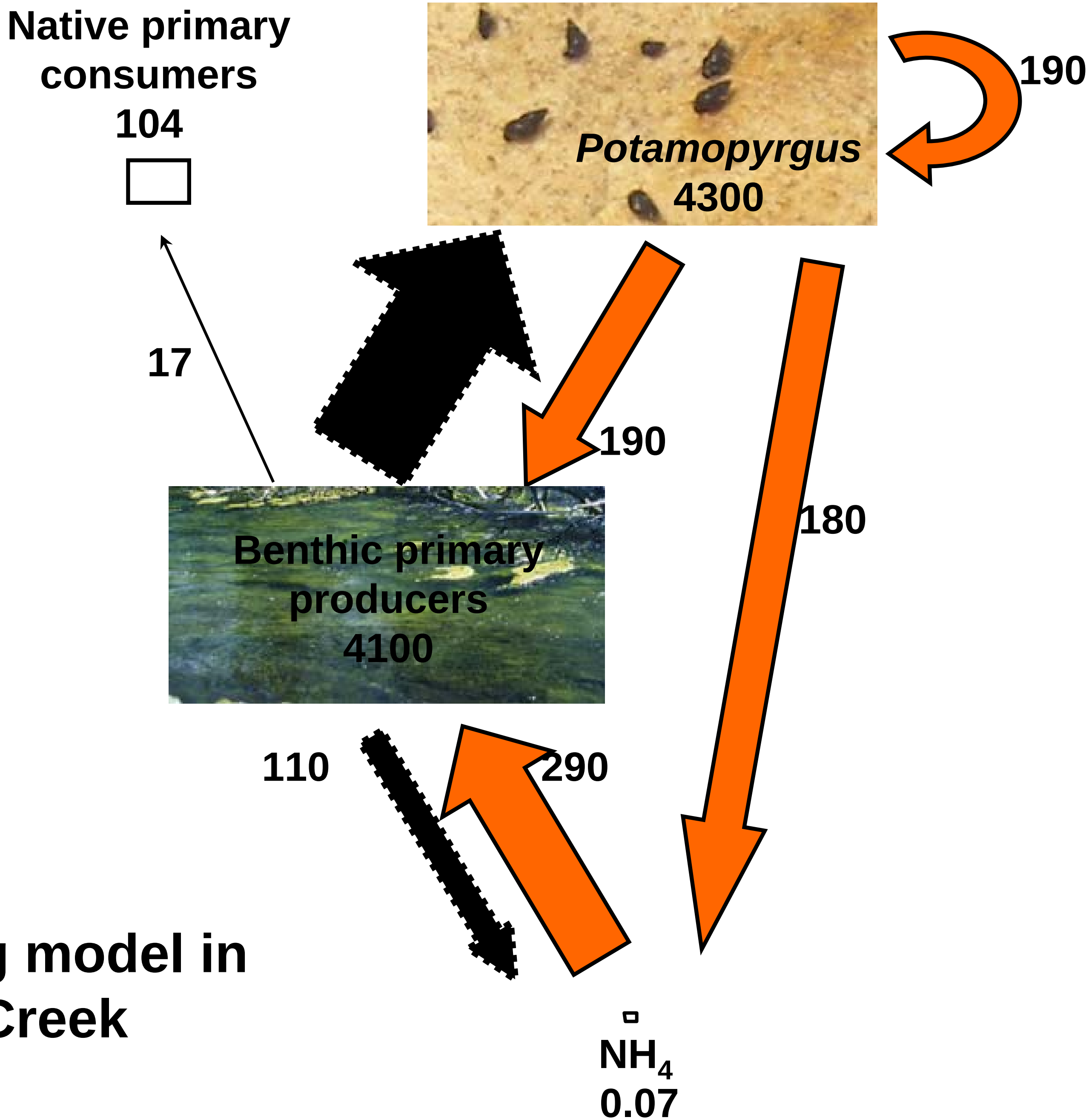
Primary and secondary production. This method can accurately calculate flows of energy through a population of animals or through the primary producer trophic level but in absence of any other information it cannot describe flows between trophic levels.



Trophic basis of production methods. This method combines the top two approaches to describe flow between components of the food web. It is not limited to strict trophic levels but can be resolved to individual species of animals



A example of the high-resolution food web that can be estimated using this method. From Rosi-Marshall and Wallace (2002).



