Non-conservative DOC transformations in Maine watersheds: "Can you tell the tea by its color?"

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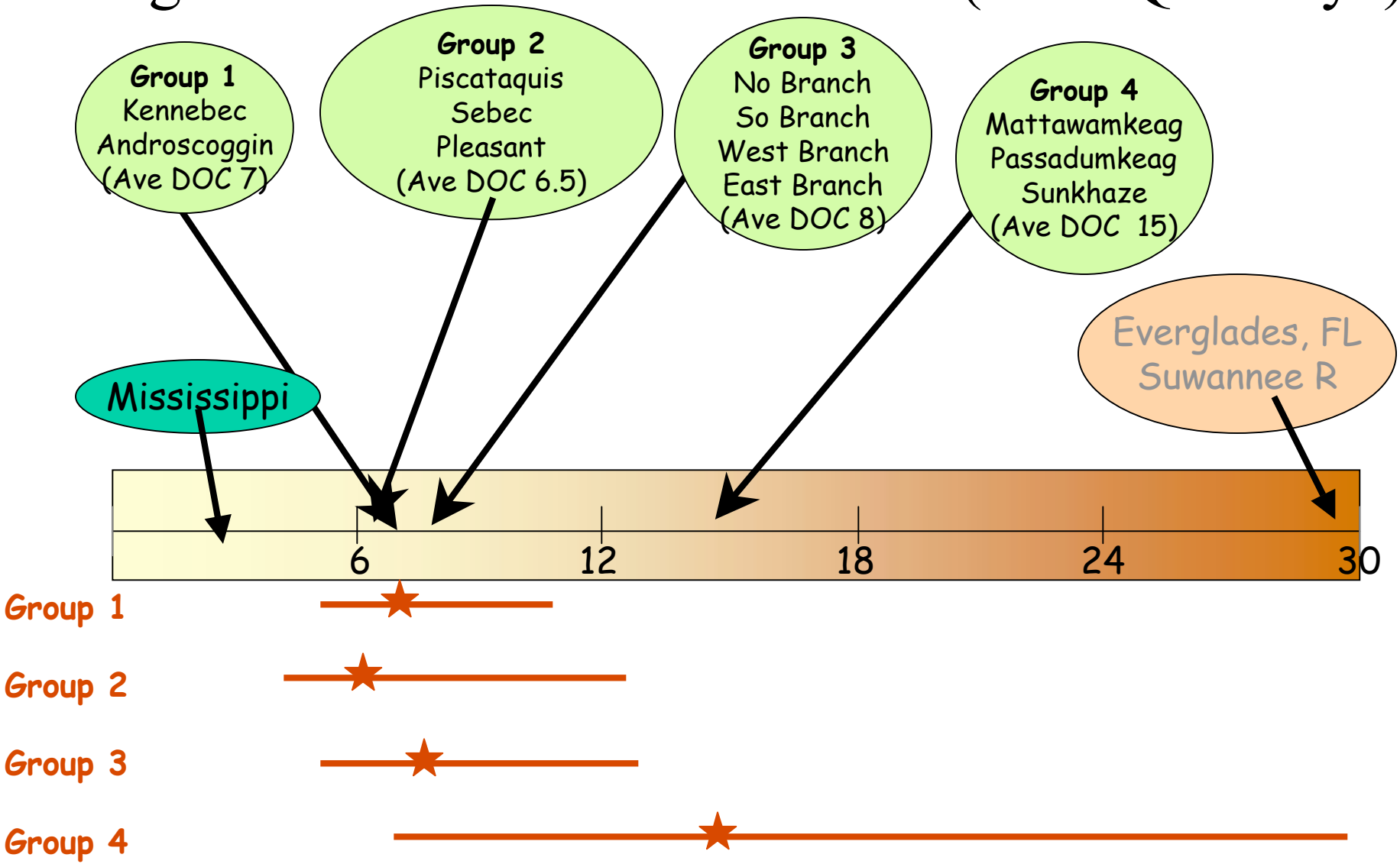
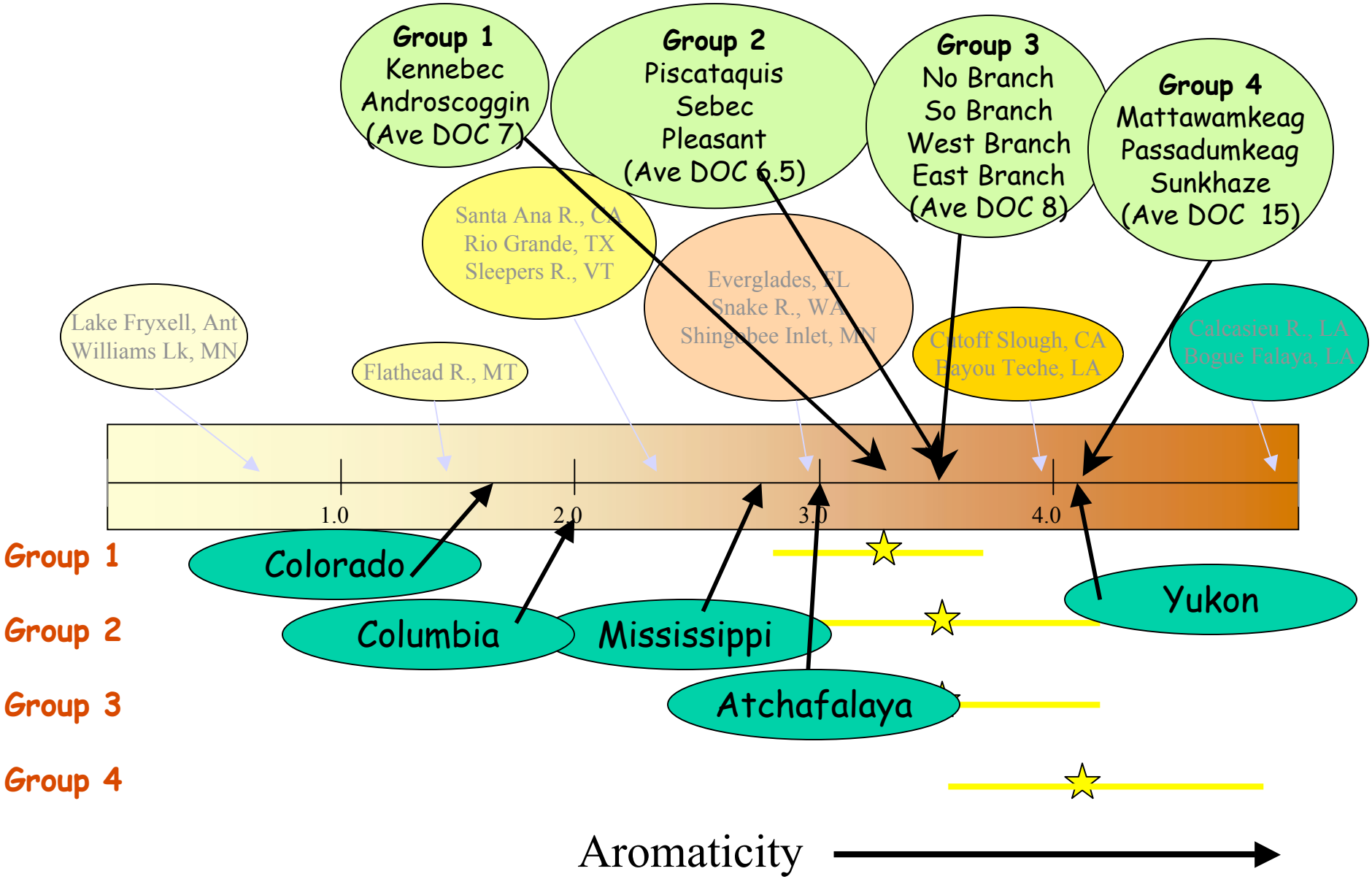
Range of DOC for Surface Waters ("Tea Quantity")

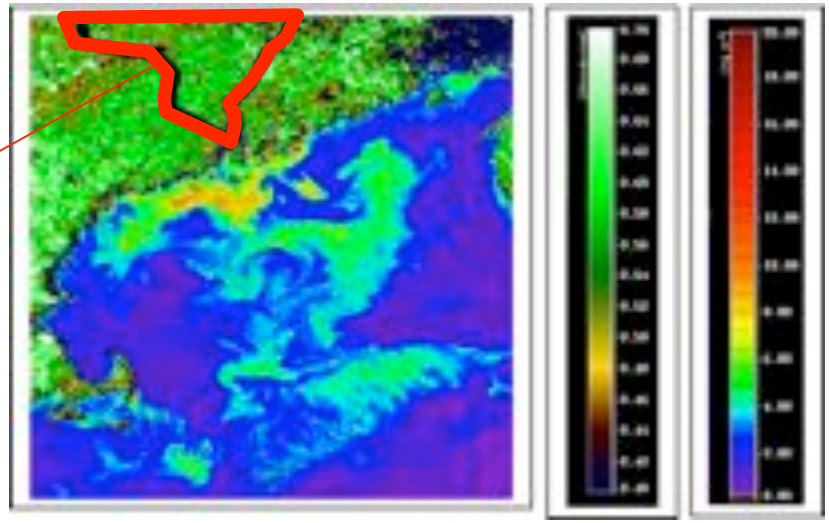


Range of SUVA [spec.UV a_{254}] = aromaticity ("Tea flavor")



Assets used in this study

Remote sensing



Upper water shed/river sampling for flow, optical proxies, chemical analyses

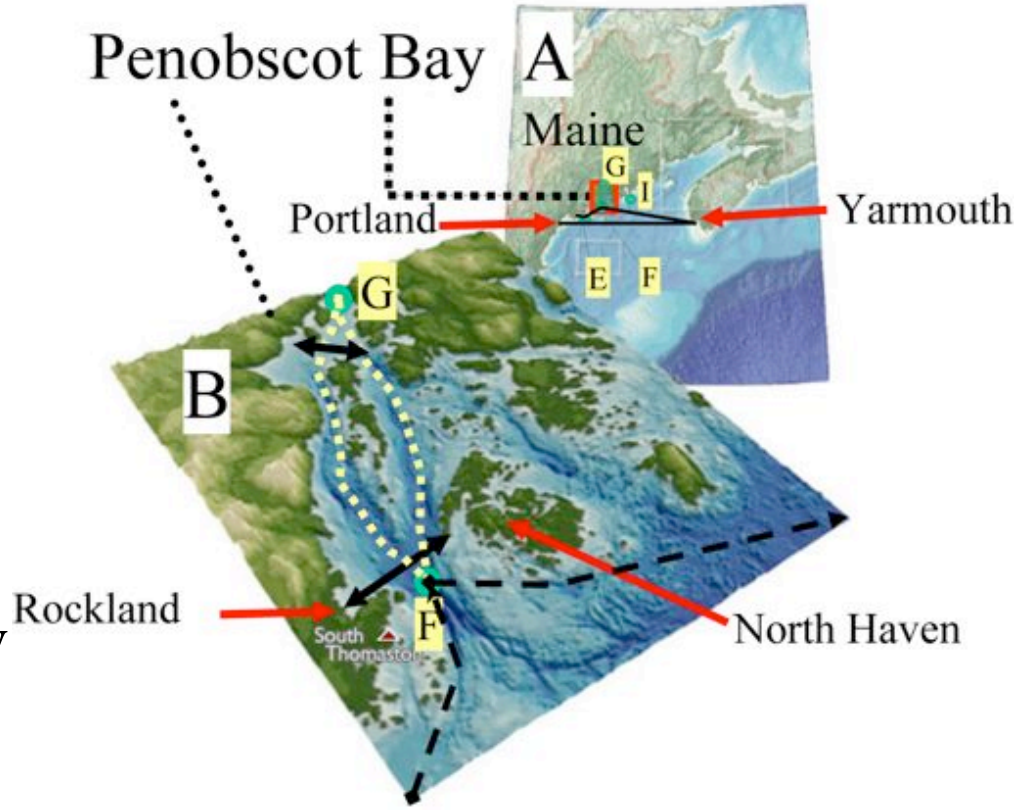
Bay & Gulf sampling: Ships, buoys, AUV's

