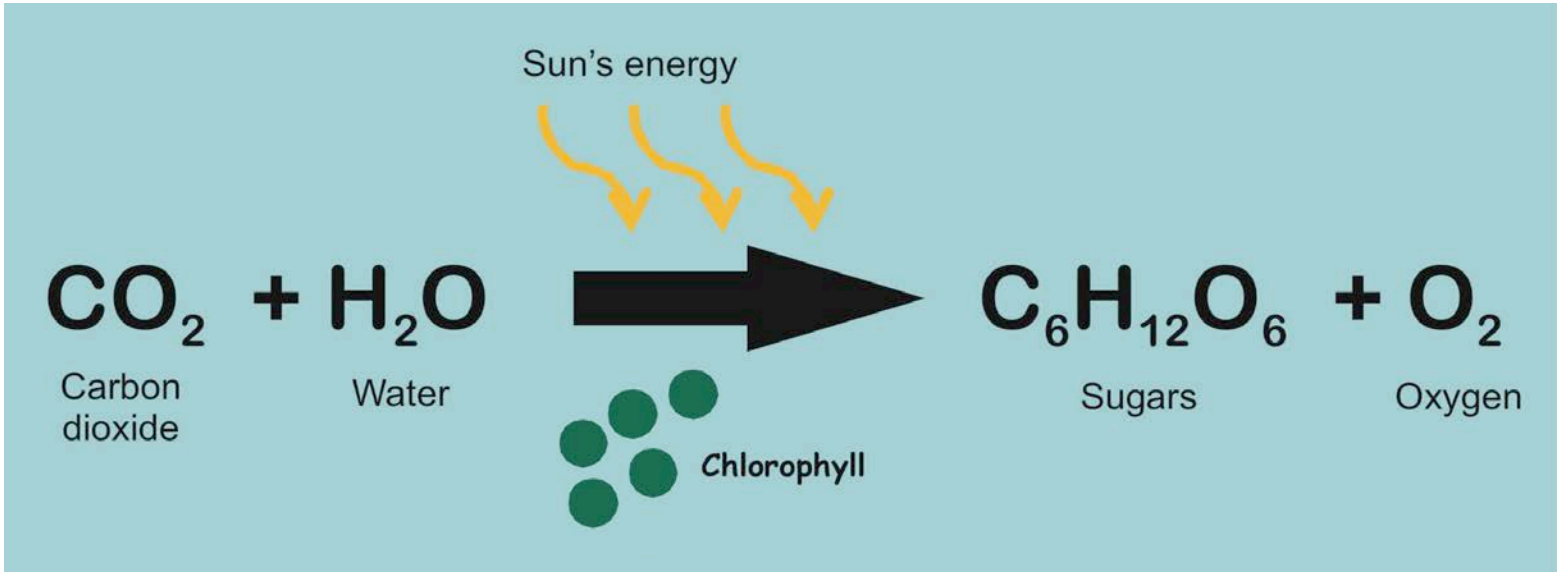
Using Biovolume to Assess Phytoplankton Productivity

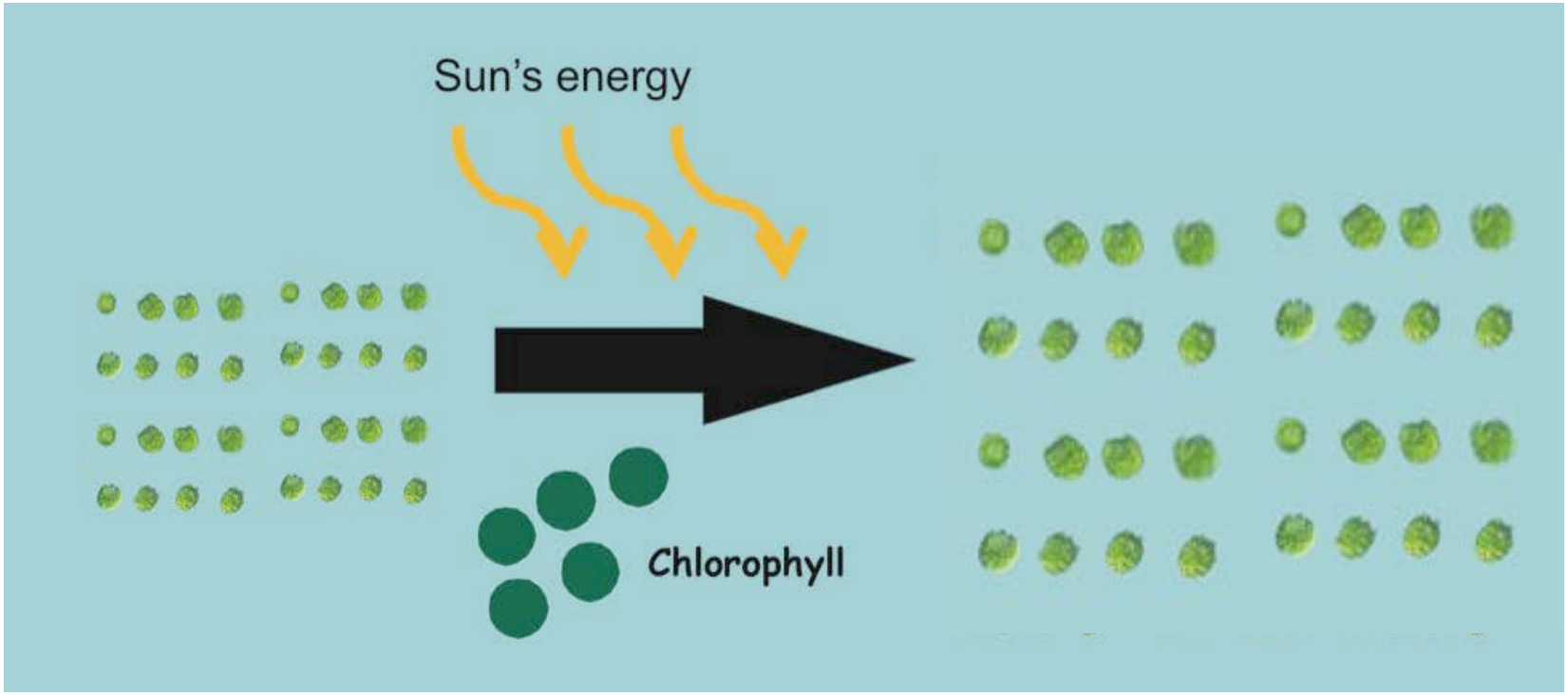
Christopher Melrose
Jason Krumholz
Conor McManus

