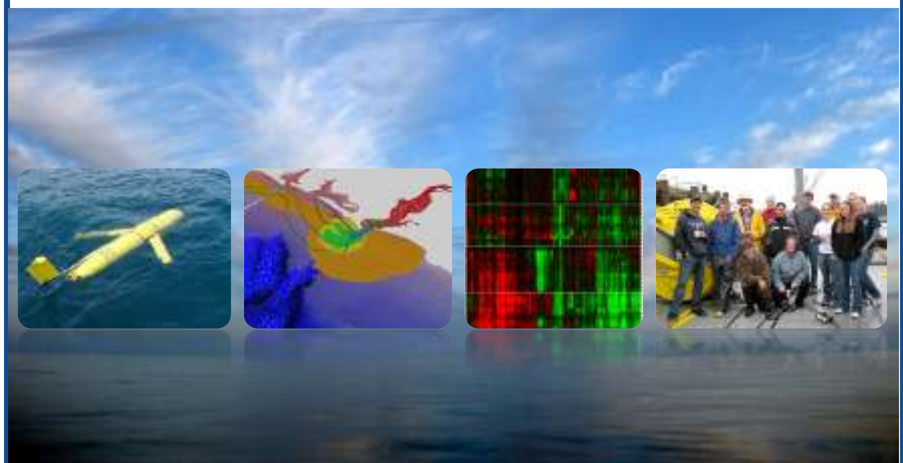
What is the role of fluvial phytoplankton in Lower Columbia River food webs?

Observation ● Prediction ● Analysis ● Collaboration



CMOP
Center for Coastal Margin Observation & Prediction

www.stccmop.org

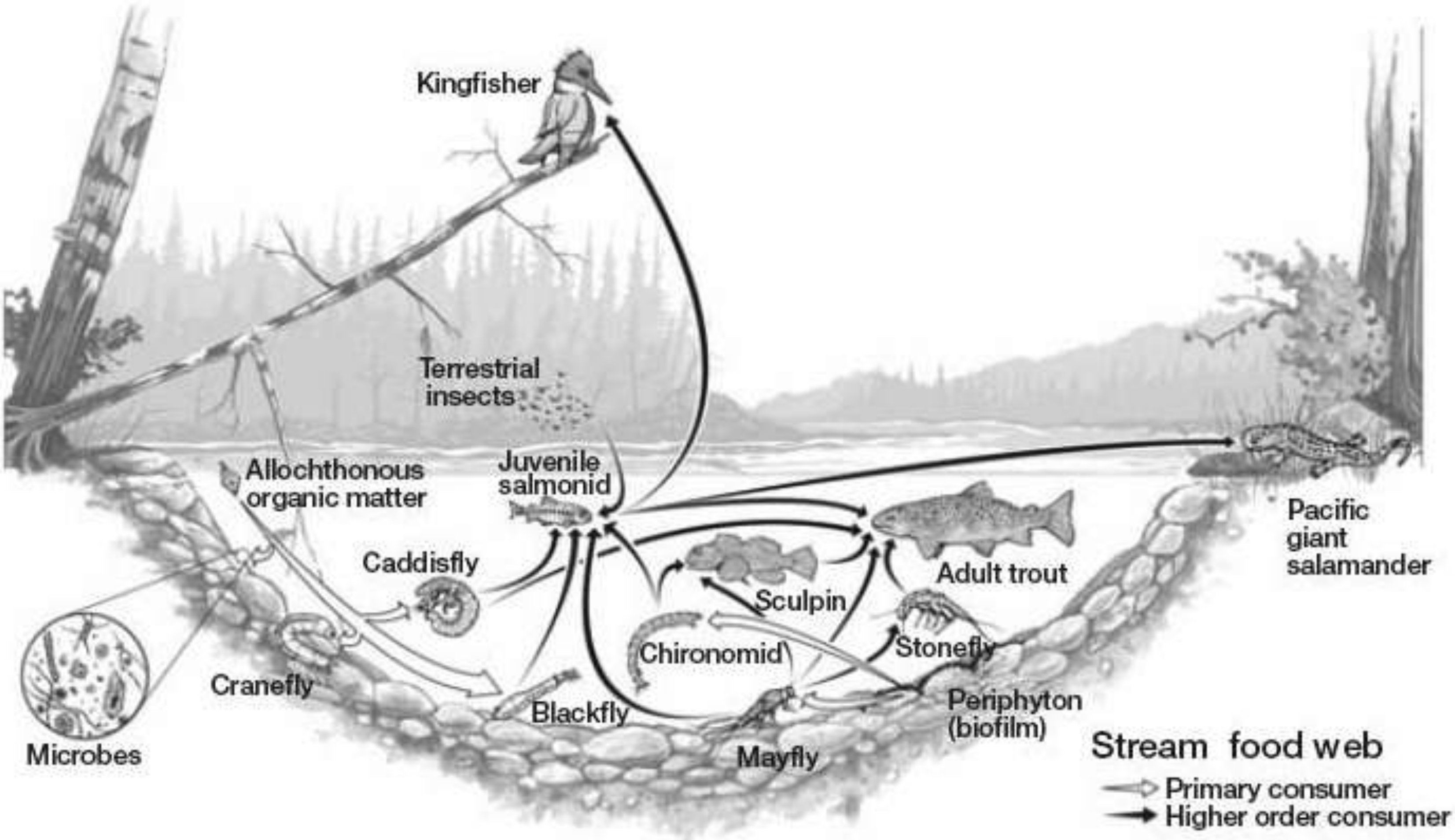
Tawnya D. Peterson, Michelle A. Maier, Joseph A. Needoba

Oregon Health & Science University

Jina Sagar and Catherine Corbett

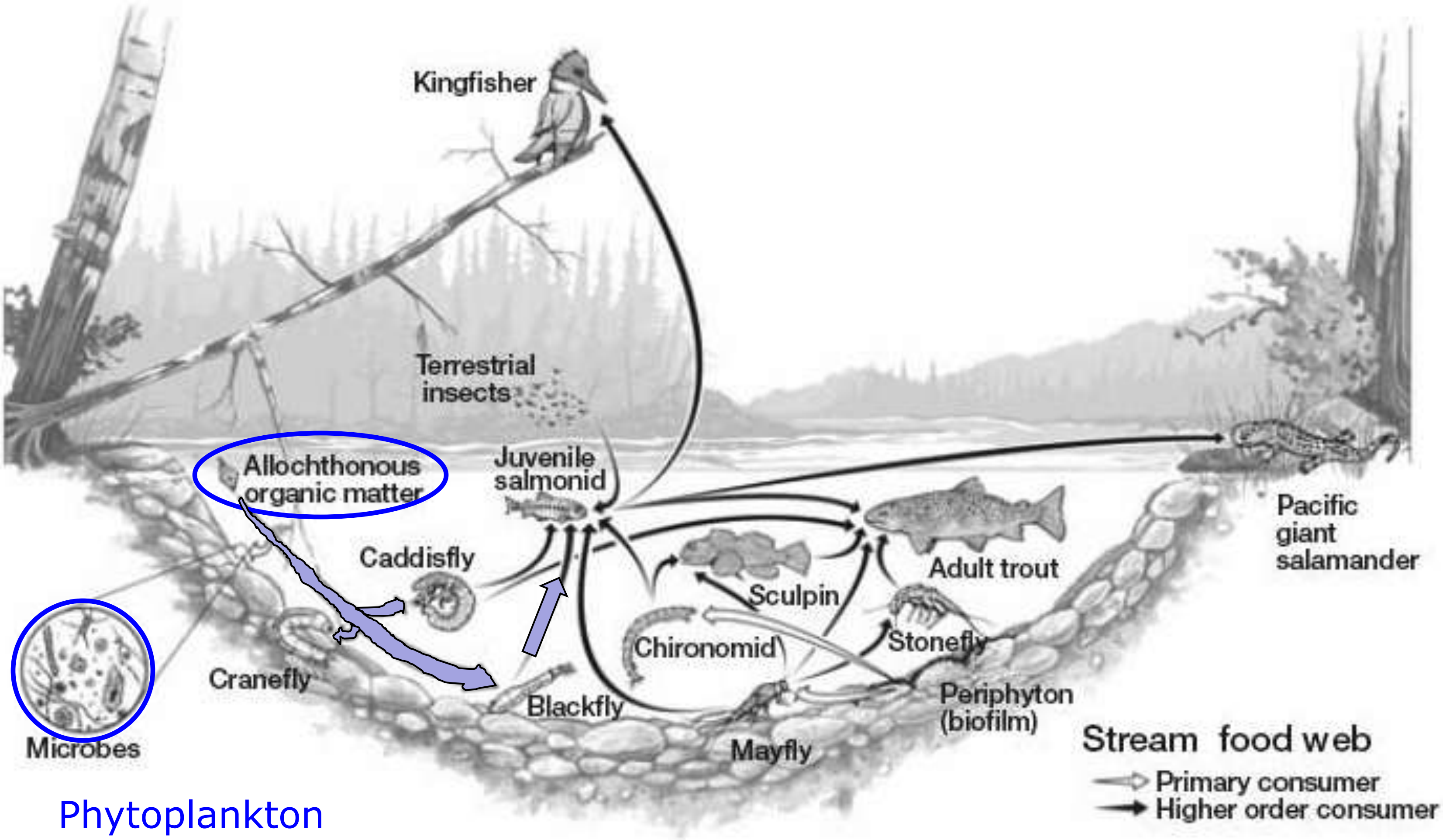
Lower Columbia River Estuary Partnership

