Source and formation pathway of colloidal organic matter (COM) from river to ocean: clue from lipids and their $\delta^{13}C$ ratios

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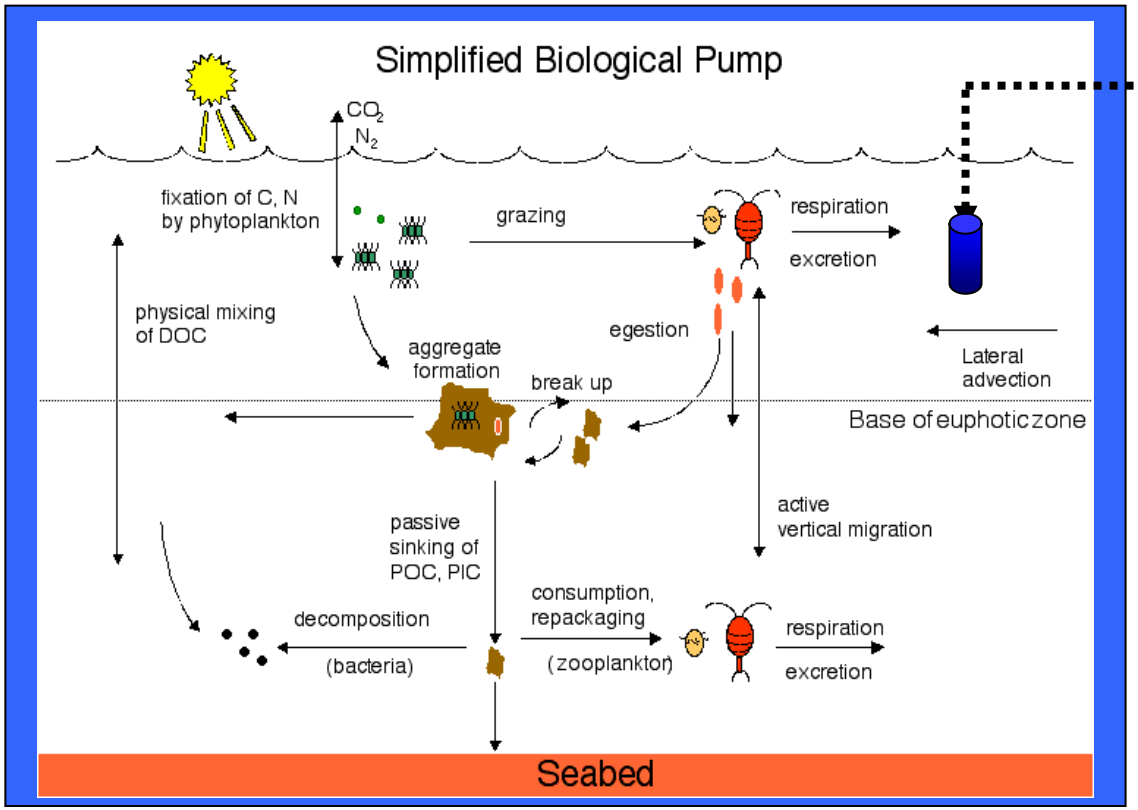
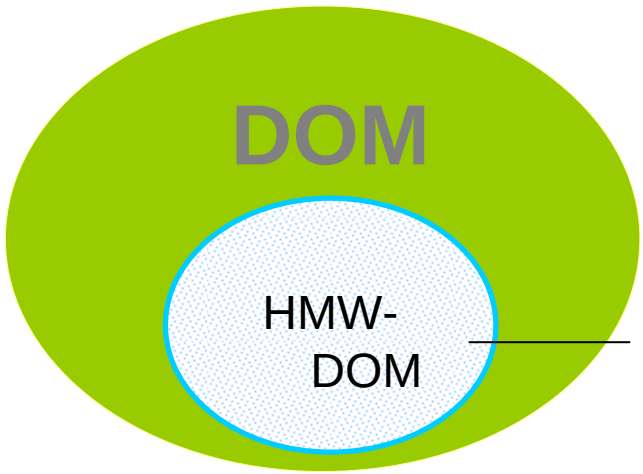
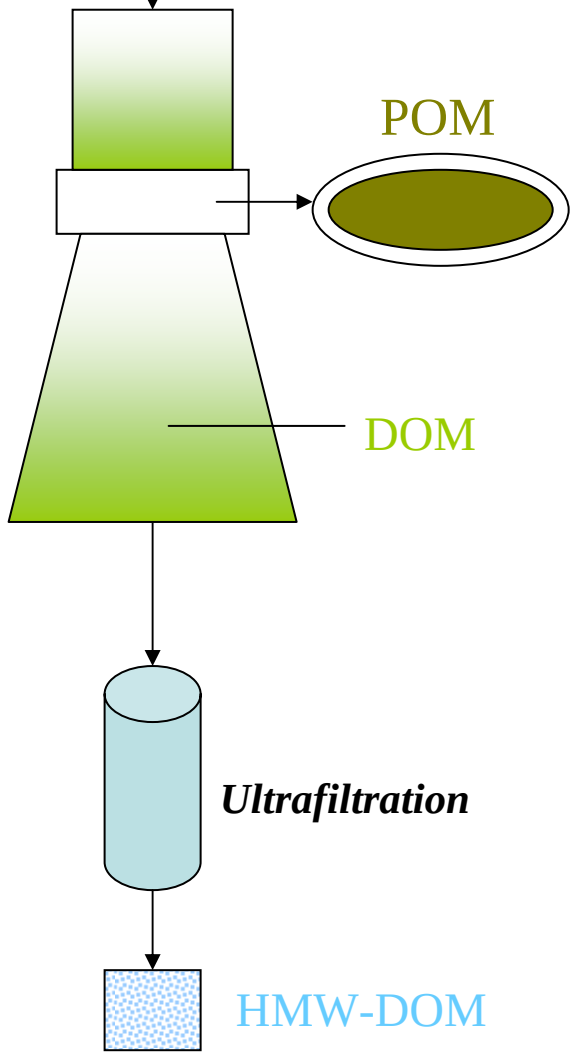
University of Georgia



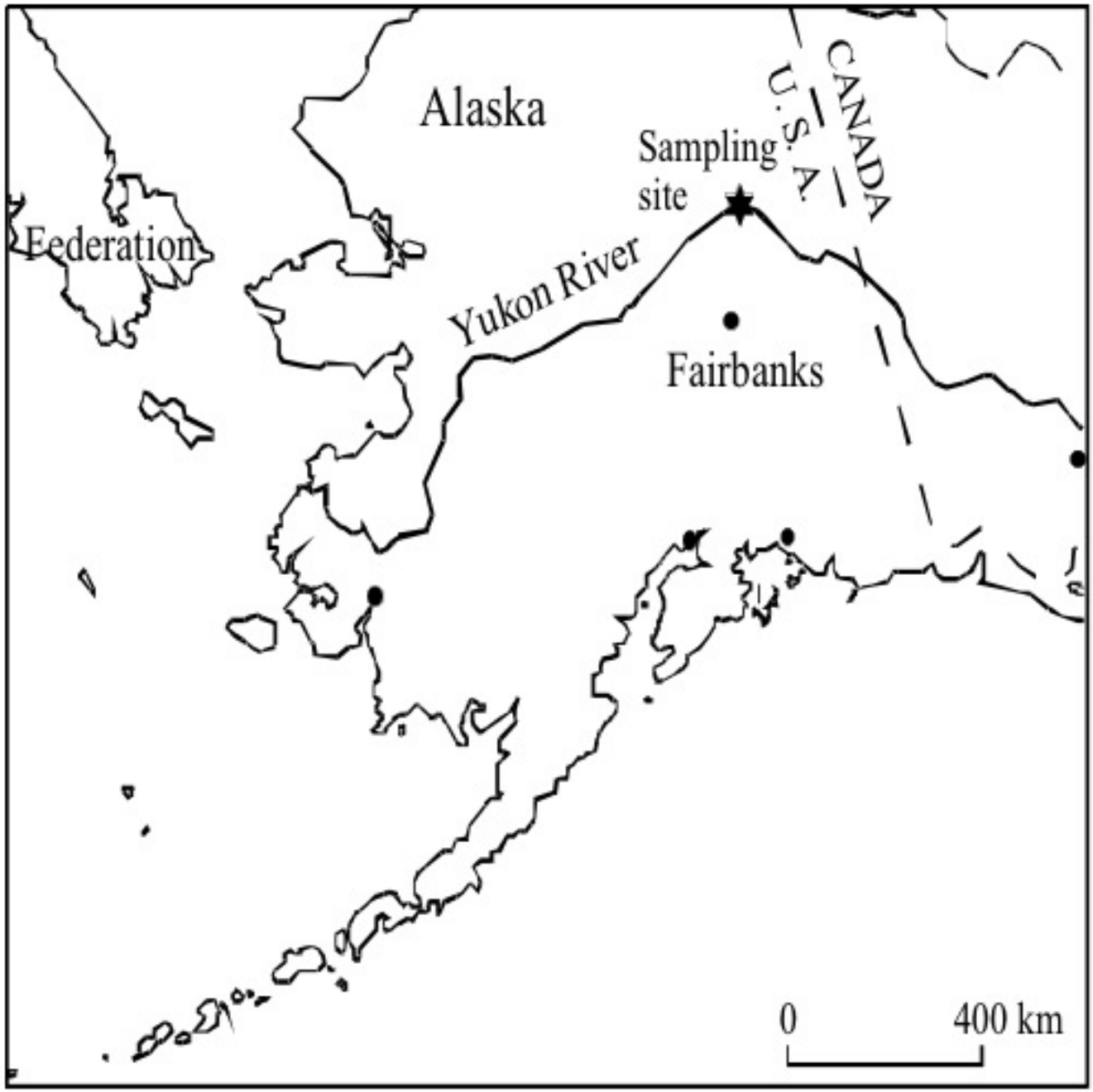
(Karl et al. - Biological pump working group summary)