What is primary production



http://lifeadrift.info/ages-11-16/phytoplankon-extra.aspx

or….



Biovolume vs Primary Production

* Primary production results in new biomass
* Biomass is proportional to biovolume
* If you can measure the change biovolume due to photosynthesis over time accurately enough you can estimate primary production

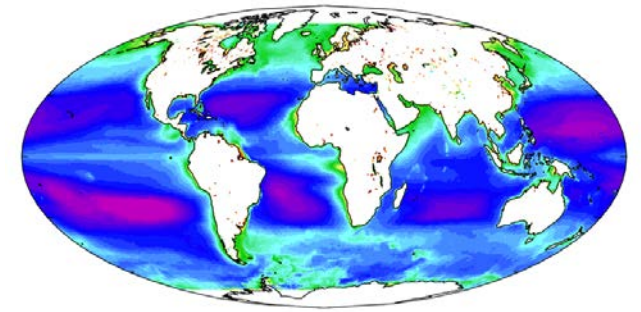
Why is phytoplankton primary production important to Aquaculture?

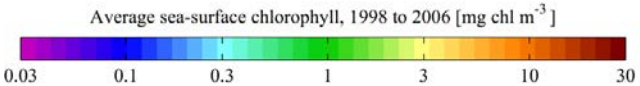
* Plankton are the primary food source for filter feeding shellfish
* Primary Productivity tells us the rate of supply of food rather than the quantity
* Biovolume is a measure of net productivity – the amount left over after metabolism

How do we currently measure primary production?

“Traditional” Methods

* Collect discrete plankton samples and incubate them in bottles under natural or artificial light
* Measure a tracer
  * ^{14}C and ^{13}C uptake
  * Oxygen release
* Use satellite measurements of ocean color
  * Not very useful in coastal environments





