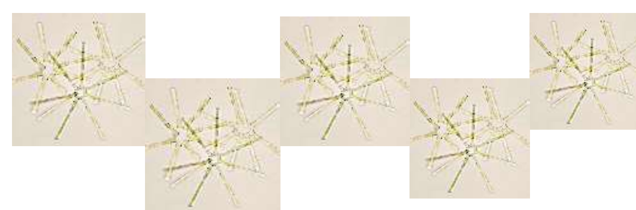
Offchannel Marsh Habitats

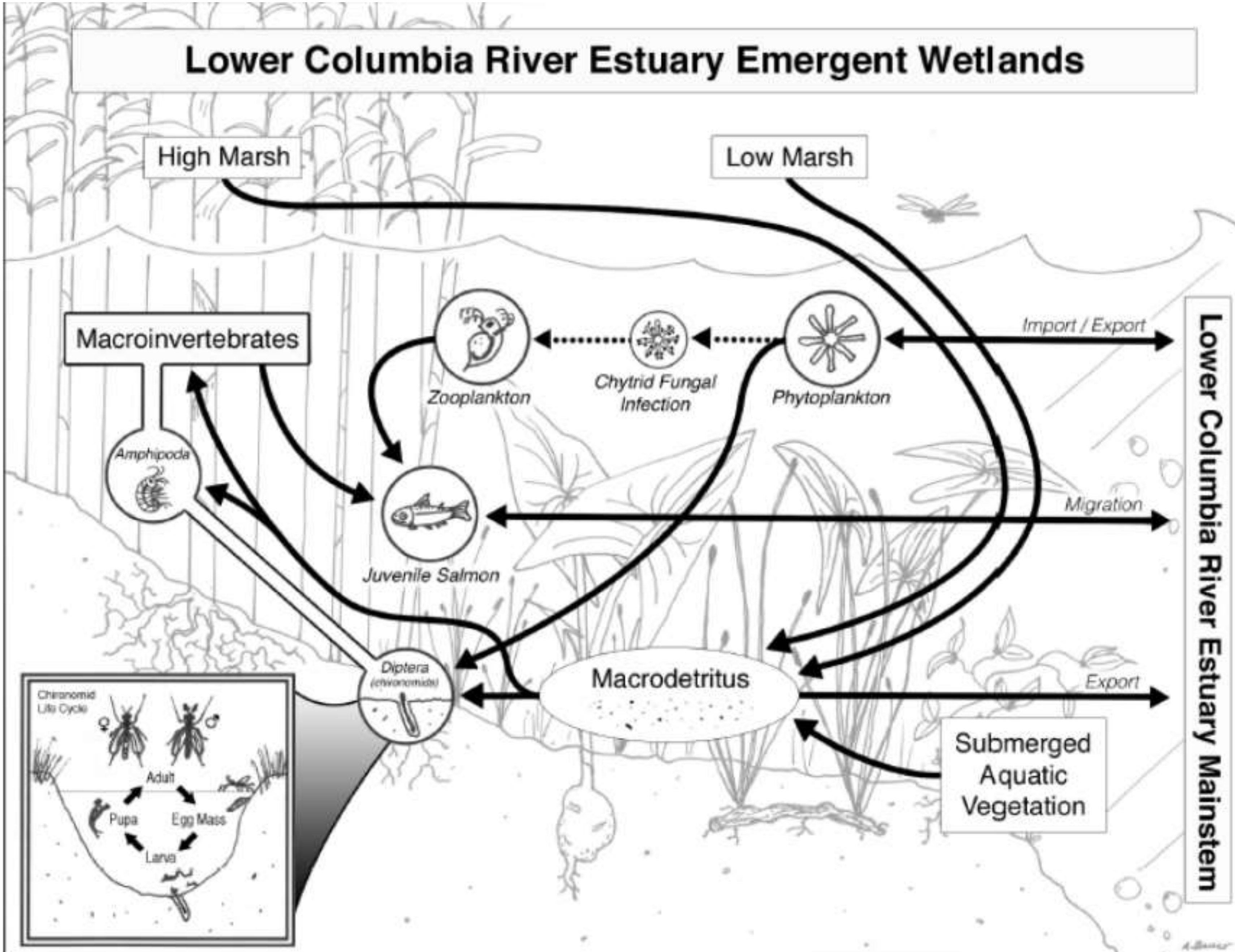
- Base of aquatic food web
- Juvenile Chinook diet inferred from natural abundance stable isotopes