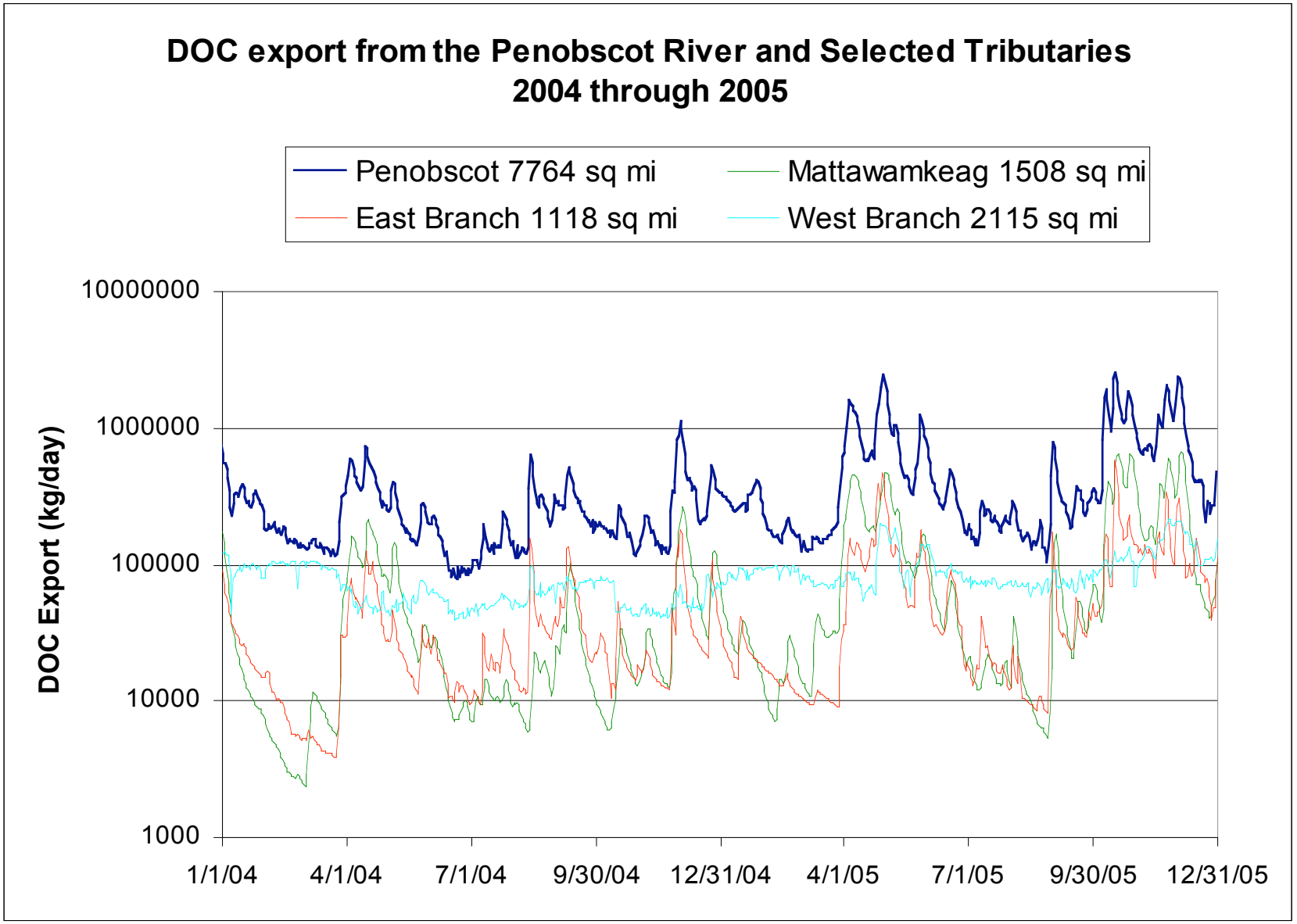
The "glue" that holds it all together:

-Analytical organic chemistry

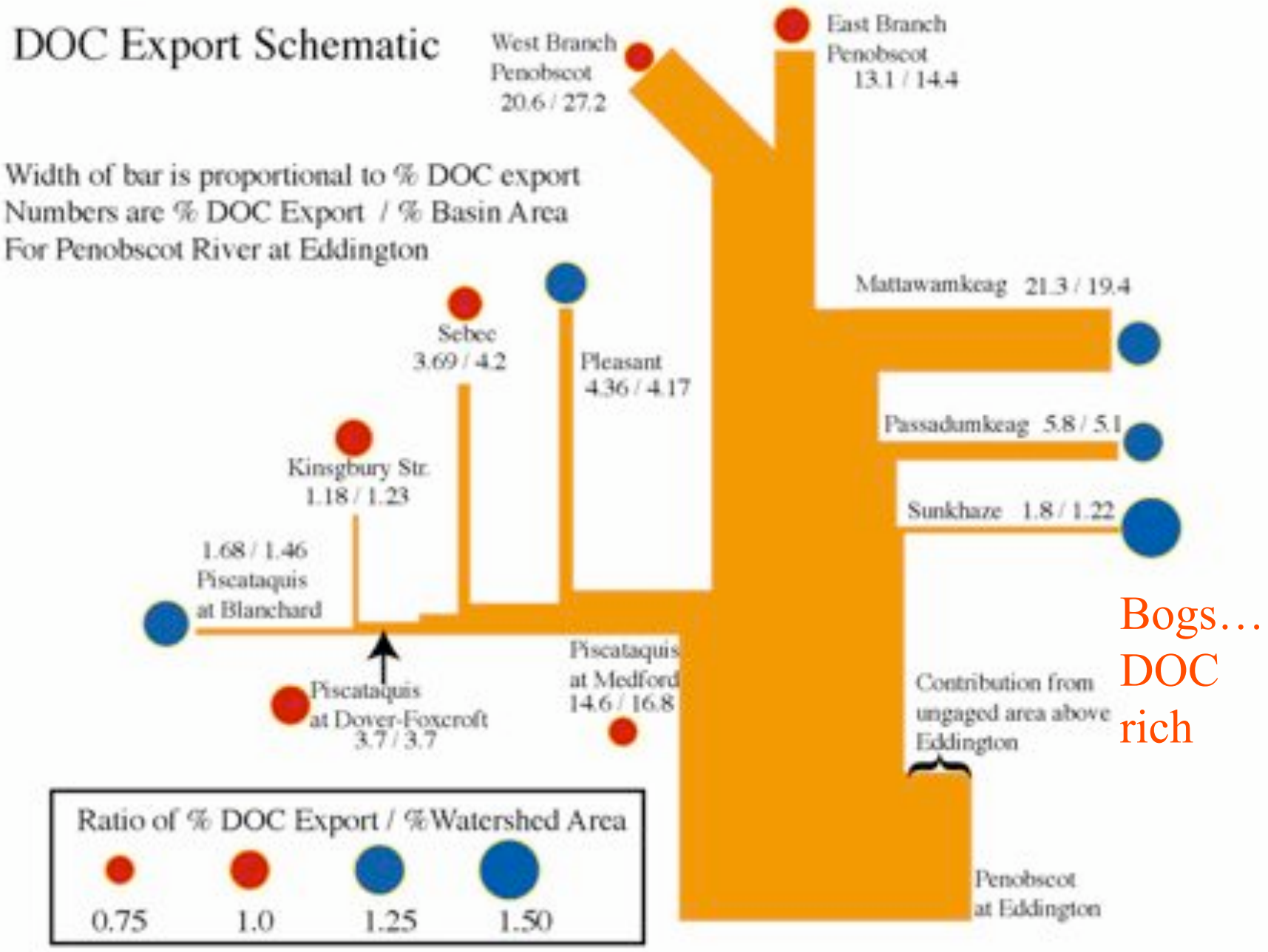
-Optical proxies for carbon

-Modeling



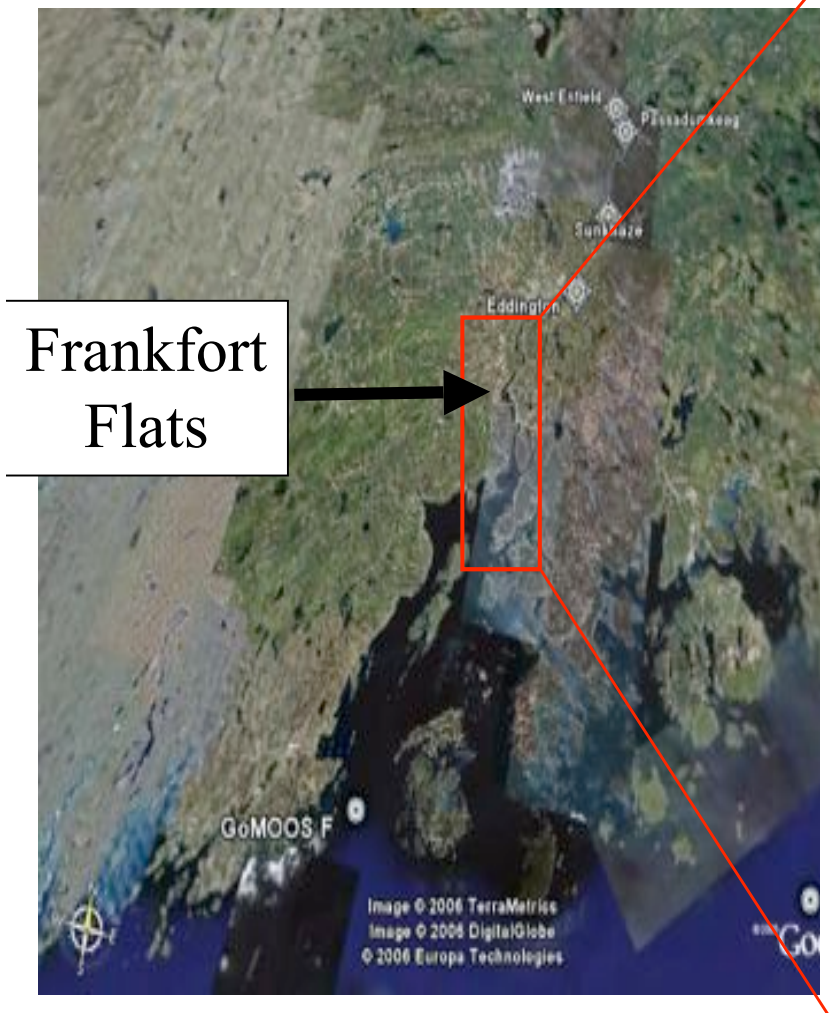

DOC export from the Penobscot River and Selected Tributaries
2004 through 2005
Penobscot 7764 sq mi
Mattawamkeag 1508 sq mi
East Branch 1118 sq mi
West Branch 2115 sq mi
DOC Export (kg/day)
10000000
1000000
100000
10000
1000
1/1/04
4/1/04
7/1/04
9/30/04
12/31/04
4/1/05
7/1/05
9/30/05
12/31/05

