Organic Carbon 101

A few thoughts on aquatic organic carbon dynamics in the Bay-Delta system

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Jacob Fleck
Miranda Fram
Roger Fujii
Many, many others

OUTLINE

- Introduction Organic Carbon
- Introduction to Environmental fate of organic carbon
- Introduction to Drinking water impacts
- DOC sources dynamics in the Delta (Bergamaschi)
- Sources of DOC in the Central Valley watersheds (Pellerin)
- Sources of DOC in the Delta (Kraus)
- Summary questions and conflicts

4.5 mg Organic Carbon

4.5 mg Organic Carbon

Total Organic Carbon
TOC

4.5 mg Organic Carbon

1.5 mg Particualte Organic Carbon	3.0 mg Dissolved Organic Carbon
POC	DOC

4.5 mg Organic Carbon

1.5 mg POC

3.0 mg DOC

4.5 mg Organic Carbon

1.5 mg POC

Sedimentary Organic Carbon

Detrital Organic Carbon

Planktonic Organic Carbon

3.0 mg DOC

4.5 mg Organic Carbon

1.5 mg POC

Sedimentary Organic Carbon

Detrital Organic Carbon

Planktonic Organic Carbon

3.0 mg DOC

[redacted]

OC IS *NOT* ONE THING

- Organic carbon is a mixture of OC from many different sources and forms
- The quality of organic carbon is highly variable
- Organic carbon is not inert in the environment
- The ecosystem function of organic carbon is dependent on quality, location, size, hydrodynamic class, season
- Organic carbon of different types follows different trophic trajectories

4.5 mg Organic Carbon

1.5 mg POC

Sedimentary Organic Carbon

Old, highly degraded, terrestrial, derived from soils

Detrital Organic Carbon

Modern, derived from aquatic and riparian plants, somewhat degraded, hydrodynamically light

Planktonic Organic Carbon

Fresh, new, and juicy

4.5 mg Organic Carbon

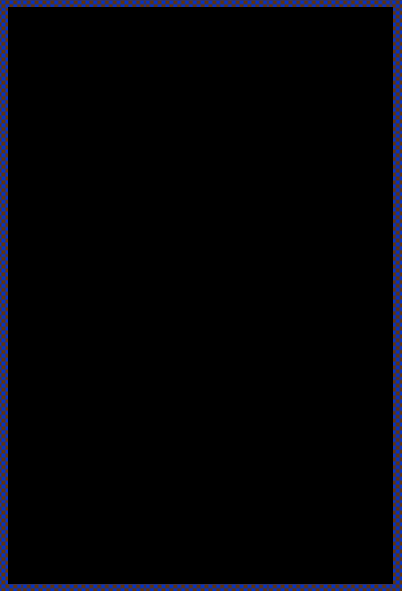
3.0 mg DOC

1000s of different compounds

Modern

Degraded

Easily transported



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What controls Organic Carbon Supply?

- Production
  - Source type and location
- Transport
  - From location of production to use
- Environmental Processing
- Quality
- Season

THESE PROPERTIES ALL INTERACT

?

Why does the form and quality of organic carbon matter?

What happens to organic carbon?

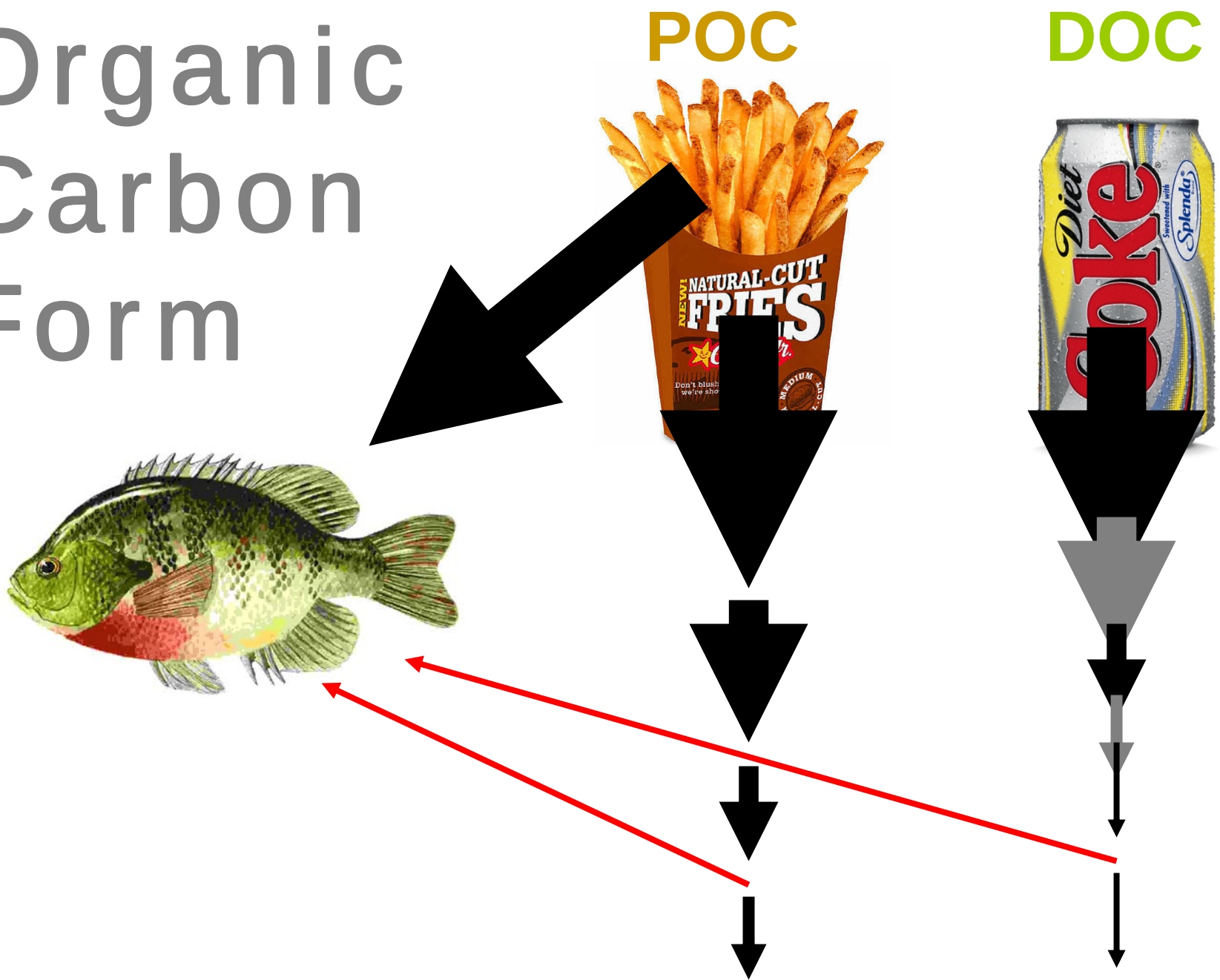
- Transported
- Biodegraded
- Photodegraded
- Settles, floculates