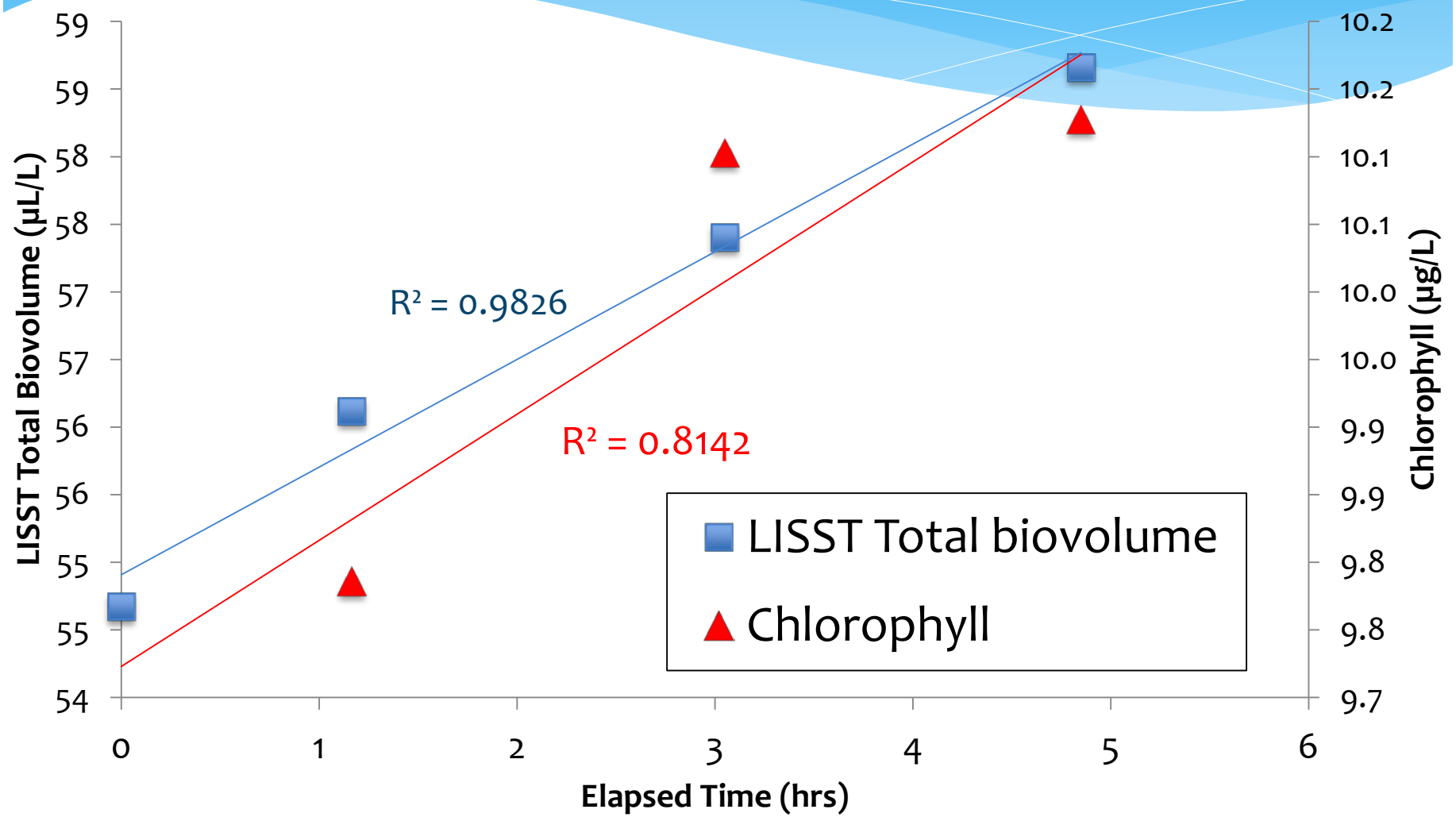
Possible advantages of biovolume based measurements of productivity

* Non-destructive continuous or repeated measurements
  * Traditional carbon uptake incubations measure only the end point of the incubation
* *In situ* depth resolved sampling
* Size fractionated production
* No hazardous materials
* Less expensive and time consuming than incubations

Laser In Situ Scattering Transmissometer (LISST)

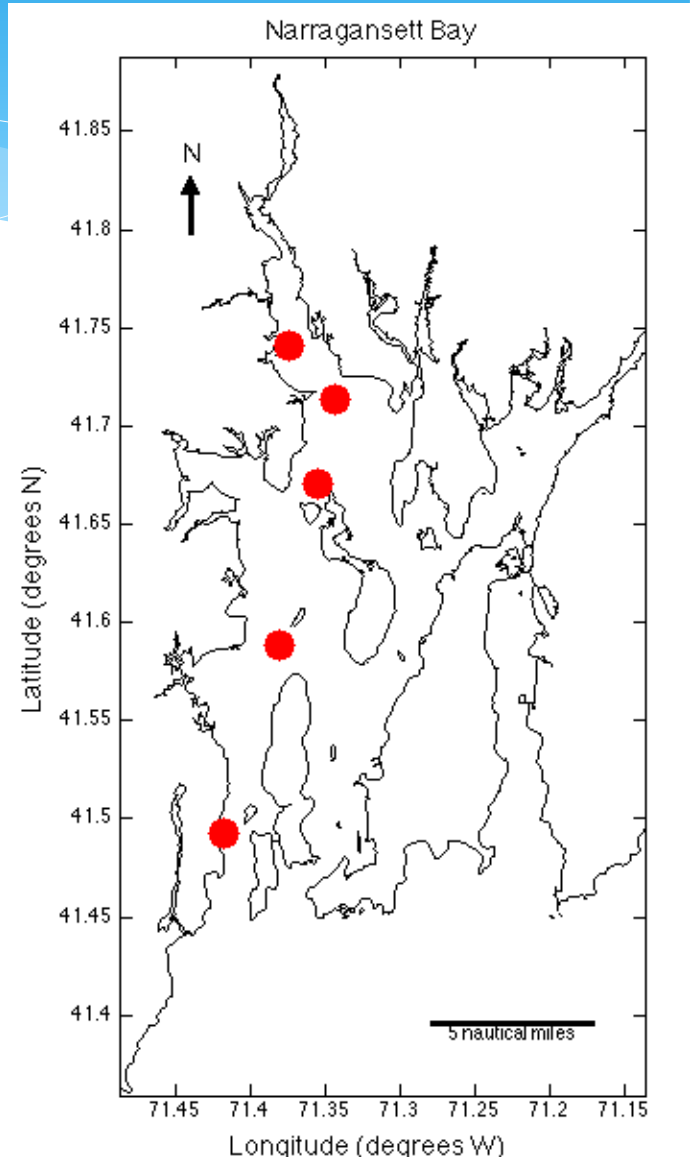
* This is an instrument used to measure particles in water (living and non-living).
* Can enumerate and place into size 'bins' all particles between 2.5-500μM
* Limitations:
  * Does not distinguish between living and non-living particles.
    * Less important for primary production applications since non-living particles don't grow
  * The LISST does not distinguish between phytoplankton and zooplankton
  * Diatom chains or aggregates may be confused with single particles