Tawnya D. Peterson (OHSU)
& Estuary Partnership's EMP team

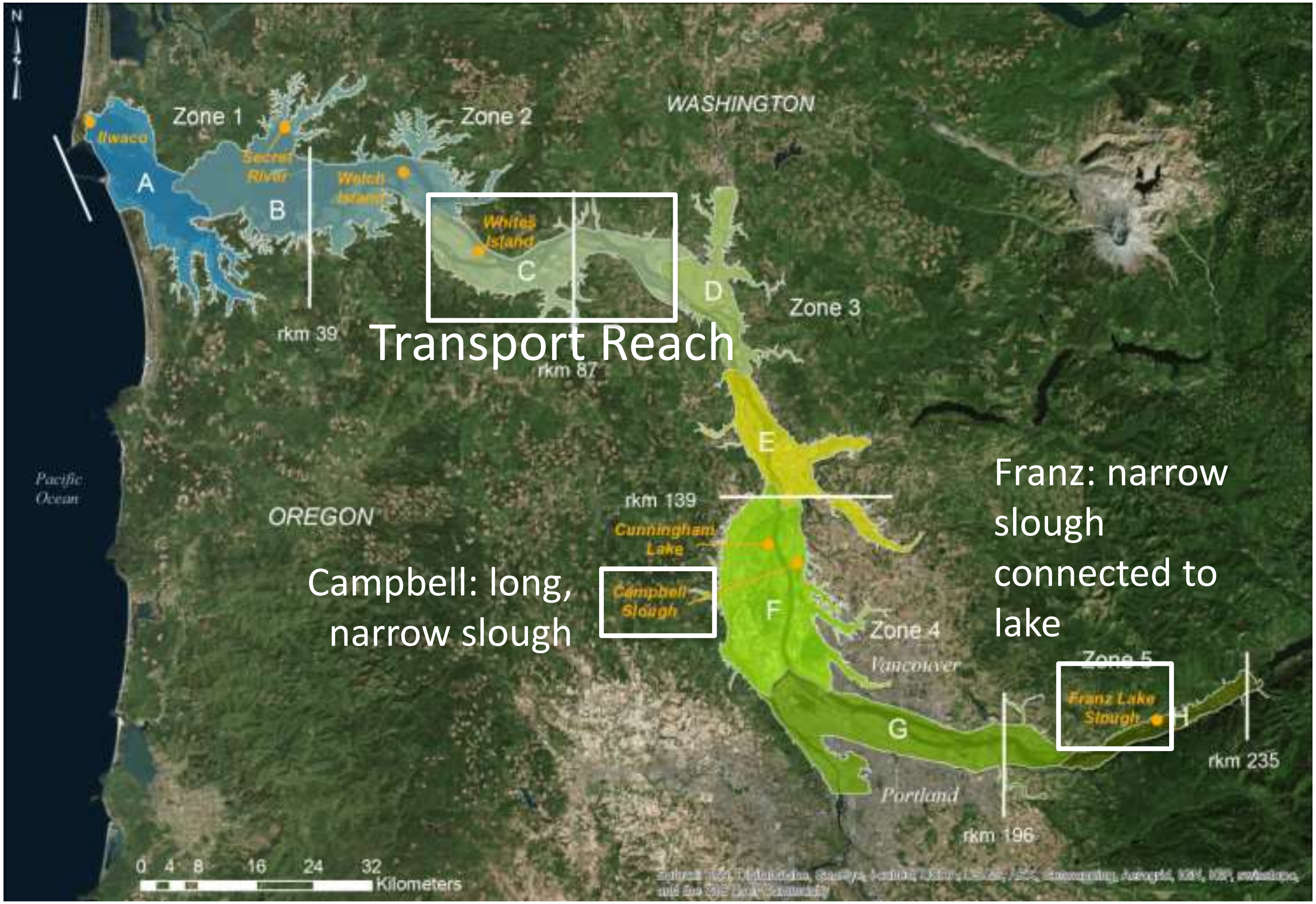
http://www.flycraftangling.com

https://ameblo.jp



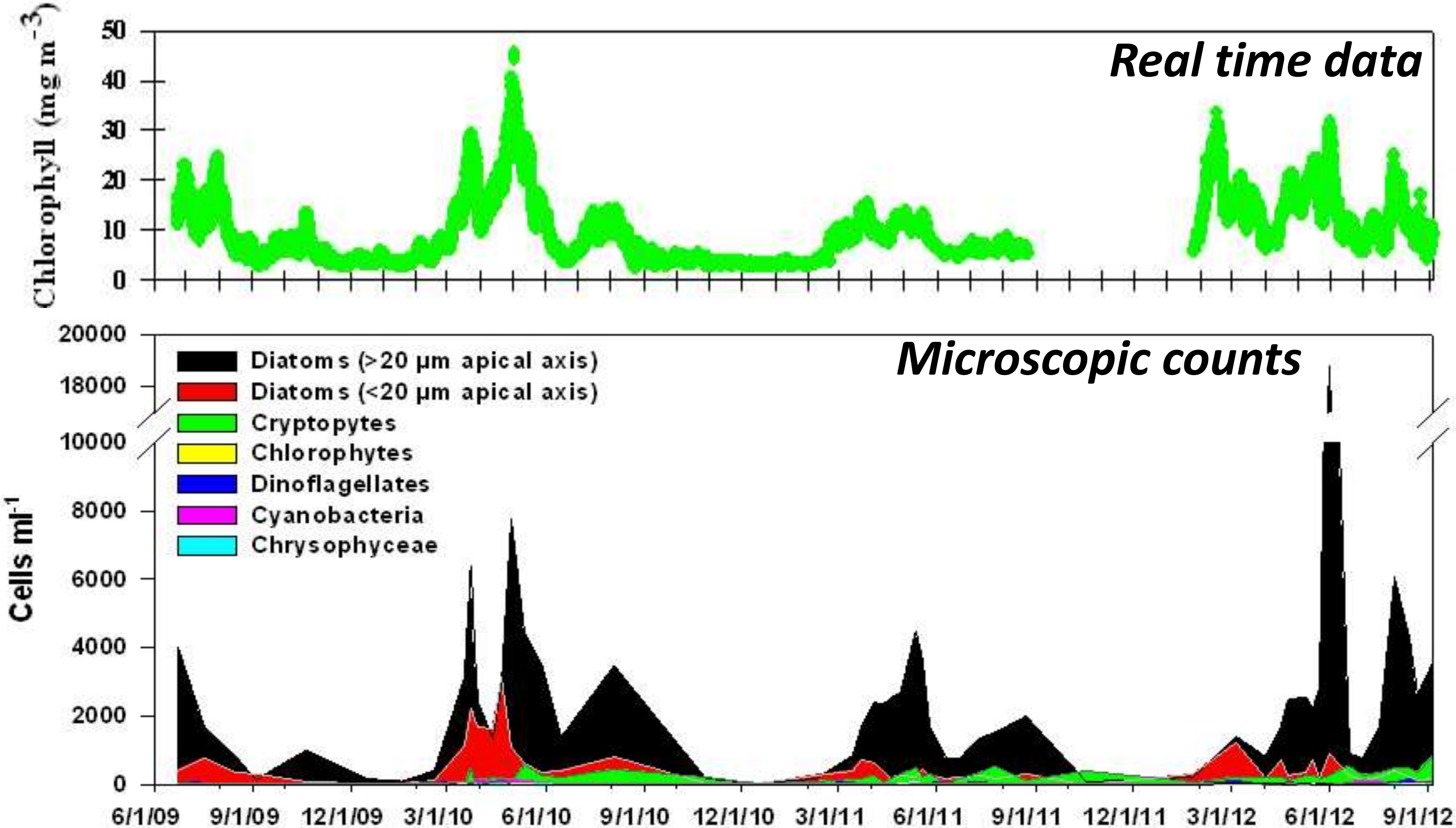


Lower Columbia River Estuary Emergent Wetlands
High Marsh
Low Marsh
Macroinvertebrates
Zooplankton
Chytrid Fungal Infection
Phytoplankton
Import / Export
Amphipoda
Juvenile Salmon
Migration
Diptera
Macrodetritus
Export
Submerged Aquatic Vegetation
Lower Columbia River Estuary Mainstem
Chironomid Life Cycle
Adult
Pupa
Egg Mass
Larva



Increasing tidal influence

Chlorophyll peaks are dominated by diatoms in the mainstem Columbia River



Maier, 2014

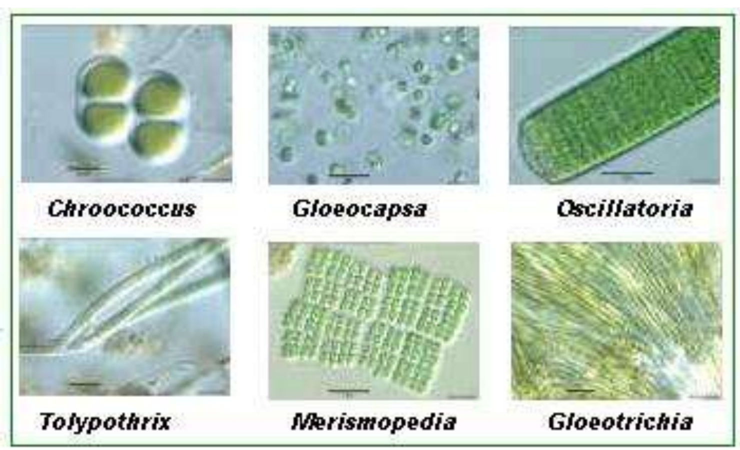
DIATOMS

http://www.daviddarling.info

Diatoms

- High polyunsaturated fatty acids
- High nutritional quality
- Dominate spring blooms
- Thrive under moderate to high turbulence

CYANOBACTERIA

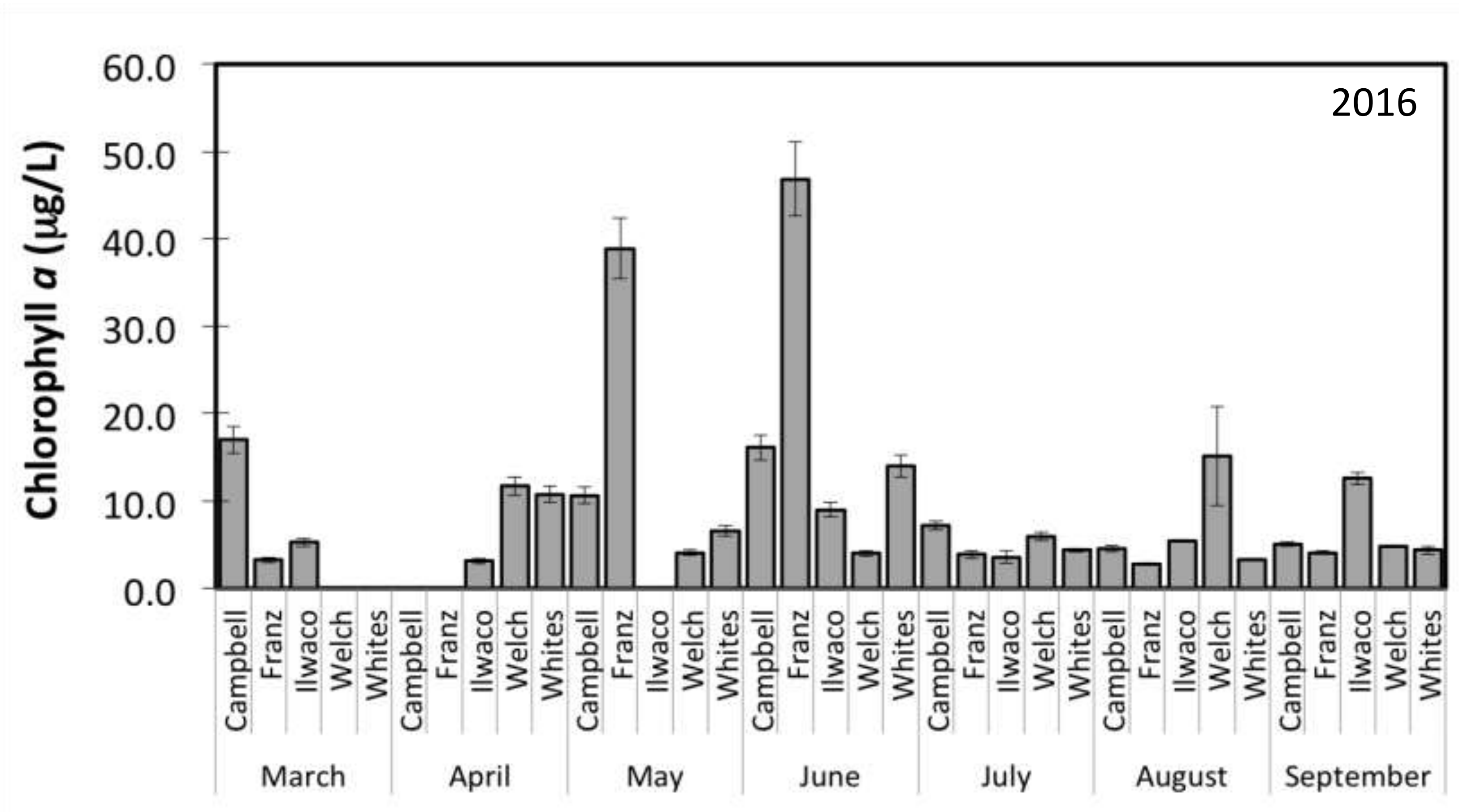


http://www.tutorvista.com

CHLOROPHYTES

Mark Lane, slideplayer.com

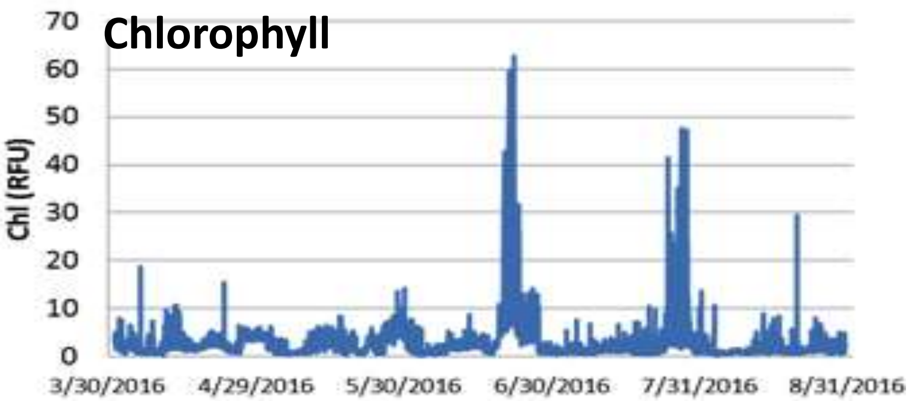
Peaks in total phytoplankton biomass tend to be highest at Campbell Slough and Franz Lake Slough

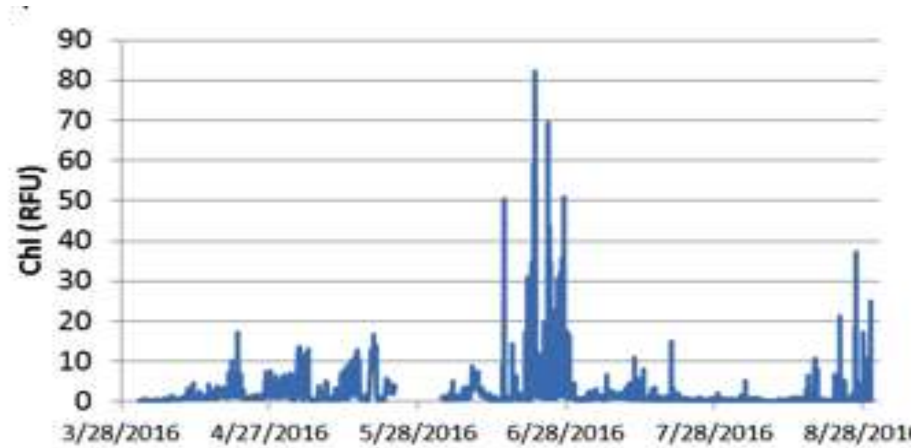


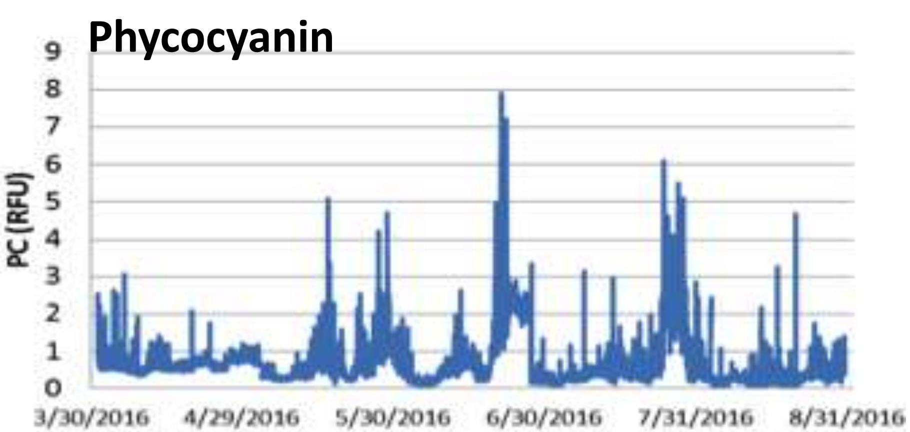
High resolution data show peaks in cyanobacteria pigments at Campbell and Franz

