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Ecosystem Monitoring Program: Food web, primary & secondary production 2010—2013

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Salmonid habitat characterization

- Background
  - Changes to Columbia R. estuary habitats and food web have reduced its capacity to support juvenile salmonids
    - Evidence of shift from wetland/detrital to phytoplankton base of food web
  - Need long-term monitoring of habitat conditions and use by juvenile salmonids to fill key info gaps for appropriate restoration planning:
    - 1. Trophic pathways
    - 2. Primary and secondary production patterns

1. Trophic pathways

- Determine the **relative contributions of instream and wetland primary producers** to the food web supporting juvenile salmonids in the Lower Columbia River & Estuary

  - Stable isotope analysis: juvenile Chinook salmon, invertebrates, primary producers (USGS)

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Trophic pathways: 4 trend sites

Ilwaco (reach A)

rkm 5

Whites Island (C)

rkm 72

Campbell Slough, Ridgefield (F)

rkm 149

Franz Lake Slough (H)

rkm 221

Stable isotope overview

- Most C atoms have 12 neutrons (^{12}C), ~1% have 13 (^{13}C)
- Nitrogen: mostly ^{14}N, <1% ^{15}N
- Measure ratio of heavy to light isotope
  - compare to a standard → $\delta^{13}C$, $\delta^{15}N$ in parts per thousand (permil)
- δ values of consumers' tissues reflect food sources
- Metabolic loss of light isotopes → consumers in higher trophic levels become enriched in heavy isotope ("trophic enrichment")

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Stable isotope samples

- Muscle 2010-12 Campbell, Whites; May-July
  - 27 unmarked, 21 marked
  - 4 mucus samples (1u, 3m)

- Potential food sources
  - For salmon:
    - Hatchery food
    - Chironomid larvae

    - *Corophium spp.* amphipods

  - For salmon prey:
    - Vegetation, periphyton, phytoplankton

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Stable isotope mixing models

- **Use SI ratios of consumers and food sources to estimate dietary proportions**
- **SIAR model**
  - **Parnell & others, 2010**
  - **Many potential food sources**
  - **Incorporates source variability**

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Preliminary findings (2010-2012)

- Salmon diets (SIAR models)
  - Hatchery food largest dietary source for marked juvenile Chinook
  - Chironomids contribute increasingly to unmarked Chinook diets with later month of fish catch

- Marine/maternal influence on SI of small Chinook muscle
  - Mucus/liver reflect more recent diet sources
  - Muscle, liver, mucus from all salmon 2013

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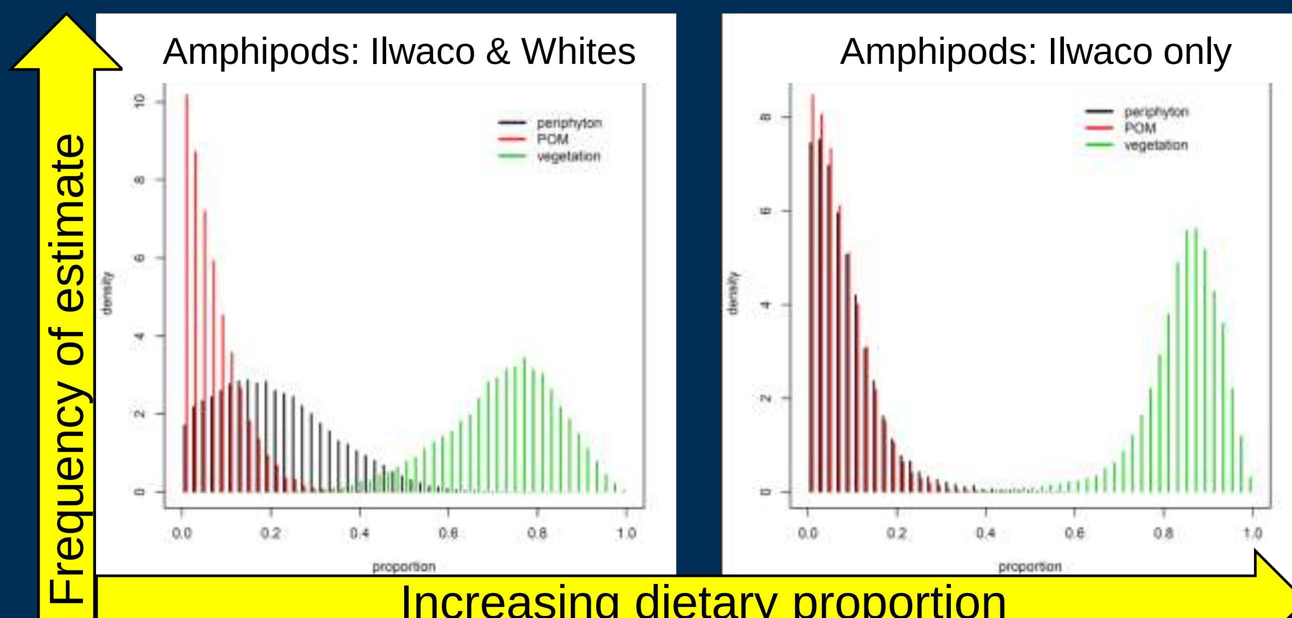
Preliminary findings (2010-2012)