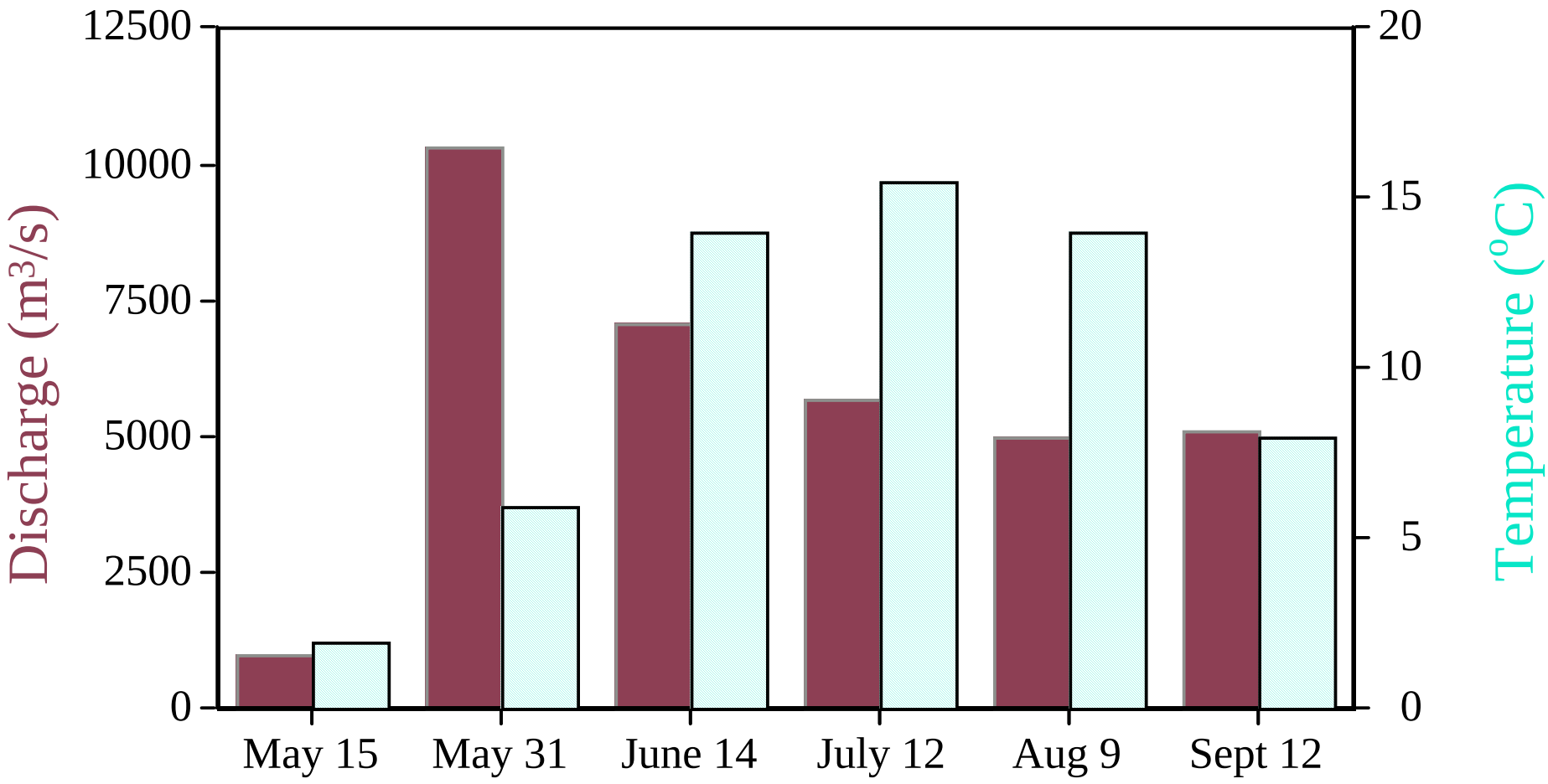
20-35% of DOM

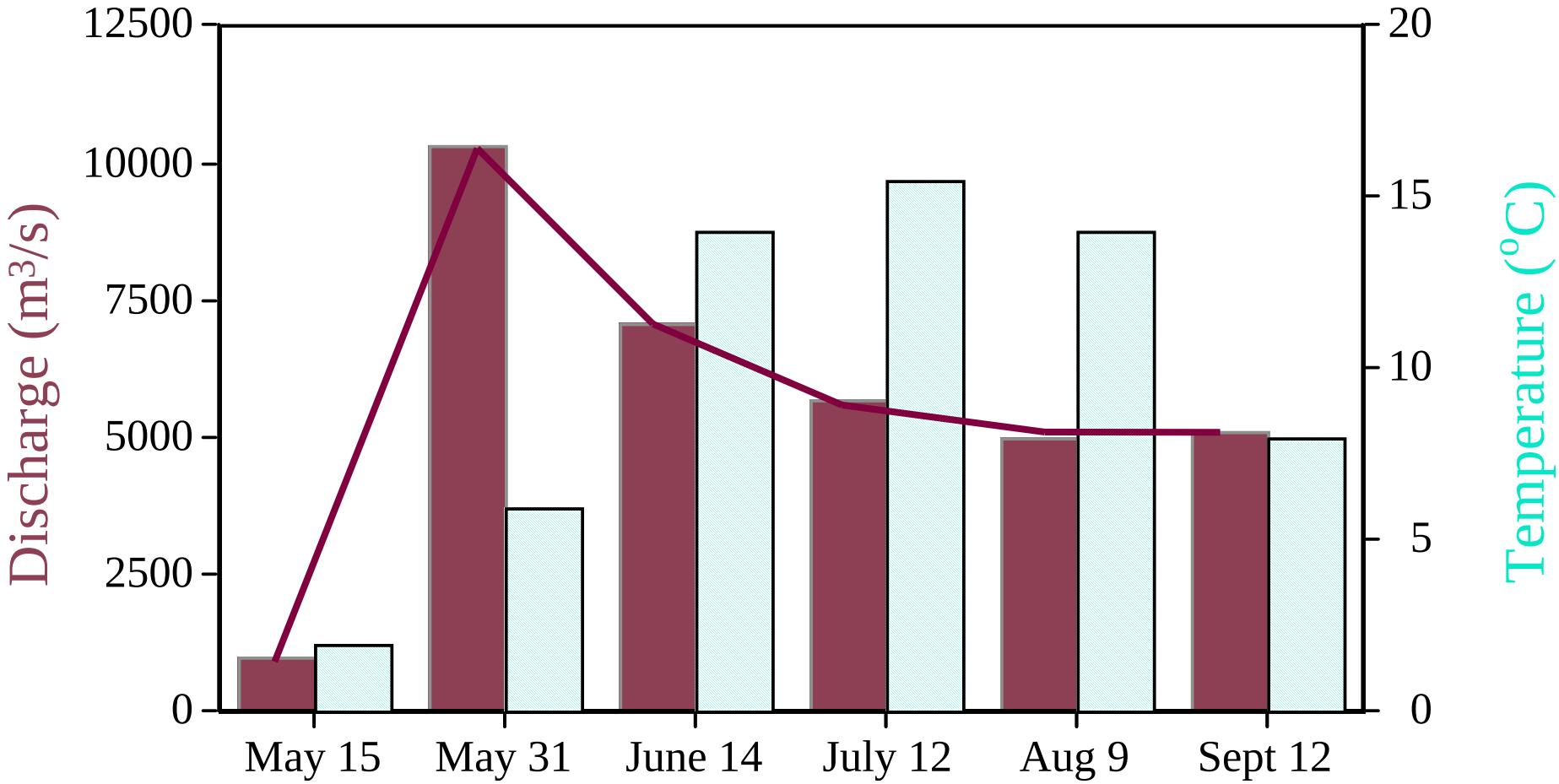


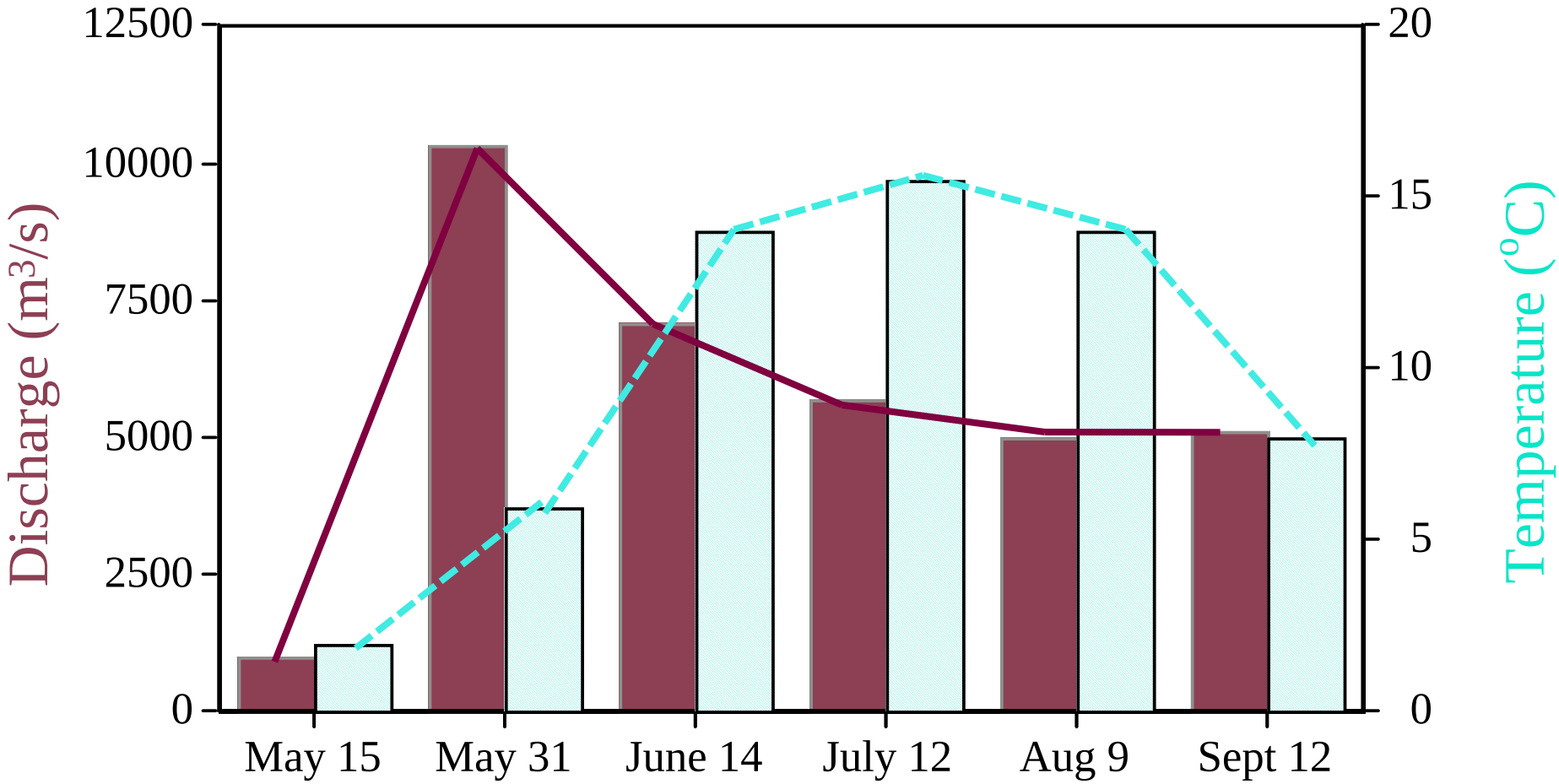

RUSSIA
90°
60°
Microsoft
MapPoint
ASIA
ARCTIC OCEAN
75°
60°
Arctic Circle
(Yukon River)
CANADA
NORTH AMERICA
(BH)
(SFB)
ATLANTIC OCEAN
UNITED STATES
(SDB)
(DCB)
(MAB)
Tropic of Cancer
PACIFIC OCEAN
SOUTH AMERICA
Equator
©2008 Microsoft Corp.
105°
90°