N cycling model in Polecat Creek

Objectives:

1. Measure inputs, stocks, outputs, and transport of organic matter in the Colorado River.

2. Measure secondary production of invertebrates.

3. Quantify organic matter flow in the Colorado River food web from basal resources to fishes.

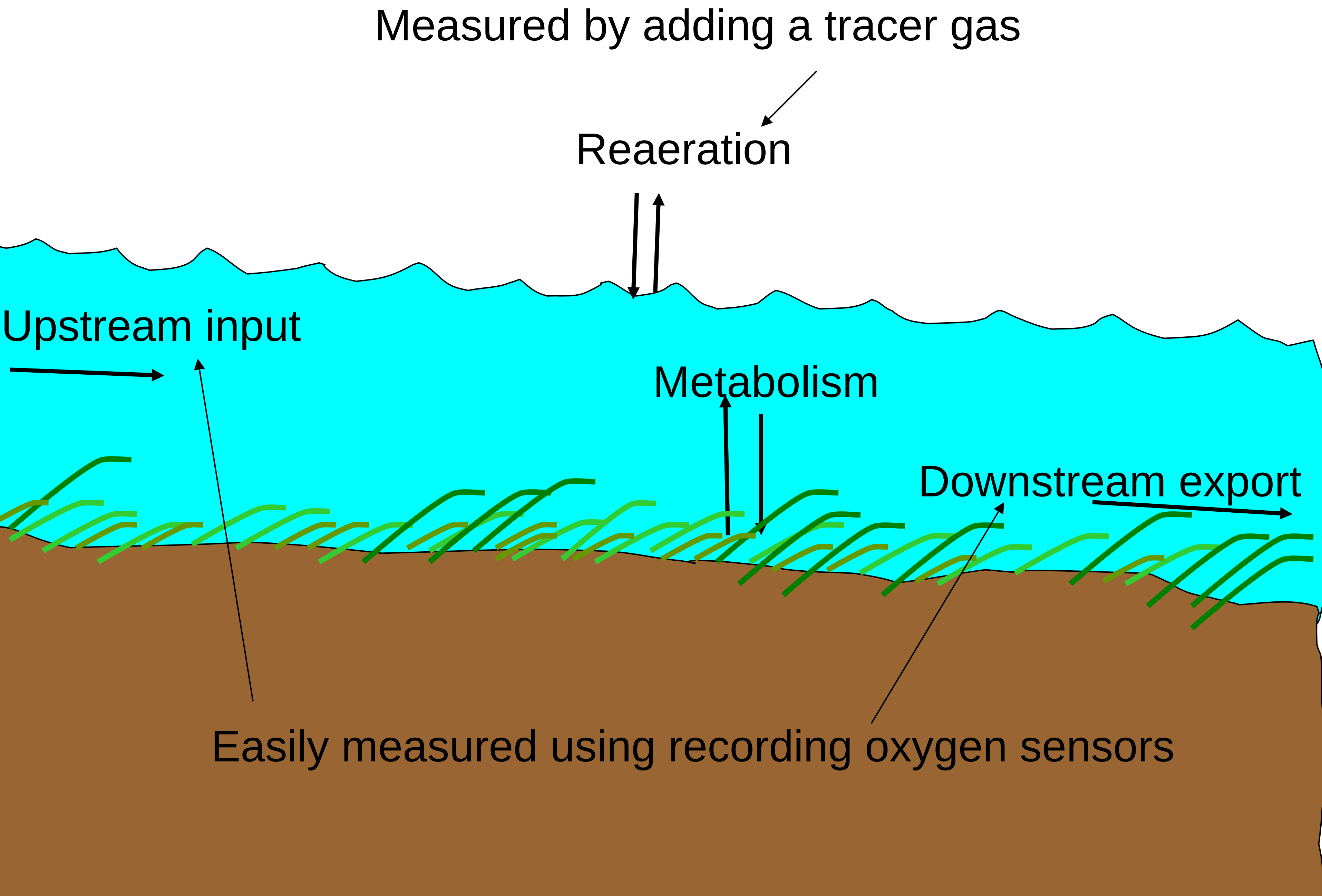
Measure inputs, stocks, outputs, and transport of organic matter in the Colorado River.