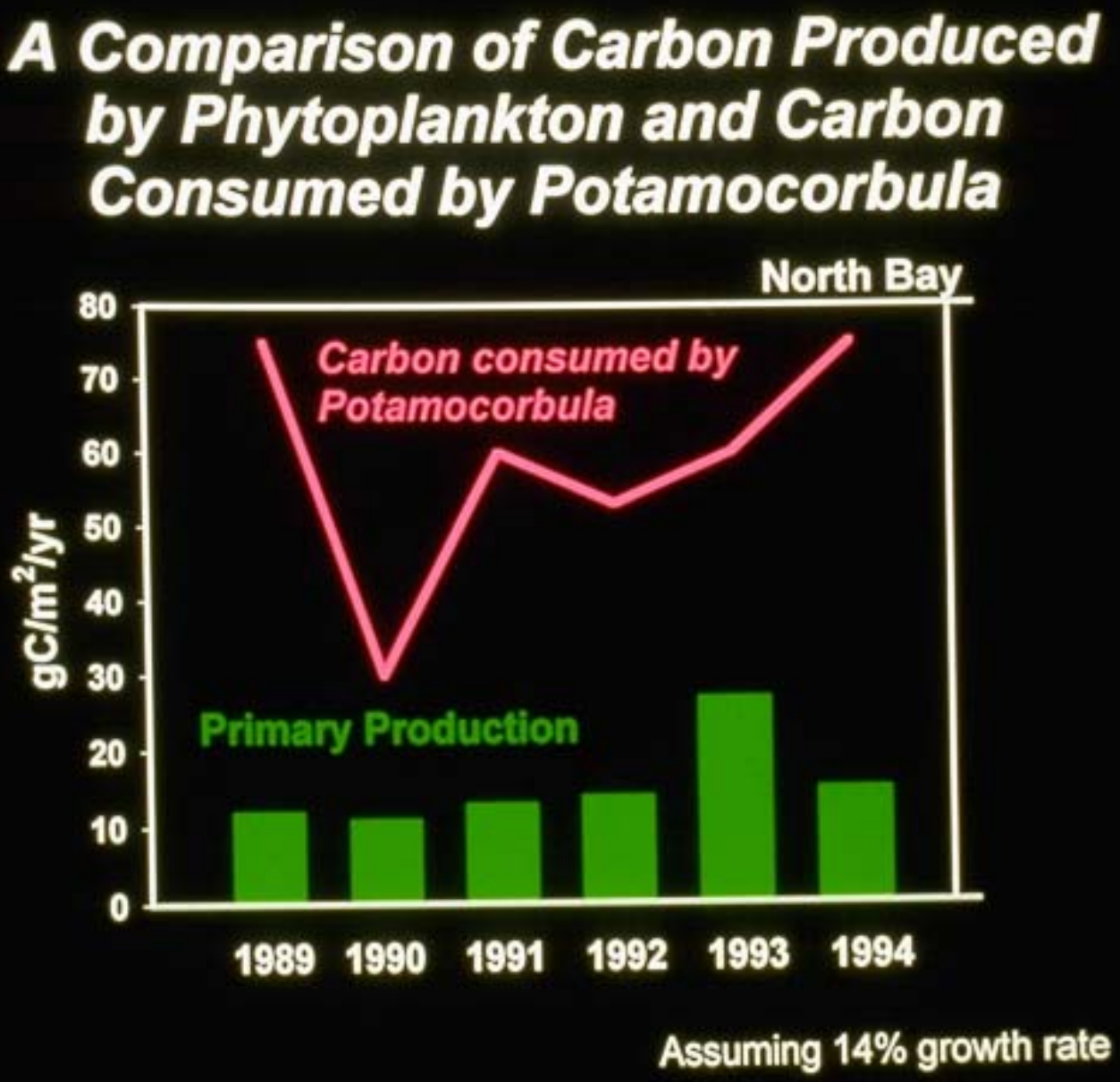
Organic Carbon Quality

Quality = bioavailability
reactivity
hydrophobicity
etc.

