Impact of iron on DMS cycling in the Subarctic Pacific: a synthesis of SERIES and SEEDS-II

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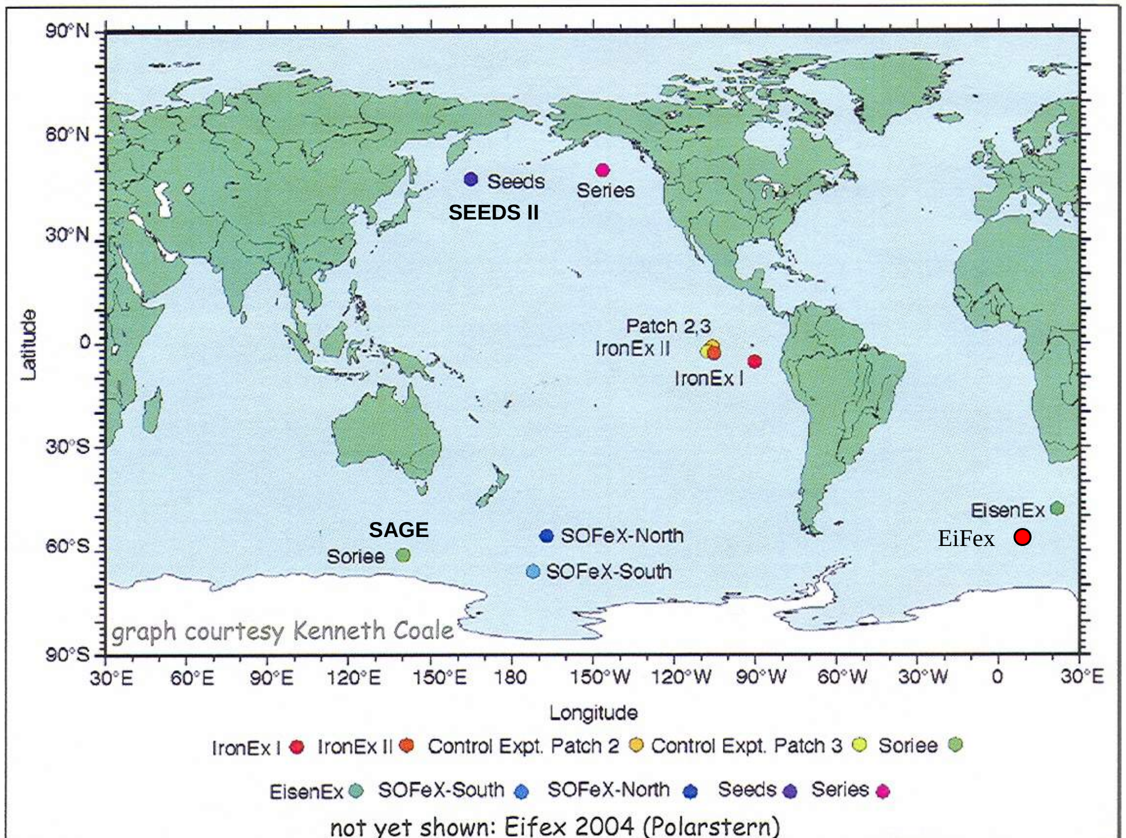
FeAX's



(adapted from de Baar et al. 2005)

Impact of Fe on DMS during FeAX's
(the pre-SEEDS/SERIES era)

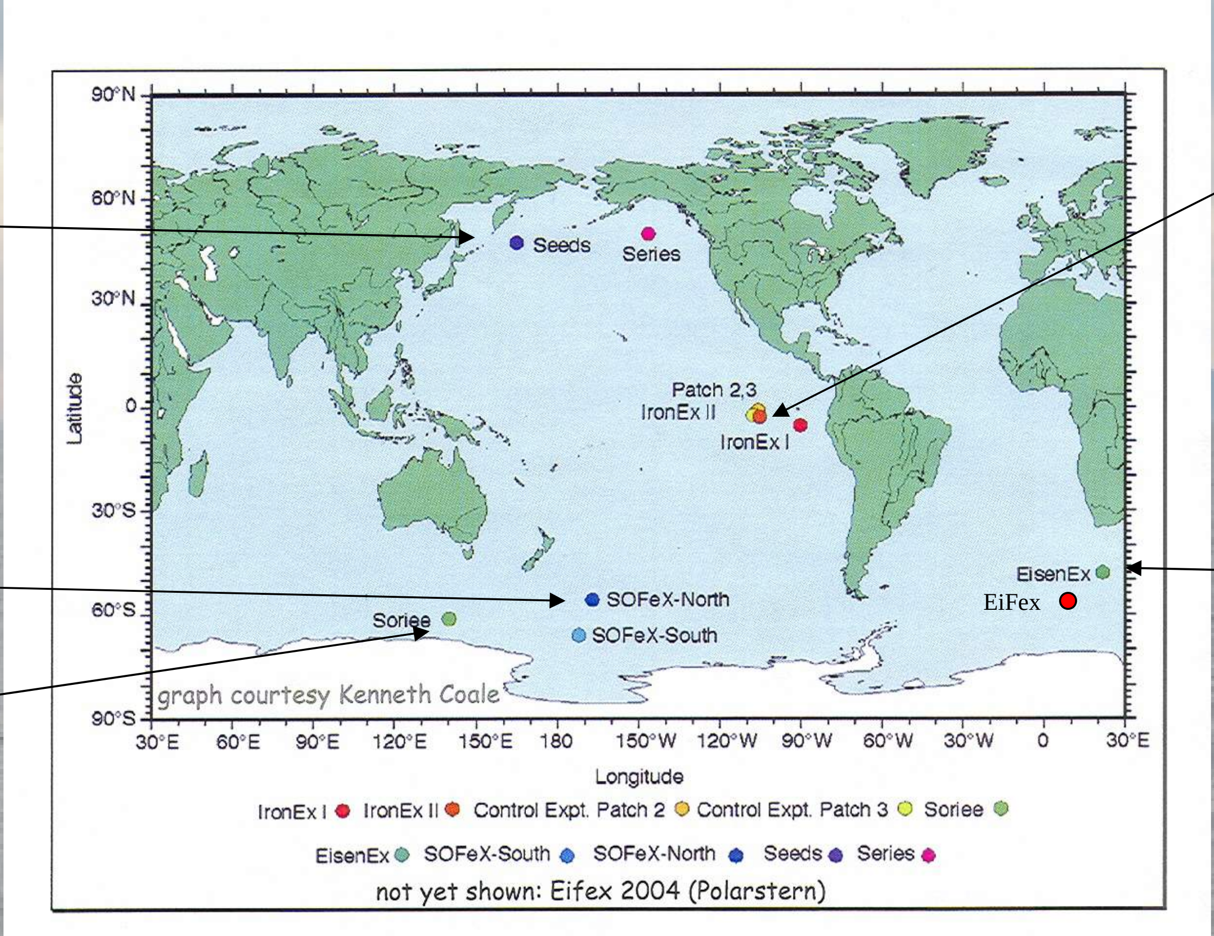
X 1

X 2

X 5

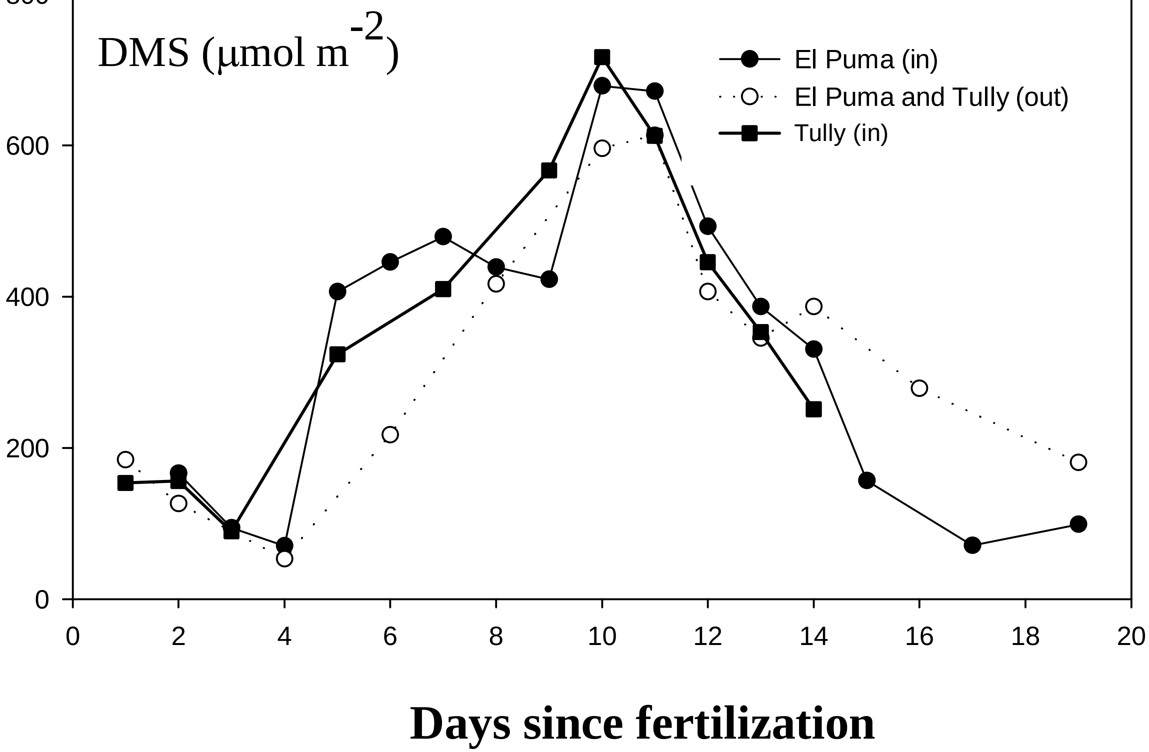
X 7

X 2



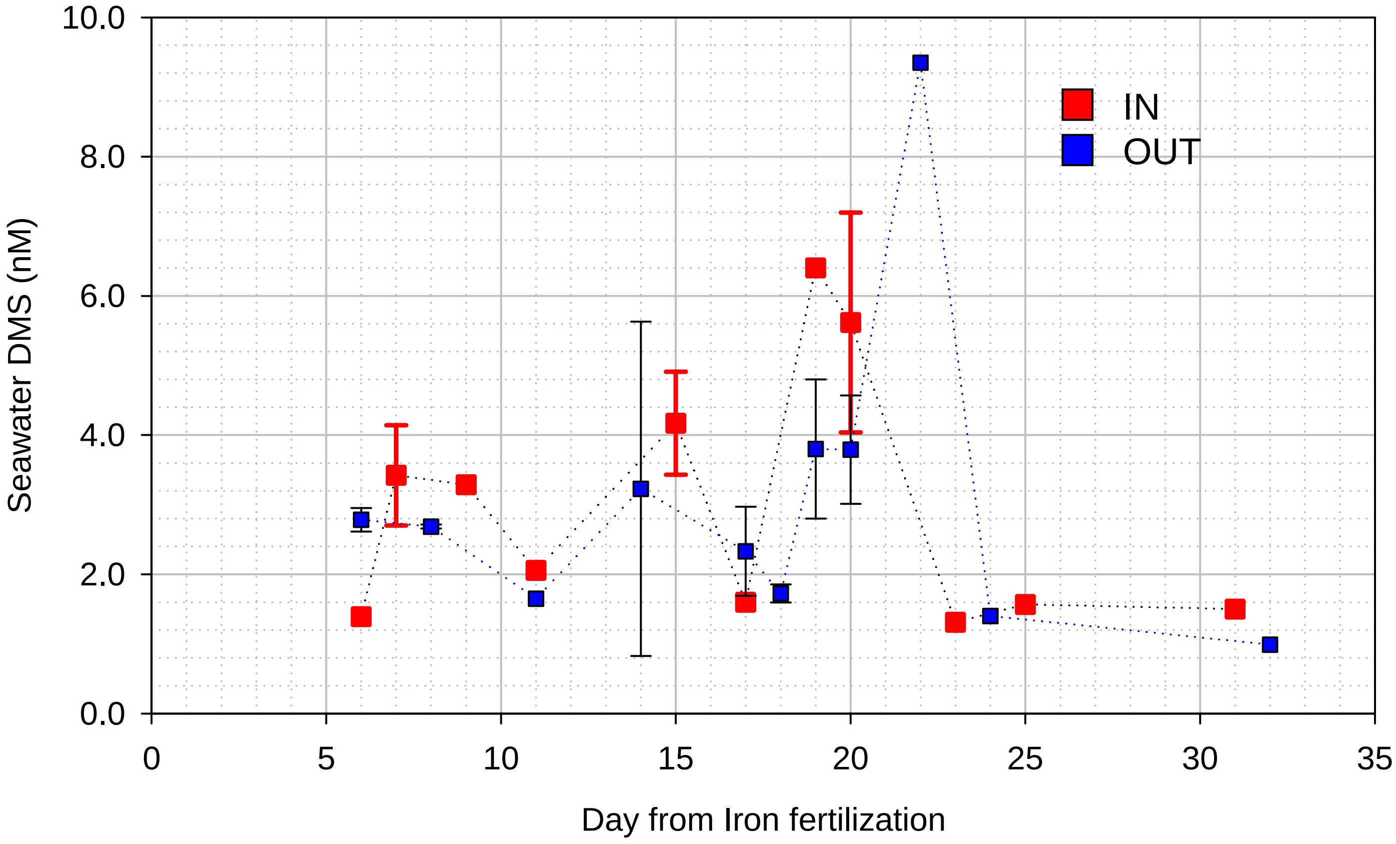
(de Baar et al. 2005)