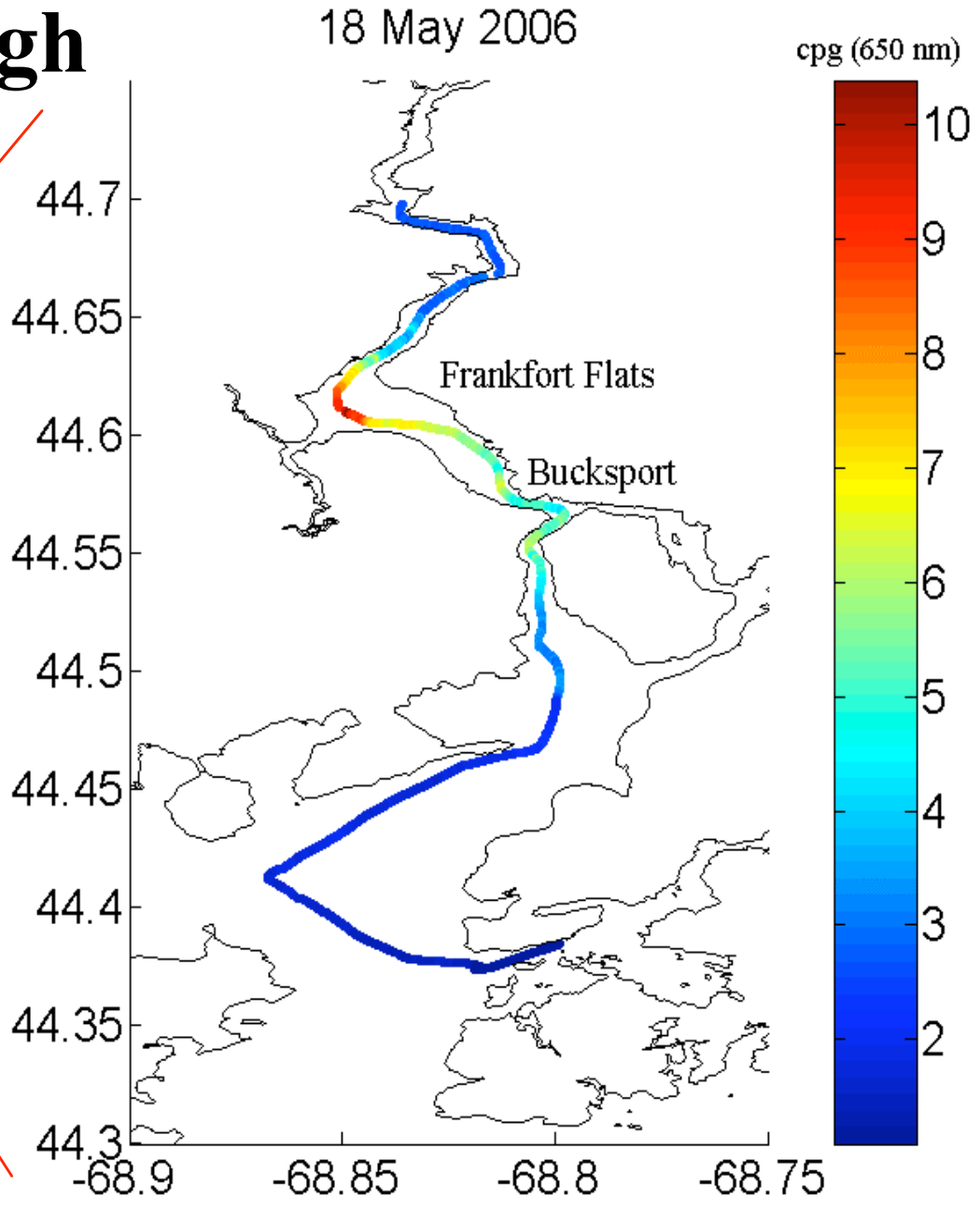
Forested/Lumbered



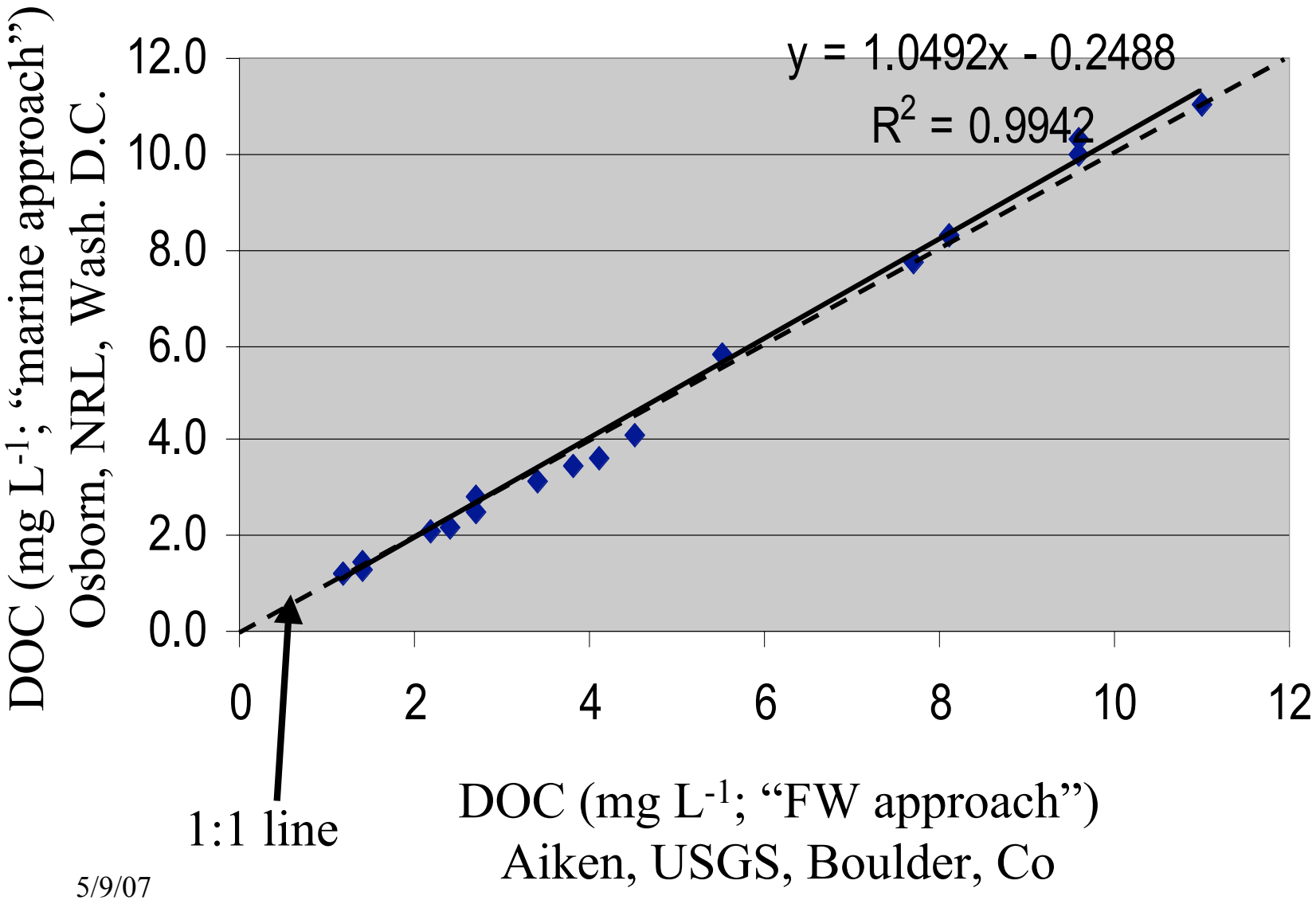
Bogs… DOC rich

POC changes through river…

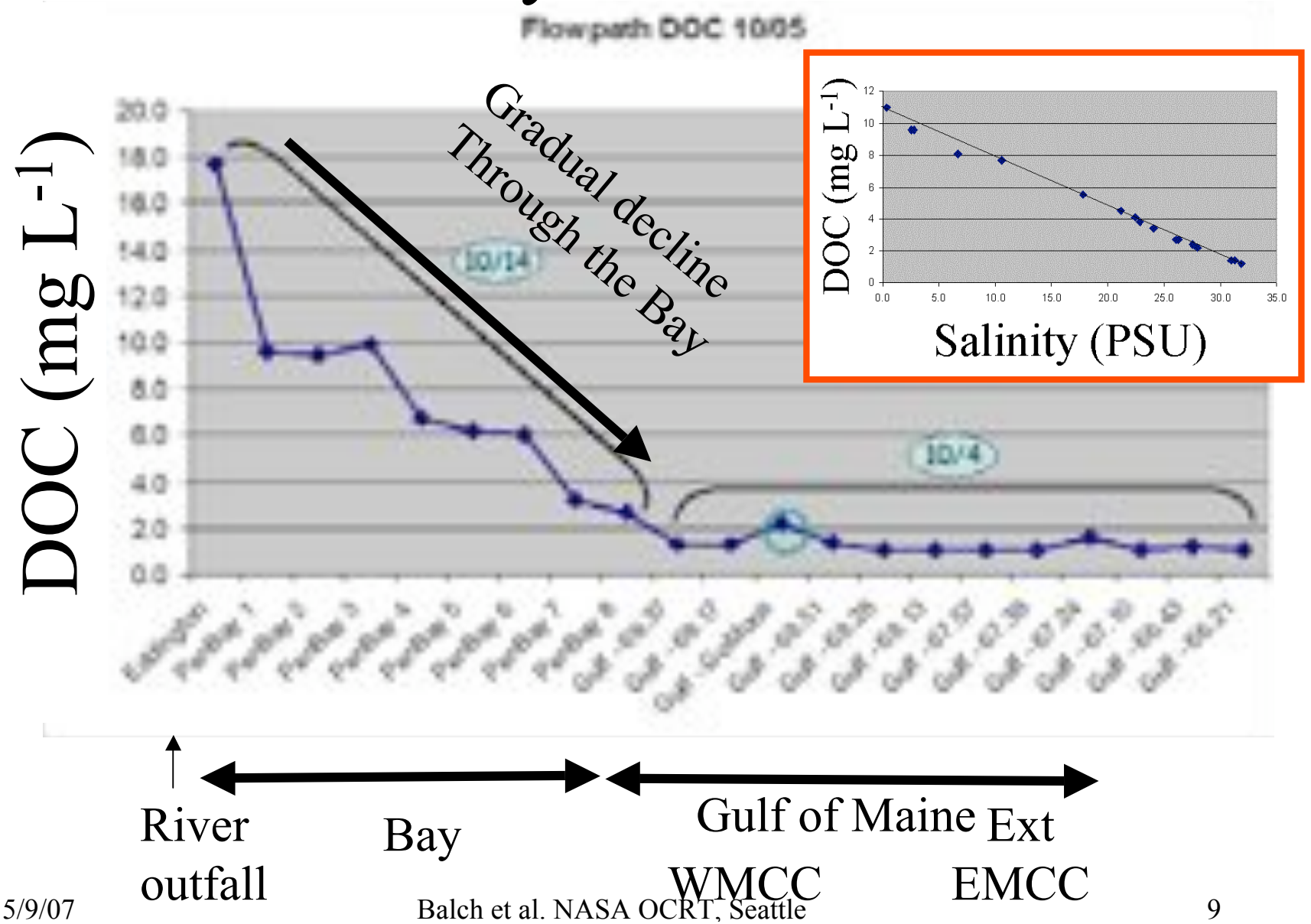




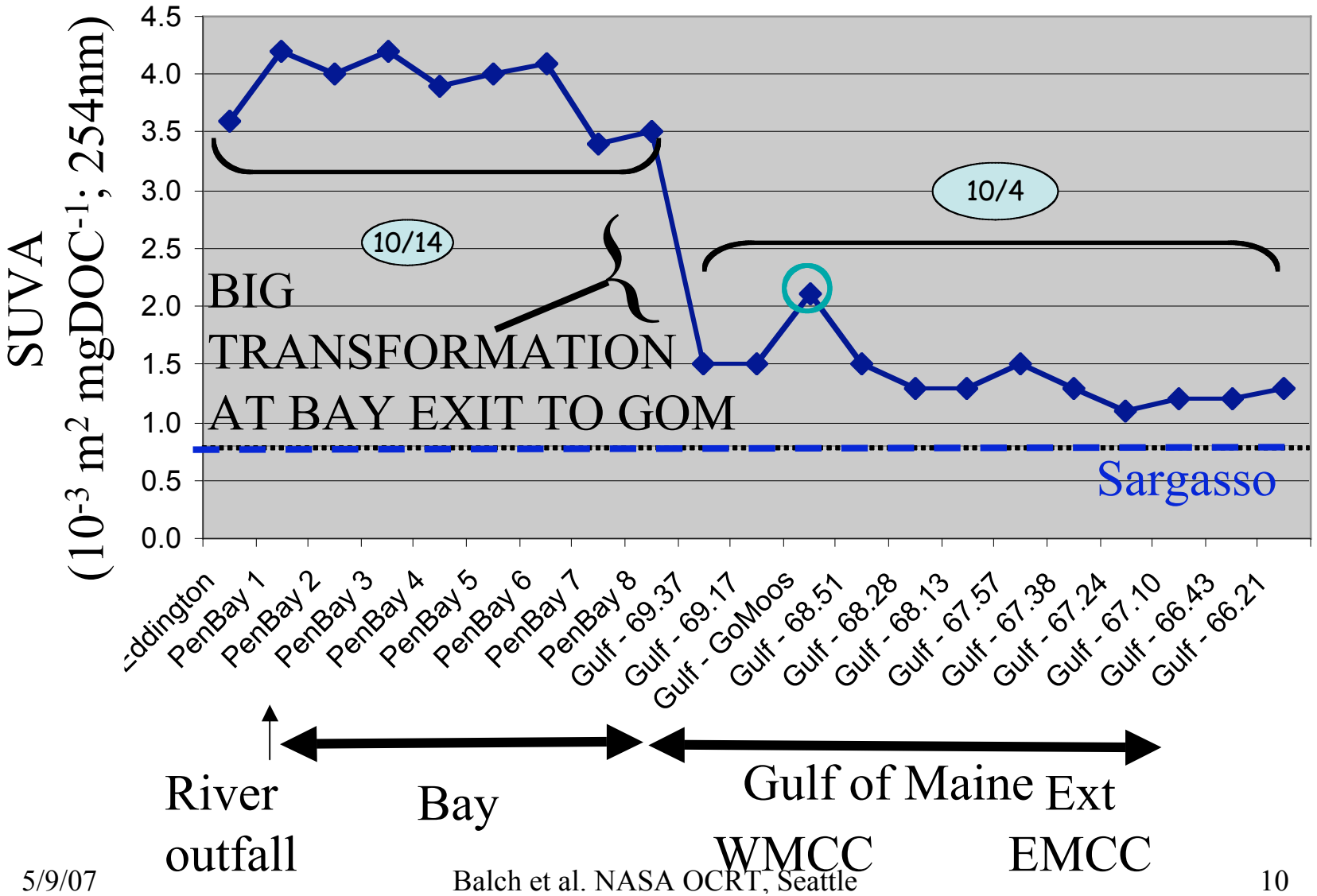
How do our DOC techniques compare to others?