Fries vs. Wrappers

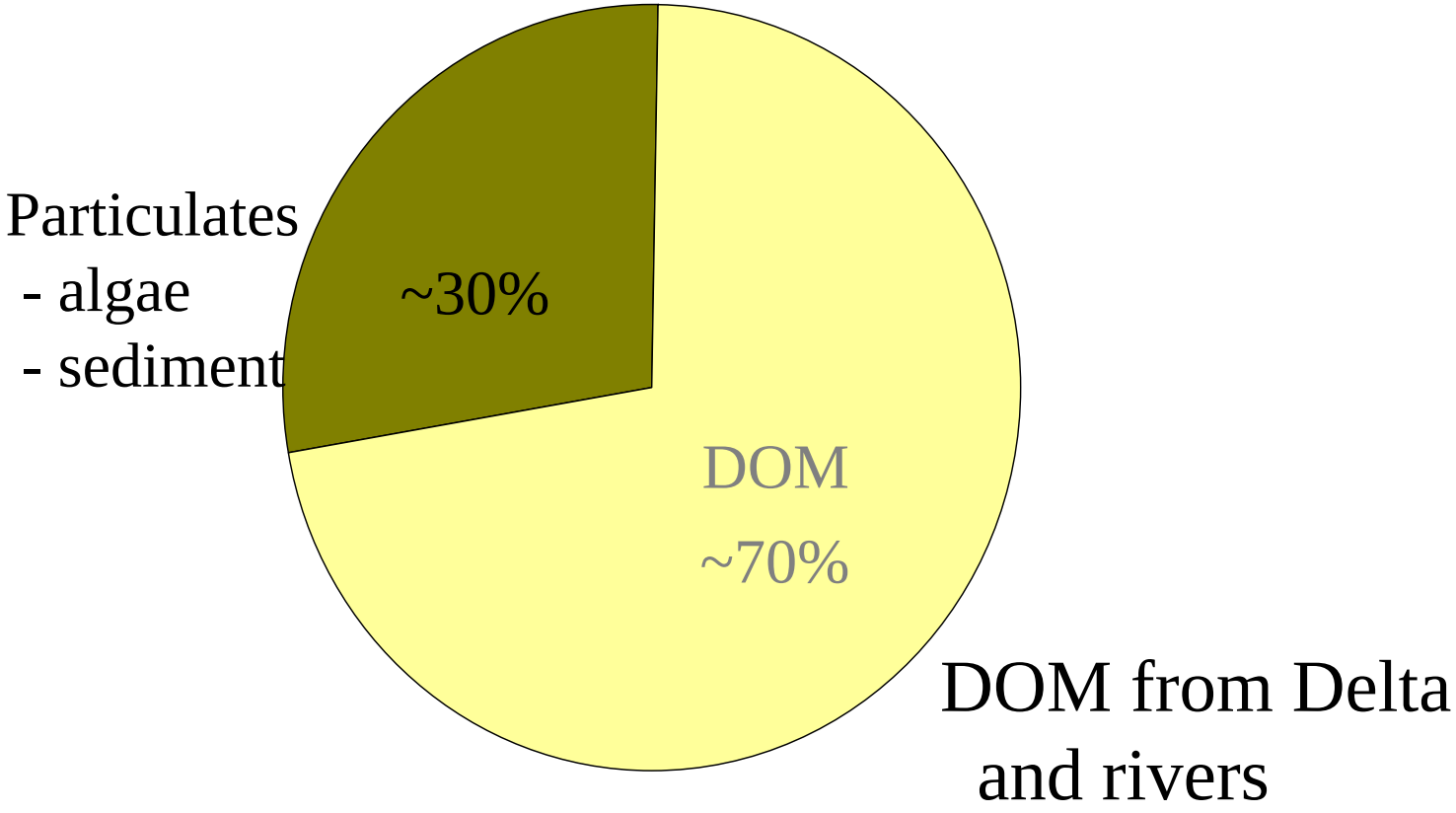
Organic Carbon Form



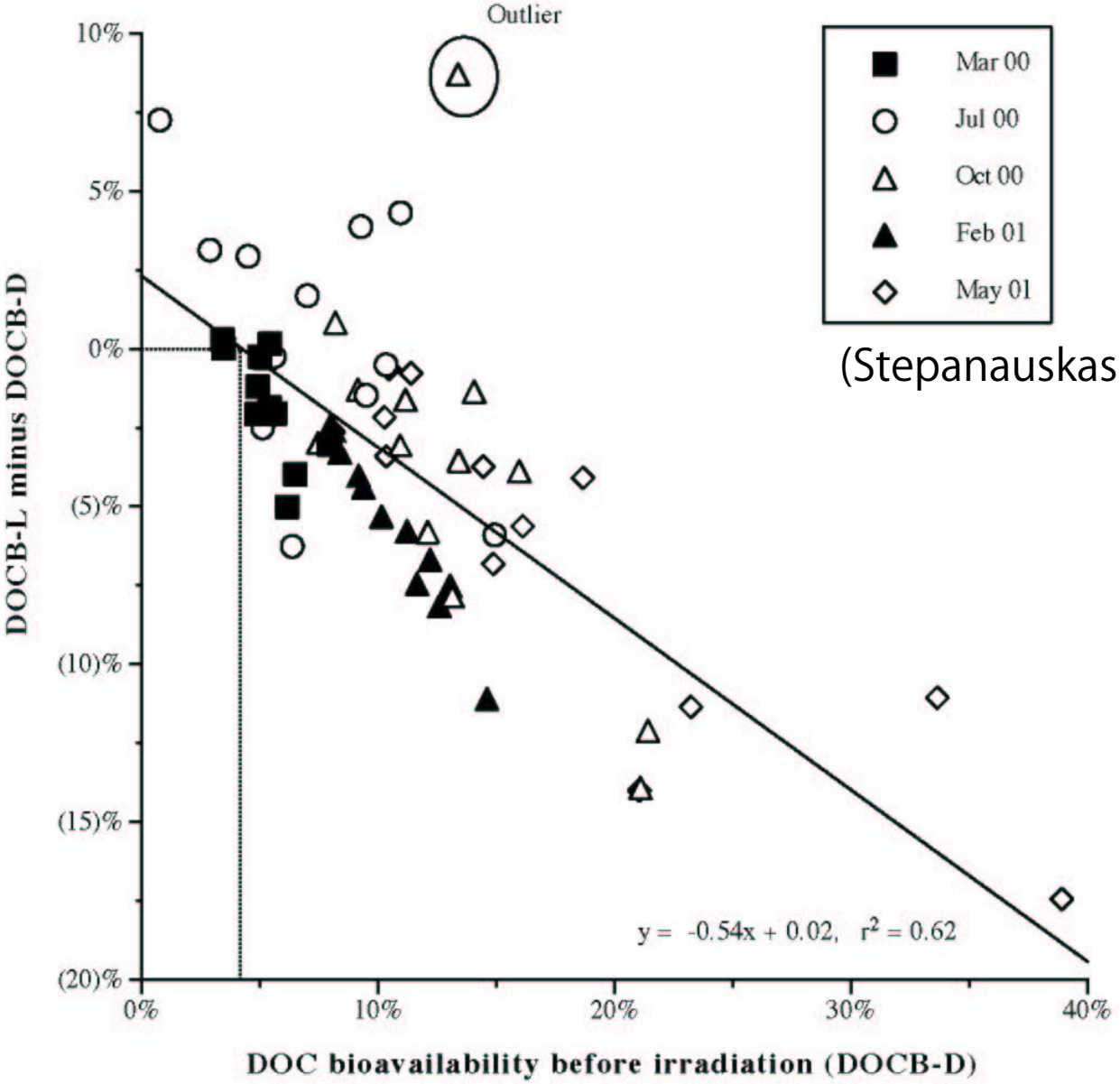


Jan Thompson (2002)

DOC is a major source of energy supplying estuary heterotrophic demand – but not a good energy supply for fish



Example of how quality, reactivity, and bioavailability interact



(Stepanauskas et al., 2003)

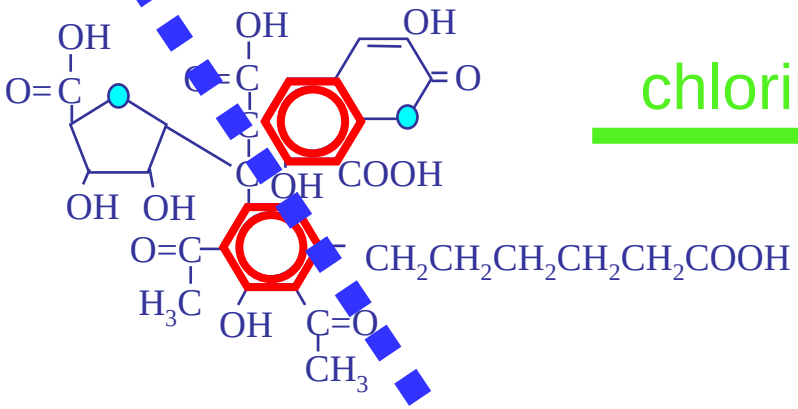
Drinking water and organic carbon

Mainly an issue of DOC
T&O issues from algae
Turbidity causes problems

Drinking Water Treatment issues affected by DOM amount and quality

- DBP formation
- Ozone interaction
- Membrane fouling
- Increased flocculent demand
- Microbial nutrient supply