Impact of FE on DMS SERIES

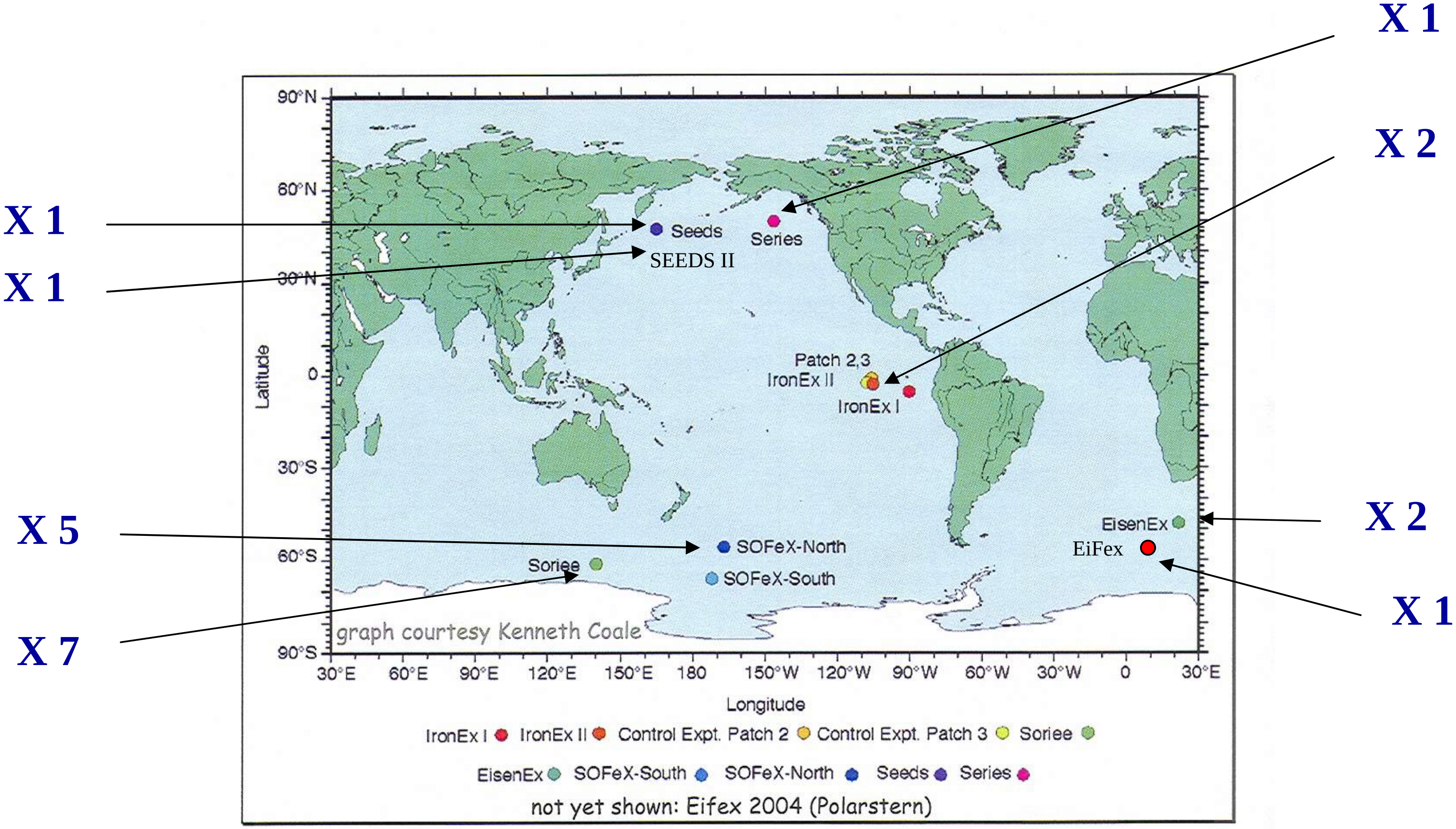


Levasseur et al. in press

Impact of Fe on DMS
SEEDS II

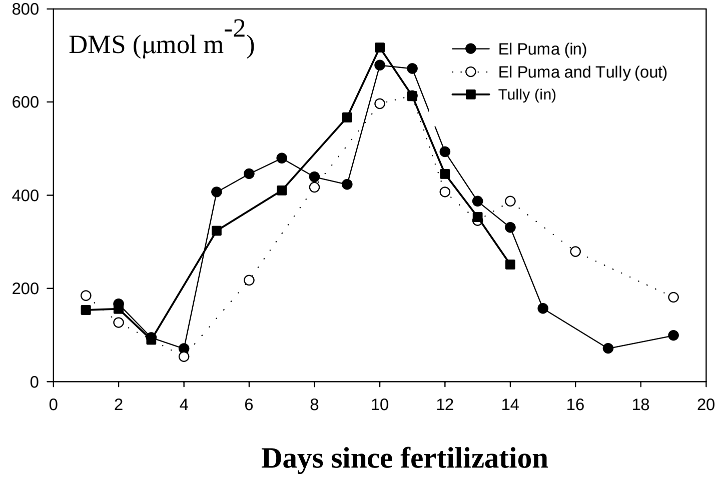


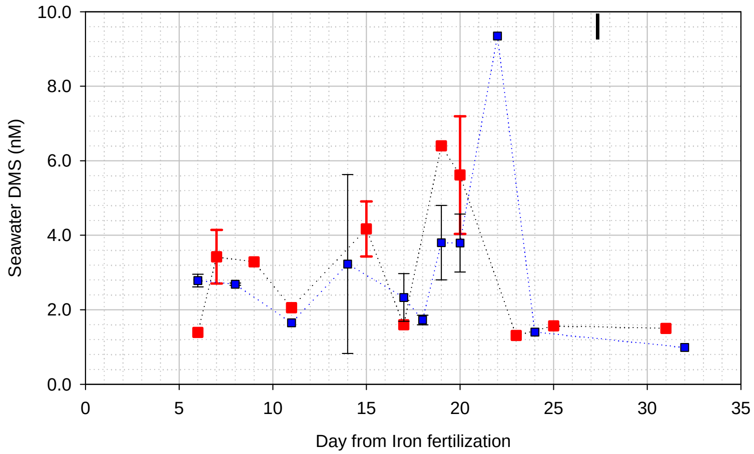
Courtesy of I. Nagao et al.


X 1
X 2
X 1
X 1
Seeds
Series
SEEDS II
90°N
60°N
30°N
0
30°S
60°S
90°S
Latitude
Patch 2,3
IronEx II
IronEx I
EisenEx
EiFex
X 2
X 5
SOFeX-North
Soriee
SOFeX-South
X 1
X 7
graph courtesy Kenneth Coale
30°E
60°E
90°E
120°E
150°E
180
150°W
120°W
90°W
60°W
30°W
0
30°E
Longitude
IronEx I
IronEx II
Control Expt. Patch 2
Control Expt. Patch 3
Soriee
EisenEx
SOFeX-South
SOFeX-North
Seeds
Series
not yet shown: Eifex 2004 (Polarstern)

What we learned from SEEDS and SERIES?

The impact of iron on DMS production is more variable than suggested by the results from first FeAX's