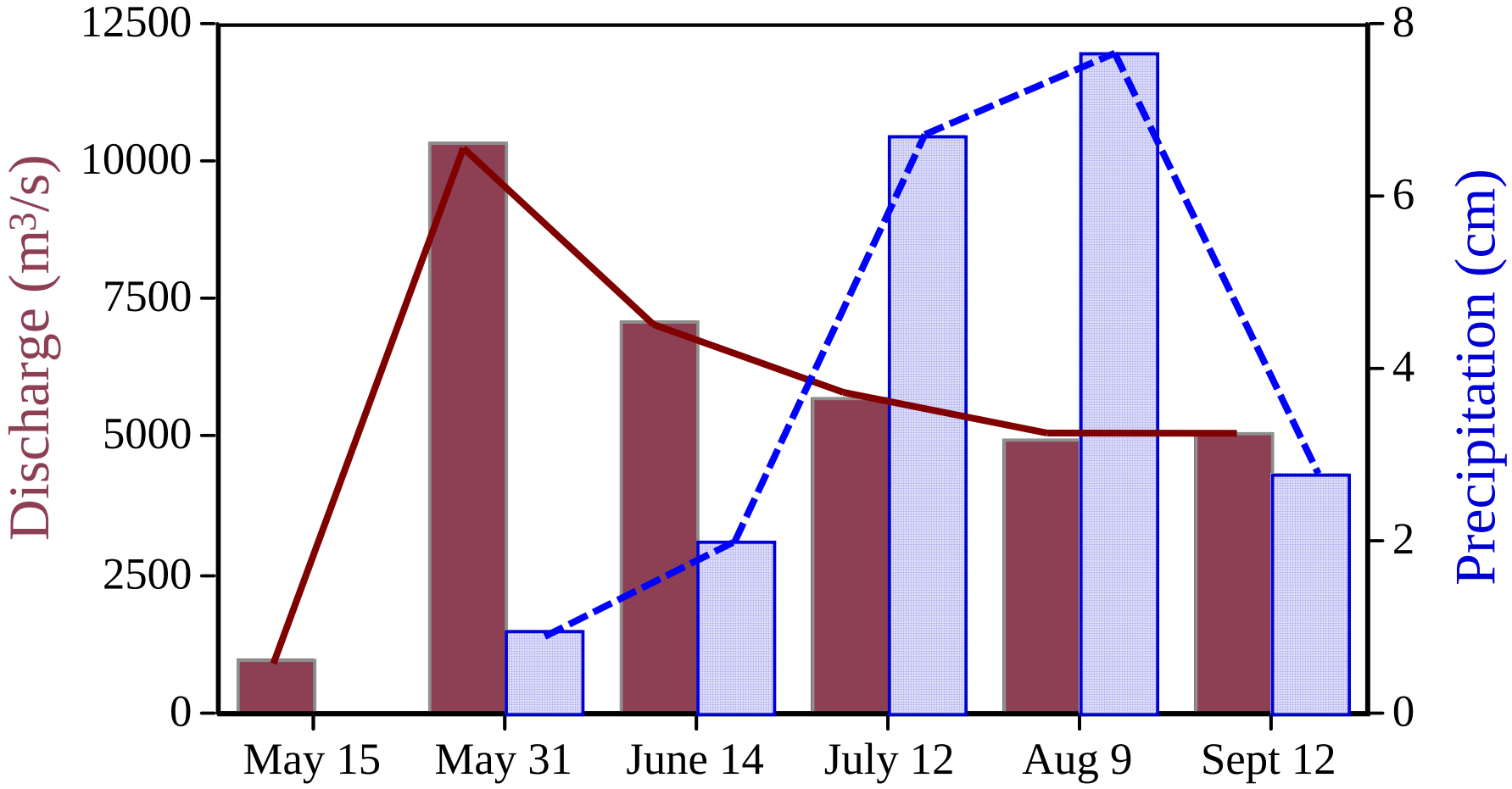

Alaska
Sampling site
U.S.A.
CANADA
Federation
Yukon River
Fairbanks
0
400 km

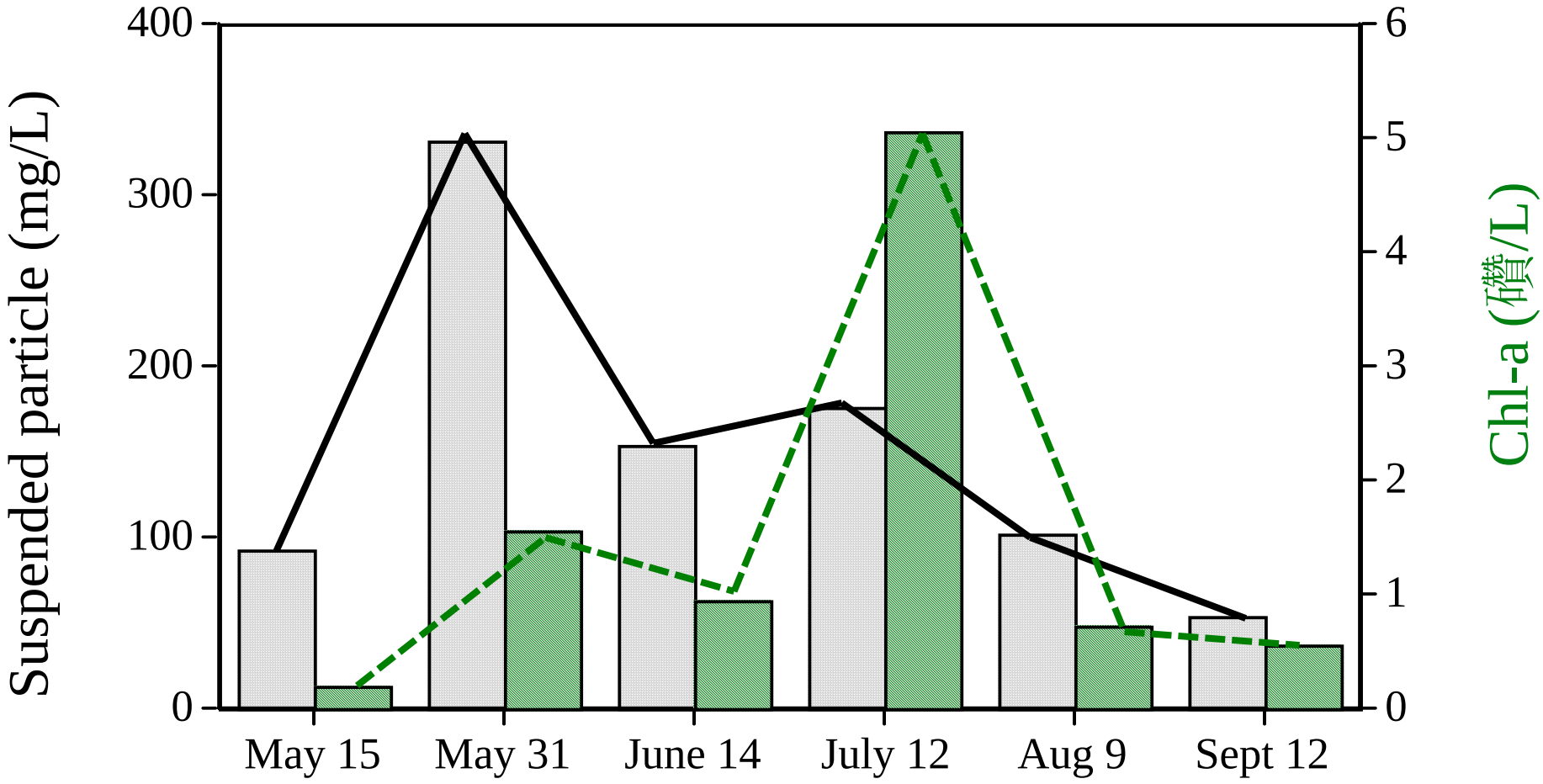

Temporal variations of POM, COM, and DOM during open season?

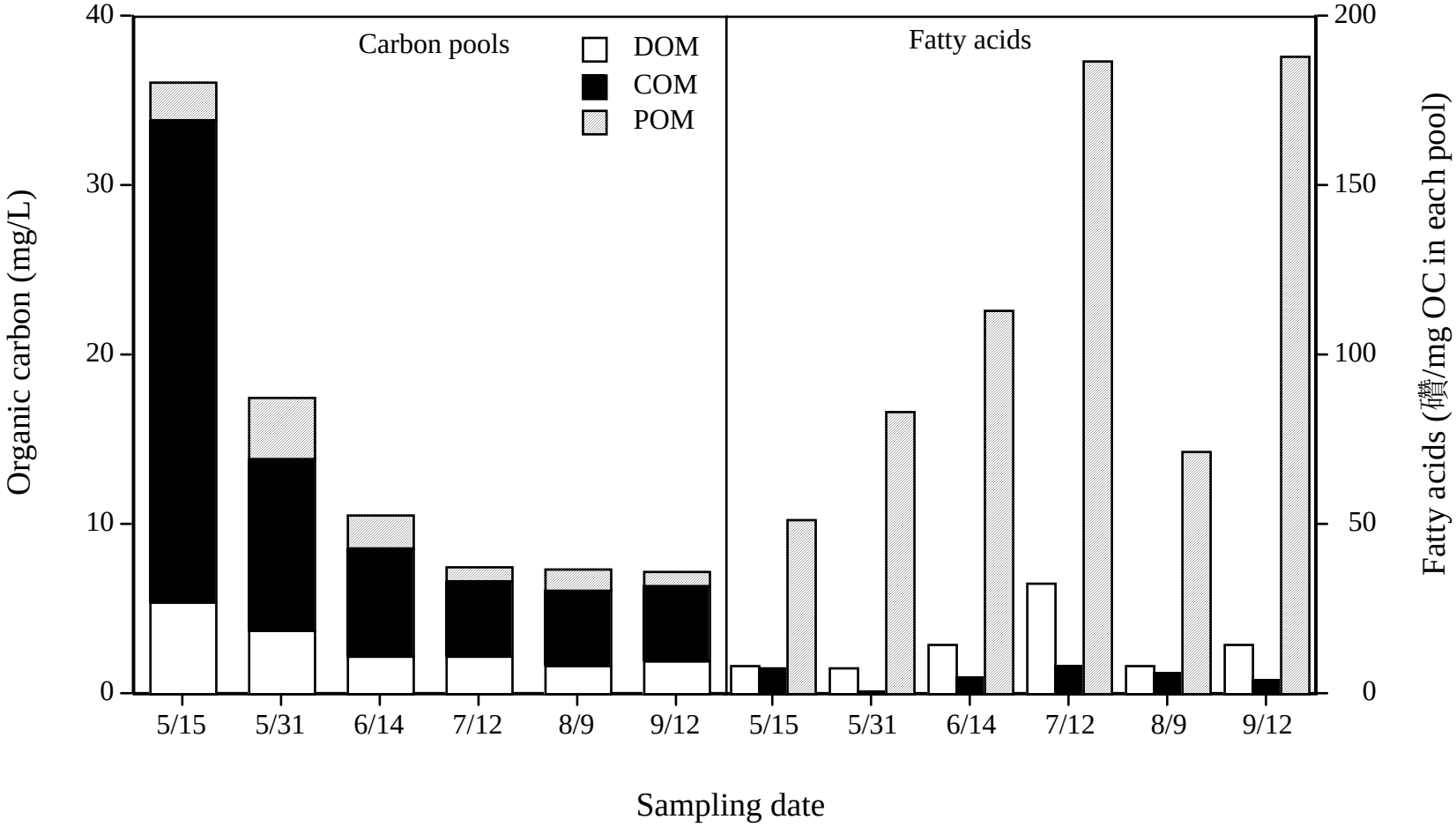

12500
10000
7500
5000
2500
0
Discharge (m³/s)
20
15
10
5
0
Temperature (°C)
May 15
May 31
June 14
July 12
Aug 9
Sept 12