Proof of Concept Experiment



Methods

* Collected water from stations along the estuarine gradient of Narragansett Bay ~bi-weekly during the summer of 2012

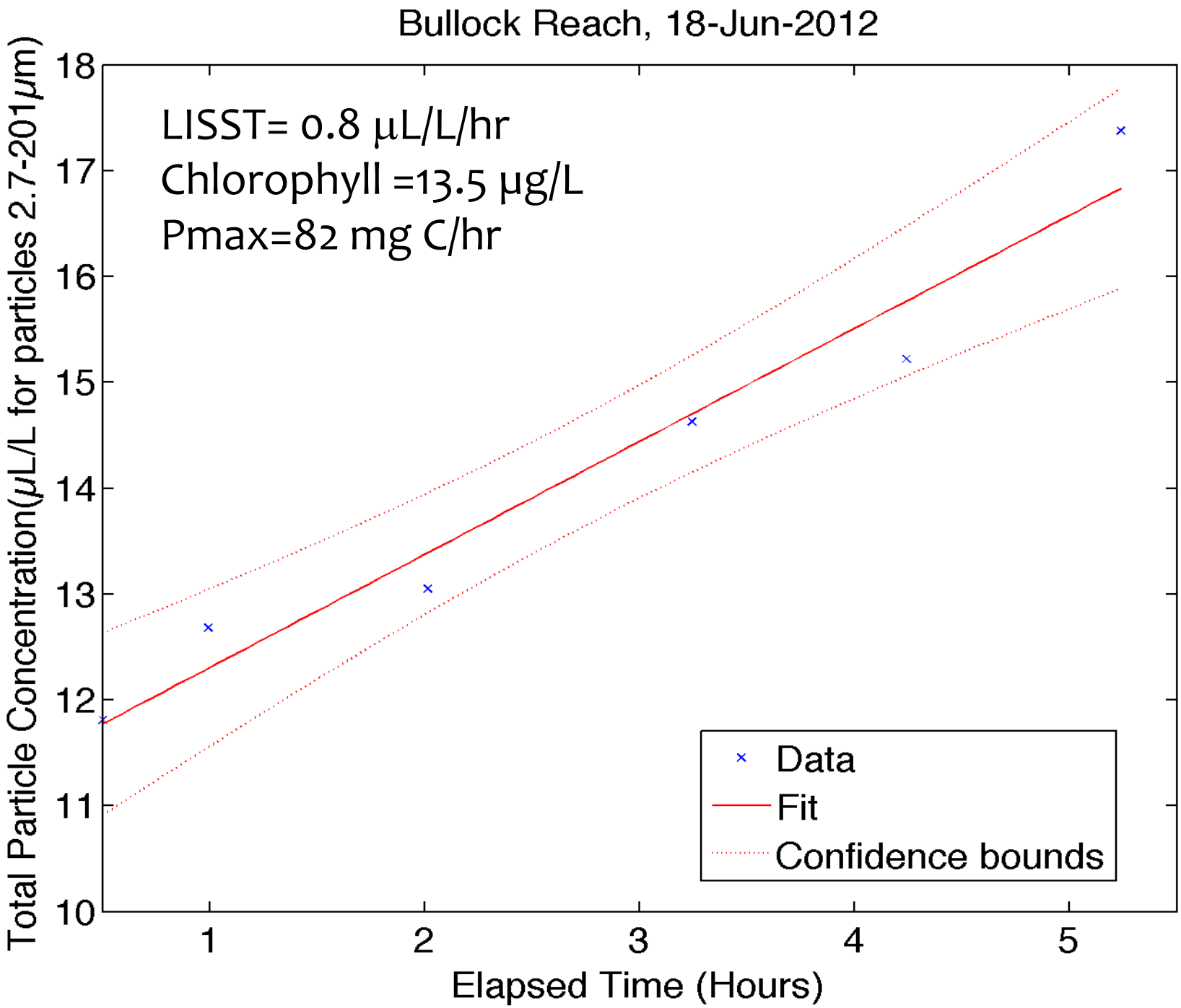


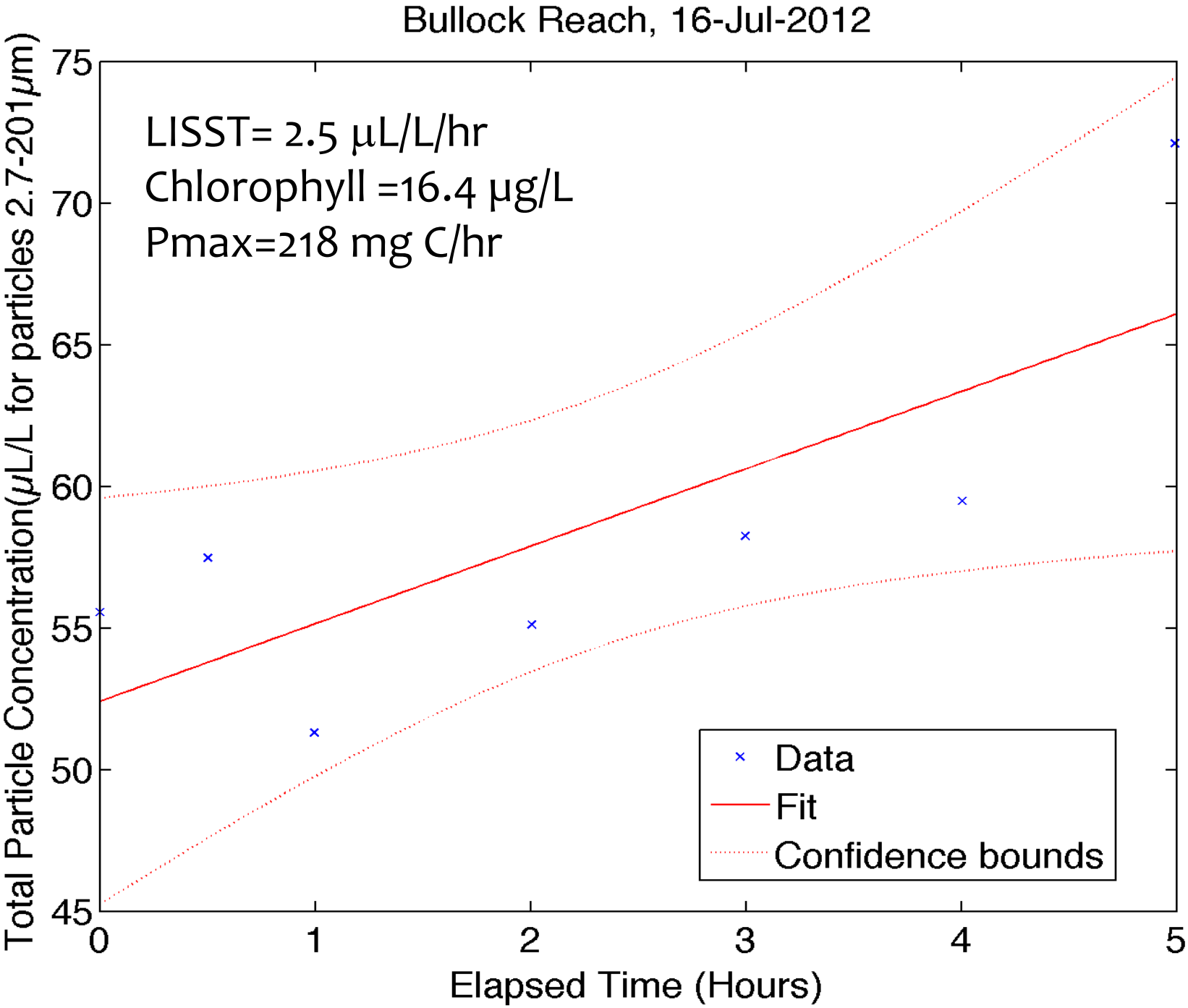
Methods part 2

