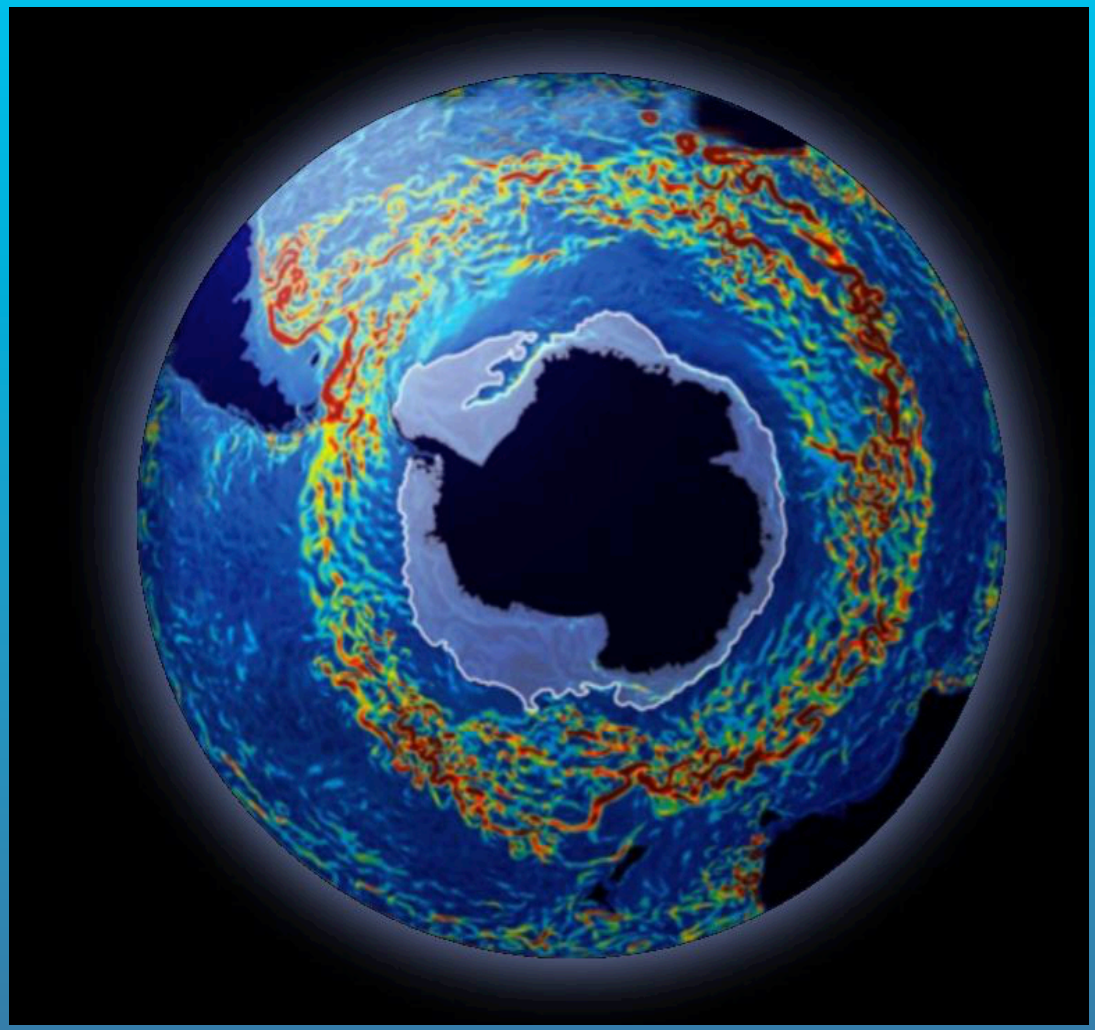
The Southern Ocean, the climate system and why you and your students should care!

Ken Johnson

MBARI



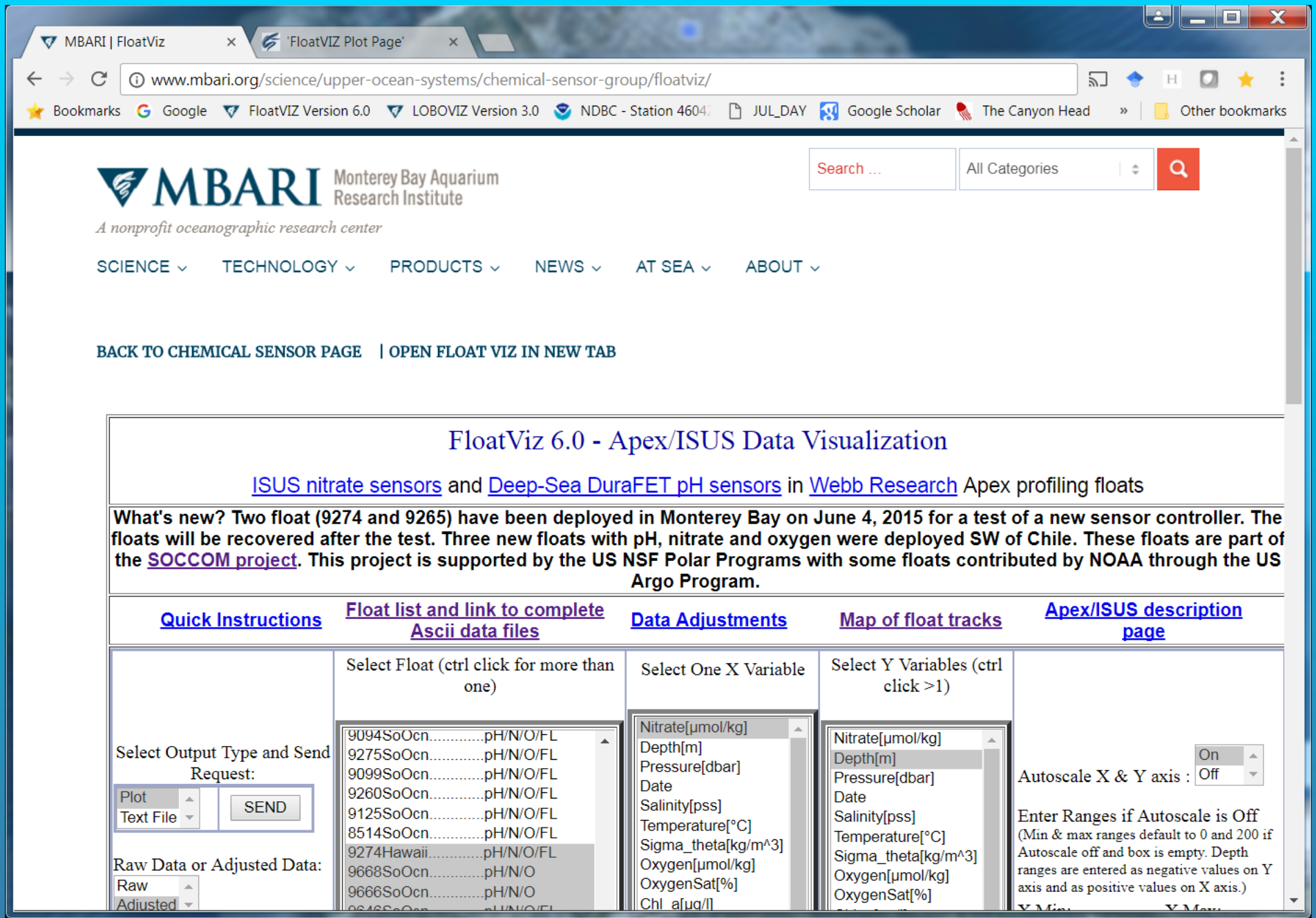
biogeochemical Argo

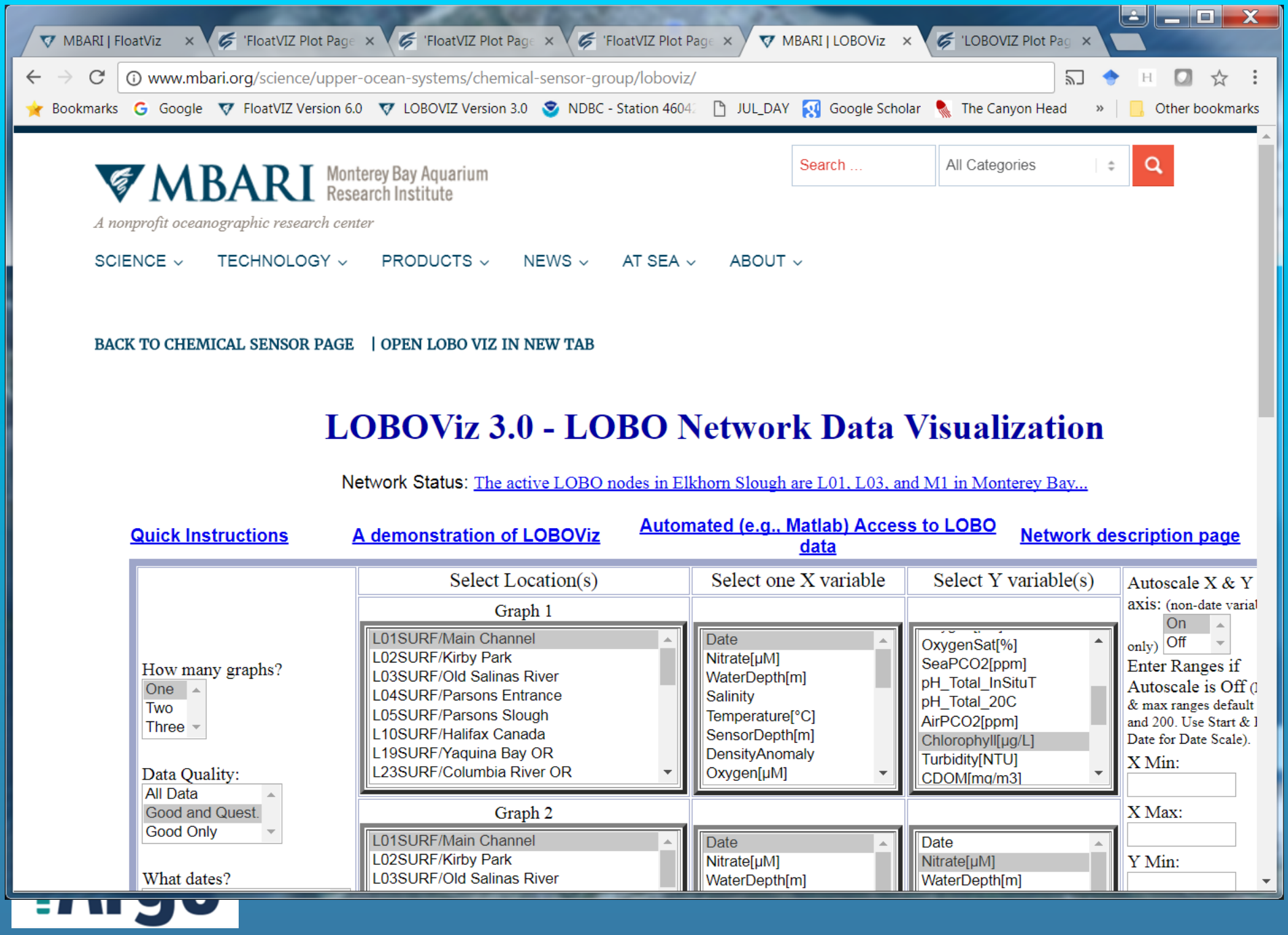
Ocean observing, chemistry, climate, and robots!

Edvard Munch “The Scream” c. 1895

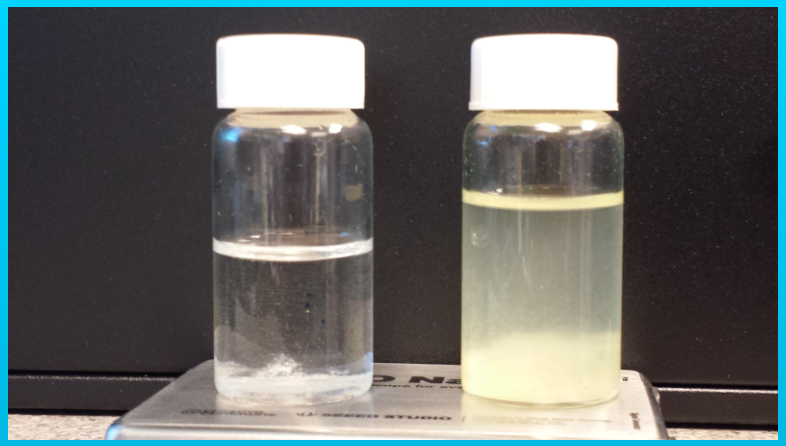
biogeochemical Argo

Thanks to Kelly Lance, MBARI


MBARI | FloatViz
'FloatVIZ Plot Page'
www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/floatviz/
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
MBARI Monterey Bay Aquarium Research Institute
A nonprofit oceanographic research center
Search ...
All Categories
SCIENCE
TECHNOLOGY
PRODUCTS
NEWS
AT SEA
ABOUT
BACK TO CHEMICAL SENSOR PAGE
| OPEN FLOAT VIZ IN NEW TAB
FloatViz 6.0 - Apex/ISUS Data Visualization
ISUS nitrate sensors and Deep-Sea DuraFET pH sensors in Webb Research Apex profiling floats
What's new? Two float (9274 and 9265) have been deployed in Monterey Bay on June 4, 2015 for a test of a new sensor controller. The floats will be recovered after the test. Three new floats with pH, nitrate and oxygen were deployed SW of Chile. These floats are part of the SOCCOM project. This project is supported by the US NSF Polar Programs with some floats contributed by NOAA through the US Argo Program.
Quick Instructions
Float list and link to complete Ascii data files
Data Adjustments
Map of float tracks
Apex/ISUS description page
Select Output Type and Send Request:
Plot
Text File
SEND
Raw Data or Adjusted Data:
Raw
Adjusted
Select Float (ctrl click for more than one)
9094SoOcn.....pH/N/O/FL
9275SoOcn.....pH/N/O/FL
9099SoOcn.....pH/N/O/FL
9260SoOcn.....pH/N/O/FL
9125SoOcn.....pH/N/O/FL
8514SoOcn.....pH/N/O/FL
9274Hawaii.....pH/N/O/FL
9668SoOcn.....pH/N/O
9666SoOcn.....pH/N/O
Select One X Variable
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
Select Y Variables (ctrl click >1)
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Autoscale X & Y axis :
On
Off
Enter Ranges if Autoscale is Off
(Min & max ranges default to 0 and 200 if Autoscale off and box is empty. Depth ranges are entered as negative values on Y axis and as positive values on X axis.)


MBARI | FloatViz
'FloatVIZ Plot Page
'FloatVIZ Plot Page
'FloatVIZ Plot Page
MBARI | LOBOViz
'LOBOVIZ Plot Pag
www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/loboviz/
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
MBARI Monterey Bay Aquarium Research Institute
A nonprofit oceanographic research center
Search ...
All Categories
SCIENCE
TECHNOLOGY
PRODUCTS
NEWS
AT SEA
ABOUT
BACK TO CHEMICAL SENSOR PAGE
| OPEN LOBO VIZ IN NEW TAB
LOBOViz 3.0 - LOBO Network Data Visualization
Network Status: The active LOBO nodes in Elkhorn Slough are L01, L03, and M1 in Monterey Bay...
Quick Instructions
A demonstration of LOBOViz
Automated (e.g., Matlab) Access to LOBO data
Network description page
How many graphs?
One
Two
Three
Data Quality:
All Data
Good and Quest.
Good Only
What dates?
Select Location(s)
Graph 1
L01SURF/Main Channel
L02SURF/Kirby Park
L03SURF/Old Salinas River
L04SURF/Parsons Entrance
L05SURF/Parsons Slough
L10SURF/Halifax Canada
L19SURF/Yaquina Bay OR
L23SURF/Columbia River OR
Select one X variable
Date
Nitrate[µM]
WaterDepth[m]
Salinity
Temperature[°C]
SensorDepth[m]
DensityAnomaly
Oxygen[µM]
Select Y variable(s)
OxygenSat[%]
SeaPCO2[ppm]
pH_Total_InSituT
pH_Total_20C
AirPCO2[ppm]
Chlorophyll[µg/L]
Turbidity[NTU]
CDOM[mg/m3]
Autoscale X & Y axis: (non-date variables only)
On
Off
Enter Ranges if Autoscale is Off
& max ranges default and 200. Use Start & E Date for Date Scale).
X Min:
X Max:
Y Min:
Graph 2
L01SURF/Main Channel
L02SURF/Kirby Park
L03SURF/Old Salinas River
Date
Nitrate[µM]
WaterDepth[m]
Date
Nitrate[µM]
WaterDepth[m]

Open ocean plankton tow



Coastal ocean plankton tow

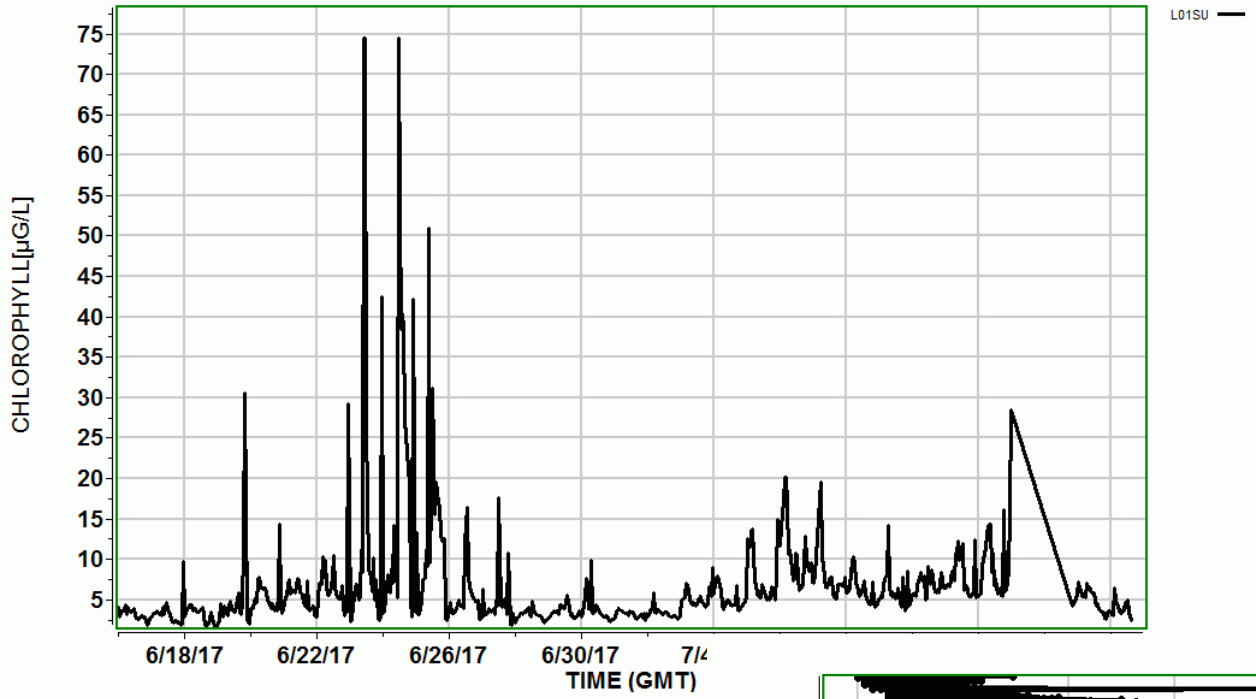
Question 1 : Why is the open ocean tow clearer?