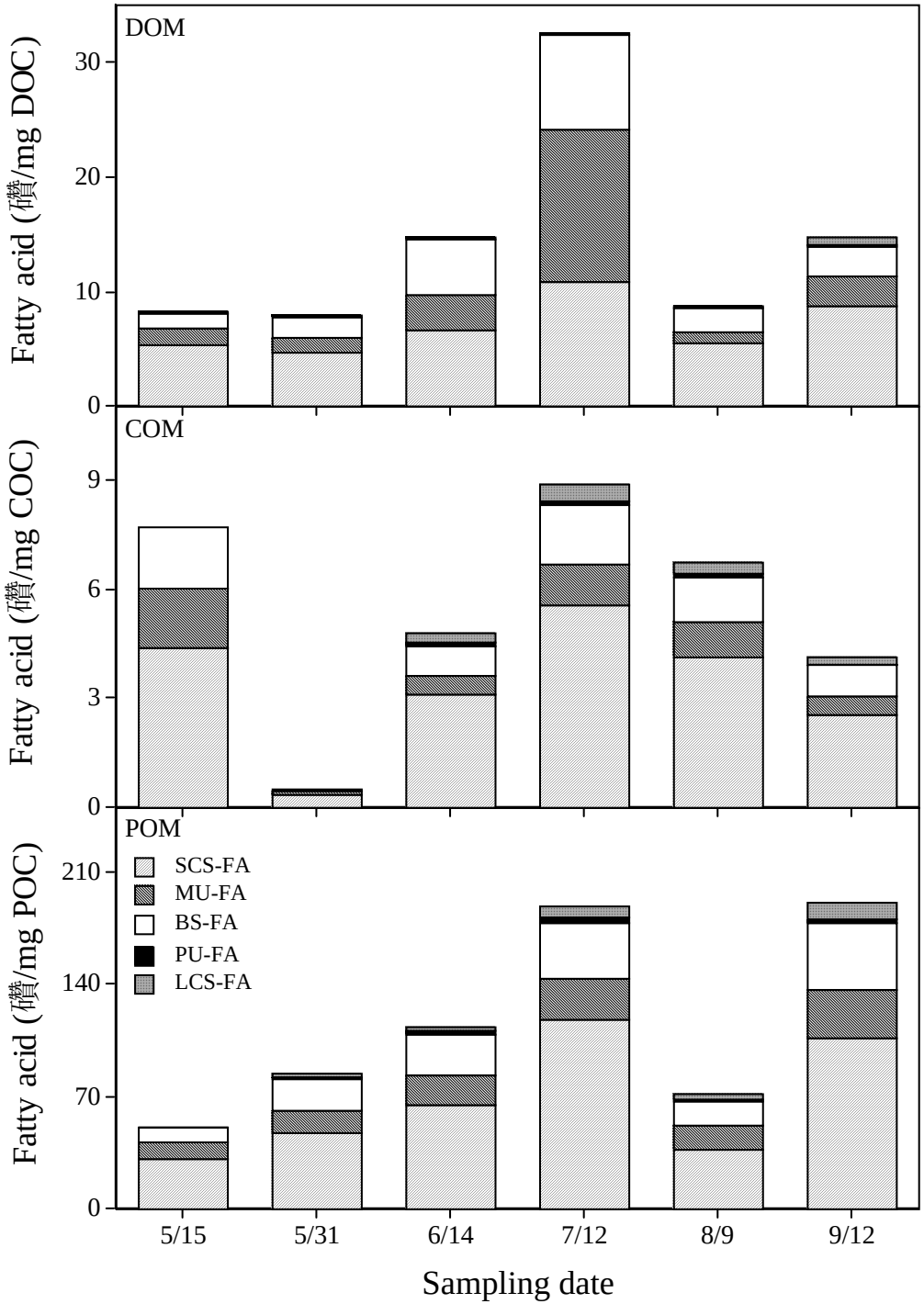

12500
10000
7500
5000
2500
0
Discharge (m³/s)
20
15
10
5
0
Temperature (°C)
May 15
May 31
June 14
July 12
Aug 9
Sept 12

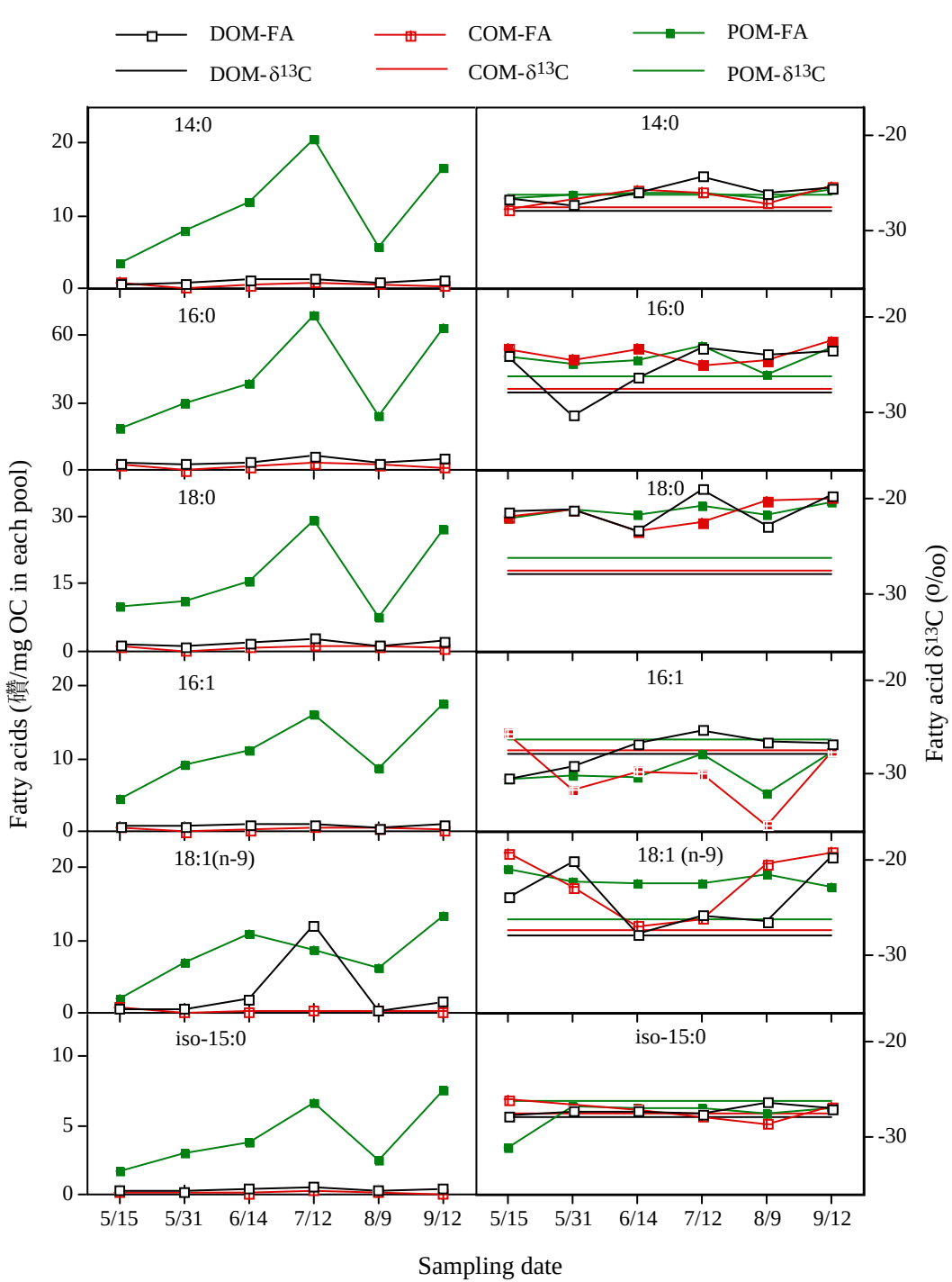

12500
10000
7500
5000
2500
0
Discharge (m³/s)
20
15
10
5
0
Temperature (°C)
May 15
May 31
June 14
July 12
Aug 9
Sept 12


12500
10000
7500
5000
2500
0
Discharge (m³/s)
8
6
4
2
0
Precipitation (cm)
May 15
May 31
June 14
July 12
Aug 9
Sept 12


Suspended particle (mg/L)
400
300
200
100
0
6
5
4
3
2
1
0
Chl-a (磺/L)
May 15
May 31
June 14
July 12
Aug 9
Sept 12


Carbon pools
Fatty acids
DOM
COM
POM
Organic carbon (mg/L)
Fatty acids (μg/mg OC in each pool)
Sampling date
0
10
20
30
40
0
50
100
150
200
5/15
5/31
6/14
7/12
8/9
9/12
5/15
5/31
6/14
7/12
8/9
9/12


DOM
COM
POM
Fatty acid (磷/mg DOC)
Fatty acid (磷/mg COC)
Fatty acid (磷/mg POC)
0
10
20
30
3
6
9
70
140
210
SCS-FA
MU-FA
BS-FA
PU-FA
LCS-FA
5/15
5/31
6/14
7/12
8/9
9/12
Sampling date


DOM-FA
COM-FA
POM-FA
DOM-δ13C
COM-δ13C
POM-δ13C
14:0
16:0
18:0
16:1
18:1(n-9)
iso-15:0
18:1 (n-9)
Fatty acids (糟/mg OC in each pool)
Fatty acid δ13C (o/oo)
Sampling date
5/15
5/31
6/14
7/12
8/9
9/12

Summary

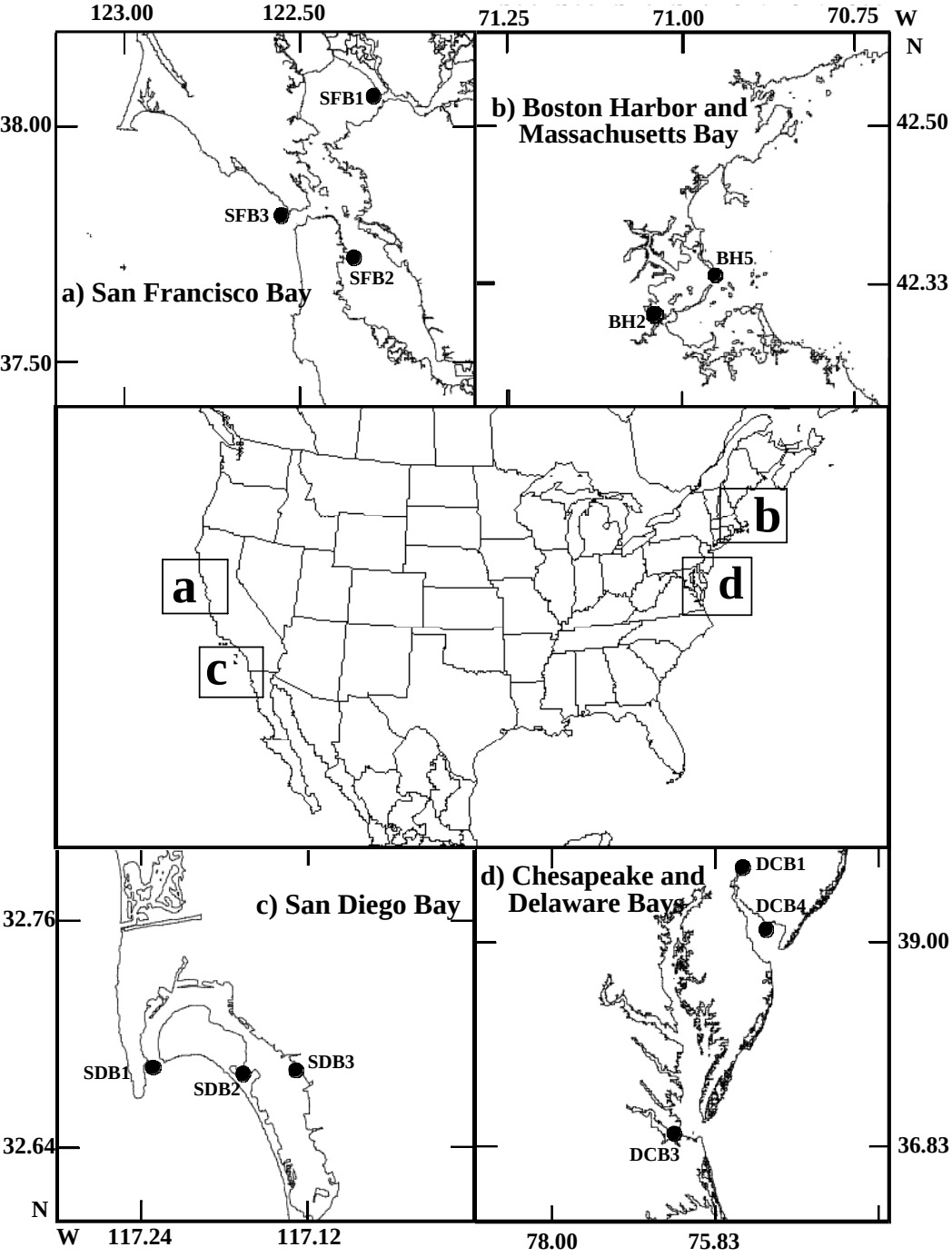
- Three carbon pools (POC, COC, and DOC) in the upper Yukon River are affected by soil erosion, hydrological dynamics, and biochemical cycling

