Nitrogen fixation:

Current parameterization and experimental findings

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Three biogeochemical models: ERGOM
SCOBI
BALTSEM

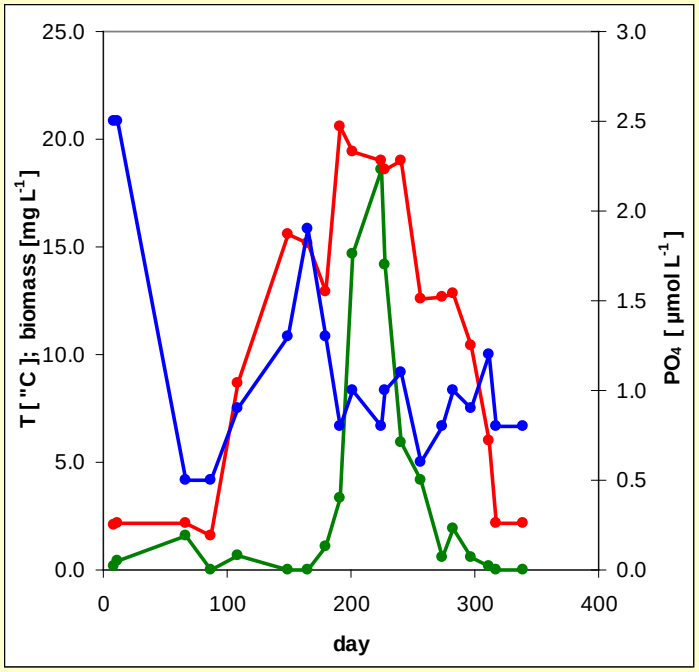
Nitrogen fixation rate control by: temperature, phosphate, light;

The data basis for the parameterizations:

Wasmund (1997), Int. Revue ges. Hydrobiol., 82, 169 – 184;

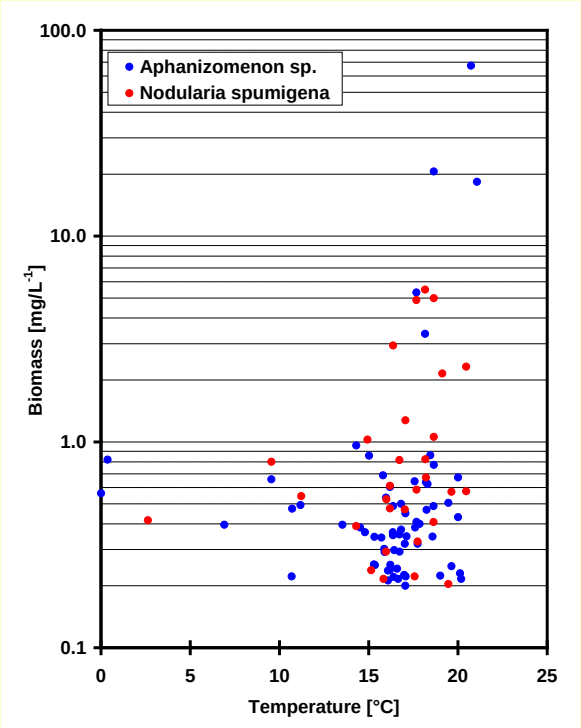
Wallström (1991), Dissertation Uppsala University;

Kononen (1992), Finn. Mar. Res., 261, 1 – 36.



Time series in the Darss-Zingst lagoon system,

1984 -1990:

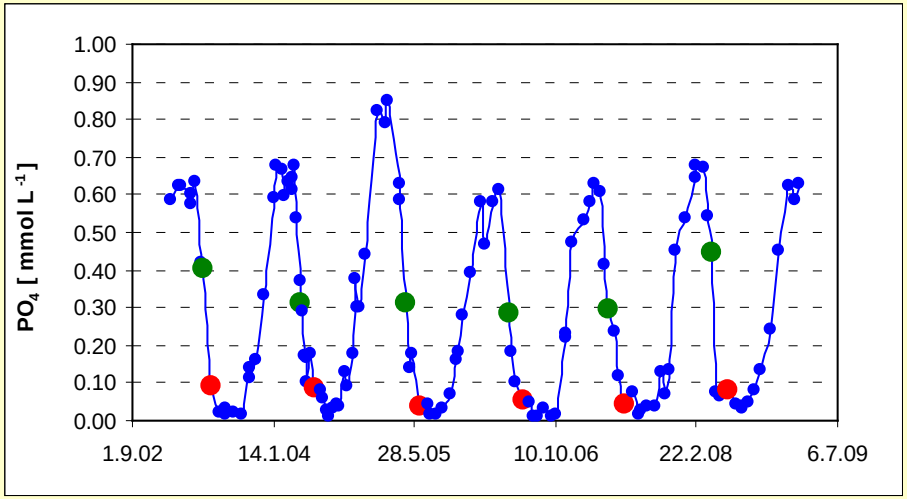


Nodularia and Aphanizomenon abundance (> 2 mg L^{-1})

1979 -1993, HELCOM Monitoring;

Phosphorus limitation:

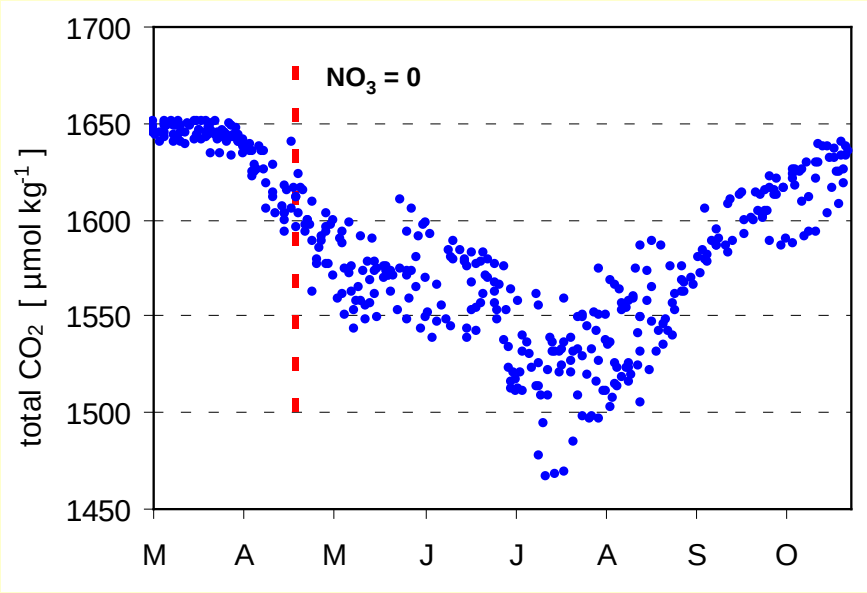
Phosphate data (SMHI, Monitoring, BY15):