Stream food web



Macneale et al. 2010

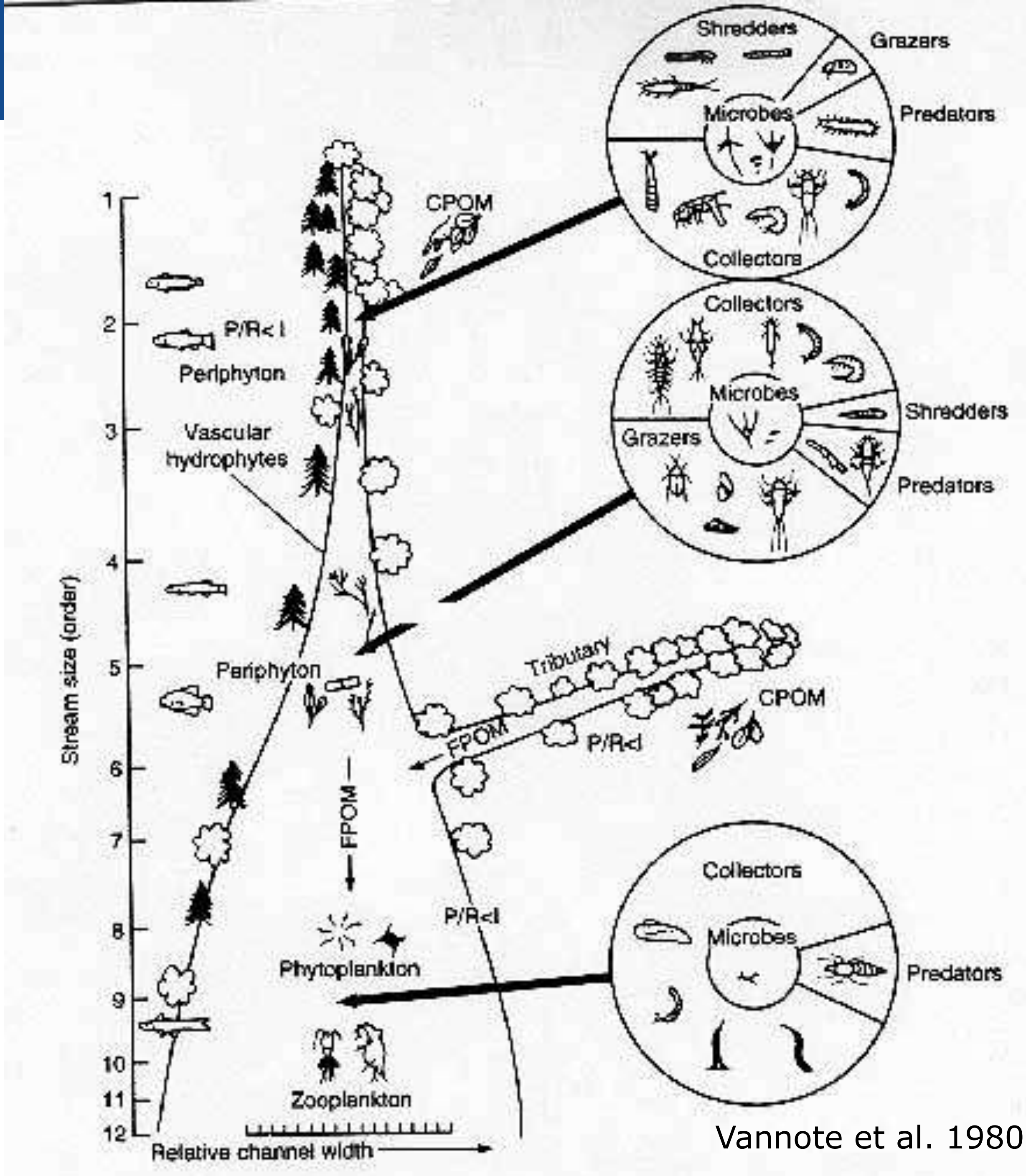
Stream food web



Phytoplankton

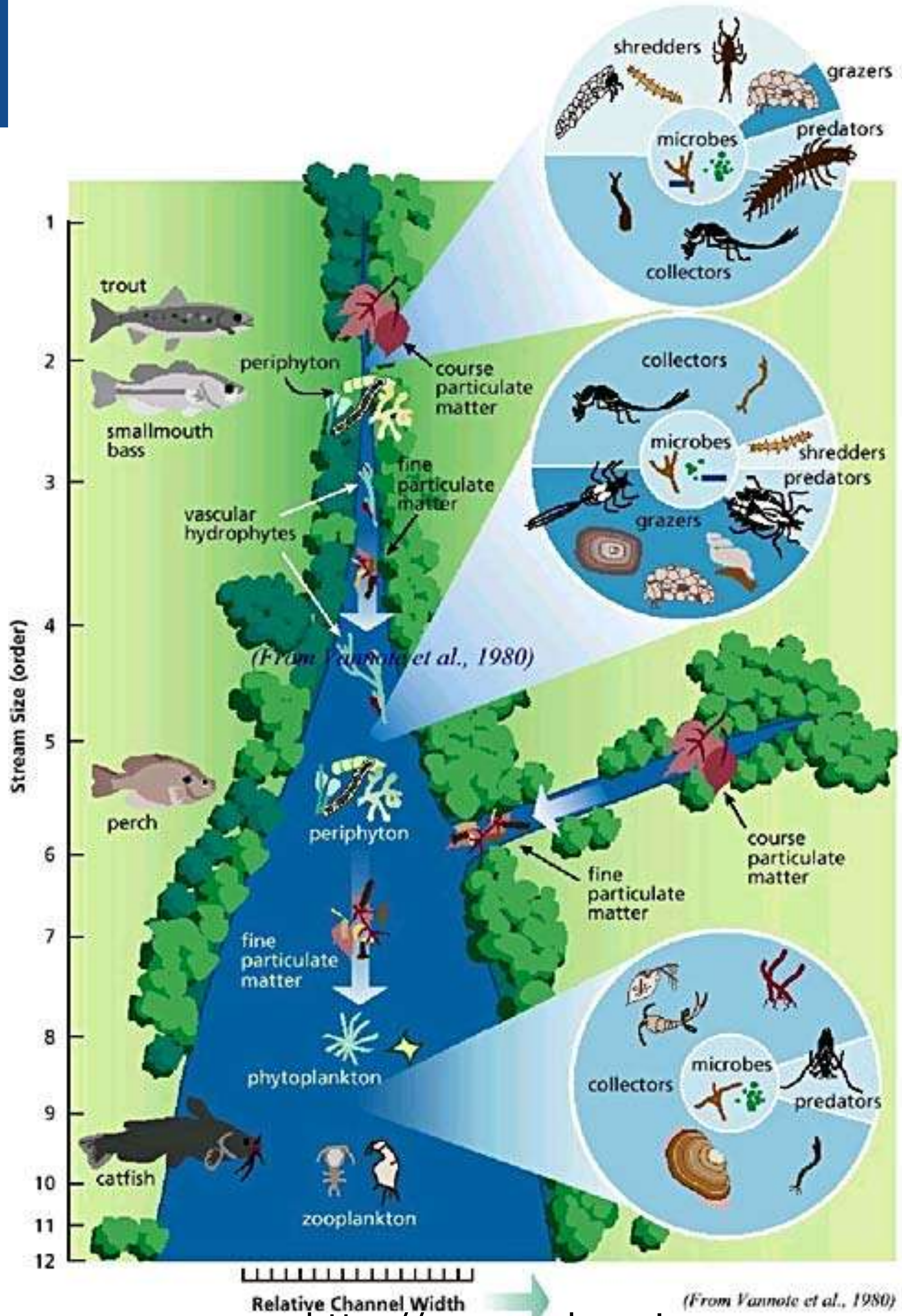
Macneale et al. 2010

The River Continuum Concept



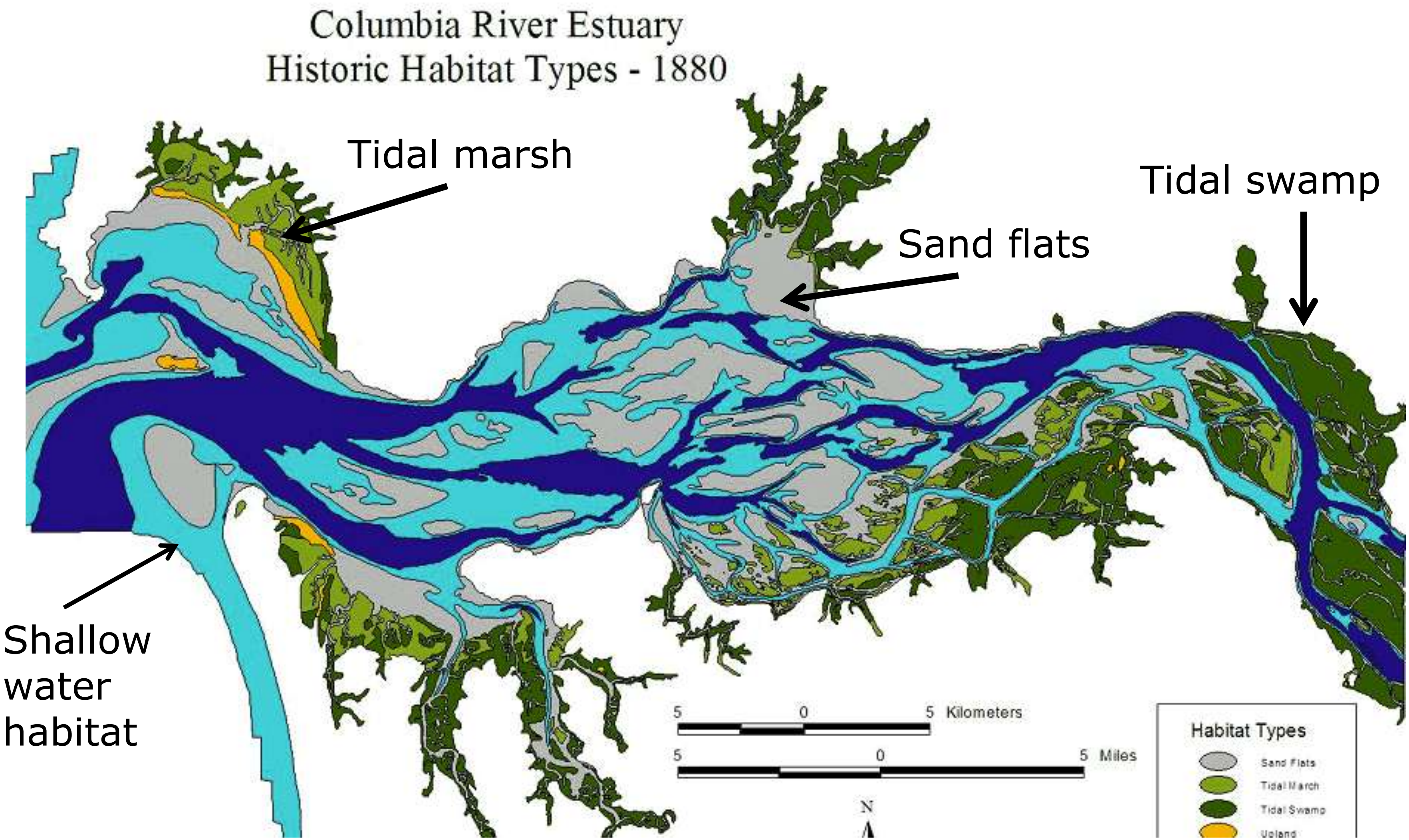
Vannote et al. 1980

The River Continuum Concept



http://www.oxbowriver.com

Historic Columbia River



Russell, 2009

Modern Day Columbia River

Shared use:

- Endangered Species
- Hydropower management
- Land use, irrigation, agriculture

Additional stressors:

- Urbanization (e.g. contaminants)
- Changing climate

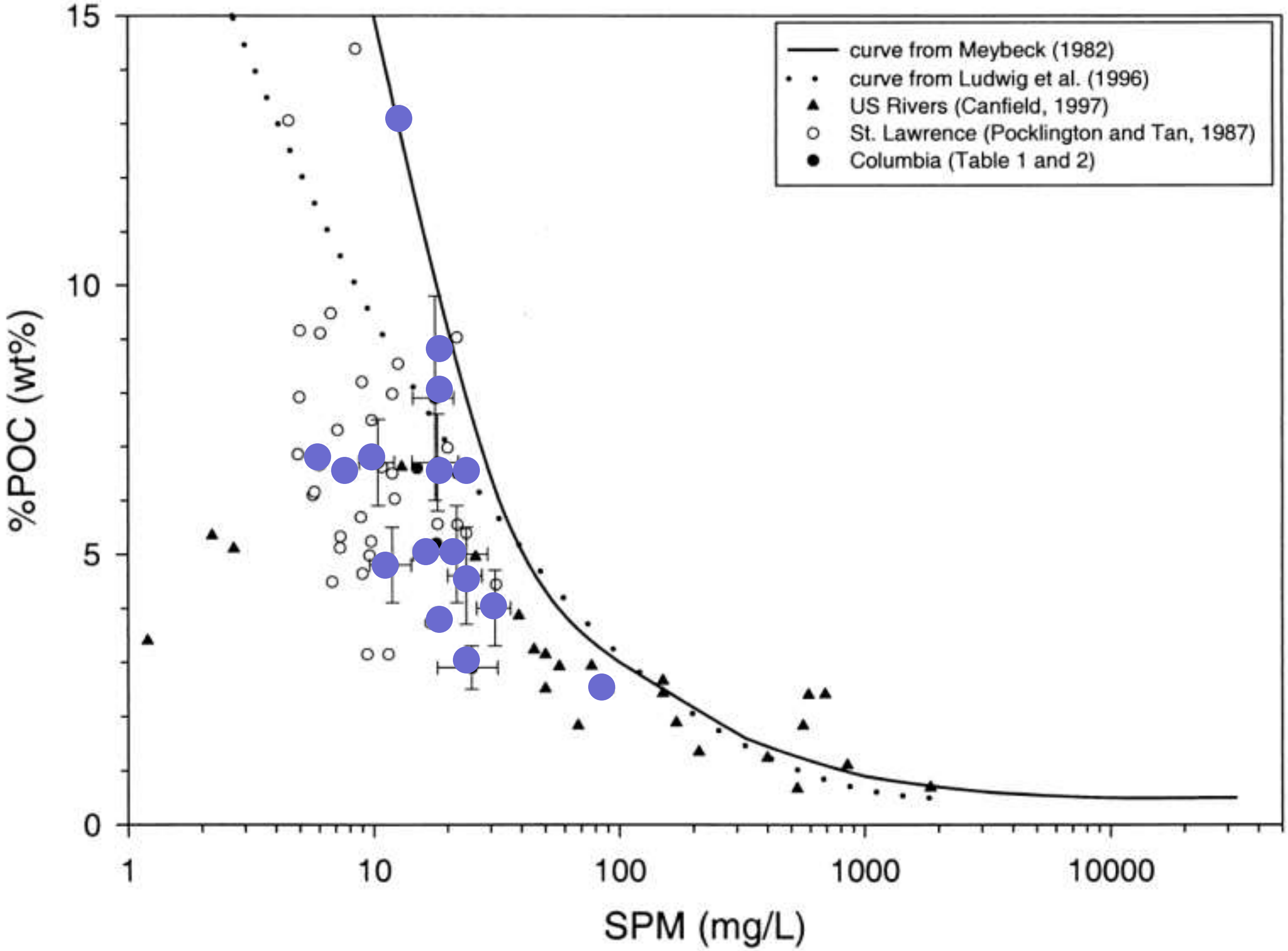
http://en.wikipedia.org/wiki/File:Columbiarivermap.png