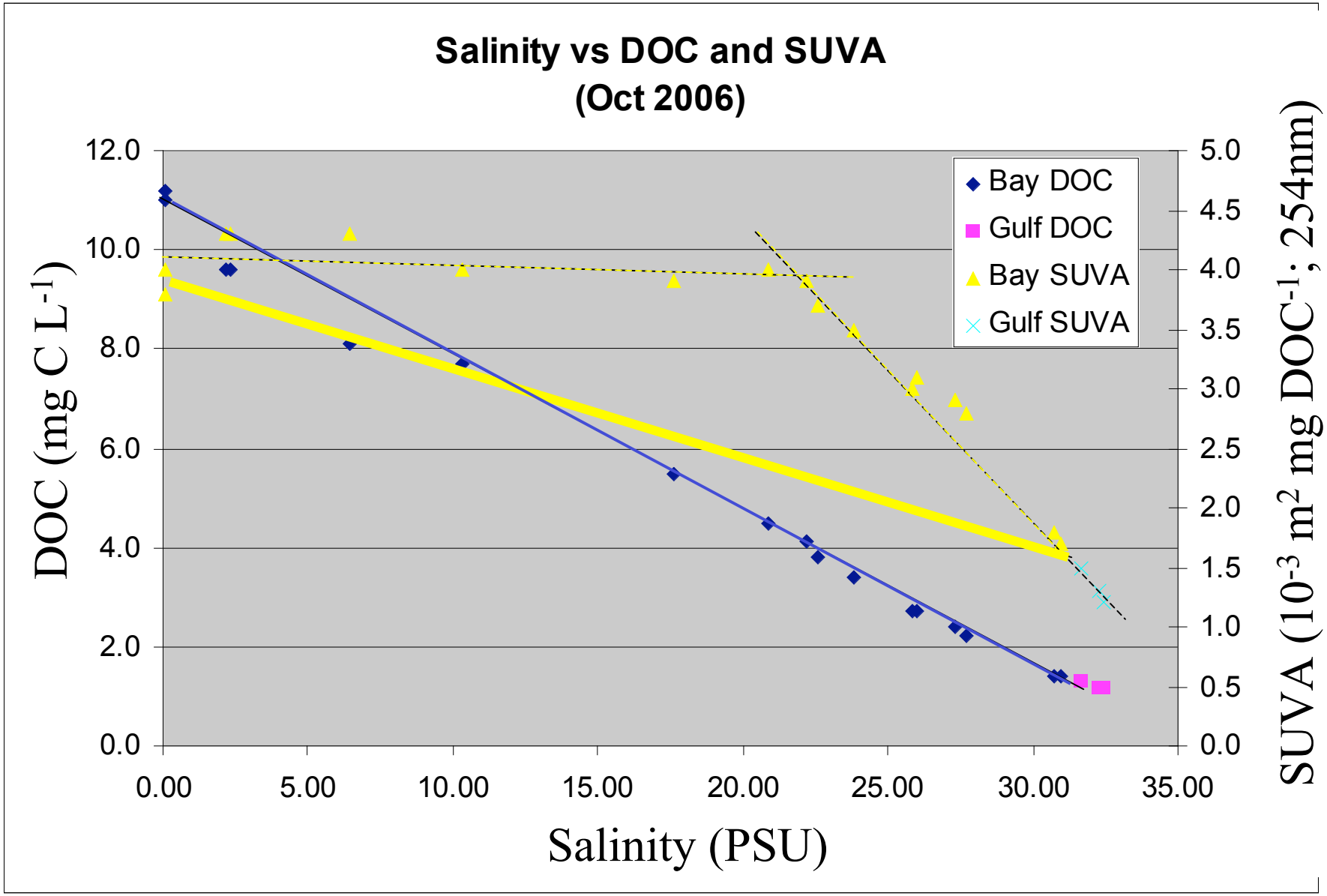


How much does DOC quantity change from Penobscot Bay to the Gulf of Maine?

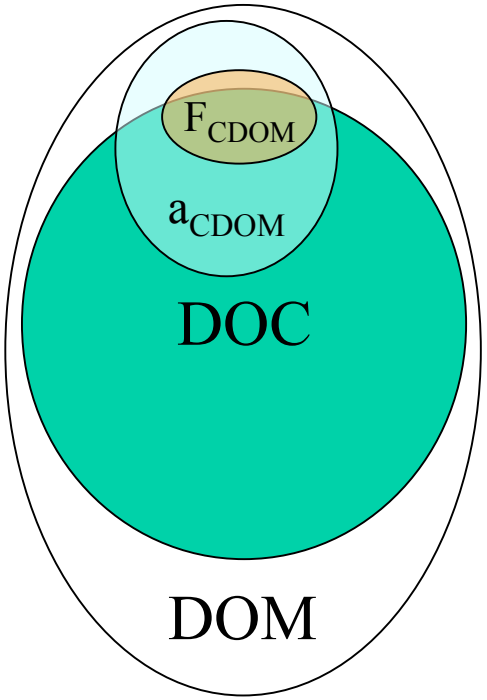


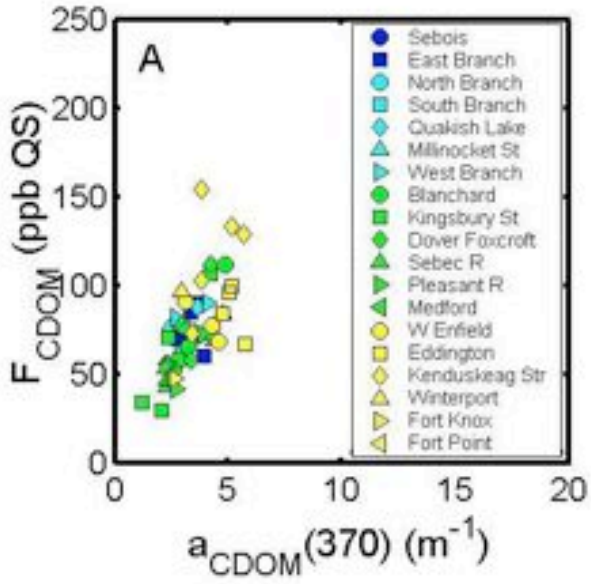
How does the aromaticity of the DOC ("flavor") change from Bay to Gulf?

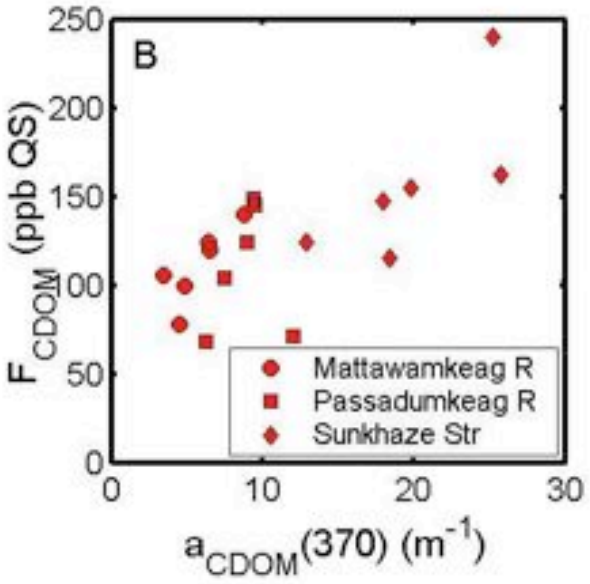


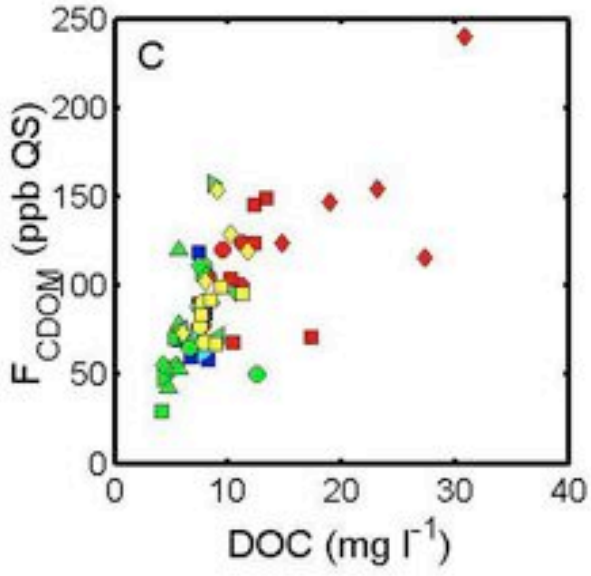

Salinity vs DOC and SUVA
(Oct 2006)
DOC (mg C L-1)
SUVA (10-3 m2 mg DOC-1; 254nm)
Salinity (PSU)
Bay DOC
Gulf DOC
Bay SUVA
Gulf SUVA
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