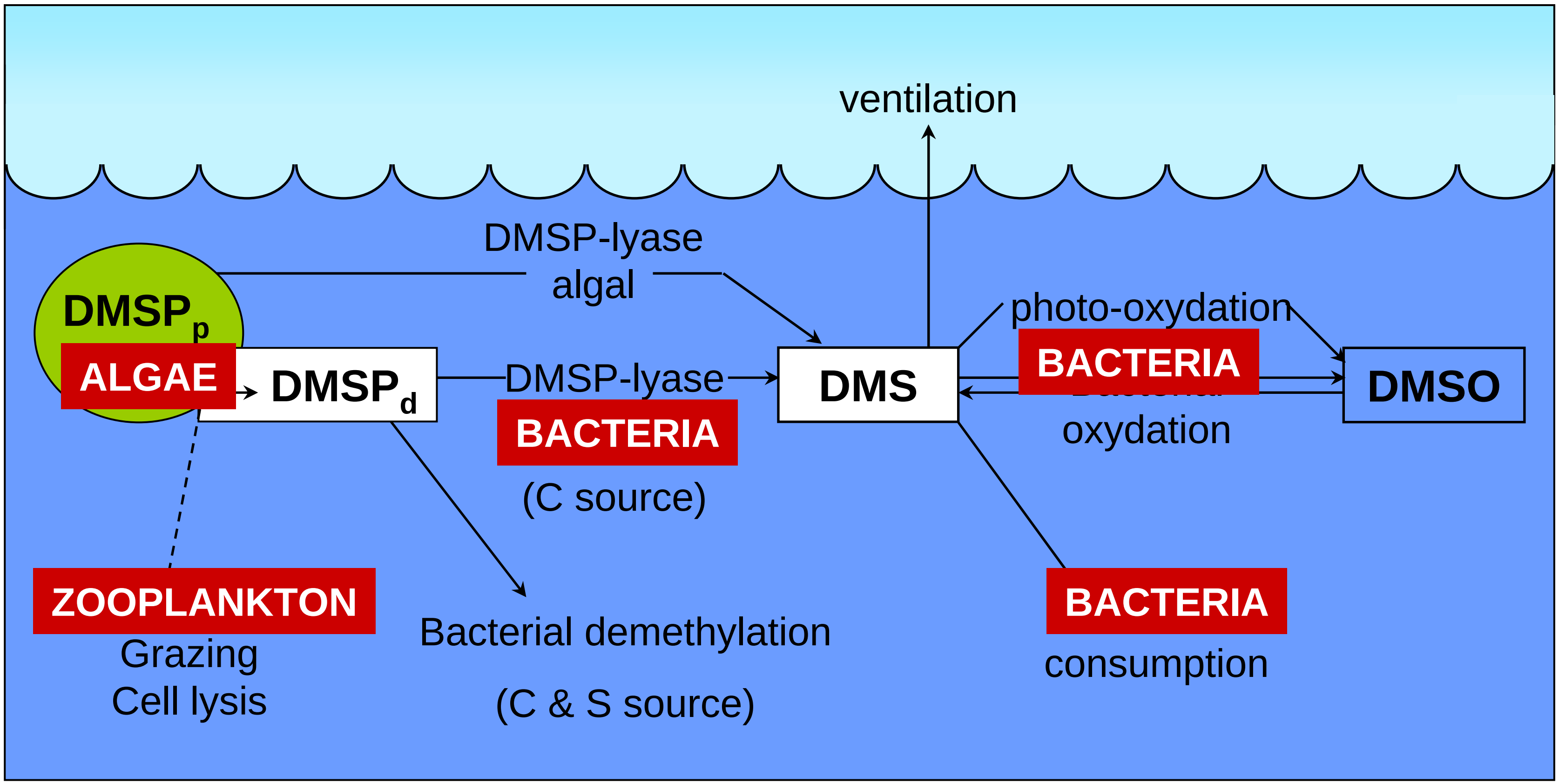


Large temporal variations in DMS outside the patch

Large day-to-day variations

Importance of the 'control' station

Marine DMS production

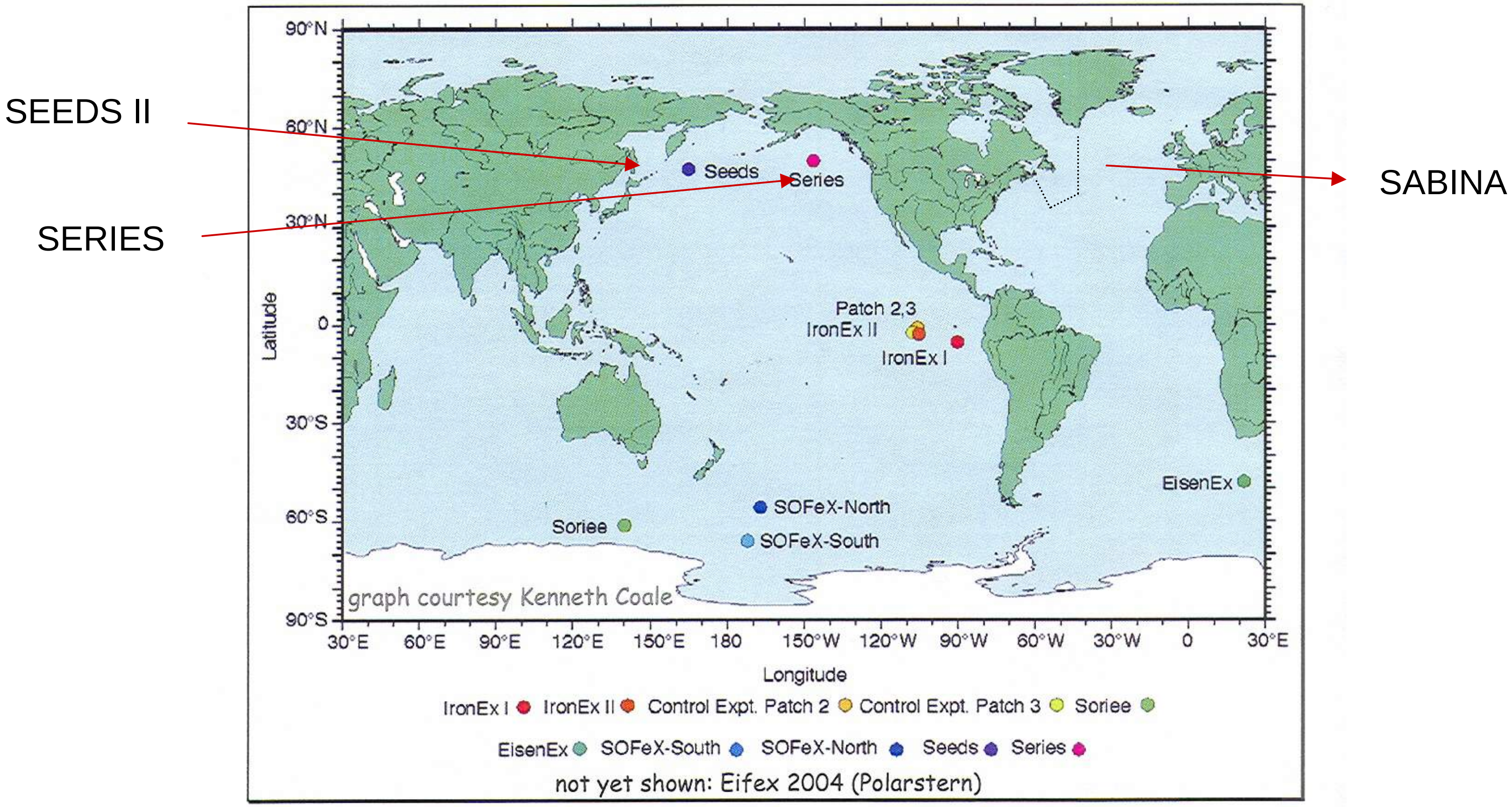


QUESTIONS

1. What makes a HNLC region DMS-rich?

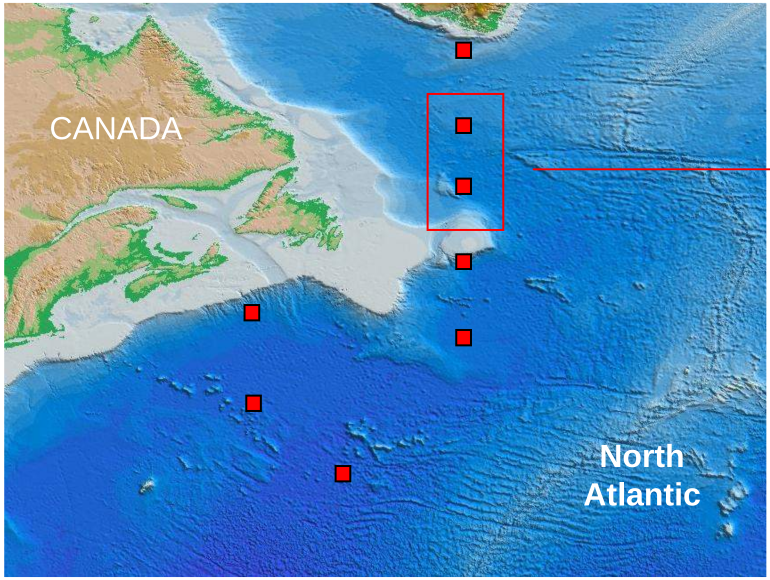
More algal DMSP?
More dissolved DMSP?
More grazing?
More bacteria?
More efficient conversion of DMSP into DMS?

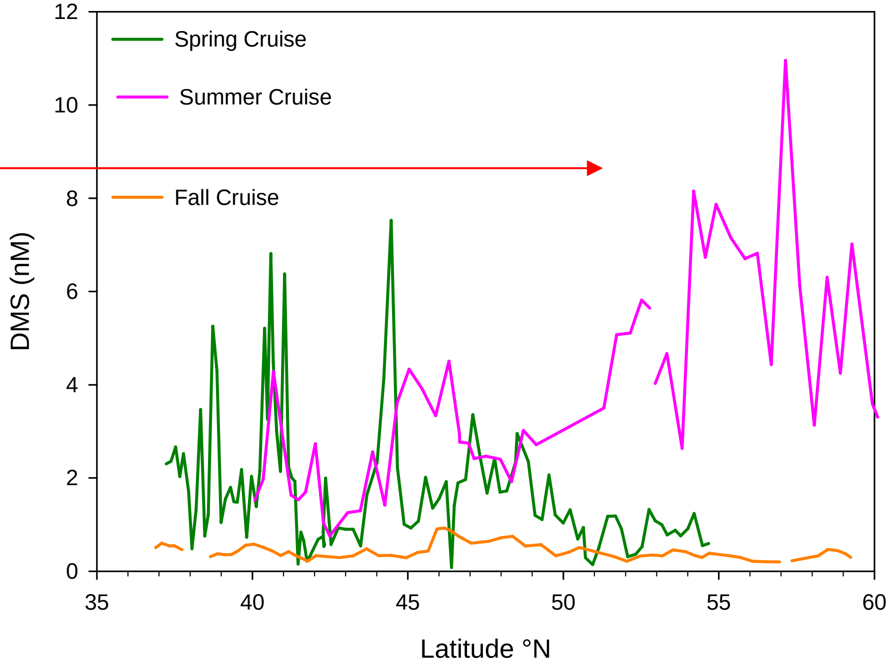
THREE SYSTEMS WILL BE COMPARED



SABINA

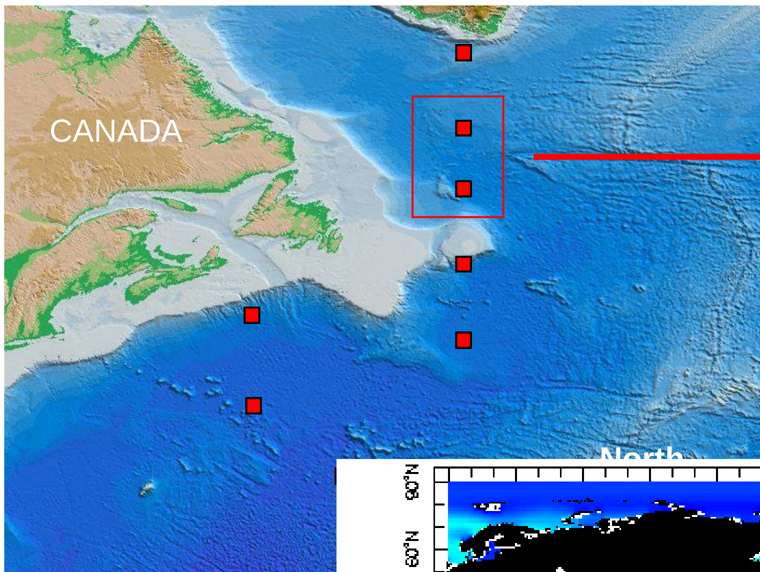
Study of Air-sea Biogeochemical Interactions in the North Atlantic