- Invertebrate diets (SIAR models)
  - **Chironomids: POM (phytoplankton)** largest food source overall during season, esp. May
    - Secondary: macrophytes/periphyton
  - **Amphipods: Vegetation** largest contributor, esp. at Ilwaco; POM not likely food source



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2. Primary & secondary production

- Examine patterns in **abundance/composition of primary & secondary producers** in shallow wetland habitats during juvenile salmon migration
  - Primary and secondary production (USGS, OHSU):
    - phytoplankton abundance, productivity rates, species composition
    - periphyton abundance, productivity rates
    - zooplankton abundance, species composition

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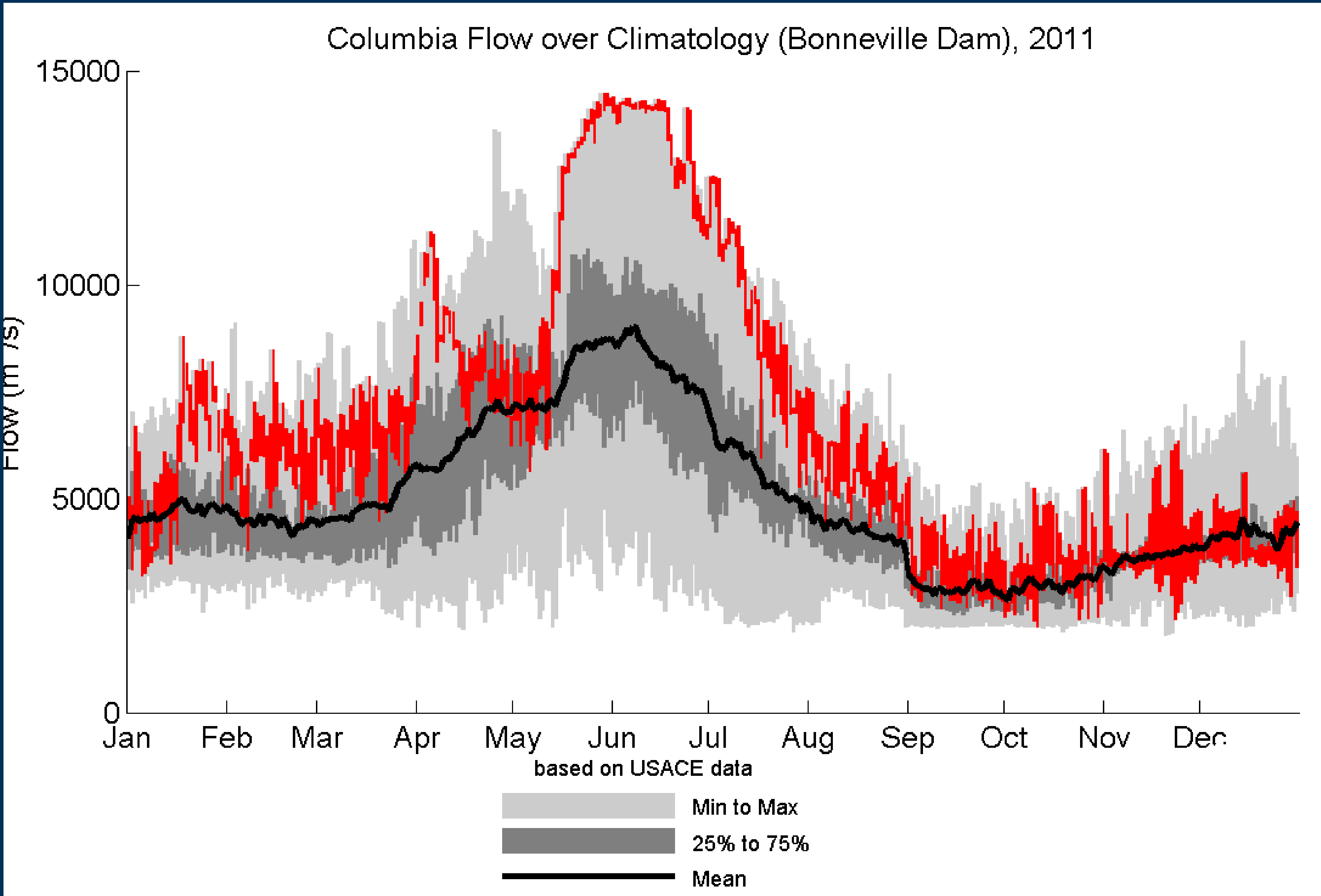
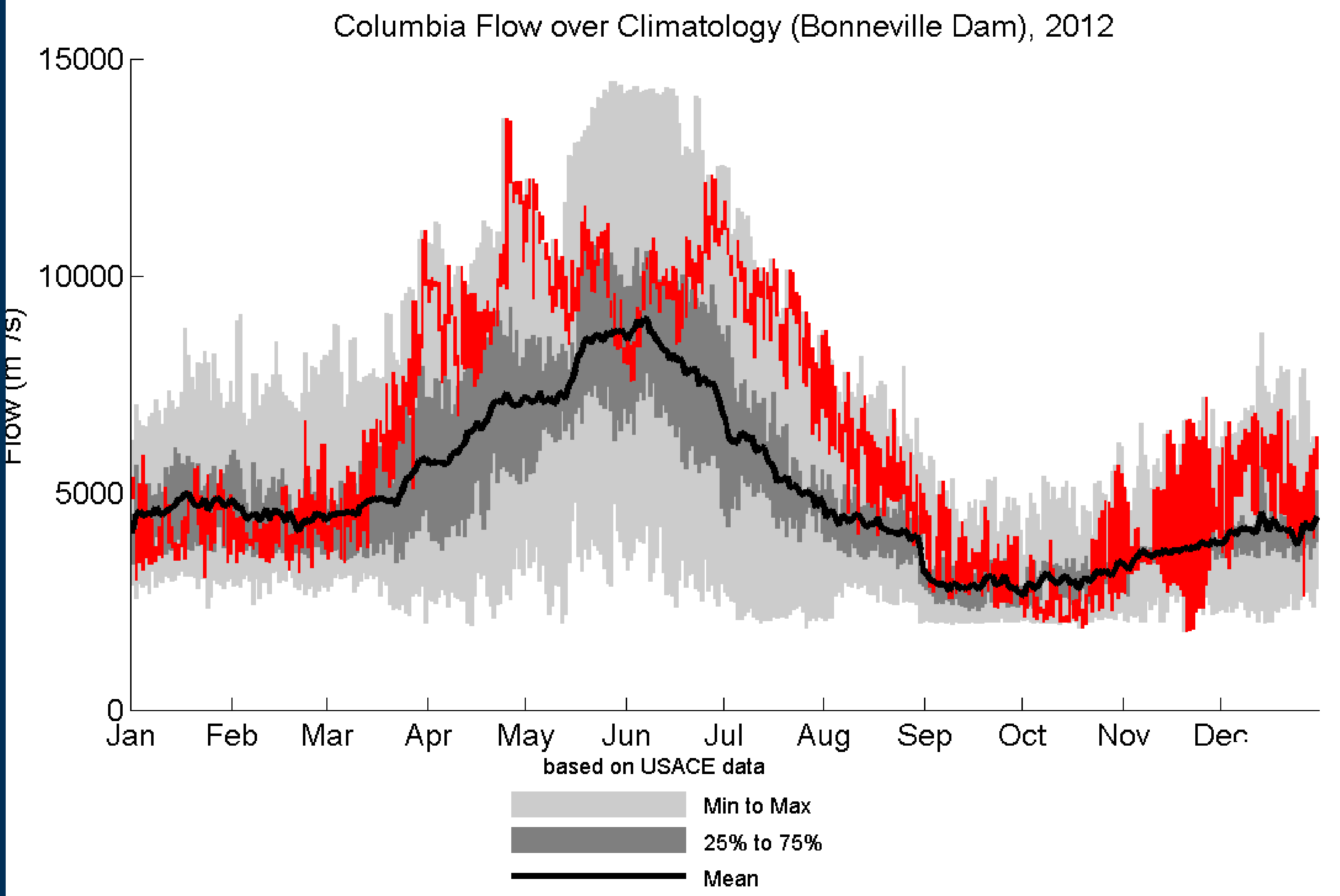
What role do plankton play in salmon food webs?