● $NO_3 = 0$

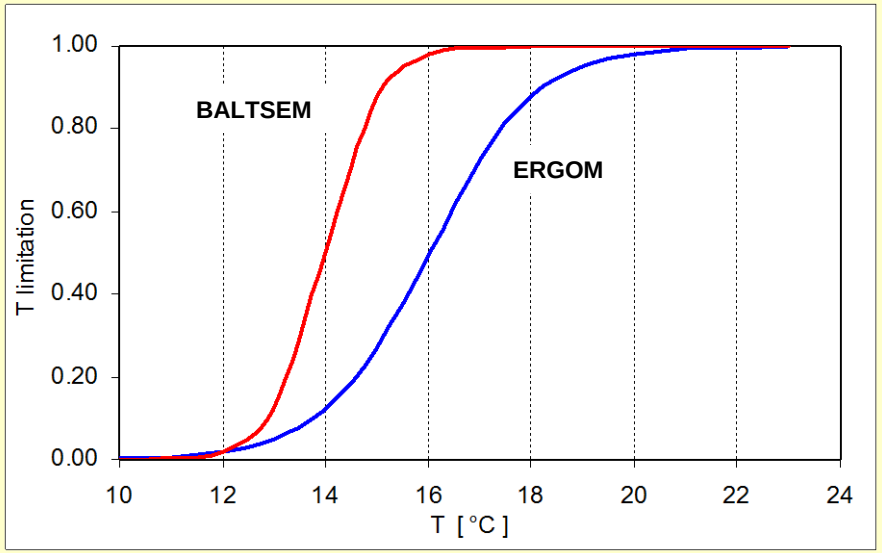
● earliest start of the mid-summer nitrogen fixation

Seasonality of total CO_2 northeastern Gotland Sea (cargoship FINNMAID):

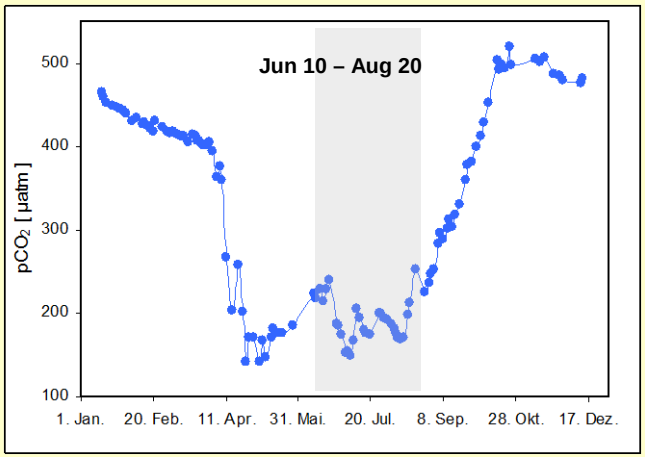


Temperature dependency:

(scaling factor)

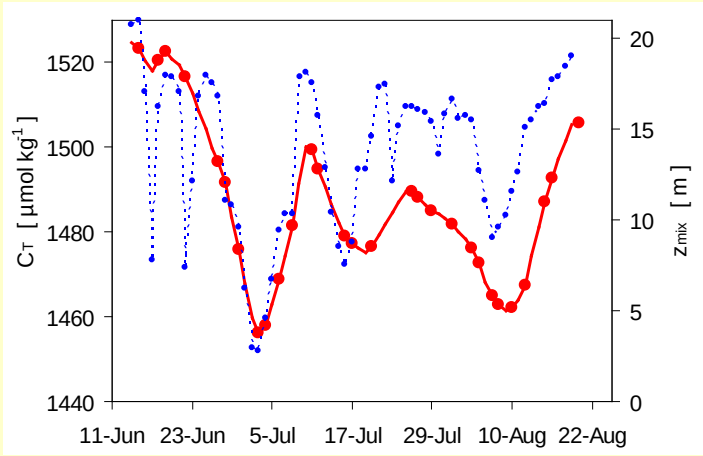


Determination of organic matter production by pCO_2 measurements on a cargo ship:

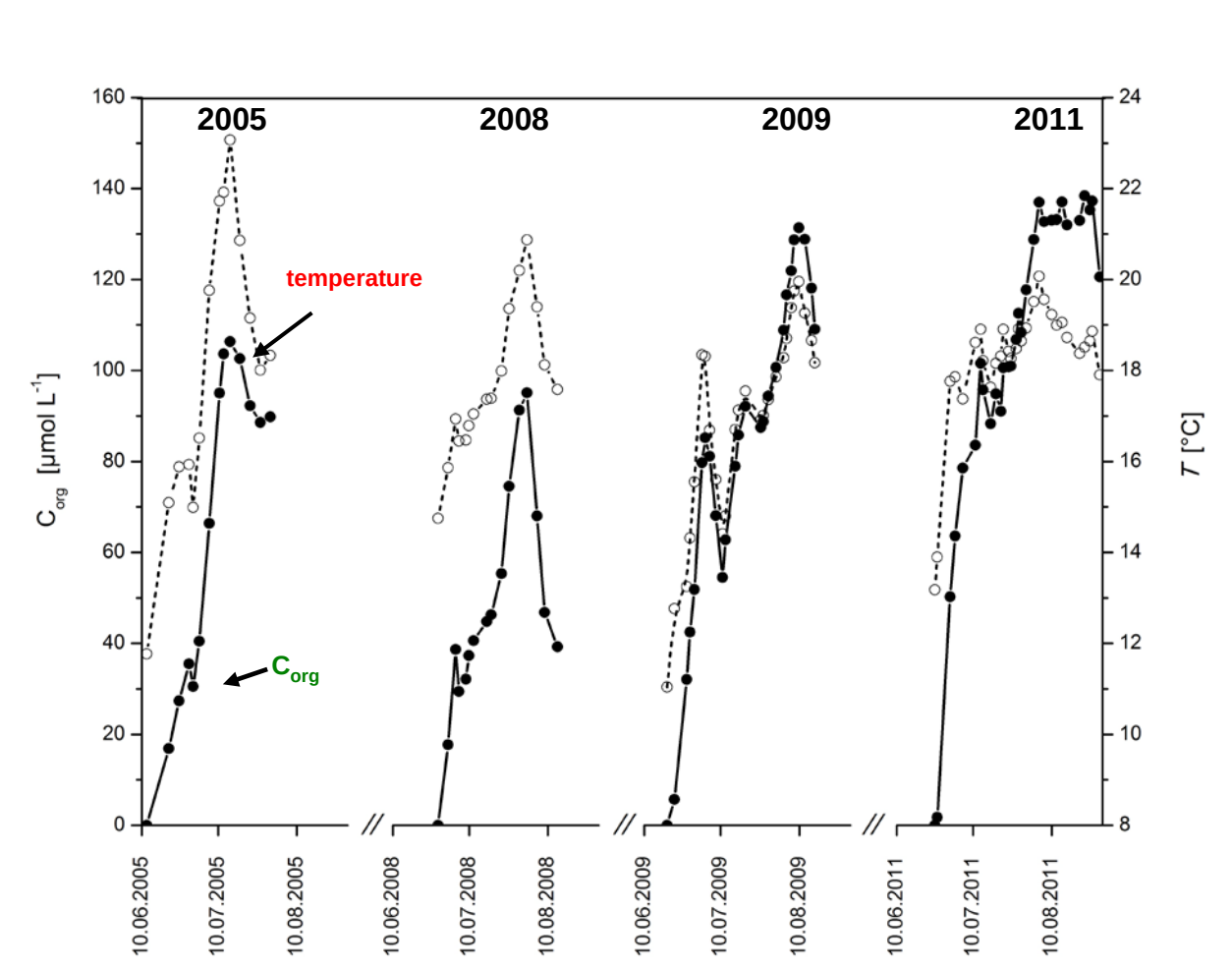


alkalinity

T, S

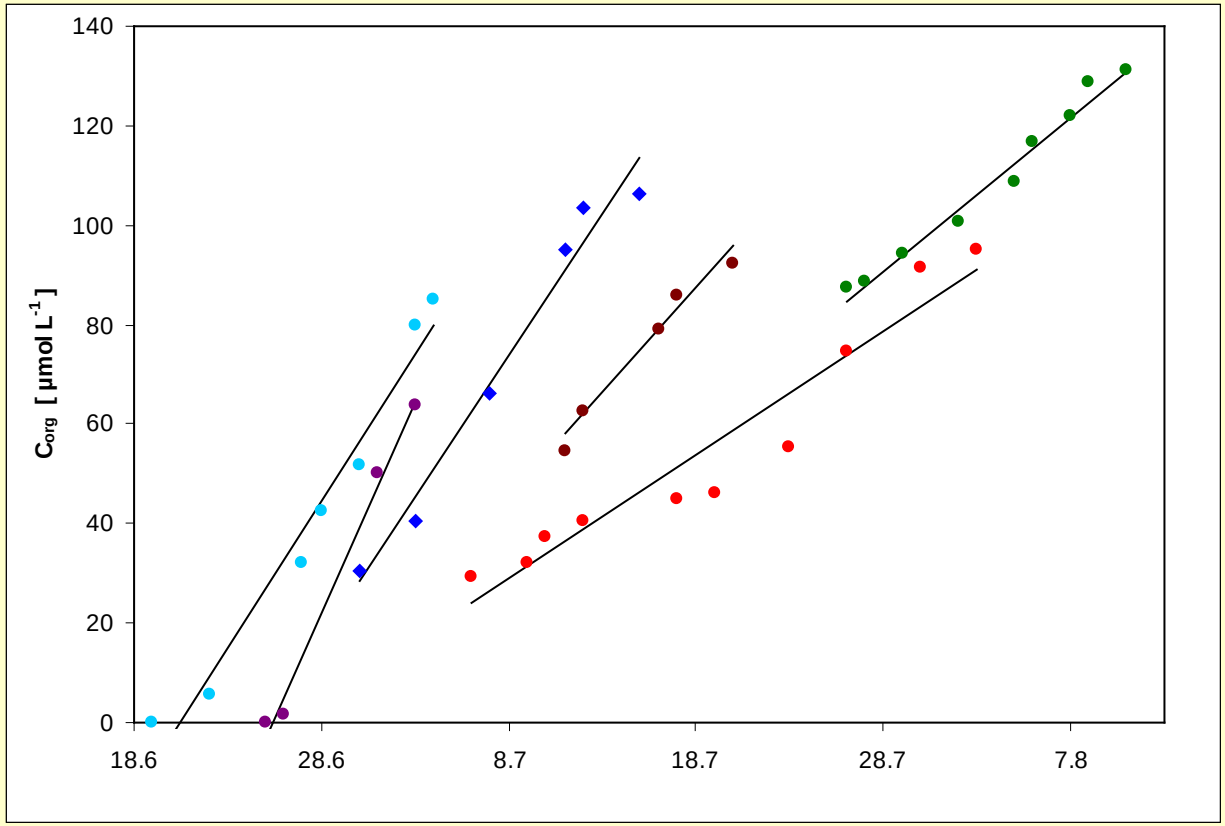


Taking into account air-sea gas exchange, total CO_2 decrease yields organic matter, C_{org}, production:



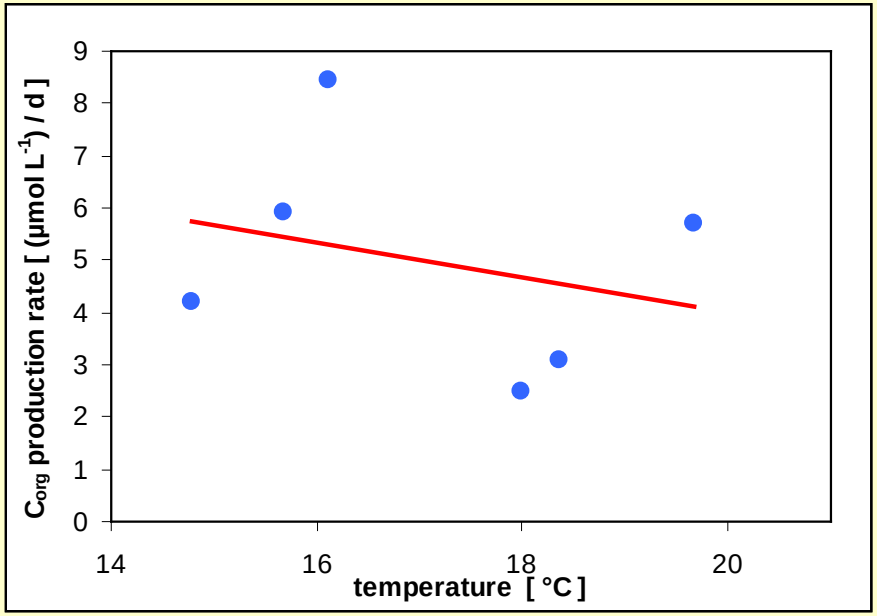
Distinct coincidence between the increase of C_{org} and temperature

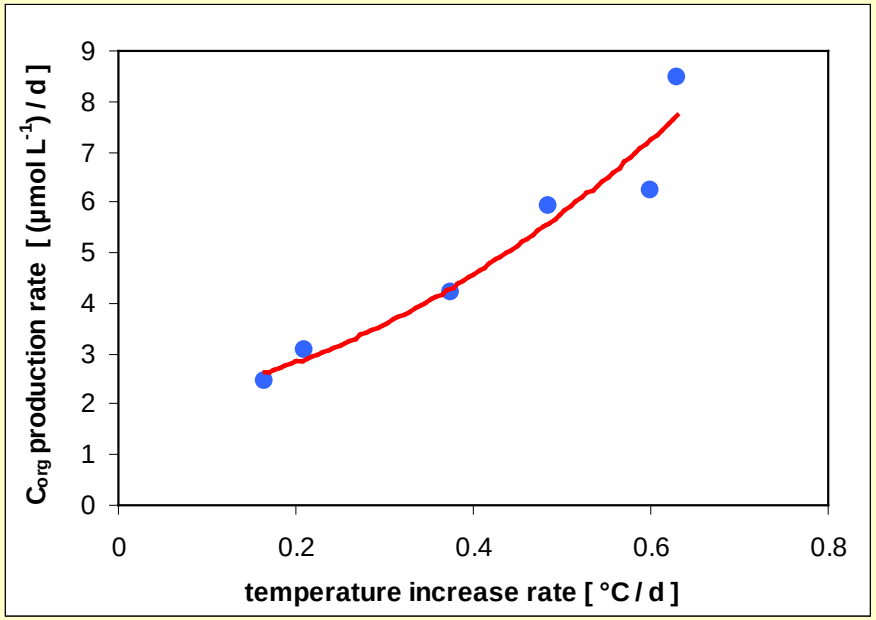
Development of the C_{org} concentration with reference to the onset of the mid-summer production period:



- linear approximation of the C_{org} increase (slope) yields the C_{org} production rate;
- no indication for limitation of C_{org} production (PO_4);

Relationship between temperature C_{org} production rate:





C_{org} production rate (N_2 fixation rate) does not depend on temperature;

C_{org} production rate (N_2 fixation rate) highly correlated with the temperature increase rate;