- Total OC continuously declined from the beginning of snowmelt, while fatty acid contents varied independently

- Fatty acid compositions are dominated by short-chain saturated fatty acids but bacteria-specific fatty acids (BSFAs) comprised an important fraction

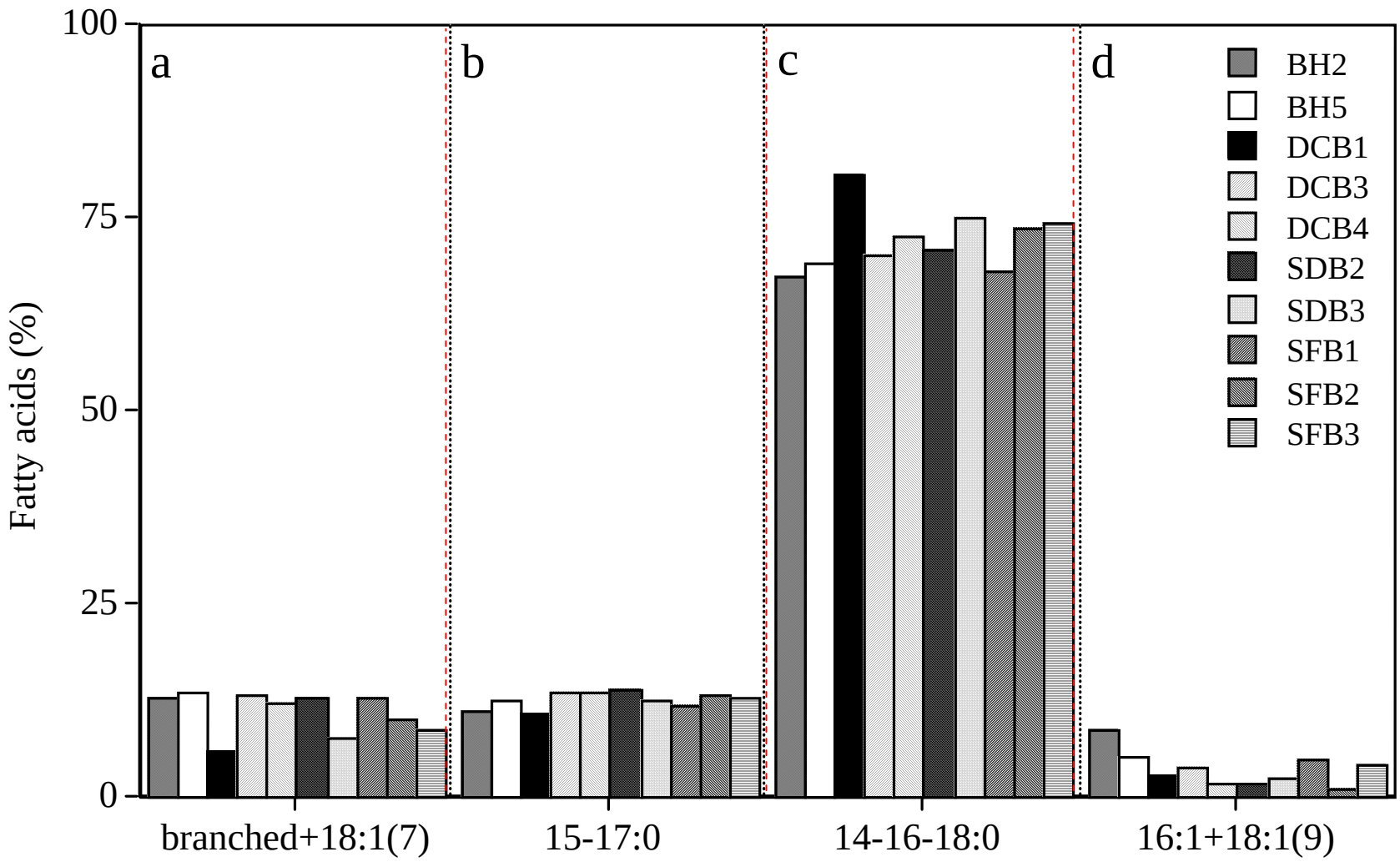
- Smaller variability in $\delta^{13}C$ of BSFAs compared to other fatty acids implies that bacteria utilize the bioavailable substrates from the same OC source

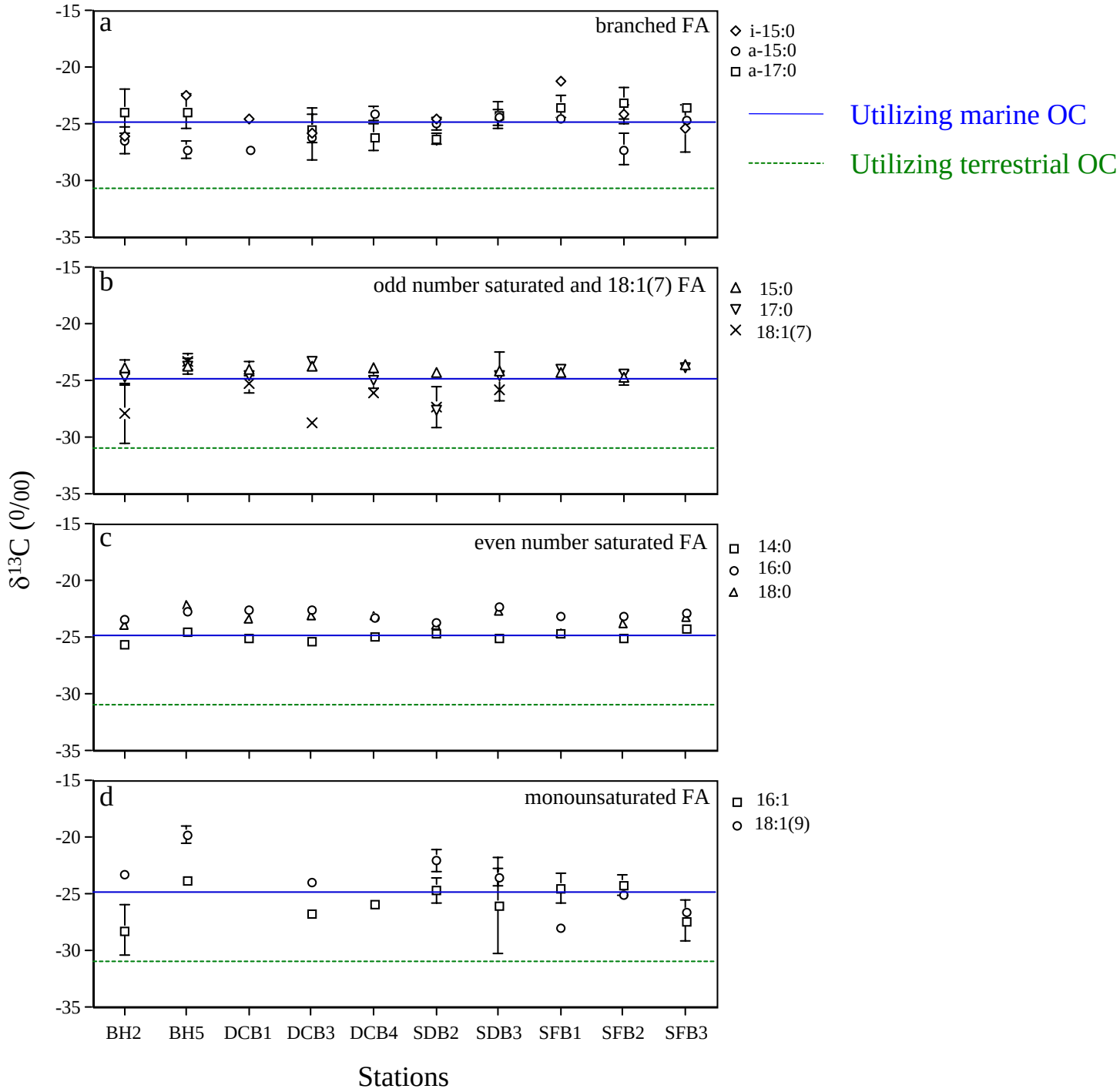
- Implication: global warming will not only release more soil OC from land but also promote production in Arctic rivers