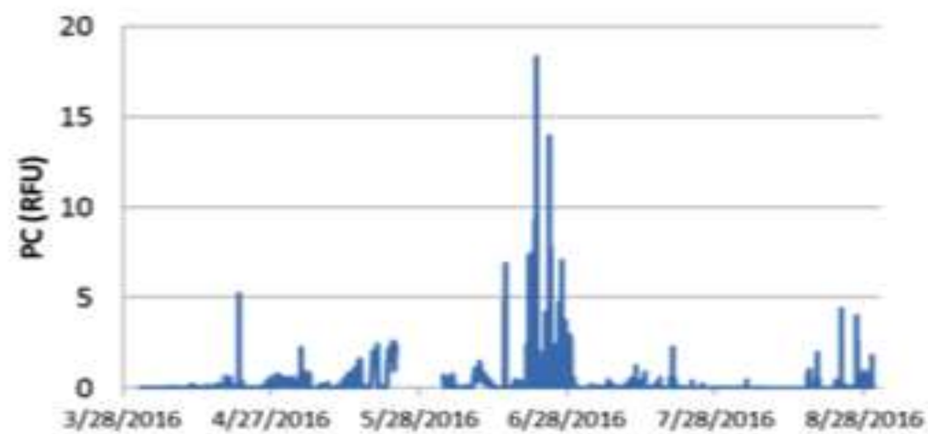
Campbell Slough

Franz Lake Slough

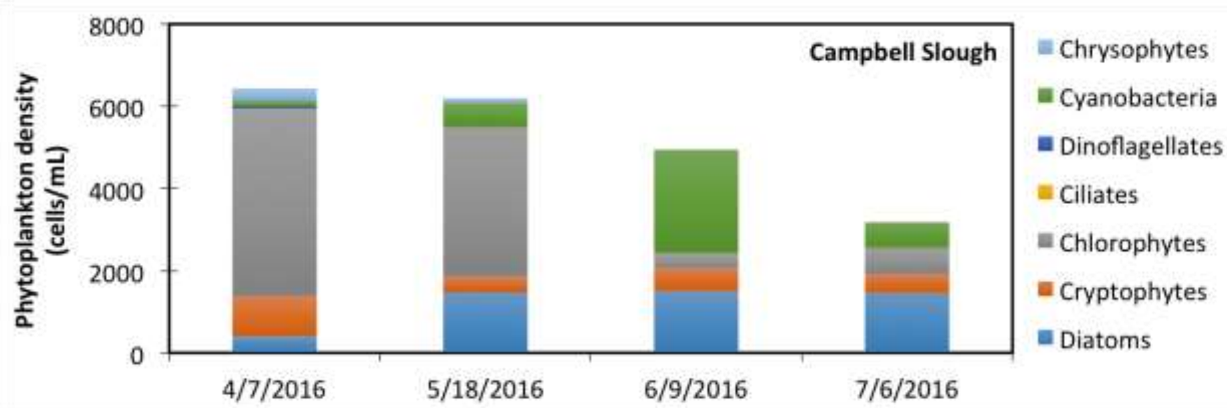


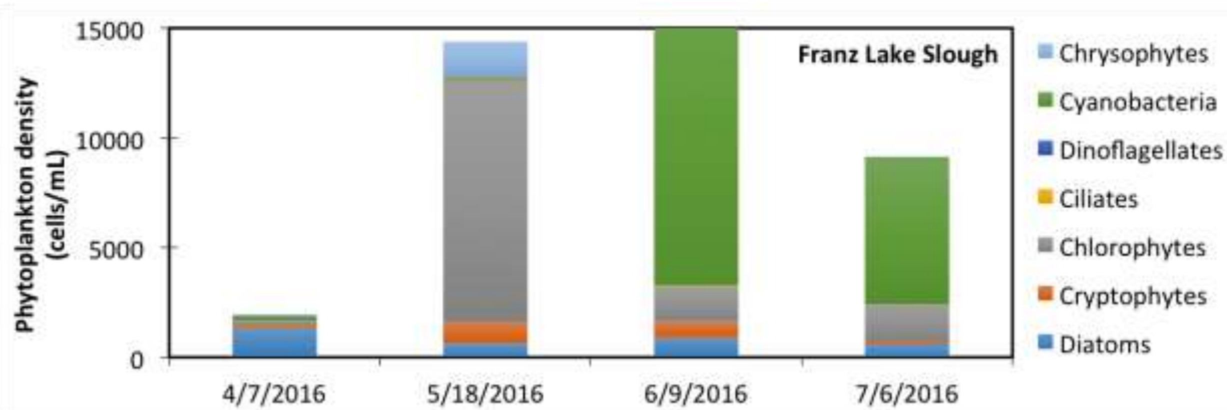




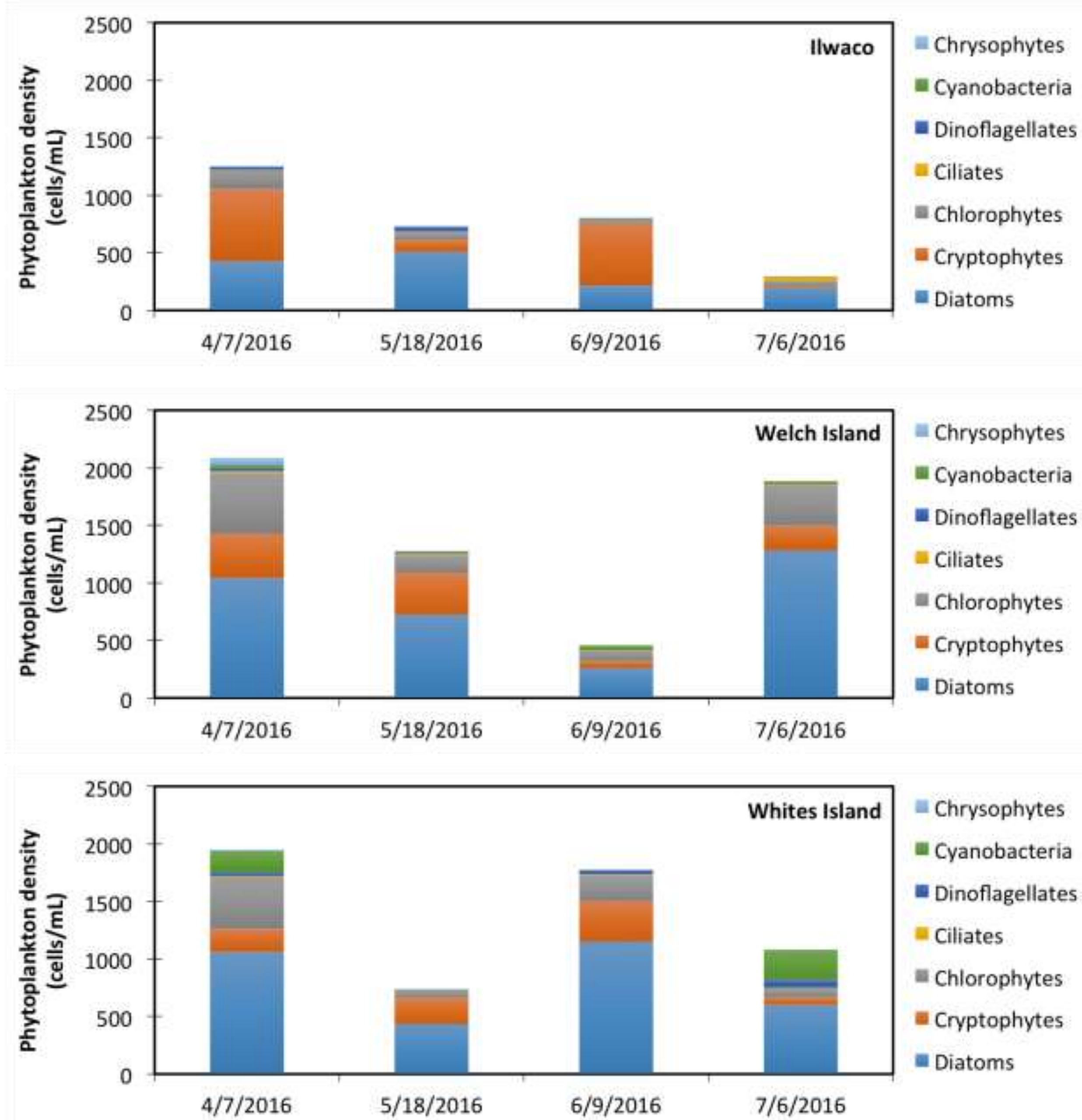


Chlorophytes and cyanobacteria dominate at Campbell and Franz

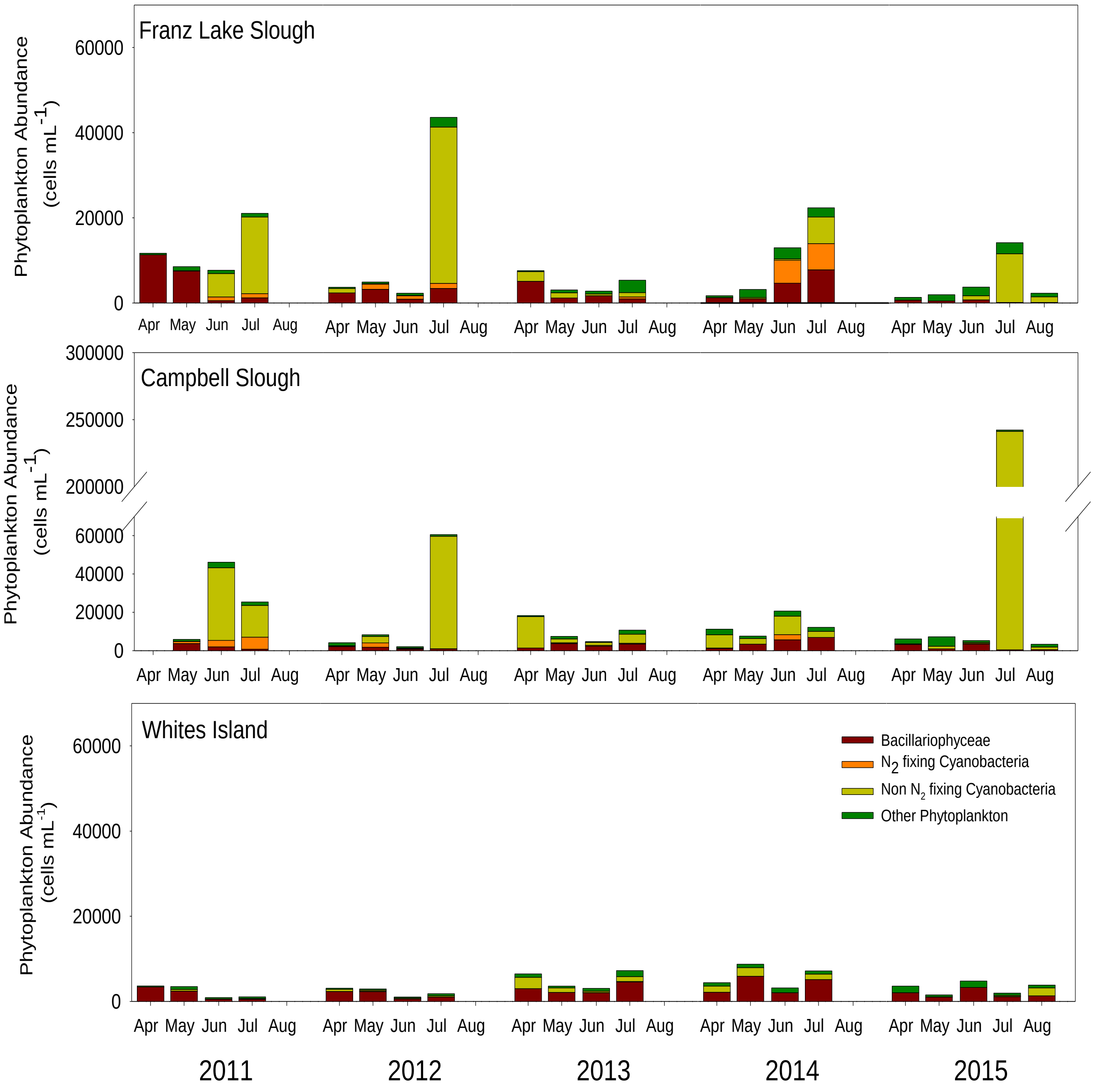




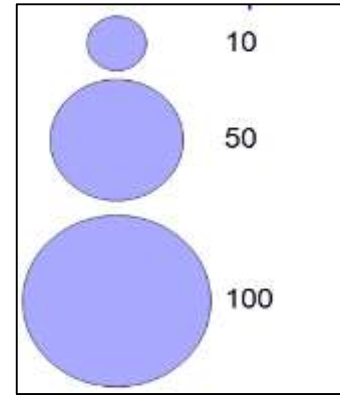