- Phytoplankton (fluvial component) fuel zooplankton production;
- Phytoplankton abundances consistently highest in early spring (Mar-May);
- Stable isotope data suggest they are important in the food web during the spring period (Maier & Simenstad, 2009);
- Outstanding questions (phytoplankton):
  - what proportion of the phytoplankton population sinks out to fuel benthic invertebrates?
  - Does the size class structure of the phytoplankton matter for the settling term (ie, does settling rate differ with size?)
  - Do differences in phytoplankton taxa influence benthic invertebrate nutrition? Does benthic secondary production differ with respect to organic matter source? What role do microbial decomposers play in the nutritional quality of macrodetritus?


Columbia Flow over Climatology (Bonneville Dam), 2011
15000
10000
5000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
based on USACE data
Min to Max
25% to 75%
Mean



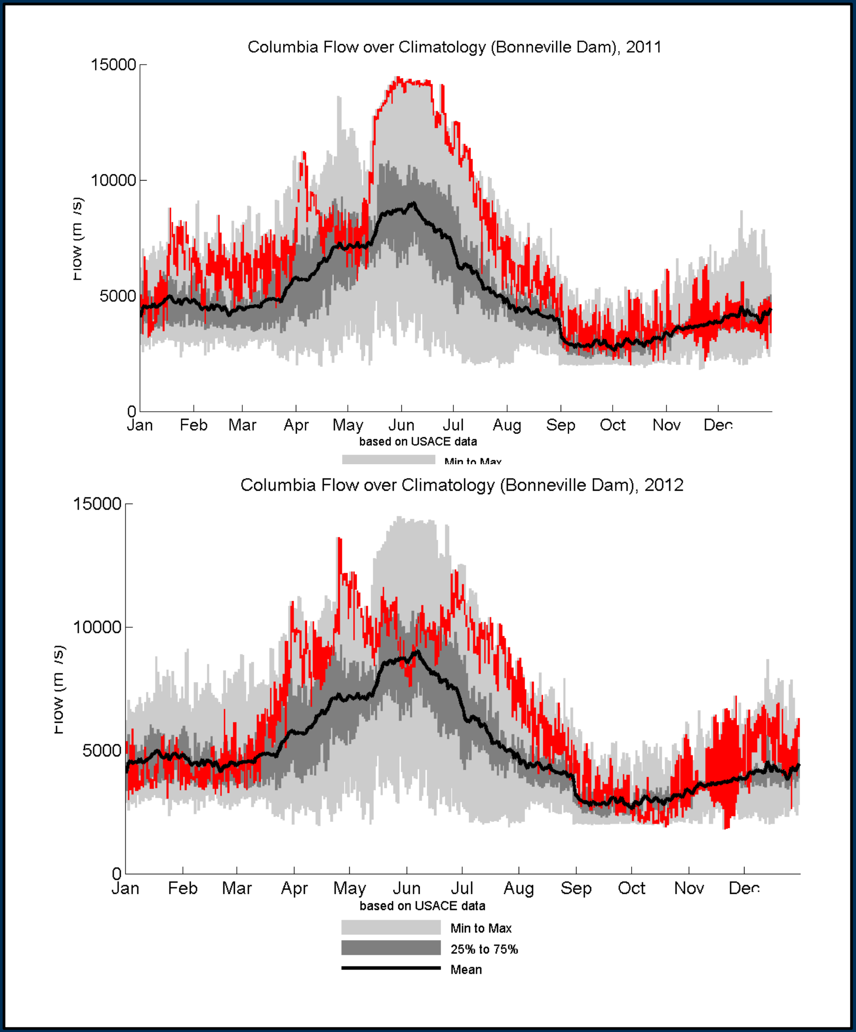
Columbia Flow over Climatology (Bonneville Dam), 2012
15000
10000
5000
0
Flow (m³/s)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
based on USACE data
Min to Max
25% to 75%
Mean

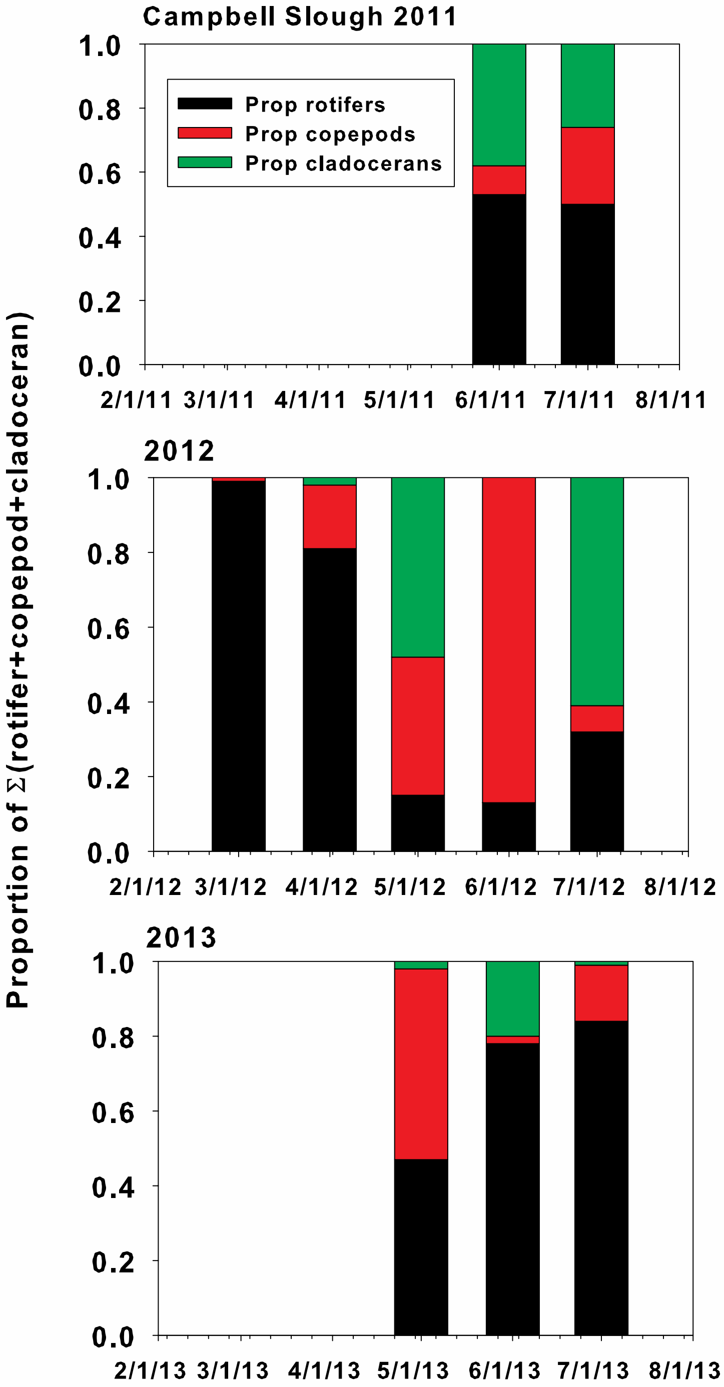
Some early conclusions: phytoplankton

- **Repeatable spring bloom** with minor blooms, dominated by similar species (*Asterionella formosa*, *Aulacoseira granulata*, *Skeletonema potamos*, etc.);
- **Inverse spatial relationship** between **phytoplankton vs. periphyton** primary production (C-uptake rates);
- **Phytoplankton** seem to **contribute to salmon diet** in **early spring** (based on stable isotope of organic matter)
- **Phytoplankton biomass/abundance/species** composition strongly **influenced by river flow**

