Overview of how we will be tracing sources/sinks of organic matter and nitrate using isotopic techniques in several new DO-related projects

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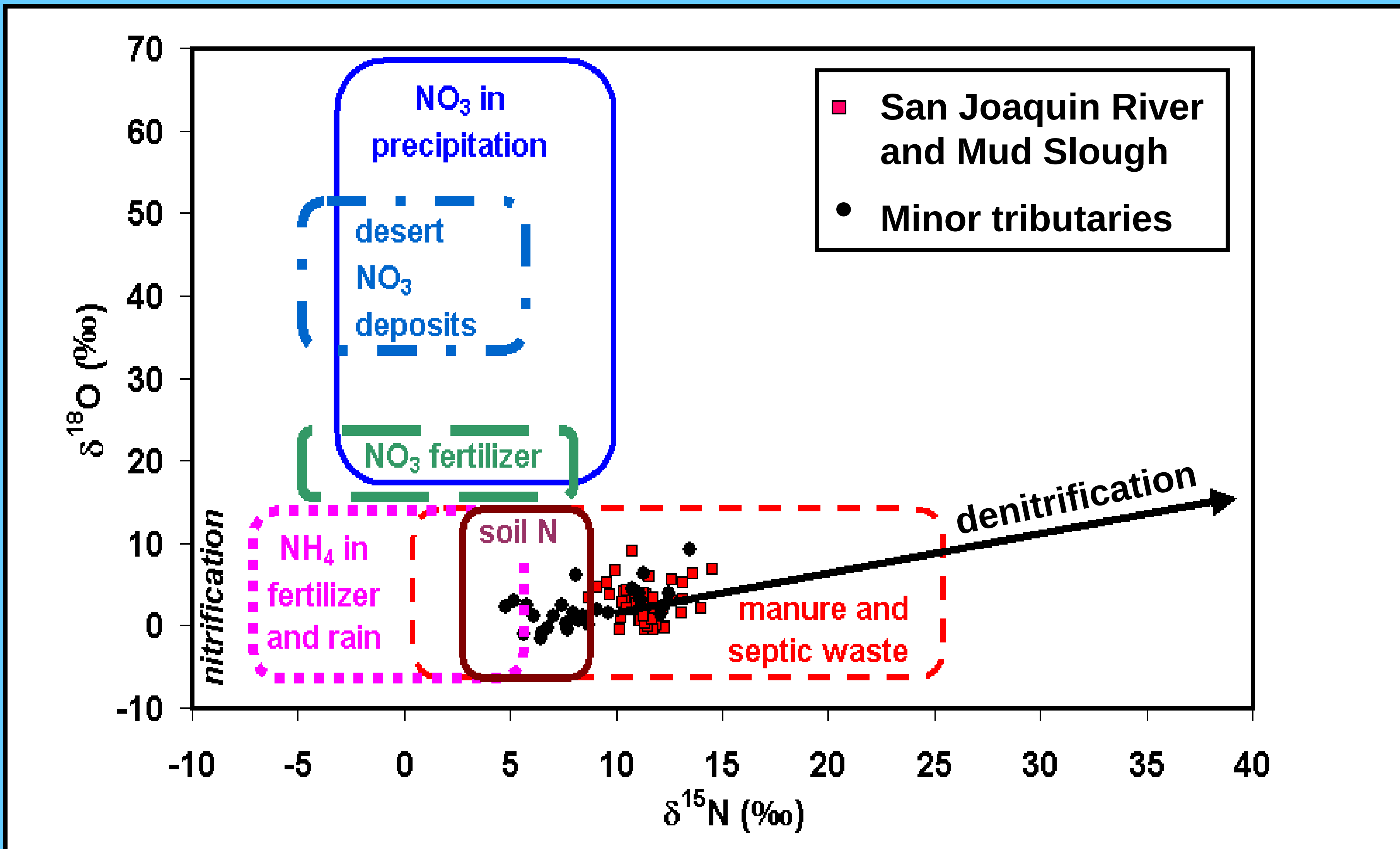
How do isotopes help trace sources of nitrate and organic matter ?

Sources and sinks can often be identified, traced, and semi-quantified because:

- nitrate and organic matter derived from different sources and land uses often have distinctively different isotope compositions, and
- different kinds of sinks can sometimes cause distinctive shifts in isotopic compositions.

