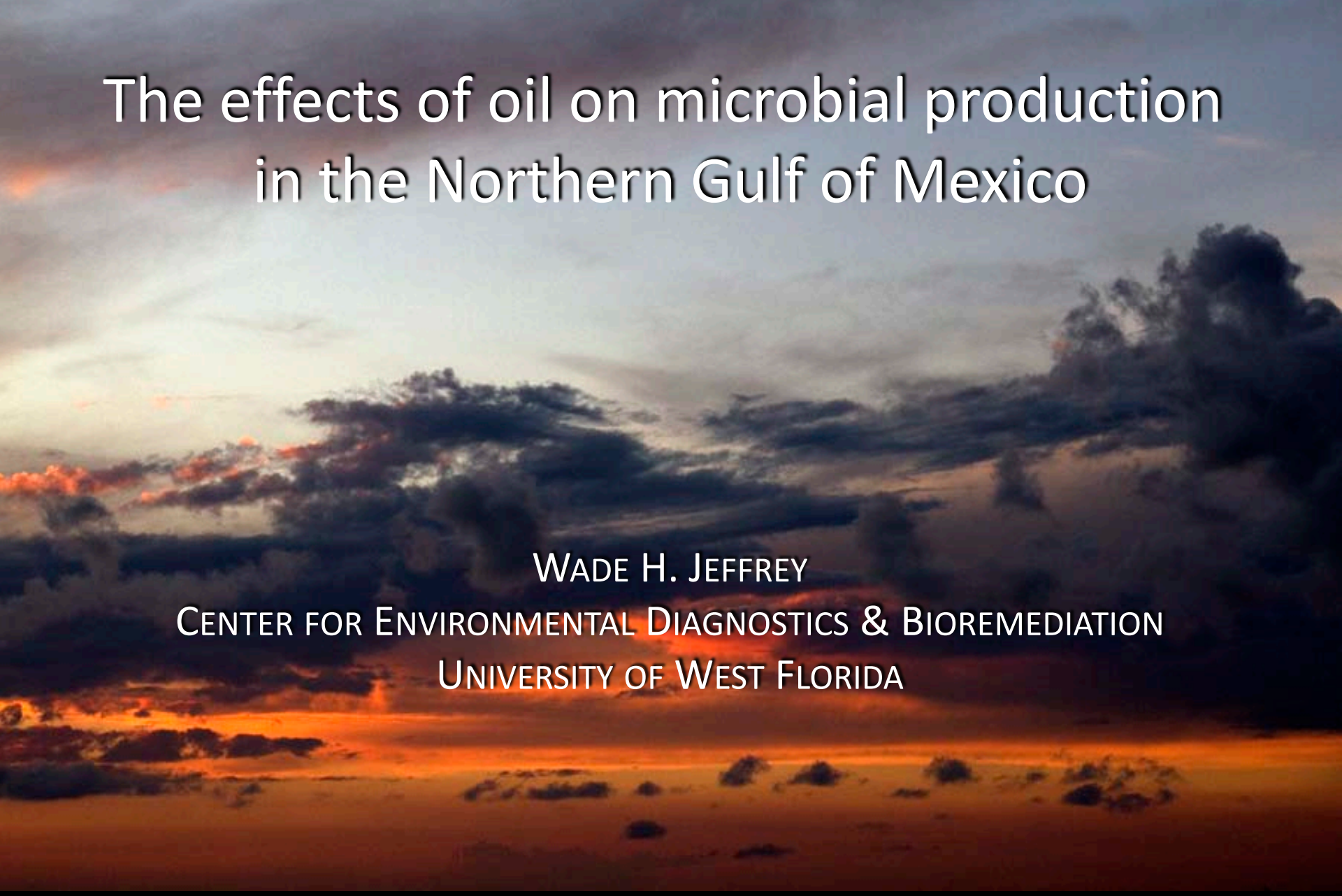
The effects of oil on microbial production in the Northern Gulf of Mexico