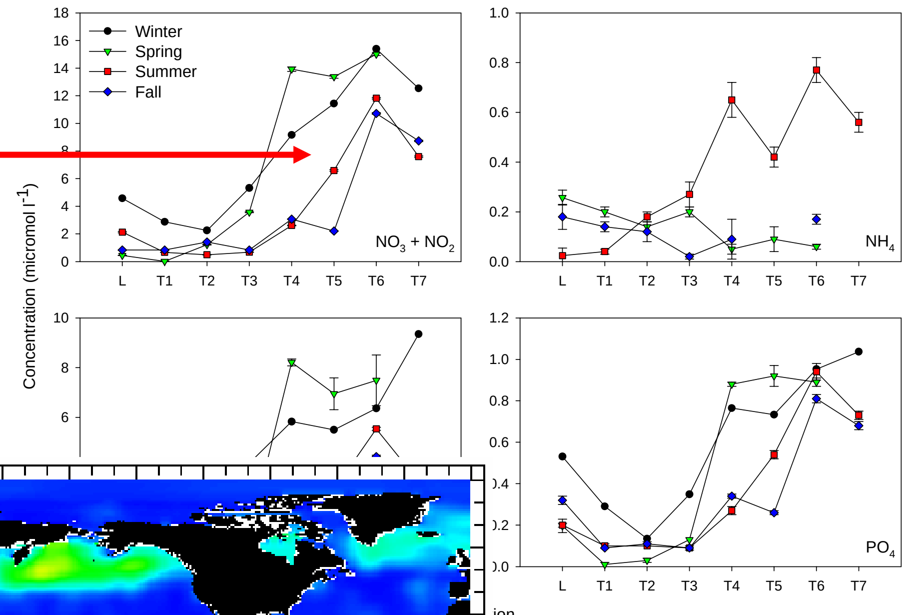


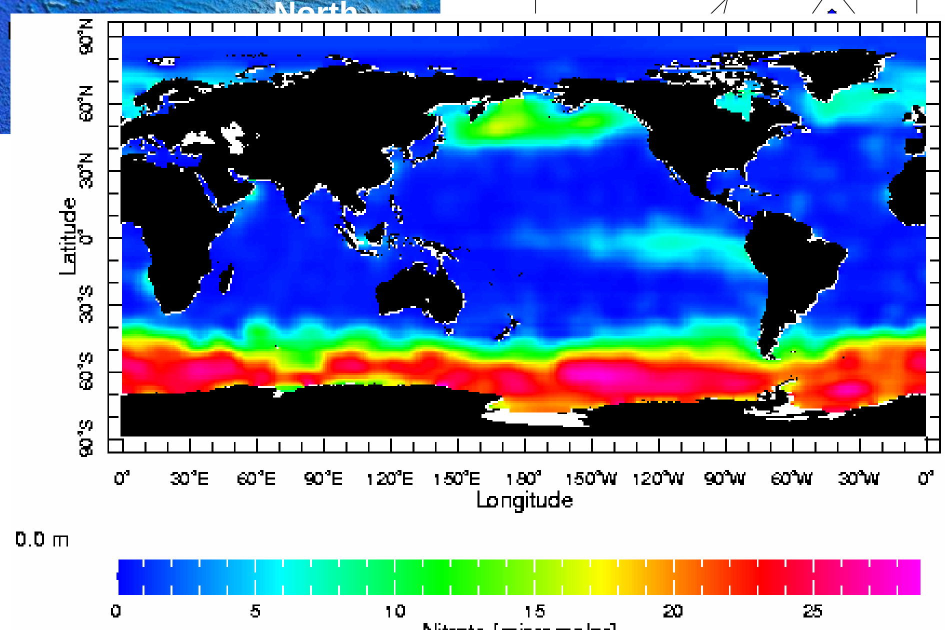


SABINA

Study of Air-sea Biogeochemical Interactions in the North Atlantic





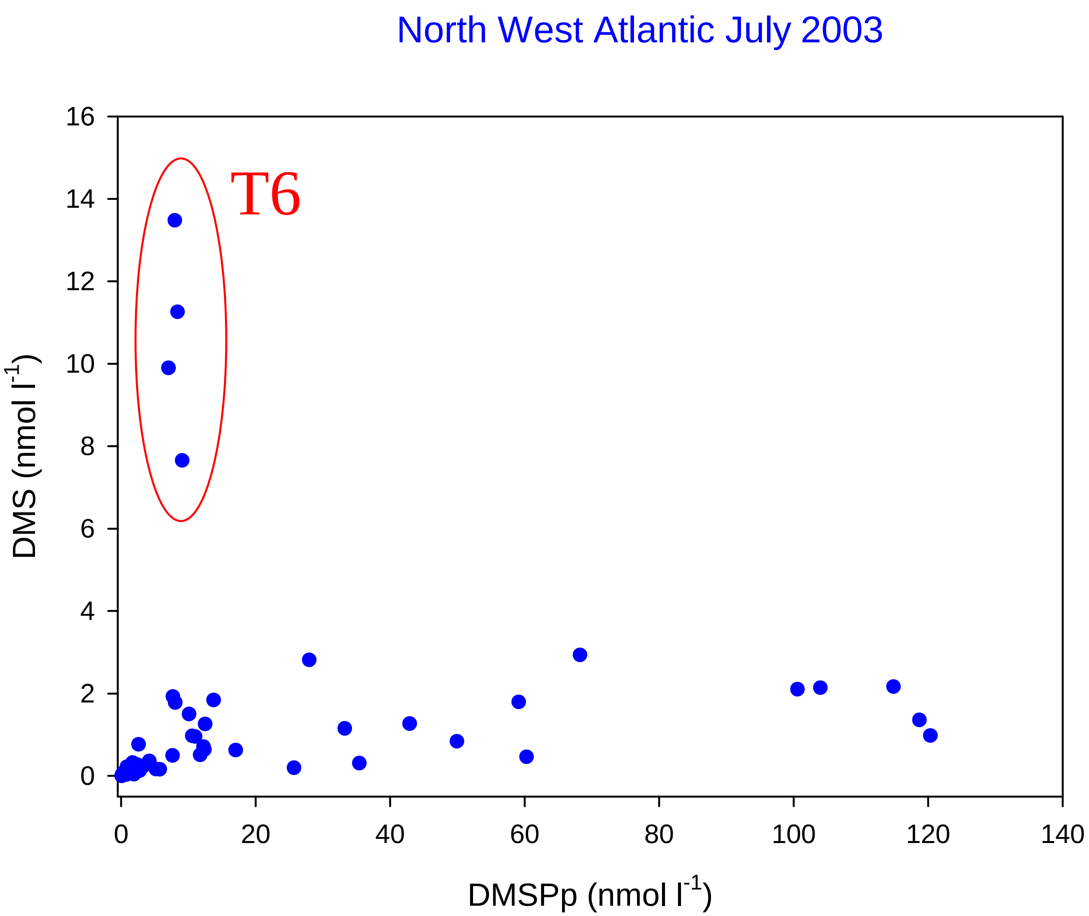


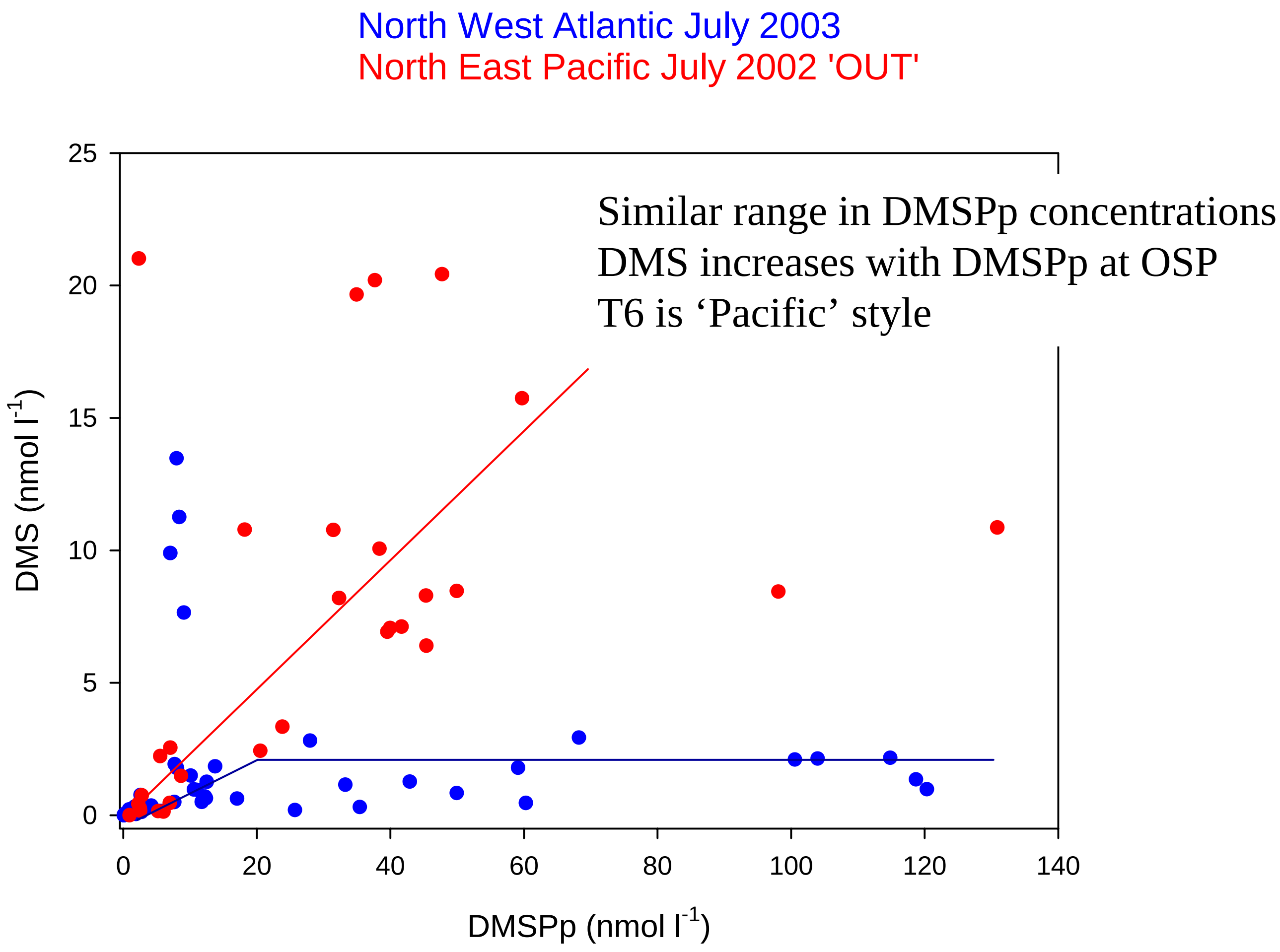
Forgotten HNLC REGION

Relationships between three S pools

DMSP particulate
DMSP dissolved
DMS

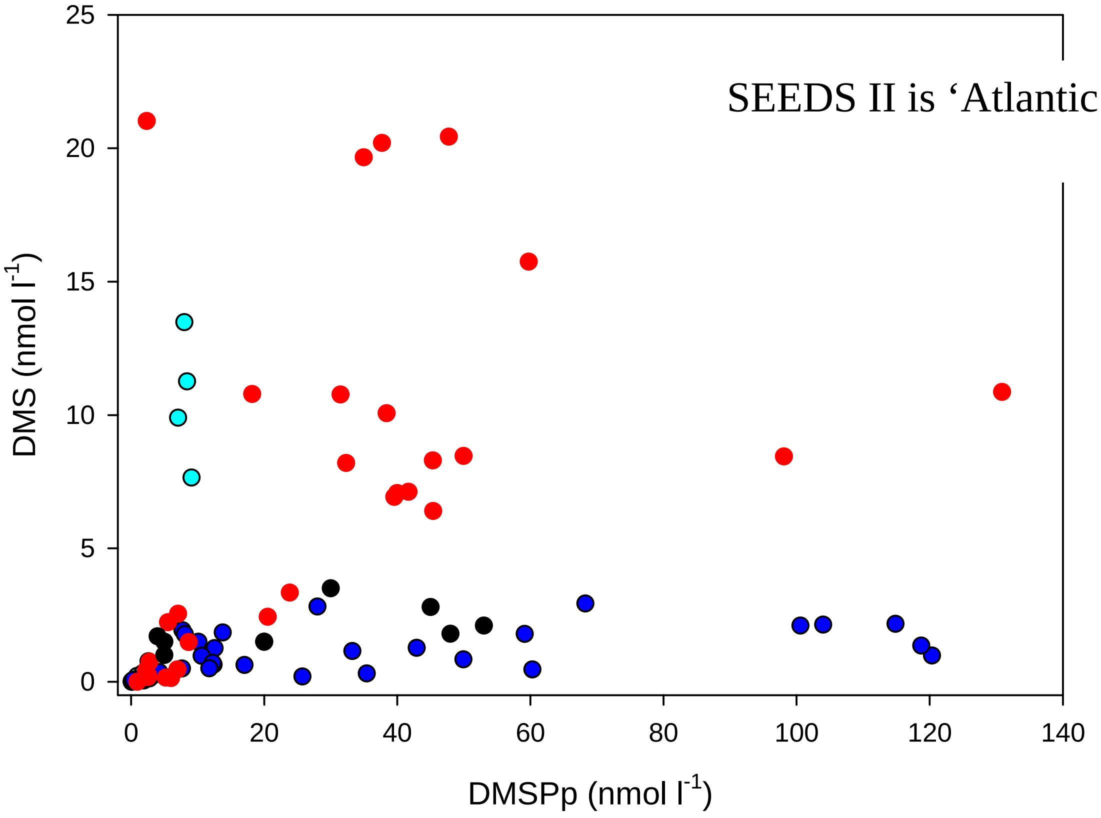
DMS *versus* DMSPp




North West Atlantic July 2003
North East Pacific July 2002 'OUT'
Similar range in DMSPp concentrations
DMS increases with DMSPp at OSP
T6 is 'Pacific' style
DMS (nmol l-1)
DMSPp (nmol l-1)
0
5
10
15
20
25
0
20
40
60
80
100
120
140

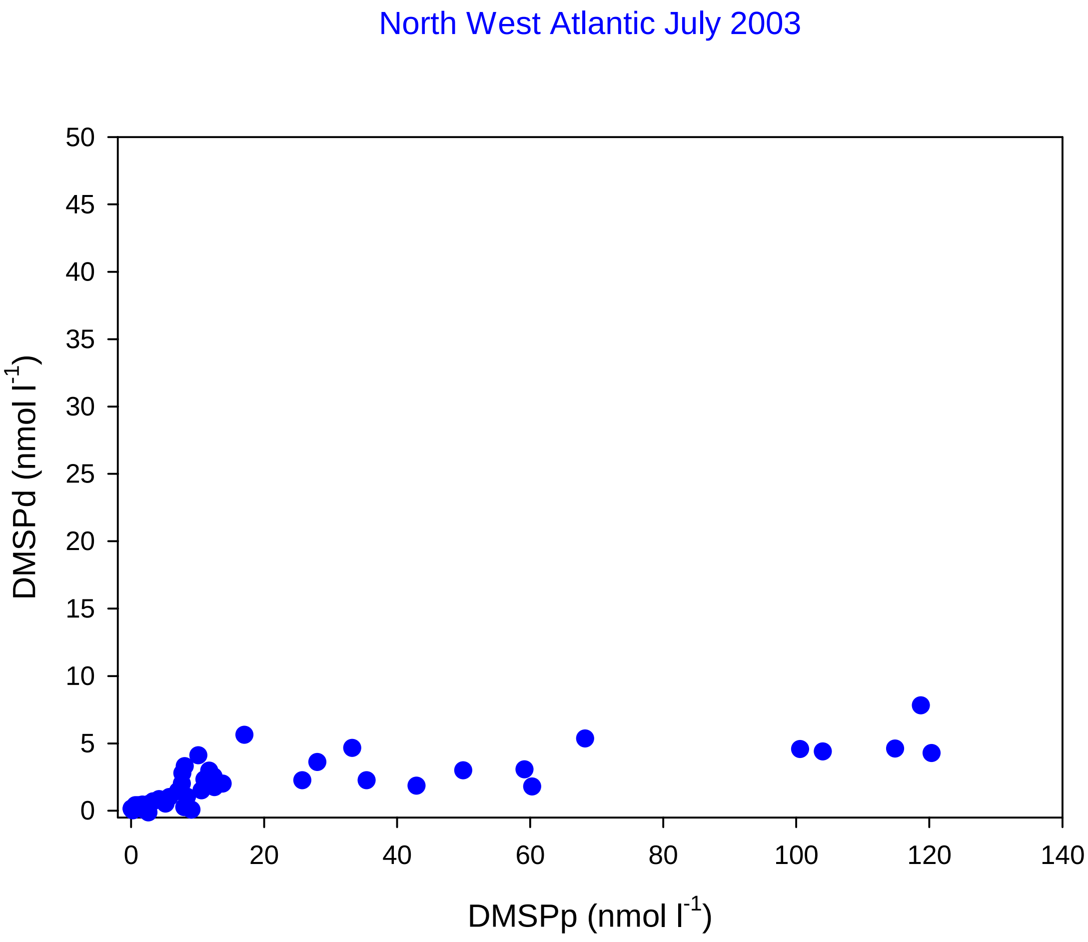
SEEDS II

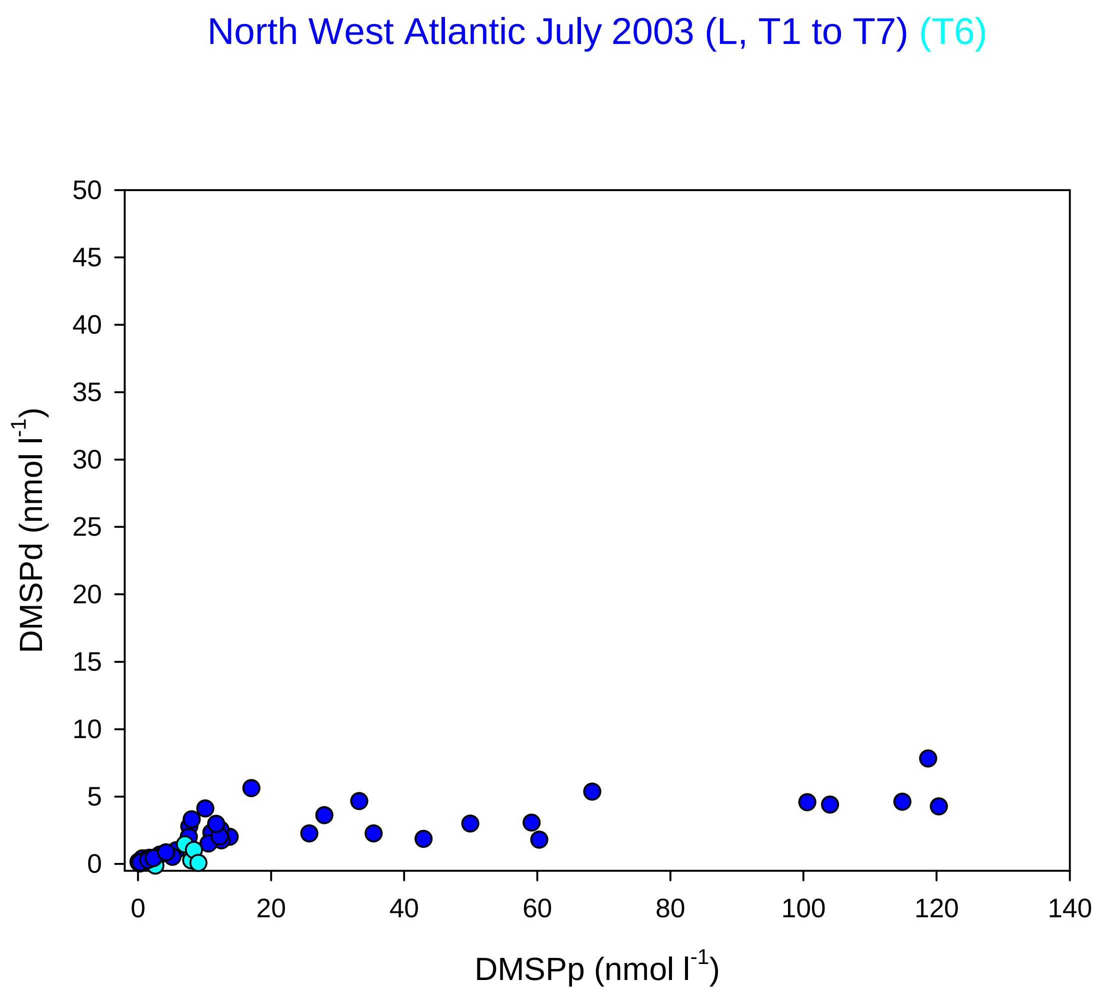
North West Atlantic July 2003 (L, T1 to T7) (T6)
North East Pacific July 2002 'OUT'