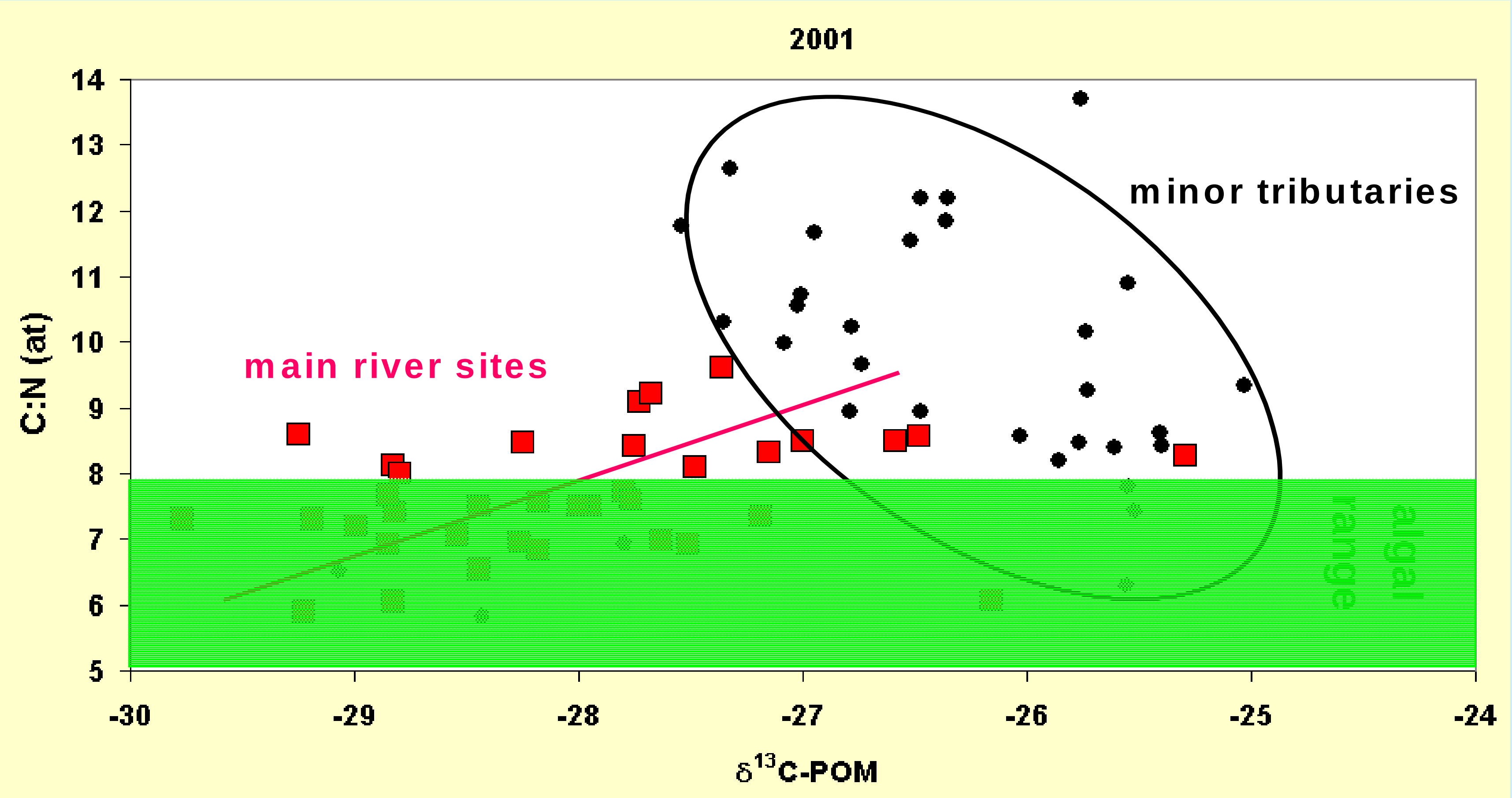
In other words, different sources of nitrate and organic matter often have distinctive isotope “fingerprints” that can provide a better understanding of the system than just using mass balance “black box models”.

The $\delta^{18}O$ and $\delta^{15}N$ values of nitrate in San Joaquin River samples