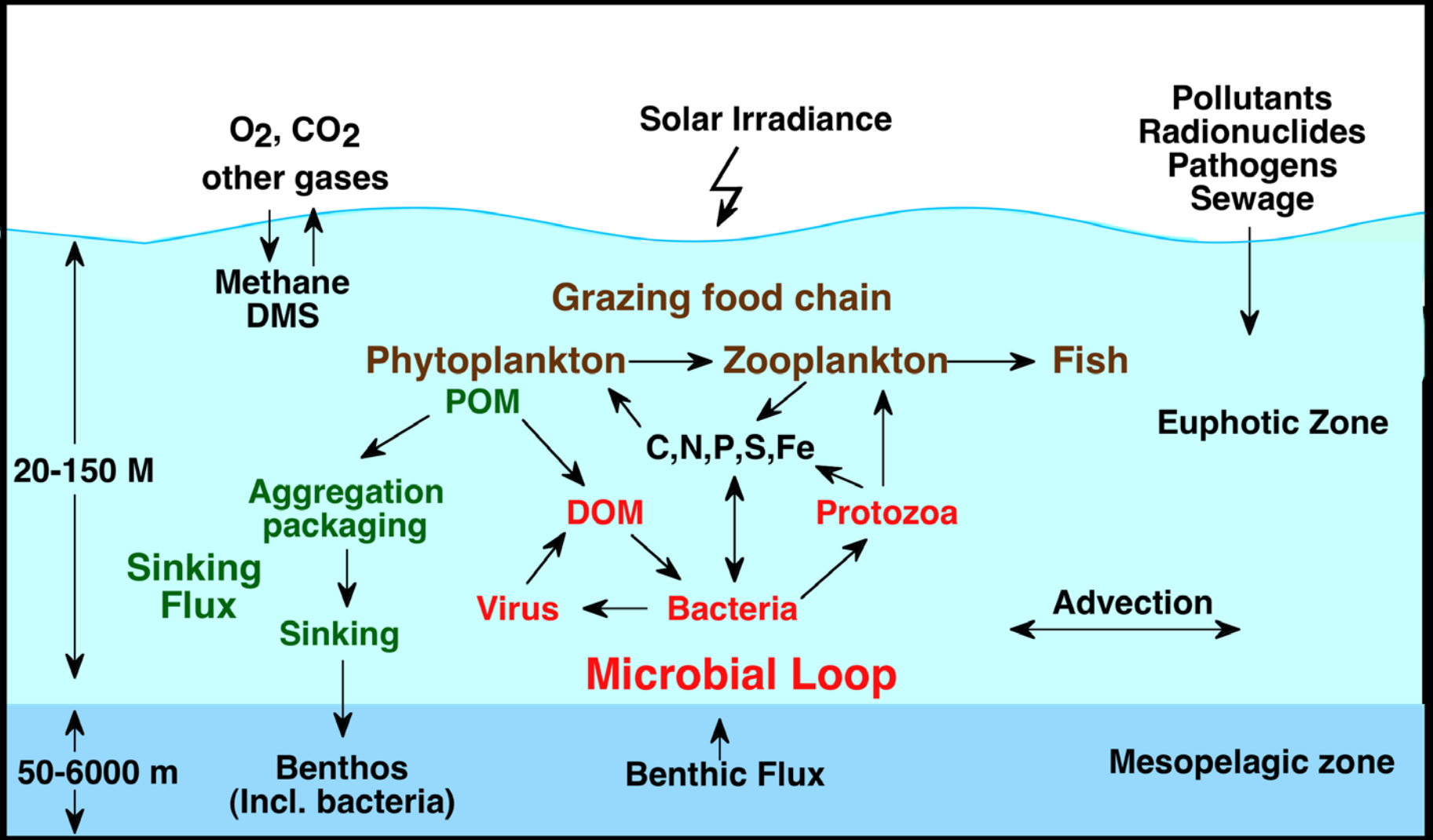


Wade H. Jeffrey
Center for Environmental Diagnostics & Bioremediation
University of West Florida