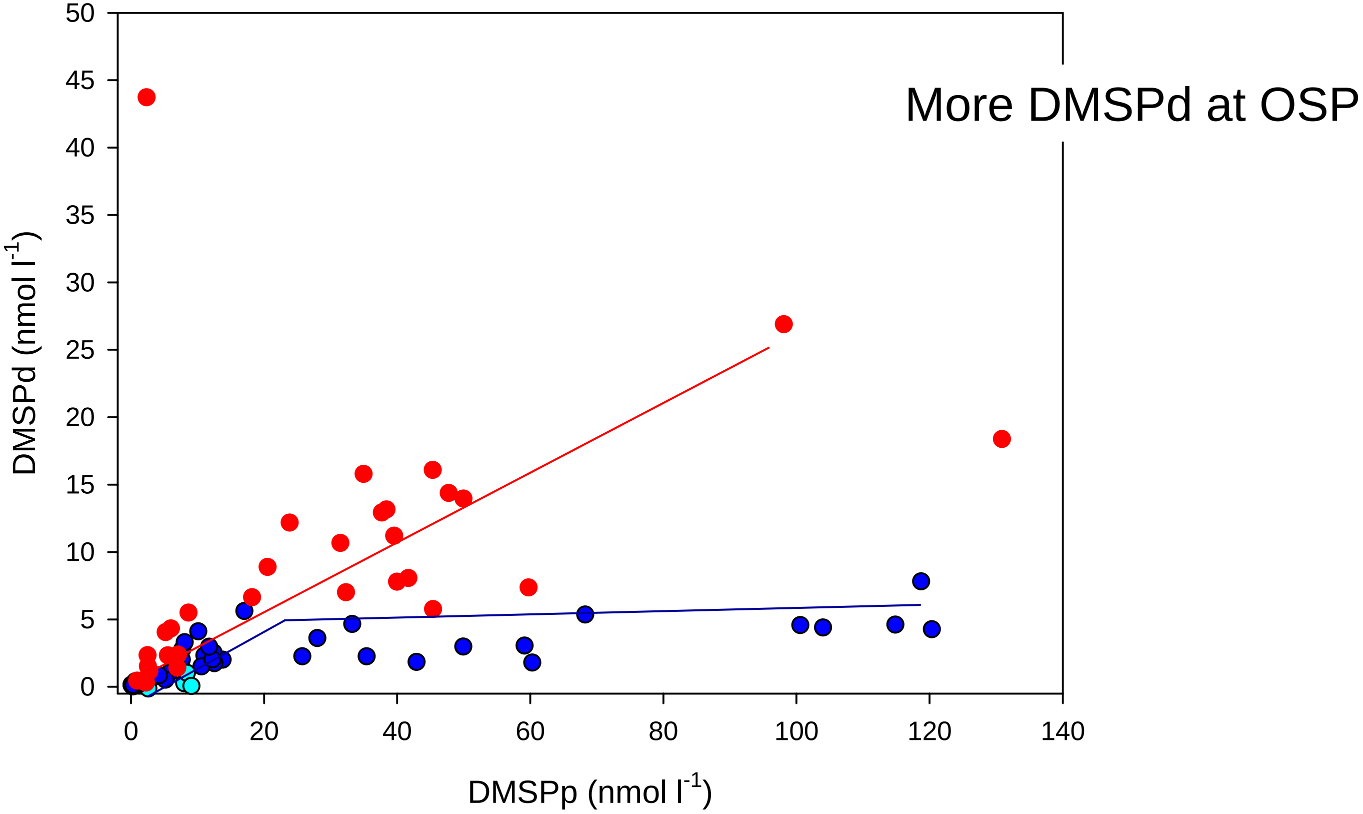
SEEDS II is ‘Atlantic style’

Dissolved DMSP *versus* particulate DMSP



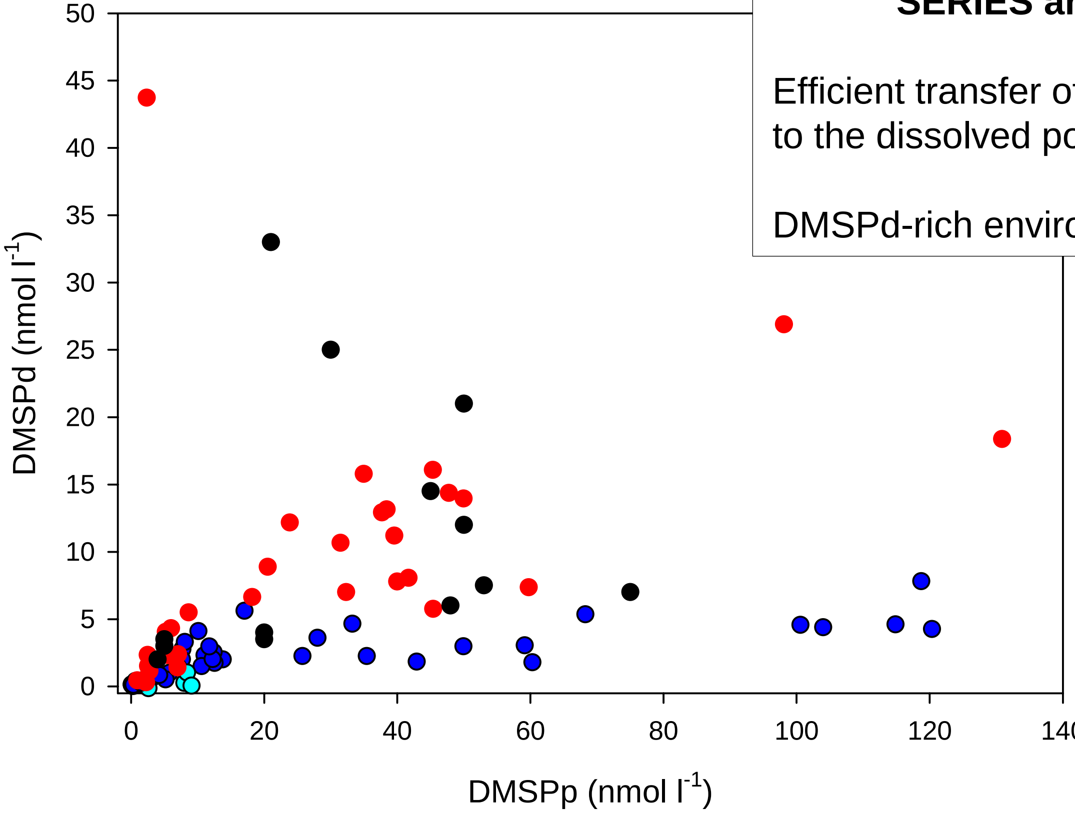

North West Atlantic July 2003 (L, T1 to T7) (T6)
DMSPd (nmol l-1)
DMSPp (nmol l-1)
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100
120
140

North West Atlantic July 2003 (L, T1 to T7) (T6)
North East Pacific July 2002 'OUT'



SEEDS II

North West Atlantic July 2003 (L, T1 to T7) (T6)
North East Pacific July 2002 'OUT'



SERIES and SEEDS II

Efficient transfer of particulate DMSP to the dissolved pool.

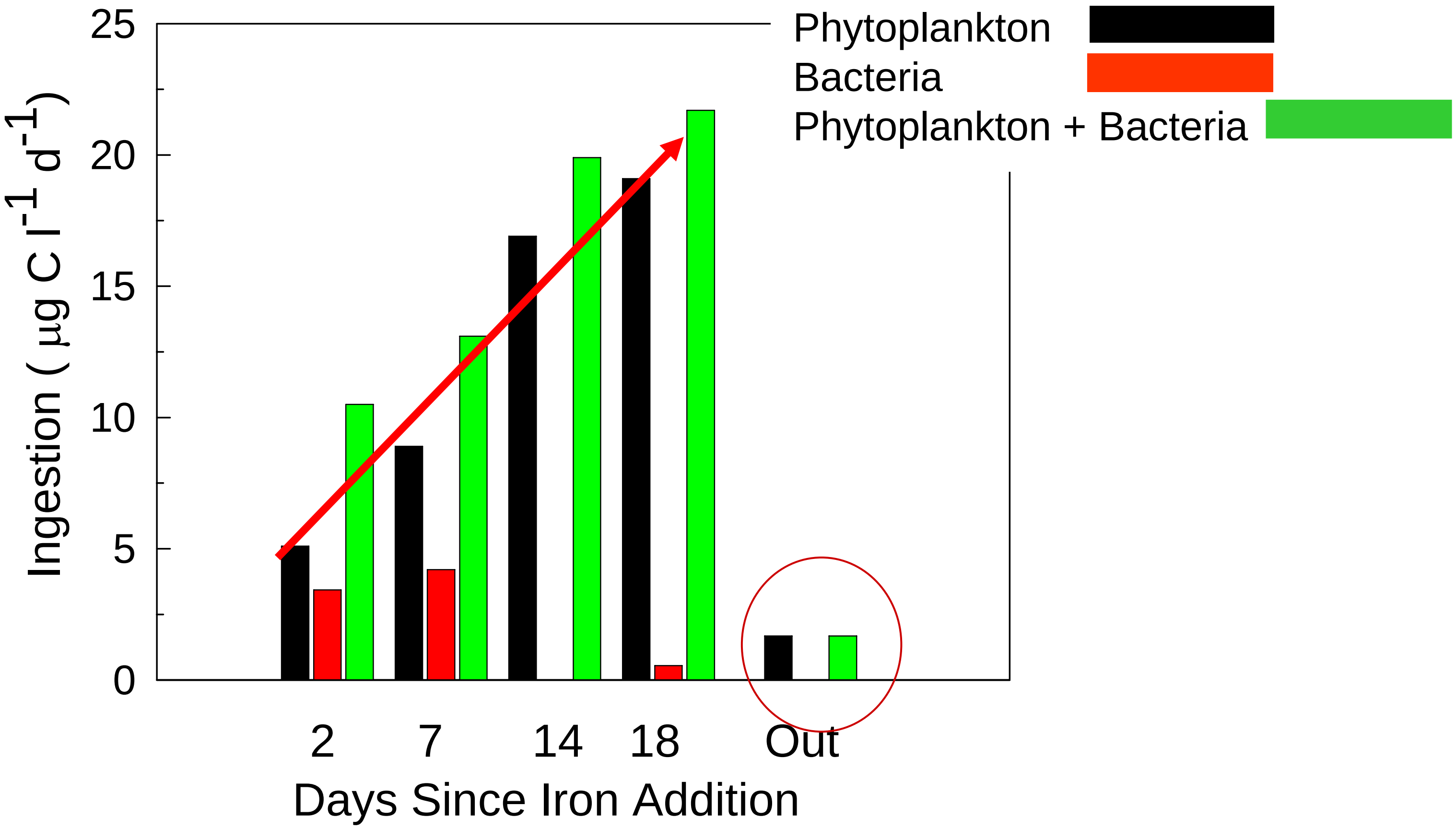
DMSPd-rich environment for bacteria.

QUESTIONS

1. What makes a HNLC region DMS-rich?

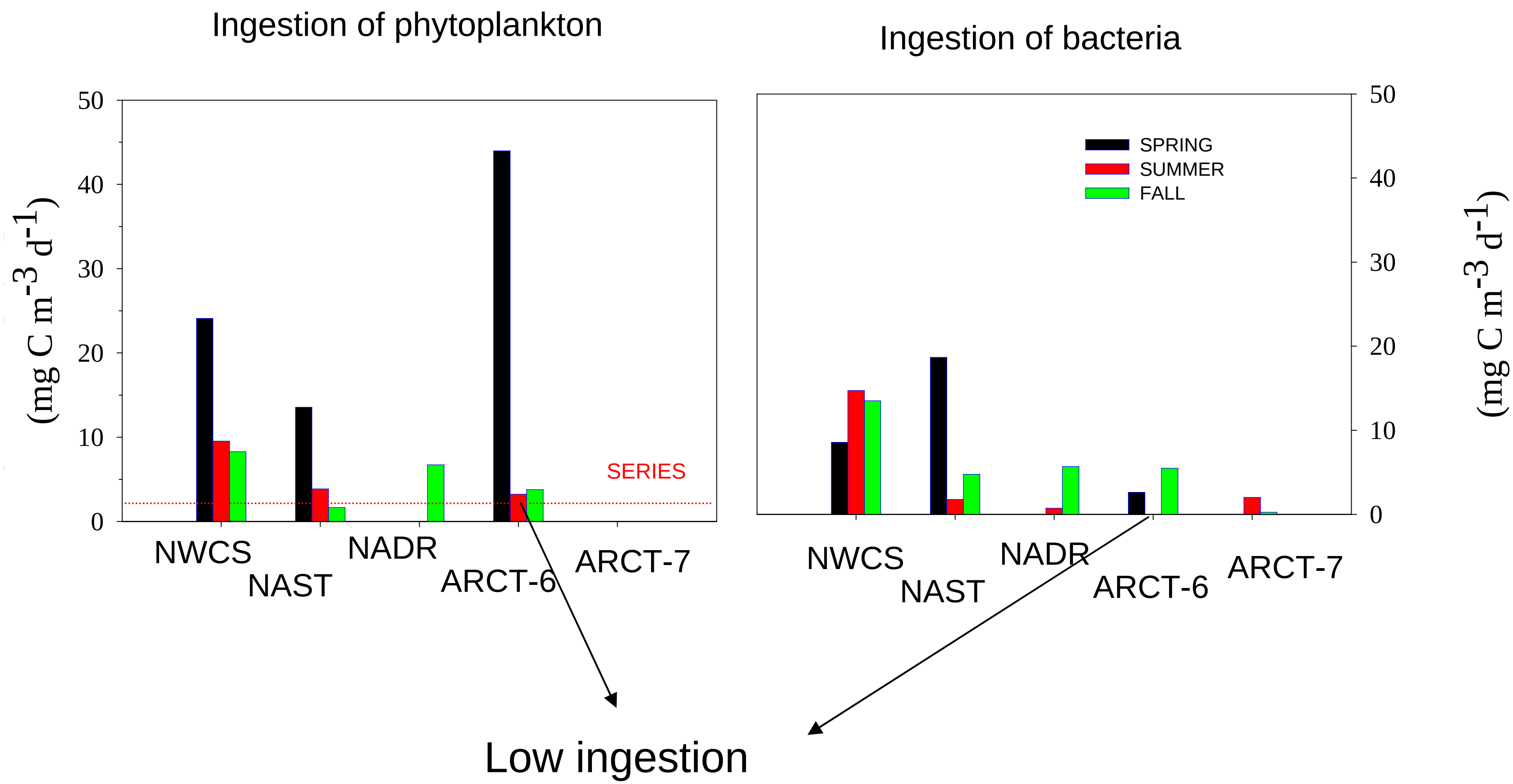
More algal DMSP? NO
More dissolved DMSP? MAYBE
More grazing?
More bacteria?
More efficient conversion of DMSP into DMS?