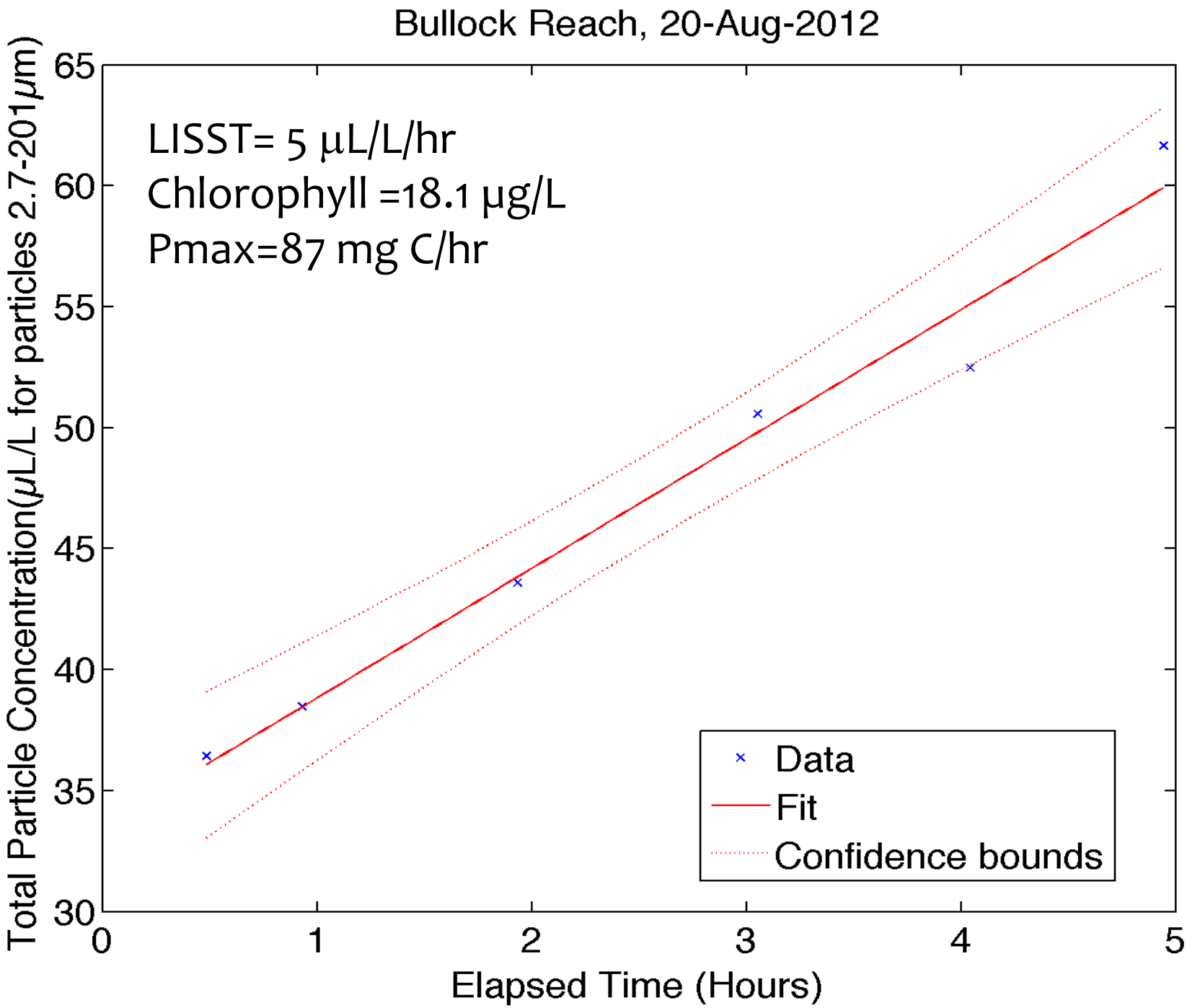
* At each station
  * Vertical Profile with LISST
  * Vertical Profile with fluoroprobe
  * Collect surface water for:
    * LISST productivity incubations
    * ^{14}C incubations
    * phytoplankton identification