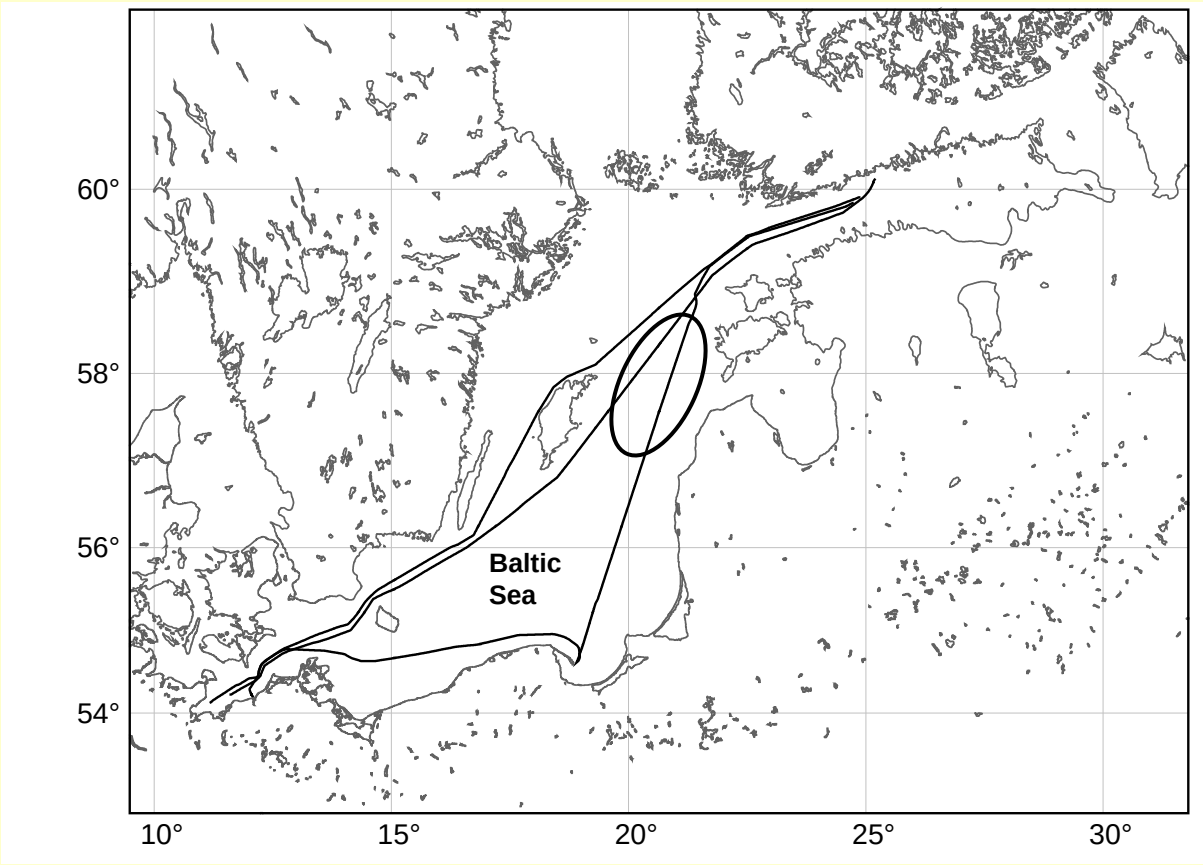
$N_{fix} \sim (I / z_{mix})^x$

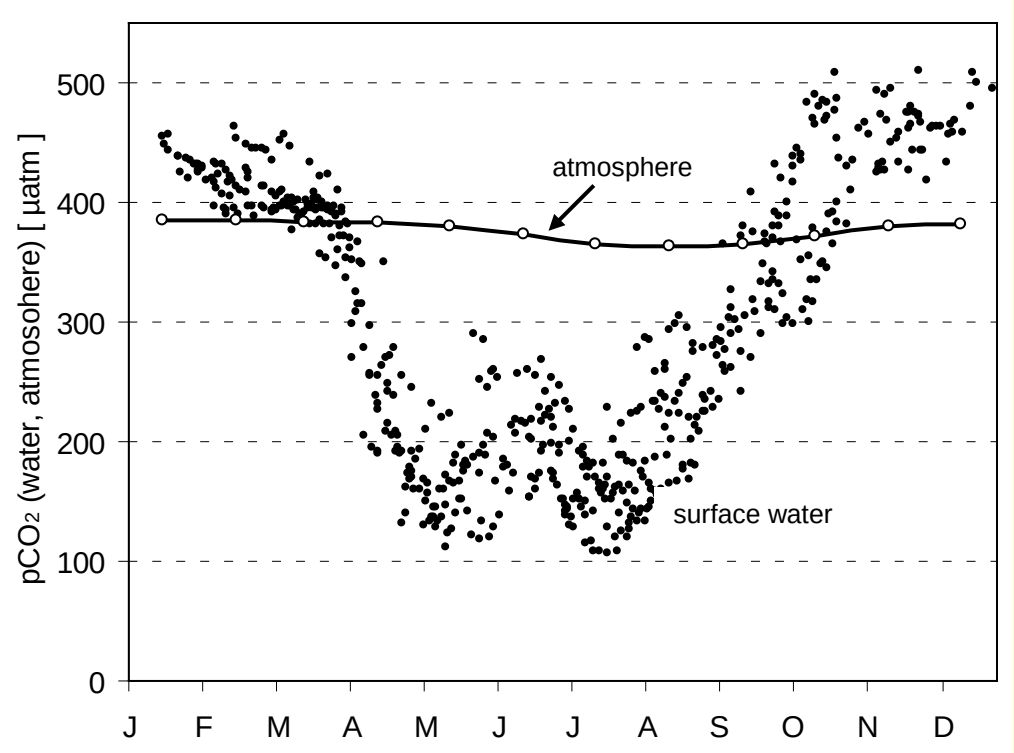
function of „light concentration“ [W /m³]

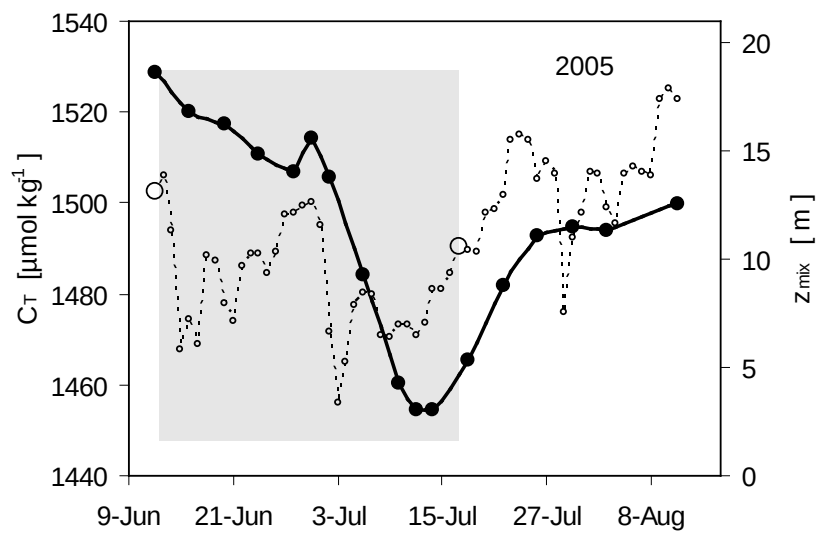
But: Upper limit ?