Fe stimulated microzooplankton ingestion rates of nanoplankton



Courtesy of Rivkin's lab

Microzooplankton ingestion rates during SABINA



Courtesy of R. Rivkin

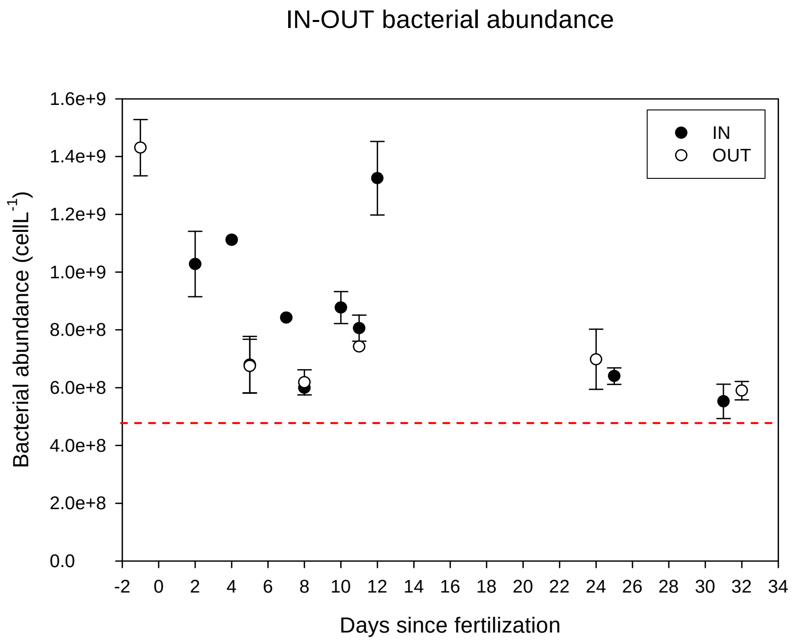
QUESTIONS

1. What makes a HNLC region DMS-rich?

High algal DMSP?	NO
High dissolved DMSP?	MAYBE
High microzooplankton grazing?	NO
High bacterial abndance?	
More efficient conversion of DMSP into DMS?	

Bacterial abundance

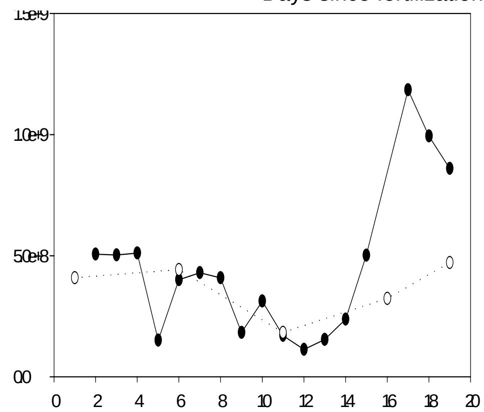
SEEDS II



No clear effet of Fe in SEEDS II

→ **Mean abundance in SERIES**

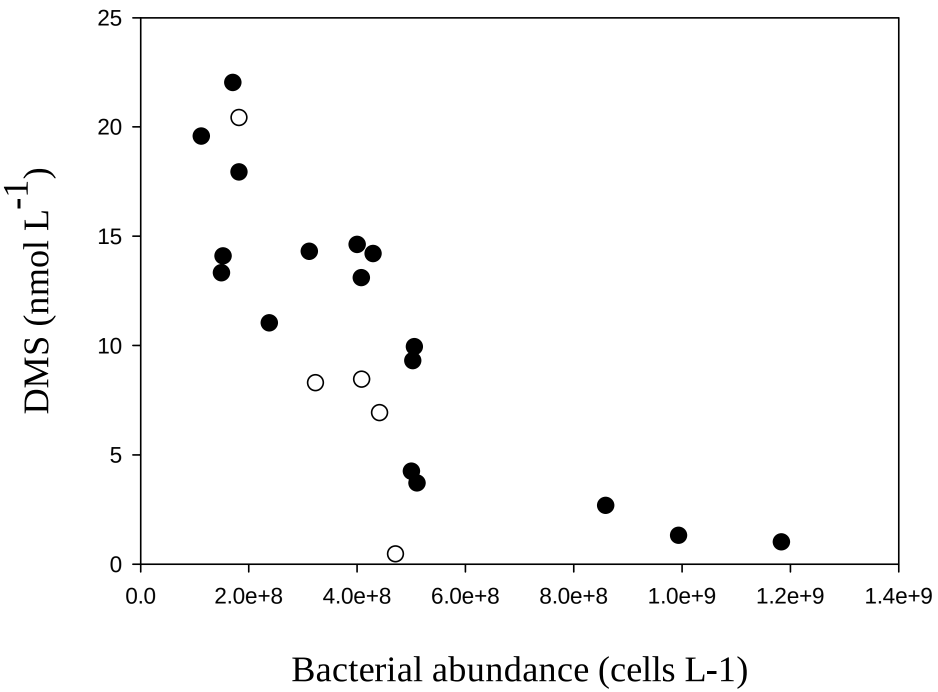
SERIES



Increase in bacterial abundance at the end in SERIES

DMS versus bacterial abundance

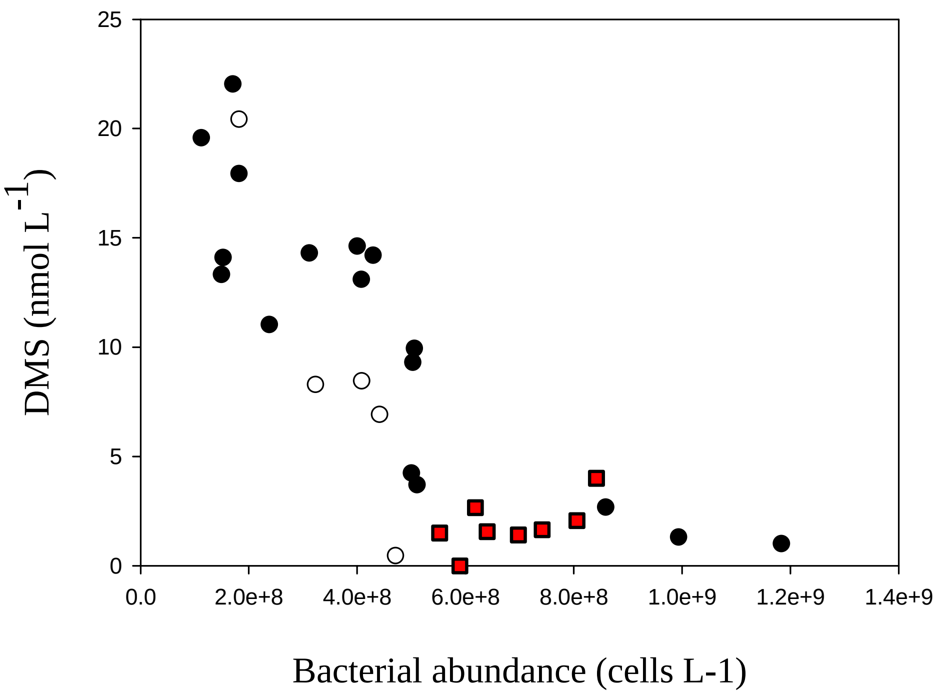
SERIES



Levasseur et al. in press

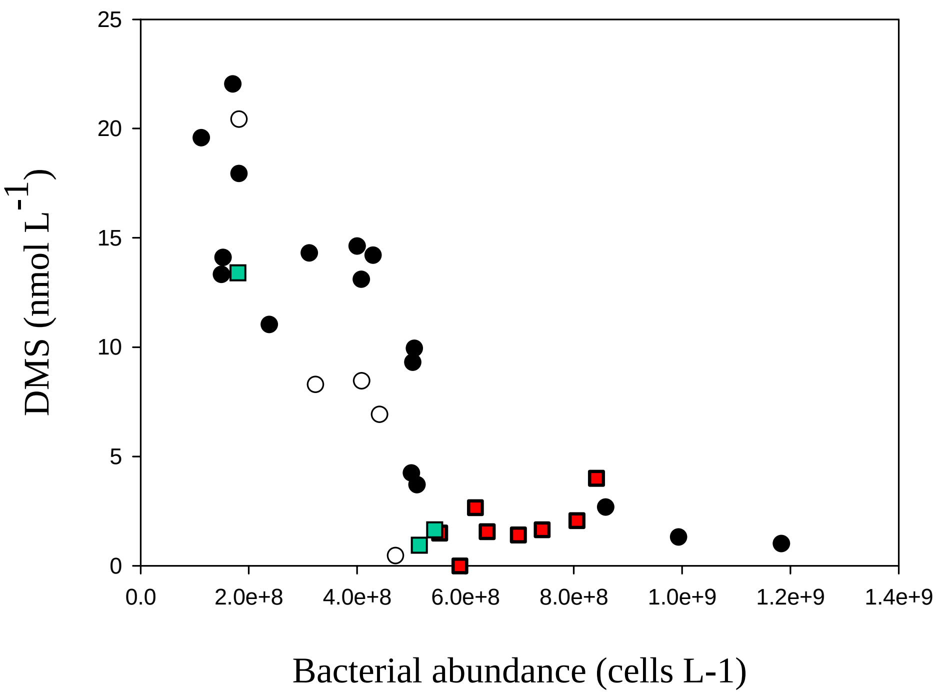
DMS versus bacterial abundance

SERIES and SEEDS-II



Low Bacteria High DMS regions (LBHD)

SERIES, SEEDS-II, and T6



QUESTIONS

1. What makes a HNLC region DMS-rich?

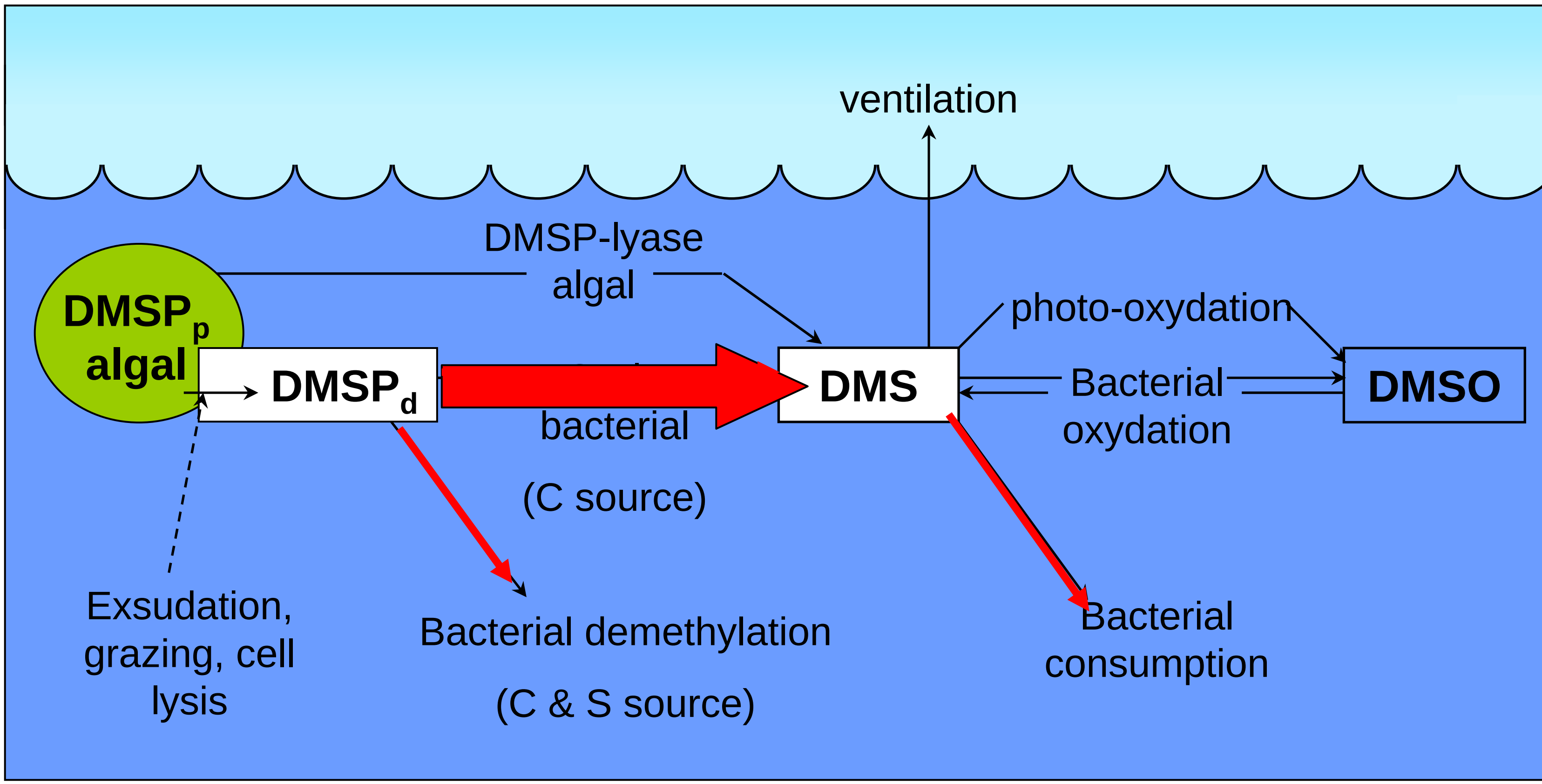
More algal DMSP?	NO
More dissolved DMSP?	MAYBE
More grazing?	NO
More bacteria?	NO (less is better actually!)

HOW LESS BACTERIA MAY PRODUCE MORE DMS?