Diatoms dominate at Welch and Whites

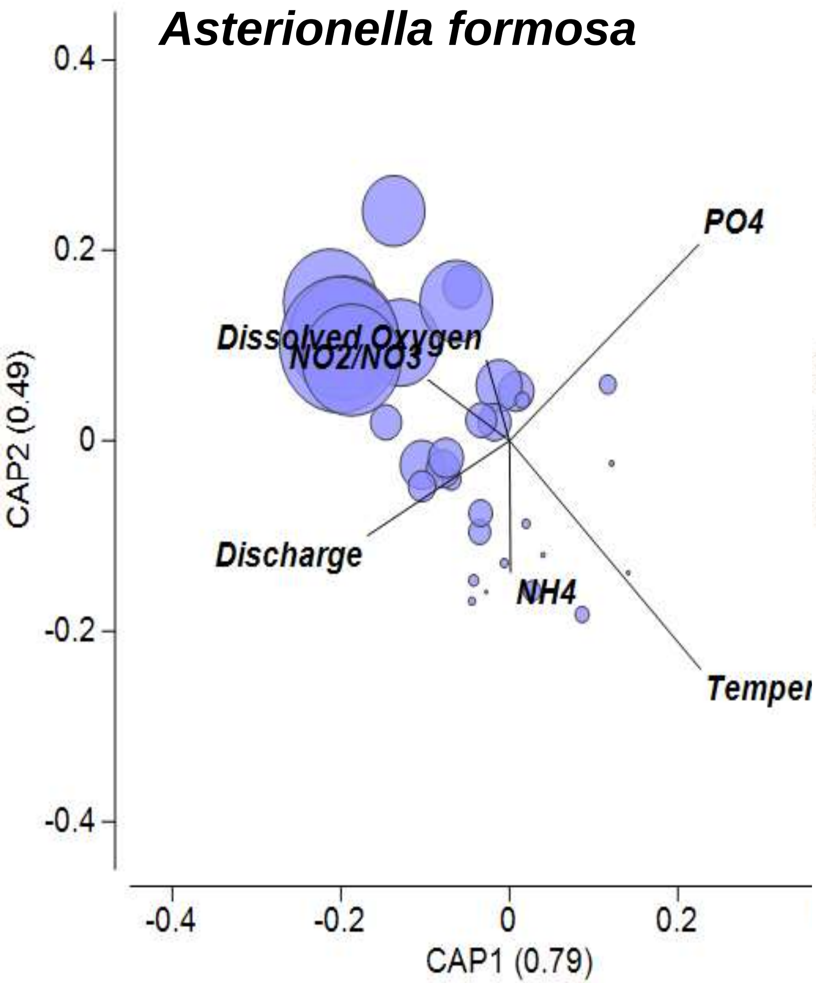


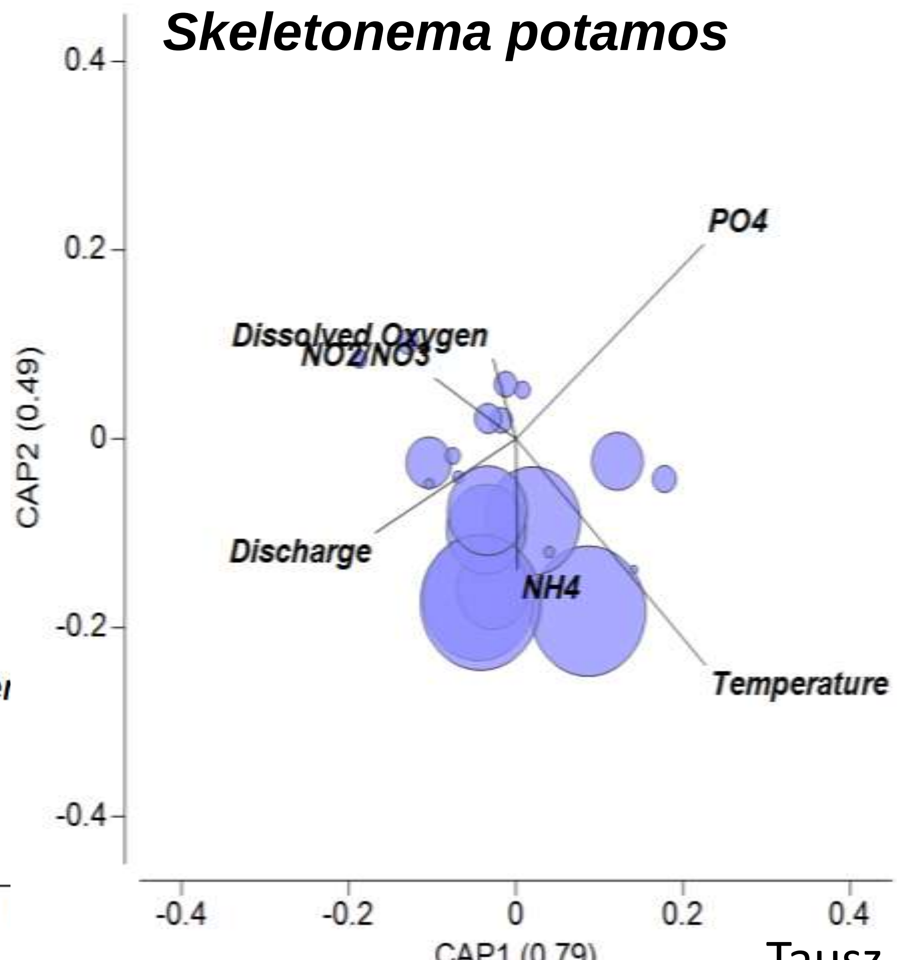
- **Chlorophyll peaks include more flagellate and cyano-bacteria in sluggish off-channel sites**
- **Concentrations are more variable**



Canonical Correspondence Analysis illuminated environmental variables associated with changes in phytoplankton species