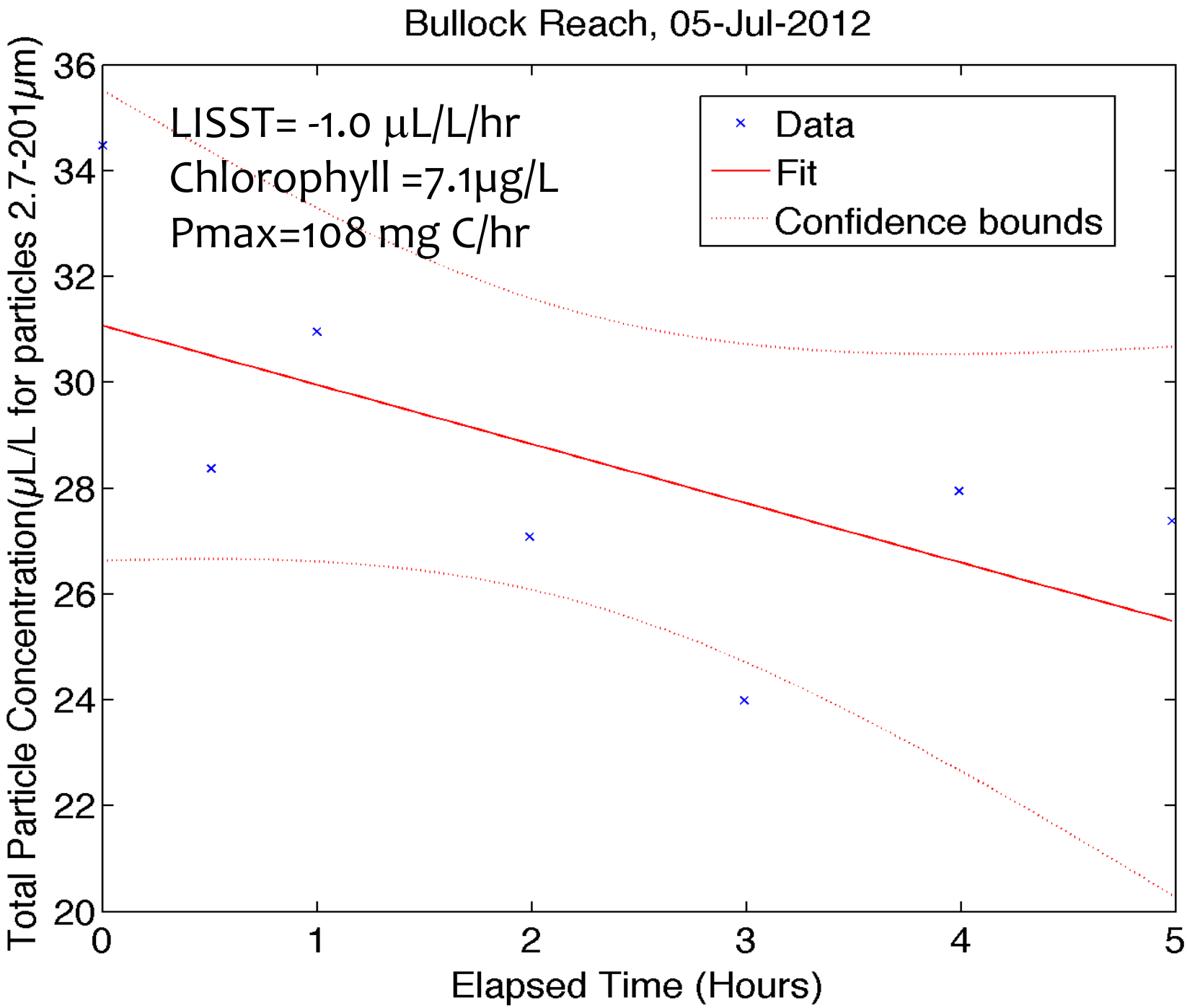
LISST Incubation Methods

* Place water samples in transparent buckets and incubate under an artificial light source for ~5 hrs
  * Buckets immersed in continuously circulating water drawn from the GSO dock to maintain constant, near ambient temperature
  * Measure particle size and fluorescence every hour


Bullock Reach, 18-Jun-2012
LISST= 0.8 µL/L/hr
Chlorophyll =13.5 µg/L
Pmax=82 mg C/hr
Total Particle Concentration(µL/L for particles 2.7-201µm)
Elapsed Time (Hours)
18
17
16
15
14
13
12
11
10
1
2
3
4
5
Data
Fit
Confidence bounds


Bullock Reach, 16-Jul-2012
LISST= 2.5 µL/L/hr
Chlorophyll =16.4 µg/L
Pmax=218 mg C/hr
Total Particle Concentration(µL/L for particles 2.7-201µm)
Elapsed Time (Hours)
75
70
65
60
55
50
45
0
1
2
3
4
5
Data
Fit
Confidence bounds


Bullock Reach, 20-Aug-2012
LISST= 5 µL/L/hr
Chlorophyll =18.1 µg/L
Pmax=87 mg C/hr
Total Particle Concentration(µL/L for particles 2.7-201µm)
Elapsed Time (Hours)
65
60
55
50
45
40
35
30
0
1
2
3
4
5
Data
Fit
Confidence bounds


Bullock Reach, 05-Jul-2012
LISST= -1.0 µL/L/hr
Chlorophyll =7.1µg/L
Pmax=108 mg C/hr
Data
Fit
Confidence bounds
Total Particle Concentration(µL/L for particles 2.7-201µm)
Elapsed Time (Hours)
36
34
32
30
28
26
24
22
20
0
1
2
3
4
5

Additional Analysis Still to be done

* Is there a species specific effect?
  * Dinoflagellates
  * Size fractionated analysis
* Is the relationship with production predicted by C14 uptake consistent?
* Can signal to noise ratio in LISST data be improved upon?
  * Longer sample time/larger sample size
  * Bubbles/dirt/optical issues
  * Post processing

Summary

* Still a work in progress, but a signal is detectable under the right conditions
  * Generally a growth signal was clearest in samples with >10 µg/L chlorophyll
  * Lower chlorophyll/lower bay samples only had a detectable growth signal about 2/3rds of the time
* The work shows some promise but additional effort is required before it can be used for monitoring
  * Improve signal to noise ratio
  * Lower detection limit
  * Better understand relationship to 14C primary productivity