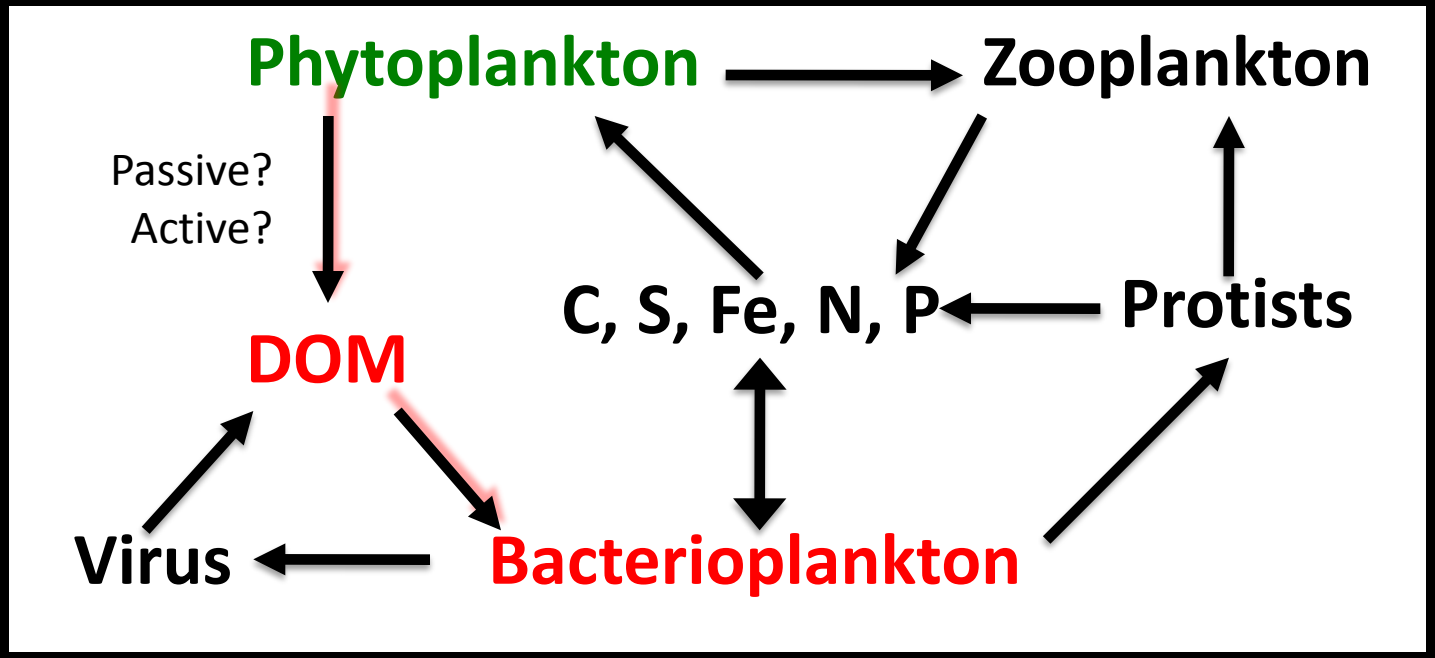
Bacteria → Biodegradation

Pensacola Beach, FL 23 June 2010