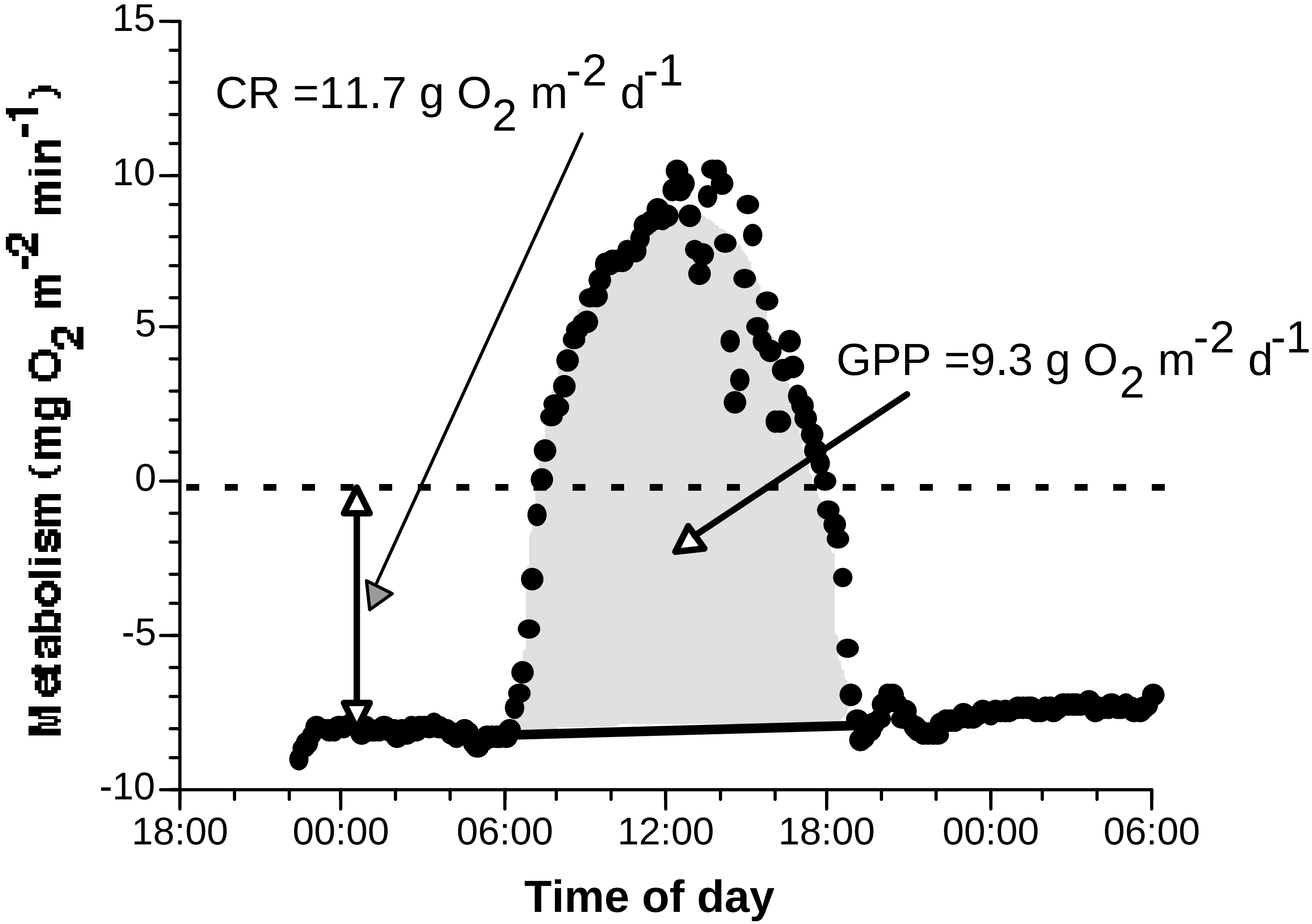
1. Reach scale photosynthesis and respiration

2. Measure allochthonous inputs

3. Measure longitudinal transport to estimate upstream/ downstream linkages

An oxygen budget for a stream reach





CR =11.7 g O2 m-2 d-1
GPP =9.3 g O2 m-2 d-1
Metabolism (mg O2 m-2 min-1)
15
10
5
0
-5
-10
18:00
00:00
06:00
12:00
18:00
00:00
06:00
Time of day

Objective 2.
Measure secondary production of invertebrates.