Acknowledgements

* Meng Zhou for the idea
* Candace Oviatt
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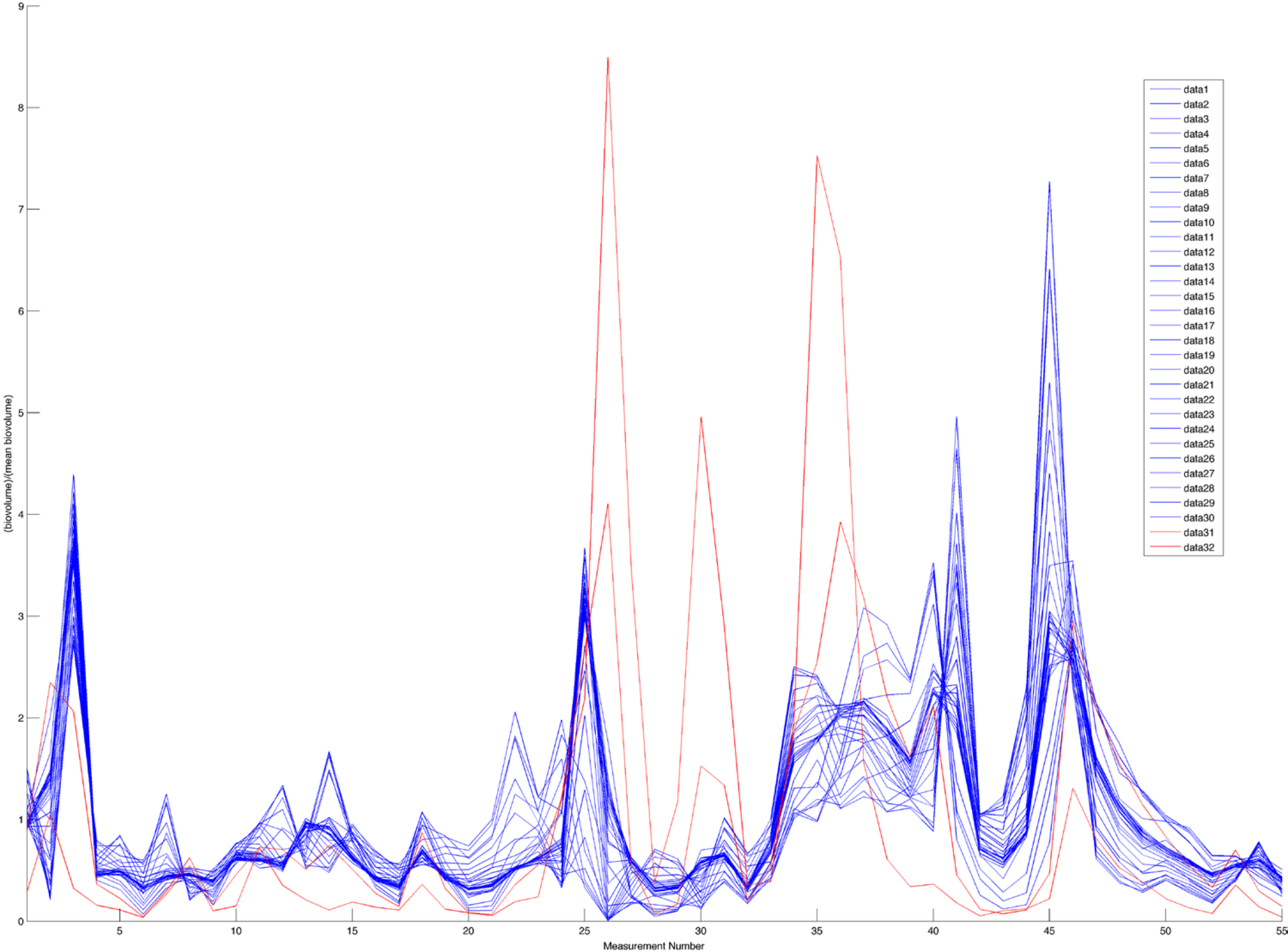
* Jon Hare
* Chris Taylor
* Kim Hyde
* David Borkman

LISST-100X (Type C)

* Using scattering of a laser beam to measure particle volume
  * Angular scattering is measured by 32 rings
  * This is then converted into particle volume concentrations within 32 logarithmically distributed size bins
  * Particles between 2.5 µm and 500µm in size
    * Nanoplankton (2-20µm), microplankton (20-200µm), some mesoplankton (0.2mm-2mm)


(biovolume)/(mean biovolume)
Measurement Number
0
1
2
3
4
5
6
7
8
9
5
10
15
20
25
30
35
40
45
50
55
data1
data2
data3
data4
data5
data6
data7
data8
data9
data10
data11
data12
data13
data14
data15
data16
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data19
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data29
data30
data31
data32

Sampling Noise

* Sampling noise is a significant issue with the LISST measurements
  * Potentially some unknown electronics issues
  * Bubbles, dust contamination, dirty optics are all concerns
  * Small sample volume (2.5 cm^3) so for every 400 phytoplankton cells per liter, on average only 1 cell would be measured.
    * More pronounced effect on larger phytoplankton/size bins
  * To reduce the noise data outside the 95% confidence interval were excluded. Remaining data were then averaged.