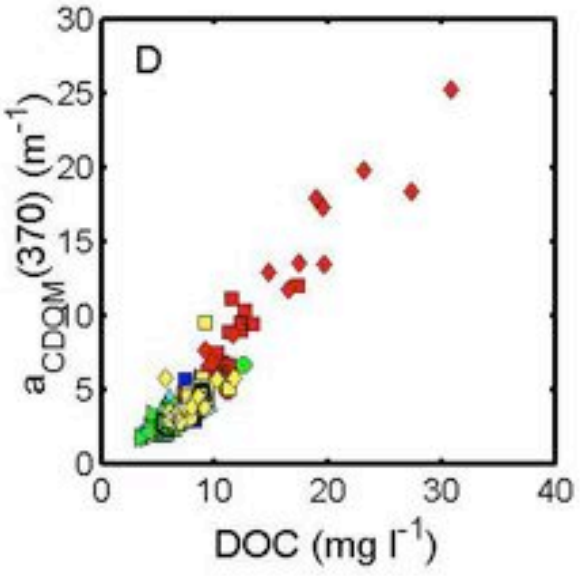
Dissolved Organic Carbon Proxies

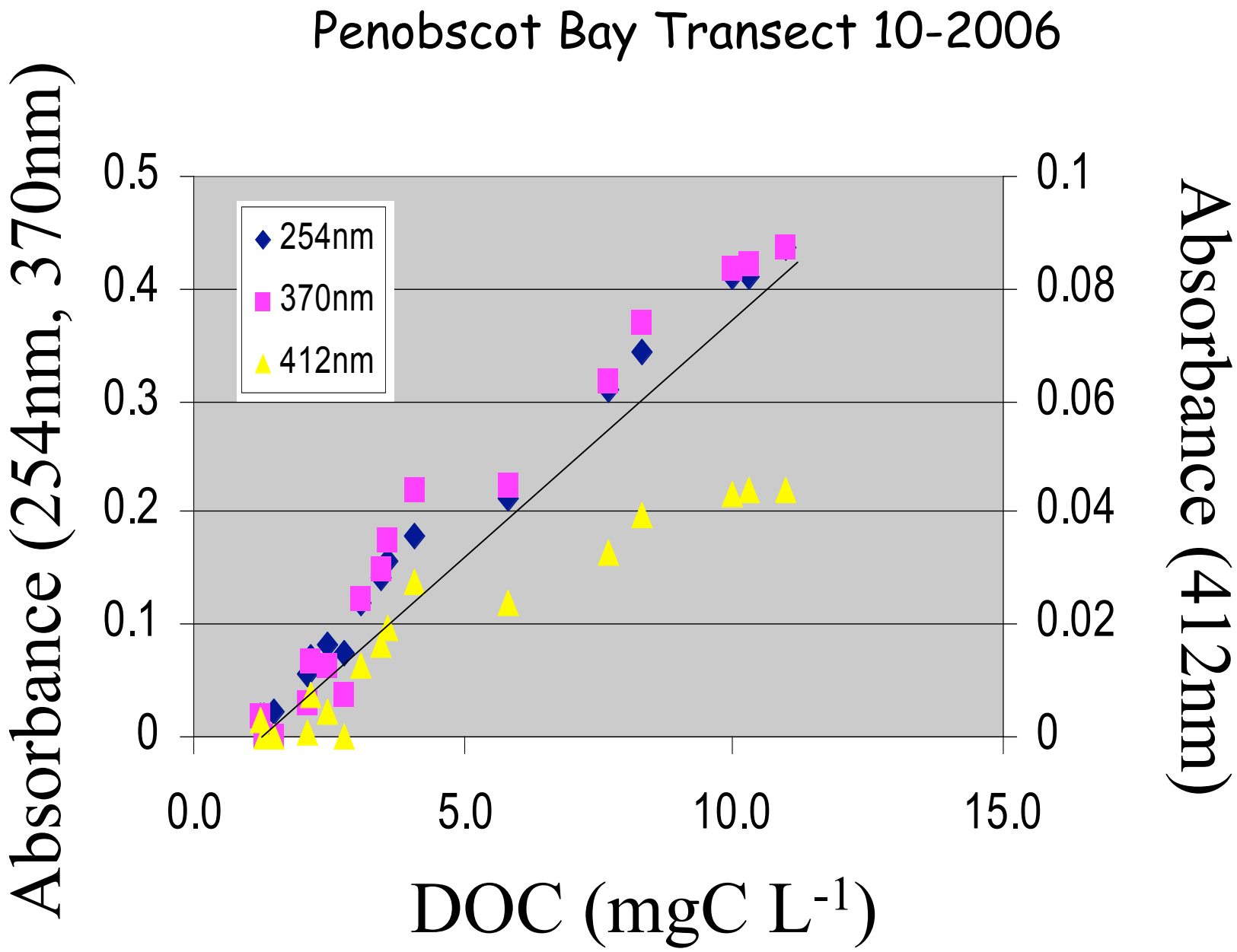




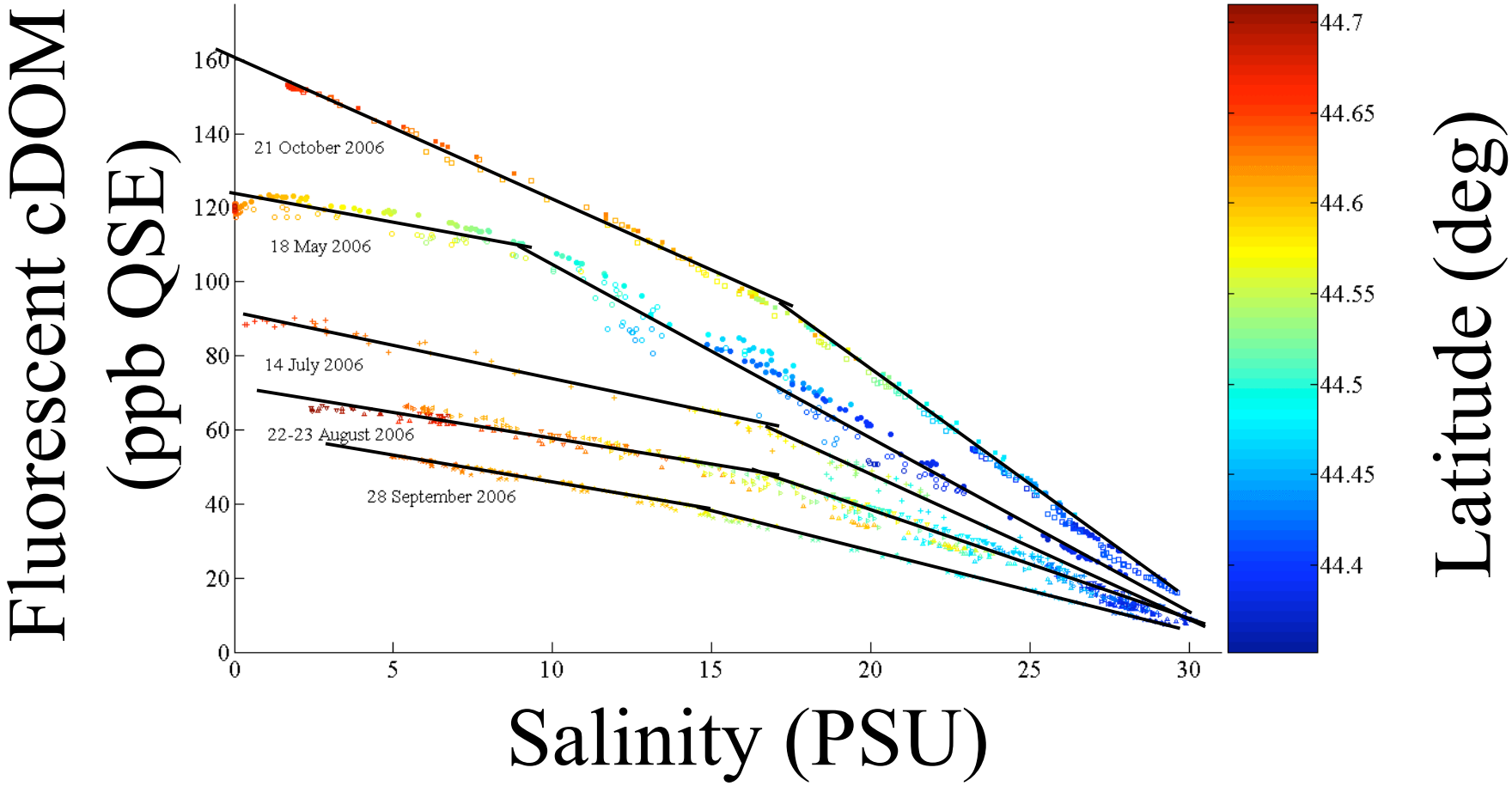




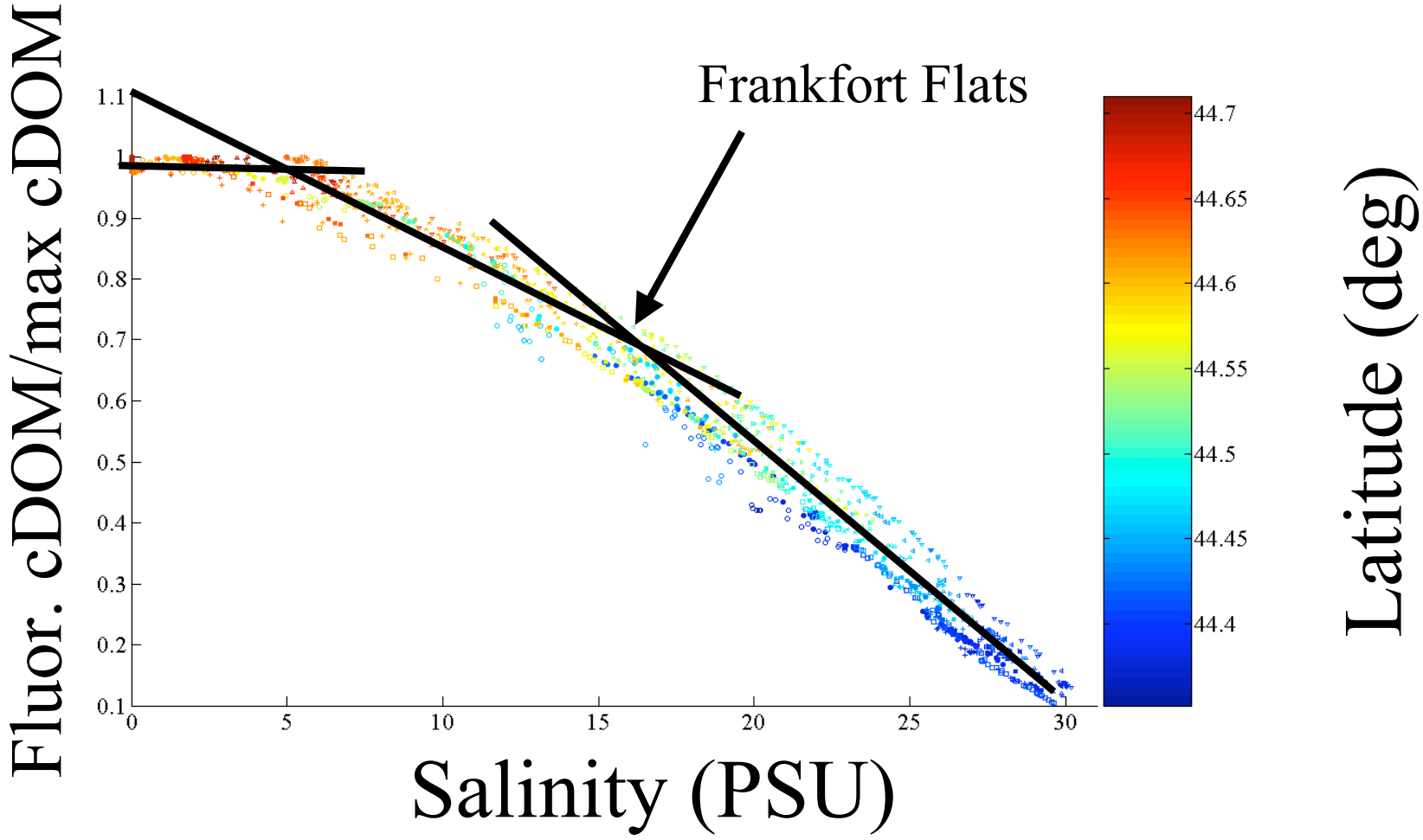



Penobscot Bay Transect 10-2006
Absorbance (254nm, 370nm)
Absorbance (412nm)
DOC (mgC L-1)
254nm
370nm
412nm
0.5
0.4
0.3
0.2
0.1
0
0.1
0.08
0.06
0.04
0.02
0
0.0
5.0
10.0
15.0