Role of dams in river ecological function

Grand Coulee Dam

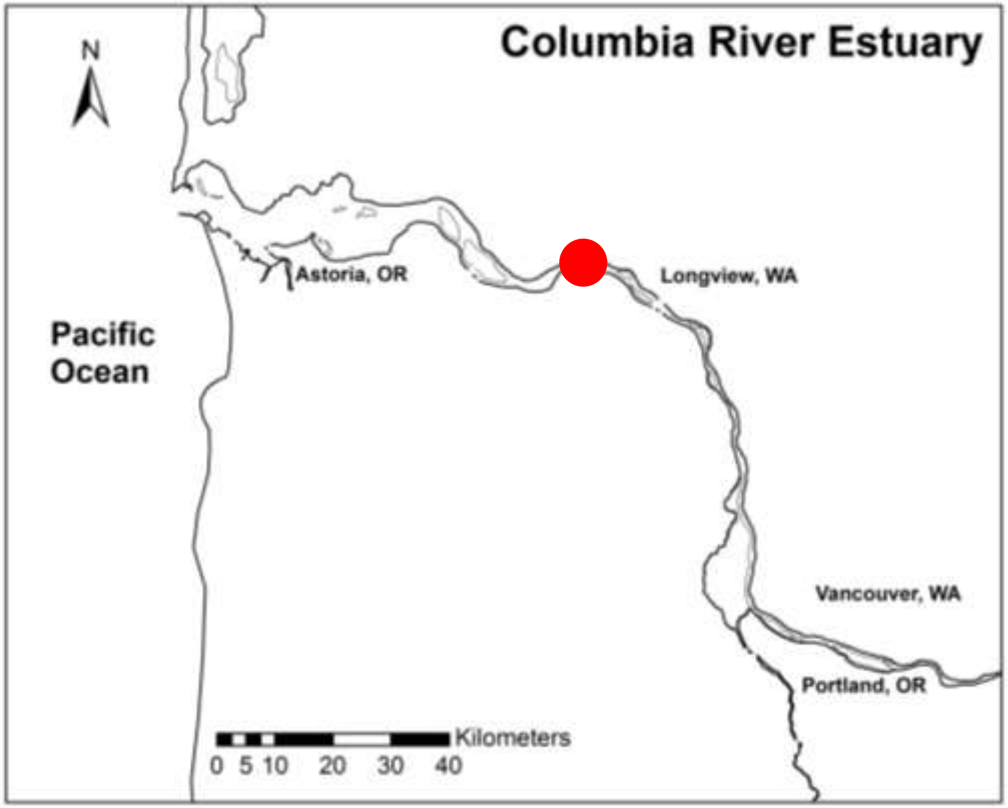
http://www.usbr.gov

‘Greening’ of the Columbia River



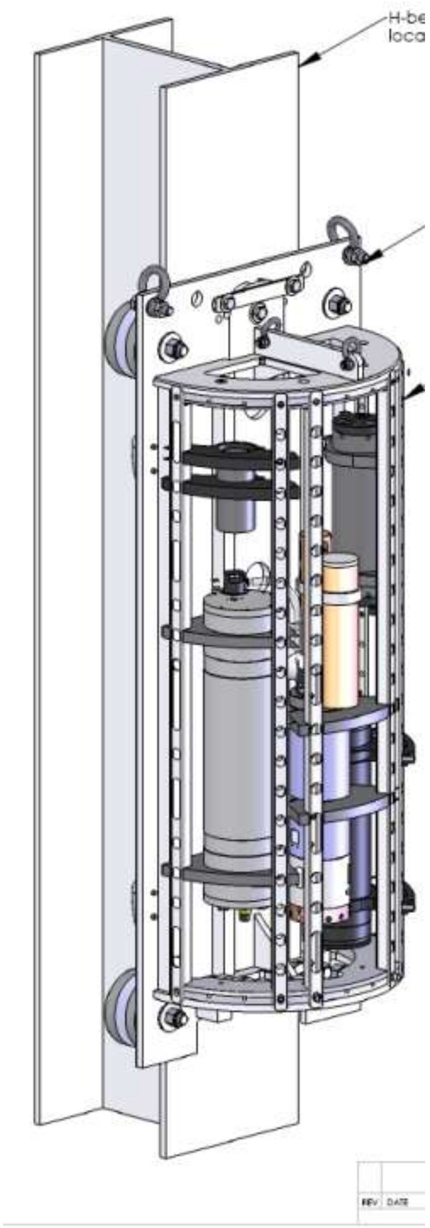
Sullivan et al. 2001

A sensors approach for quantifying river 'greening'



A sensors approach for quantifying river 'greening'

A sensors approach for quantifying river 'greening'

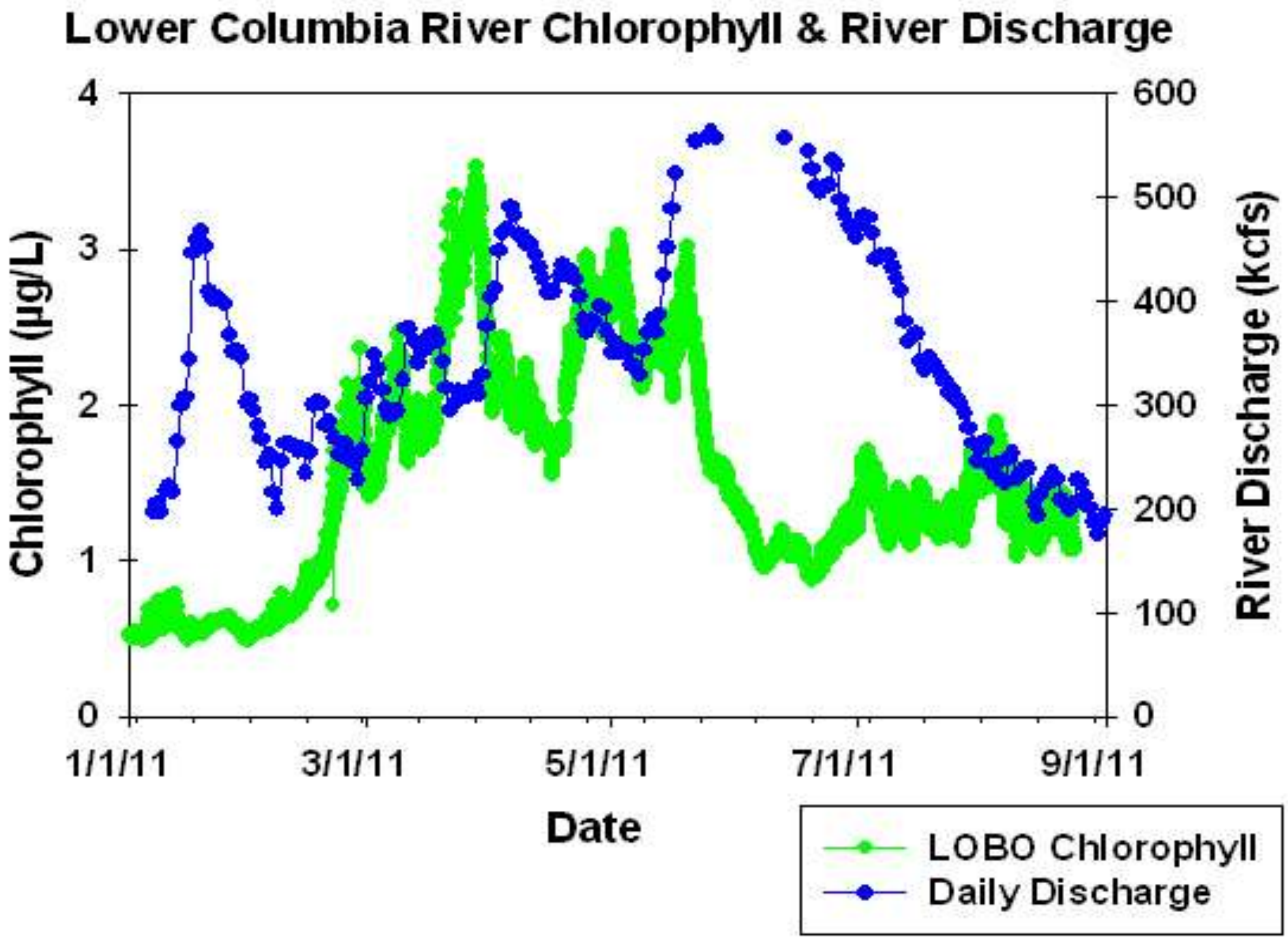


A sensors approach for quantifying river 'greening'

Latest

Lower Columbia River
2012-02-20 11:00:00 PST

CDOM	23.11	QSDE
Chlorophyll	6.68	µg/L
Conductivity	0.0090	S/m
Depth	3.822	m
Dissolved O_2	9.23	ml/l
Nitrate	29.7	µM
O_2 Saturation	8.90	ml/l
O_2 % Saturation	103.7	%
Salinity	0.07	PSU
Temperature	5.10	°C
Turbidity	4.90	NTU
Battery Voltage	12.8	V

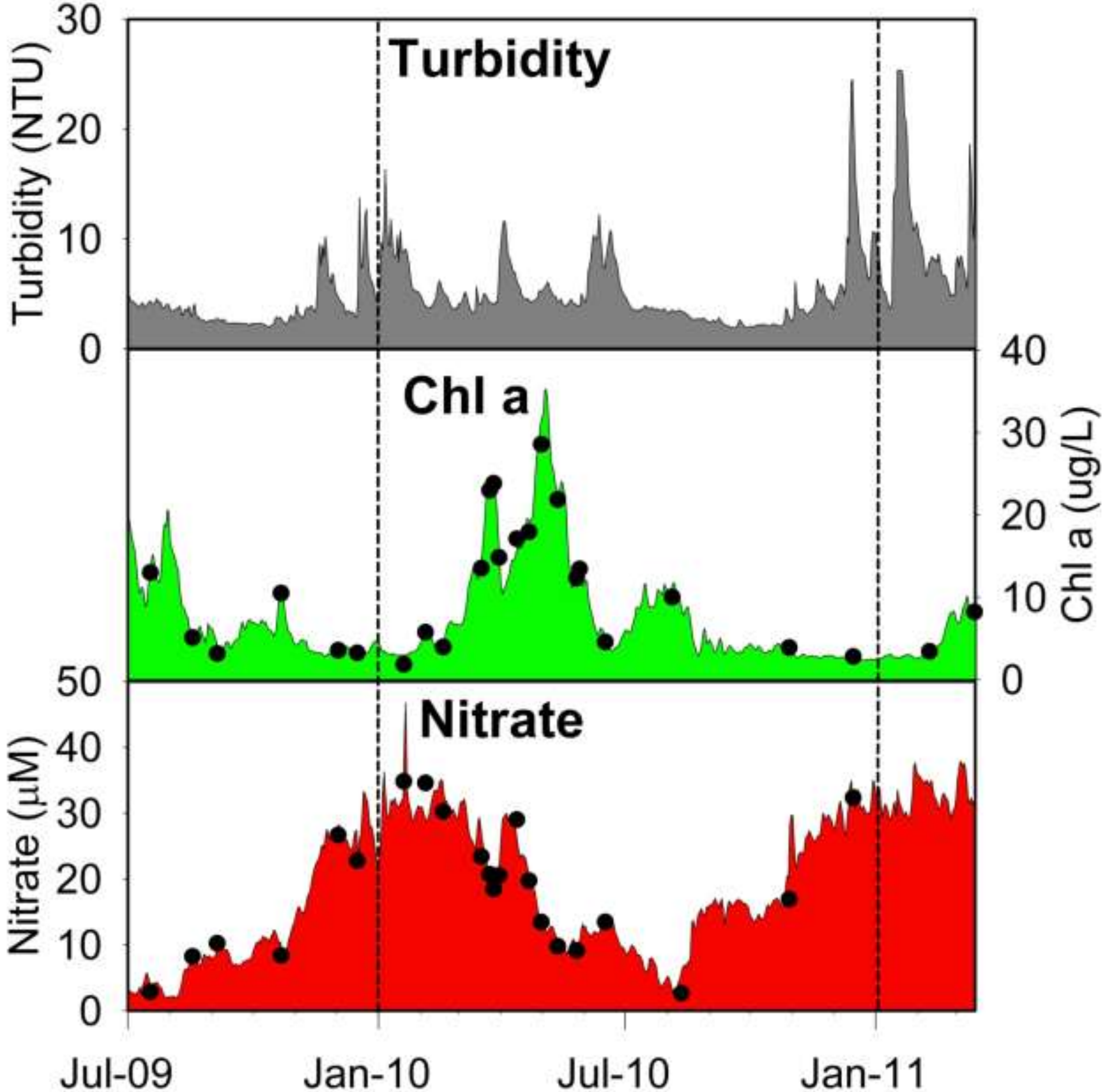


Lower Columbia River Chlorophyll & River Discharge
Chlorophyll (µg/L)
River Discharge (Kcfs)
0
1
2
3
4
0
100
200
300
400
500
600
1/1/11
3/1/11
5/1/11
7/1/11
9/1/11
Date
LOBO Chlorophyll
Daily Discharge