Disinfection byproduct formation



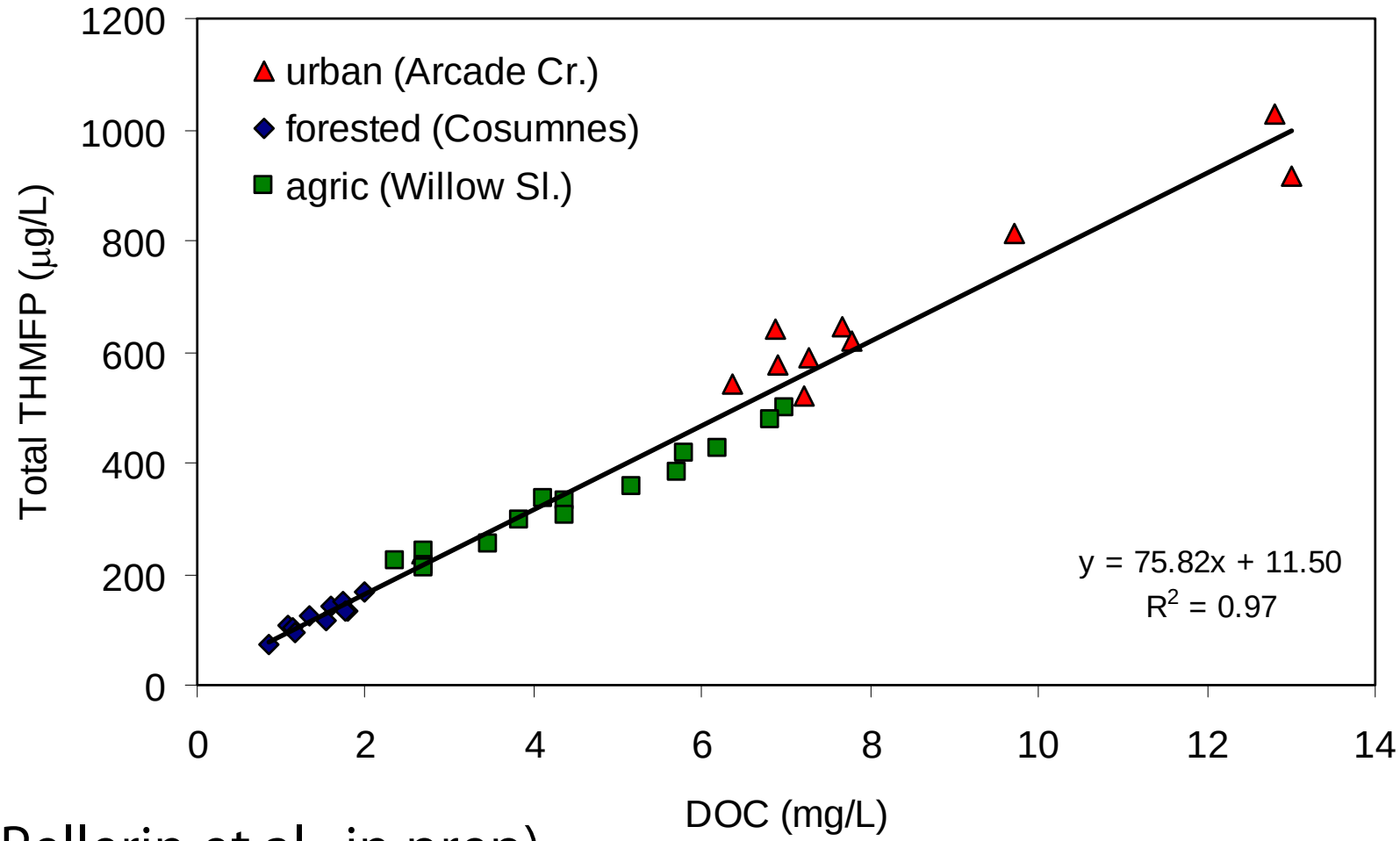
chlorination →

$CHCl_3$

THM formation
(STHMFP)