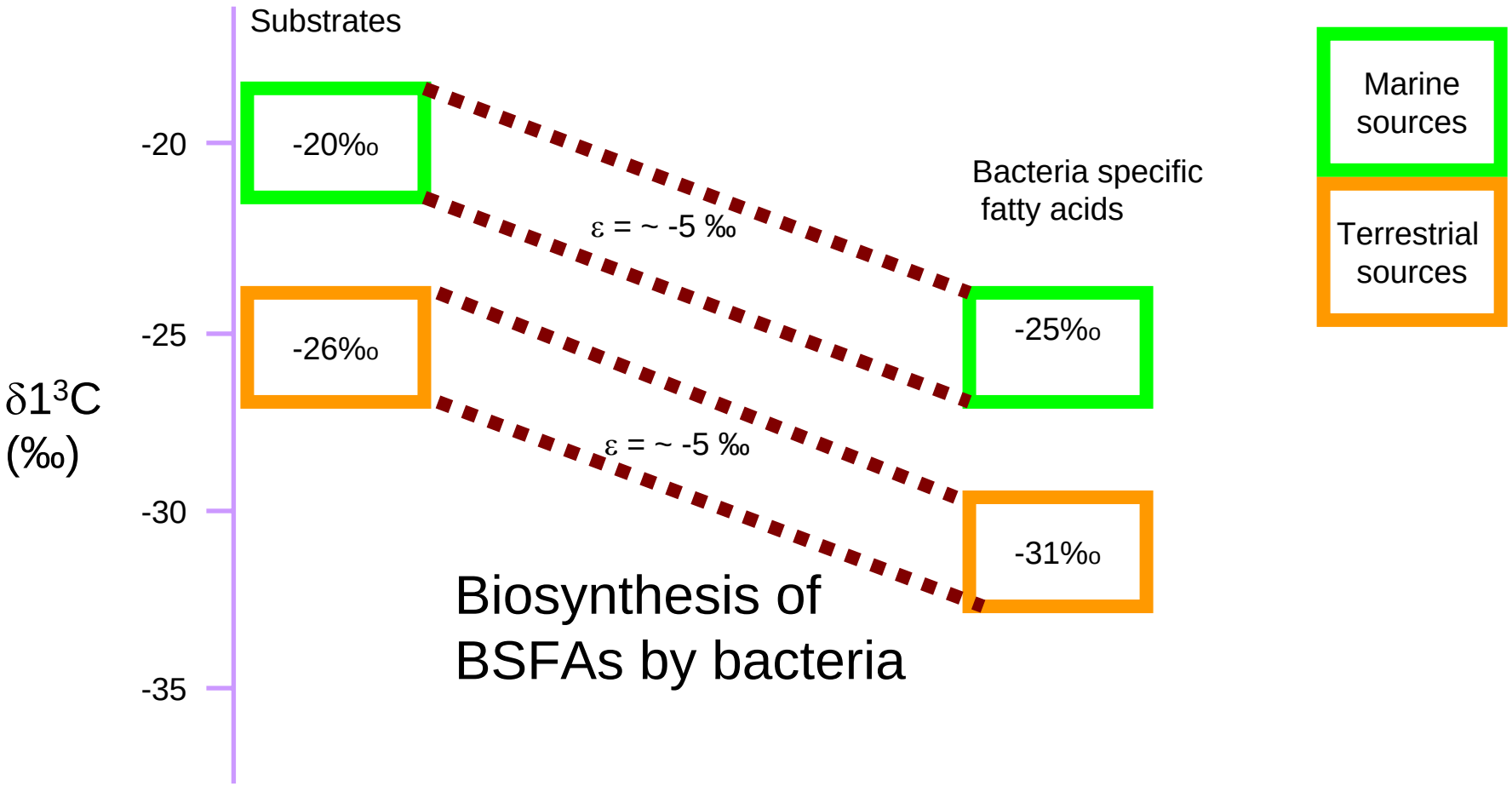


Sta.	Date	Latitude	Longitude	Salinity	C/N	δ^{13}C-TOM	δ^{15}N-TOM	t-fatty acids
		(N)	(W)		(Mole)	(ä)	(ä)	(μg mg^{-1})
Boston Harbor/Massachusetts Bay								
BH2	**Jul 98**	**42?7 .14'**	**71°02.26'**	**25.0**	**13.0**	**-25.7**	**3.27**	**1.27**
BH5	**Jul 98**	**42?0 .38'**	**70°57.35'**	**30.3**	**10.9**	**-24.3**	**2.86**	**3.79**
Delaware/Chesapeake Bay								
DCB1	**Aug 98**	**39°48.21'**	**75°24.53'**	**0.2**	**16.1**	**-24.8**	**4.40**	**1.05**
DCB3	**Aug 98**	**36°59.28'**	**76°19.79'**	**20.0**	**11.7**	**-24.5**	**8.92**	**3.62**
DCB4	**Aug 98**	**39°04'**	**75°16'**	**26.0**	**11.4**	**-23.1**	**5.98**	**2.81**
San Diego Bay								
SDB2	Jan 99	32?0 .81'	117°10.39'	33.9	9.1	-22.2	6.01	1.20
SDB3	**Jan 99**	**32?1 .27'**	**117°07.88'**	**33.9**	**10.9**	**-25.1**	**5.27**	**1.65**
San Francisco Bay								
SFB1	**Jun 99**	**38?6 '**	**122°30'**	**17.1**	**15.5**	**-26.1**	**5.10**	**4.82**
SFB2	**Jun 99**	**37?3 ?**	**122°35**	**28.5**	**12.9**	**-23.1**	**6.35**	**3.68**
SFB3	**Jun 99**	**37?1 '**	**122°51'**	**32.3**	**7.9**	**-27.8**	**4.00**	**0.94**

Spatial variations of HMW-DOM lipids?


100
75
50
25
0
Fatty acids (%)
a
b
c
d
BH2
BH5
DCB1
DCB3
DCB4
SDB2
SDB3
SFB1
SFB2
SFB3
branched+18:1(7)
15-17:0
14-16-18:0
16:1+18:1(9)

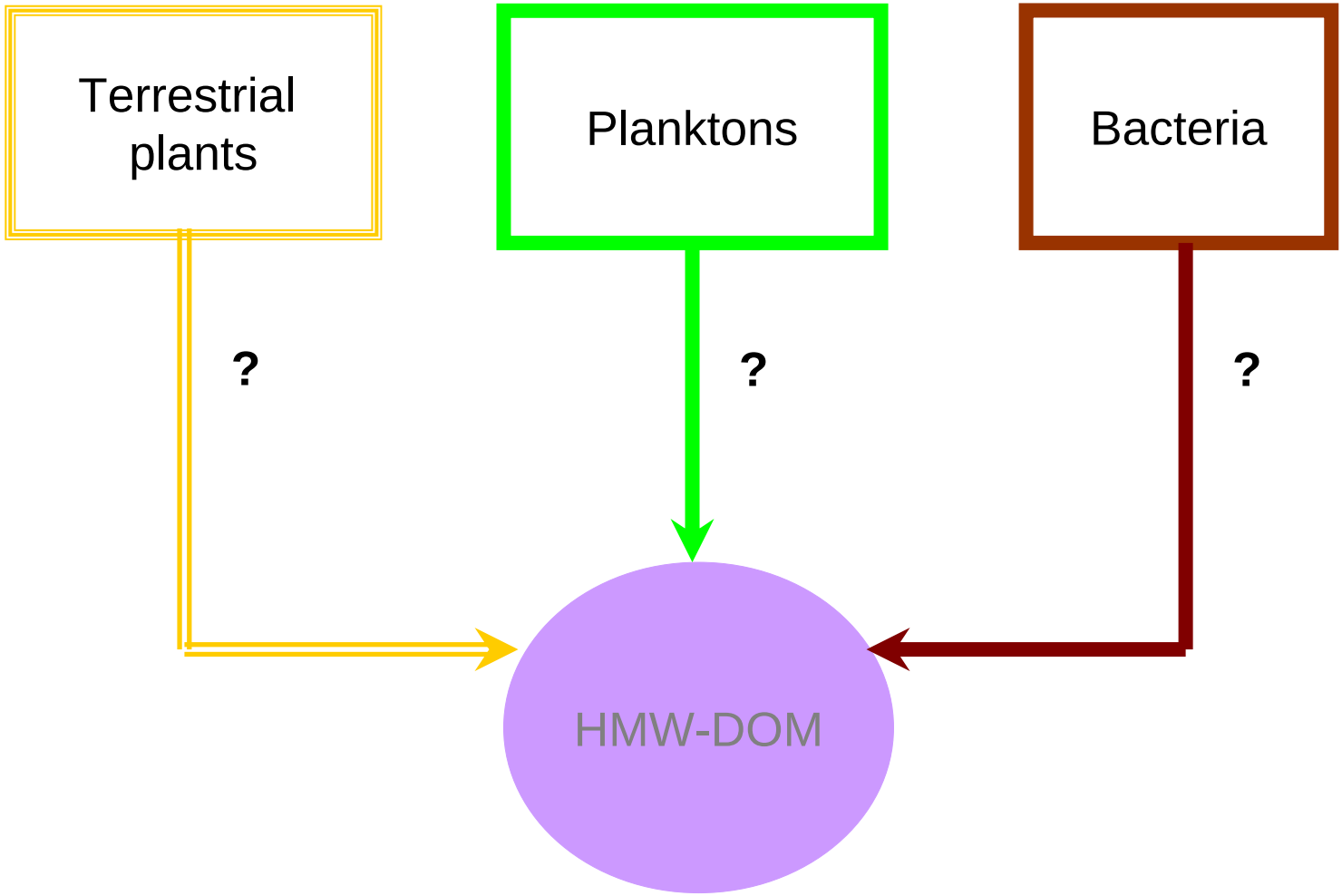

a
branched FA
i-15:0
a-15:0
a-17:0
b
odd number saturated and 18:1(7) FA
15:0
17:0
18:1(7)
c
even number saturated FA
14:0
16:0
18:0
d
monounsaturated FA
16:1
18:1(9)
Utilizing marine OC
Utilizing terrestrial OC
δ13C (0/00)
-15
-20
-25
-30
-35
BH2
BH5
DCB1
DCB3
DCB4
SDB2
SDB3
SFB1
SFB2
SFB3
Stations



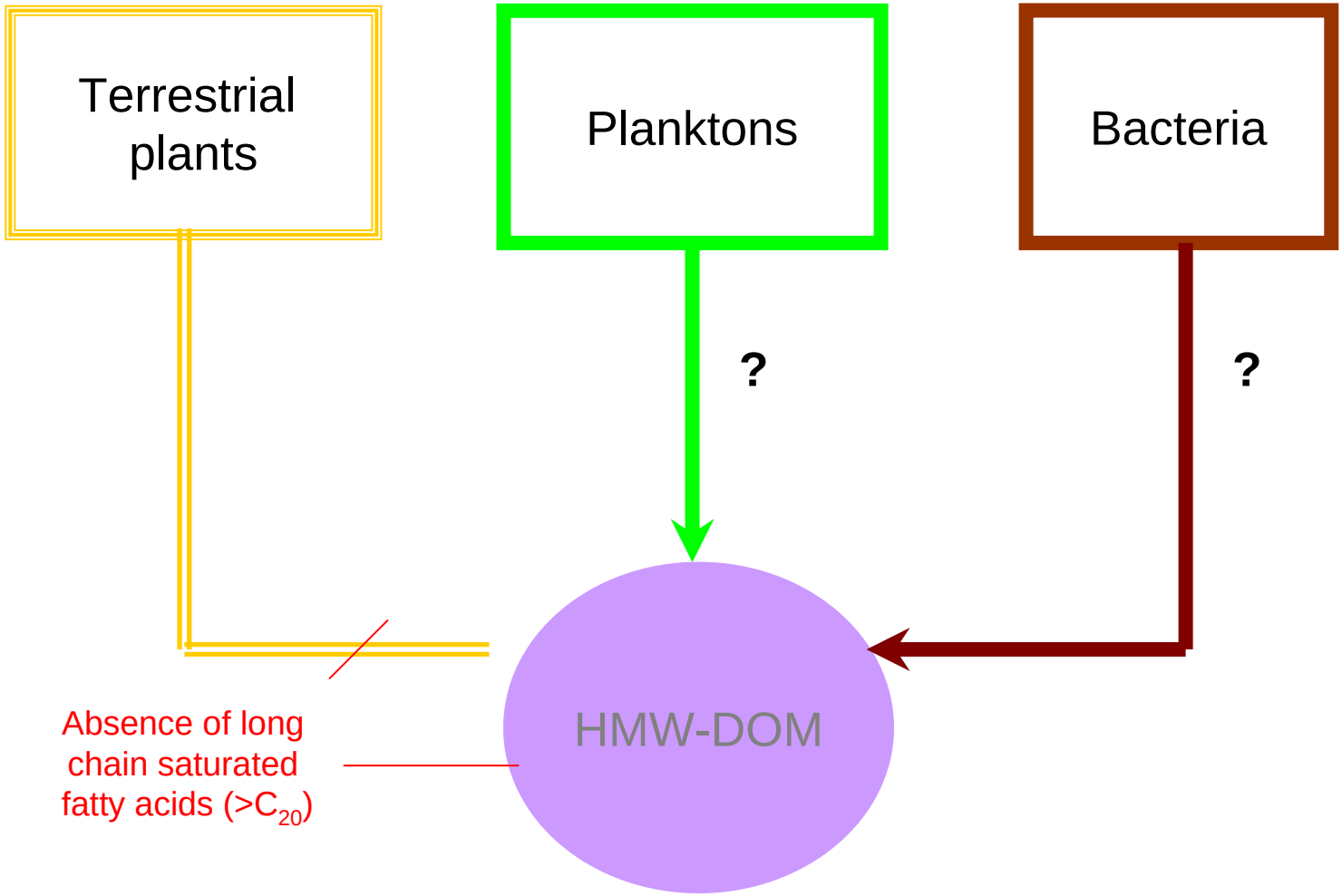
References:

Canuel et al., 1997; Boschker et al., 1999; Teece et al., 1999

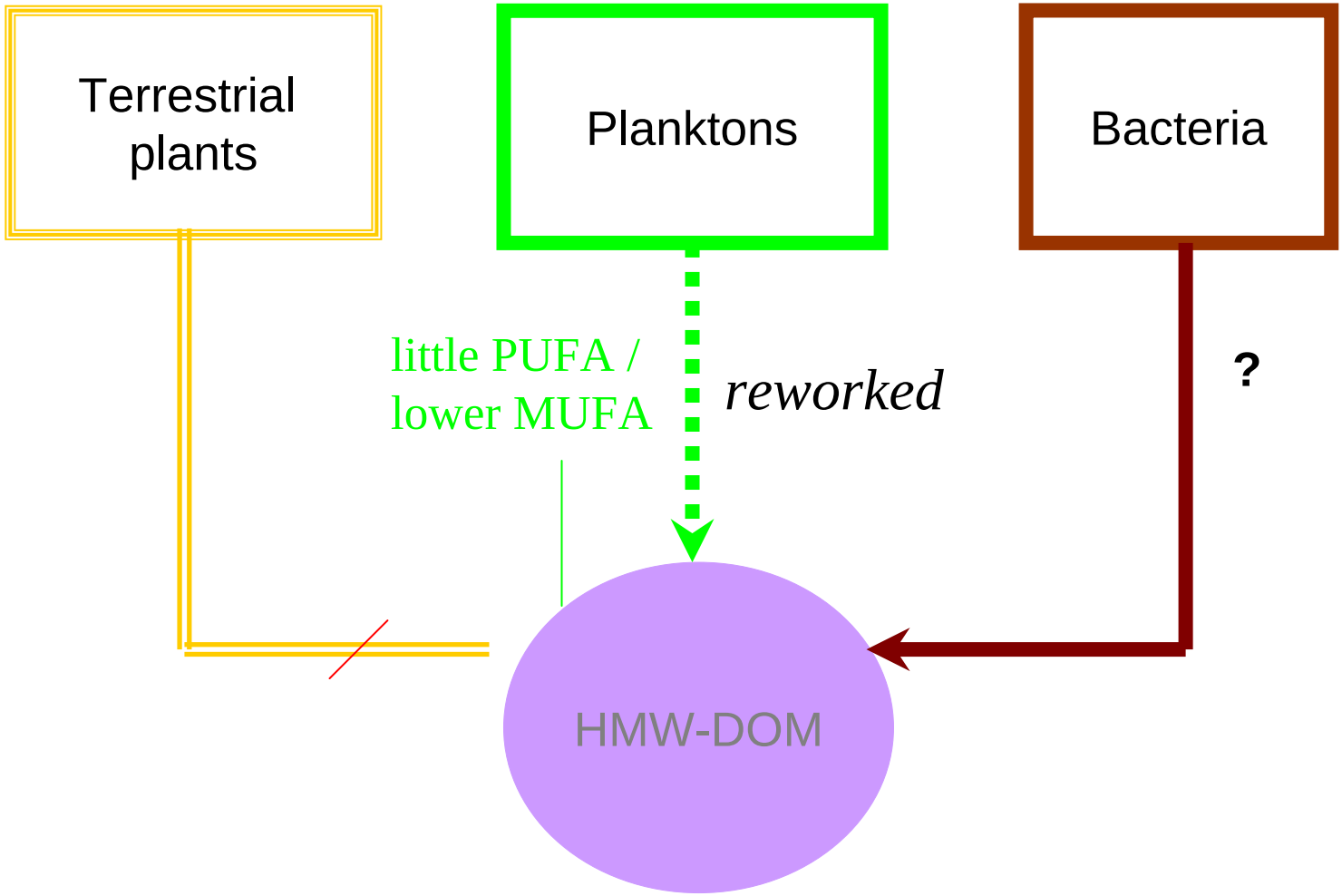
Potential sources of HMW-DOM (lipid fraction):



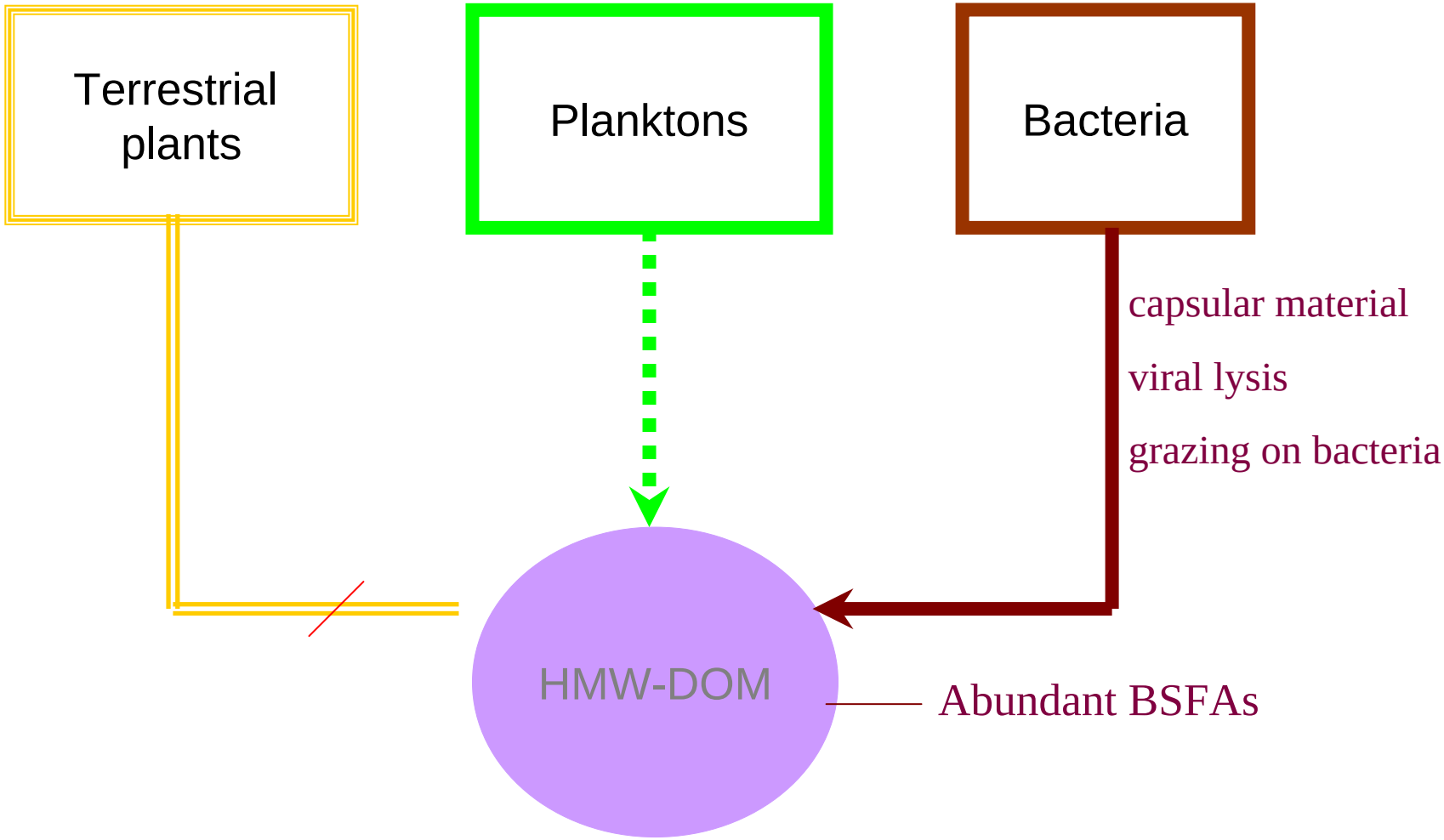
Potential sources of HMW-DOM (lipid fraction):



Potential sources of HMW-DOM (lipid fraction):



Potential sources of HMW-DOM (lipid fraction):

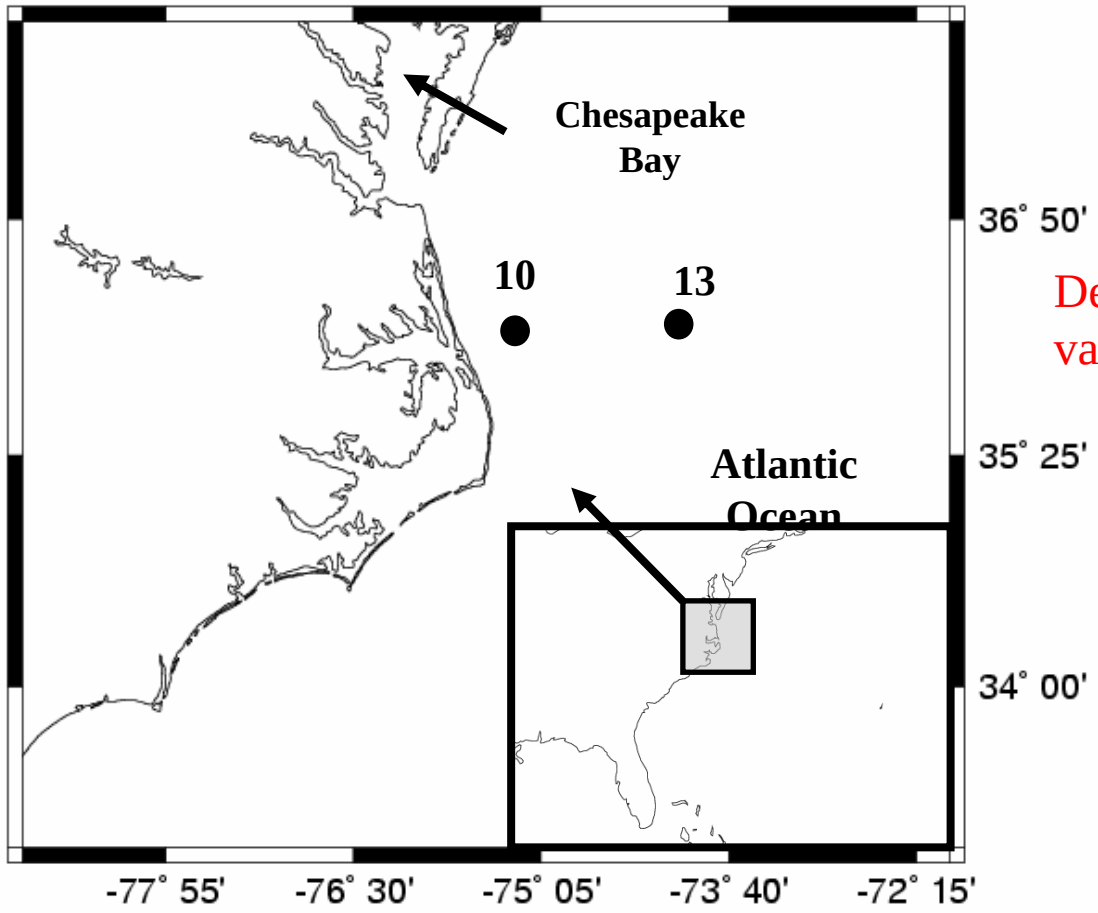


Summary

- Bacteria and phytoplankton are major contributors of HMW-DOM lipids in coastal surface waters

- This fraction of HMW-DOM is formed by direct release of bacterial membrane components and bacterial reworking of phytoplankton-derived OM

- Despite the diversity of coastal regions, the fatty acid compositions and their $\delta^{13}C$ ratios in HMW-DOM samples are remarkably consistent, suggesting a universal formation pathway