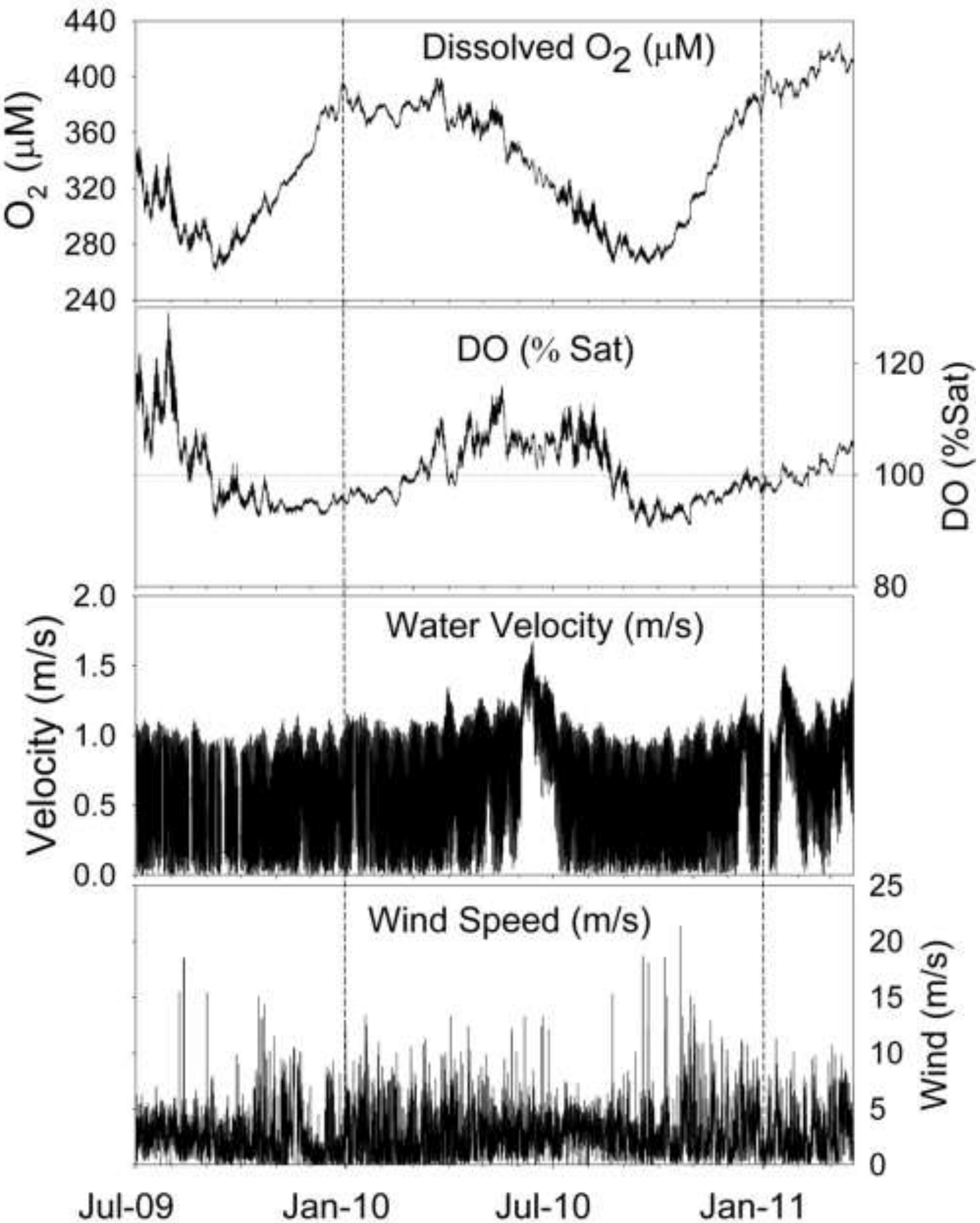
High turbidity associated with episodic storm events

Chlorophyll a biomass characteristic of temperate latitude phytoplankton blooms

Nitrate highest during winter, decreases correlated with chl *a*

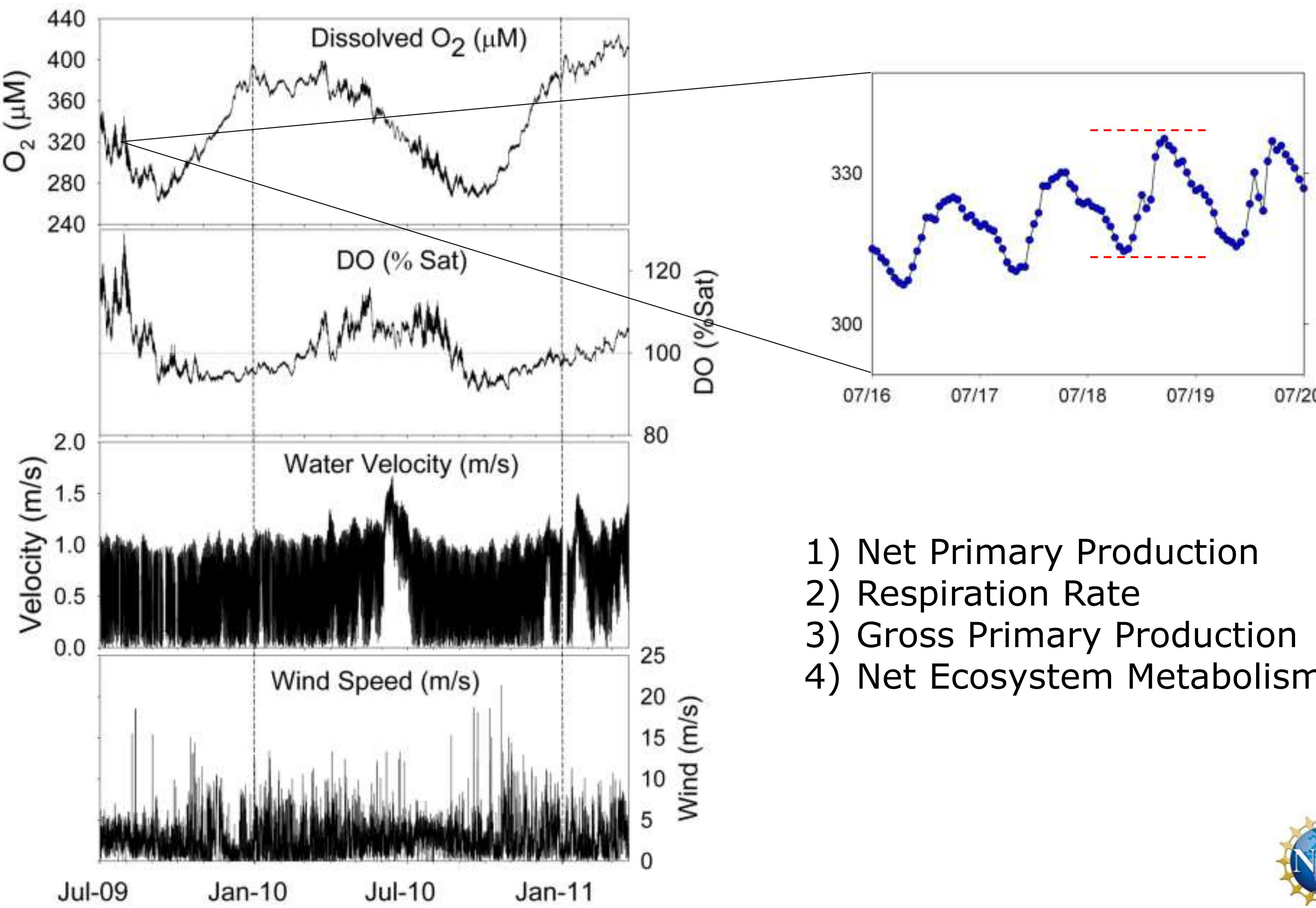


Using dissolved O_2 to calculate metabolic rates



1) Net Primary Production
2) Respiration Rate
3) Gross Primary Production
4) Net Ecosystem Metabolism

Using dissolved O2 to calculate metabolic rates



1) Net Primary Production
2) Respiration Rate
3) Gross Primary Production
4) Net Ecosystem Metabolism

Calculating oxygen flux

1) Biological Oxygen Change per hour:

$$BDO_t = (DO_t - DO_{t-1}) * h - F_{O2}$$

2) Oxygen Flux by air-water diffusion:

$$F_{O2} = -\mathrm{v}O_2 \times (O_{2\,meas} - O_{2\,sat})$$

3) Piston velocity estimates:

$$k_{flow} = U\left(\frac{v}{D}\right)^{-\frac{1}{2}}\left(\frac{Uh}{v}\right)^{-\frac{1}{2}} = \sqrt{\frac{UD}{h}}$$

O'Connor DJ and WE Dobbins (1958)

$$k_{wind} = 0.31 \times u_{10}^2\left(\frac{Sc}{660}\right)^{-0.5}$$

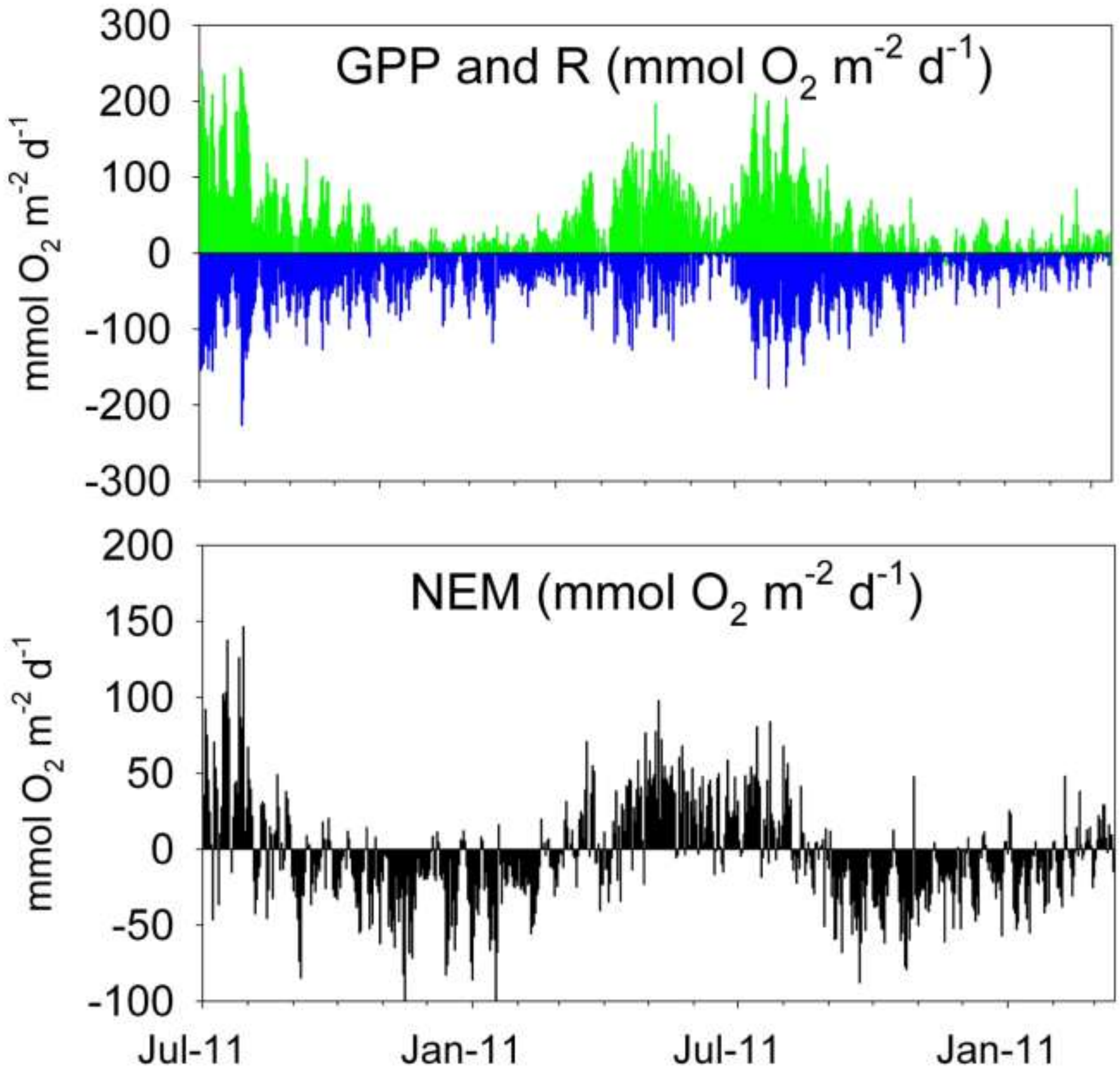
Wanninkhof R. (1992)

Net Ecosystem Metabolism of Columbia River

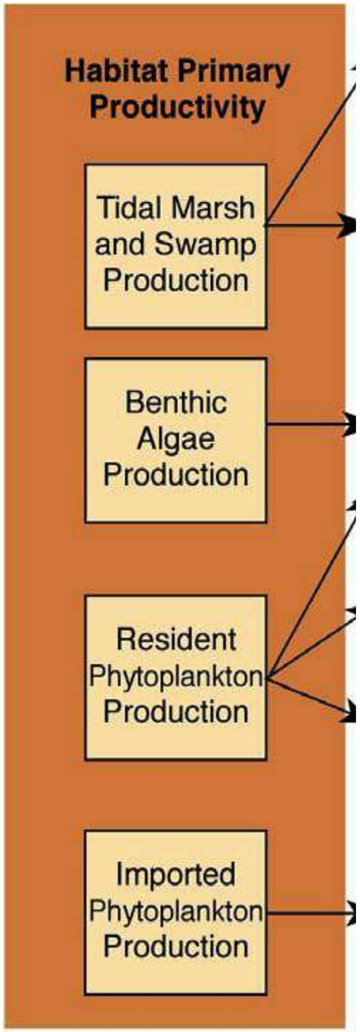
Productivity > respiration during summer