- Increasing their DMSP consumption per cell
- Decreasing their DMS consumption
- <u>Increasing their DMS yield</u>

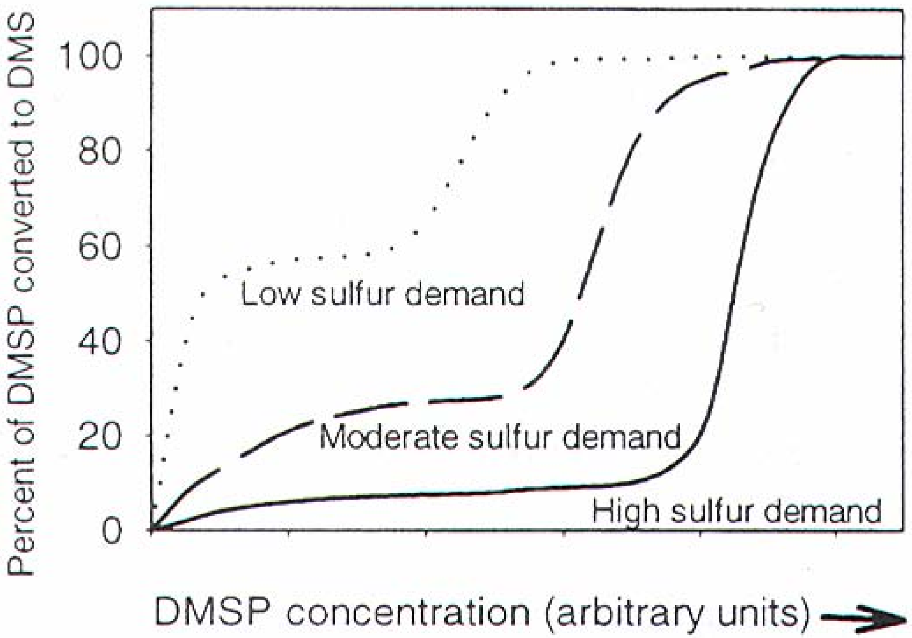
Marine DMS production

What is controlling this ‘bacterial switch’ in DMSP metabolism?



DMS bacterial yield as a function of DMSP concentrations and S demand

Kiene et al. 2000 hypothesis



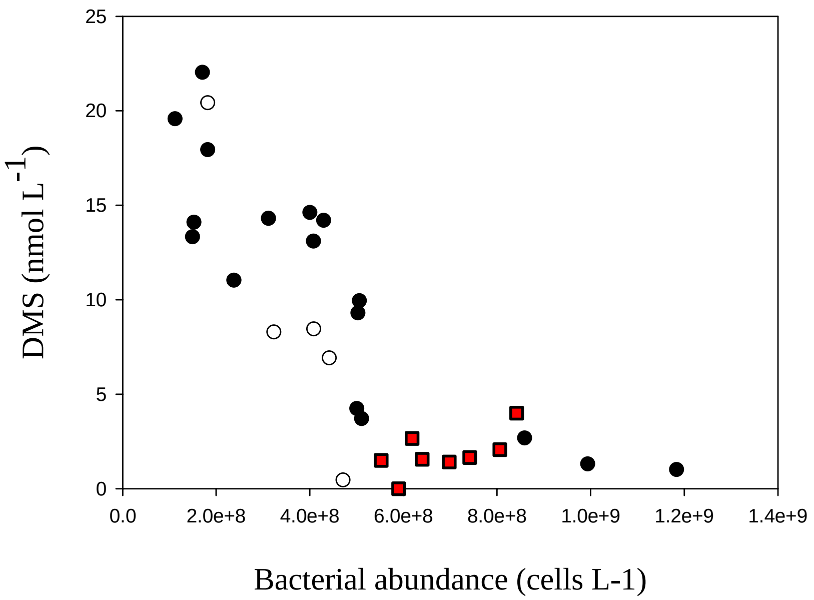
Evolution of Kiene et al. hypothesis

1. **DMS bacterial yield varies with the bacterial S demand and the <u>availability</u> of DMSP (Kiene et al. 2000)**

2. **DMS bacterial yield varies with the bacterial S demand and the <u>production</u> of dissolved DMSP (Simó 2001)**

3 **Bacterial DMS yield varies with the bacterial S demand and the <u>relative contribution of dissolved DMSP to the total dissolved organic S pool/organic matter pool</u> (Pinhassi et la. 2005)**

Low Bacteria High DMS regions (LBHD)



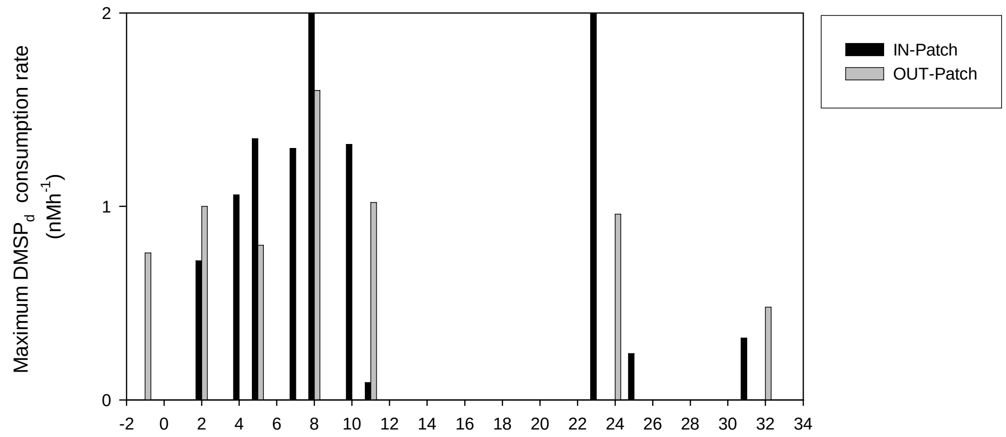
Our results support Pinhassi et al. hypothesis

… **and suggest that conditions leading to high DMS yields are mostly encountered when bacterial abundance is low.**

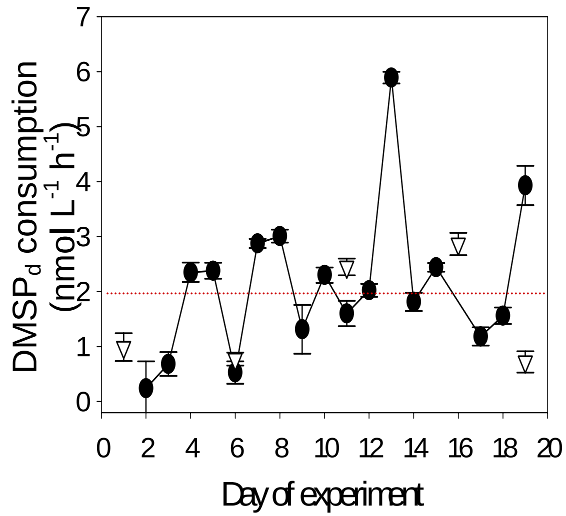
Low bacterial S demand in a high DMSPd environment.

Bacterial consumption of DMSP

SEEDS II



SERIES

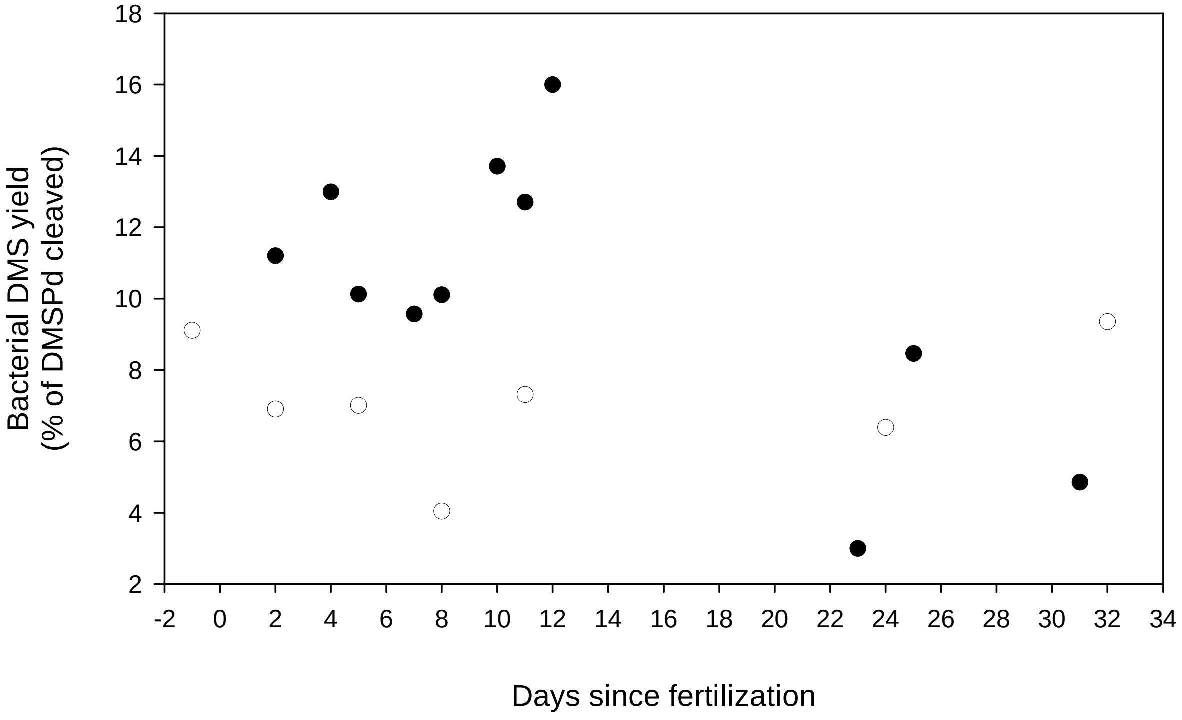


Very high utilisation rate in SERIES in spite of low bacterial abundance

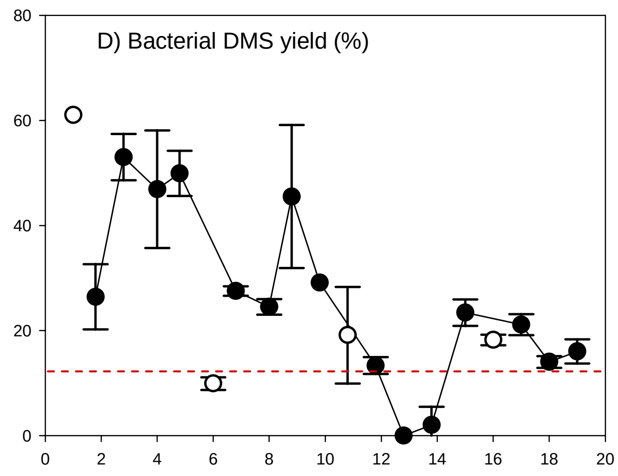
Maximum rate in SEEDS II

Bacterial DMS yield in SEEDS II

Proportion of DMSP taken up and cleaved into DMS

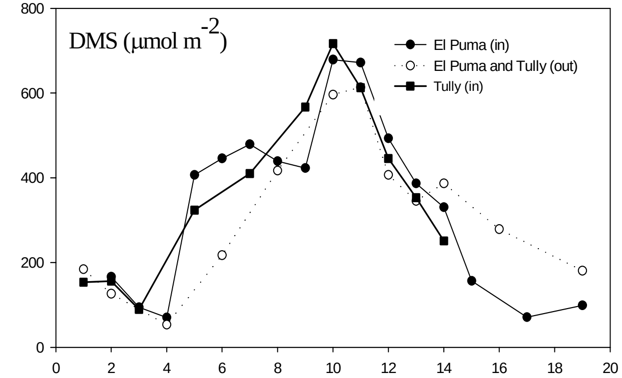


<u>Microbial</u> DMS yield in SEEDS II



Few outpatch values

Maximum yield in SEEDS II



Days since fertilization

Future Works

We need better sampling of the unfertilized region (control)

- Same sampling frequency, same rate measurements

We need better characterisation of the bacterial DMS(P) dynamics

- DOC and DOS measurements
- Bacterial DMS yield
- Bacterioplankton assemblage

Collaborators

Michael Scarratt

Sonia Michaud

CS Wong

Richard Rivkin

Michelle Hale

Ronald Kiene

Alain Vézina

Atsushi Tsuda

Yvonnick Le Clainche

Gitane Caron

Anissa Merzouk

Martine Lizotte

…and all SERIES and SEEDS II colleagues

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Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)

Fisheries and Oceans Canada | Pêches et Océans Canada

Environment Canada | Environnement Canada

Department of Fisheries and Oceans (DFO)

Meteorological Service Of Canada (MSC)