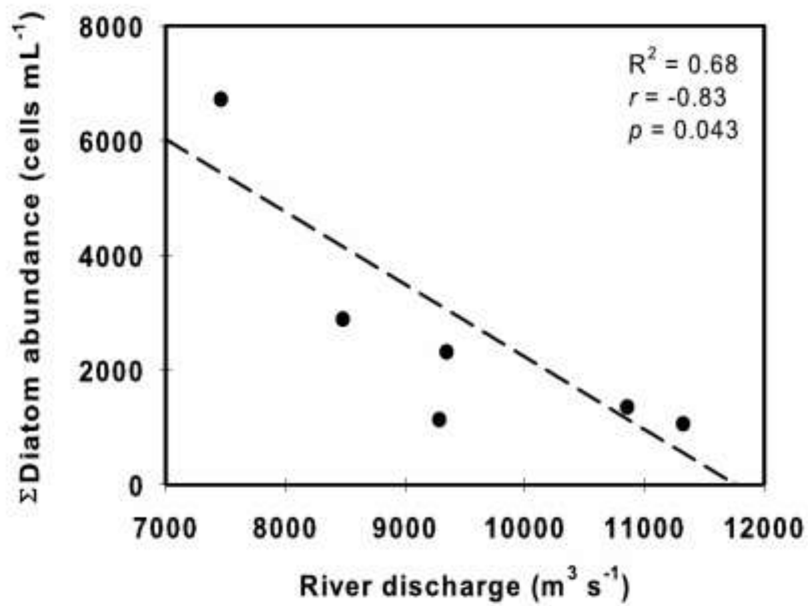


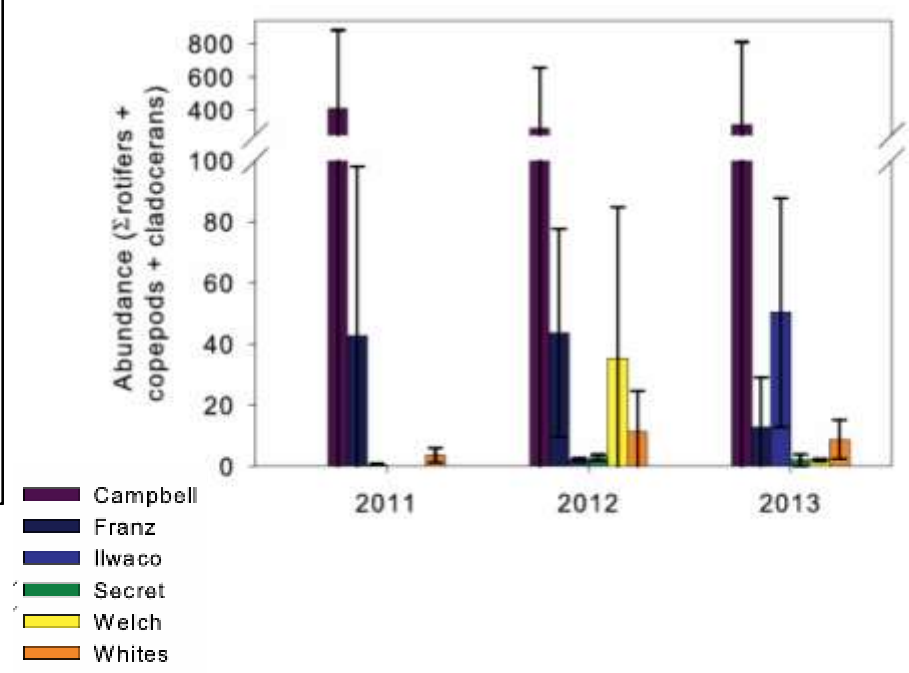
Tausz, 2015

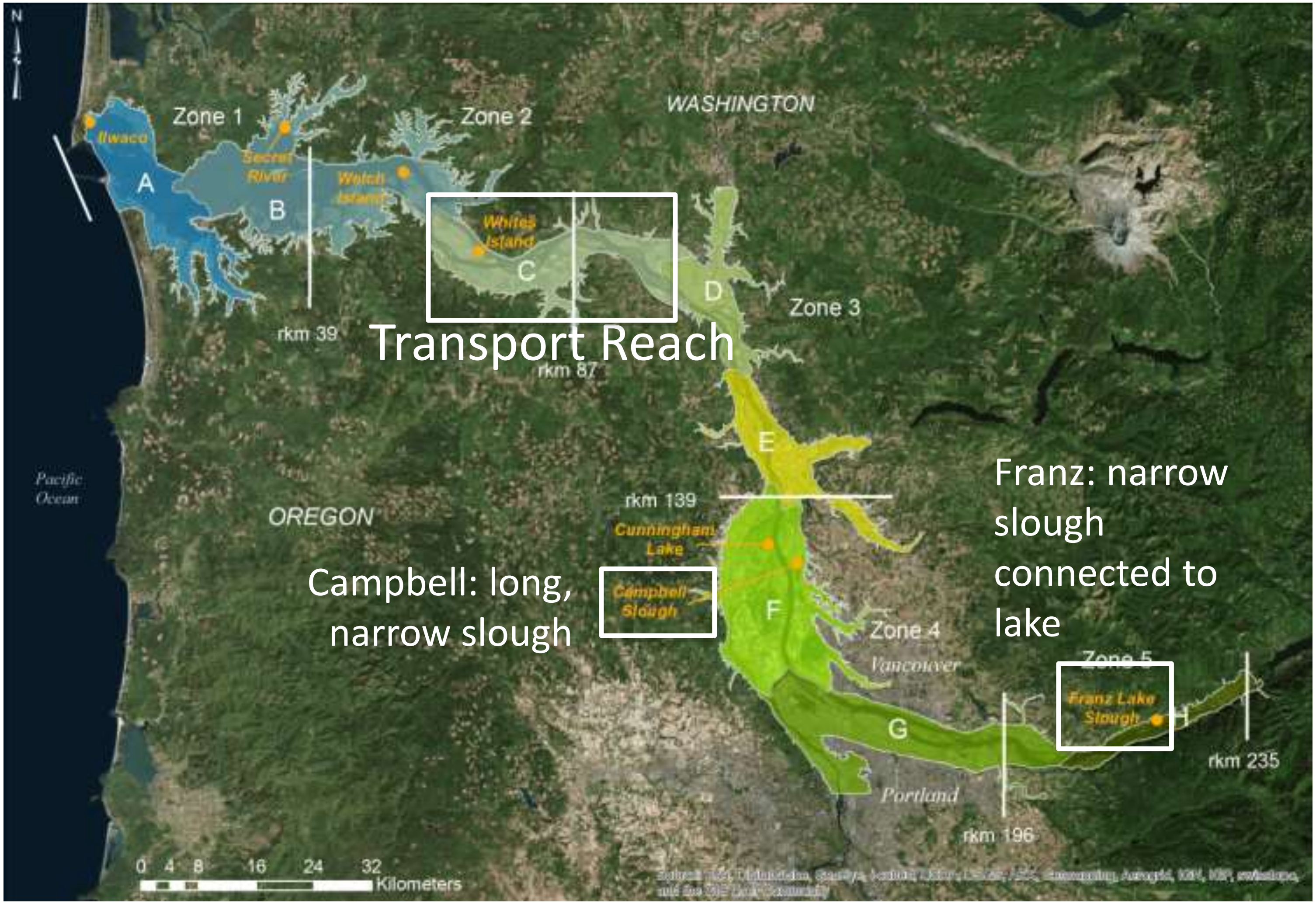
Trends in plankton abundance

- Phytoplankton abundance
  - inversely correlated with river discharge;
  - ~10% higher in shallow water habitats compared to mainstem;
  - abundances can be higher in areas of longer retention than well-flushed areas

- Zooplankton abundance
  - highest at Campbell Slough







Increasing tidal influence

Observations

- Site differences
  - **Whites Island**: same as mainstem
  - **Campbell and Franz**: different from mainstem when connectivity is low (summer, drought)

- *Asterionella* (spring) → *Skeletonema* (summer)
  - Similar to mainstem, originate in mainstem
  - Poor connectivity = difference in diatoms (small *Nitzschia* sp.)

- Cyanobacteria (*Microcystis* sp.) dominant in summer at Campbell Slough and Franz Lake Slough

Significance

- Phytoplankton groups differ in their food quality (e.g., diatoms > chlorophytes > cyanobacteria)
  - $\Sigma_{flagellates}:\Sigma_{total}$ phytoplankton nutritional quality/water quality index
- Phytoplankton influence water quality: dissolved oxygen, pH
- Some species produce toxins

Food web

Invertebrates

Lyn Topinka, 2007

Vascular plants

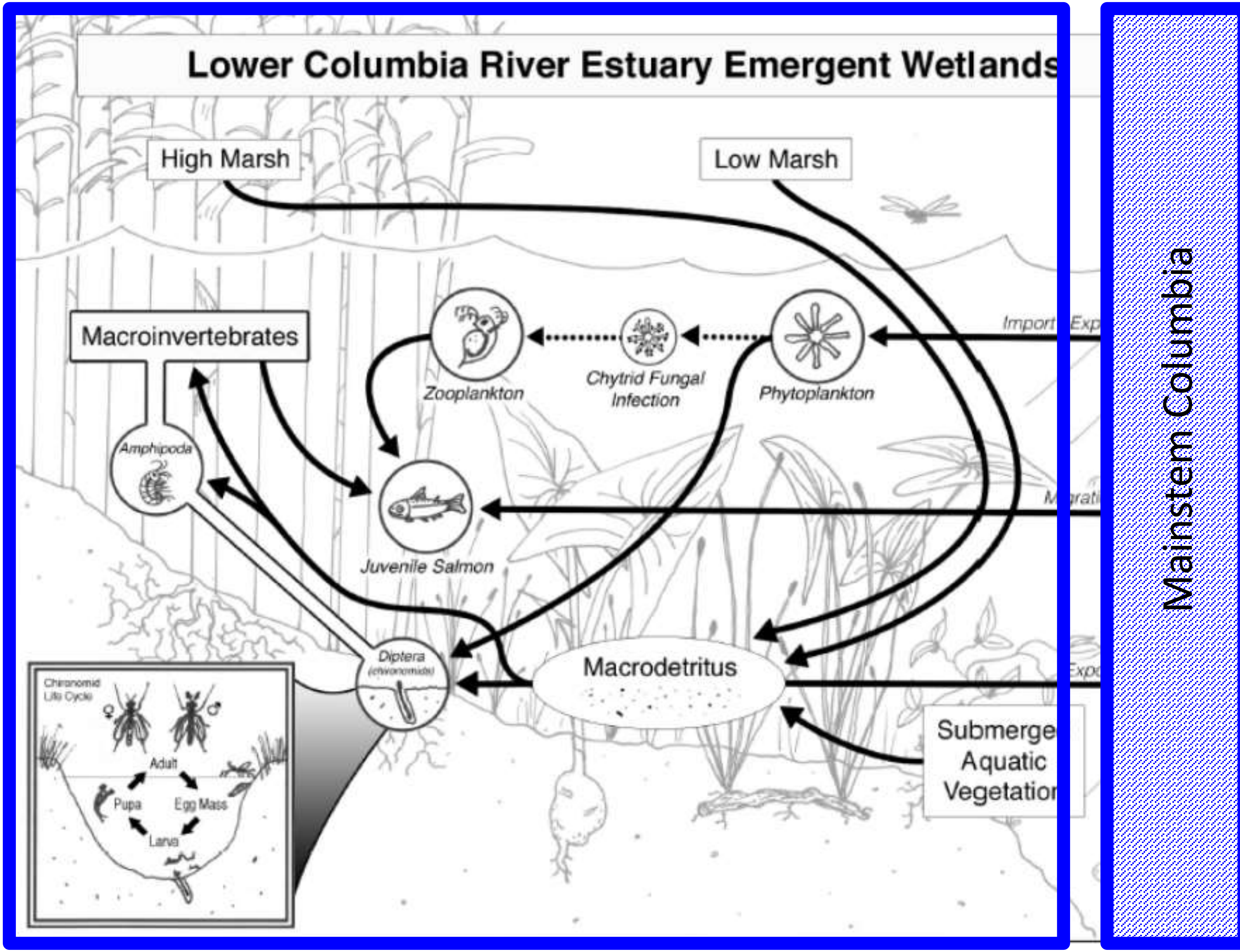
Aquatic, terrestrial

Freshwater & marine

Phytoplankton & macroalgae

Fluvial, benthic

Freshwater & marine



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Adult
Pupa
Egg Mass
Larva
Mainstem Columbia

Sampling methods

Samples include:

- Juvenile Chinook salmon muscle and liver
- April – August
- Franz, Campbell, Whites, Welch, Ilwaco
- Food sources: invertebrates (amphipods, chironomids, nematodes, polychaetes, oligochaetes, copepods, cladocerans, etc.)
- Primary producers (live & dead vegetation, periphyton, particulate organic matter)