Spring Freshet depressed metabolic rates

NEM has distinct seasonal cycles

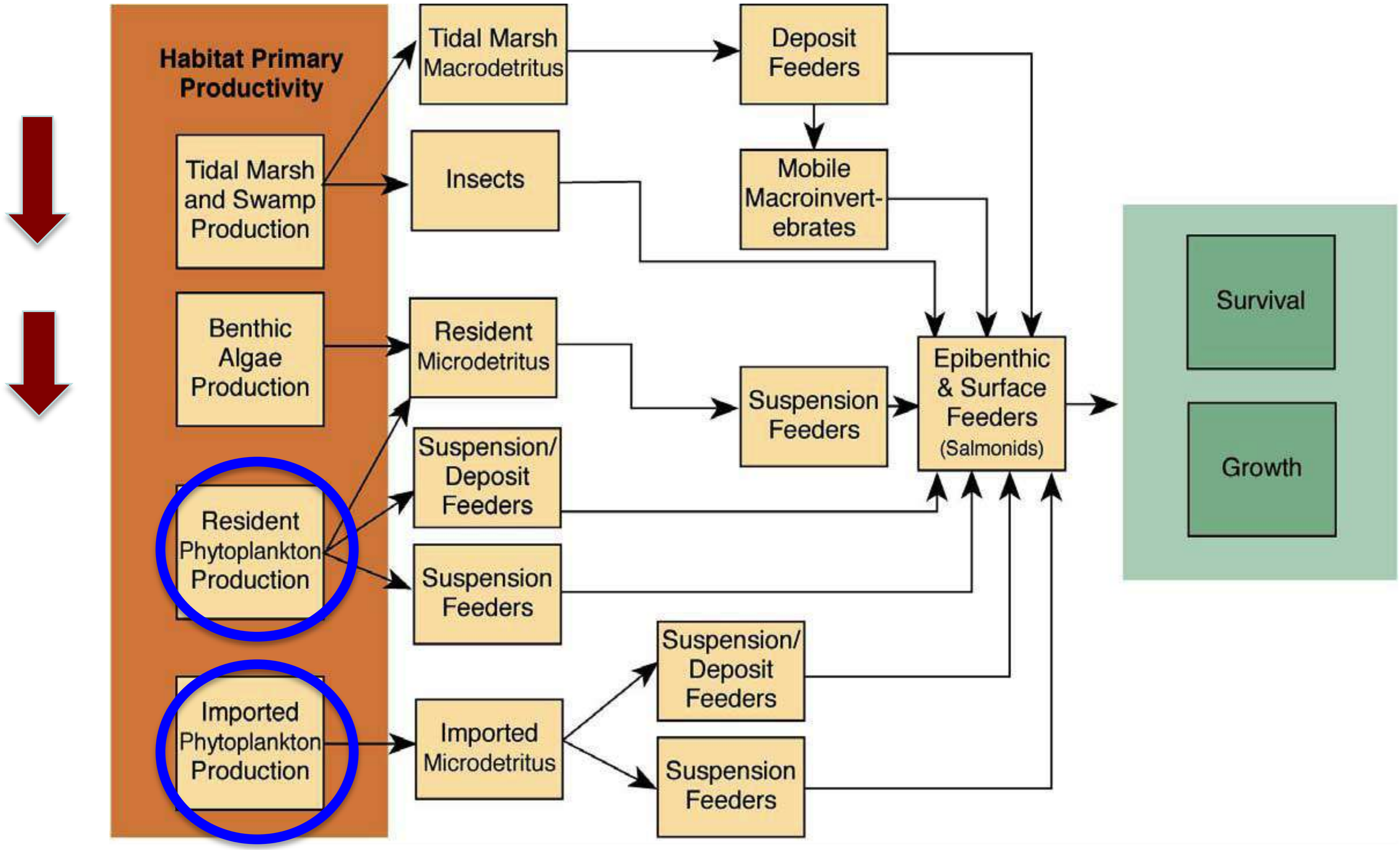


Lower Columbia River food web components



Johnson et al., 2003

Lower Columbia River food web components

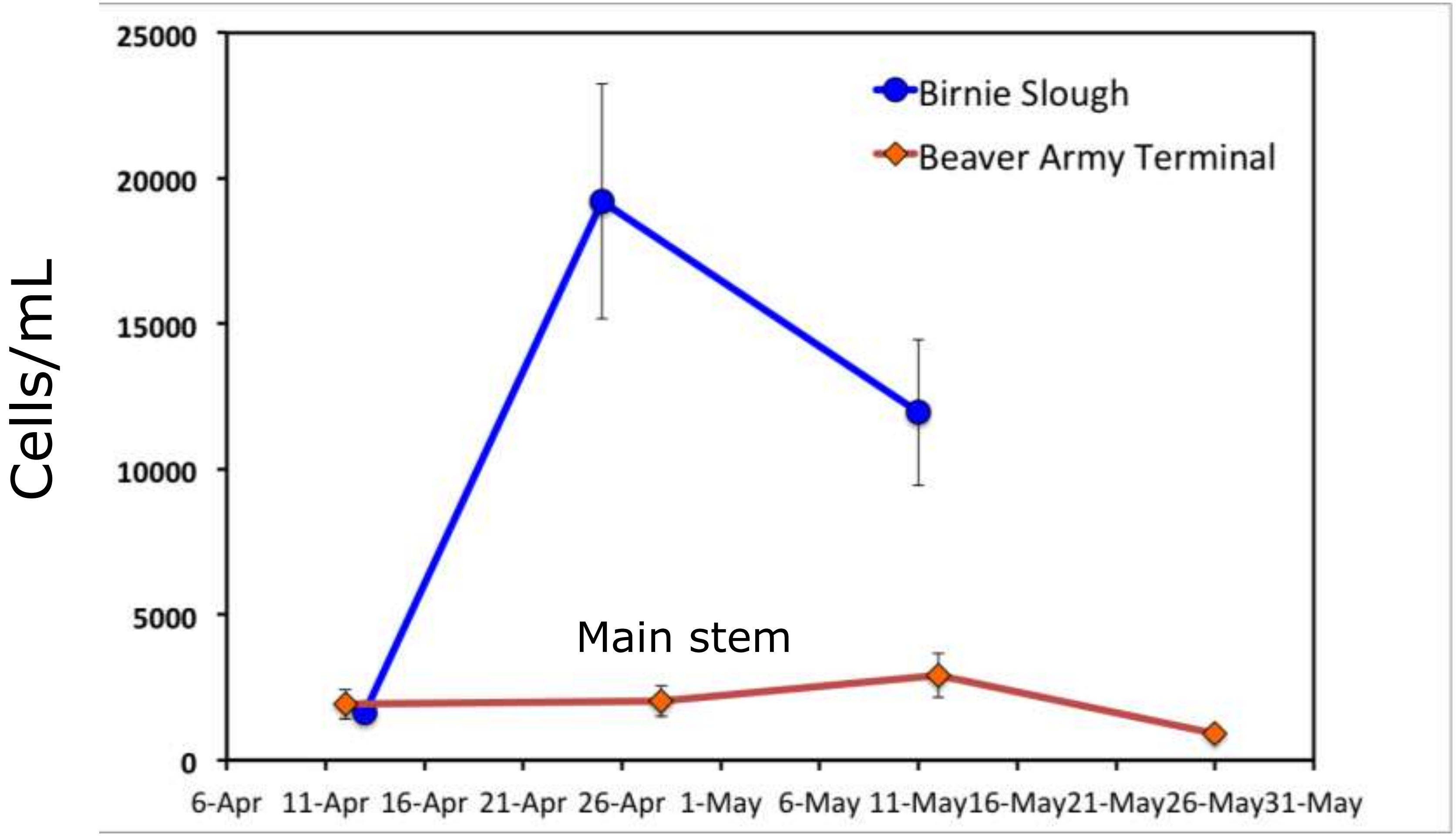


Johnson et al., 2003

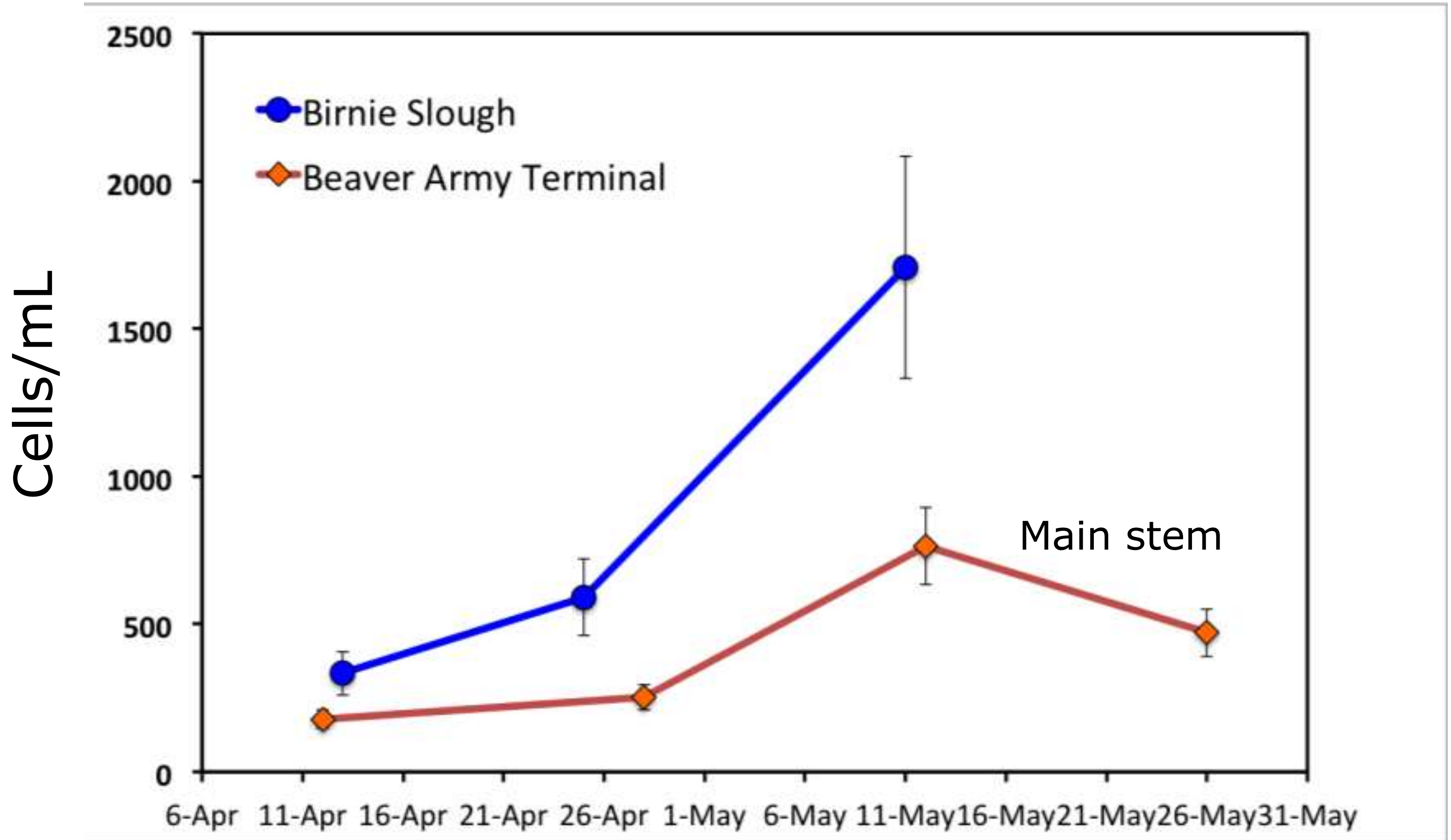
How might the landscape affect phytoplankton biomass?