And a special thank
to
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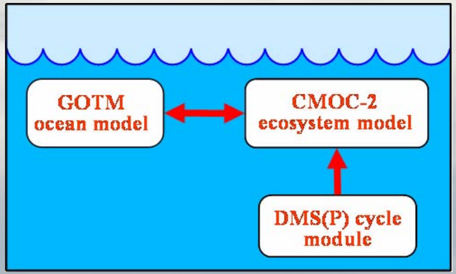
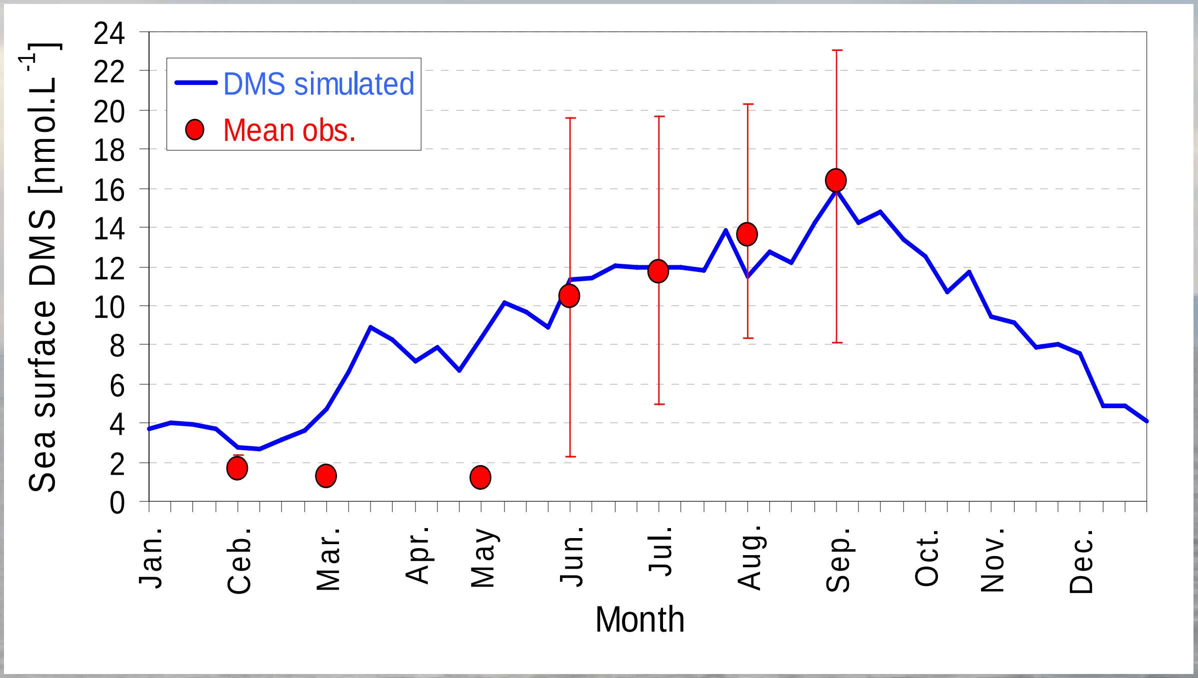
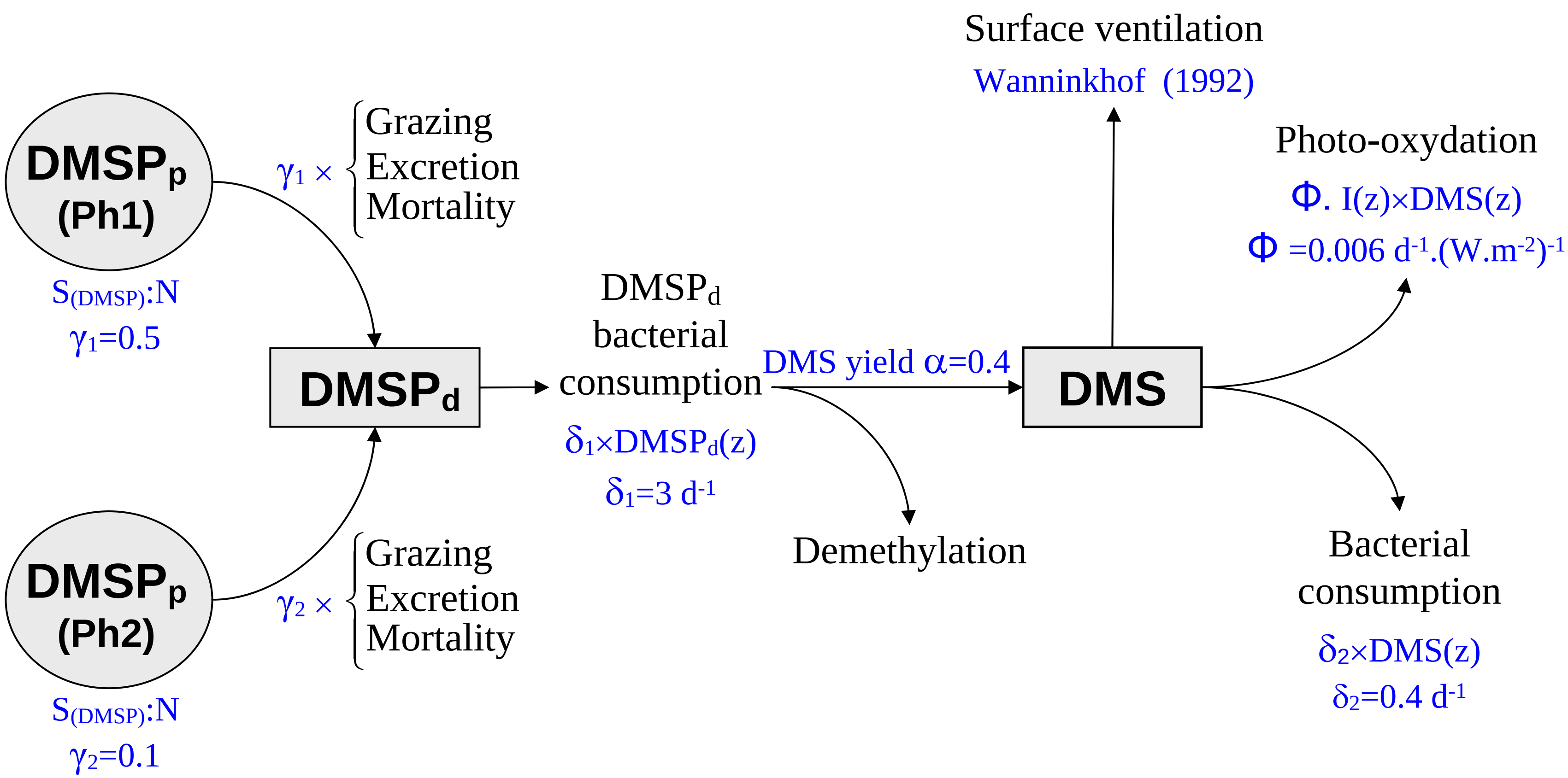
for
their travel support

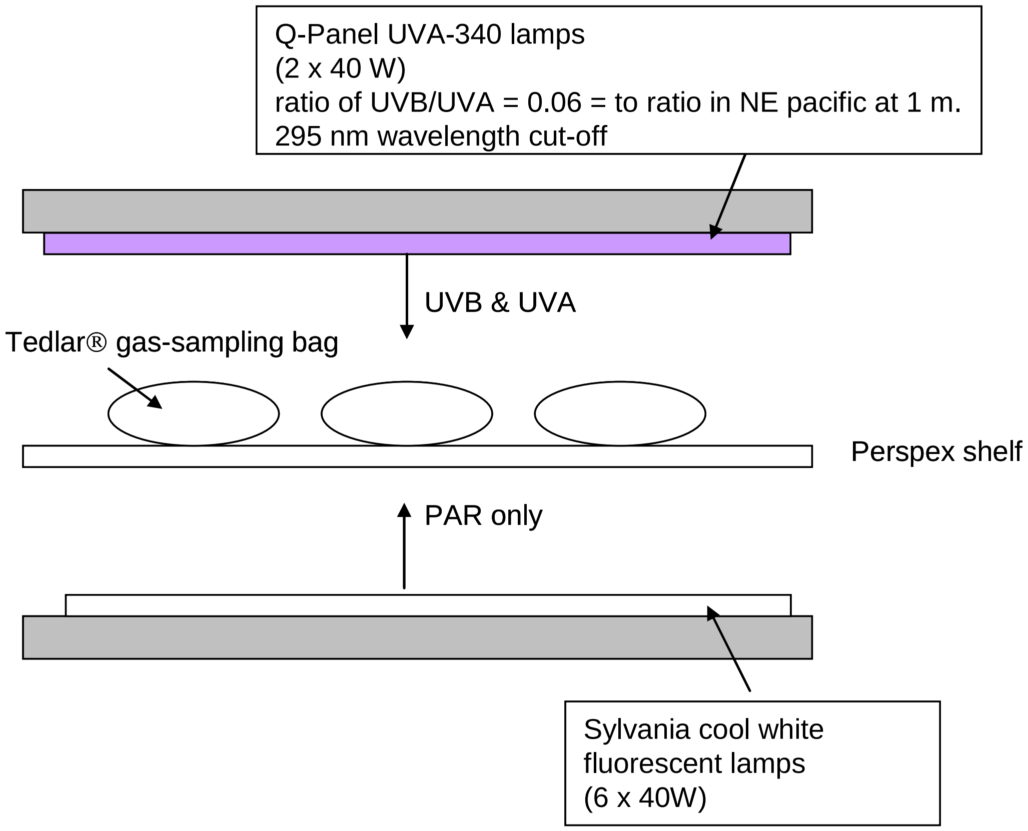




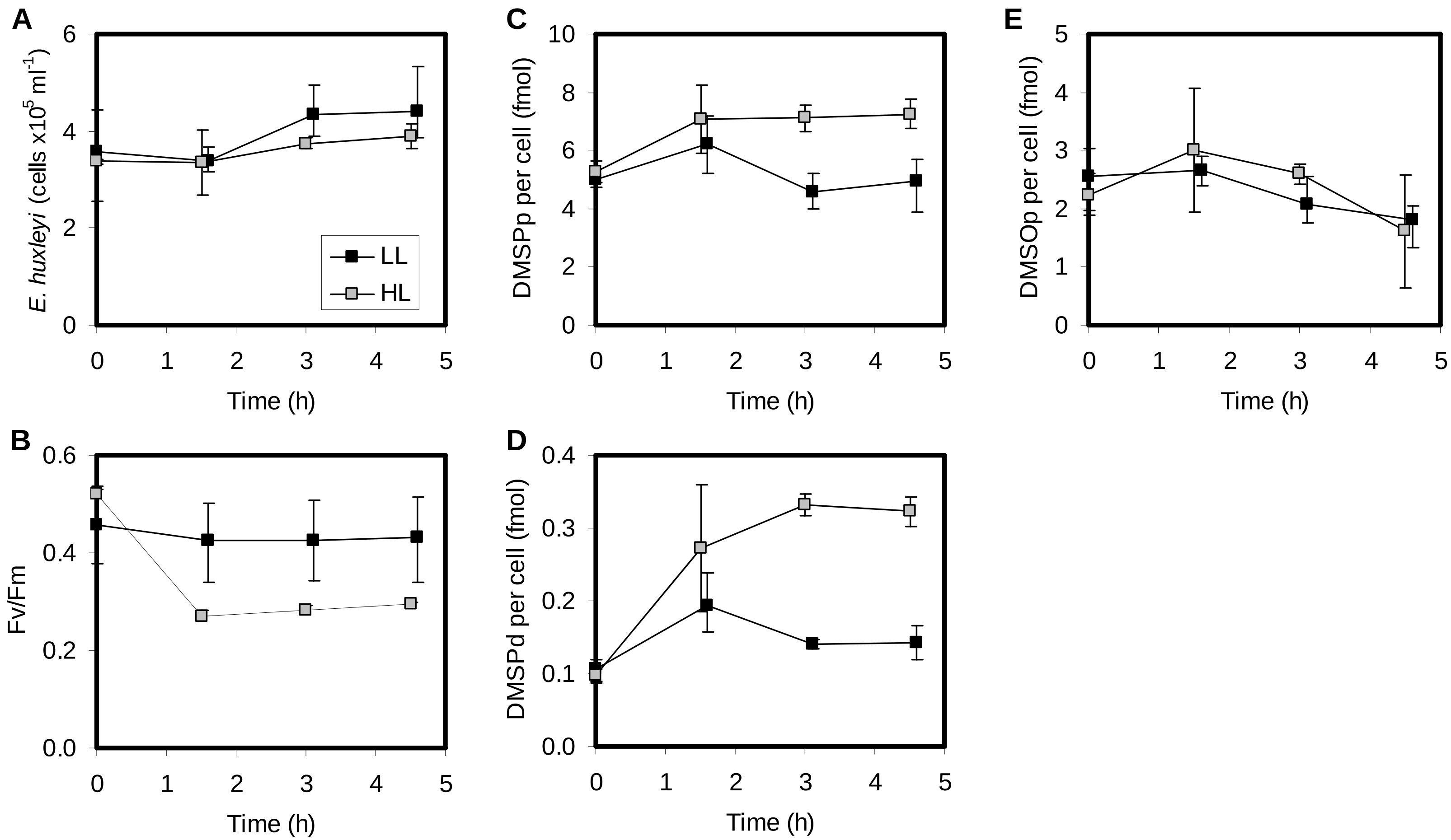
Simulation of the seasonal cycle of sea surface DMS concentration at OSP (subarctic N E Pacific) using the coupled ocean-biogeochemical model developed in collaboration between U.LAVAL (Y. Le Clainche, M. Levasseur) and CCCma (N. Steiner, K. Denman)



DMSPp (Ph1)
S(DMSP):N
γ1=0.5
γ1 ×
Grazing
Excretion
Mortality
DMSPp (Ph2)
S(DMSP):N
γ2=0.1
γ2 ×
Grazing
Excretion
Mortality
DMSPd
DMSPd bacterial consumption
δ1×DMSPd(z)
δ1=3 d-1
DMS yield α=0.4
Demethylation
DMS
Surface ventilation
Wanninkhof (1992)
Photo-oxydation
Φ. I(z)×DMS(z)
Φ =0.006 d-1.(W.m-2)-1
Bacterial consumption
δ2×DMS(z)
δ2=0.4 d-1


Q-Panel UVA-340 lamps
(2 x 40 W)
ratio of UVB/UVA = 0.06 = to ratio in NE pacific at 1 m.
295 nm wavelength cut-off
UVB & UVA
Tedlar® gas-sampling bag
Perspex shelf
PAR only
Sylvania cool white
fluorescent lamps
(6 x 40W)

Testing the light hypothesis



Courtesy of Louise Darroch

Initial concentrations in algal DMSP in FeAX'x

Study area	DMSPp (nmol L^{-1})	DMS (nmol L^{-1})	Reference
Equatorial Pacific (IronEx-1)	30	2.7	Turner et al. (2004)
Equatorial Pacific (IronEx-2)	14	2.5	Turner et al. (2004)
Southern Ocean (SOIREE)	27	0.5	Turner et al. (2004)
Southern Ocean (EisenEx)	45	1.9	Turner et al. (2004)
South-East Pacific	4-16	n.m.*	Riseman and DiTullio (2004)
North East Pacific (SERIES)	98-130	8.5-10.9	This study
North West Pacific (SEEDS II)	5-53	~3.8	I. Nagao (pers. Comm.)

SERIES: HIGHEST LEVELS OF DMSPp
SEEDS II: SIMILAR CONCENTRATIONS THAN EisenEx

Levasseur et al. (in press)