Methods

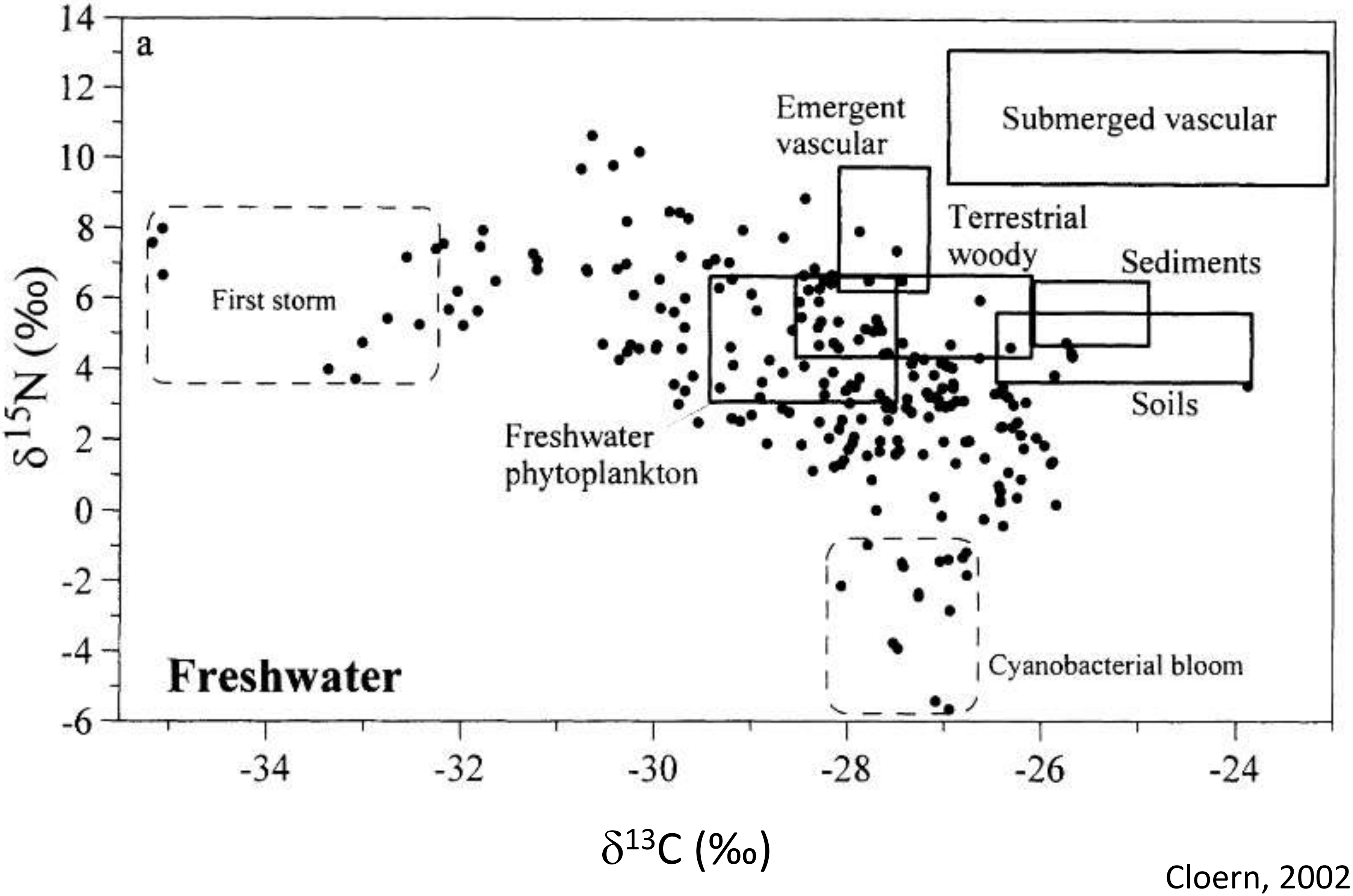
- Stable isotopes can be used to infer relationships between consumers and food sources
  - Different tissues integrate over different timescales
  - Overcomes biases associated with assimilation vs. ingestion, as well as difficulty identifying partially digested prey
  - $\delta^{13}C = R_{sample} - R_{standard} / R_{standard} \times 1000$ (units = ‰)

Methods

- There are a variety of Isotope mixing models that try to predict who is eating what, when
- Bayesian mixing model: Simmr
- Sample several sources to determine $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios and make a series of iterative “best guesses” about how a consumer is composed of combinations of sources

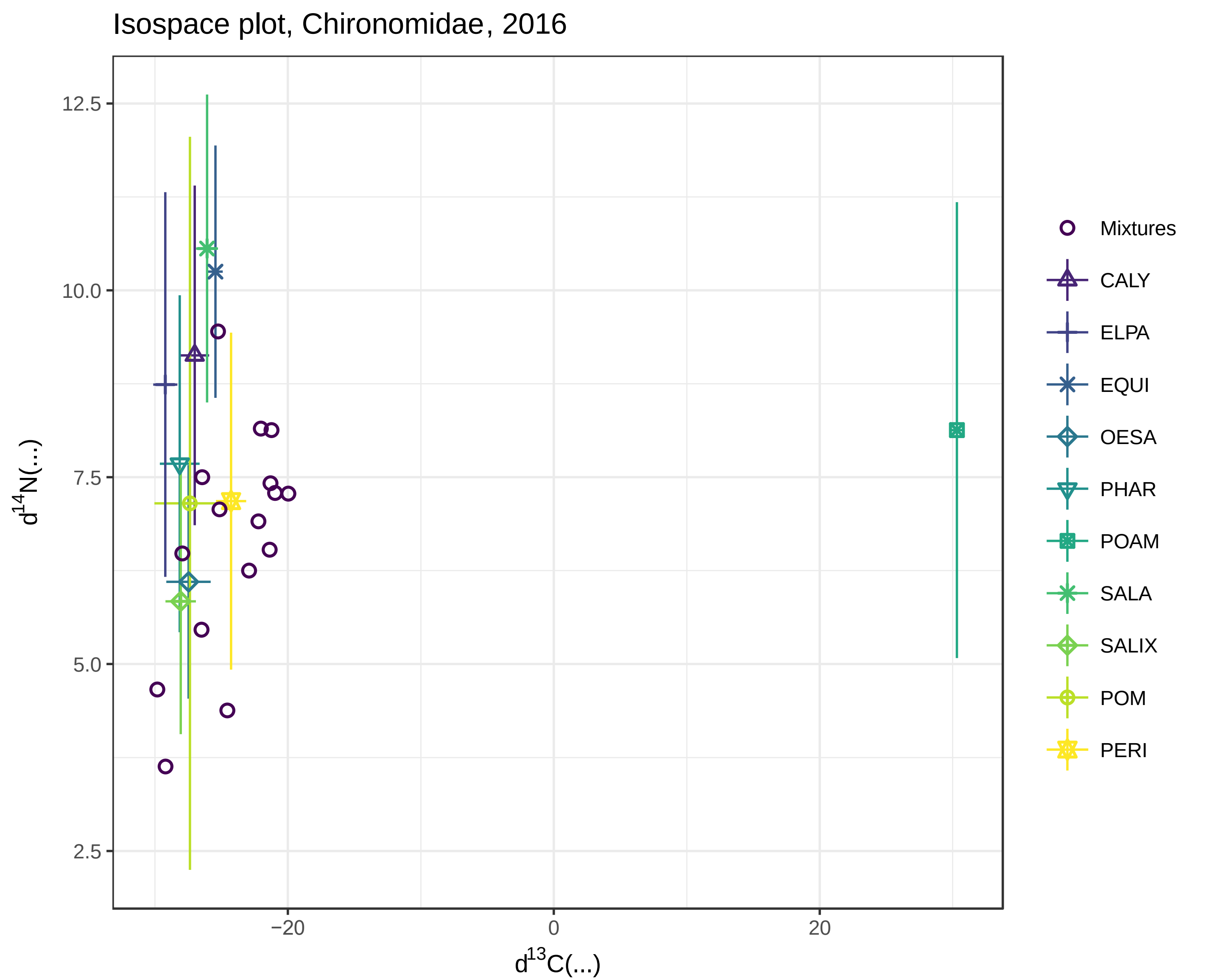
Assumptions

- Different food sources have distinct enough signatures to discriminate between them
- Assume an increase in ^{13}C and ^{15}N with each ascending trophic level of ~1 per mil and 3-5 per mil, respectively
- Did not account for differences in concentration/availability

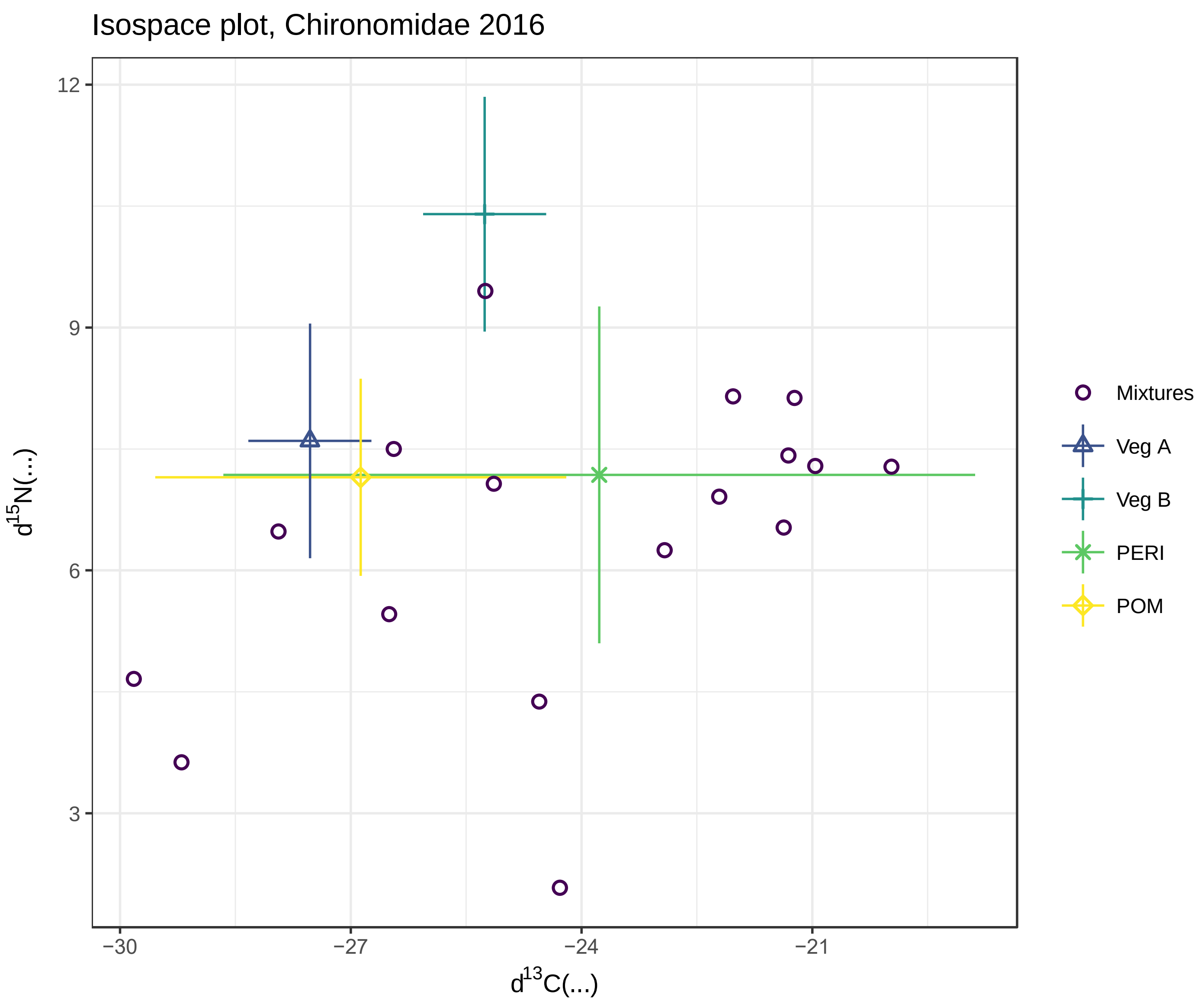

a
Freshwater
First storm
Emergent
vascular
Submerged vascular
Terrestrial
woody
Sediments
Soils
Freshwater
phytoplankton
Cyanobacterial bloom
δ15N (‰)
δ13C (‰)
14
12
10
8
6
4
2
0
-2
-4
-6
-34
-32
-30
-28
-26
-24