Cell count comparison: mainstem vs. side channels

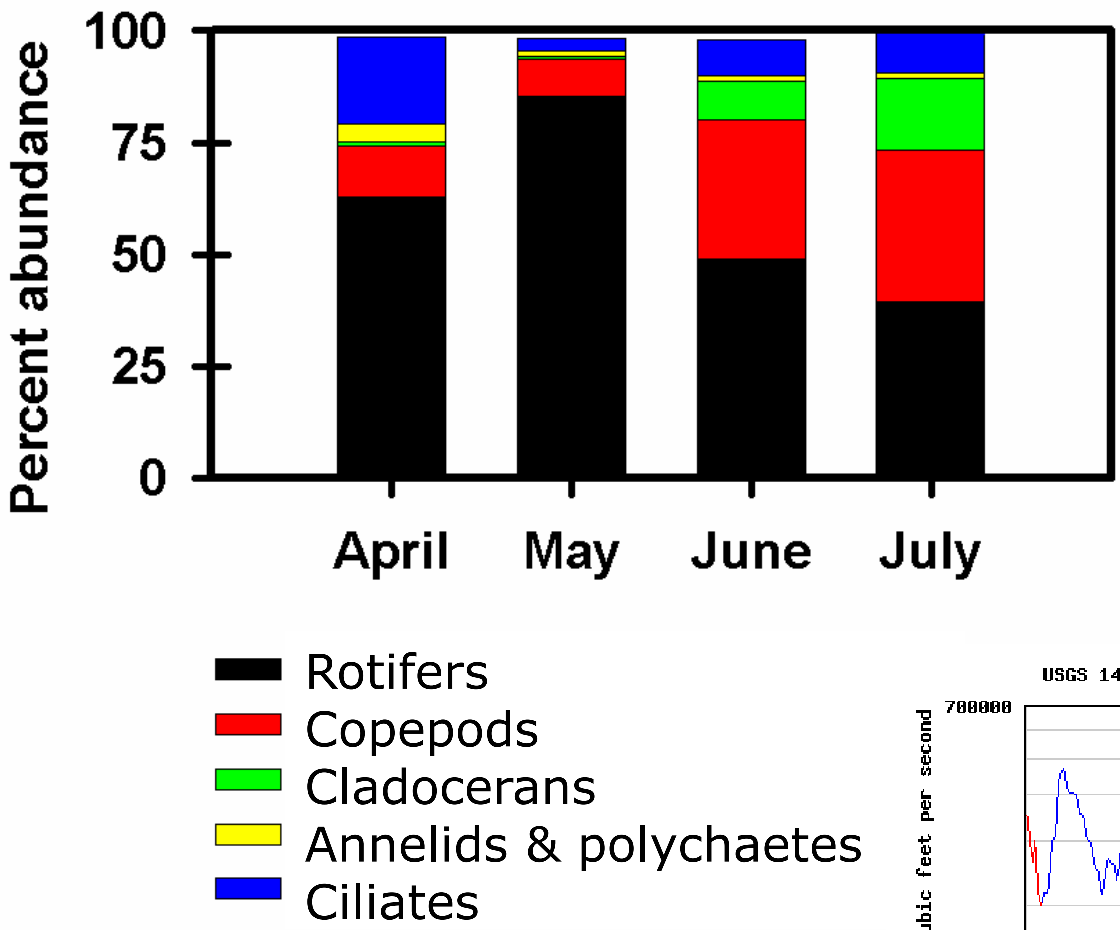
Asterionella formosa

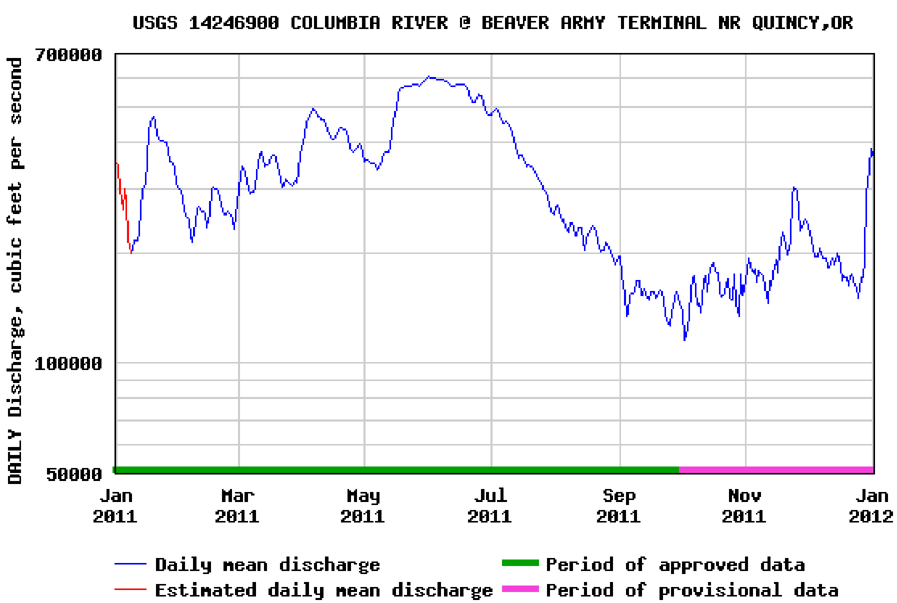


Aulacoseira granulata

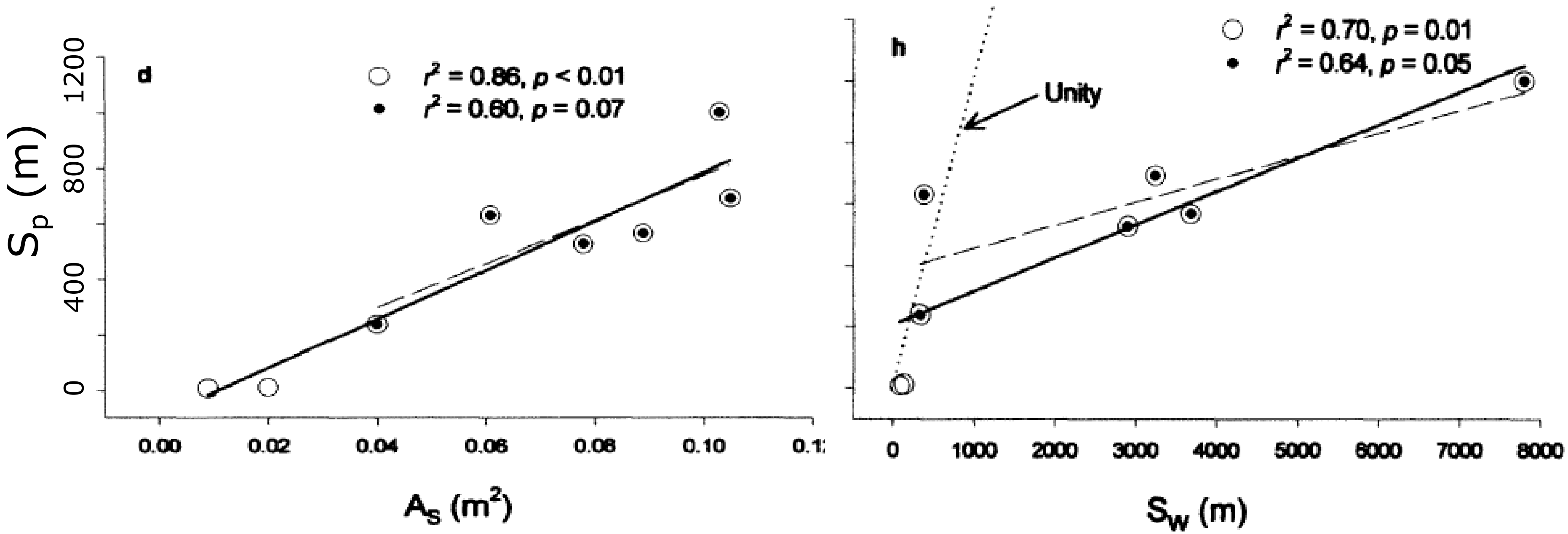


Zooplankton percent abundance at Whites Island (Birnie Slough)





Fine Particulate Organic Matter deposition in streams



(Cross-sectional area of transient storage zone)

(uptake length of water)

- *Water velocity, u*
- *Scaling factor (u*water depth)*
- *Discharge (Q)*
- *Cross-sectional area of channel (A)*
- *Relative storage zone (A_s/A)*
- *Transient storage zone coefficient (α)*

Minshall et al., 2000

Questions

- What is the importance of deposited material (FPOM) in shallow streams, and how does it change with main channel river flow and tidal exchange?

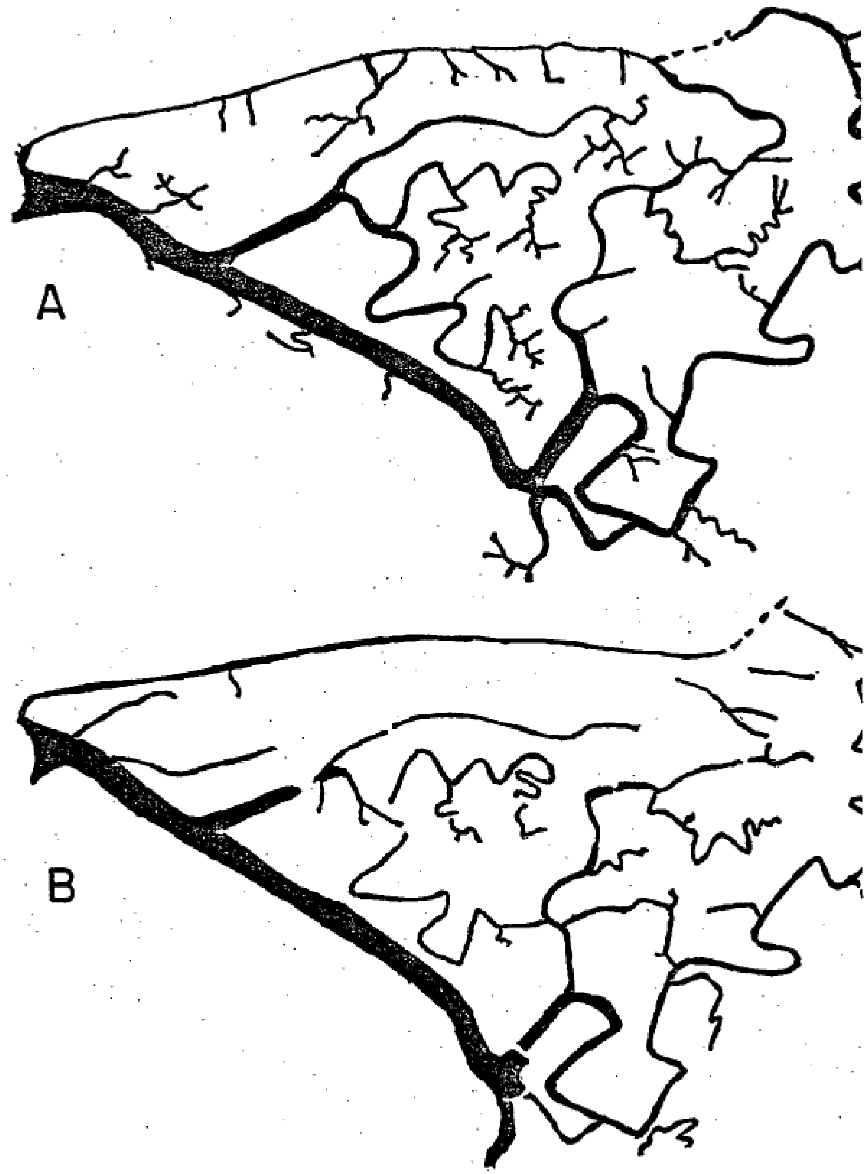
- How do depositional patterns differ in tidal vs. non-tidal streams?

- What contribution to benthic food webs does the deposition of fluvial phytoplankton make?

Changes in tide channels (Brownsmead, Clatsop County)

How has the reduction in tidal channels and streams influenced deposition rates of organic matter?

1875



1977

Thomas (1983)

Summary & management implications

- Net ecosystem metabolism calculated using in situ sensors provides a continuous picture of ecosystem function, which can be routinely monitored
- River flow influences plankton composition and abundance
- Stream environments may be important depositional environments where fluvial phytoplankton might accumulate and feed benthic deposit feeders

Acknowledgments

USGS

Whitney Temple

Jennifer Morace

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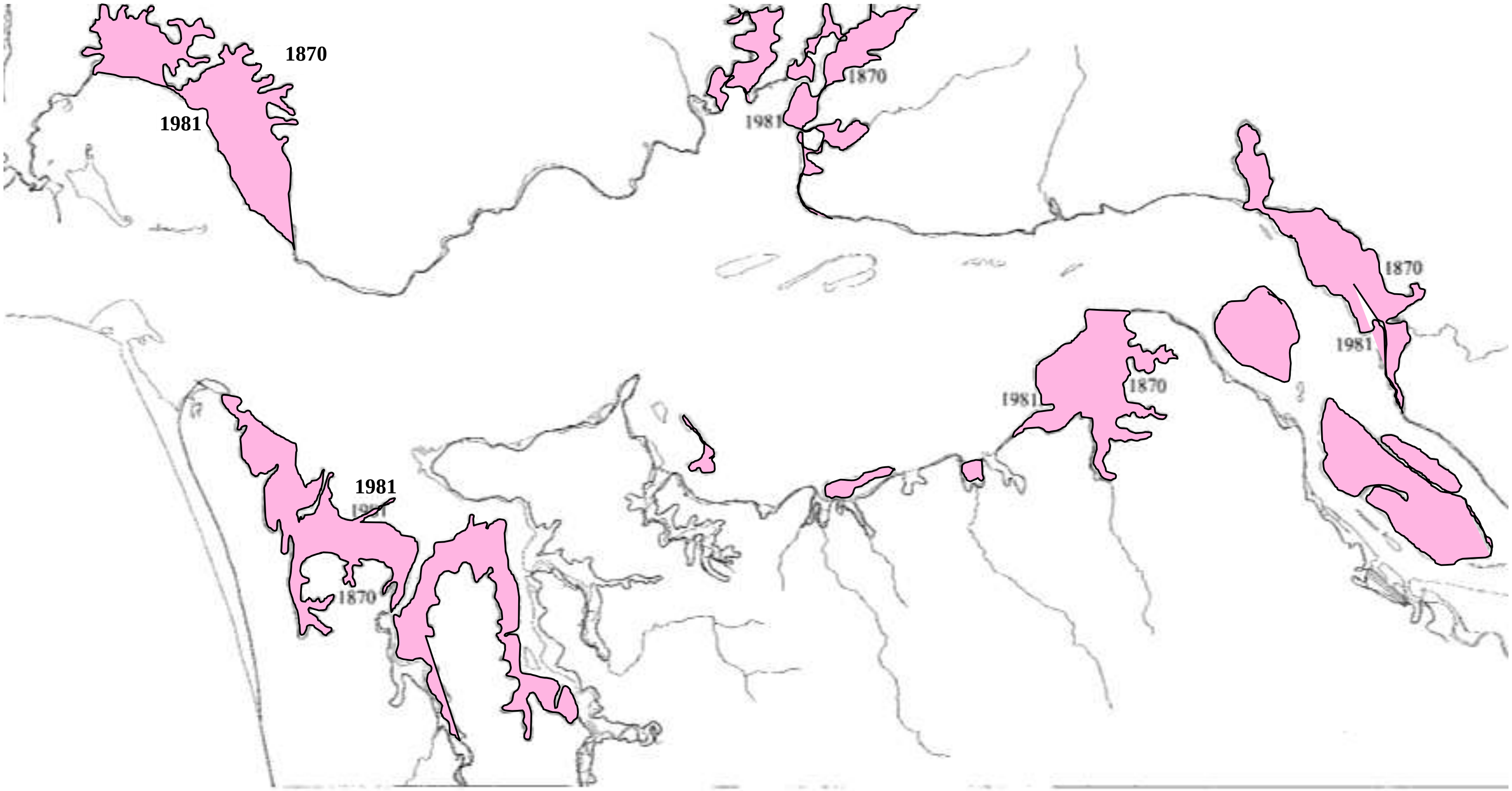
Melissa Gilbert