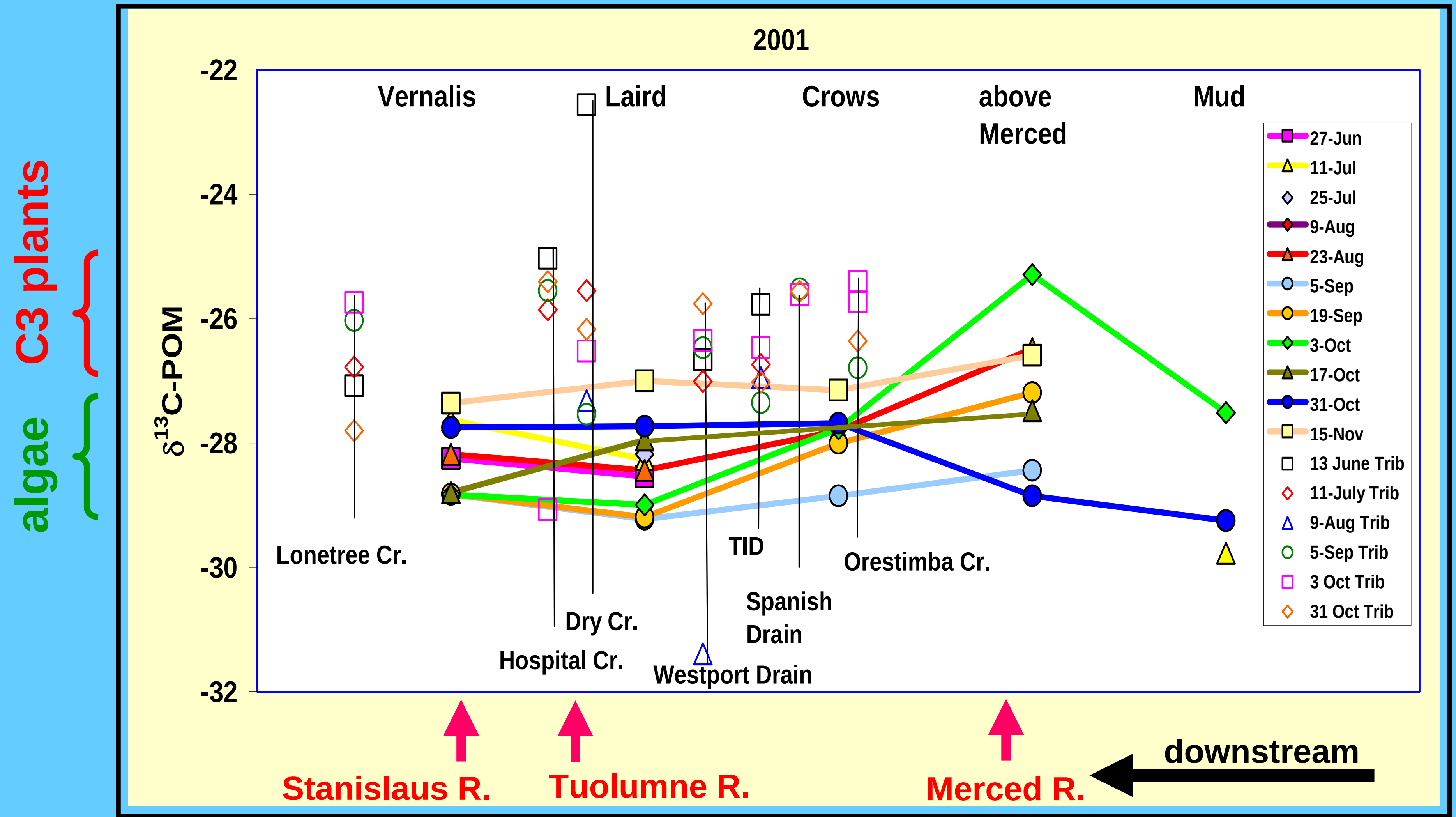
(Kratzer et al., 2003)

The POM from main SJR sites has lower $\delta^{13}C$ and C:N values than at tributary sites. The trend line suggests mixing of riverine algae and terrestrial debris in the SJR



Therefore, the terrestrial soil derived from the tributaries is not a major source of POM to the main river sites, which are dominated by algae.

The POM in the minor tributaries generally has a higher $\delta^{13}C$ than that in the San Joaquin River



Therefore, the POM from the minor tributaries is not a major source of POM to the main river sites, which are dominated by algae.

What substance is causing most of the O demand?

BOD

type

ammonium | DOM | POM

source

wetlands | sewage | CAFO | terrestrial | algal | terrestrial | algal

mechanism

surface runoff | tributaries | groundwater | in-stream production

Isotope tools we are applying in our SJR studies

Tracers of NO_3 sources and sinks:

$\delta^{15}N$, $\delta^{18}O$, $\delta^{17}O$

Tracers of NH_4 sources and sinks:

$\delta^{15}N$

Tracers of POM and DOM sources and sinks:

$\delta^{15}N$, $\delta^{13}C$, $\delta^{34}S$

Tracers of O producing and consuming reactions:

$\delta^{18}O$ of O_2
$\delta^{13}C$ of DIC

Tracers of H_2O sources and sinks:

$\delta^{18}O$, $\delta^{2}H$

Tracers of PO_4 sources and sinks:

$\delta^{18}O$

Our involvement in applying various isotope tools to several past, current, and soon-to-start CALFED-funded projects:

DO TMDL-related projects:

- Kratzer's 2000-2001 study: "Sources of nutrients, organic matter, and Chl A to the lower SJR"
- Kendall's Task 7 of Stringfellow's Upstream DO TMDL project: "Characterization of BOD fractions and sources"
- Kendall's PIN 700 study: "Development of new isotope tools for assessing sources of nutrients and organic matter"
- Kratzer's PIN 755 study: "Groundwater nitrate inputs to the SJR"

Other Drinking Water Quality Program projects:

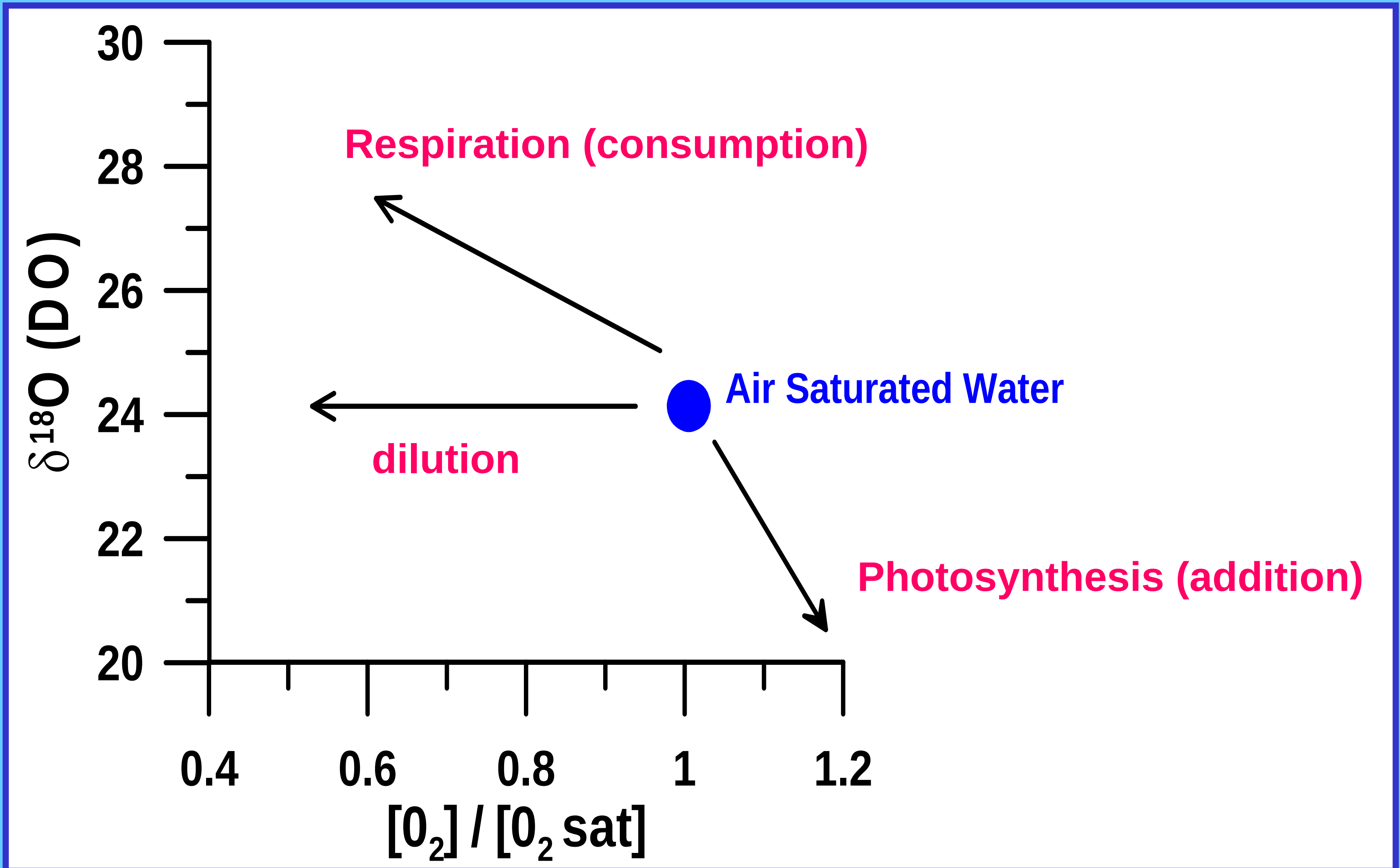
- Bergamaschi's 1999-2002 study: "Sources of DBPs to the Delta"
- Bergamaschi's 2004-2005 study: "Sources of DBPs to the SWP"
- Bergamaschi's PIN 396 study: "Management of DOC, DBP, and nutrient release from major agricultural land uses"
- Harter's PIN 708 study: "Risk of dairies and other non-point sources to groundwater"

Our different approaches for investigating the causes of low DO conditions

As part of 4 projects that are approved for funding, we plan to do the following over the next 3 years:

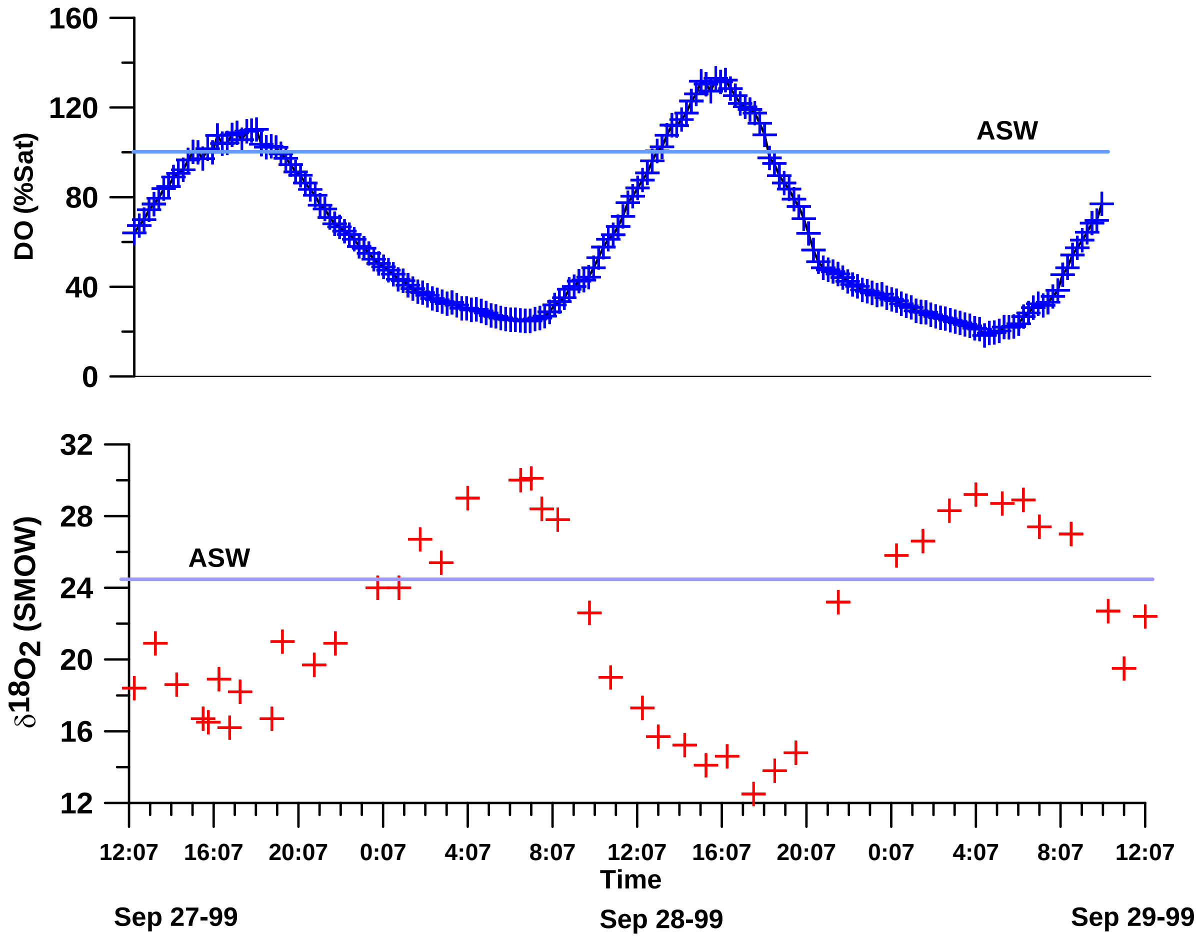
- **Add a complete suite of isotope measurements to the DO TMDL monitoring program, to evaluate the spatial and seasonal patterns biweekly for 3 years at 22 sites on the SJR and major tribs, and ~30 main sub-watersheds quarterly.**
- **Conduct quarterly transects along the entire SJR-Delta-Bay system (30-40 sites), coordinated with the DO TMDL monitoring.**
- **Add isotopes to detailed evaluation of the source of nitrate in groundwater that is leaking into the SJR, using transects and multi-level samplers (Kratzer)**
- **Add isotopes to detailed investigations of N sources and sinks at dairies at different locations, to better characterize the isotopic signature of dairy waste (Harter)**
- **Test some relatively new isotope techniques in the DWSC for "added value":**
  - **using the isotopic compositions of clams to monitor spatial and temporal changes in DO conditions and food sources,**
  - **mapping DO sources and sinks in the Stockton channel with DO-δ^{18}O,**
  - **analyzing the isotopes of the bacteria that are respiring the decayed algae in the channel to determine which specific types and sources of the algae are the ones most responsible for the low DO conditions.**