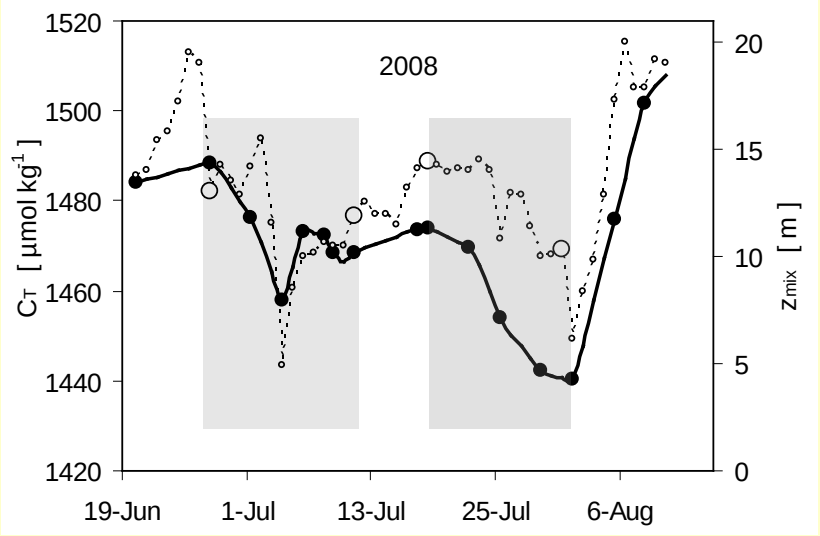
Research gaps:

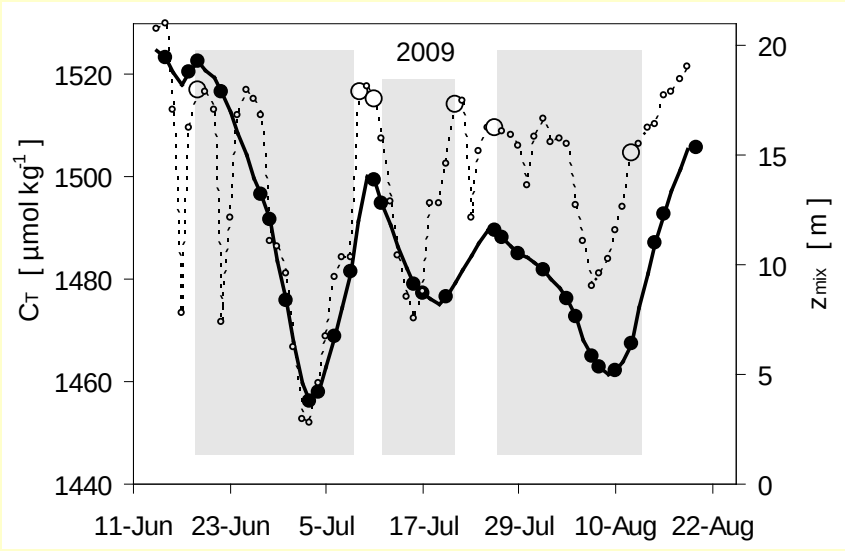
1. What drives the net production after spring nitrate depletion?
2. What is the fate of of the phosphate excess, transfer to mid-summer cyanobacteria?
3. What controls and limits the mid-summer nitrogen fixation?

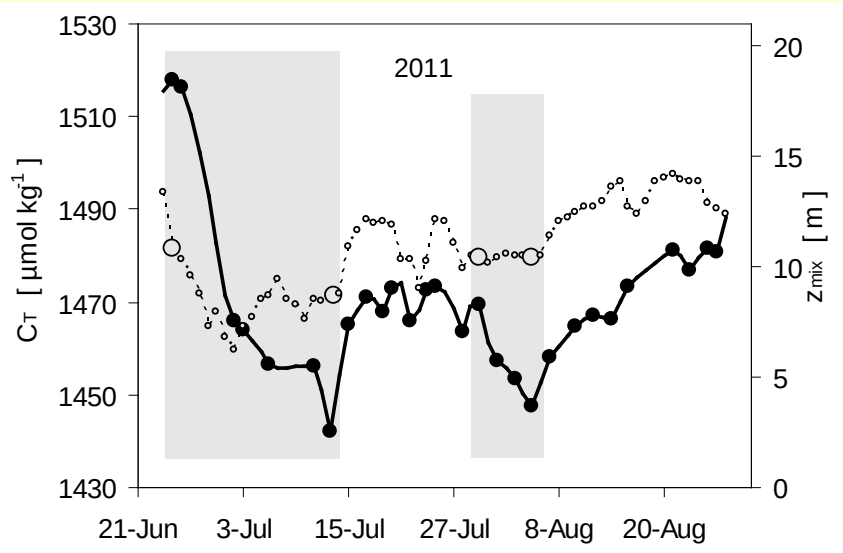

60°
58°
56°
54°
10°
15°
20°
25°
30°
Baltic
Sea

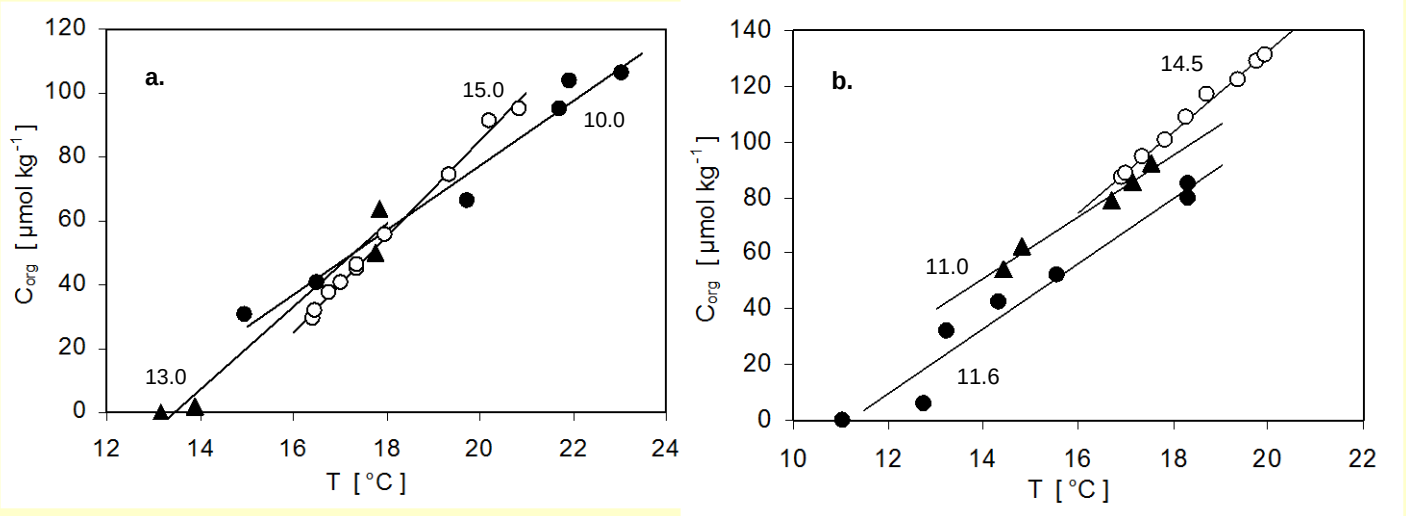

500
400
300
200
100
0
pCO2 (water, atmosohere) [µatm]
atmosphere
surface water
J
F
M
A
M
J
J
A
S
O
N
D