Light absorbance
Fluorescence
% aromaticity

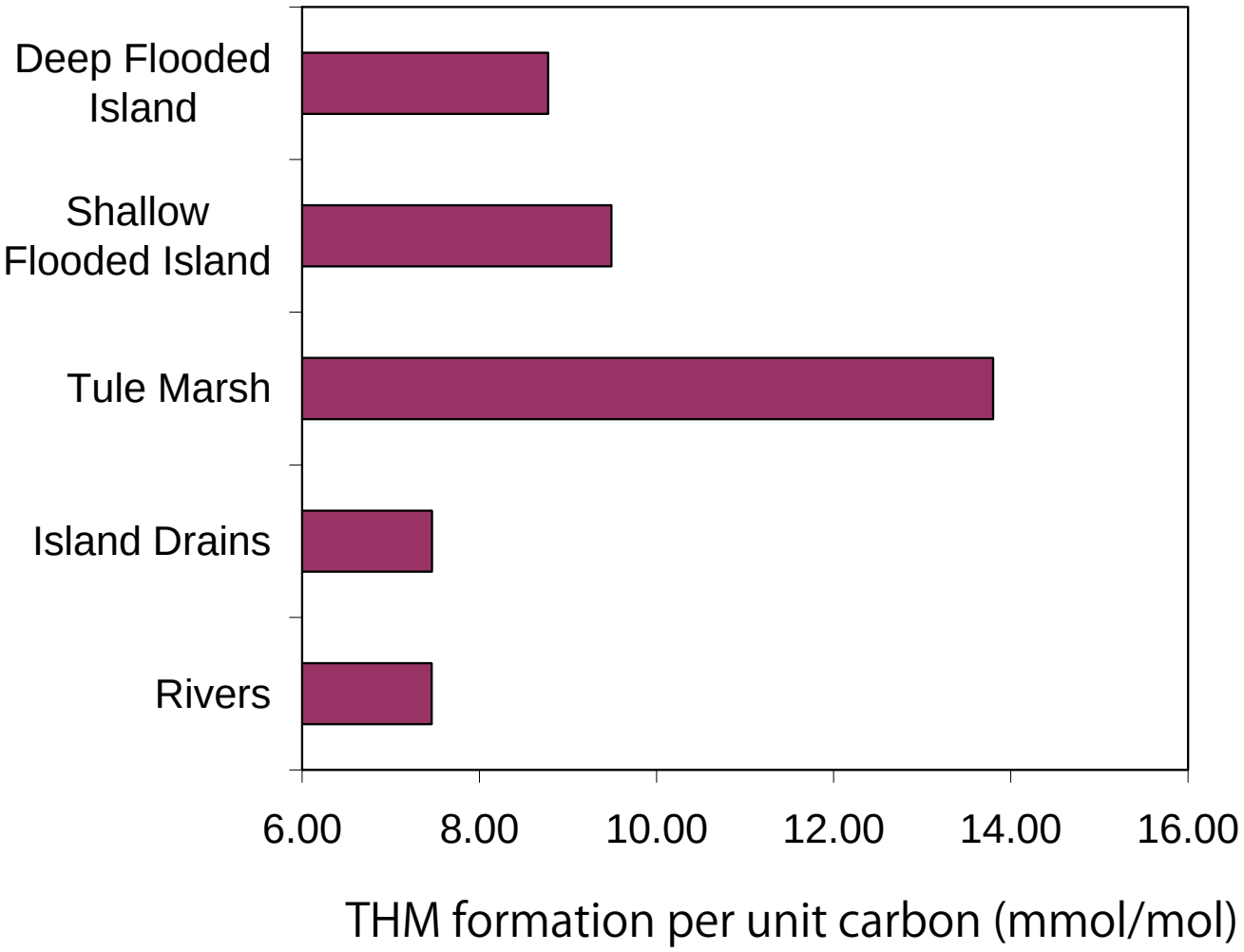
Source matters
Comparison of watersheds



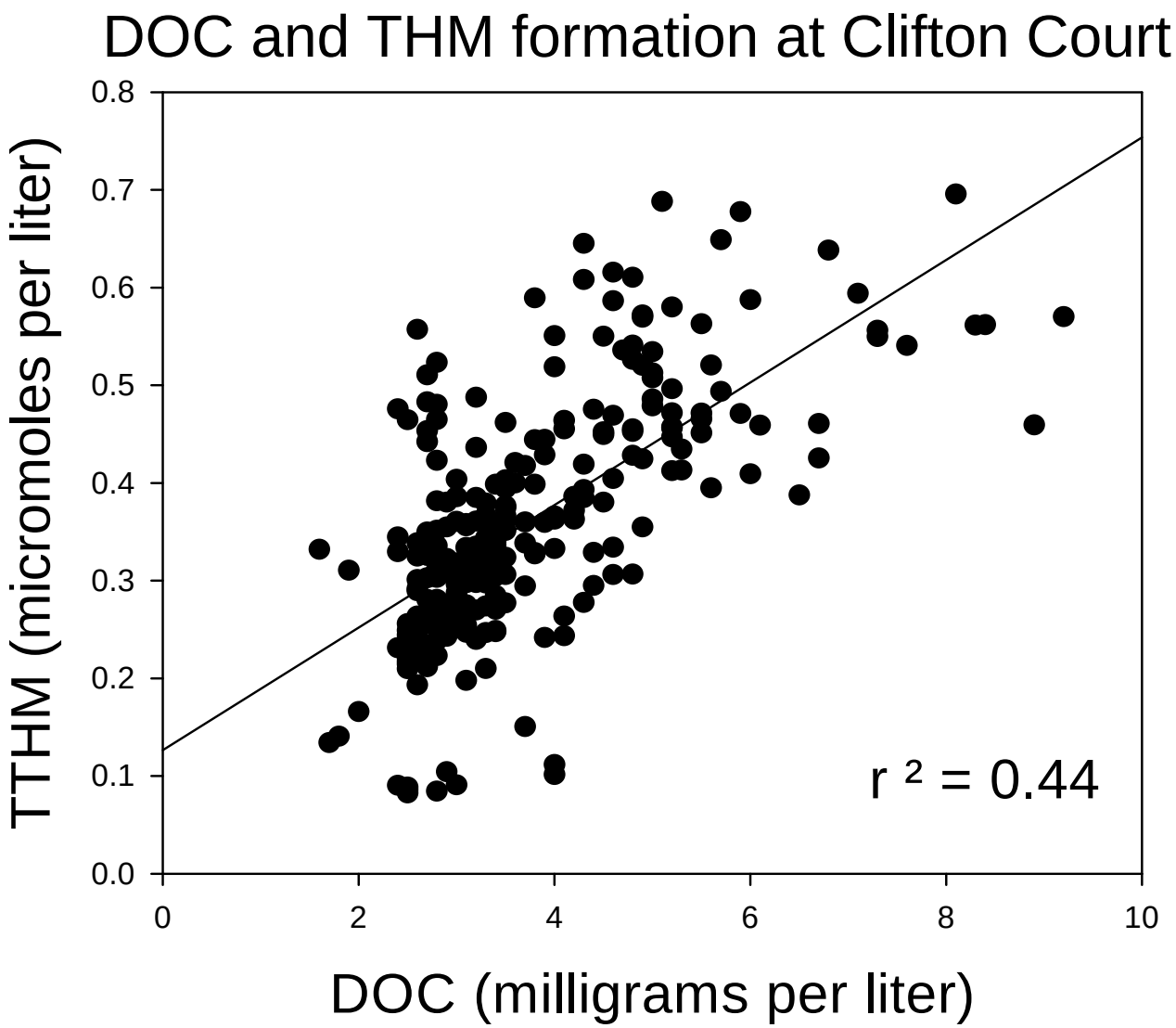
(Pellerin et al., in prep)

Quality Matters

THM Precursor content from different sources



DOC AMOUNT vs. THMFP (quality)



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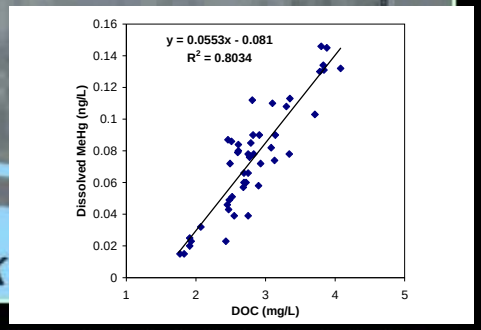
Hydrodynamic connection matters

slough
mouth
B2
main slough
Apr. 20, 2005 at 02:39 AM
B4
Brown's Island
Pittsburg
New York


y = 0.0553x - 0.081
R² = 0.8034
Dissolved MeHg (ng/L)
DOC (mg/L)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
2
3
4
5

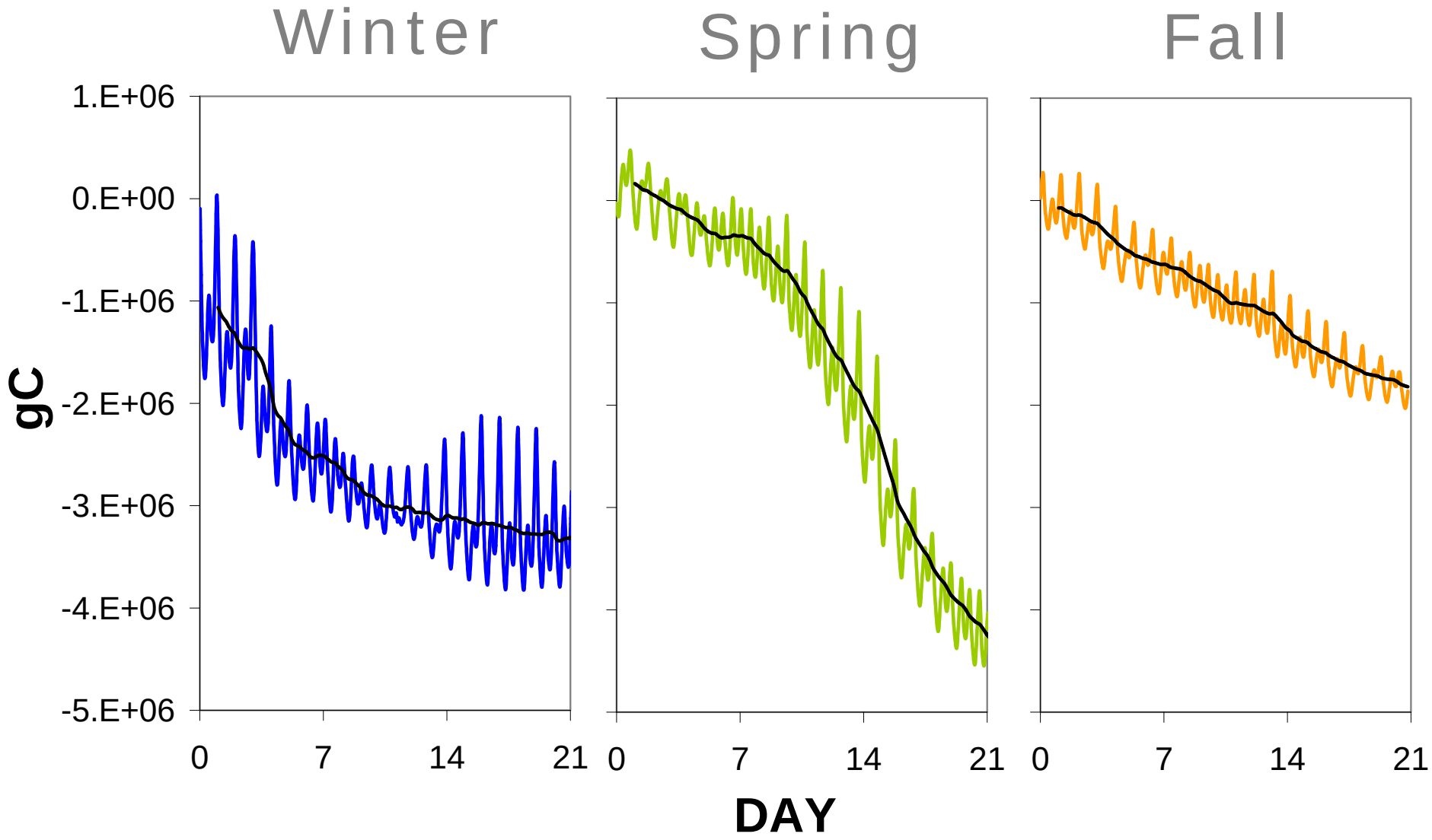
B2 Preliminary MeHg (filtered)
0.15
0.10
0.05
102.5
105.0
107.5
110.0
112.5
115.0
117.5
120.0
122.5
125.0
127.5
B2 Water Height
3.5
3.0
2.5
2.0
1.5

!