The $\delta^{18}O$ of DO reflects the ratio of productivity to respiration in the water column



(from Len Wassenaar, 2001)

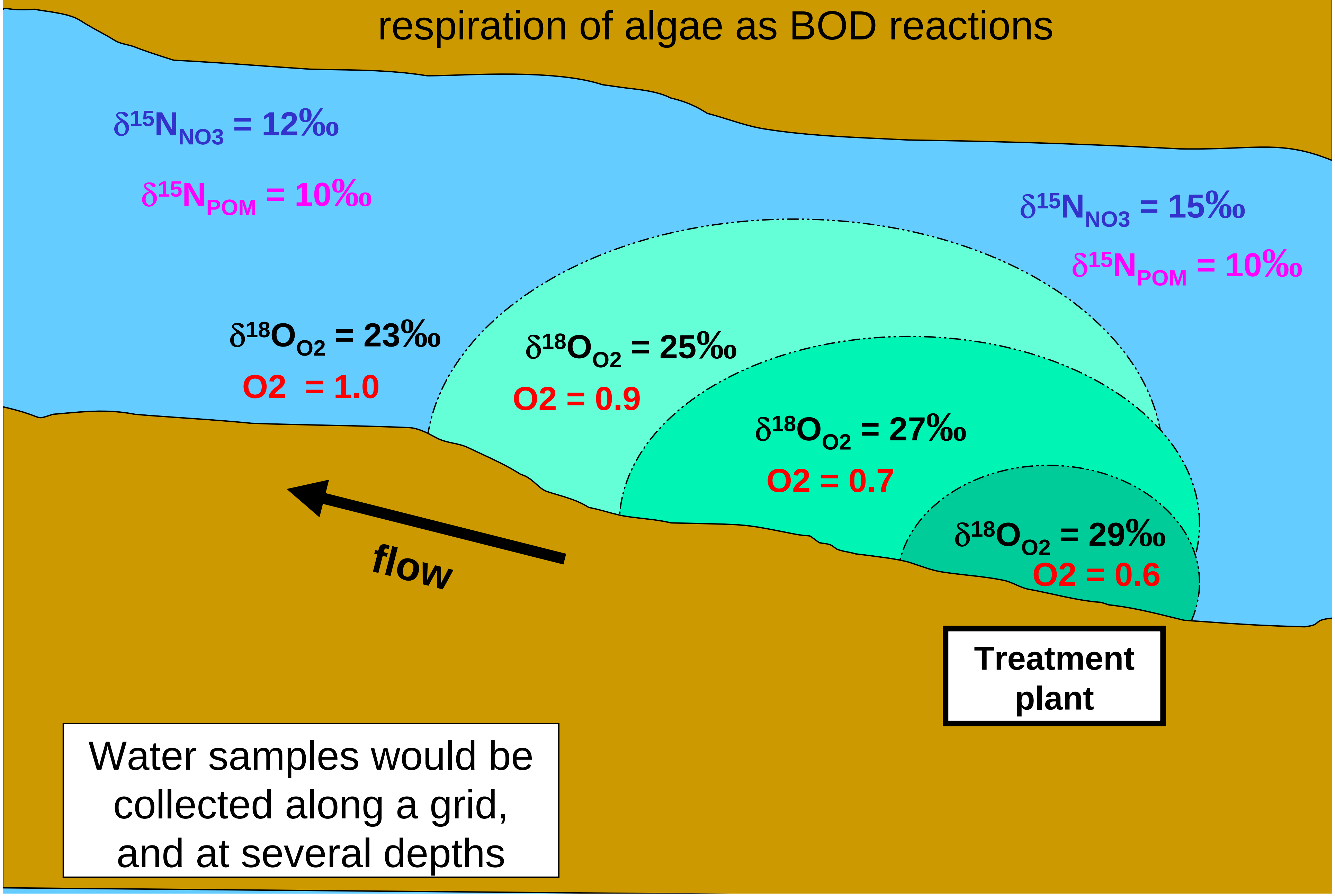
48-Hour Diel Cycle of DO concentrations and $\delta^{18}O$