Some early conclusions: zooplankton

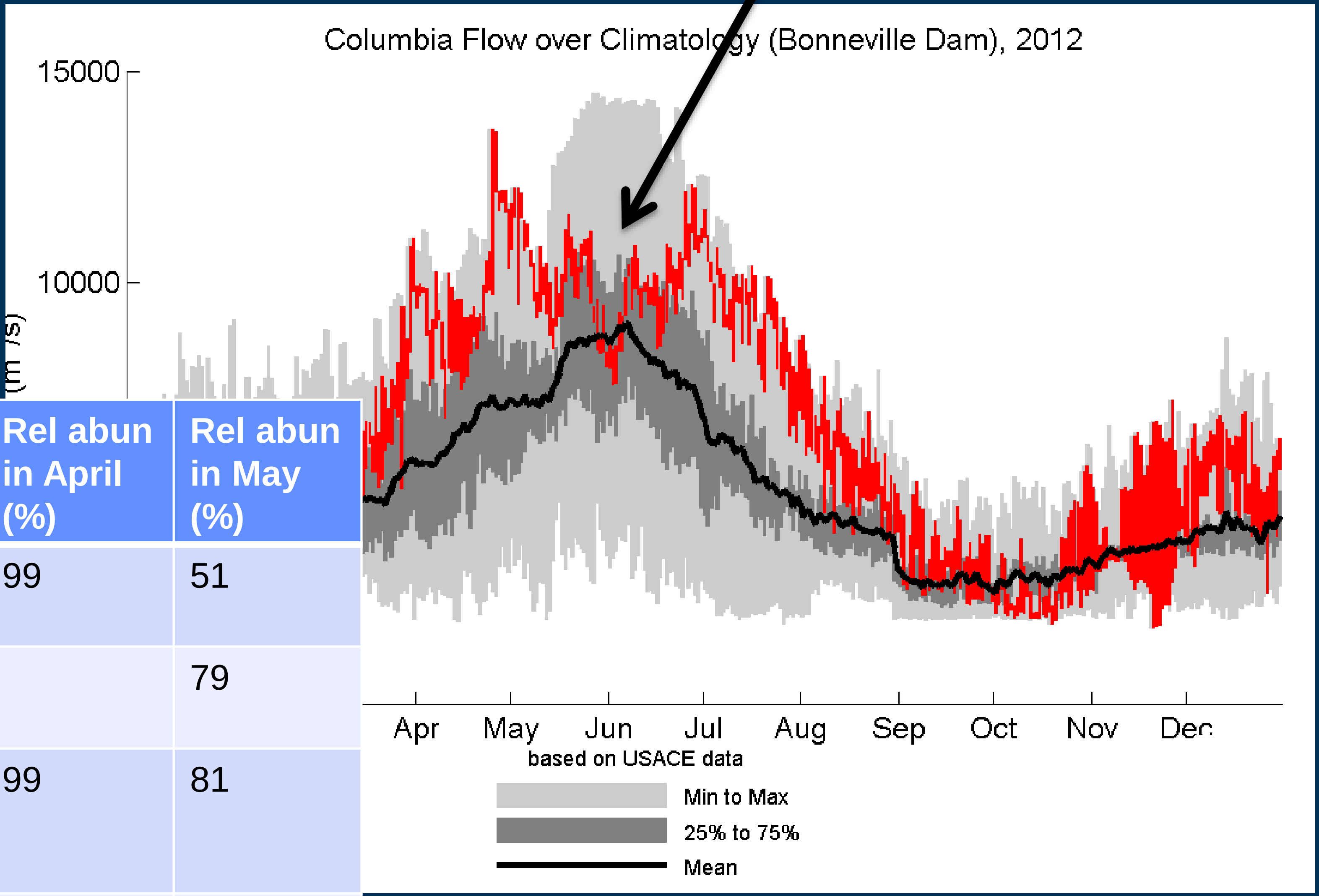
- **Shift** in **zooplankton taxa** with **water level**, with **rotifers** (small zooplankton) being more **abundant pre-freshet**
- **Copepods and cladocerans** increase in abundance (both absolute and relative) in **June and July**