Season matters

Different production and transport in different seasons

Seasonal Fluxes



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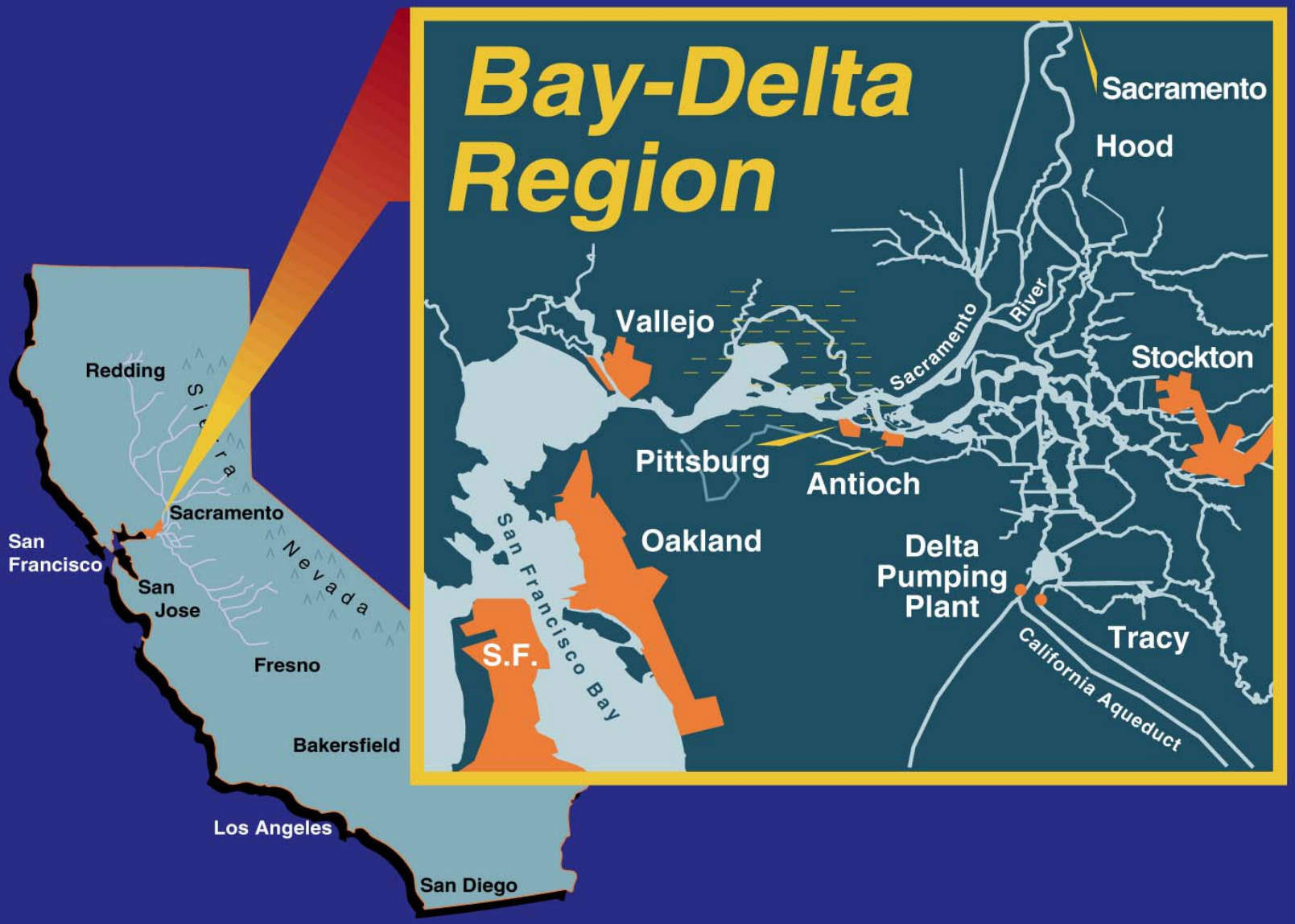
Transport matters


Bay-Delta Region
Sacramento
Hood
Vallejo
Sacramento River
Stockton
Pittsburg
Antioch
Oakland
San Francisco Bay
S.F.
Delta Pumping Plant
Tracy
California Aqueduct
Redding
Sierra Nevada
Sacramento
San Francisco
San Jose
Fresno
Bakersfield
Los Angeles
San Diego

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- The concentration and quality of organic carbon is highly variable
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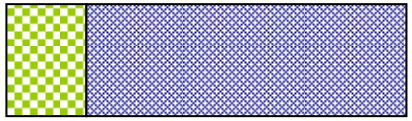
- Organic carbon of different types follows different trophic trajectories