Photo by Ray Palmer

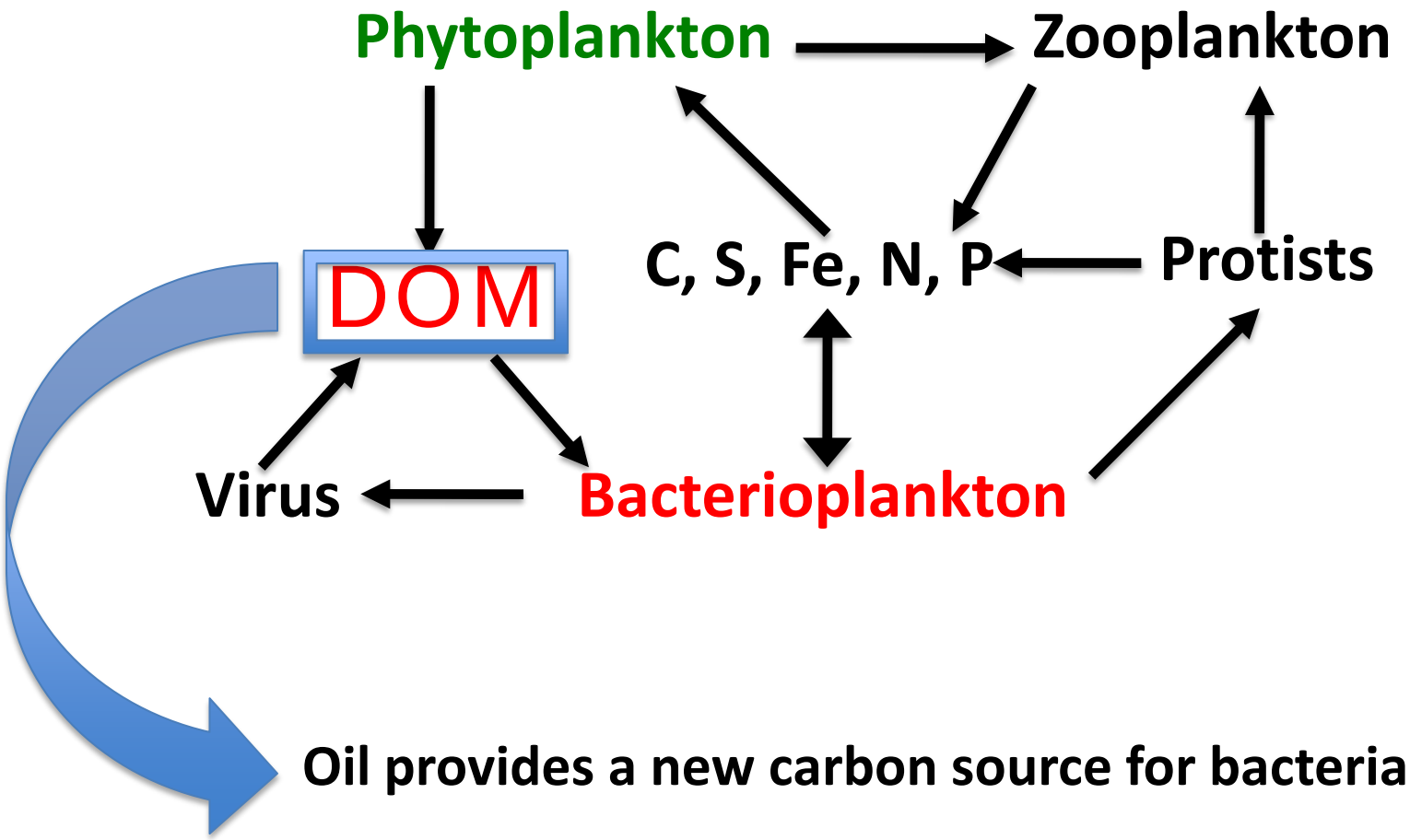


F. Azam (1998). Science 280: 694