A. .

B. Fewer phytoplankton (microscopic, photosynthetic organisms).

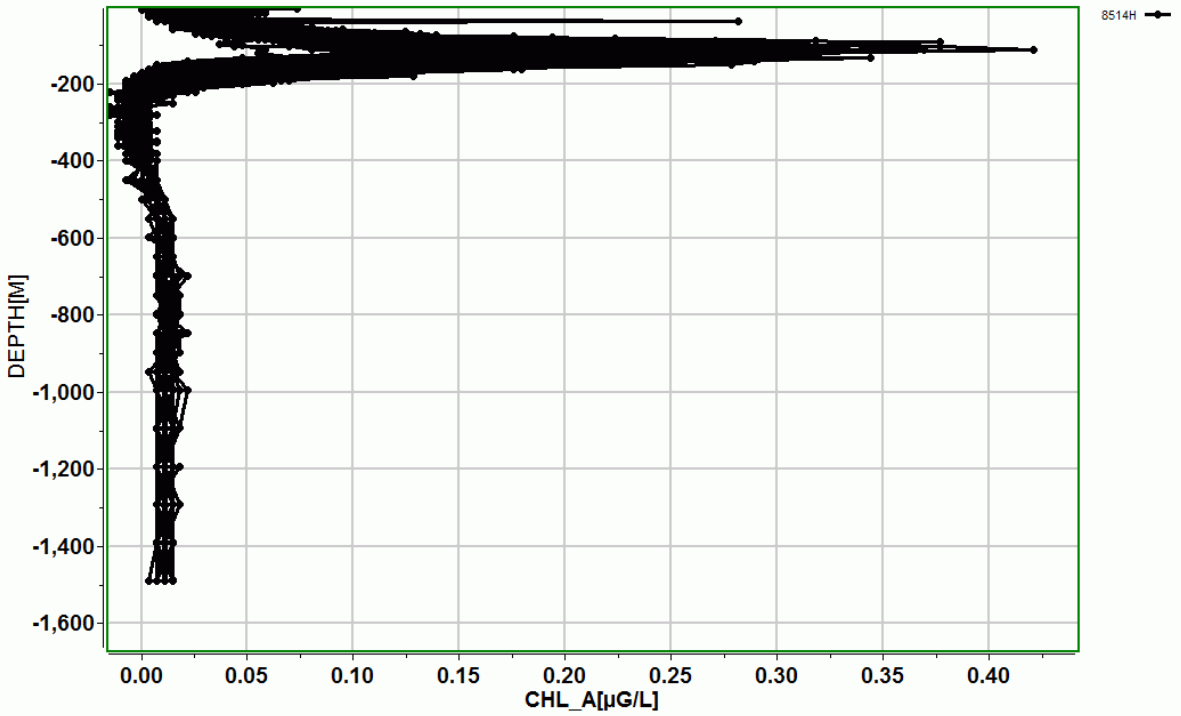
C.

biogeochemical Argo

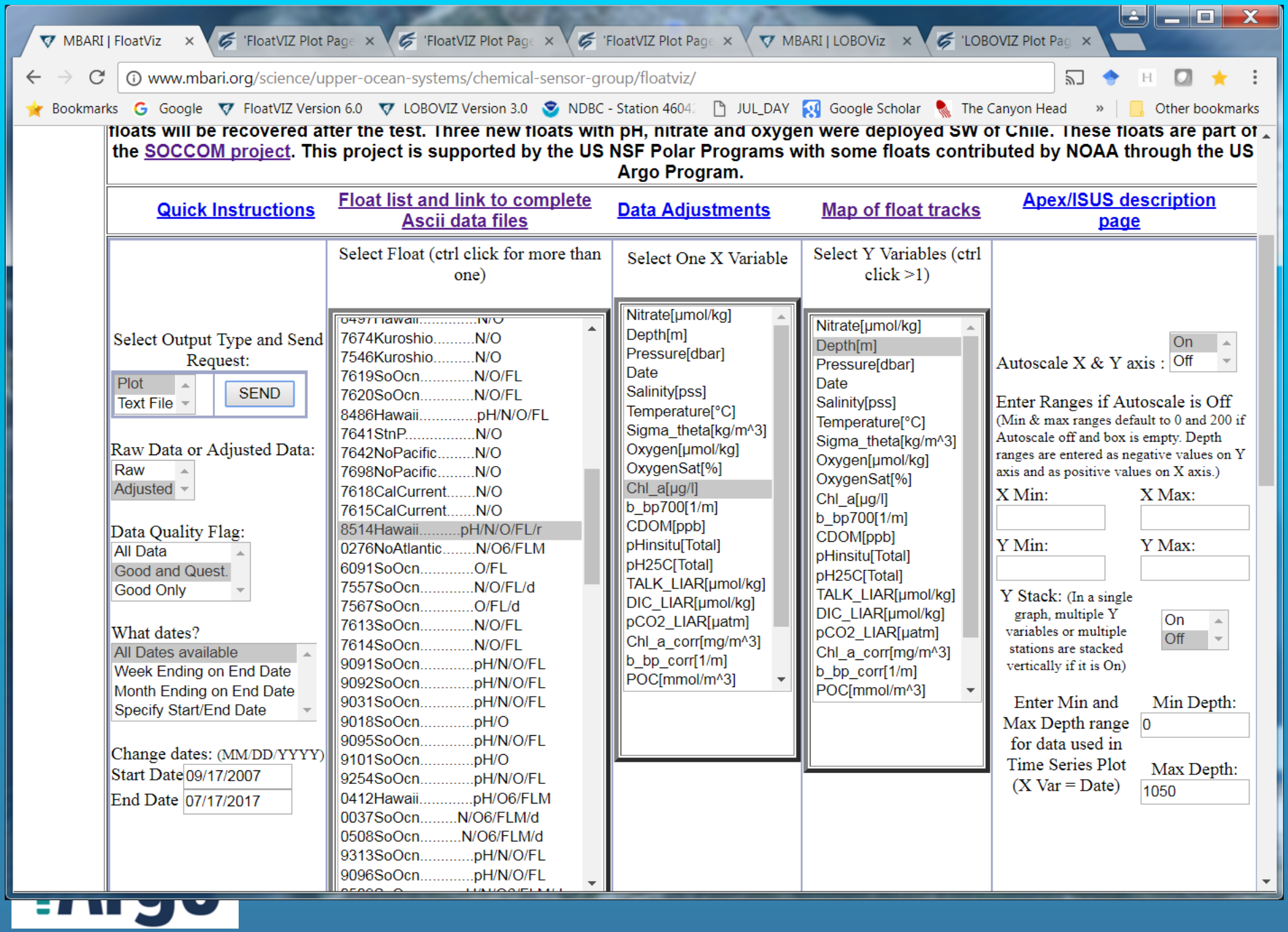


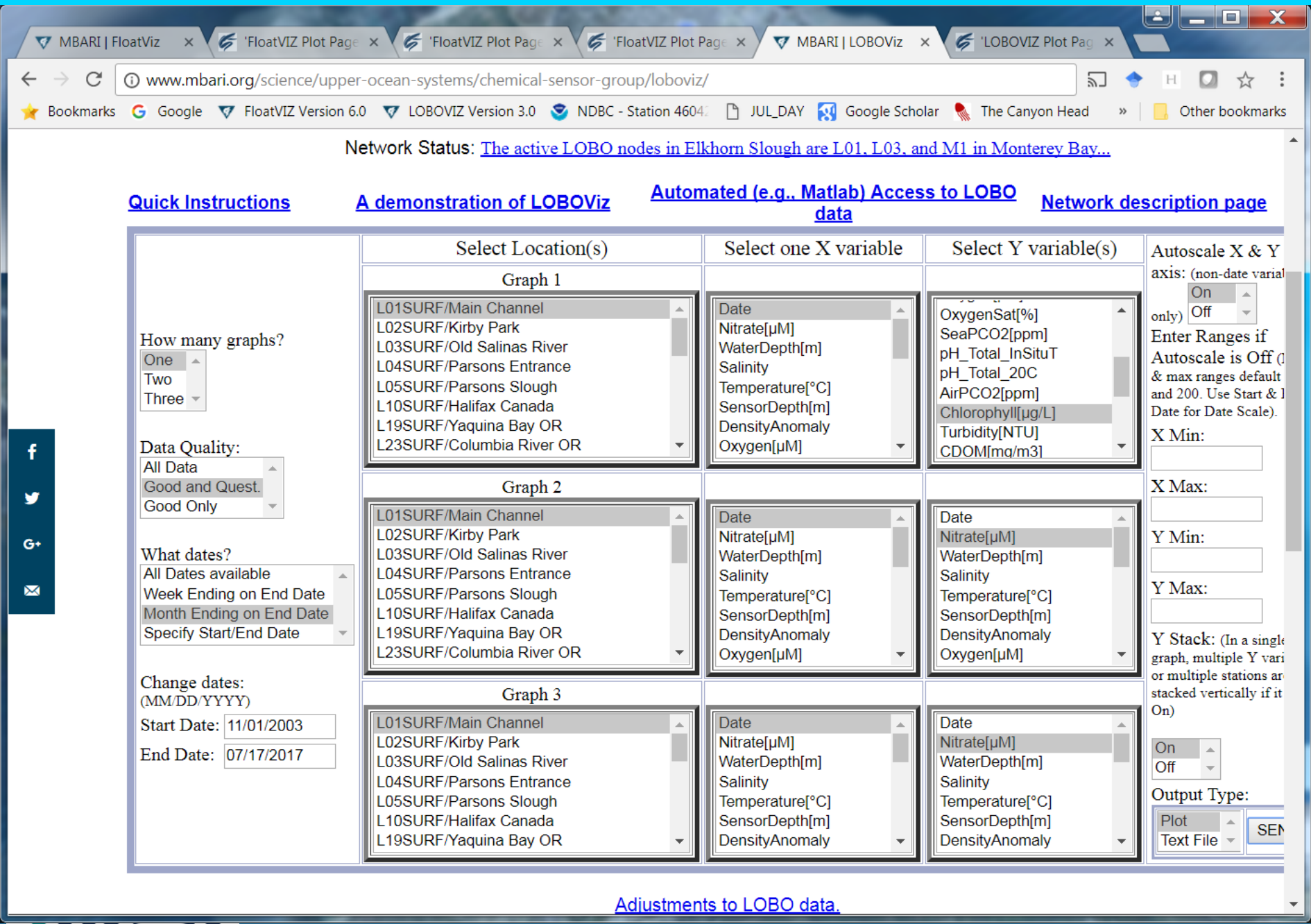
LOBO L01 mooring near coast (water depth 8 m)

Float 8514 open ocean near Hawaii (water depth 4500 m)

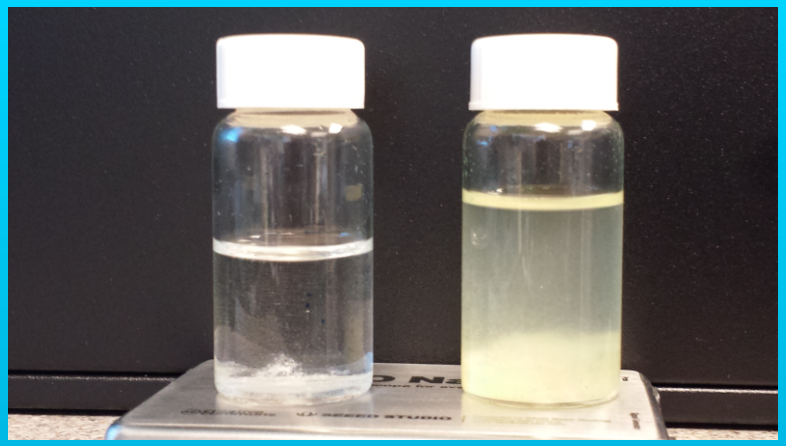


biogeochemical Argo


MBARI | FloatViz
'FloatVIZ Plot Page
'FloatVIZ Plot Page
'FloatVIZ Plot Page
MBARI | LOBOViz
'LOBOVIZ Plot Pag
www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/floatviz/
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
floats will be recovered after the test. Three new floats with pH, nitrate and oxygen were deployed SW of Chile. These floats are part of the SOCCOM project. This project is supported by the US NSF Polar Programs with some floats contributed by NOAA through the US Argo Program.
Quick Instructions
Float list and link to complete Ascii data files
Data Adjustments
Map of float tracks
Apex/ISUS description page
Select Output Type and Send Request:
Plot
Text File
SEND
Raw Data or Adjusted Data:
Raw
Adjusted
Data Quality Flag:
All Data
Good and Quest.
Good Only
What dates?
All Dates available
Week Ending on End Date
Month Ending on End Date
Specify Start/End Date
Change dates: (MM/DD/YYYY)
Start Date 09/17/2007
End Date 07/17/2017
Select Float (ctrl click for more than one)
7674Kuroshio.....N/O
7546Kuroshio.....N/O
7619SoOcn.....N/O/FL
7620SoOcn.....N/O/FL
8486Hawaii.....pH/N/O/FL
7641StnP.....N/O
7642NoPacific.....N/O
7698NoPacific.....N/O
7618CalCurrent.....N/O
7615CalCurrent.....N/O
8514Hawaii.....pH/N/O/FL/r
0276NoAtlantic.....N/O6/FLM
6091SoOcn.....O/FL
7557SoOcn.....N/O/FL/d
7567SoOcn.....O/FL/d
7613SoOcn.....N/O/FL
7614SoOcn.....N/O/FL
9091SoOcn.....pH/N/O/FL
9092SoOcn.....pH/N/O/FL
9031SoOcn.....pH/N/O/FL
9018SoOcn.....pH/O
9095SoOcn.....pH/N/O/FL
9101SoOcn.....pH/O
9254SoOcn.....pH/N/O/FL
0412Hawaii.....pH/O6/FLM
0037SoOcn.....N/O6/FLM/d
0508SoOcn.....N/O6/FLM/d
9313SoOcn.....pH/N/O/FL
9096SoOcn.....pH/N/O/FL
Select One X Variable
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Select Y Variables (ctrl click >1)
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Autoscale X & Y axis : On Off
Enter Ranges if Autoscale is Off
(Min & max ranges default to 0 and 200 if Autoscale off and box is empty. Depth ranges are entered as negative values on Y axis and as positive values on X axis.)
X Min:
X Max:
Y Min:
Y Max:
Y Stack: (In a single graph, multiple Y variables or multiple stations are stacked vertically if it is On)
On
Off
Enter Min and Max Depth range for data used in Time Series Plot (X Var = Date)
Min Depth: 0
Max Depth: 1050


MBARI | FloatViz
'FloatVIZ Plot Page
'FloatVIZ Plot Page
'FloatVIZ Plot Page
MBARI | LOBOViz
'LOBOVIZ Plot Pag
www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/loboviz/
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
Network Status: The active LOBO nodes in Elkhorn Slough are L01, L03, and M1 in Monterey Bay...
Quick Instructions
A demonstration of LOBOViz
Automated (e.g., Matlab) Access to LOBO data
Network description page
How many graphs?
One
Two
Three
Data Quality:
All Data
Good and Quest.
Good Only
What dates?
All Dates available
Week Ending on End Date
Month Ending on End Date
Specify Start/End Date
Change dates:
(MM/DD/YYYY)
Start Date: 11/01/2003
End Date: 07/17/2017
Select Location(s)
Select one X variable
Select Y variable(s)
Graph 1
L01SURF/Main Channel
L02SURF/Kirby Park
L03SURF/Old Salinas River
L04SURF/Parsons Entrance
L05SURF/Parsons Slough
L10SURF/Halifax Canada
L19SURF/Yaquina Bay OR
L23SURF/Columbia River OR
Date
Nitrate[µM]
WaterDepth[m]
Salinity
Temperature[°C]
SensorDepth[m]
DensityAnomaly
Oxygen[µM]
OxygenSat[%]
SeaPCO2[ppm]
pH_Total_InSituT
pH_Total_20C
AirPCO2[ppm]
Chlorophyll[µg/L]
Turbidity[NTU]
CDOM[mg/m3]
Graph 2
Graph 3
Autoscale X & Y axis: (non-date variables only)
On
Off
Enter Ranges if Autoscale is Off (
& max ranges default
and 200. Use Start &
Date for Date Scale).
X Min:
X Max:
Y Min:
Y Max:
Y Stack: (In a single graph, multiple Y vari or multiple stations ar stacked vertically if it On)
On
Off
Output Type:
Plot
Text File
SEN
Adjustments to LOBO data.

Open ocean plankton tow



Coastal ocean plankton tow

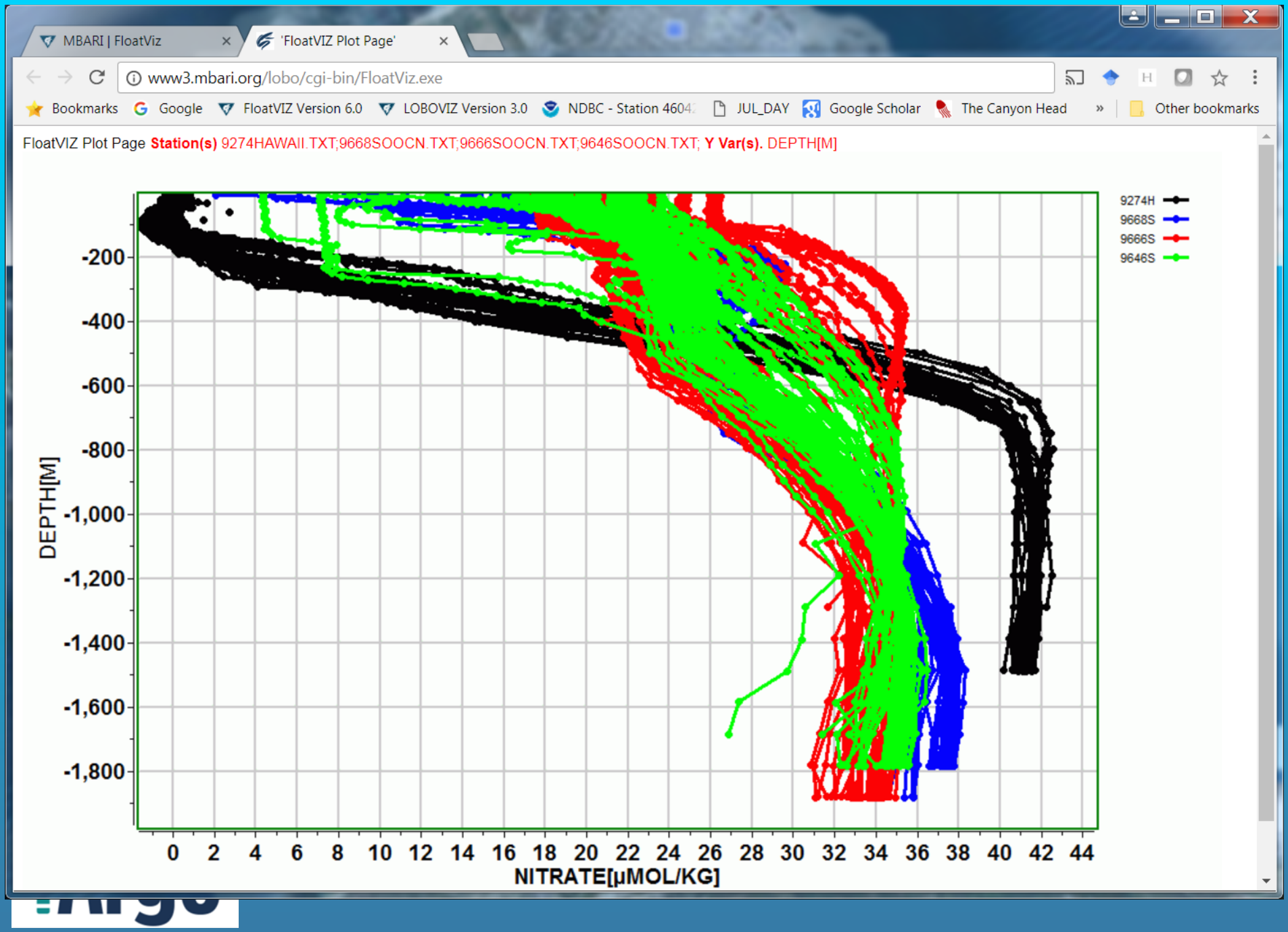
Question 2 : Why are there few plankton in the open ocean?