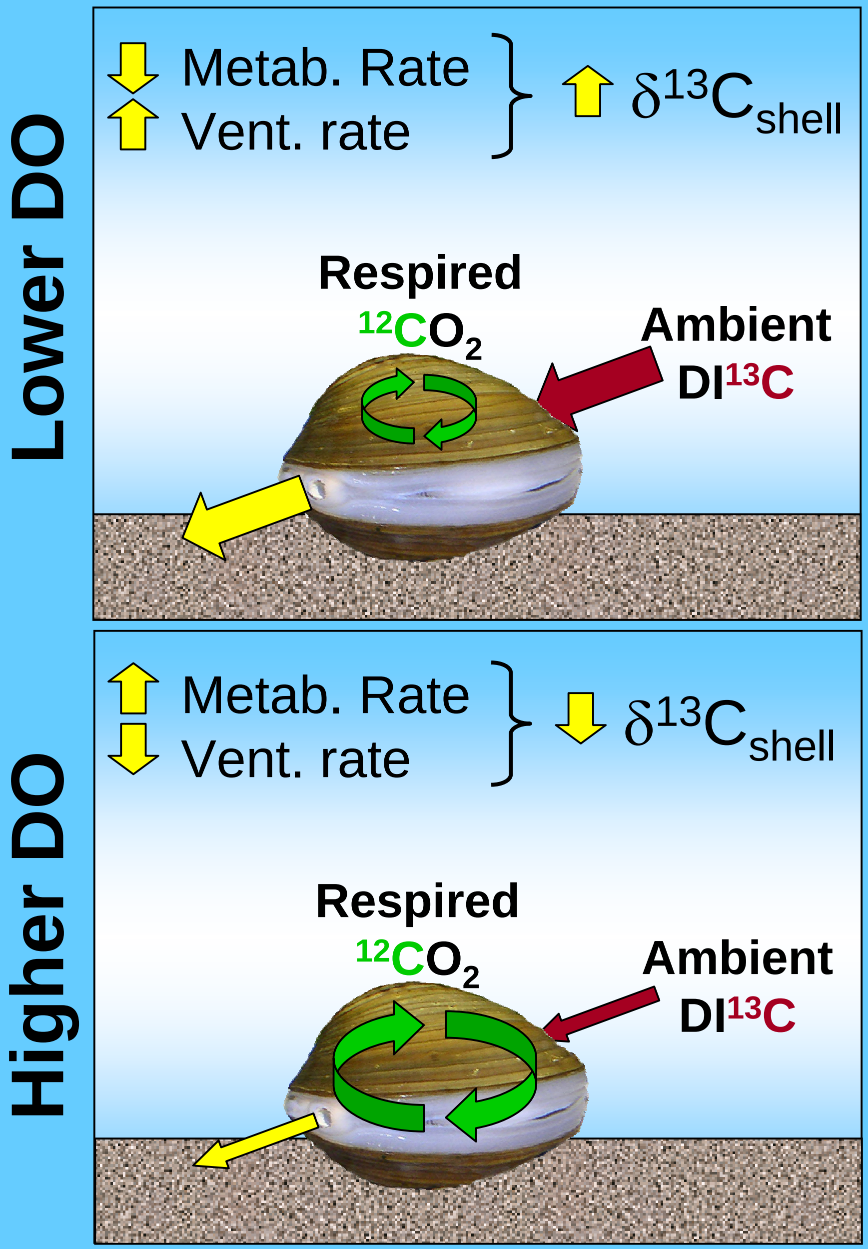
- Typical pattern found in small lakes and streams:
- 140 % range in O_2 saturation in 24 hours
- 17 ‰ range in $\delta^{18}O$ of DO over 24 hours

(from Len Wassenaar, 2001)

Cartoon showing how isotopic compositions of O2, NO3, and POM can be used to separate the effects of nitrification of ammonium vs respiration of algae as BOD reactions