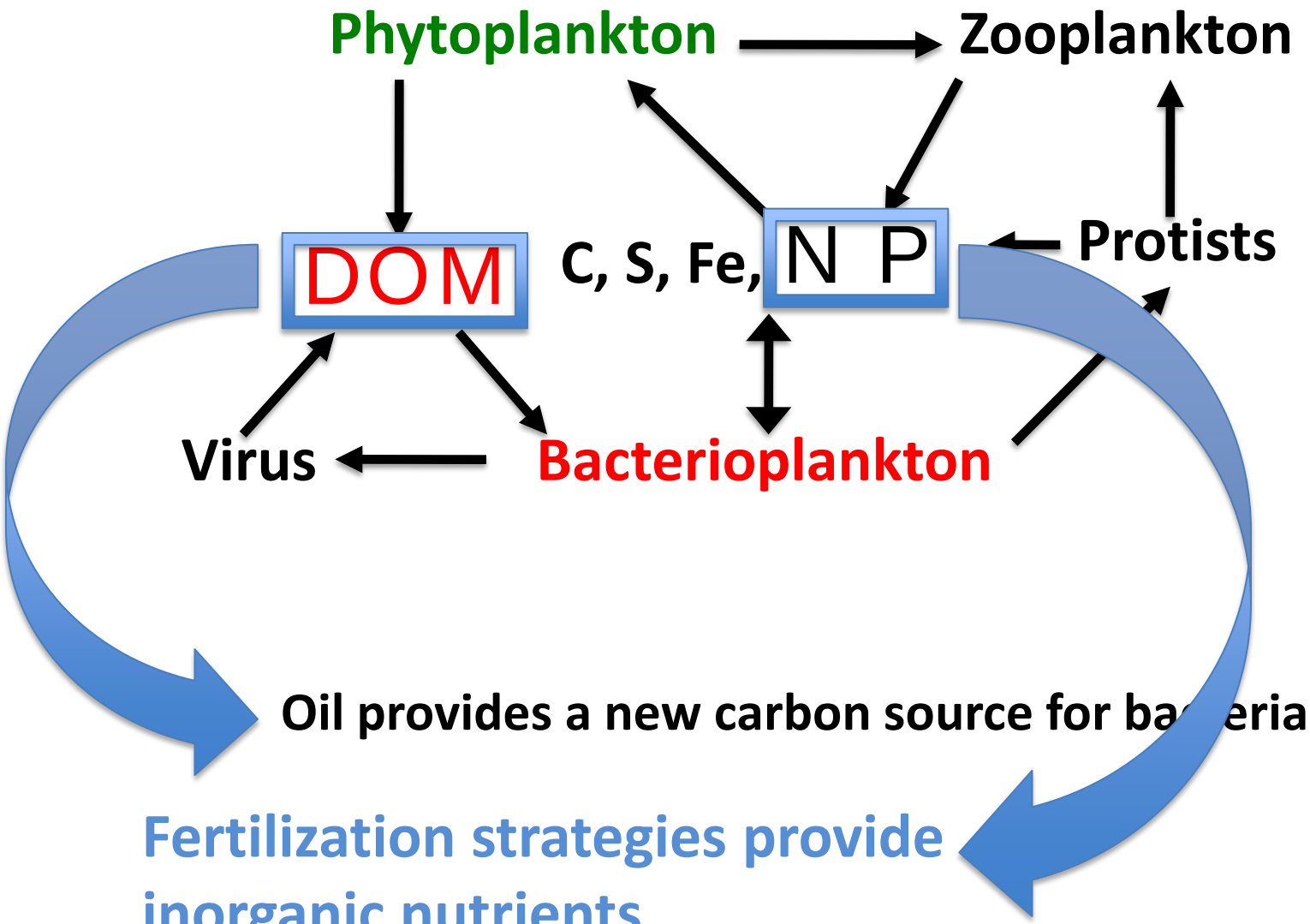
What about toxicity?

What about trophic interactions?