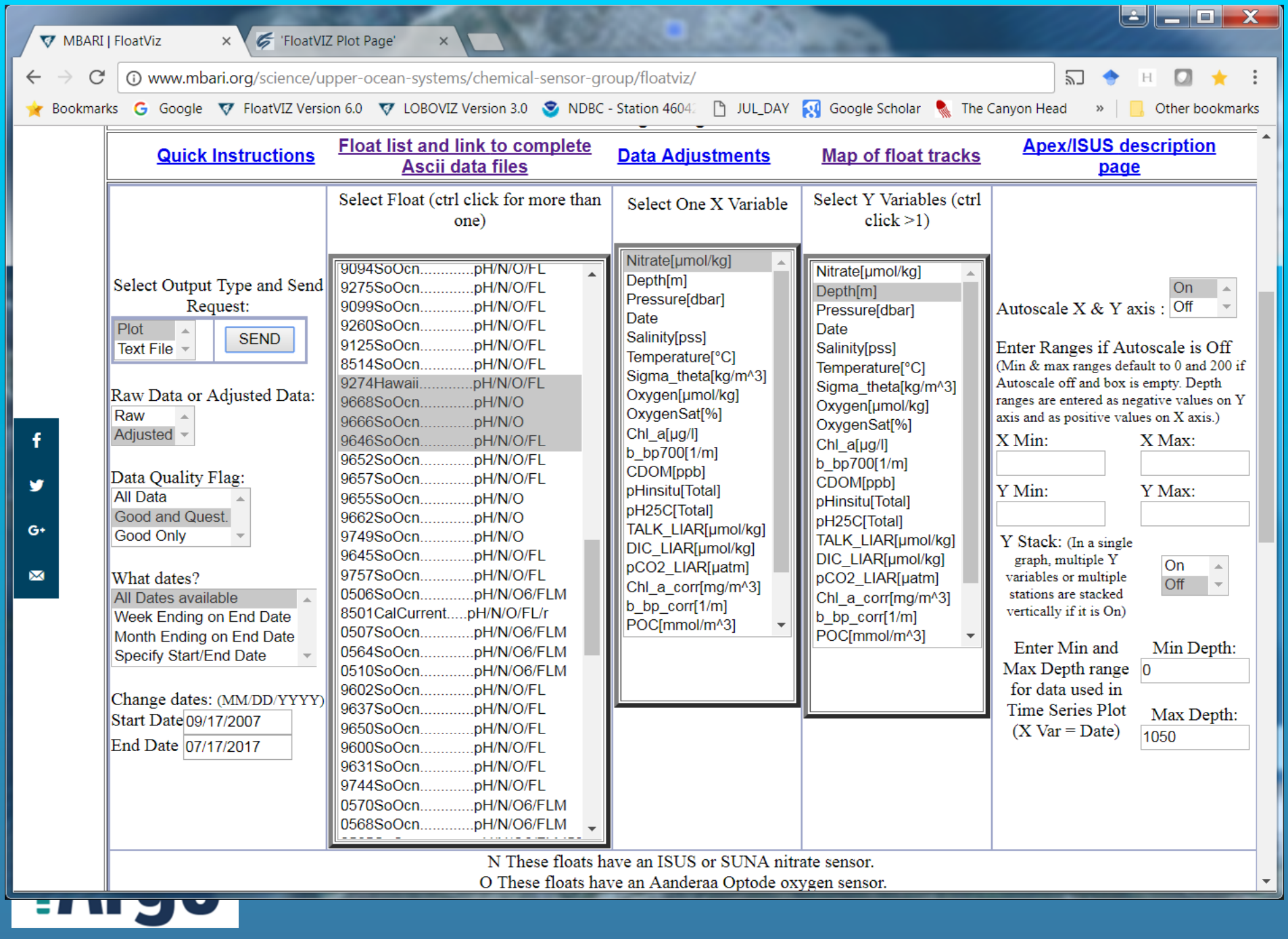
A. .

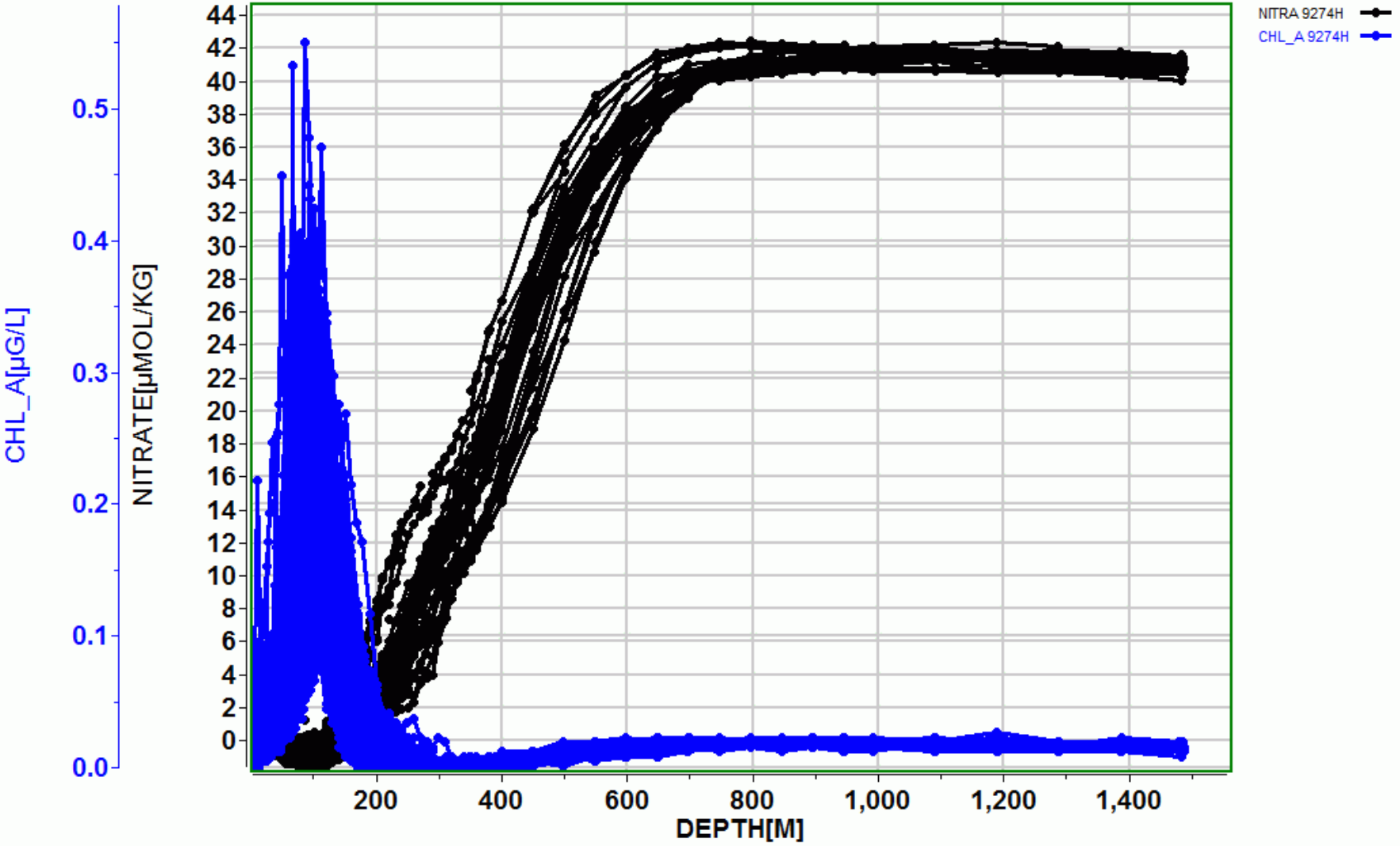
B. .

C. There is not enough fertilizer (Nitrate, Phosphate, Iron).

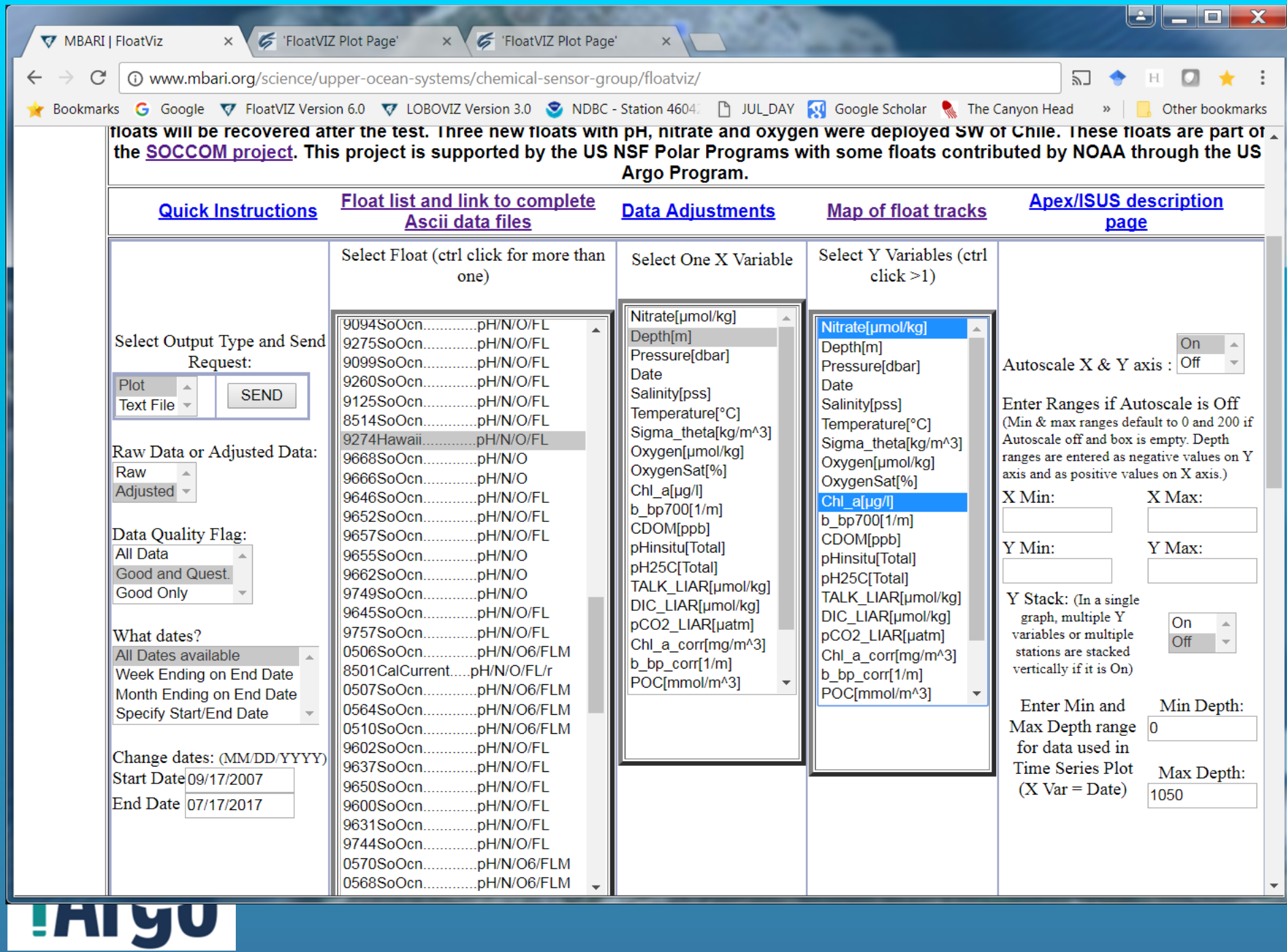
biogeochemical Argo


MBARI | FloatViz
'FloatVIZ Plot Page'
www3.mbari.org/lobo/cgi-bin/FloatViz.exe
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
FloatVIZ Plot Page Station(s) 9274HAWAII.TXT;9668SOOCN.TXT;9666SOOCN.TXT;9646SOOCN.TXT; Y Var(s). DEPTH[M]
9274H
9668S
9666S
9646S
DEPTH[M]
-200
-400
-600
-800
-1,000
-1,200
-1,400
-1,600
-1,800
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44
NITRATE[µMOL/KG]


MBARI | FloatViz
'FloatVIZ Plot Page'
www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/floatviz/
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
Quick Instructions
Float list and link to complete Ascii data files
Data Adjustments
Map of float tracks
Apex/ISUS description page
Select Output Type and Send Request:
Plot
Text File
SEND
Raw Data or Adjusted Data:
Raw
Adjusted
Data Quality Flag:
All Data
Good and Quest.
Good Only
What dates?
All Dates available
Week Ending on End Date
Month Ending on End Date
Specify Start/End Date
Change dates: (MM/DD/YYYY)
Start Date 09/17/2007
End Date 07/17/2017
Select Float (ctrl click for more than one)
9094SoOcn.....pH/N/O/FL
9275SoOcn.....pH/N/O/FL
9099SoOcn.....pH/N/O/FL
9260SoOcn.....pH/N/O/FL
9125SoOcn.....pH/N/O/FL
8514SoOcn.....pH/N/O/FL
9274Hawaii.....pH/N/O/FL
9668SoOcn.....pH/N/O
9666SoOcn.....pH/N/O
9646SoOcn.....pH/N/O/FL
9652SoOcn.....pH/N/O/FL
9657SoOcn.....pH/N/O/FL
9655SoOcn.....pH/N/O
9662SoOcn.....pH/N/O
9749SoOcn.....pH/N/O
9645SoOcn.....pH/N/O/FL
9757SoOcn.....pH/N/O/FL
0506SoOcn.....pH/N/O6/FLM
8501CalCurrent.....pH/N/O/FL/r
0507SoOcn.....pH/N/O6/FLM
0564SoOcn.....pH/N/O6/FLM
0510SoOcn.....pH/N/O6/FLM
9602SoOcn.....pH/N/O/FL
9637SoOcn.....pH/N/O/FL
9650SoOcn.....pH/N/O/FL
9600SoOcn.....pH/N/O/FL
9631SoOcn.....pH/N/O/FL
9744SoOcn.....pH/N/O/FL
0570SoOcn.....pH/N/O6/FLM
0568SoOcn.....pH/N/O6/FLM
Select One X Variable
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Select Y Variables (ctrl click >1)
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Autoscale X & Y axis : On Off
Enter Ranges if Autoscale is Off
(Min & max ranges default to 0 and 200 if Autoscale off and box is empty. Depth ranges are entered as negative values on Y axis and as positive values on X axis.)
X Min:
X Max:
Y Min:
Y Max:
Y Stack: (In a single graph, multiple Y variables or multiple stations are stacked vertically if it is On)
On Off
Enter Min and Max Depth range for data used in Time Series Plot (X Var = Date)
Min Depth: 0
Max Depth: 1050
N These floats have an ISUS or SUNA nitrate sensor.
O These floats have an Aanderaa Optode oxygen sensor.



biogeochemical Argo


MBARI | FloatViz
'FloatVIZ Plot Page'
'FloatVIZ Plot Page'
www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/floatviz/
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
floats will be recovered after the test. Three new floats with pH, nitrate and oxygen were deployed SW of Chile. These floats are part of the SOCCOM project. This project is supported by the US NSF Polar Programs with some floats contributed by NOAA through the US Argo Program.
Quick Instructions
Float list and link to complete Ascii data files
Data Adjustments
Map of float tracks
Apex/ISUS description page
Select Output Type and Send Request:
Plot
Text File
SEND
Raw Data or Adjusted Data:
Raw
Adjusted
Data Quality Flag:
All Data
Good and Quest.
Good Only
What dates?
All Dates available
Week Ending on End Date
Month Ending on End Date
Specify Start/End Date
Change dates: (MM/DD/YYYY)
Start Date 09/17/2007
End Date 07/17/2017
Select Float (ctrl click for more than one)
9094SoOcn.....pH/N/O/FL
9275SoOcn.....pH/N/O/FL
9099SoOcn.....pH/N/O/FL
9260SoOcn.....pH/N/O/FL
9125SoOcn.....pH/N/O/FL
8514SoOcn.....pH/N/O/FL
9274Hawaii.....pH/N/O/FL
9668SoOcn.....pH/N/O
9666SoOcn.....pH/N/O
9646SoOcn.....pH/N/O/FL
9652SoOcn.....pH/N/O/FL
9657SoOcn.....pH/N/O/FL
9655SoOcn.....pH/N/O
9662SoOcn.....pH/N/O
9749SoOcn.....pH/N/O
9645SoOcn.....pH/N/O/FL
9757SoOcn.....pH/N/O/FL
0506SoOcn.....pH/N/O6/FLM
8501CalCurrent.....pH/N/O/FL/r
0507SoOcn.....pH/N/O6/FLM
0564SoOcn.....pH/N/O6/FLM
0510SoOcn.....pH/N/O6/FLM
9602SoOcn.....pH/N/O/FL
9637SoOcn.....pH/N/O/FL
9650SoOcn.....pH/N/O/FL
9600SoOcn.....pH/N/O/FL
9631SoOcn.....pH/N/O/FL
9744SoOcn.....pH/N/O/FL
0570SoOcn.....pH/N/O6/FLM
0568SoOcn.....pH/N/O6/FLM
Select One X Variable
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Select Y Variables (ctrl click >1)
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Autoscale X & Y axis : On Off
Enter Ranges if Autoscale is Off
(Min & max ranges default to 0 and 200 if Autoscale off and box is empty. Depth ranges are entered as negative values on Y axis and as positive values on X axis.)
X Min:
X Max:
Y Min:
Y Max:
Y Stack: (In a single graph, multiple Y variables or multiple stations are stacked vertically if it is On)
On
Off
Enter Min and Max Depth range for data used in Time Series Plot (X Var = Date)
Min Depth: 0
Max Depth: 1050

Looking down Moro Cojo Slough to Moss Landing Harbor. Where's the water? Why can't we see it?