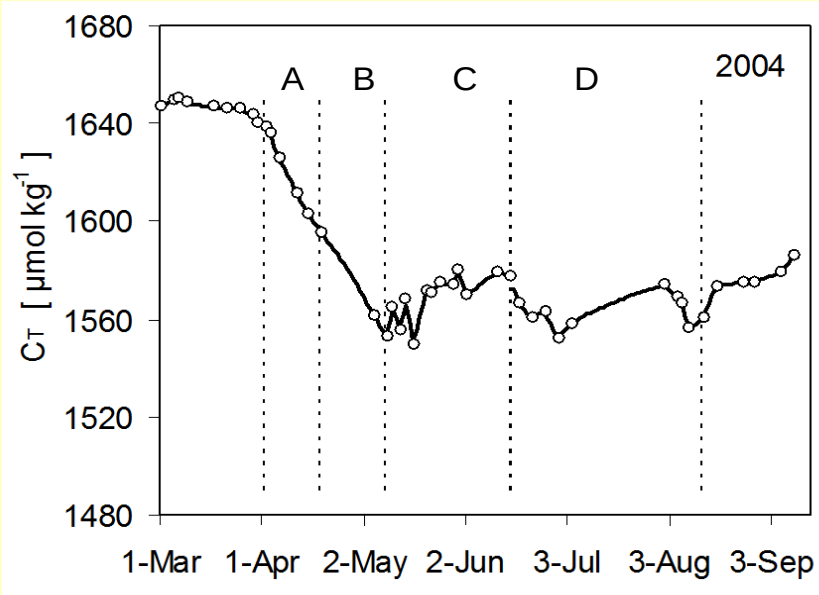

2005
C_T [µmol kg^{-1}]
z_{mix} [m]
1540
1520
1500
1480
1460
1440
20
15
10
5
0
9-Jun
21-Jun
3-Jul
15-Jul
27-Jul
8-Aug

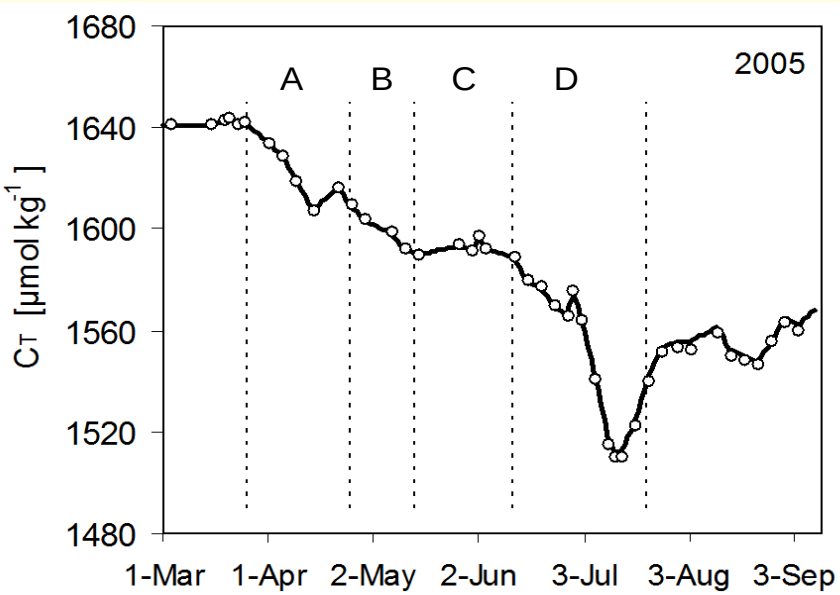

2008
C_T [µmol kg^{-1}]
z_{mix} [m]
1520
1500
1480
1460
1440
1420
20
15
10
5
0
19-Jun
1-Jul
13-Jul
25-Jul
6-Aug

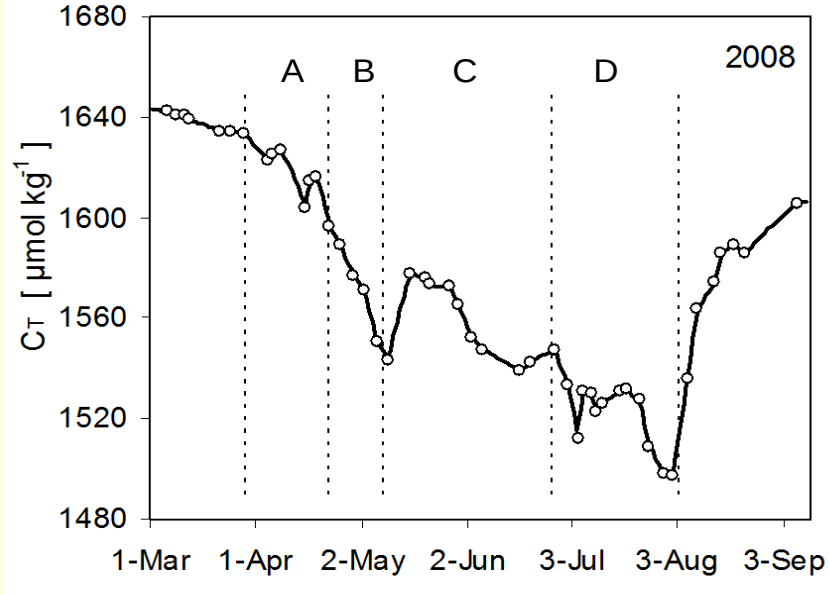

2009
C_T [µmol kg^{-1}]
z_{mix} [m]
1520
1500
1480
1460
1440
20
15
10
5
0
11-Jun
23-Jun
5-Jul
17-Jul
29-Jul
10-Aug
22-Aug