Oil provides a new carbon source for bacteria

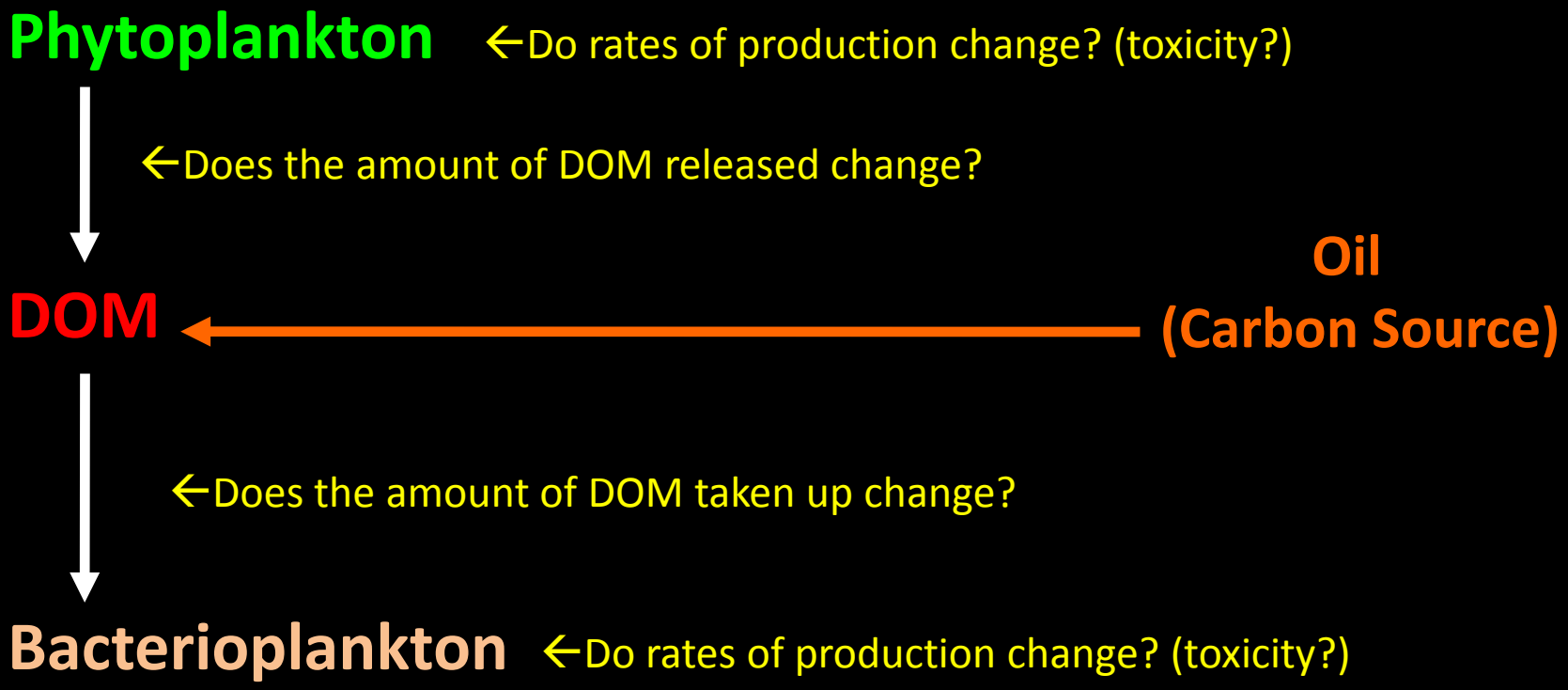
Do dispersants provide further change?


Phytoplankton
Zooplankton
DOM
C, S, Fe,
N P
Protists
Virus
Bacterioplankton
Oil provides a new carbon source for ba eria
Fertilization strategies provide
inorganic nutrients

Experimentally
Two Processes:

(1) Phytoplankton Primary Production
^{14}C-bicarbonate fixation

(2) Bacterial Heterotrophic Production
^{3}H-leucine incorporation into protein



Uncoupling of autotrophy and heterotrophy: effects of the Deepwater Horizon Oil Spill on microbial food webs

Wade H. Jeffrey
University of West Florida

Jennifer Cherrier & Ashvini Chauhan
Florida A & M University

Jessie Rosanbalm (UWF) Tiffany Baskerville (FAMU)

Seems simple enough…..