A. .

B. .

C. Too much fertilizer from land to water – that's eutrophication.

Oceans are undergoing remarkable stresses:

- warming,
- acidification,
- nutrient supply,
- melting ice,
- losing oxygen,
- over fishing,
- circulation changes….

biogeochemical Argo

“Given the prominent role of the ocean in the Earth system as a vital service provider, one wonders why so little attention is still paid to its physical state and the health of its ecosystems in the policy arena. Should we not step up efforts to better measure, understand, and project ocean processes?”

Thomas Stocker, Science, 2015

biogeochemical Argo

Fate of anthropogenic CO_2 emissions (2006-2015)

34.1 $GtCO_2$/yr

91%

9%

3.5 $GtCO_2$/yr

Sources = Sinks

16.4 $GtCO_2$/yr

44%

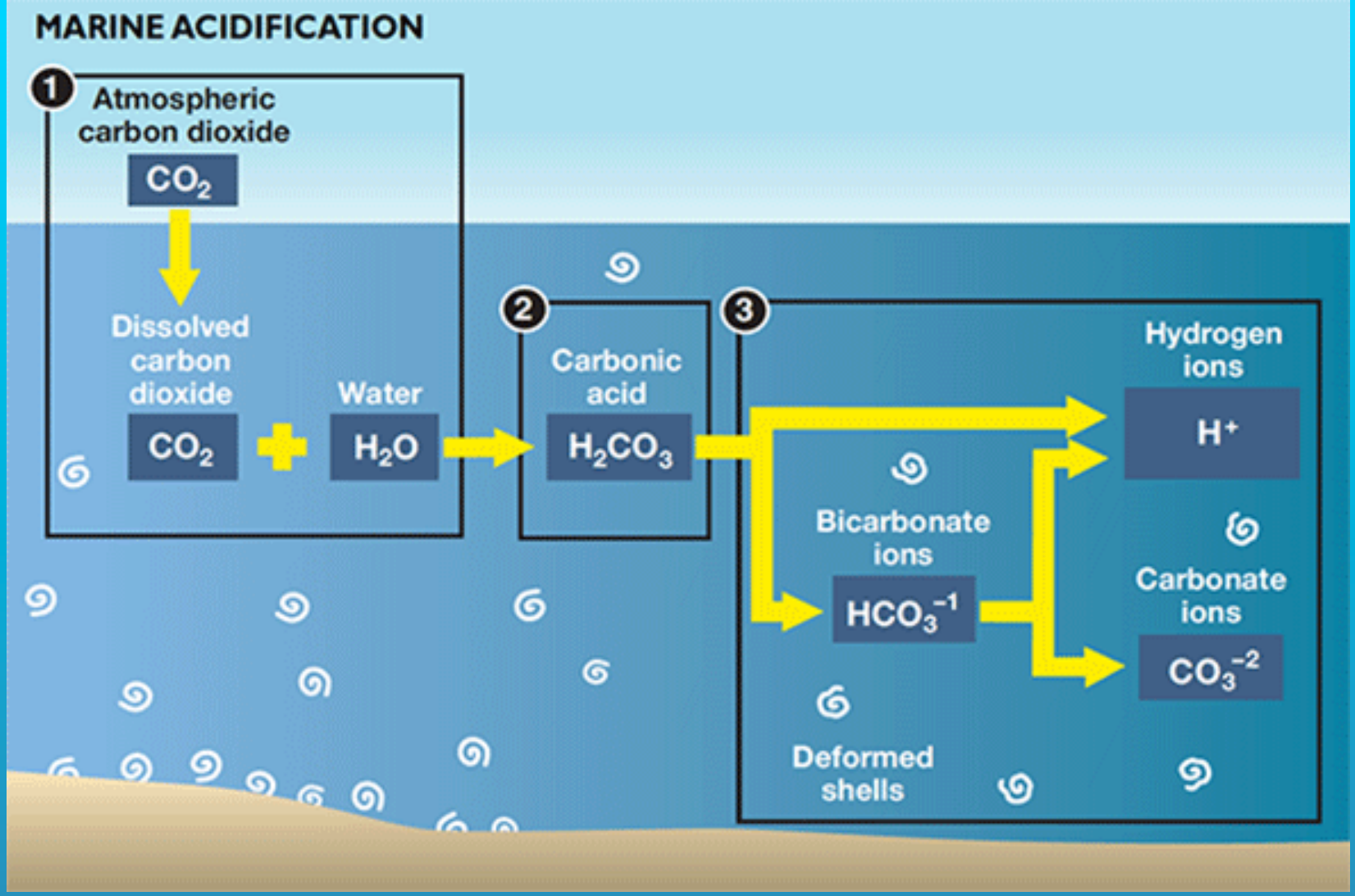
31%

11.6 $GtCO_2$/yr

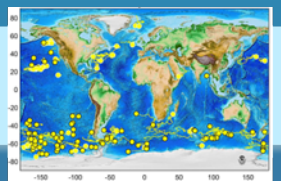
26%

9.7 $GtCO_2$/yr

Source: CDIAC; NOAA-ESRL; Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2016; Global Carbon Budget 2016



$$H_2CO_3 + CO_3^{2-} \rightarrow 2\ HCO_3^-$$



Southern Ocean acidification: A tipping point at 450-ppm atmospheric CO_2

Ben I. McNeil[a,1] and Richard J. Matear[b]

18860–18864 | PNAS | December 2, 2008 | vol. 105 | no. 48

nature geoscience

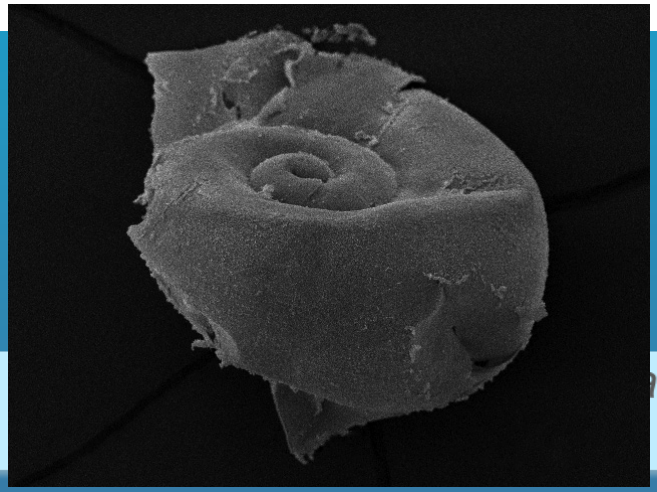
LETTERS

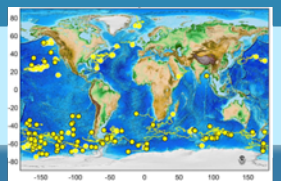
PUBLISHED ONLINE: 25 NOVEMBER 2012 | DOI: 10.1038/NGEO1635

Extensive dissolution of live pteropods in the Southern Ocean

$$CaCO_3 \rightarrow Ca^{2+} + CO_3^{2-}$$

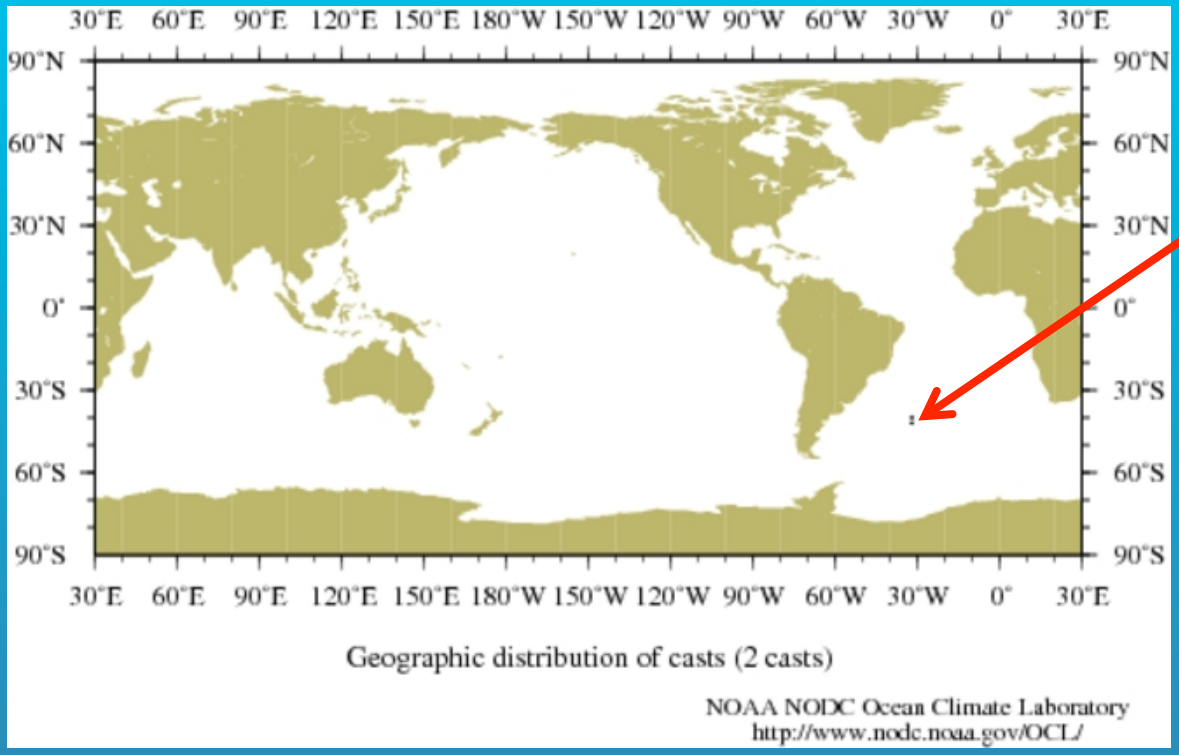
N. Bednaršek[1,2,3], G. A. Tarling[1]*, D. C. E. Bakker[2], S. Fielding[1], E. M. Jones[4], H. J. Venables[1], P. Ward[1], A. Kuzirian[5], B. Lézé[2], R. A. Feely[6] and E. J. Murphy[1]





NATIONAL OCEANOGRAPHIC DATA CENTER (NODC)
UNITED STATES DEPARTMENT OF COMMERCE

- 55,584 pH profiles since measurements were standardized (1990) in US National Ocean Database



For 1990 – 2016 there are **only 2 pH profiles** found South of 40° S in the database for the Austral Winter (June 1- Sep 31).

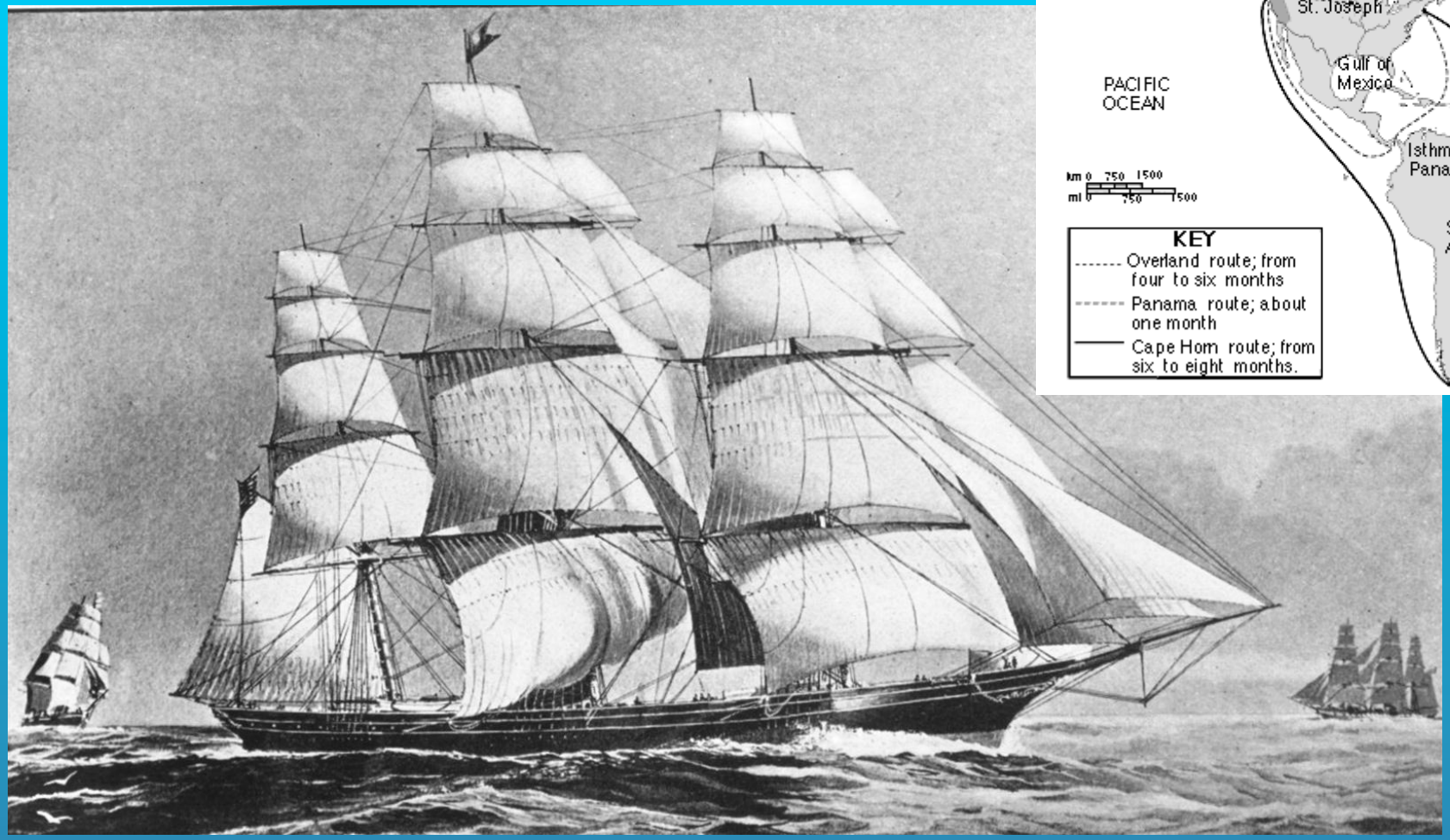
Sampling from ships is not the solution.

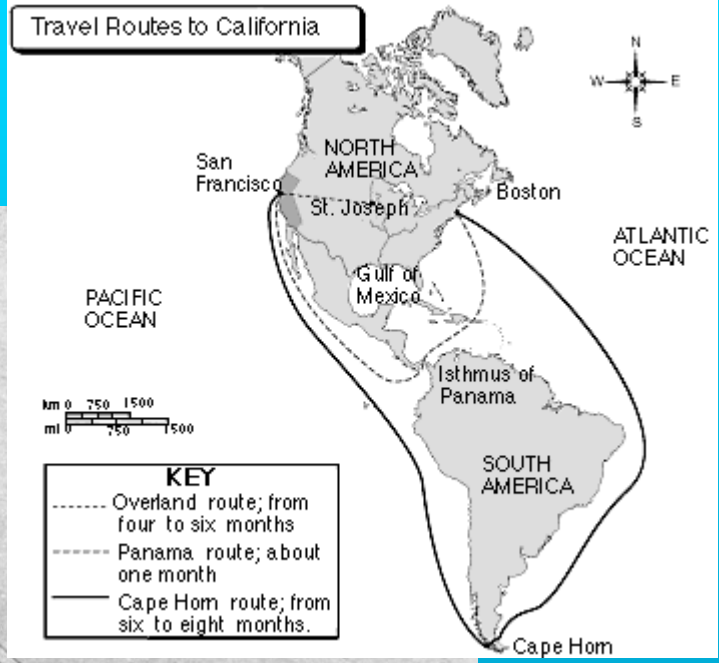
Robotic platforms with chemical & biological sensors are the solution!

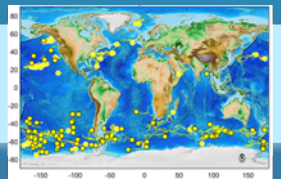
Mon Jun 5 15:55:46 2017
COPY OF YOUR DATABASE SEARCH CRITERIA:
Button back to build a form

OBSERVATION DATES:	**Year** from 1990 to 2014; **Month** from 6 to 9; **Day** from 1 to 30
GEOGRAPHIC COORDINATES:	**Longitude** from -180.0000 to 180.0000; **Latitude** from -40.0000 to -90.0000
DATASET:	OSD,CTD,XBT,MBT,PFL,DRB,MRB,APB,UOR,SUR,GLD
MEASURED VARIABLES (must):	pH

In the 1840 gold rush, it took 3 months to California around Cape Horn!







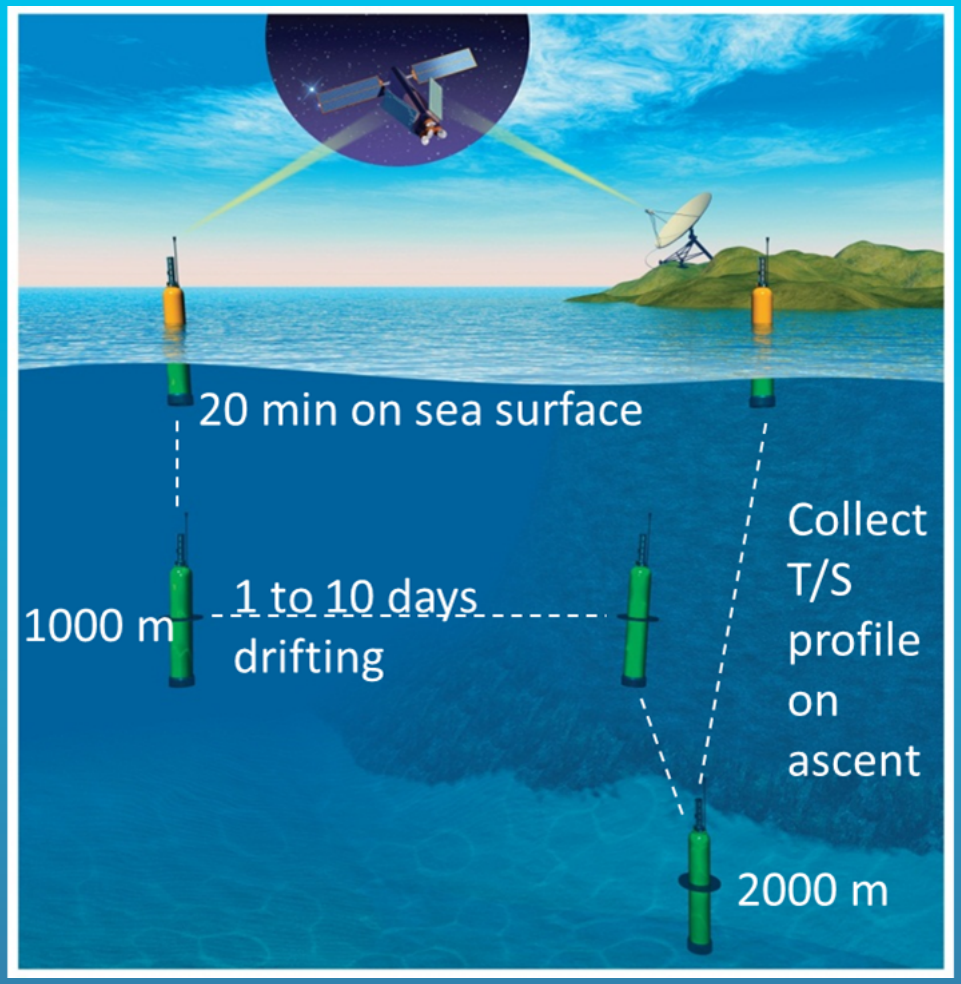
MBARI Chemical Sensor Lab
Global Biogeochemistry

150 years later, the ships used for research still go the same speed. We plan for 10 knot transit speeds and daily costs of $30,000 to $40,000/day.

biogeochemical Argo

The Argo profiling float. The model shown here is an APEX.