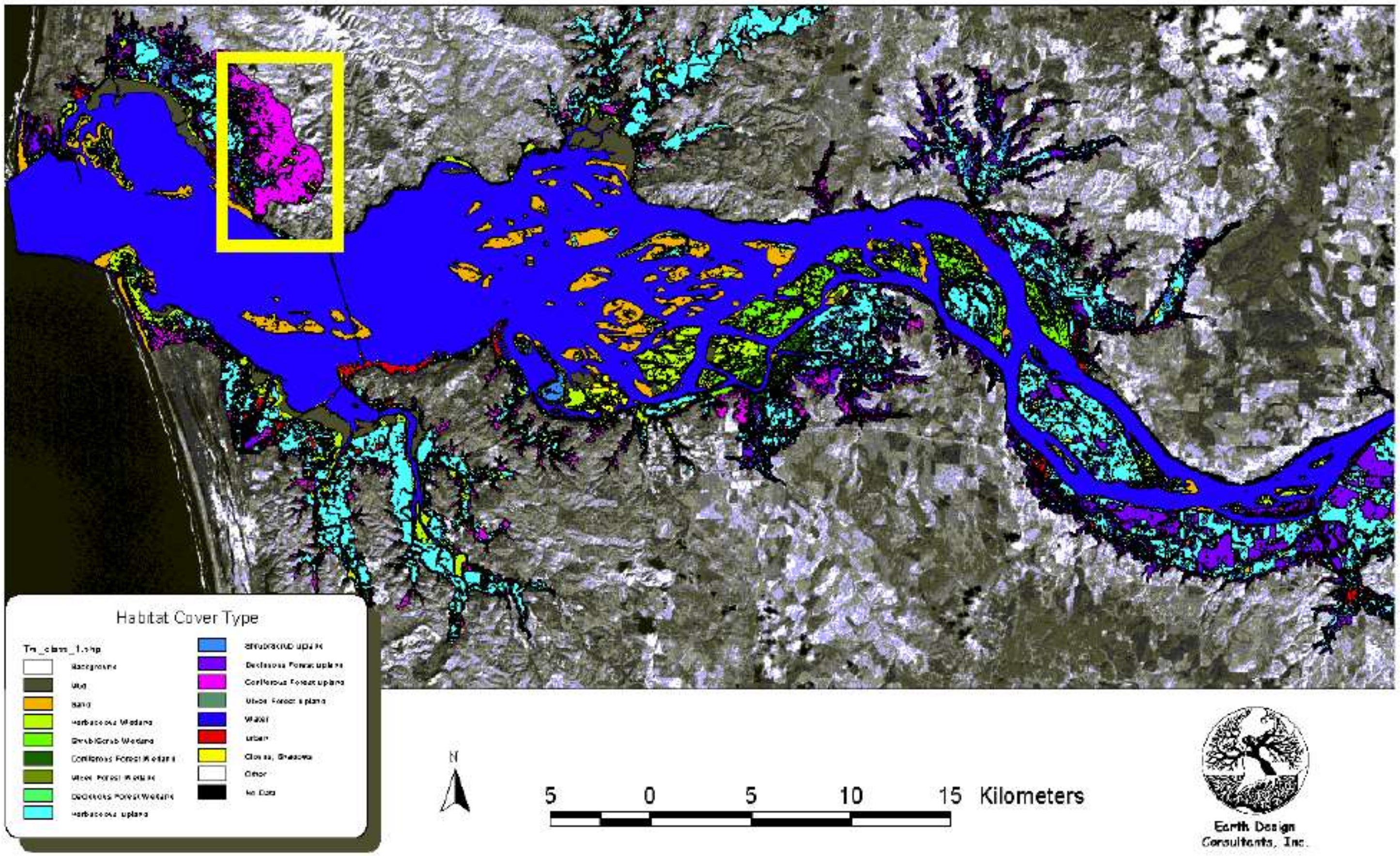
Bonneville Power Administration, U.S. Army Corps of Engineers



5. Comparison of the present estuarine boundaries with those of 1870, illustrating the loss of estuarine surface area due primarily to diking (modified from Th

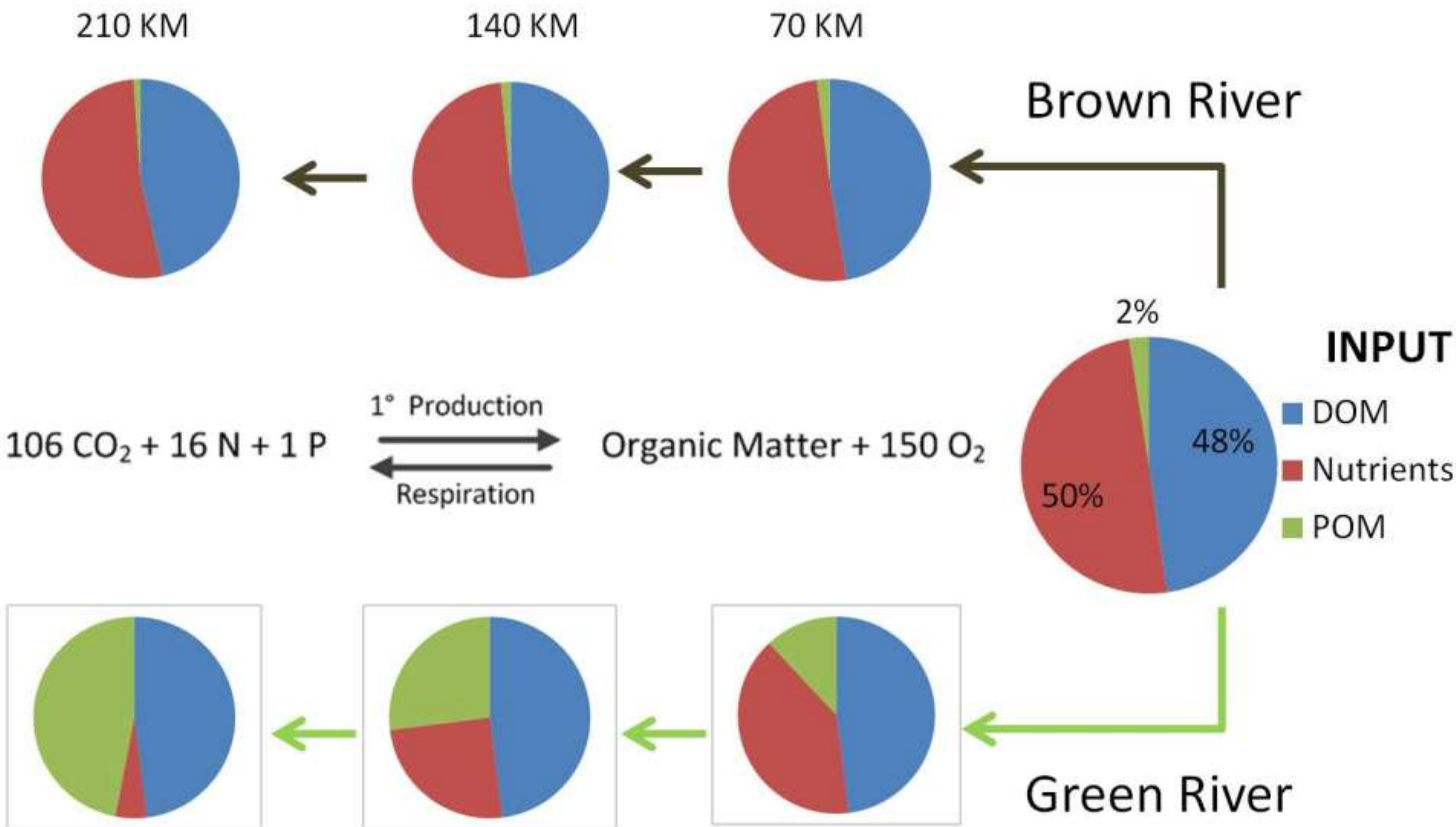
From Thomas, 1983

Lower Columbia River Estuary

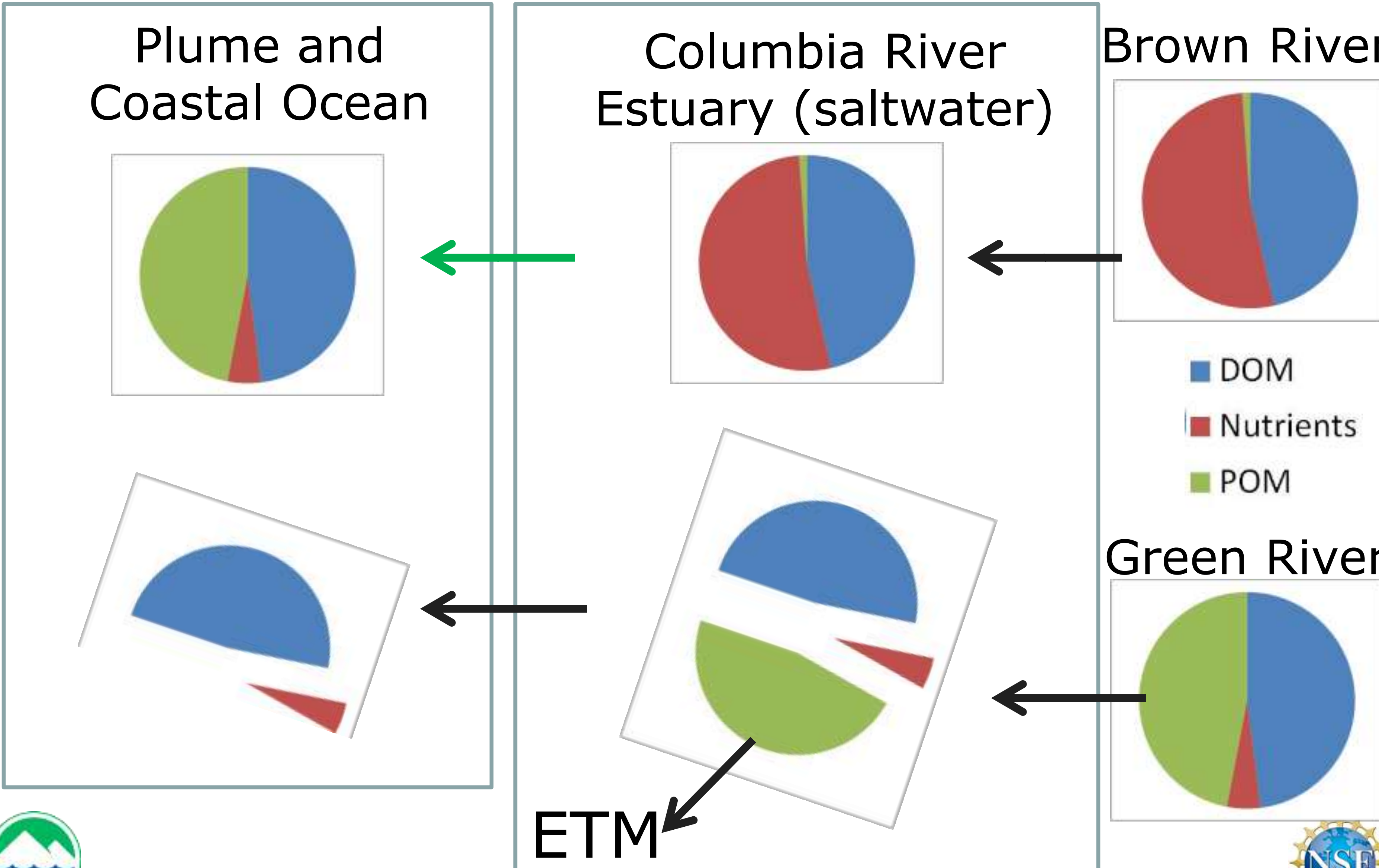


Garono & Robinson, 2003

How does ‘greening’ alter river export flux?