Cloern, 2002

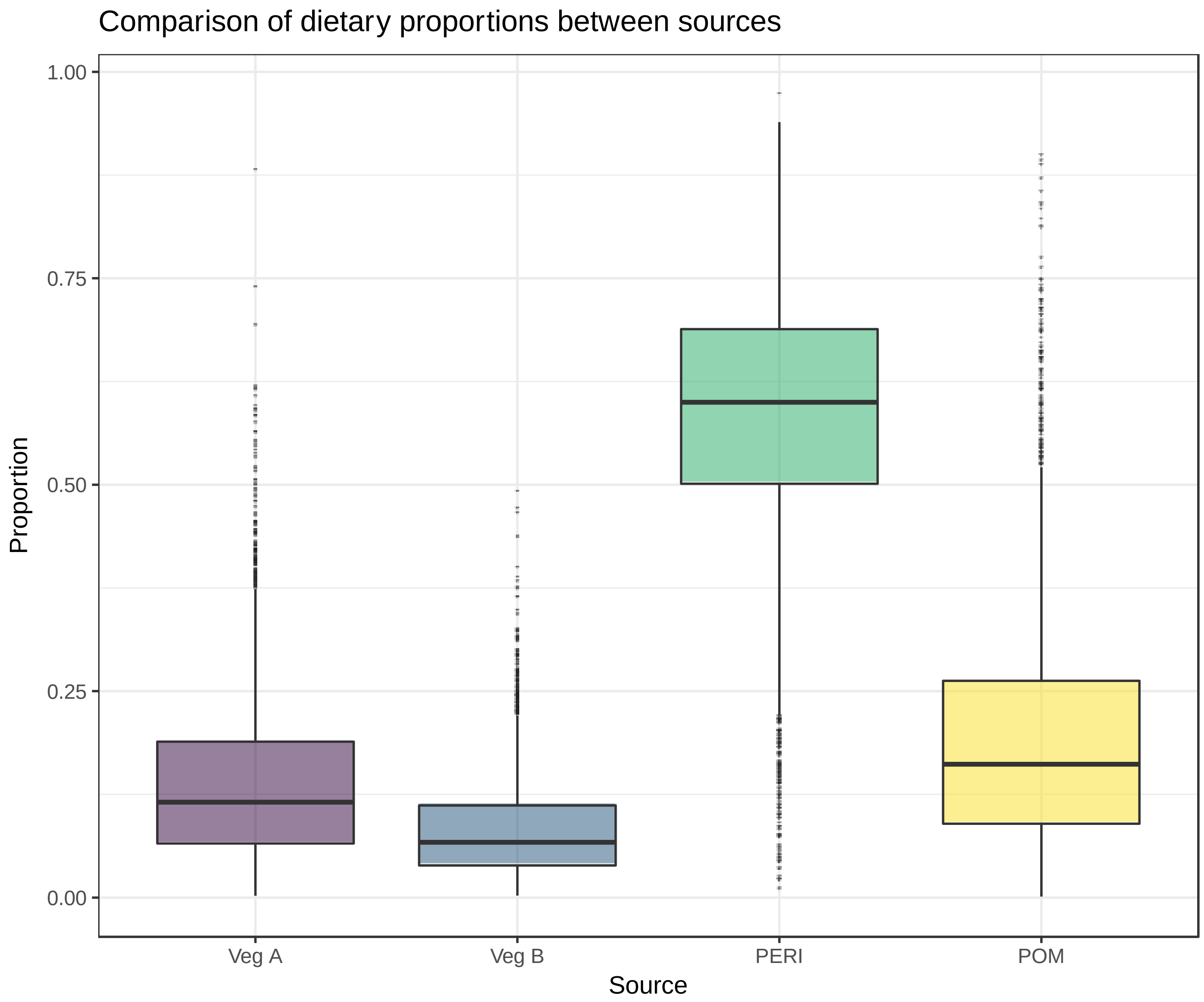
Primary producers supporting chironomids



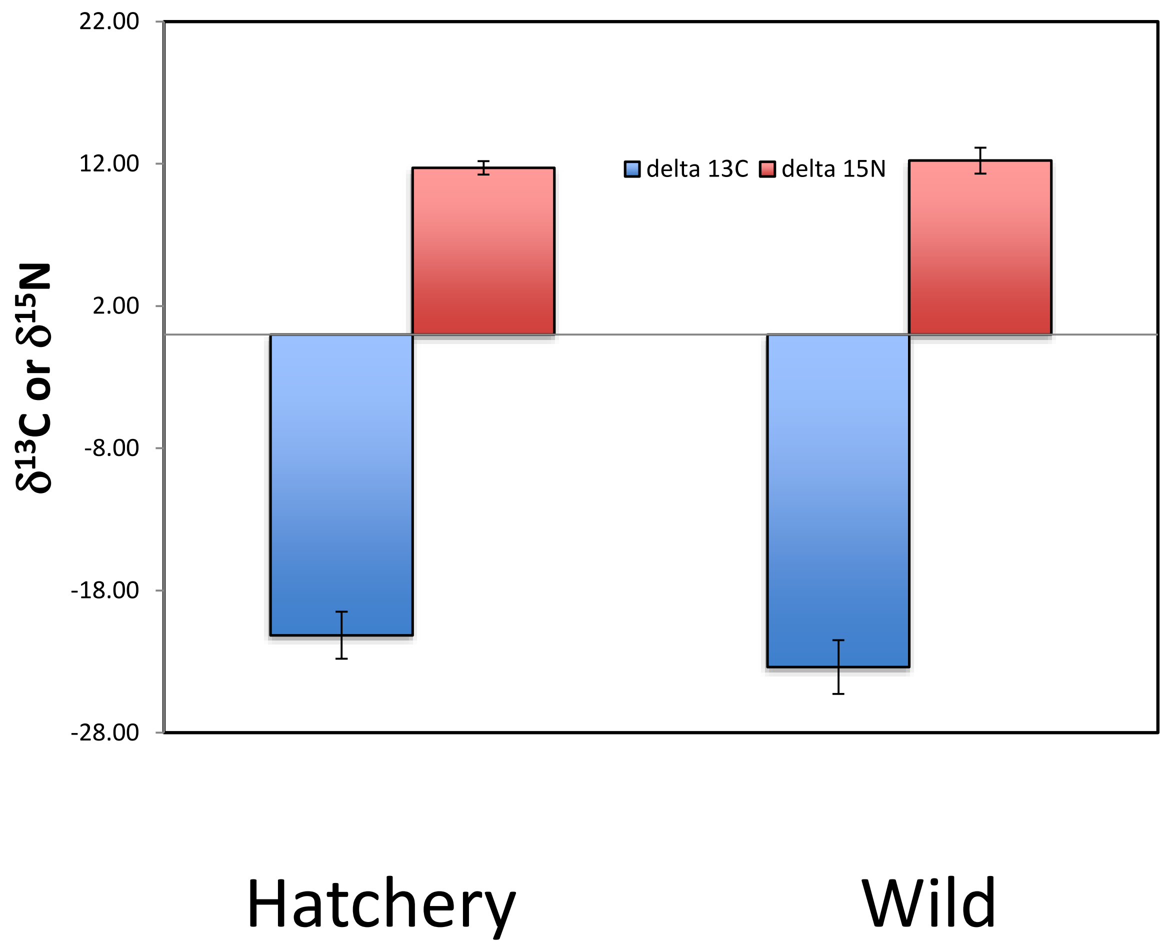
Primary producers supporting chironomids