280 cycles at 10 day intervals = 7 year lifetime



biogeochemical Argo

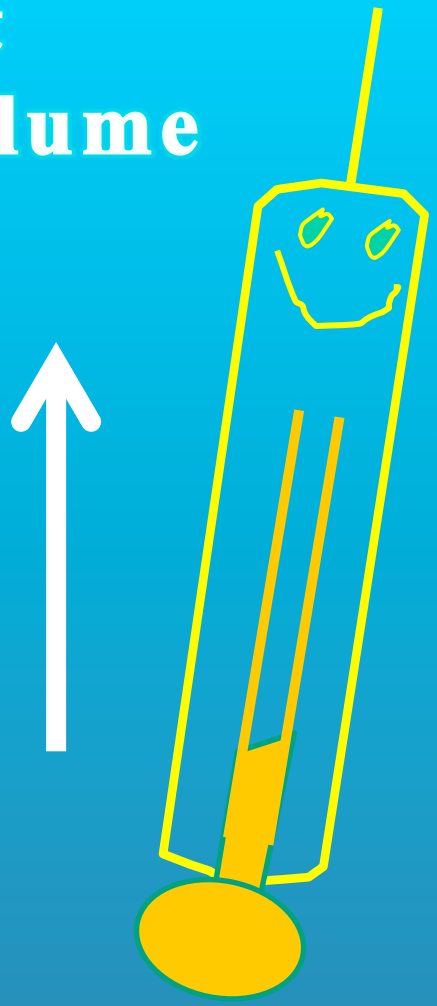
Profiling float
Density = Mass/Volume

Oil inside the float, volume decreased and float sinks

biogeochemical Argo

Profiling float
Density = Mass/Volume

Oil pumped into external bladder, volume increased and float rises



biogeochemical Argo

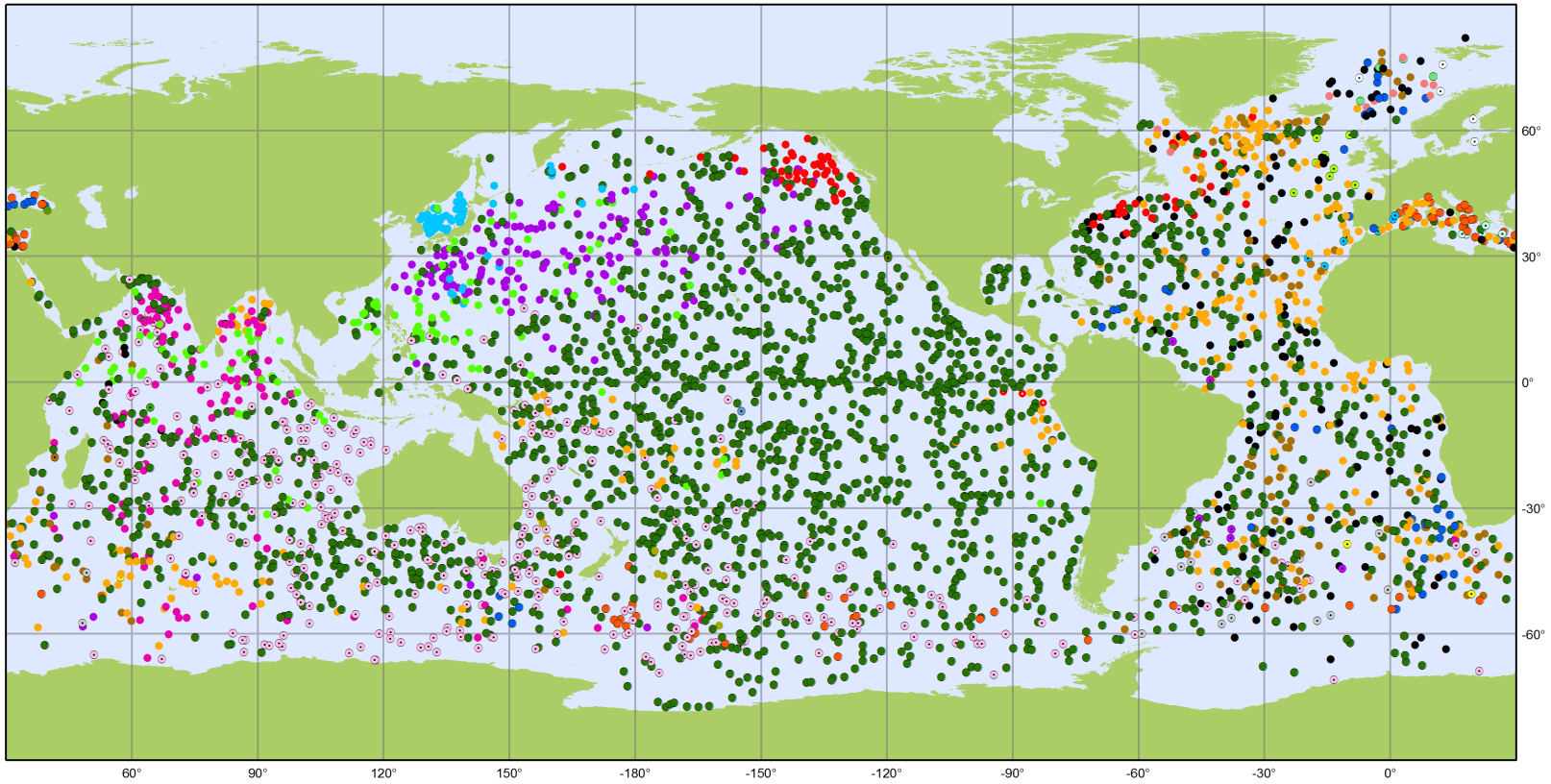
Extra Credit Question:

If density near the surface is 1022 kg/m^3 and 1028 kg/m^3 near 2000 m, how much volume change does a 30 liter (~30 kg) float need to make for a 2000 m vertical profile? (ignore compressibility of water and float)

Also note that oceanographers usual talk about the density anomaly, Sigma_Theta (units of kg/m^3)
= density – 1000

If density = 1022, Sigma_Theta = 22

biogeochemical Argo



Argo

National contributions - 3991 Operational Floats

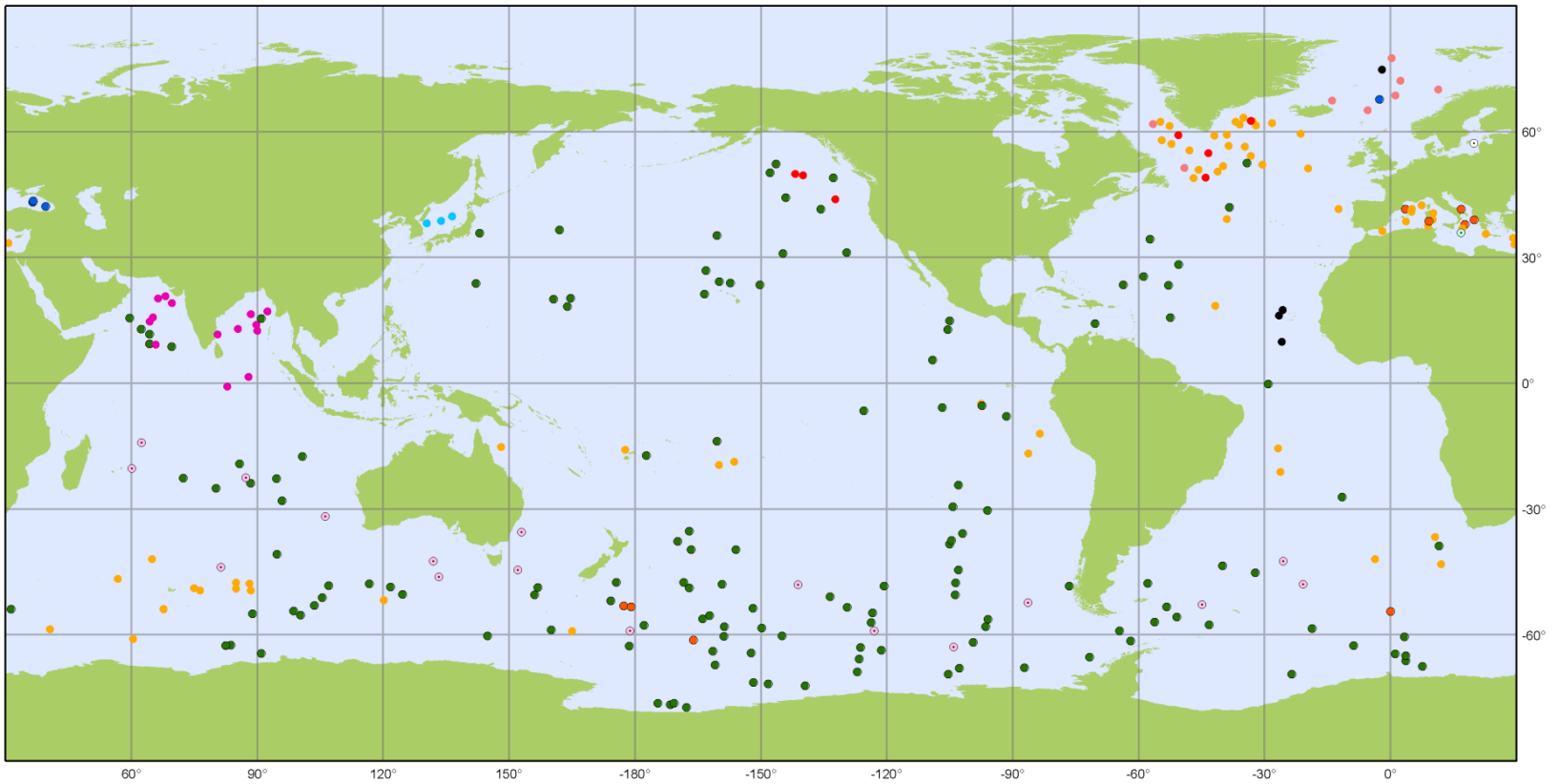
February 2017

Latest location of operational floats (data distributed within the last 30 days)

- ARGENTINA (3)
- AUSTRALIA (387)
- BRAZIL (6)
- BULGARIA (1)
- CANADA (73)
- CHINA (122)
- ECUADOR (1)
- EUROPE (51)
- FINLAND (5)
- FRANCE (324)
- GERMANY (148)
- GREECE (5)
- INDIA (129)
- IRELAND (10)
- ITALY (73)
- JAPAN (162)
- KENYA (1)
- MAURITIUS (1)
- MEXICO (2)
- NETHERLANDS (18)
- NEW ZEALAND (7)
- NORWAY (10)
- PERU (3)
- POLAND (4)
- KOREA, REPUBLIC OF (63)
- SPAIN (8)
- UK (136)
- USA (2239)

Generated by www.jcommops.org, 02/03/2017

biogeochemical Argo



Argo BioGeoChemical

National contributions - 275

Latest location of operational floats (data distributed within the last 30 days)

March 2017

AUSTRALIA (17) EUROPE (4) FRANCE (65) GREECE (1) ITALY (9) NORWAY (8)
CANADA (7) FINLAND (1) GERMANY (4) INDIA (14) KOREA, REPUBLIC OF (3) USA (142)

Also, UK, China, Chile

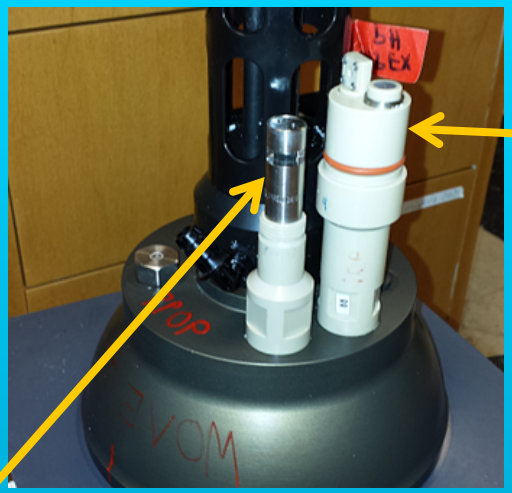
Generated by www.jcommops.org, 10/04/2017

biogeochemical Argo

A set of chemical and biological sensors now exist that track the basics of ocean metabolism:

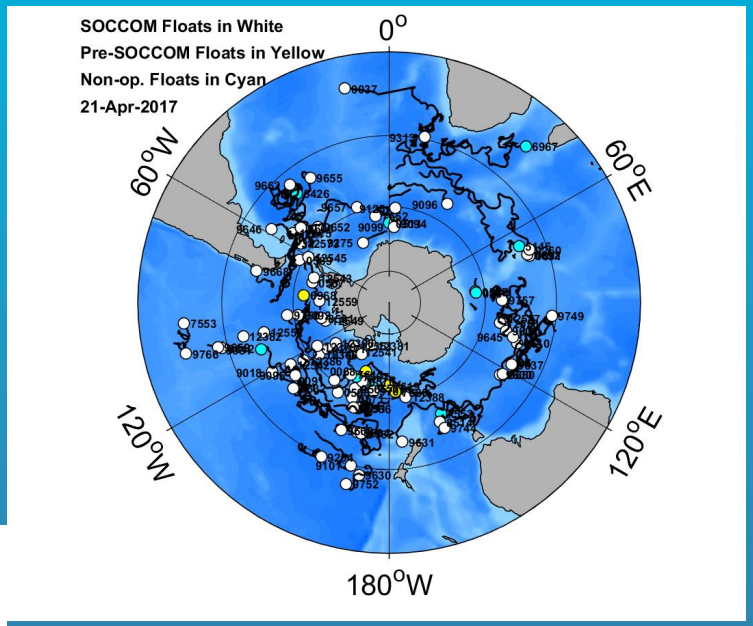
respiration, net production by phytoplankton, biomass, chlorophyll, ocean acidification, ocean deoxygenation….

biogeochemical Argo



MBARI
pH sensor

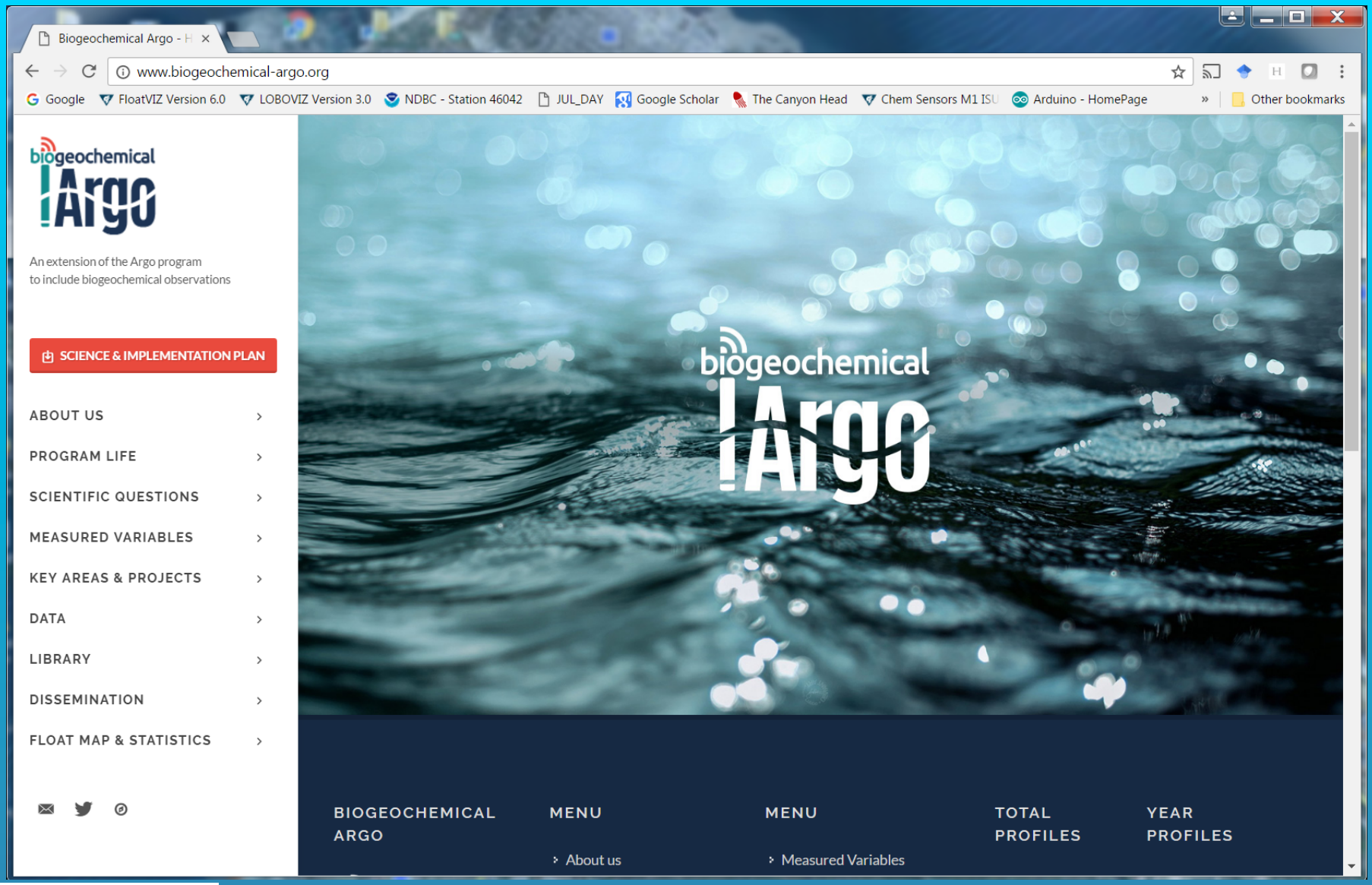
MBARI
nitrate
sensor



Southern Ocean Carbon and Climate Observations and Modeling

soccom.princeton.edu

biogeochemical Argo



biogeochemical Argo

http://biogeochemical-argo.org

What is the role of the Southern Ocean in the global climate system?