How does 'greening' alter estuarine flux?



Conclusion

- How does 'greening' alter river fluxes to the coastal margin?

  - Nutrients: PP converts a relatively small proportion of inorganic nutrients to organic matter during spring and summer. Therefore very little change to coastal zone flux and not enough to account for summer declines in nutrients

  - POC is altered significantly in all seasons, with important implications for salt water estuary organic matter supply

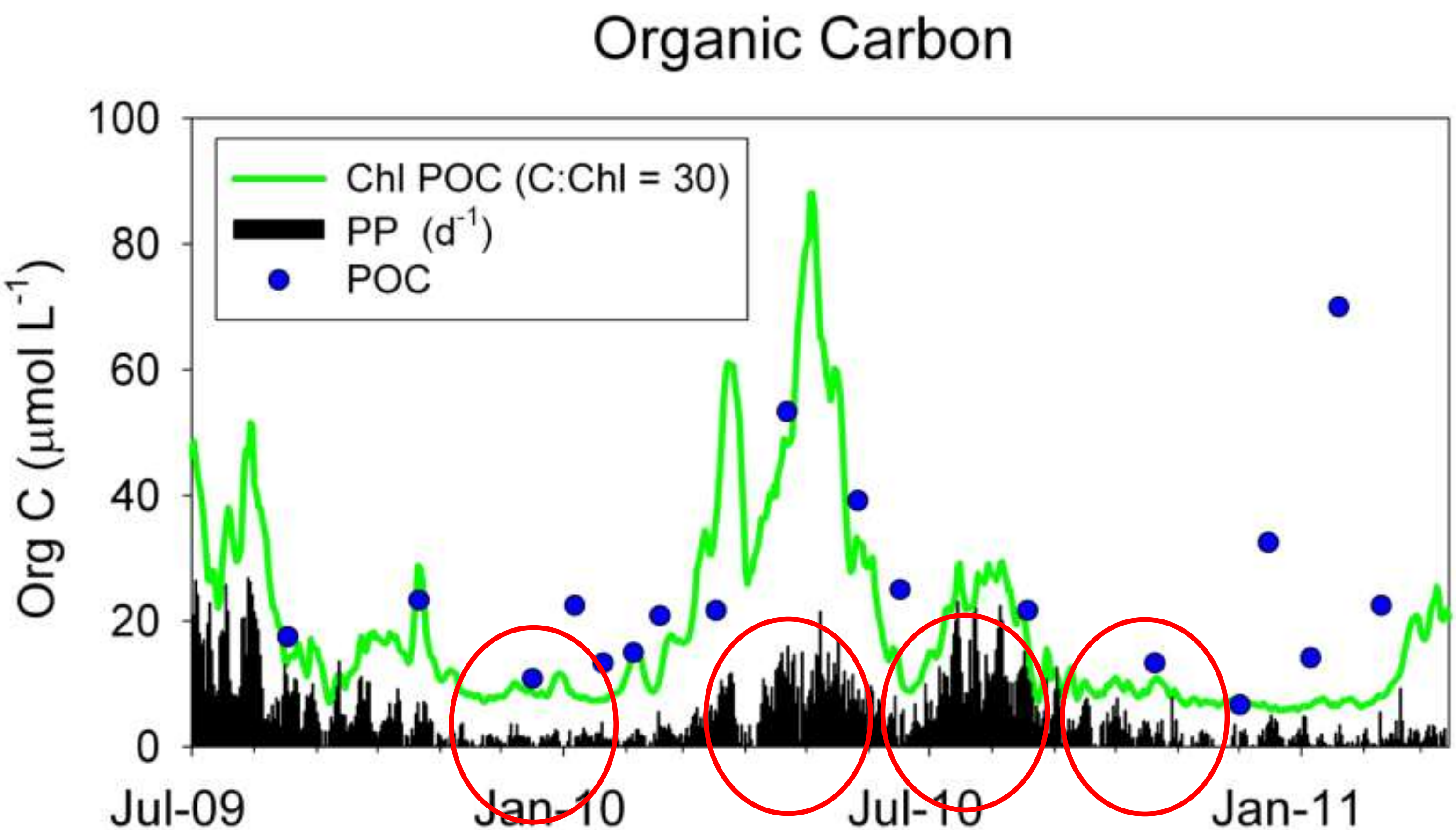
Lower River: Seasonal Impacts of Net Metabolism

		Bonneville Dam	Salt water estuary	% Change
DOC (μmol L^{-1})	Winter	113	108	-4
	Spring	129	133	3
	Summer	189	191	1
	Fall	138	133	-4

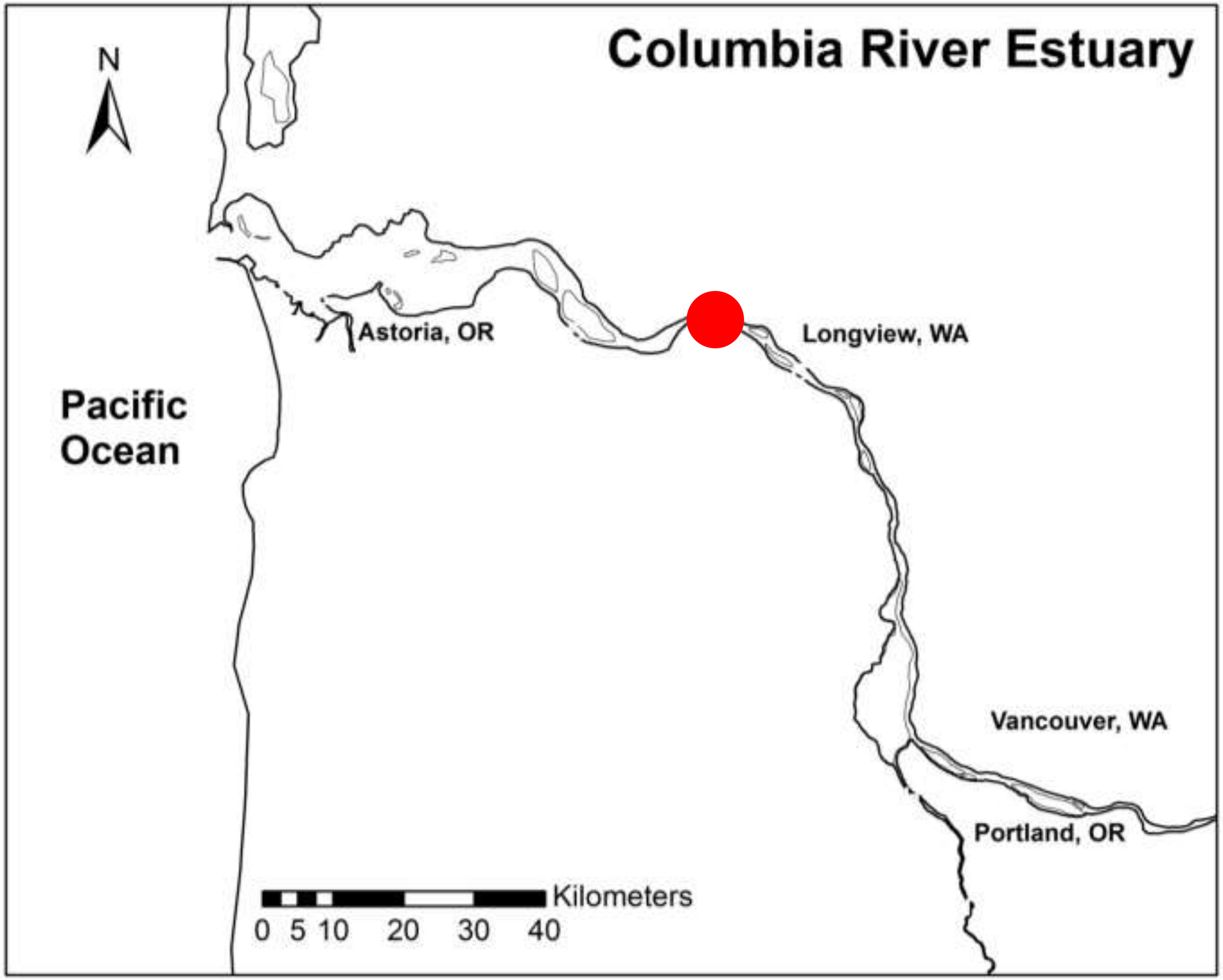
		Bonneville Dam	Salt water estuary	% Change
Nitrate (μmol L^{-1})	Winter	30	32	5
	Spring	17	15	-11
	Summer	7	6	-15
	Fall	22	23	7

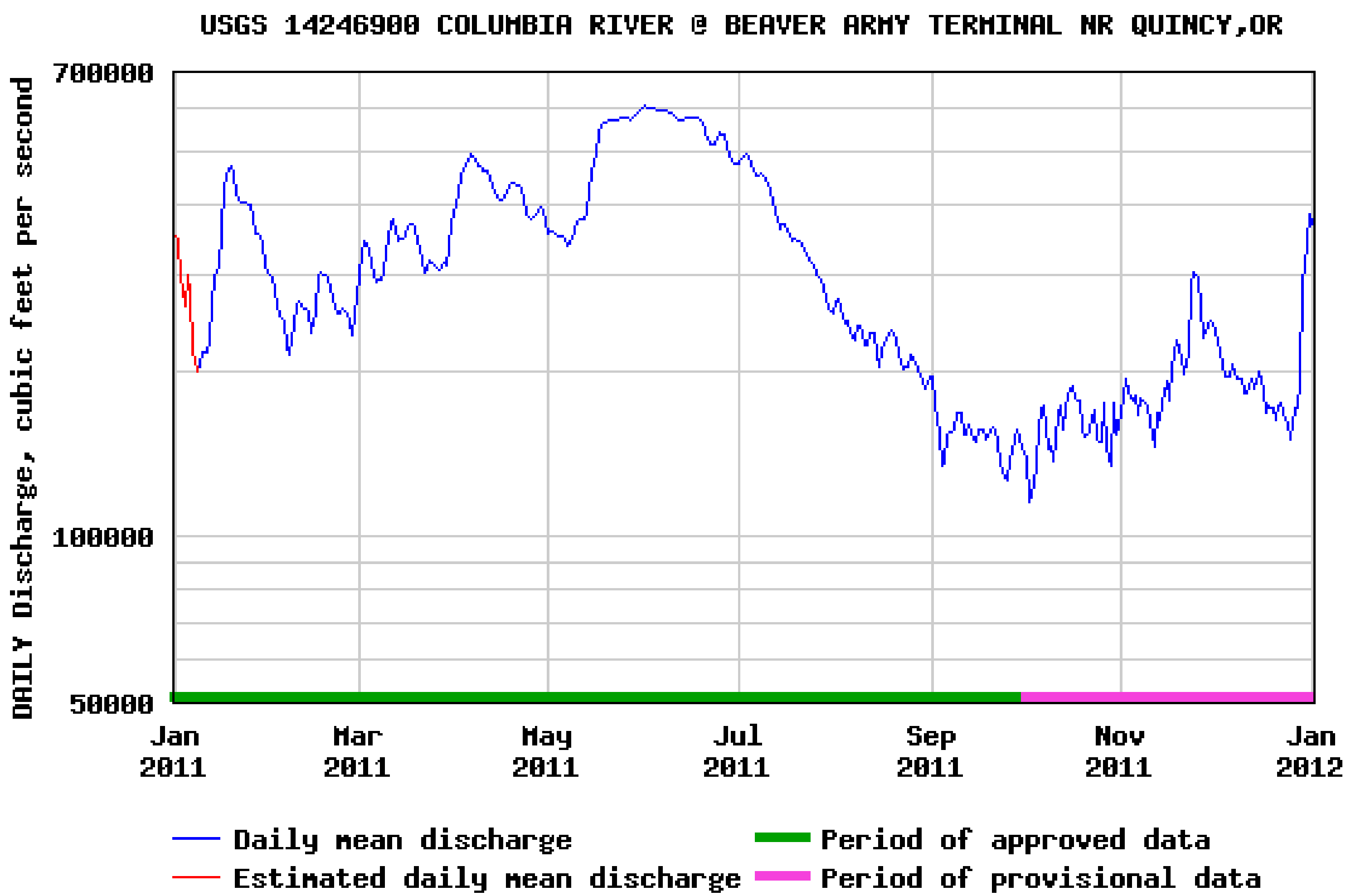
		Bonneville Dam	Salt water estuary	% Change
POC (μmol L^{-1})	Winter	20	15	-25
	Spring	45	53	19
	Summer	18	23	26
	Fall	18	13	-29

Organic Carbon: Comparison of estimates



Lower Columbia River Estuary: RM 53 fixed station




USGS 14246900 COLUMBIA RIVER @ BEAVER ARMY TERMINAL NR QUINCY,OR
DAILY Discharge, cubic feet per second
700000
100000
50000
Jan 2011
Mar 2011
May 2011
Jul 2011
Sep 2011
Nov 2011
Jan 2012
Daily mean discharge
Estimated daily mean discharge
Period of approved data
Period of provisional data