Monthly sampling at Lees Ferry and Diamond Creek.
Quarterly sampling at 4 sites with Grand Canyon

At each site measure abundance and biomass of invertebrates

Production calculations

Secondary production is biomass * growth rate

Gammarus: Size frequency methods

Black flies, *Potamopyrgus*, midges: Instantaneous growth methods. Empirically measure growth rates, multiply by biomass.

Fish: Bioenergetics models using measured biomass

Objective 3. Quantify organic matter flow in the Colorado River food web from basal resources to fishes

Fraction of production from food type *i*

Assimilation efficiency of food type *i*

$$F_{ij} = (B_i * P_j) / (AE_i * NPE)$$

Production of consumer *j*

Net production efficiency (0.4)

Flow from food type *i* to consumer *j*
mg AFDM m^{-2} d^{-1}

How to estimate B_i?

C Isotopes

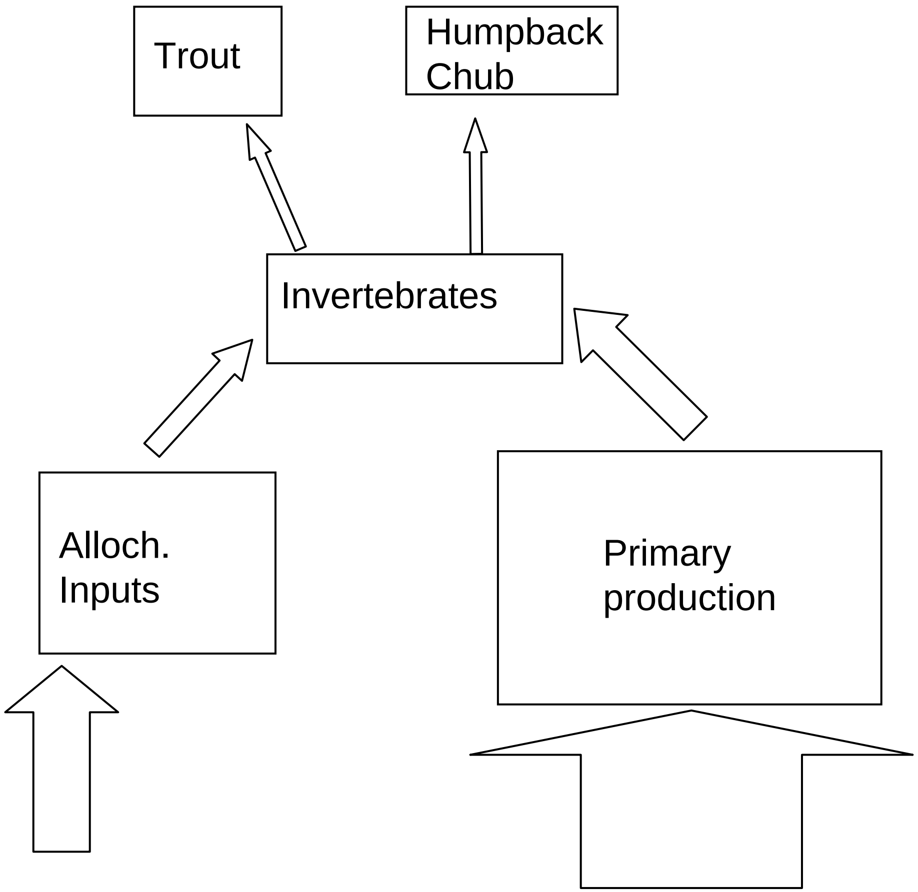
-don't need to assume assimilation efficiencies
-integrates over longer time scales
-but only works for 2 food sources (e.g. algae vs terrestrial inputs)

Gut contents

-must assume assimilation efficiencies
-works for many food sources

Amount of food type i in gut ↙

$$B_i = (G_i * AE_i) / \Sigma G_i = 1, \ldots, n$$



This energy flow food web will enable predicting how physical and biological changes in the food web affect native fishes:

Changes in wtaer temperature

Mechanical removal of trout

Reduction of primary production from suspended sediment