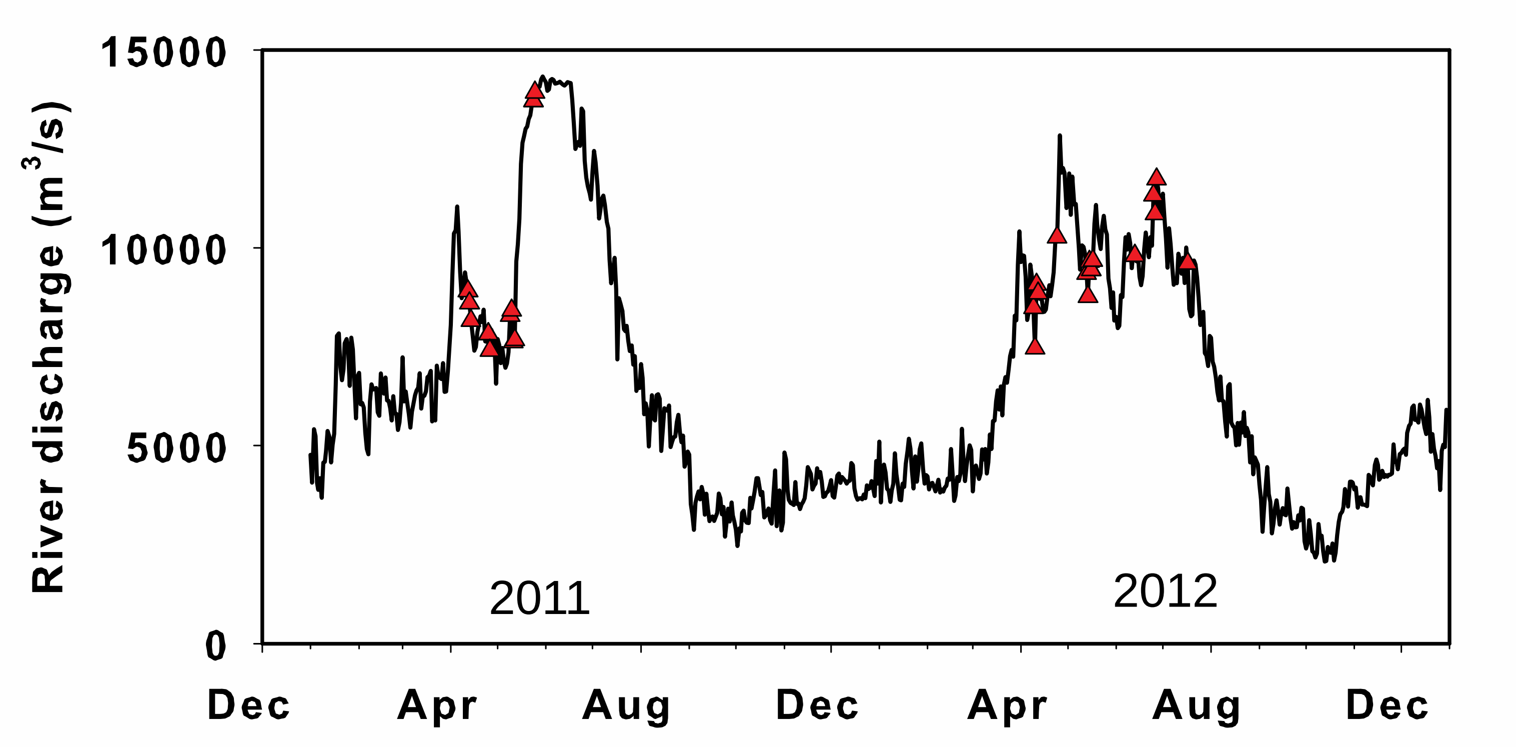
Once water levels rise, rotifer relative abundance seems to decrease; zooplankton are replaced by copepods and cladocerans

In general, dip seen in proportional abundance of rotifers



Site (2012)	Rel abun in April (%)	Rel abun in May (%)
Franz Lake (H)	99	51
Secret River (B)		79
Campbell Slough (F)	99	81
Whites Island (C)	98	92

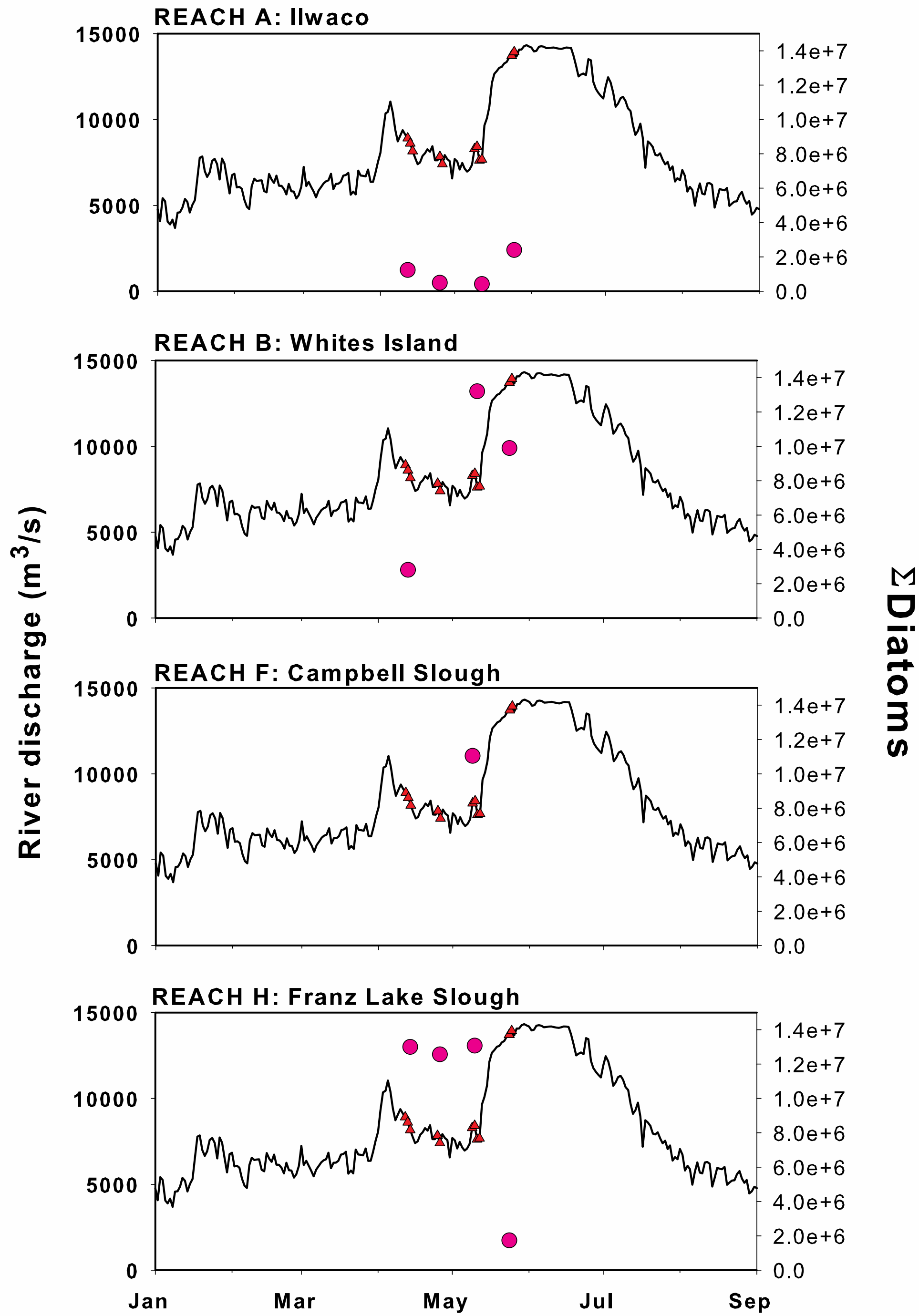
Sampling in both 2011 and 2012 did not capture post-freshet conditions very well; in 2012, freshet was extended in time