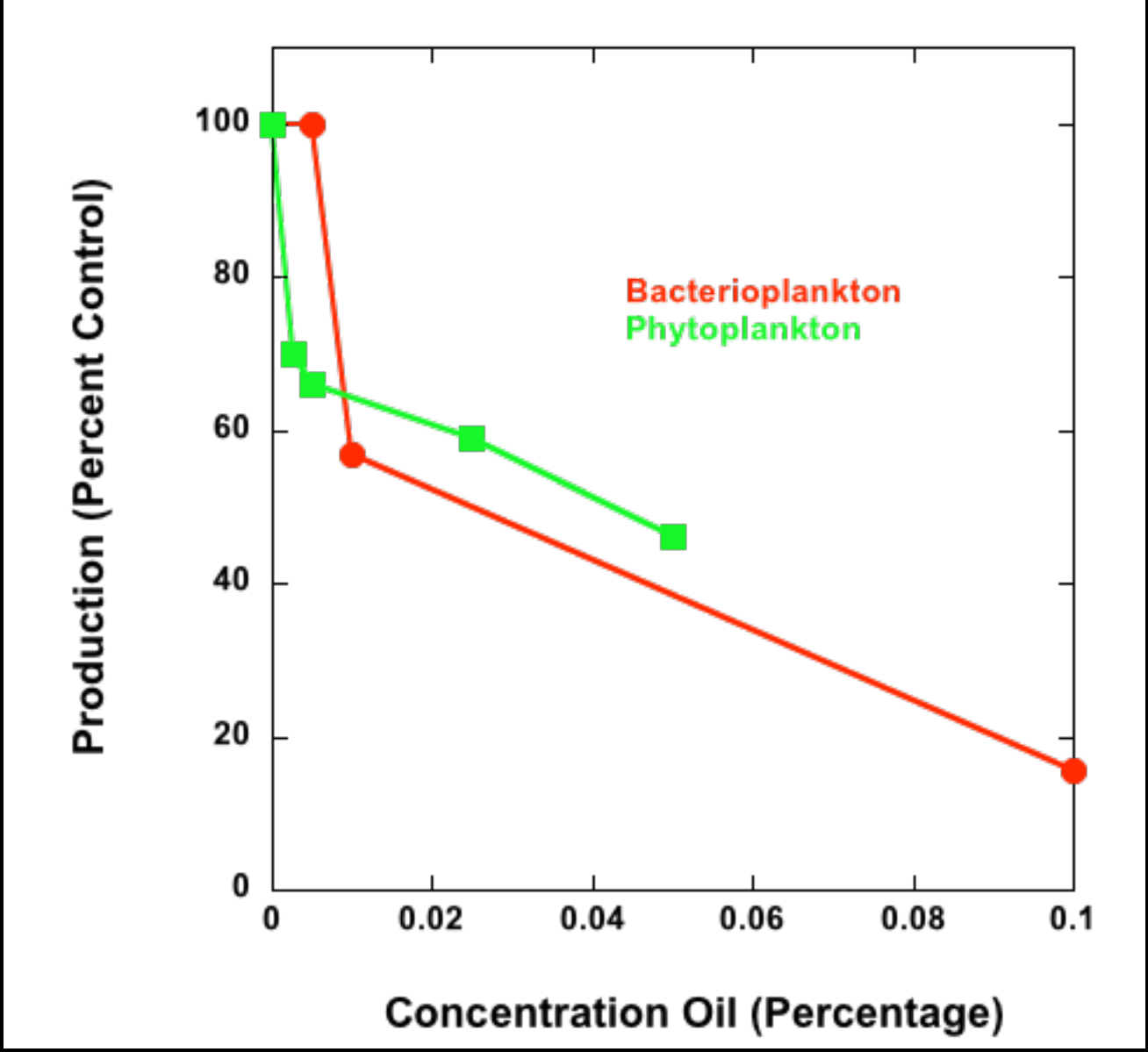
Add some oil and dispersant and watch for changes in production