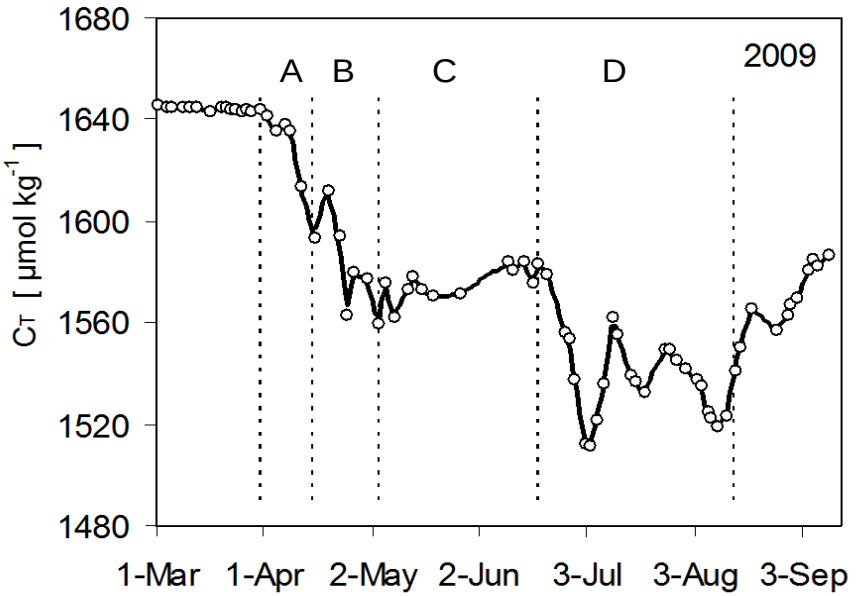

2011
C_T [µmol kg^{-1}]
z_{mix} [m]
1530
1510
1490
1470
1450
1430
20
15
10
5
0
21-Jun
3-Jul
15-Jul
27-Jul
8-Aug
20-Aug

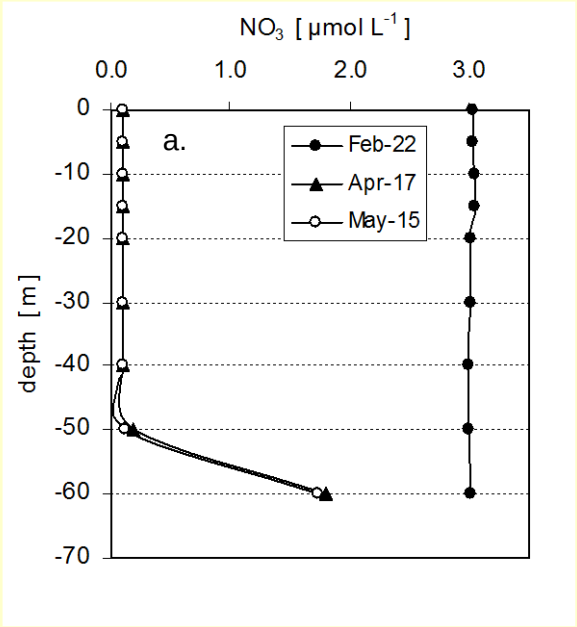

a.
15.0
10.0
13.0
C_{org} [µmol kg^{-1}]
T [°C]
b.
14.5
11.0
11.6
C_{org} [µmol kg^{-1}]
T [°C]

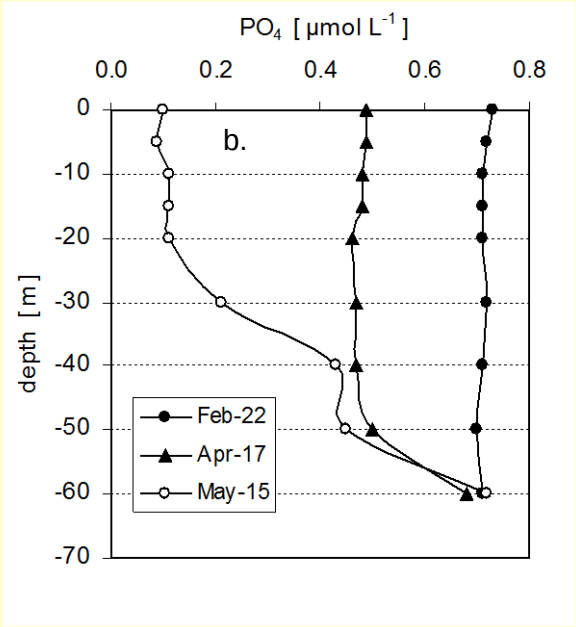

2004
A
B
C
D
1680
1640
1600
1560
1520
1480
C_T [µmol kg^{-1}]
1-Mar
1-Apr
2-May
2-Jun
3-Jul
3-Aug
3-Sep


2005
A
B
C
D
1680
1640
1600
1560
1520
1480
C_T [µmol kg^{-1}]
1-Mar
1-Apr
2-May
2-Jun
3-Jul
3-Aug
3-Sep


2008
A
B
C
D
1680
1640
1600
1560
1520
1480
C_T [µmol kg^{-1}]
1-Mar
1-Apr
2-May
2-Jun
3-Jul
3-Aug
3-Sep


2009
A
B
C
D
1680
1640
1600
1560
1520
1480
C_T [µmol kg^{-1}]
1-Mar
1-Apr
2-May
2-Jun
3-Jul
3-Aug
3-Sep


NO3 [µmol L-1]
0.0
1.0
2.0
3.0
0
-10
-20
-30
-40
-50
-60
-70
depth [m]
a.
Feb-22
Apr-17
May-15


PO4 [µmol L-1]
0.0
0.2
0.4
0.6
0.8
0
-10
-20
-30
-40
-50
-60
-70
depth [m]
b.
Feb-22
Apr-17
May-15