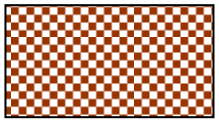
DOC in the Delta

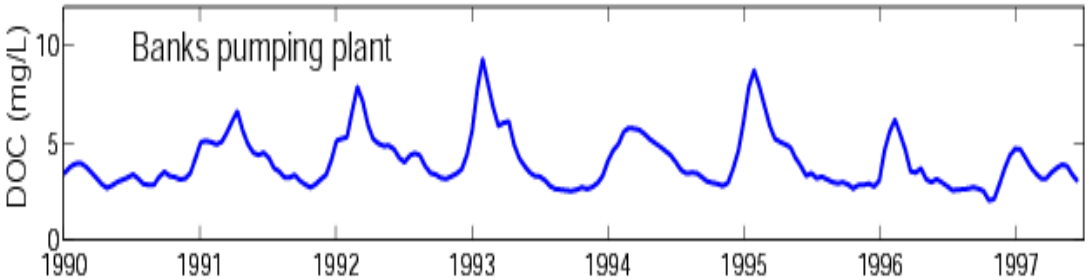
Banks

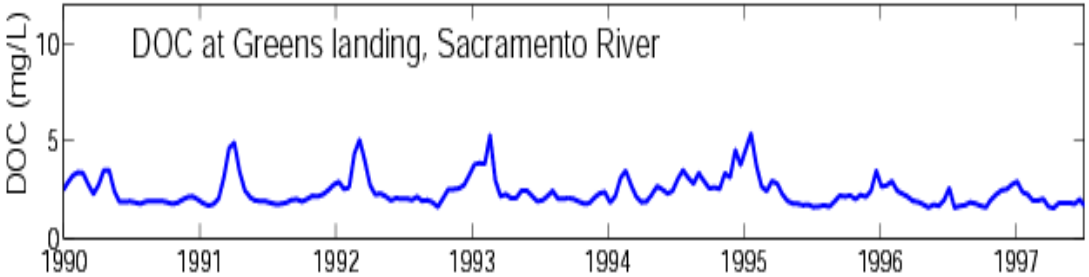
River inputs

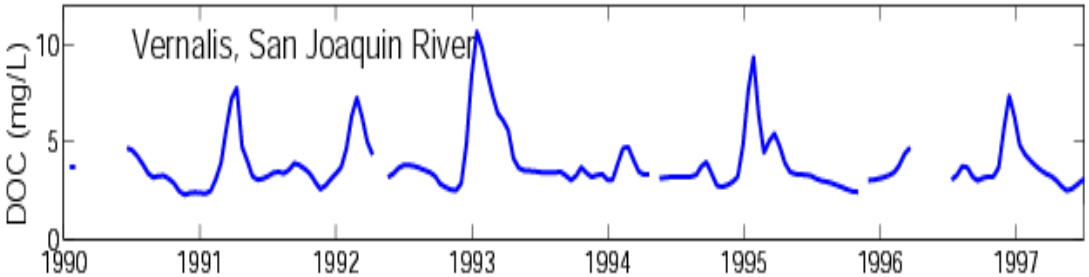


Amount added in Delta



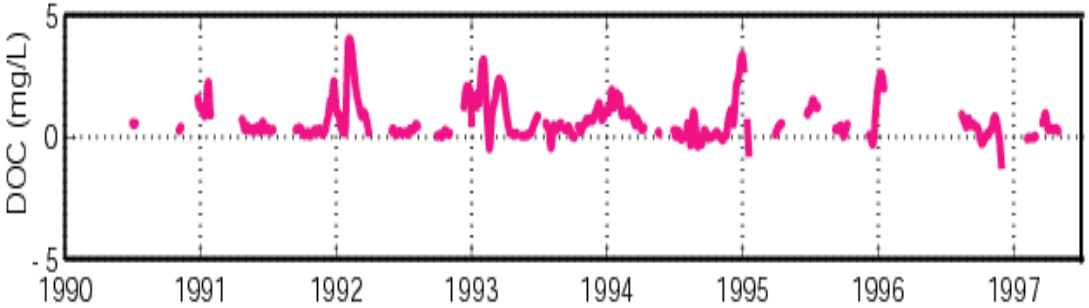




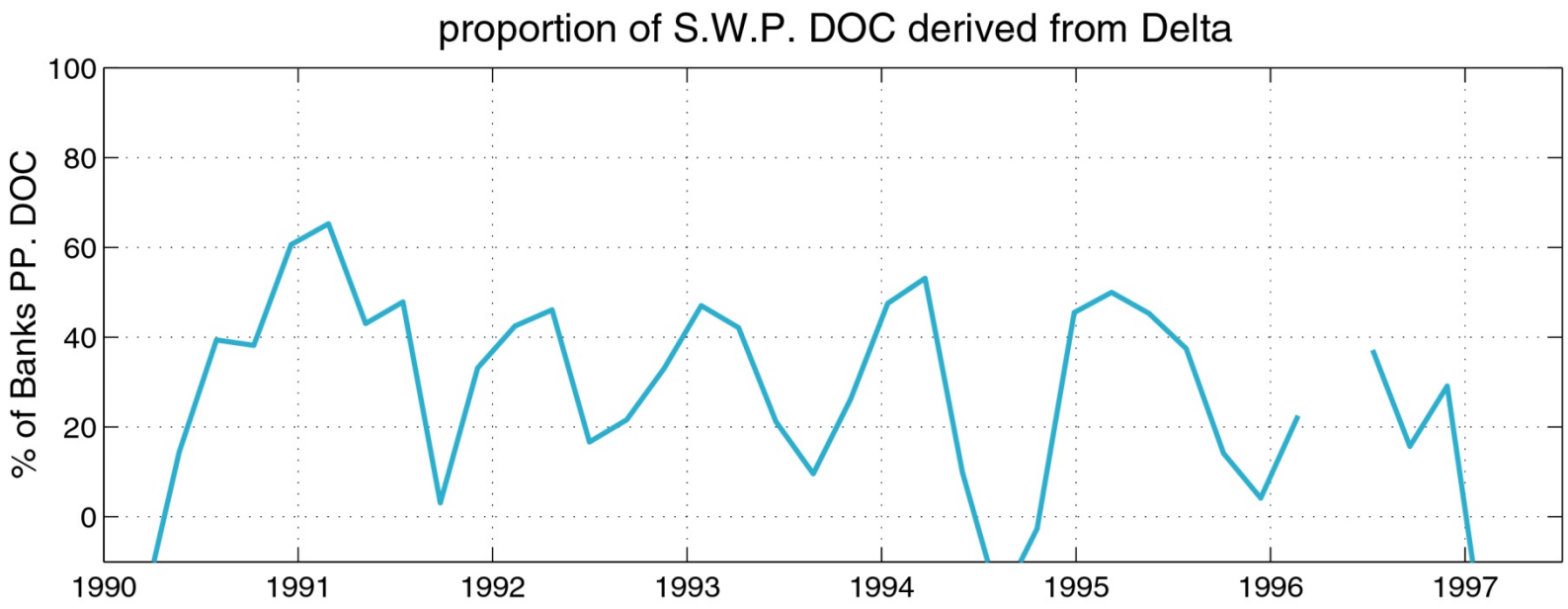


Fine Print:

1) Need to account for travel times
2) DOC is treated as conservative
3) Need more data
4) Need to account for mixing
5) Etc.
6) Etc.
7) Etc.



Delta DOC contribution at Banks



The model indicates that on average 25 %, and typically ~10 - 50%, of the DOC exported at the Banks and Tracy pumping plants is derived from in-delta processes: the majority is imported to the Delta from rivers. In July-October most DOC in delta waterways is derived from rivers, while about half of the winter peak in DOC levels is added in the Delta.

Delta DOC sources

- Most Delta DOC from rivers
- 25% of Delta DOC is produced internally
- None added by Delta in summer
- Little added by Delta in fall
- Most added by Delta in winter

What are the sources of DOM in the Sacramento-San Joaquin Delta?