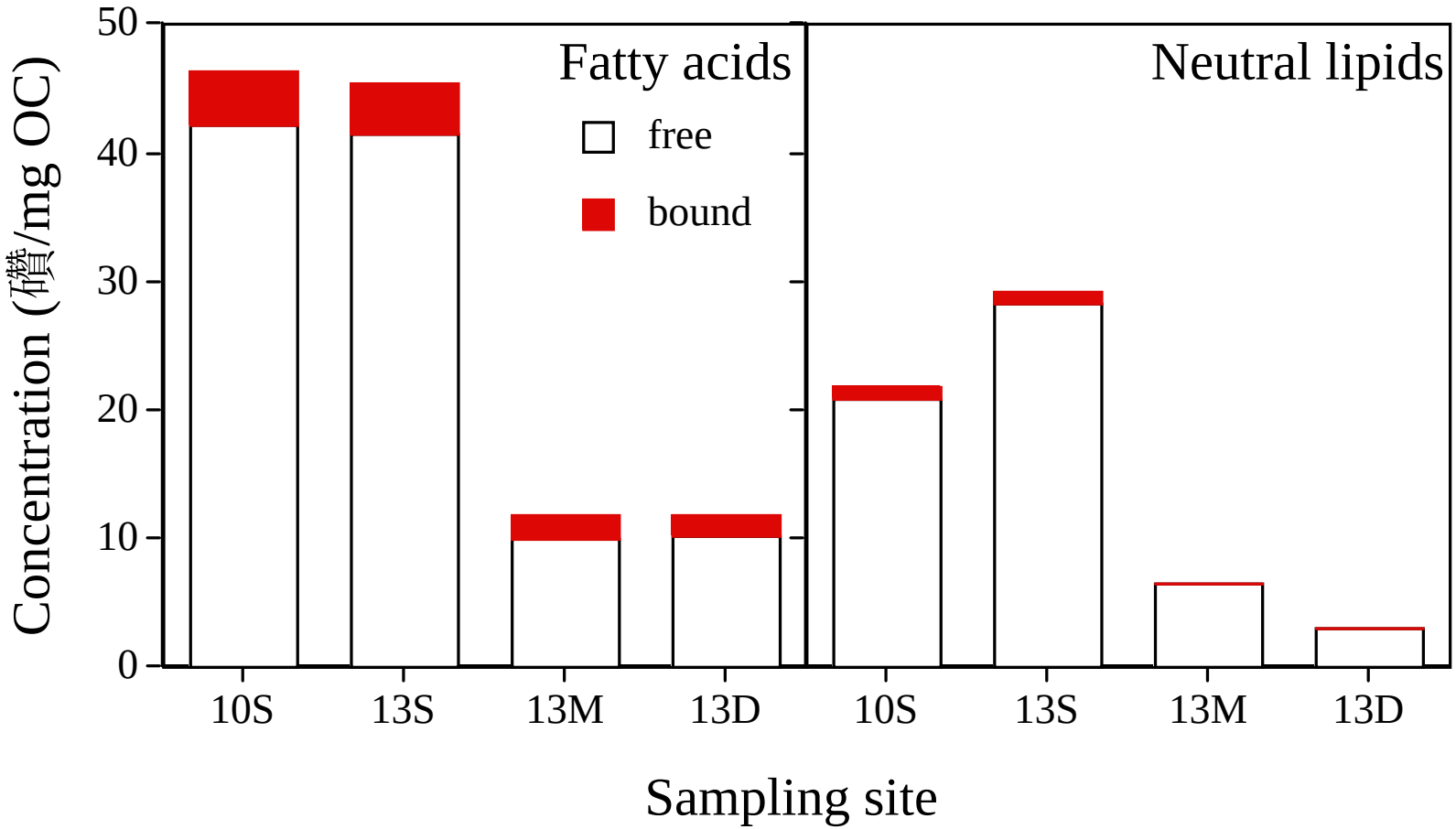


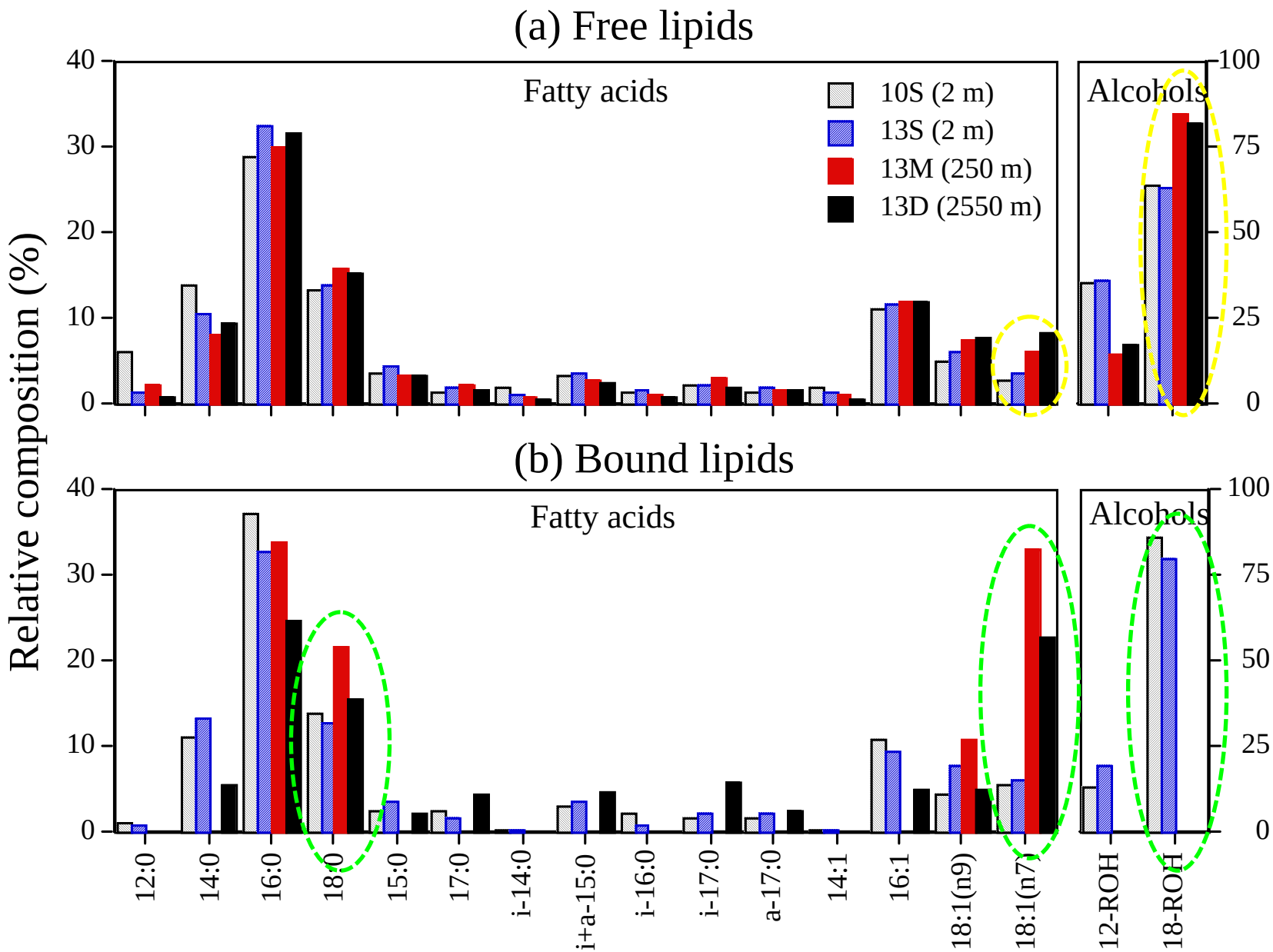
Depth-dependent variations?

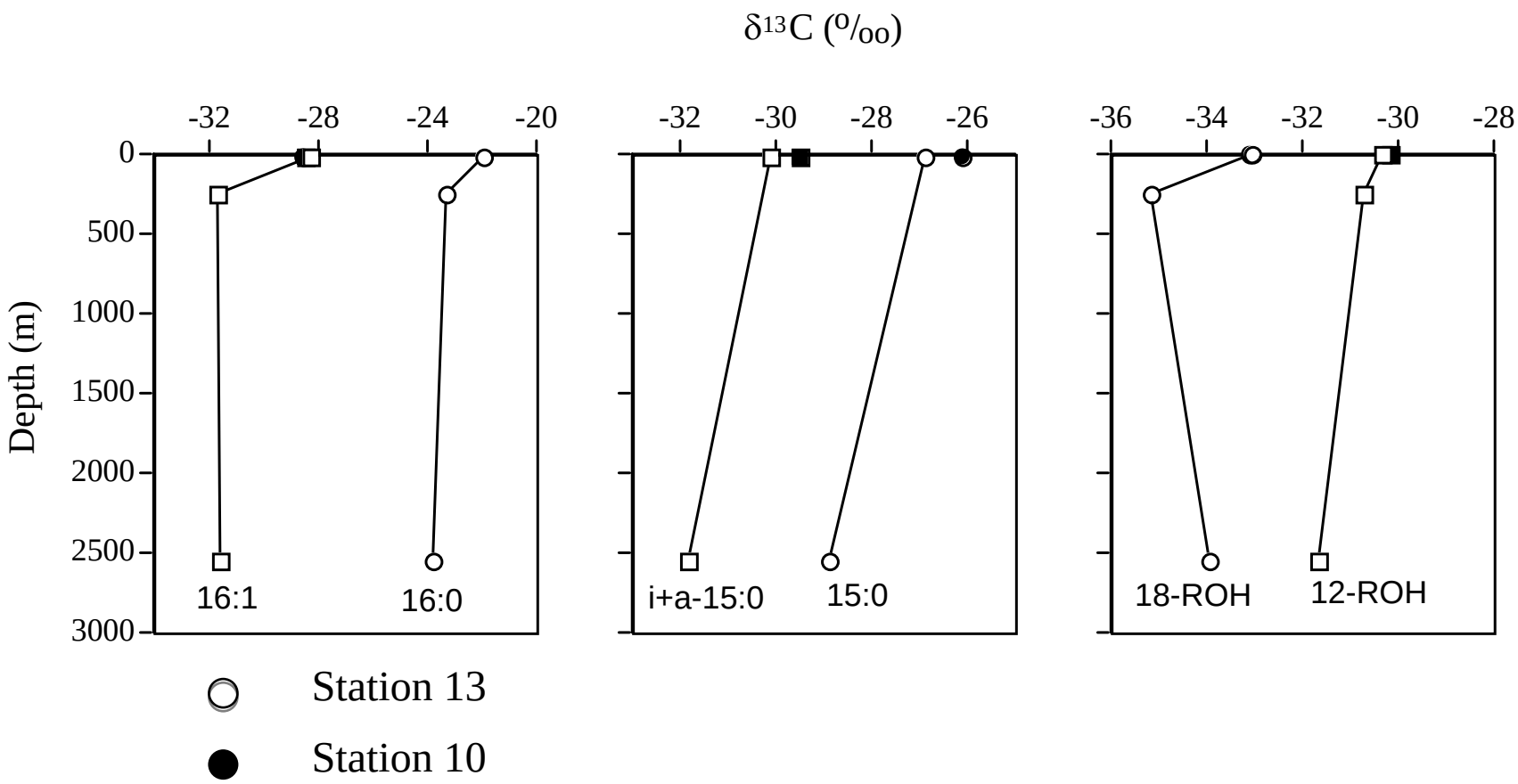
Sample ID	Sampling Depth (Water depth)	DOC (μM)	HMW-DOC (μM)	C/N	$\delta^{13}C$ (?	$\delta^{15}N$ (?	^{2} ^{14}C (?	^{14}C age (yr BP)
10-S	2 m (30 m)	98	33	13	-22.1	6.61	-89?	751?7
13-S	2 m (2600 m)	82	28	11	-21.2	5.06	-110?	935?1
13-M	250 m (2600 m)	54	16	-	-22.5	5.27	-399?	4091?6
13-D	2550 m (2600 m)	48	12	21	-21.5	5.53	-376?	3796?5

Free lipids - solvent extractable

Bound lipids - saponification-released




(a) Free lipids
(b) Bound lipids
Fatty acids
Alcohols
10S (2 m)
13S (2 m)
13M (250 m)
13D (2550 m)
Relative composition (%)
0
10
20
30
40
0
25
50
75
100
12:0
14:0
16:0
18:0
15:0
17:0
i-14:0
i+a-15:0
i-16:0
i-17:0
a-17:0
14:1
16:1
18:1(n9)
18:1(n7)
12-ROH
18-ROH


δ13C (o/oo)
-32
-28
-24
-20
-32
-30
-28
-26
-36
-34
-32
-30
-28
0
500
1000
1500
2000
2500
3000
Depth (m)
16:1
16:0
i+a-15:0
15:0
18-ROH
12-ROH
Station 13
Station 10

Summary

- Lipid compositions and compound-specific $\delta^{13}C$ ratios of HMW-DOM in the Middle-Atlantic-Bight varied with water depth, implying that the origins at different layers of the ocean may differ