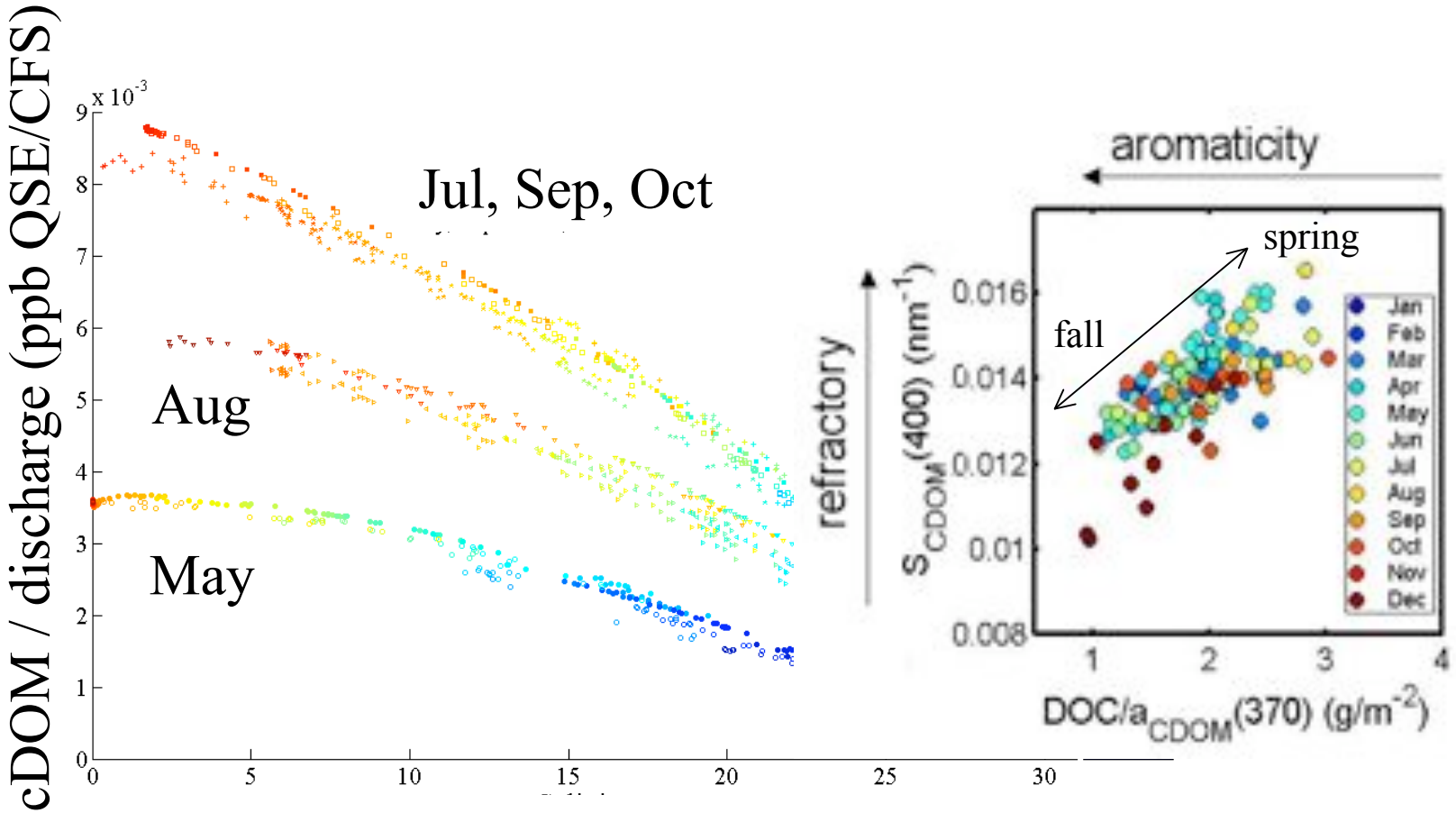
Non-linear cDOM fluorescence vs salinity…



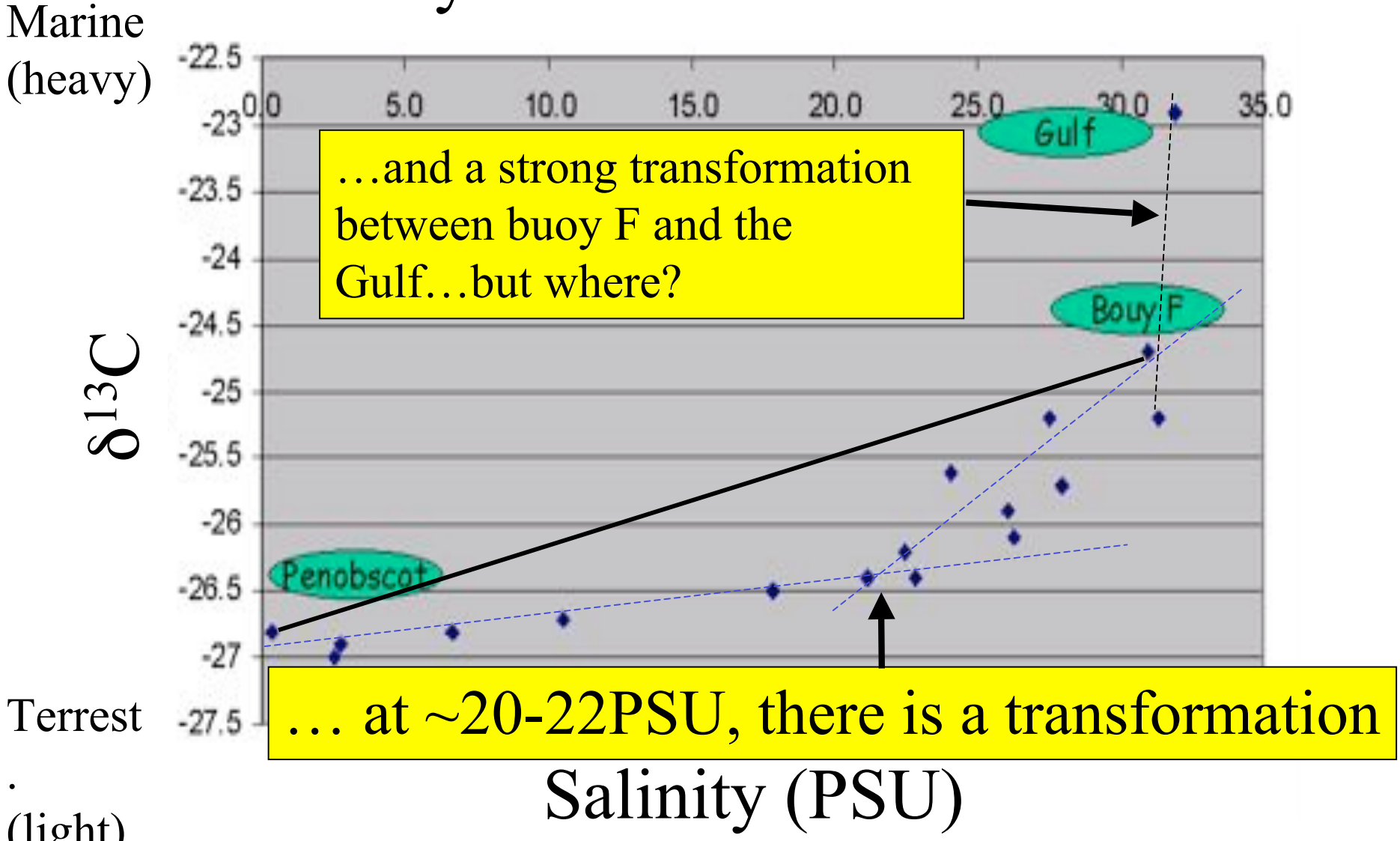
But normalize that cDOM fluorescence to the maximum observed at any one time…



Now normalize cDOM to discharge…
"How well is the tea steeped?"

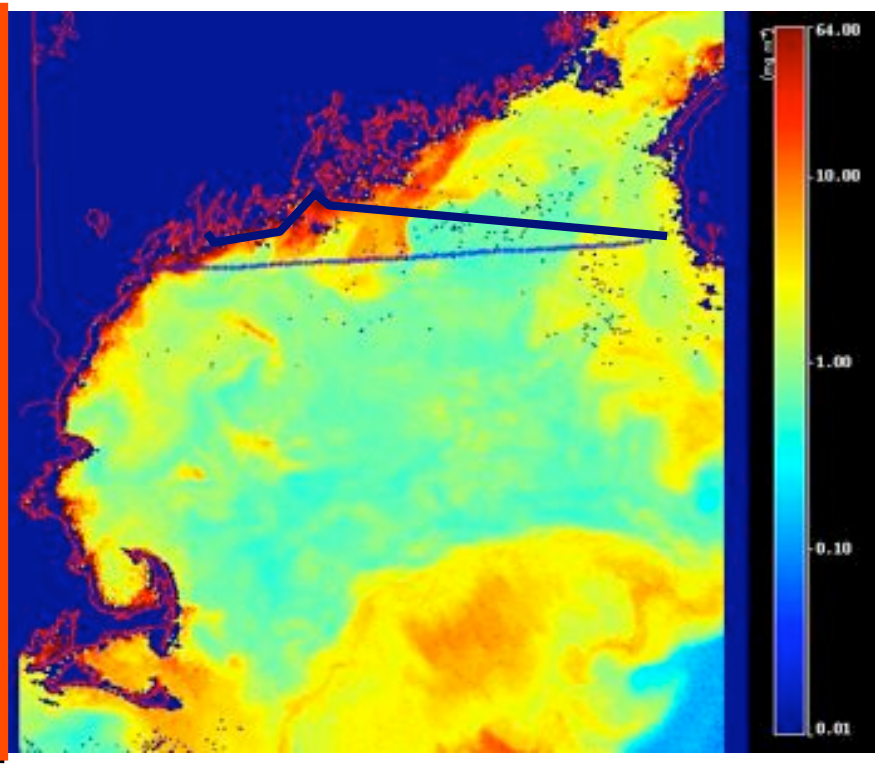


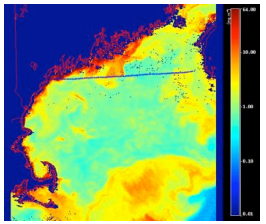
$\delta^{13}C$ behaves <u>nonconservatively</u> with respect salinity and DOC concentration



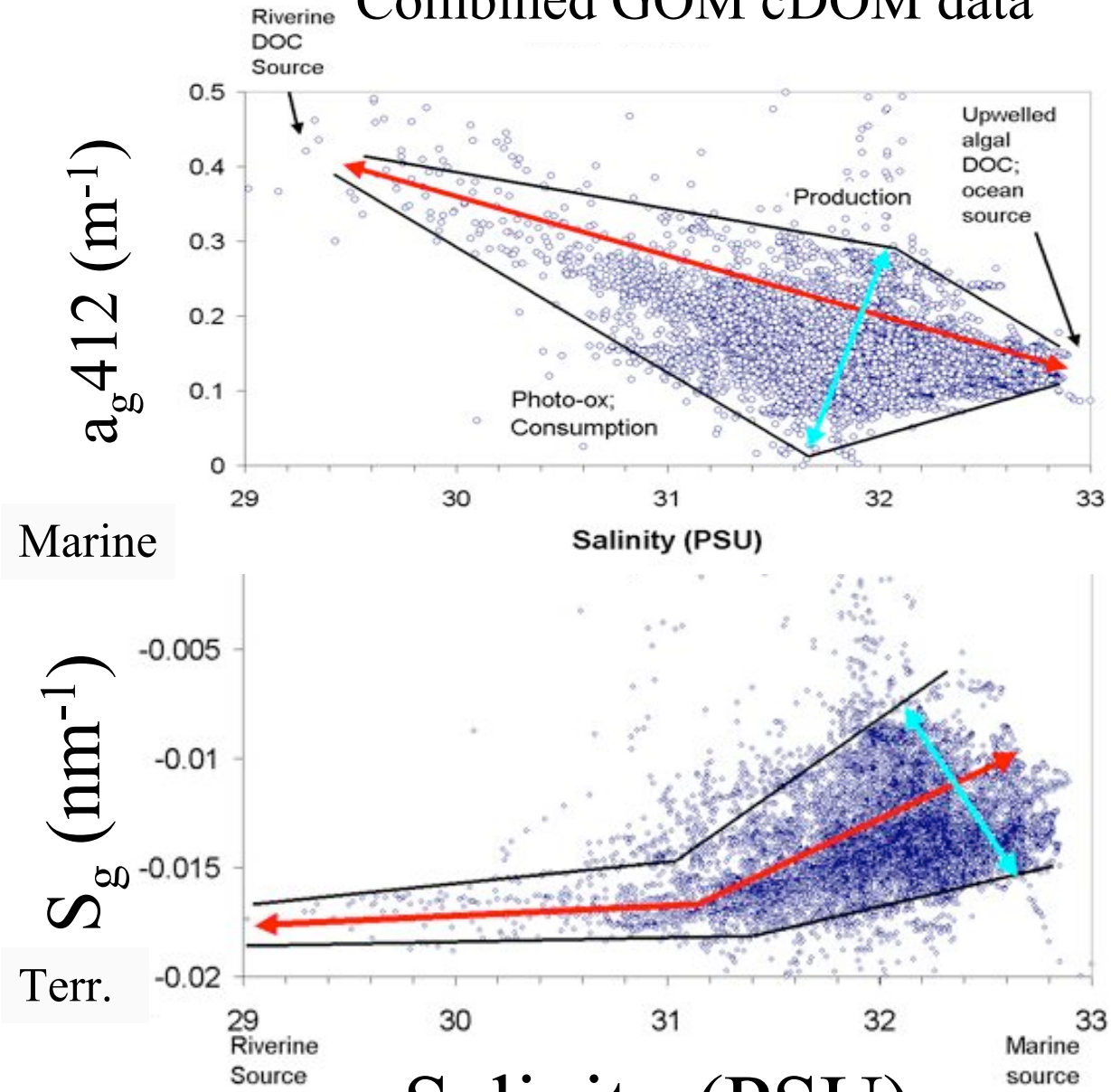
New transects

Original Line



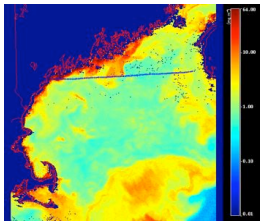


Combined GOM cDOM data



It is clear that in the Gulf of Maine, transformations are occurring, too, in [CDOM] and color