- Rivers
- Islands
- Wetlands
- Algal and microbial productivity

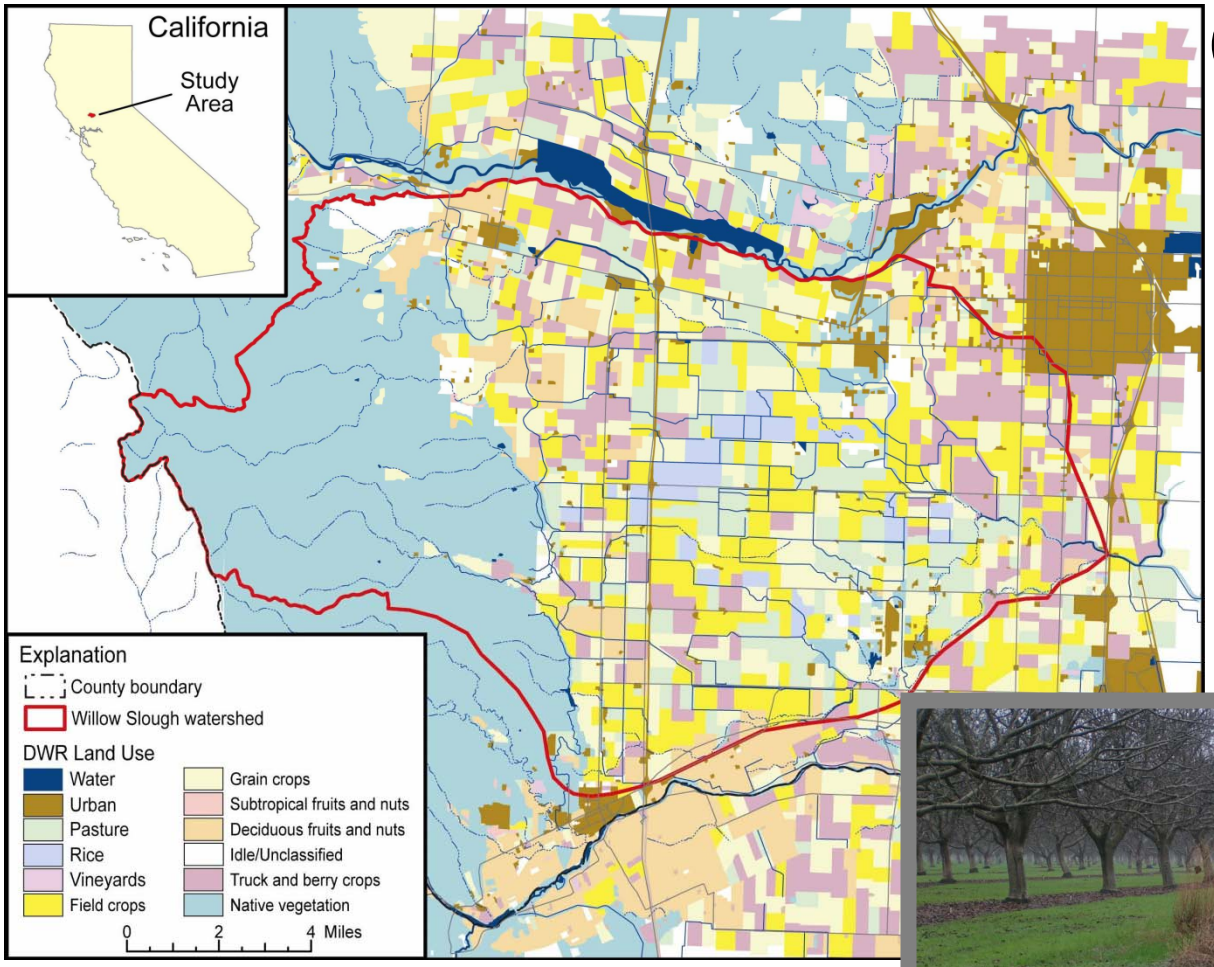
Estimated Carbon loads from major Delta sources

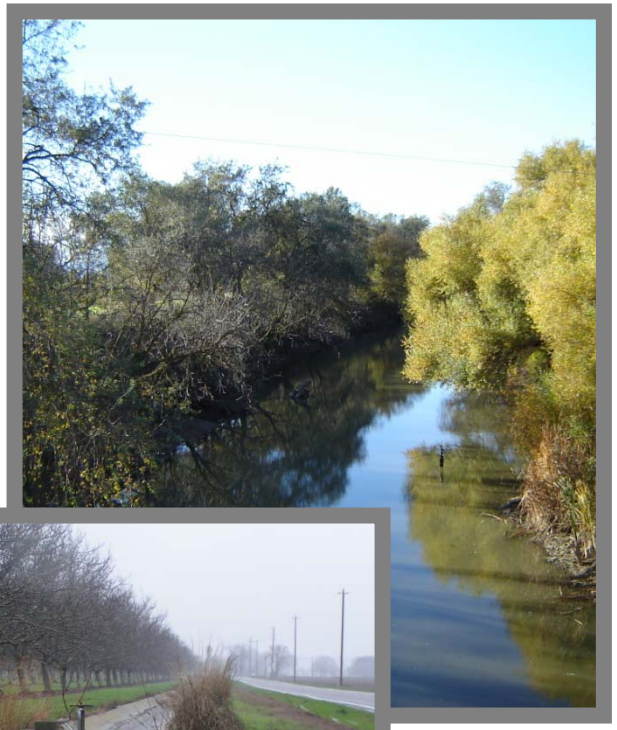
	Flux	Area	**Contribution**
Algal	7-14 gC/m^2-yr	10%	**7-12%**
Island	3-12 gC/m^2-yr	85%	**27-55%**
Wetland	80-400 gC/m^2-yr	5%	**43-68%**

What about the watershed?

Watershed Sources

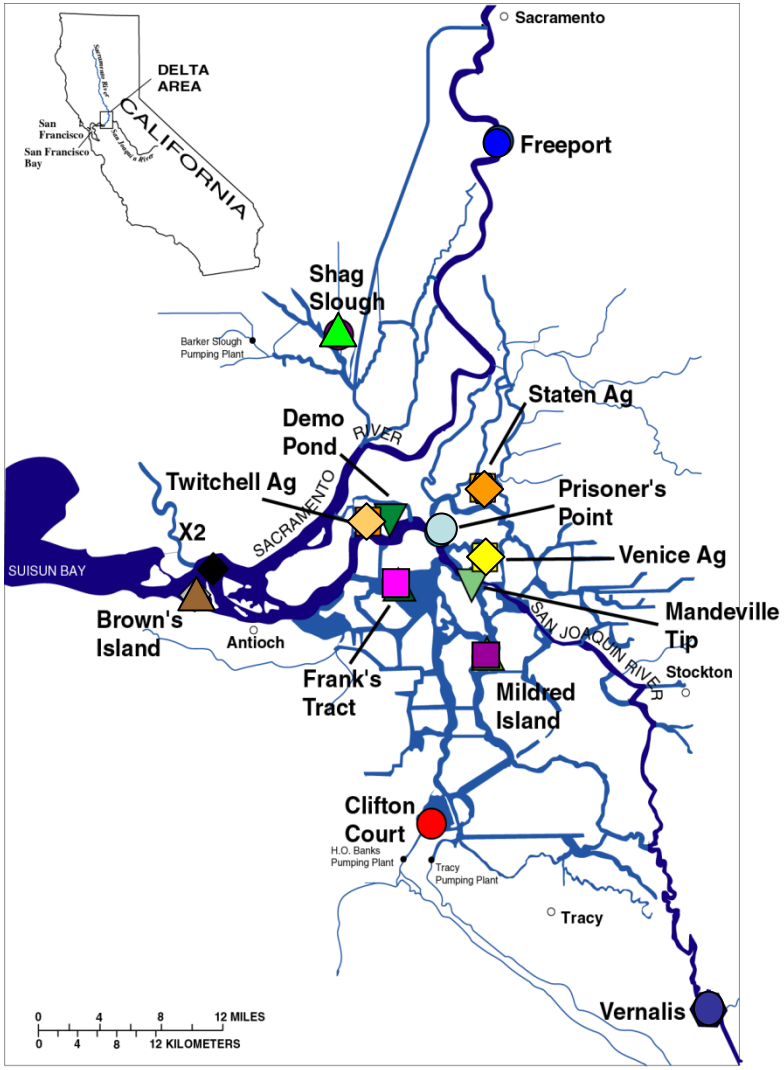
(Pellerin, et al., in prep)





Sources in the Delta

(Kraus, et al., accepted)



Summary questions

- Are Delta Island drains bad?
- Are wetlands bad?
- Are ag lands bad?
- Are natural uplands bad?
- Are cities bad?

Take-home points

- All organic carbon is not the same.
- There are many sources of organic carbon.
- Organic carbon is reactive in the environment.
- Organic carbon supply and quality changes by season, source, and location
- The benefits and problems with organic carbon depend on specifics of the site
- Organic carbon is not inert – it is modified and consumed quickly in the environment.

THANKS !