Red triangles show sampling time points in 2011 and 2012

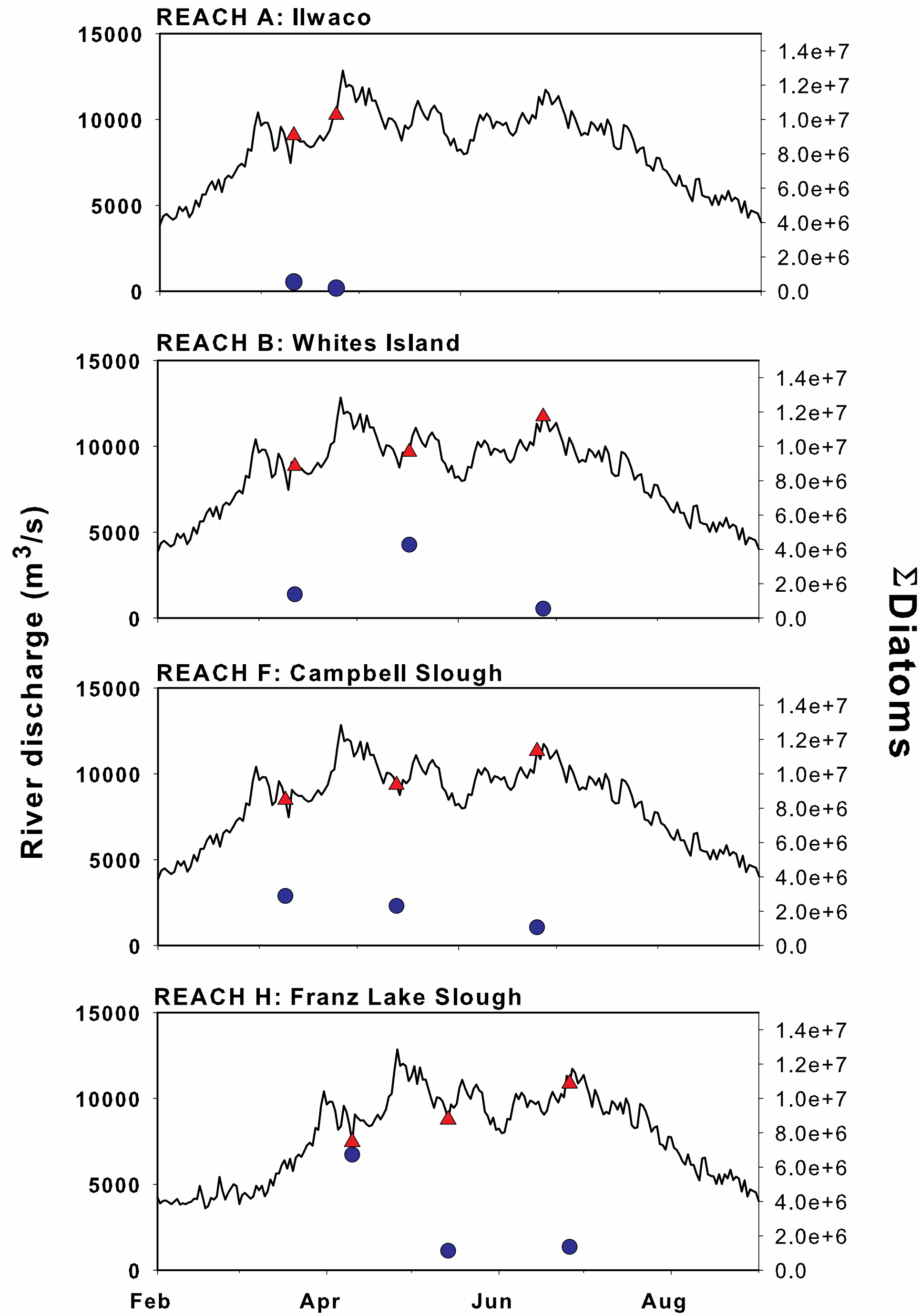
2011

- dominant phytoplankton are diatoms (Class Bacillariophyceae) throughout system;
- Abundances are lowest in Reach A (Ilwaco);
- Limited data could indicate that high water at Franz Lake Slough flushes out/dilutes phytoplankton during freshet