1

It accounts for **67-98%** of the excess heat that is transferred from the atmosphere into the ocean each year.

Roemmich et al. 2015

2

It accounts for **up to half** of the annual oceanic uptake of anthropogenic carbon dioxide from the atmosphere.

Gruber et al. 2009, Landschützer et al. 2015

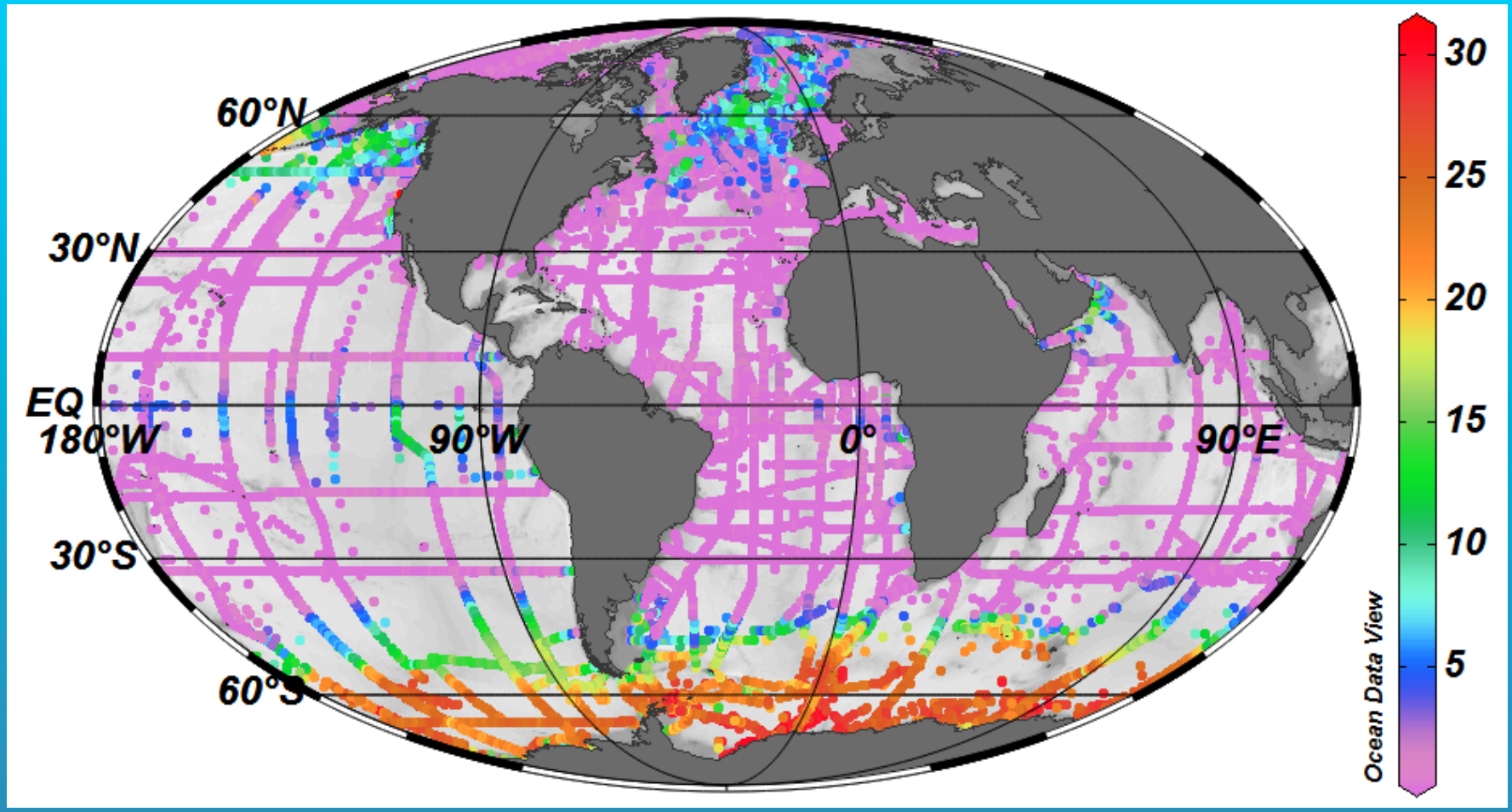
3

Vertical exchange in the Southern Ocean is responsible for supplying nutrients that fertilize **three-quarters** of the biological production in the global ocean north of 30°S.

Sarmiento et al. 2004

biogeochemical Argo

Nitrate (an essential plankton nutrient) at the surface (µmol/kg)



biogeochemical Argo

https://soccom.princeton.edu

Bookmarks | Google | FloatVIZ Version 6.0 | LOBOVIZ Version 3.0 | NDBC - Station 4604 | JUL_DAY | Google Scholar | The Canyon Head | Other bookmarks

SOCCOM

Unlocking the mysteries of the Southern Ocean

BGC Float Data Available Online

Click to access data

SEARCH SOCCOM

ABOUT US | OBSERVATIONS | MODELING | BROADER IMPACTS | NEWS | BLOGS | MEMBERS

- Photos
- Videos
- Presentations & Posters
- Articles
- Publications
- Webinar Series
- Adopt-A-Float Program
- Educational Resources
- Global BGC Argo

Latest News

Follow SOCCOM scientists deploying floats across the South Pacific

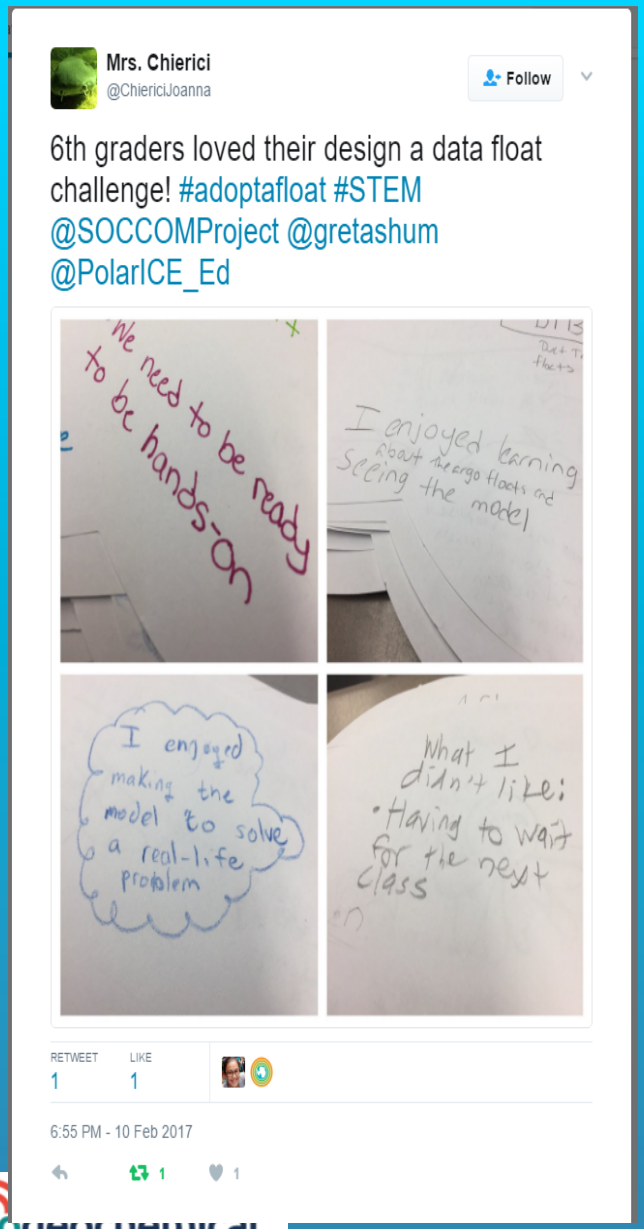
MBARI

SOUTHERN OCEAN CAR TE OBSERVATIONS AND M

The Southern Ocean Carbon and Clim ling project (SOCCOM) is an NSF-sponsored prog e mysteries of the Southern Ocean and determining

Housed at Princeton University and a n Environmental Institute, SOCCOM draws on the stre ors across the U.S. as well as participating in intern nulation efforts.

https://soccom.princeton.edu/content/broader-impacts



AdoptAFloatViz 6.0 - Data visualization for SOCCOM, a US NSF sponsored project focused on carbon and climate in the Southern Ocean

Adopt-A-Float through SOCCOM. Floats and Schools

Using ISUS nitrate sensors and Deep-Sea DuraFET pH sensors in Webb Research Apex and Sea-Bird Electronics Navis profiling floats

Quick Instructions | Float list and link to complete Ascii data files | Data Adjustments | Map of float tracks | Apex/ISUS description page

Select Output Type and Send Request: Plot / Text File — SEND

Raw Data or Adjusted Data: Raw / Adjusted

Data Quality Flag: All Data / Good and Quest / Good Only

What dates? All Dates available / Week Ending on End Date / Month Ending on End Date / Specify Start/End Date

Change dates: (MM/DD/YYYY) Start Date 09/17/2007 End Date 04/28/2017

Select Float (ctrl click for more than one)

Huey, Princeton Day....pH/N/O
Louie, Princeton Day....pH/N/O
Dewey, Princeton Day....pH/N/O/FL
Jose Iriarte, Blog Win...pH/N/O
J.W., JW Middle Sch...pH/N/O/FL
Nemo, JW Middle Sch..pH/N/O/FL
Tator Tot, Lakeside Wils..pH/N/O6/FL
Pi, Lakeside Wilson.....pH/N/O6/FL
Eep, Lakeside Wilson...pH/N/O/FL
Z-Pod, Lakeside Wilson.pH/N/O/FL
X-Pod, Lakeside Wilson.pH/N/O/FL
Kaia, Lakeside Wilson...pH/N/O/FL
Moby Dick, JW Middle...pH/N/O/FL
RE Byrd, Princeton Day...pH/N/O/FL
RF Scott, Princeton Day...pH/N/O/FL
Titus, Bear Tavern Elem....pH/N/O6/FL
Southstar, M.H. Kreps MS..pH/N/O/FL
Kirby, M.H. Kreps MS..pH/N/O/FL
Jorge, Princeton.....pH/N/O6/FL
Darwin, Passaic Valley HS.pH/N/O/FL
Mann, Passaic Valley HS...pH/N/O/FL
Bell, John Witherspoon MS.pH/N/O/FL
Sundevil Sam, Sandia Prep S..pH/N/O/FL
Sundevil Lion, Sandia Prep S..pH/N/O/FL
EH Shackleton, Princeton Day.pH/N/O/FL
12542SOOCN.....pH/N/O/FL

Select One X Variable

Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]

Select Y Variables (ctrl click >1)

Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]

Autoscale X & Y axis : On / Off

Enter Ranges if Autoscale is Off (Min & max ranges default to 0 and 200 if Autoscale off and box is empty. Depth ranges are entered as negative values on Y axis and as positive values on X axis.)

X Min: X Max:

Y Min: Y Max:

Y Stack: (In a single graph, multiple Y variables or multiple stations are stacked vertically if it is On) On / Off

Enter Min and Max Depth range for data used in Time Series Plot (X Var = Date)

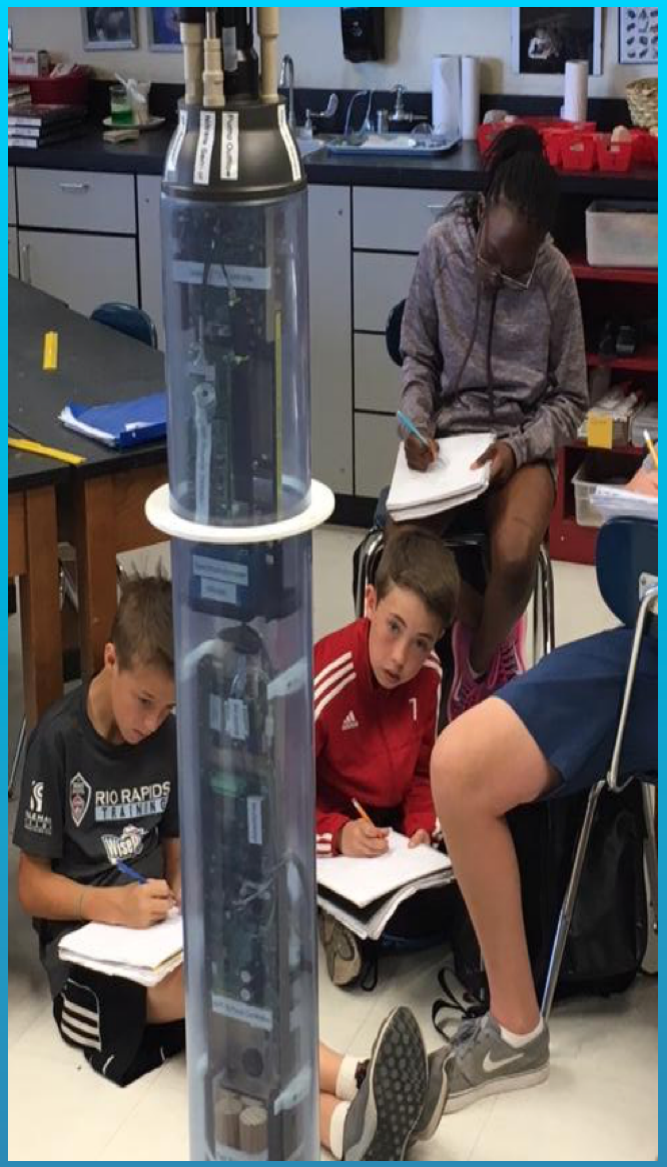
Min Depth: 0

Max Depth: 1050

biogeochemical

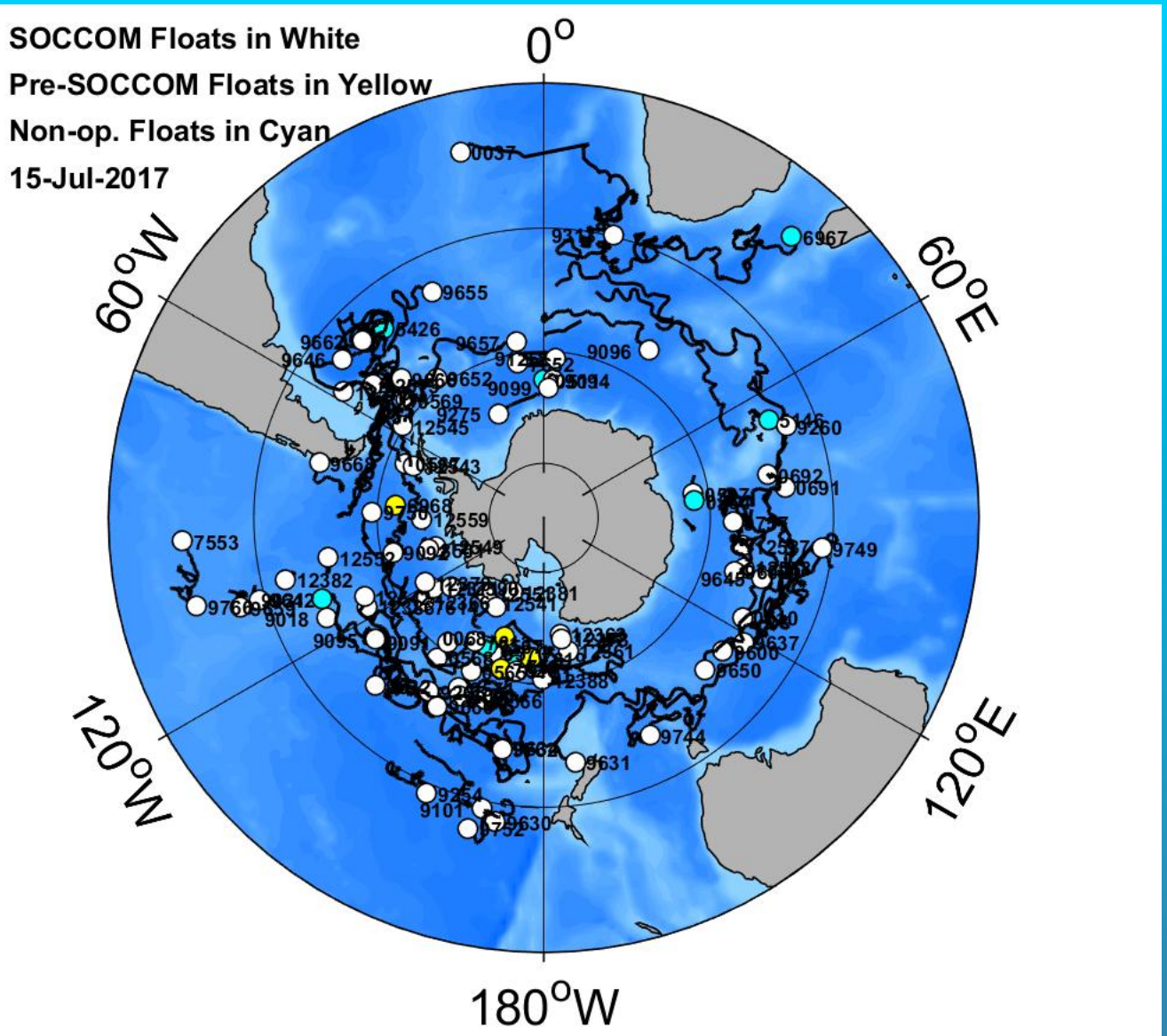
SOCCOM

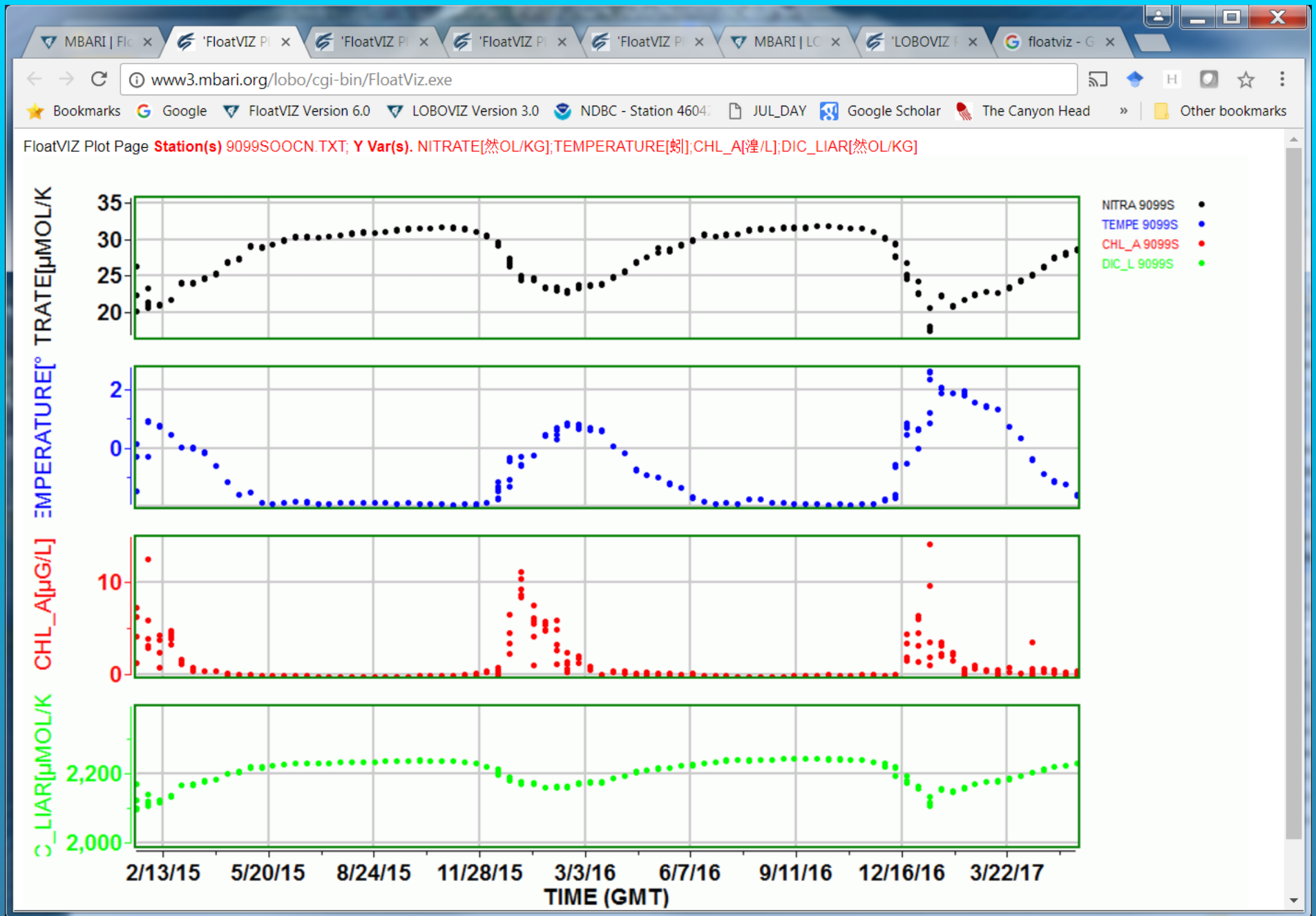
http://www3.mbari.org/SOCCOM/AdoptAFloatviz.htm