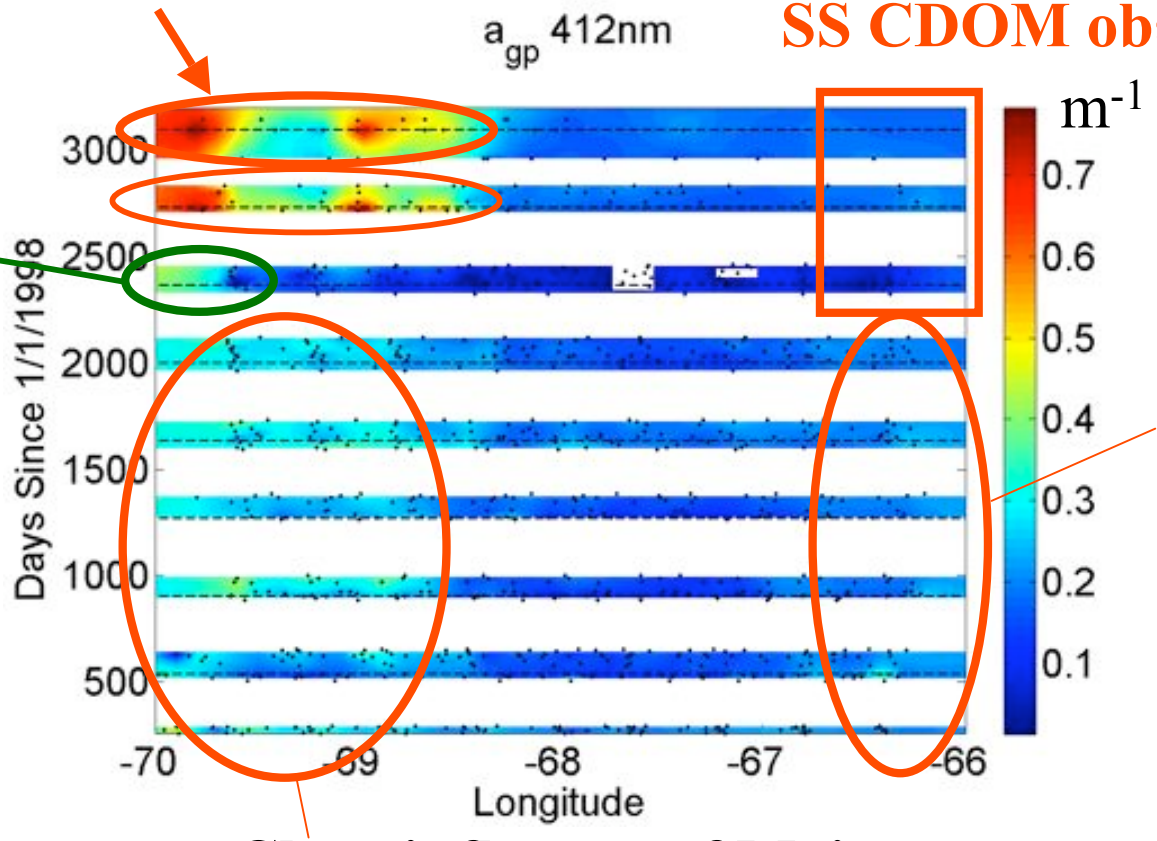
Nine years of a_{gp412} …2004 through 2006 were extraordinary years for land-sea C transport



Unprecedented input of CDOM from Maine rivers

Since 2004, little elevated SS CDOM observed!