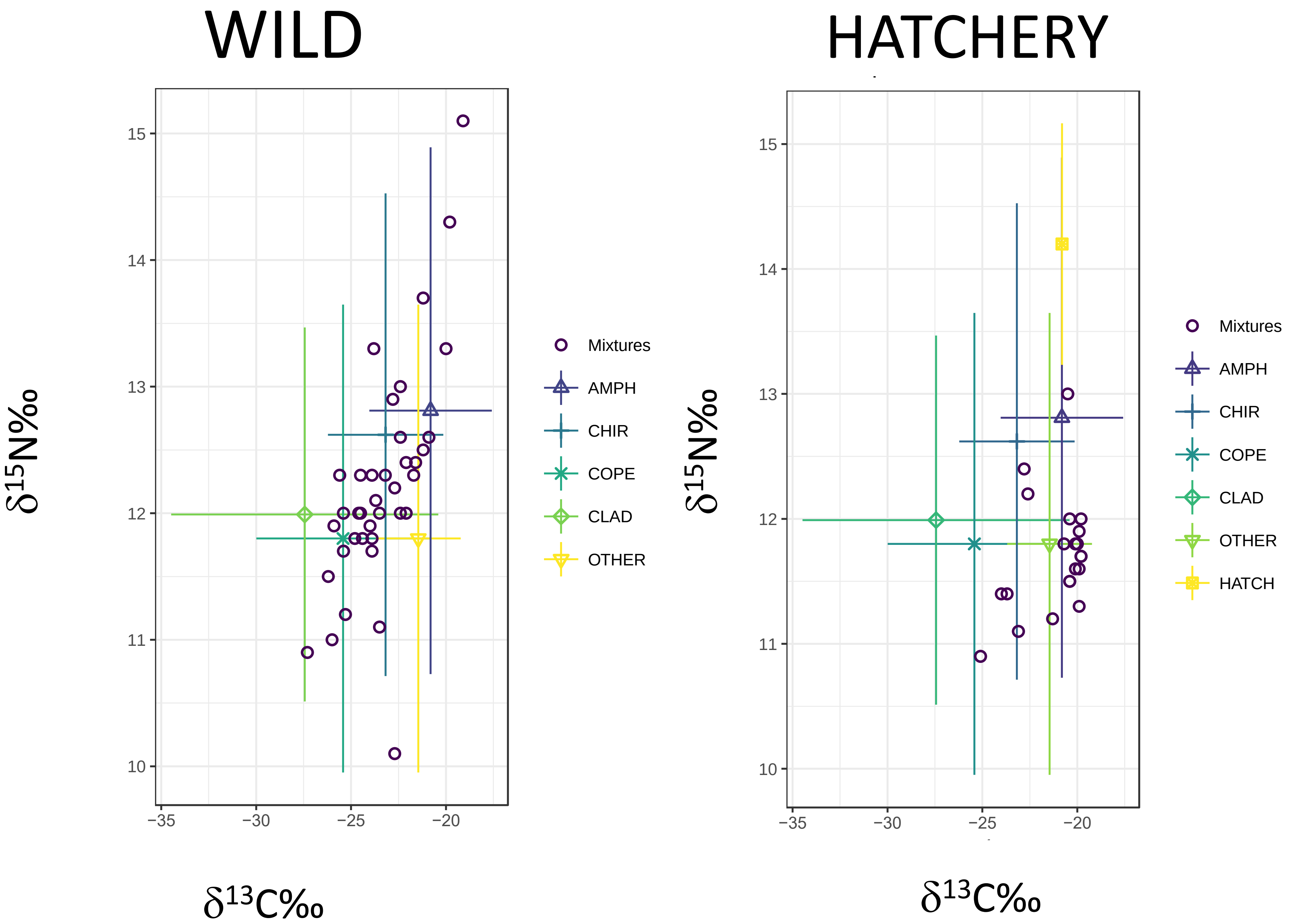


Primary producers supporting chironomids



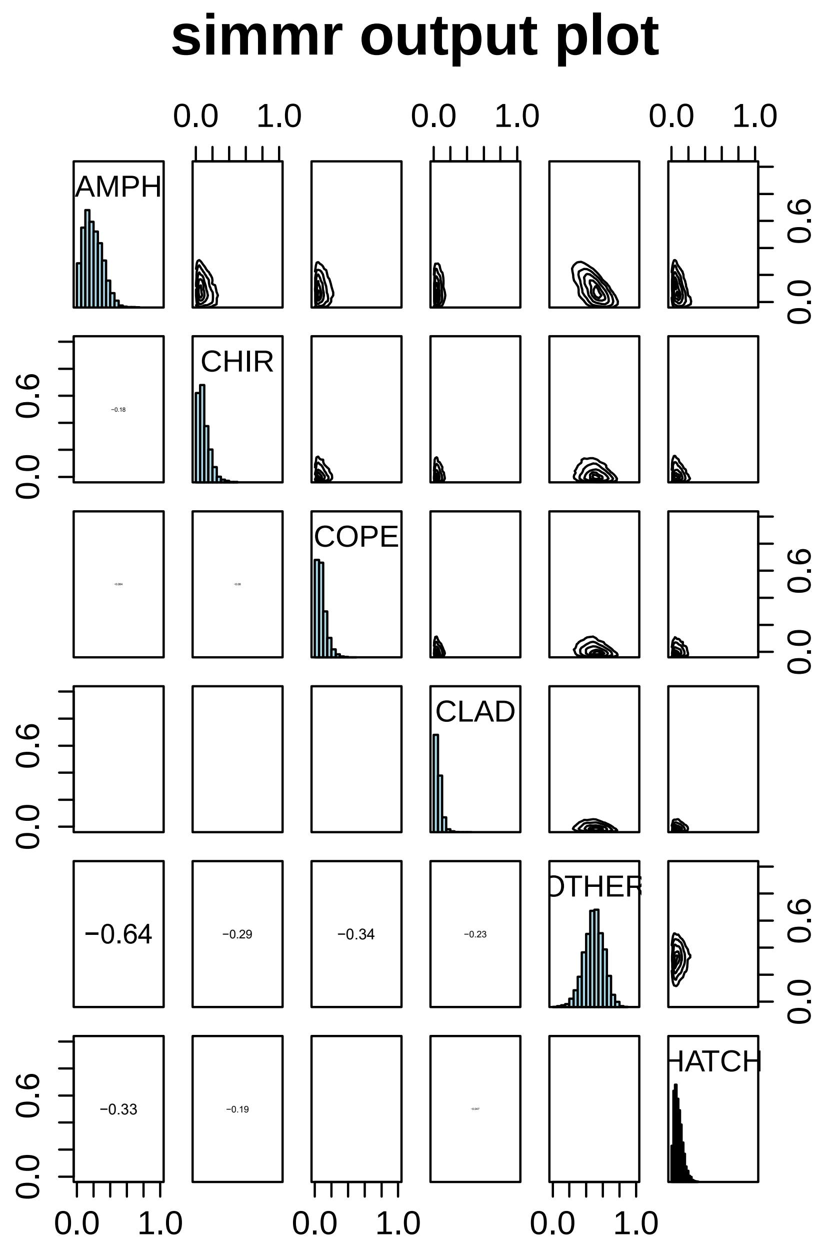
Juvenile Chinook salmon



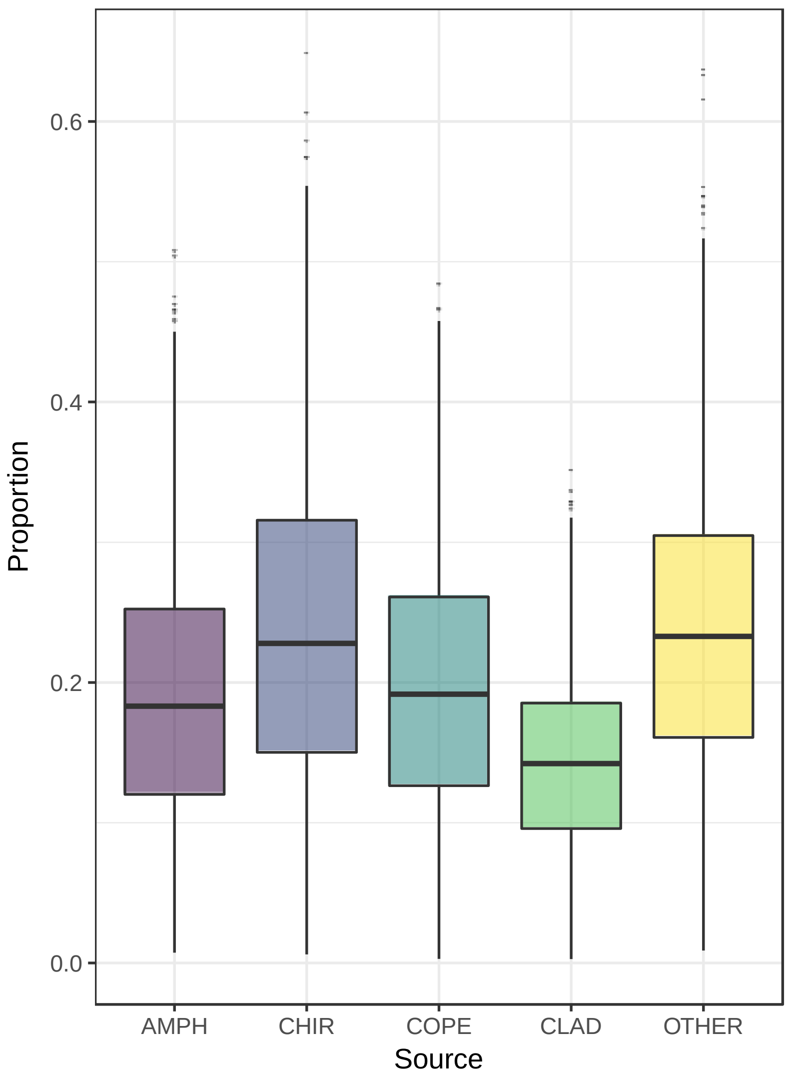


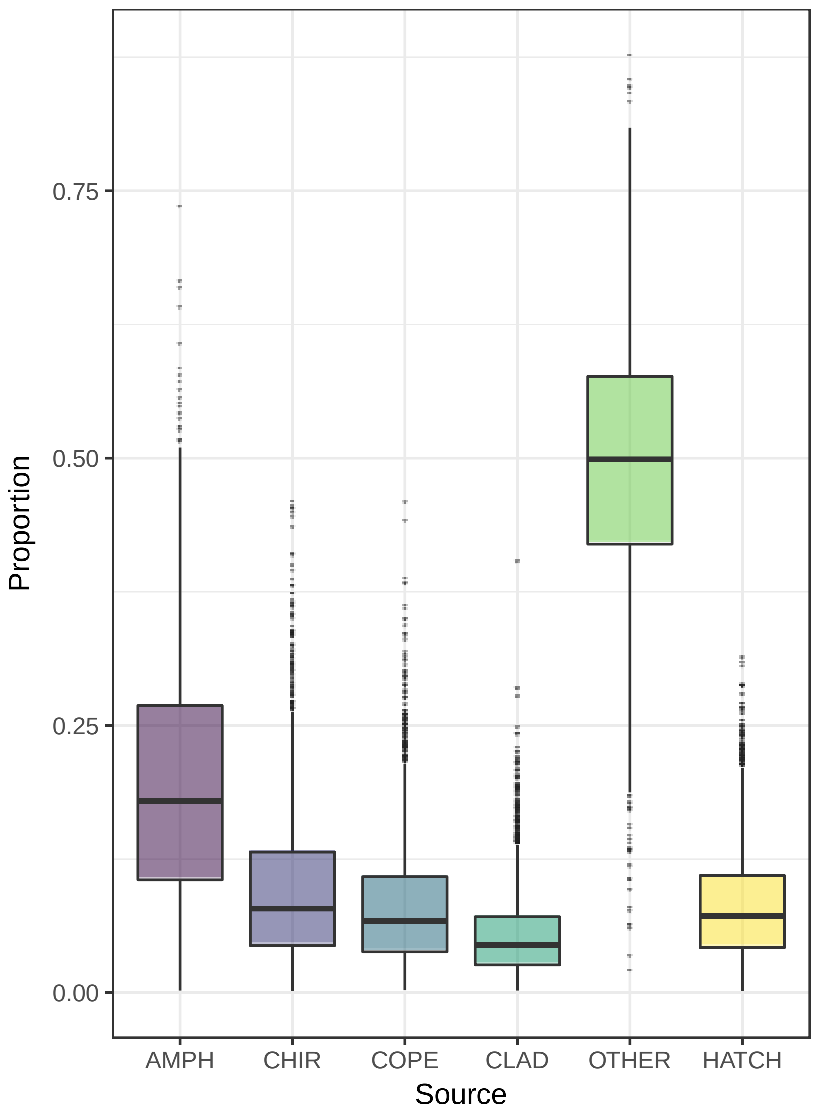
WILD
HATCHERY
15
14
13
12
11
10
−35
−30
−25
−20
δ15N‰
δ13C‰
Mixtures
AMPH
CHIR
COPE
CLAD
OTHER
HATCH

2016, Hatchery fish



WILD vs. HATCHERY fish: comparison of dietary proportions of different sources





Fish use of estuarine resources: Insights from stable isotopes

- Hatchery fish are heavier with respect to carbon, but lighter with respect to nitrogen than wild fish
- Summer source values were heavier than spring
- There were only small isotopic differences between living and dead plant matter within a given time frame
- Livers were lighter in C and N compared to muscle (data not shown here)

Ongoing work

- Separate isotope data spatially and temporally
- Compare liver and muscle tissues of fish to discern differences at varying time scales
- Explore source concentration effects and integrate with stomach contents data
- Ideally, integrate molecular approaches to trace prey consumption and assimilation patterns