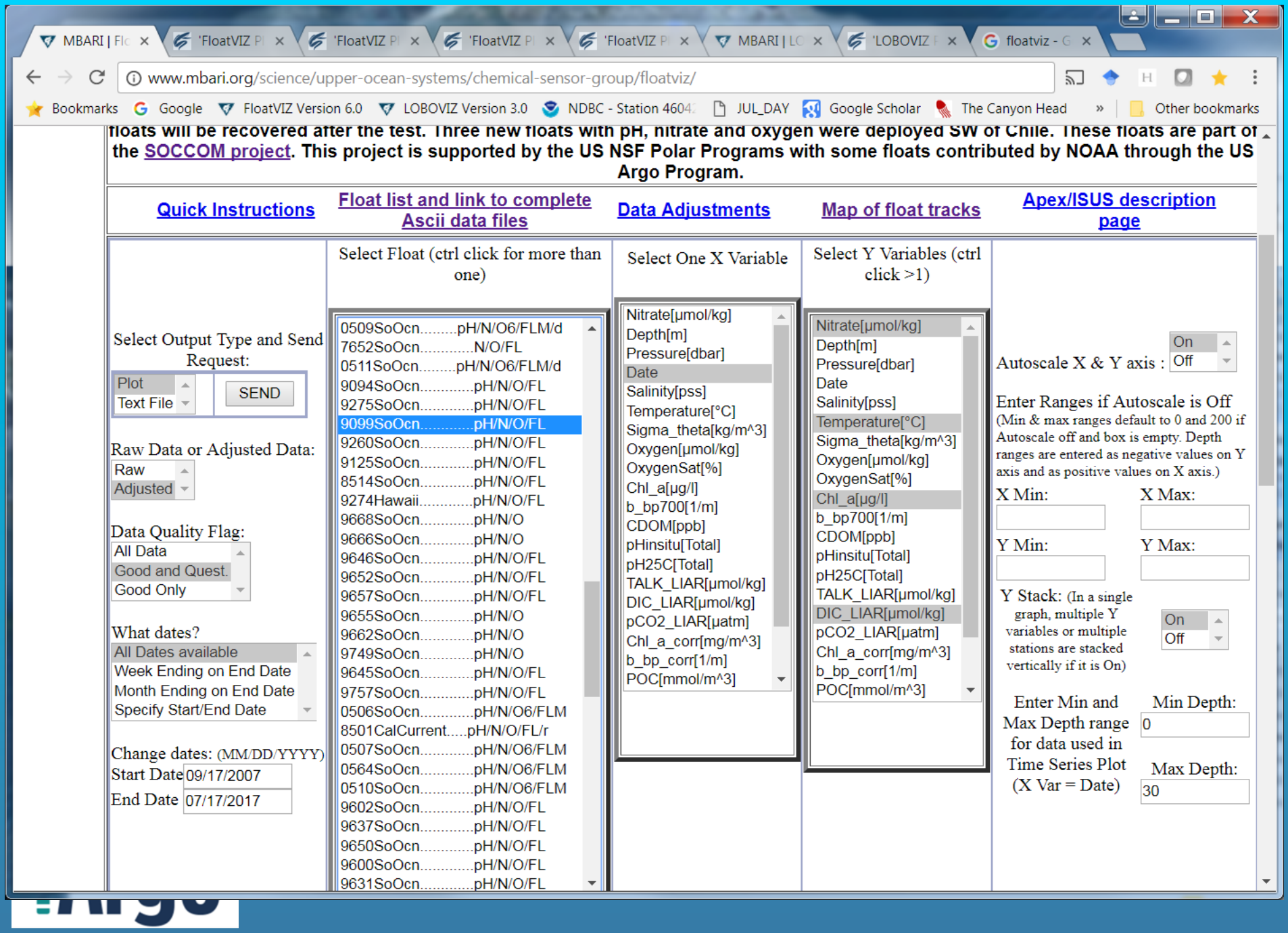


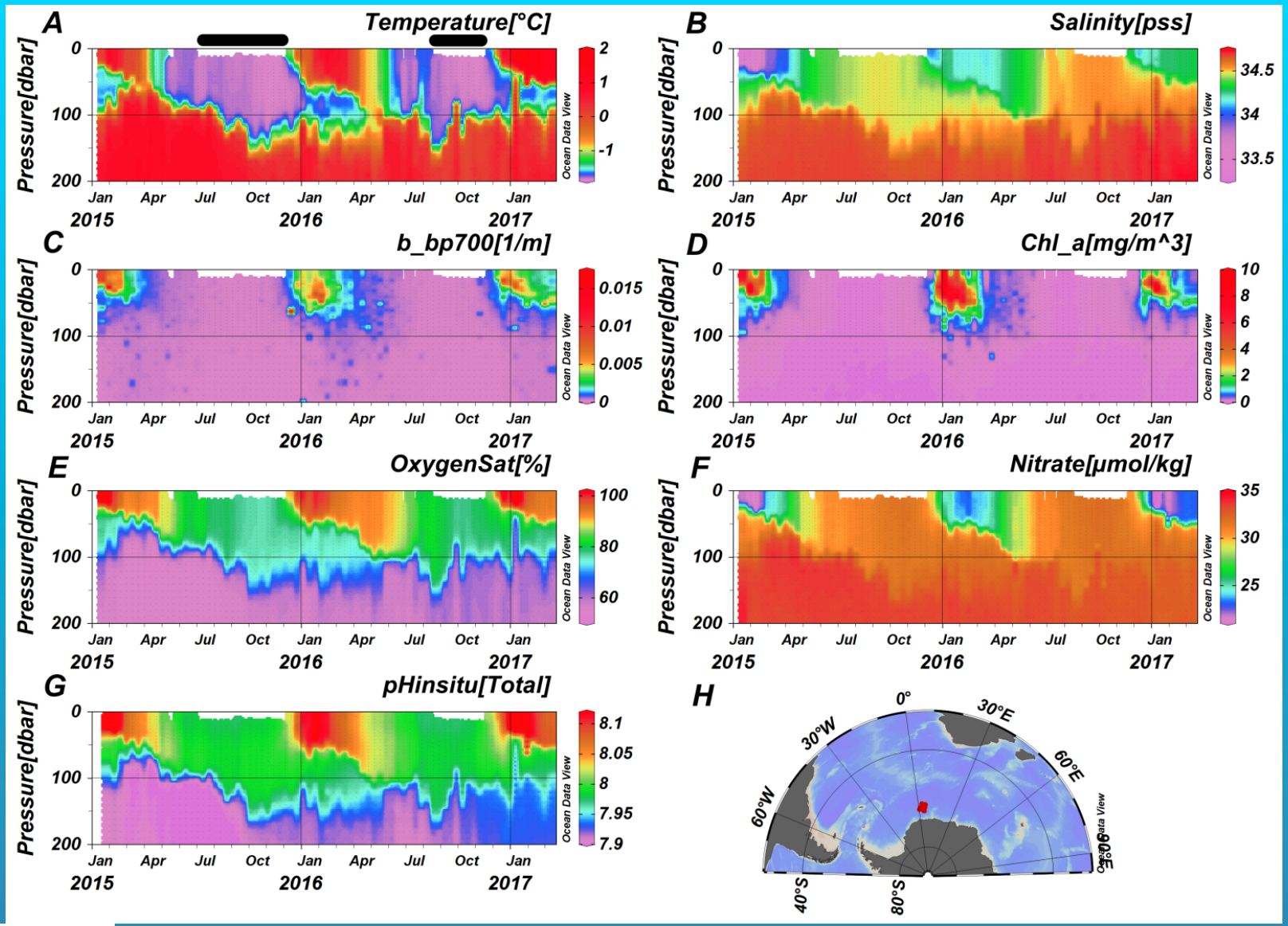
biogeochemical

SOCCOM


SOCCOM Floats in White
Pre-SOCCOM Floats in Yellow
Non-op. Floats in Cyan
15-Jul-2017
0°
60°W
60°E
120°W
120°E
180°W


MBARI | Fl
'FloatVIZ Pl
'FloatVIZ Pl
'FloatVIZ Pl
'FloatVIZ Pl
MBARI | LO
'LOBOVIZ
floatviz - G
www3.mbari.org/lobo/cgi-bin/FloatViz.exe
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
FloatVIZ Plot Page Station(s) 9099SOOCN.TXT; Y Var(s). NITRATE[然OL/KG];TEMPERATURE[蚜];CHL_A[湟/L];DIC_LIAR[然OL/KG]
TRATE[µMOL/K
EMPERATURE[°
CHL_A[µG/L]
C_LIAR[µMOL/K
35
30
25
20
2
0
10
0
2,200
2,000
NITRA 9099S
TEMPE 9099S
CHL_A 9099S
DIC_L 9099S
2/13/15
5/20/15
8/24/15
11/28/15
3/3/16
6/7/16
9/11/16
12/16/16
3/22/17
TIME (GMT)


MBARI | Flo
'FloatVIZ Pl
'FloatVIZ Pl
'FloatVIZ Pl
'FloatVIZ Pl
MBARI | LO
'LOBOVIZ F
floatviz - G
www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/floatviz/
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Other bookmarks
floats will be recovered after the test. Three new floats with pH, nitrate and oxygen were deployed SW of Chile. These floats are part of the SOCCOM project. This project is supported by the US NSF Polar Programs with some floats contributed by NOAA through the US Argo Program.
Quick Instructions
Float list and link to complete Ascii data files
Data Adjustments
Map of float tracks
Apex/ISUS description page
Select Output Type and Send Request:
Plot
Text File
SEND
Raw Data or Adjusted Data:
Raw
Adjusted
Data Quality Flag:
All Data
Good and Quest.
Good Only
What dates?
All Dates available
Week Ending on End Date
Month Ending on End Date
Specify Start/End Date
Change dates: (MM/DD/YYYY)
Start Date 09/17/2007
End Date 07/17/2017
Select Float (ctrl click for more than one)
0509SoOcn.....pH/N/O6/FLM/d
7652SoOcn.....N/O/FL
0511SoOcn.....pH/N/O6/FLM/d
9094SoOcn.....pH/N/O/FL
9275SoOcn.....pH/N/O/FL
9099SoOcn.....pH/N/O/FL
9260SoOcn.....pH/N/O/FL
9125SoOcn.....pH/N/O/FL
8514SoOcn.....pH/N/O/FL
9274Hawaii.....pH/N/O/FL
9668SoOcn.....pH/N/O
9666SoOcn.....pH/N/O
9646SoOcn.....pH/N/O/FL
9652SoOcn.....pH/N/O/FL
9657SoOcn.....pH/N/O/FL
9655SoOcn.....pH/N/O
9662SoOcn.....pH/N/O
9749SoOcn.....pH/N/O
9645SoOcn.....pH/N/O/FL
9757SoOcn.....pH/N/O/FL
0506SoOcn.....pH/N/O6/FLM
8501CalCurrent.....pH/N/O/FL/r
0507SoOcn.....pH/N/O6/FLM
0564SoOcn.....pH/N/O6/FLM
0510SoOcn.....pH/N/O6/FLM
9602SoOcn.....pH/N/O/FL
9637SoOcn.....pH/N/O/FL
9650SoOcn.....pH/N/O/FL
9600SoOcn.....pH/N/O/FL
9631SoOcn.....pH/N/O/FL
Select One X Variable
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Select Y Variables (ctrl click >1)
Nitrate[µmol/kg]
Depth[m]
Pressure[dbar]
Date
Salinity[pss]
Temperature[°C]
Sigma_theta[kg/m^3]
Oxygen[µmol/kg]
OxygenSat[%]
Chl_a[µg/l]
b_bp700[1/m]
CDOM[ppb]
pHinsitu[Total]
pH25C[Total]
TALK_LIAR[µmol/kg]
DIC_LIAR[µmol/kg]
pCO2_LIAR[µatm]
Chl_a_corr[mg/m^3]
b_bp_corr[1/m]
POC[mmol/m^3]
Autoscale X & Y axis : On Off
Enter Ranges if Autoscale is Off
(Min & max ranges default to 0 and 200 if Autoscale off and box is empty. Depth ranges are entered as negative values on Y axis and as positive values on X axis.)
X Min:
X Max:
Y Min:
Y Max:
Y Stack: (In a single graph, multiple Y variables or multiple stations are stacked vertically if it is On)
On Off
Enter Min and Max Depth range for data used in Time Series Plot (X Var = Date)
Min Depth: 0
Max Depth: 30



biogeochemical Argo

SOCCOM float 9099/WMO #5904468 operating in the Seasonal Ice Zone. soccom.princeton.edu

Extra Credit, Pop-Quiz Question:

If density near the surface is 1022 kg/m^3 and 1028 kg/m^3 near 2000 m, how much volume change does a 30 liter (~30 kg) float need to make for a 2000 m vertical profile? (ignore compressibility of water and float)

30 liters * 1028/1022 = 30.176 liters

A 30 liter float needs to change its volume by 180 milliliters to profile 2000 m (236 milliliters/1 cup)

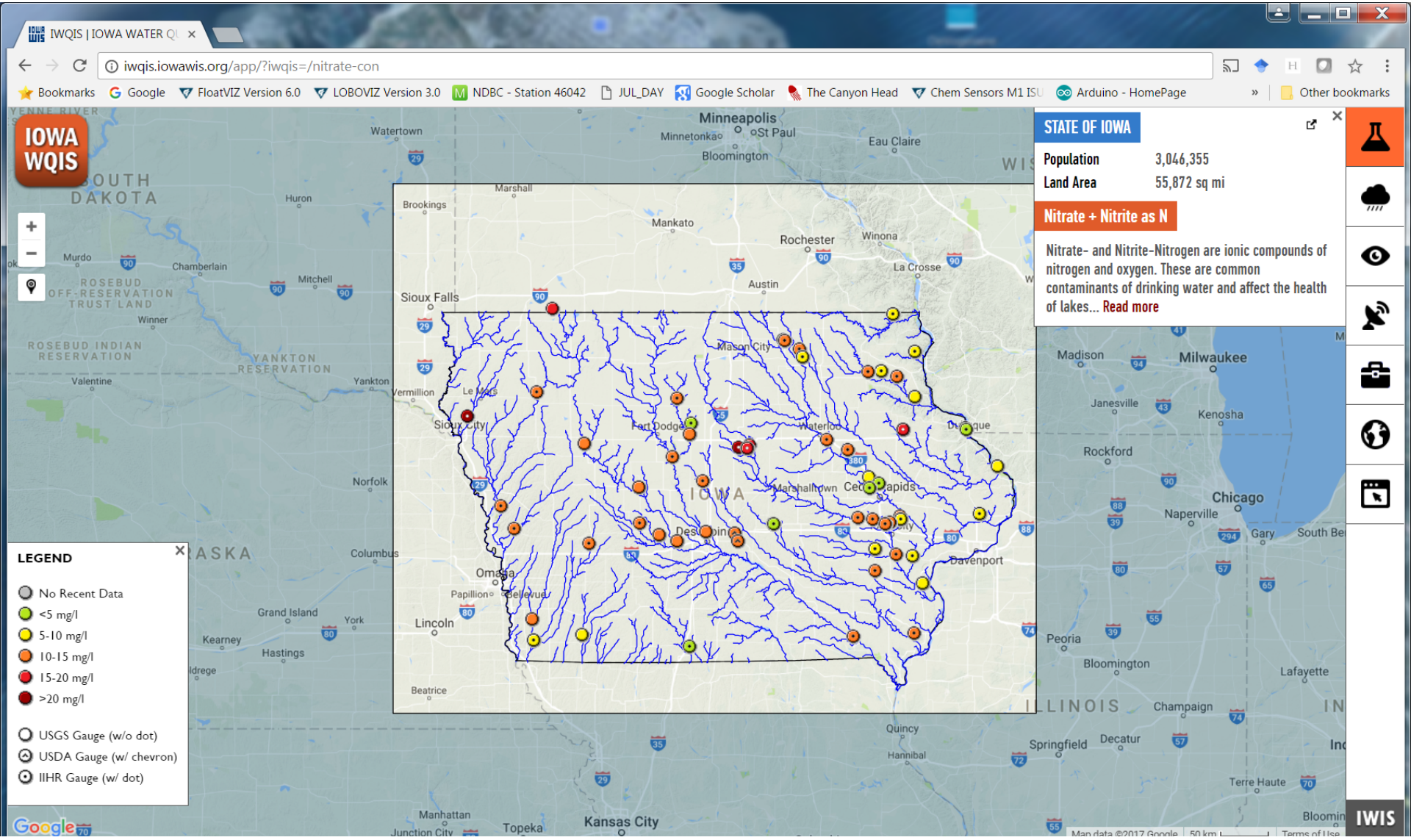
biogeochemical Argo

Looking down Moro Cojo Slough to Moss Landing Harbor. Where's the water? Why can't we see it?