#2 Wet '06
#1 Wet '05
Dry '04
'03
'02
'01
Dry '00
'99
'98



Usually saw elevated values in SS water coming from Gulf of St Lawrence

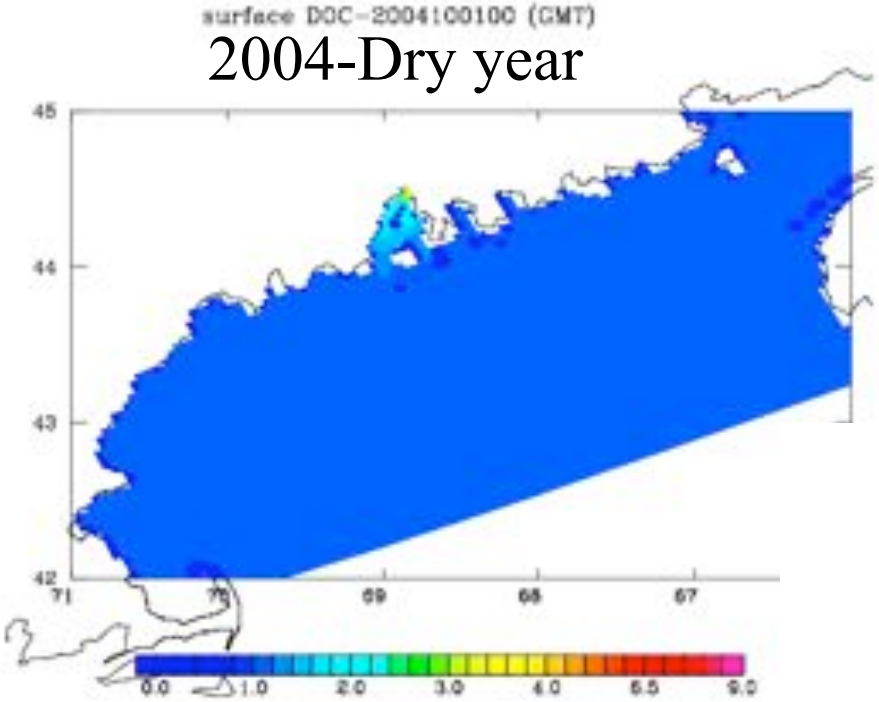
Portland, ME

Clear influence of Maine rivers

Yarmouth, NS

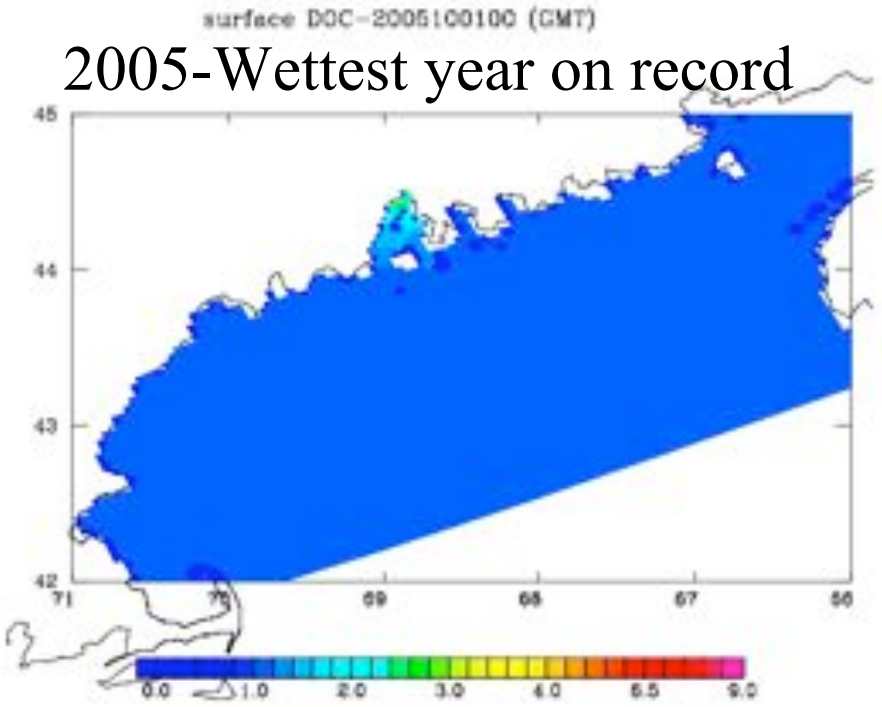
DOC MODEL
Oct to Dec

2004-Dry year



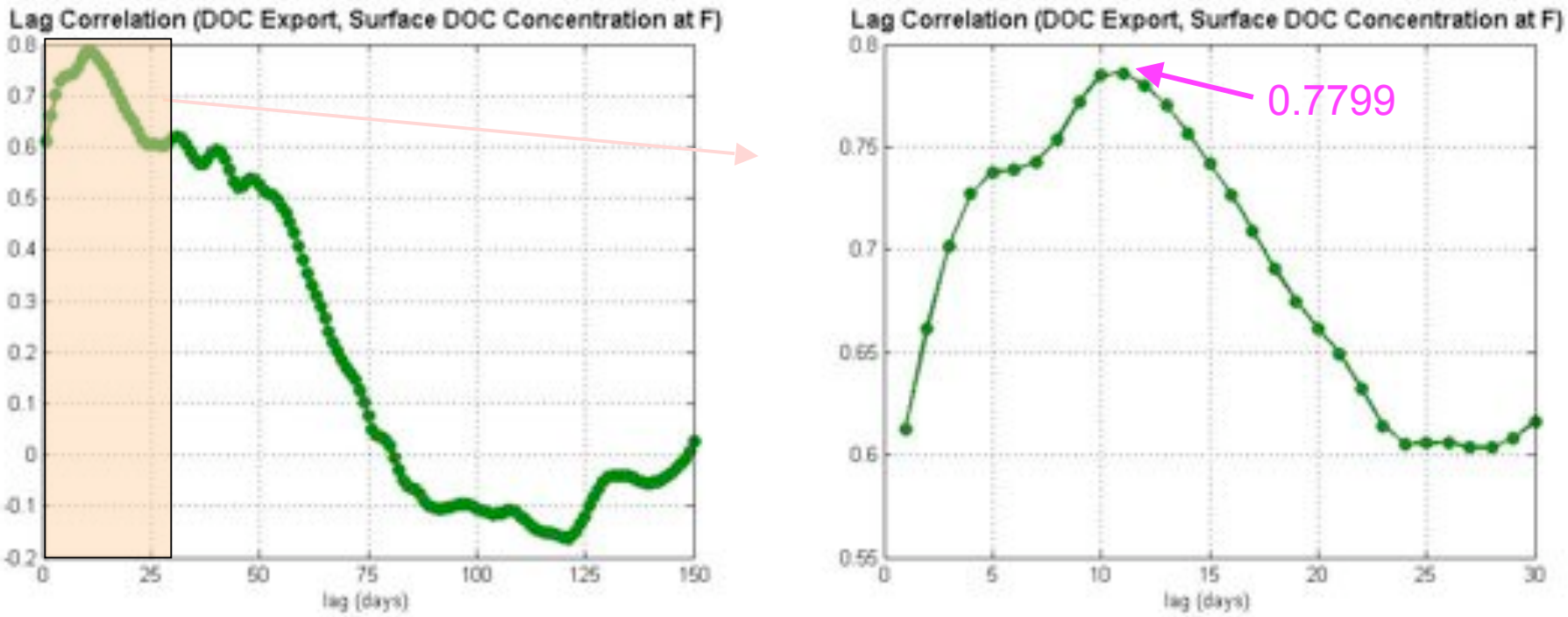
Mg DOC L^{-1}

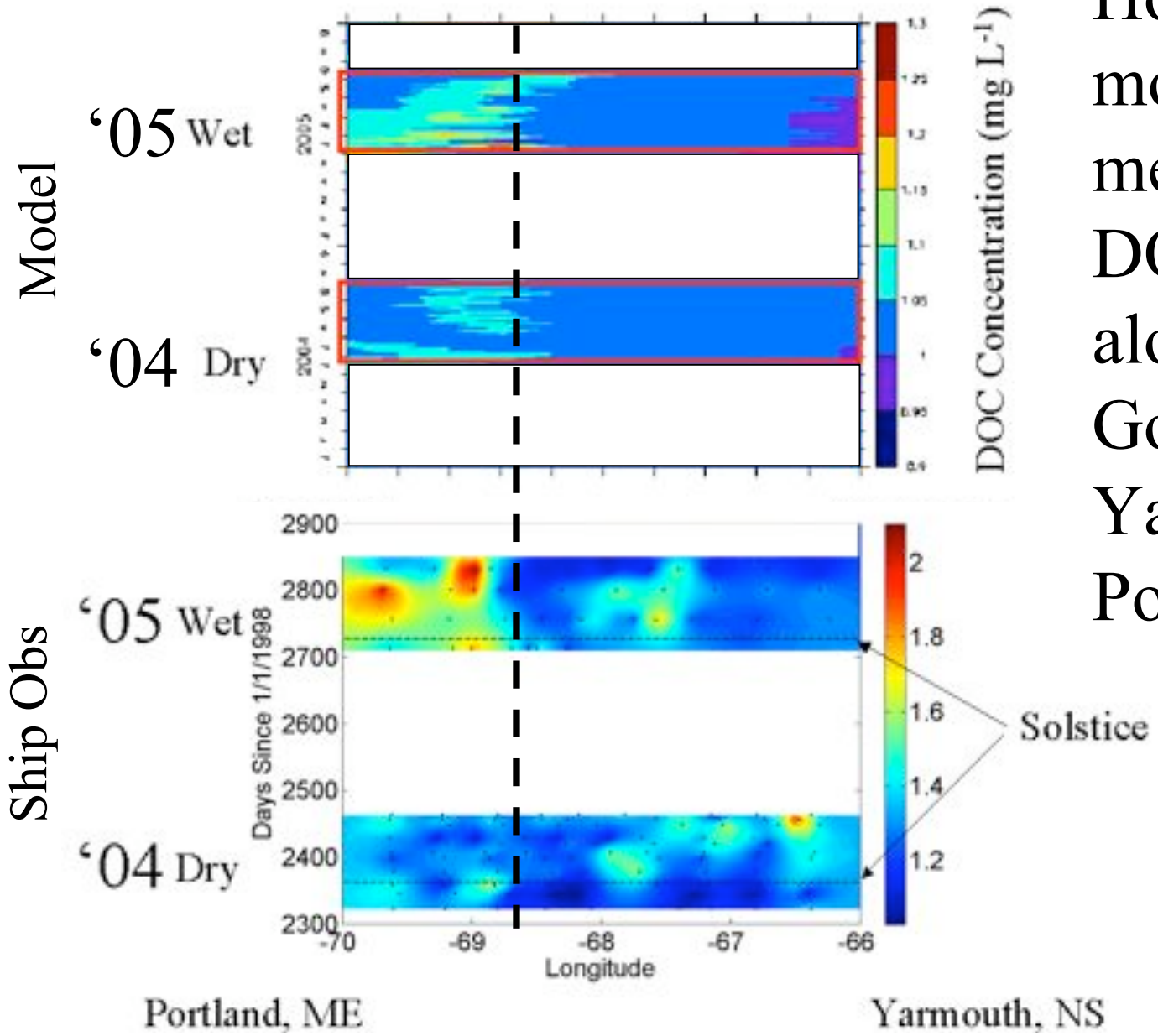
2005-Wettest year on record



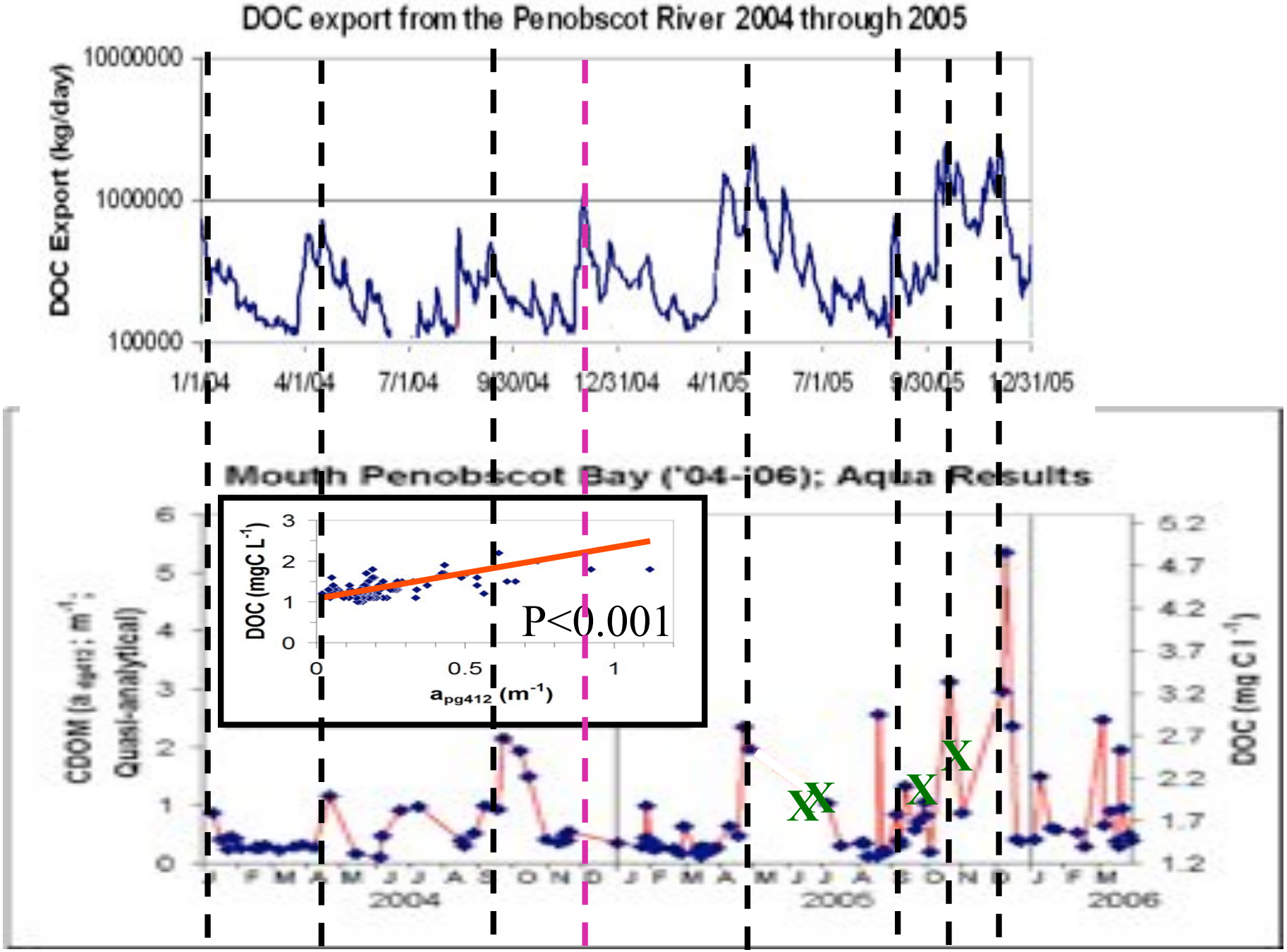
Mg DOC L^{-1}

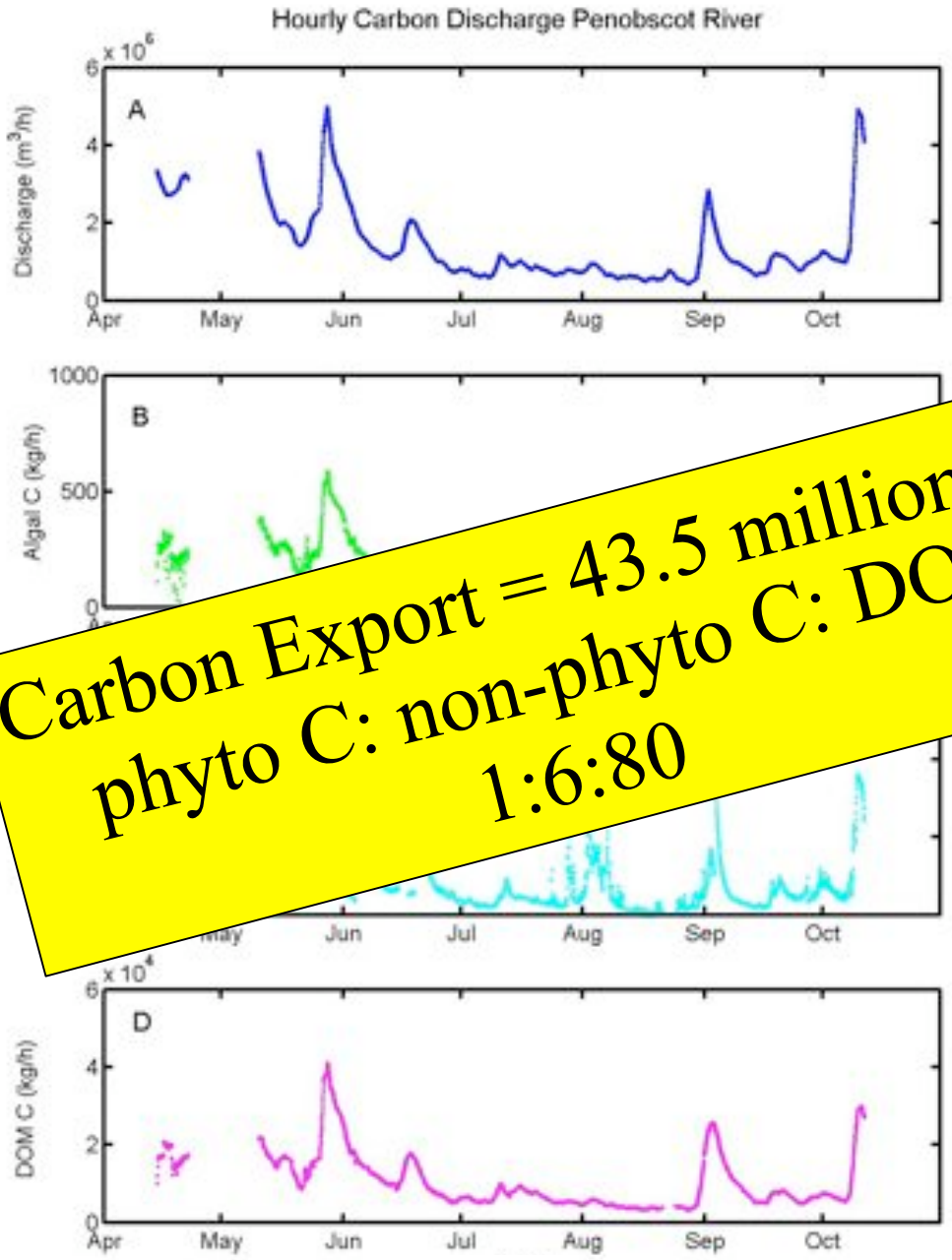
How long does it take for DOC to make it down to the Gulf of Maine (buoy F)?





How does modeled and measured DOC compare along the GoM between Yarmouth and Portland?


DOC export from the Penobscot River 2004 through 2005
DOC Export (kg/day)
10000000
1000000
100000
1/1/04
4/1/04
7/1/04
9/30/04
12/31/04
4/1/05
7/1/05
9/30/05
12/31/05
Mouth Penobscot Bay ('04-'06): Aqua Results
DOC (mgC L-1)
P<0.001
apg412 (m-1)
CDOM (apg412; m-1; Quasi-analytical)
DOC (mg C l-1)
2004
2005
2006



2005

Carbon Export = 43.5 million kg
phyto C: non-phyto C: DOC
1:6:80

Organic Carbon Time Series

- Discharge
  - Spring freshet
    - Ice melt
    - precipitation
  - Autumn rains
- Algal Organic Carbon
  - (0.5 million kg)
- Non-algal Particulate organic Carbon
  - (3 million kg)
- Dissolved Organic Carbon
  - (40 million kg)

DOC (and tea steeping)

- You can tell "tea" quantity by its color in these Maine watersheds
- Tea color tells less about composition due to nonconservative changes (e.g. can't tell if it is a "malty mix with essence of maple bark" vs. a "smokey mix of pine needles and sod)".
- Beware how long you let your tea steep…seasonal changes in strength.
- Major chemical transforms occurring at 20-22 and 31 PSU. SUCH CHANGES CAN BE MODELED.
- Extremes in precipitation associated with major bio-optical shifts in GoM as carbon moves from land to sea. DOC export from single watershed is 40% of all GOM primary production. Balance in heterotrophic vs autotrophic production?
- Future: time-series sampling, focus on carbon transformations, with improvements in modeling and optical proxies, use remote sensing to study patterns of C export and GOM production.

THANK YOU!