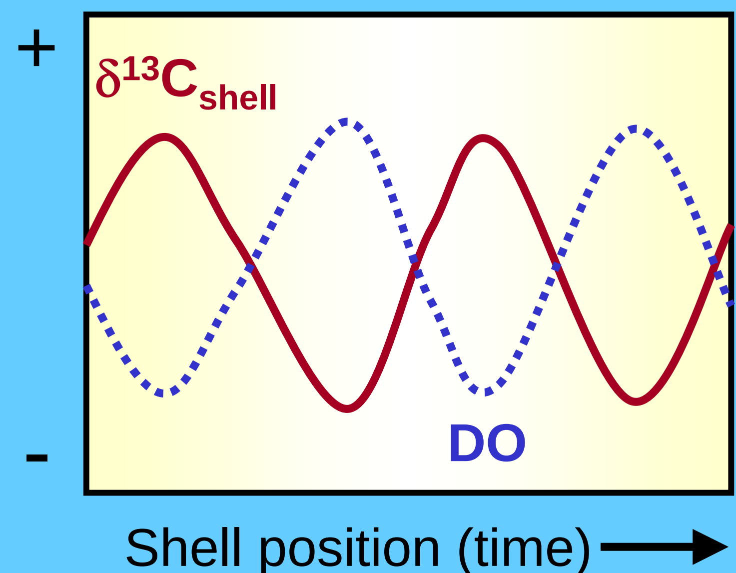
Clams as tracers of DO variations



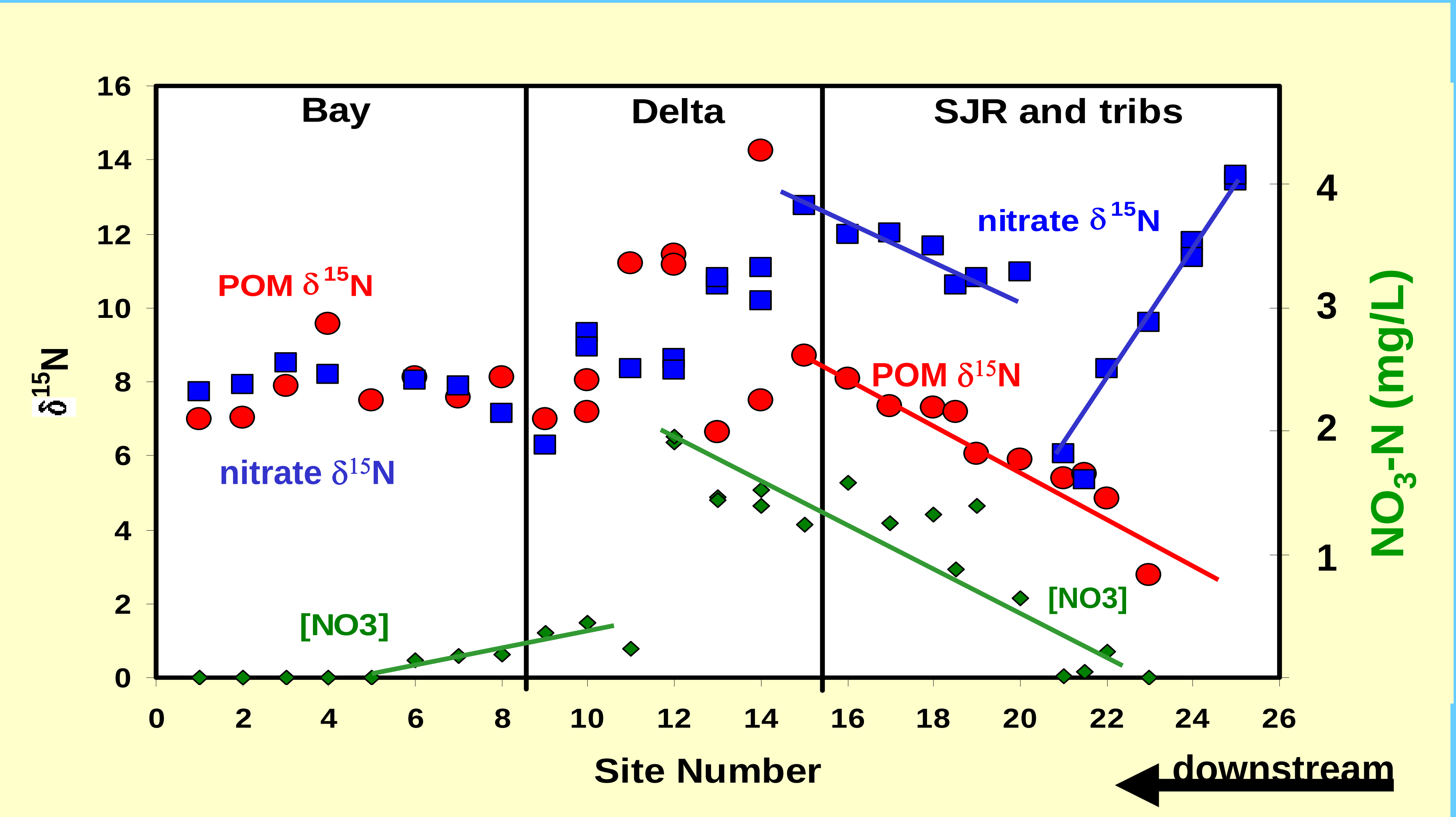
- Growth layers in clam shells record environmental history (~ 2-10 years)

- *Corbicula fluminea* adjusts its metabolic (ca. respiration) and ventilation (flushing) rates to maintain constant O_2 consumption

- Metabolic and ventilation rates influence the balance of ambient $DI^{13}C$ and respired $^{12}CO_2$ used by the clam to build shell $CaCO_3$, so **shell $\delta^{13}C$ should track relative bottom water DO variations**



The N isotope fractionation between NO_3 and POM (algae) is dependent on NO_3 concentration, and varies from ~ 0 ‰ in the Bay when NO_3 is low, to ~ 4 ‰ in the SJR and Delta when NO_3 is high.



The data are consistent with algae mainly growing in the SJR in contact with the observed nitrate