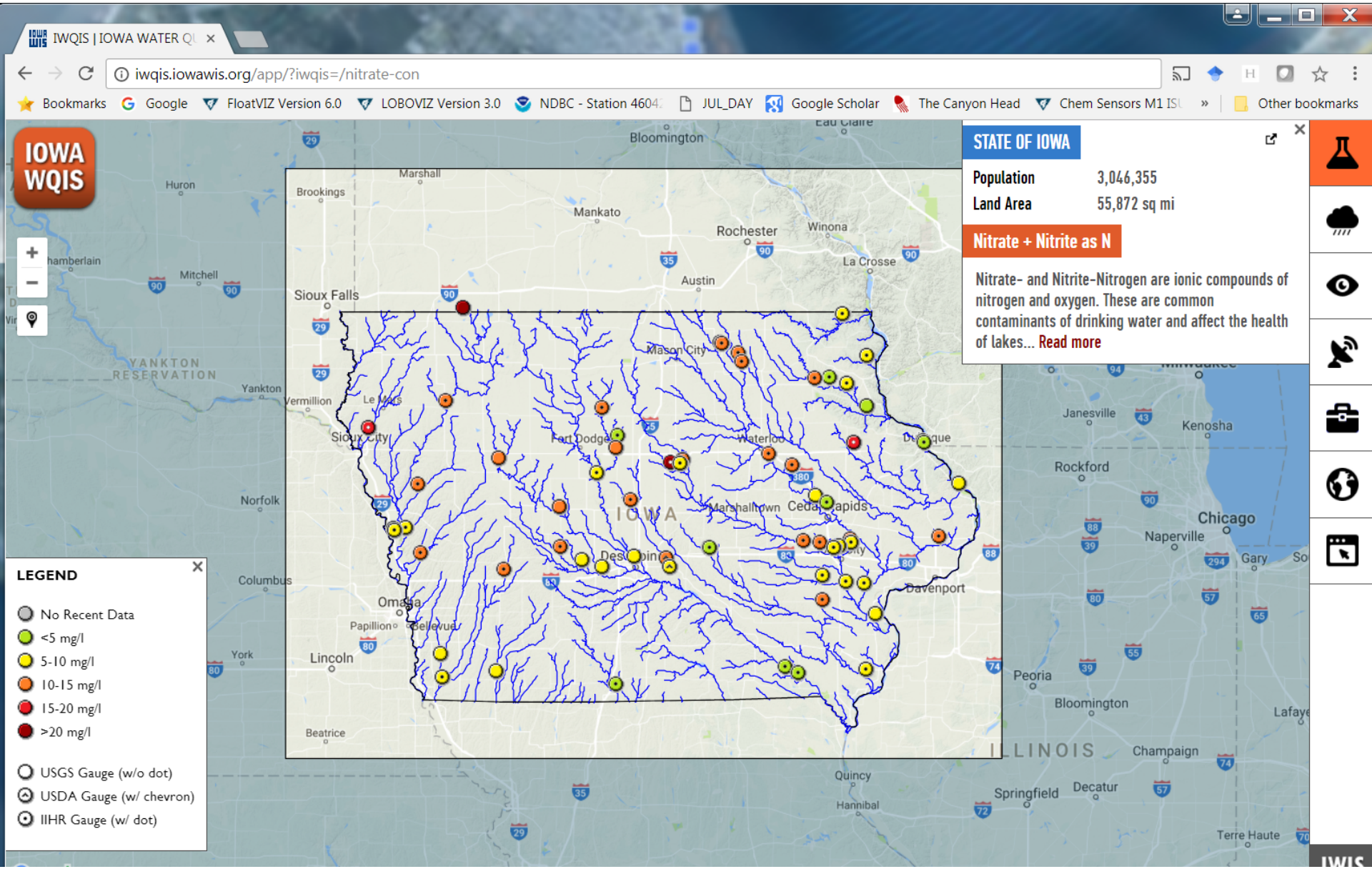
A. .

B. .

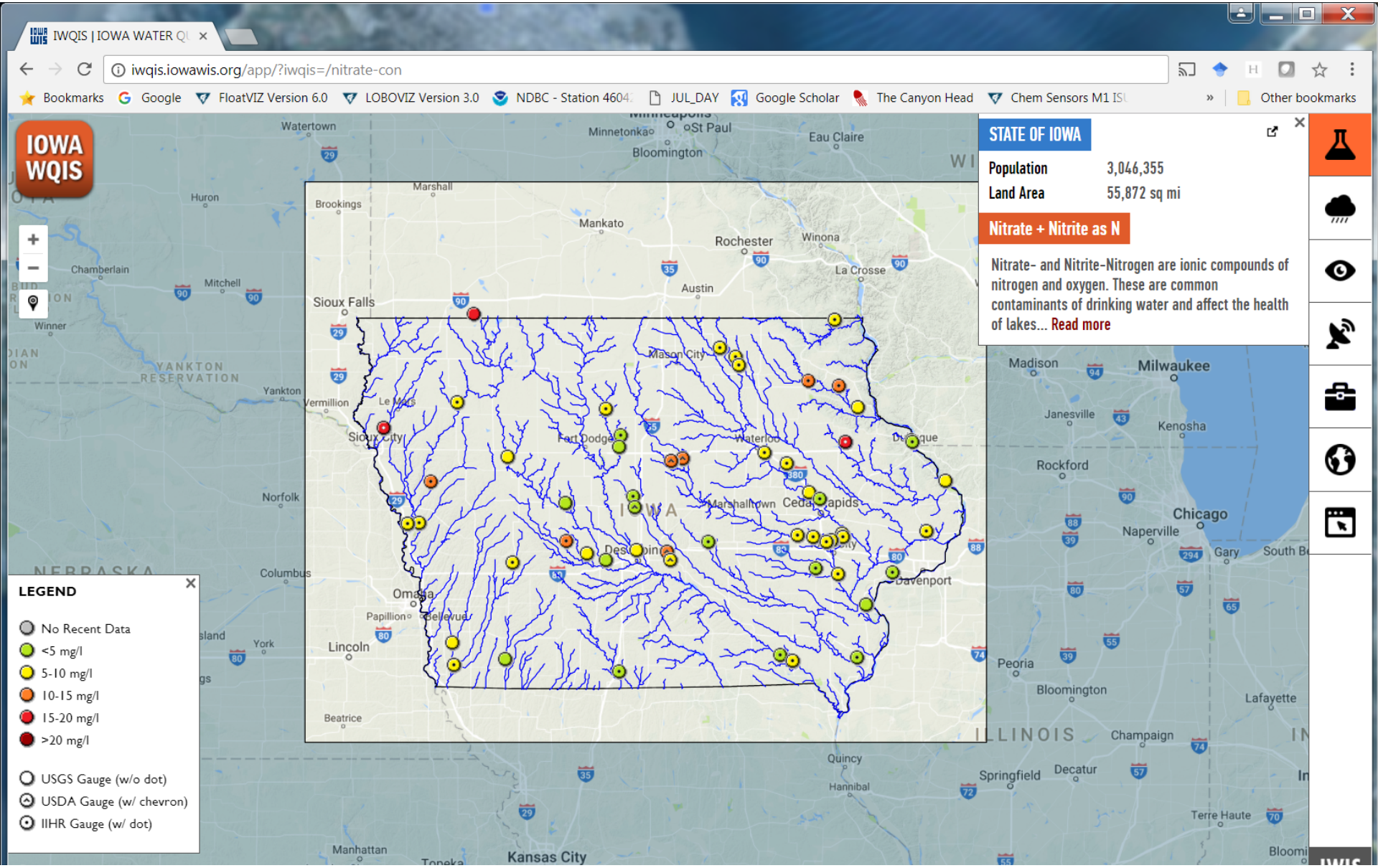
C. Too much fertilizer from land to water – that's eutrophication.


IWQIS | IOWA WATER Q
iwqis.iowawis.org/app/?iwqis=/nitrate-con
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 46042
JUL_DAY
Google Scholar
The Canyon Head
Chem Sensors M1 ISU
Arduino - HomePage
Other bookmarks
IOWA WQIS
STATE OF IOWA
Population 3,046,355
Land Area 55,872 sq mi
Nitrate + Nitrite as N
Nitrate- and Nitrite-Nitrogen are ionic compounds of nitrogen and oxygen. These are common contaminants of drinking water and affect the health of lakes... Read more
LEGEND
No Recent Data
<5 mg/l
5-10 mg/l
10-15 mg/l
15-20 mg/l
>20 mg/l
USGS Gauge (w/o dot)
USDA Gauge (w/ chevron)
IIHR Gauge (w/ dot)
Minneapolis
St Paul
Rochester
Sioux Falls
Sioux City
Des Moines
Cedar Rapids
Davenport
Omaha
Lincoln
Kansas City
Chicago
Milwaukee
IOWA
ILLINOIS
IWIS

June 10, 2017


IWQIS | IOWA WATER Q
iwqis.iowawis.org/app/?iwqis=/nitrate-con
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Chem Sensors M1 IS
Other bookmarks
IOWA WQIS
STATE OF IOWA
Population 3,046,355
Land Area 55,872 sq mi
Nitrate + Nitrite as N
Nitrate- and Nitrite-Nitrogen are ionic compounds of nitrogen and oxygen. These are common contaminants of drinking water and affect the health of lakes... Read more
LEGEND
No Recent Data
<5 mg/l
5-10 mg/l
10-15 mg/l
15-20 mg/l
>20 mg/l
USGS Gauge (w/o dot)
USDA Gauge (w/ chevron)
IIHR Gauge (w/ dot)
Bloomington
Marshall
Brookings
Huron
Mankato
Rochester
Winona
La Crosse
Austin
Sioux Falls
Mitchell
Mason City
YANKTON RESERVATION
Yankton
Vermillion
Sioux City
Fort Dodge
Waterloo
Norfolk
IOWA
Marshalltown
Cedar Rapids
Columbus
Omaha
Papillion
Bellevue
Lincoln
York
Davenport
Janesville
Kenosha
Rockford
Chicago
Naperville
Gary
Peoria
Bloomington
ILLINOIS
Champaign
Springfield
Decatur
Quincy
Hannibal
Beatrice
Terre Haute

June 29, 2017


IWQIS | IOWA WATER Q
iwqis.iowawis.org/app/?iwqis=/nitrate-con
Bookmarks
Google
FloatVIZ Version 6.0
LOBOVIZ Version 3.0
NDBC - Station 4604
JUL_DAY
Google Scholar
The Canyon Head
Chem Sensors M1 IS
Other bookmarks
IOWA WQIS
STATE OF IOWA
Population 3,046,355
Land Area 55,872 sq mi
Nitrate + Nitrite as N
Nitrate- and Nitrite-Nitrogen are ionic compounds of nitrogen and oxygen. These are common contaminants of drinking water and affect the health of lakes... Read more
LEGEND
No Recent Data
<5 mg/l
5-10 mg/l
10-15 mg/l
15-20 mg/l
>20 mg/l
USGS Gauge (w/o dot)
USDA Gauge (w/ chevron)
IIHR Gauge (w/ dot)
IOWA
ILLINOIS
Sioux Falls
Sioux City
Des Moines
Cedar Rapids
Davenport
Omaha
Lincoln
Kansas City
Chicago
Milwaukee
Minneapolis
St Paul
Rochester
Mason City
Fort Dodge
Waterloo
Marshalltown
Peoria
Bloomington
Champaign
Springfield
Decatur
Quincy
Hannibal
Rockford
Madison
Janesville
Kenosha
Naperville
Gary
Lafayette
Terre Haute
Watertown
Brookings
Marshall
Mankato
Austin
La Crosse
Winona
Eau Claire
Huron
Chamberlain
Mitchell
Winner
Yankton
Vermillion
Norfolk
Columbus
York
Beatrice
Papillion
Bellevue
Manhattan
Topeka

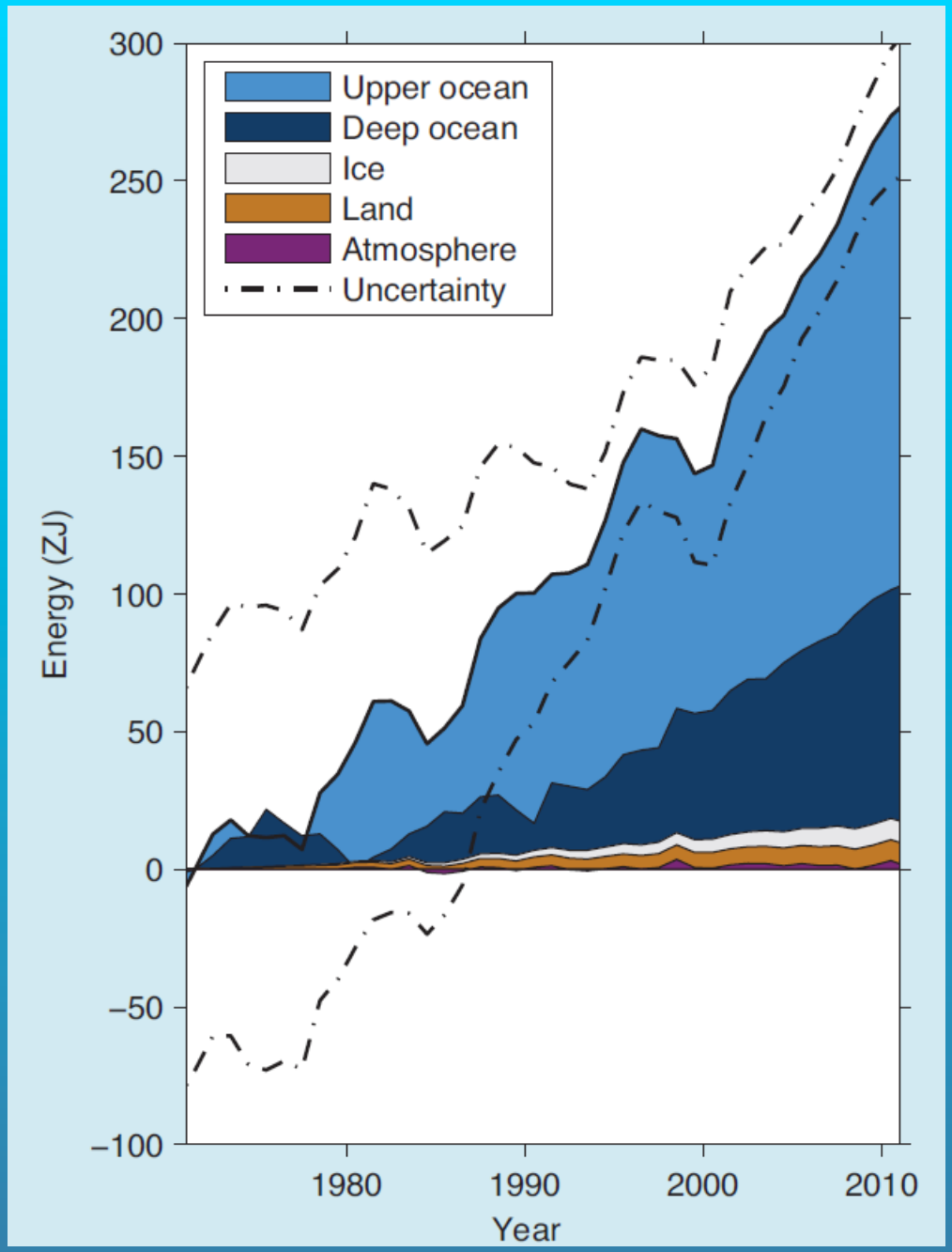
July 17, 2017


biogeochemical
Argo

Global Warming is Ocean Warming!

- Ocean warming dominates the total energy change, accounting for 93% from 1971 to 2010.
- Warming of the atmosphere makes up only 1% of the energy change.

IPCC AR5, Box 3.1 – Change in Global Energy Inventory



biogeochemical Argo

Vol 466|29 July 2010|doi:10.1038/nature09268 nature

ARTICLES

Global phytoplankton decline over the past century

Daniel G. Boyce[1], Marlon R. Lewis[2] & Boris Worm[1]

In the oceans, ubiquitous microscopic phototrophs (phytoplankton) account for approximately half the production of organic matter on Earth. Analyses of satellite-derived phytoplankton concentration (available since 1979) have suggested decadal-scale fluctuations linked to climate forcing, but the length of this record is insufficient to resolve longer-term trends. Here we combine available ocean transparency measurements and *in situ* chlorophyll observations to estimate the time

We conclude that global phytoplankton concentration has declined over the past century;

interannual to decadal phytoplankton fluctuations superimposed on long-term trends. These fluctuations are strongly correlated with basin-scale climate indices, whereas long-term declining trends are related to increasing sea surface

estimate a global rate of decline of ~1% of the global median per year.

$0.99^{100} = 0.38$

A 72% (1-0.38) decrease over 100 years?

biogeochemical Argo

nature International weekly journal of science

Home | News & Comment | Research | Careers & Jobs | Current Issue | Archive | Audio & Video | For Aut

Archive > Volume 472 > Issue 7342 > Brief Communications Arising > Article

ARTICLE PREVIEW
view full access options

NATURE | BRIEF COMMUNICATION ARISING

previous article next article

Is there a decline in marine phytoplankton?

Abigail McQuatters-Gollop, Philip C. Reid, Martin Edwards, Peter H. Burkill, Claudia Castellani, Sonia Batten, Winfried Gieskes, Doug Beare, Robert R. Bidigare, Erica Head, Rod Johnson, Mati Kahru, J. Anthony Koslow & Angelica Pena

Affiliations | Corresponding author

Nature **472**, E6–E7 (14 April 2011) | doi:10.1038/nature09950

nature International weekly journal of science

Home | News & Comment | Research | Careers & Jobs | Current Issue | Archive | Audio & Video | For A

Archive > Volume 472 > Issue 7342 > Brief Communications Arising > Article

ARTICLE PREVIEW
view full access options

NATURE | BRIEF COMMUNICATION ARISING

next article

Does blending of chlorophyll data bias temporal trend?

David L. Mackas

Nature **472**, E4–E5 (14 April 2011) | doi:10.1038/nat
Received 01 October 2010 | Accepted 01 February 2(
Article (July, 2010)
Brief Communication Arising (April, 2011)

nature International weekly journal of science

Home | News & Comment | Research | Careers & Jobs | Current Issue | Archive | Audio & Video | For A

Archive > Volume 472 > Issue 7342 > Brief Communications Arising > Article

ARTICLE PREVIEW
view full access options

NATURE | BRIEF COMMUNICATION ARISING

previous article next article

A measured look at ocean chlorophyll trends

Ryan R. Rykaczewski & John P. Dunne

Affiliations | Corresponding author

Nature **472**, E5–E6 (14 April 2011) | doi:10.1038/nature09952
Received 16 October 2010 | Accepted 01 February 2011 | Published online 13 April 2011
Article (July, 2010)
Brief Communication Arising (April, 2011)

biogeochemical Argo

OCEANOGRAPHY

Century of phytoplankton change

David A. Siegel and Bryan A. Franz

Phytoplankton biomass is a crucial measure of the health of ocean ecosystems. An impressive synthesis of the relevant data, stretching back to more than 100 years ago, provides a connection with climate change.