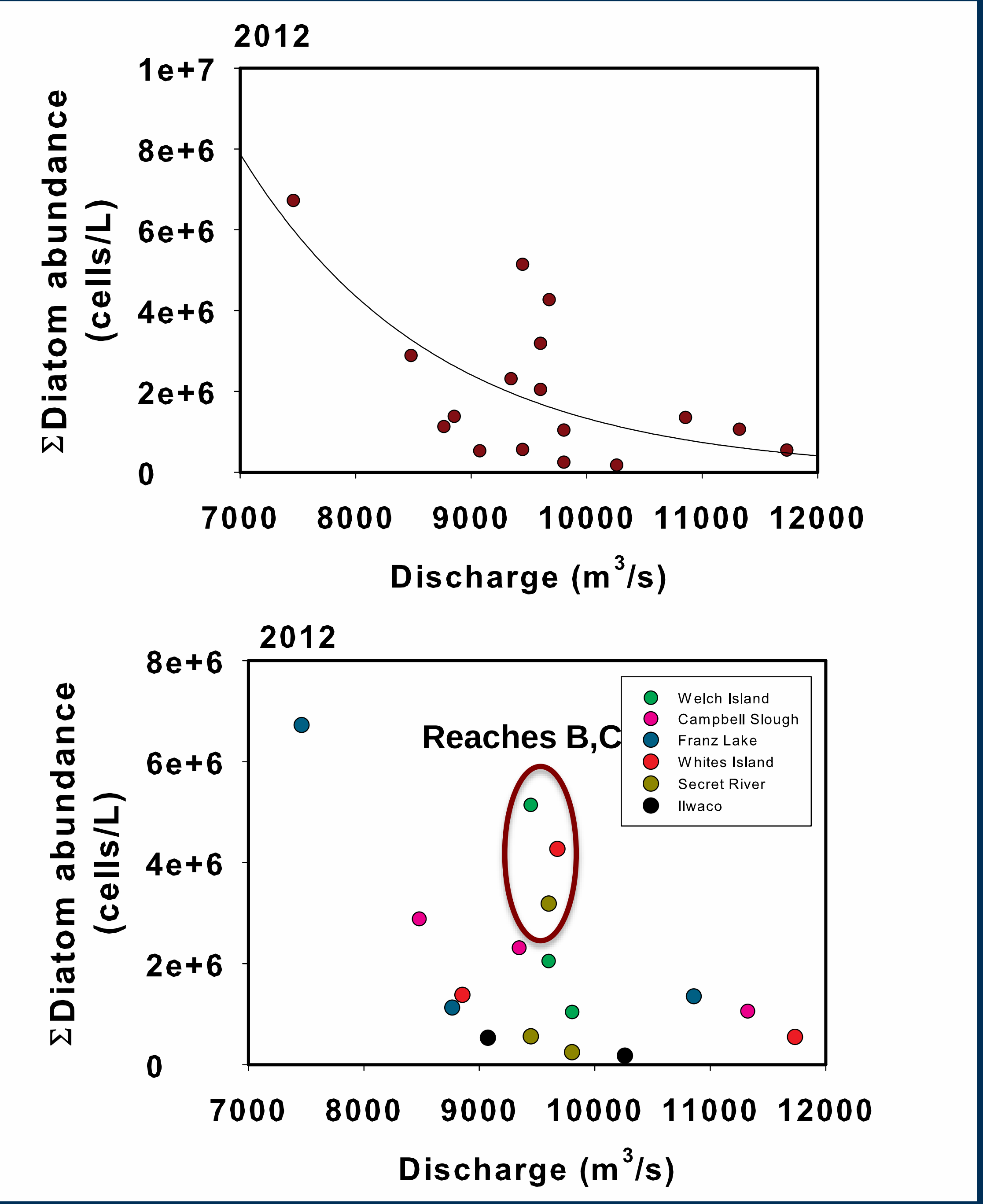


2012

- dominant phytoplankton are diatoms (Class Bacillariophyceae) throughout system;
- Abundances are lowest in Reach A (Ilwaco);
- Abundances were less variable compared to 2011 (likely reflects smaller range in river discharge over time of sampling)
- What's happening at Franz Lake?
    - In April, ortho-phosphate low (NO_3^-:PO_4^{3-}=33.8)→incr. in May, June (ie, phytos not nutrient limited)
    - Phyto abundance may have been HIGHER before onset of freshet



- River discharge linked to influence phytoplankton abundance;
- Sites in Reaches B and C had higher abundance than other sites at moderately high discharge



Questions?

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