We obtained some Macondo 252 oil from BP

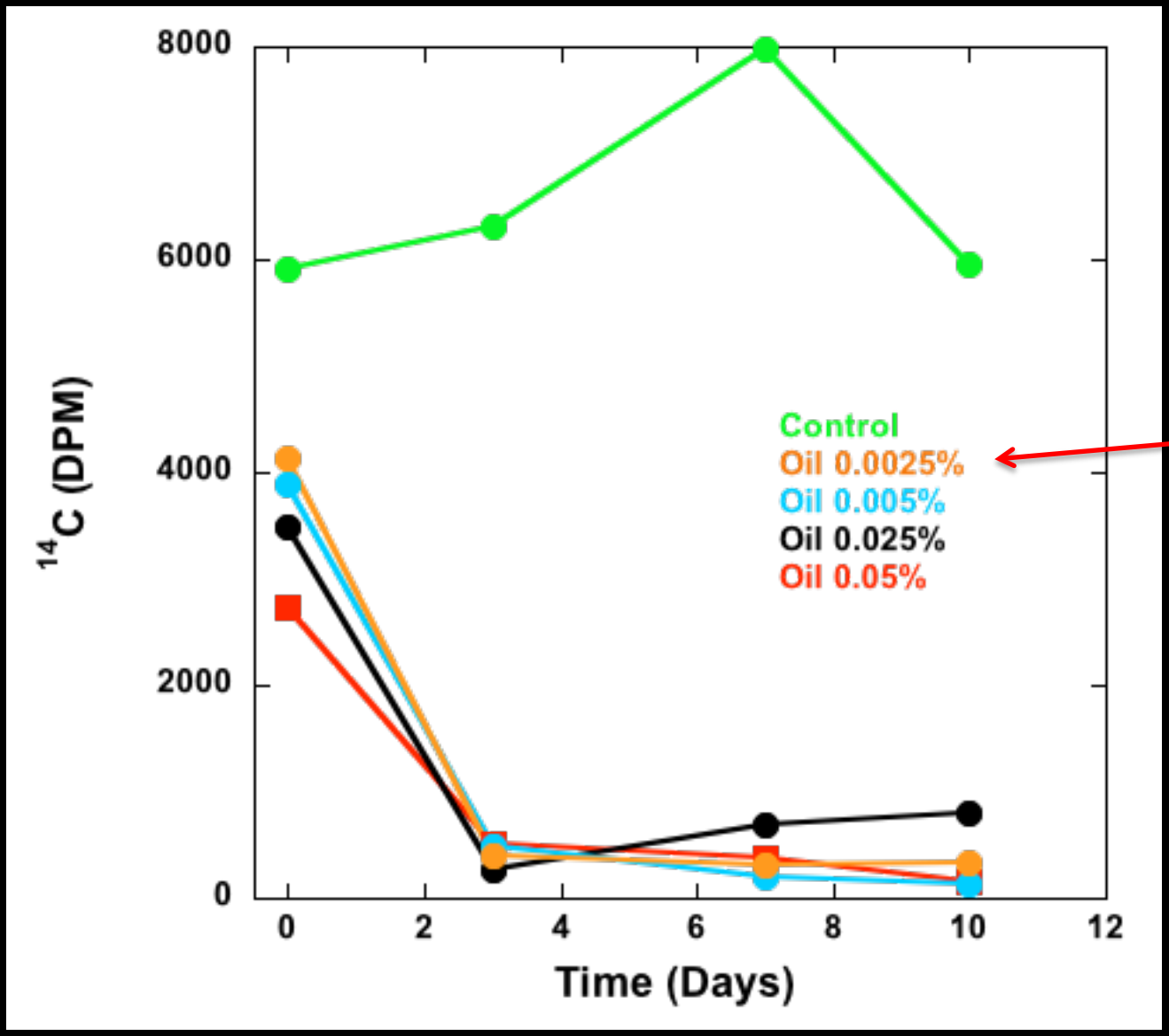
We obtained Corexit 9500A from Nalco

How much do we add? How do we add it?

Add oil, wait 2 hrs, measure production



Effect of added Macondo oil on phytoplankton production



By 3 days, no growth and no recovery when add oil directly

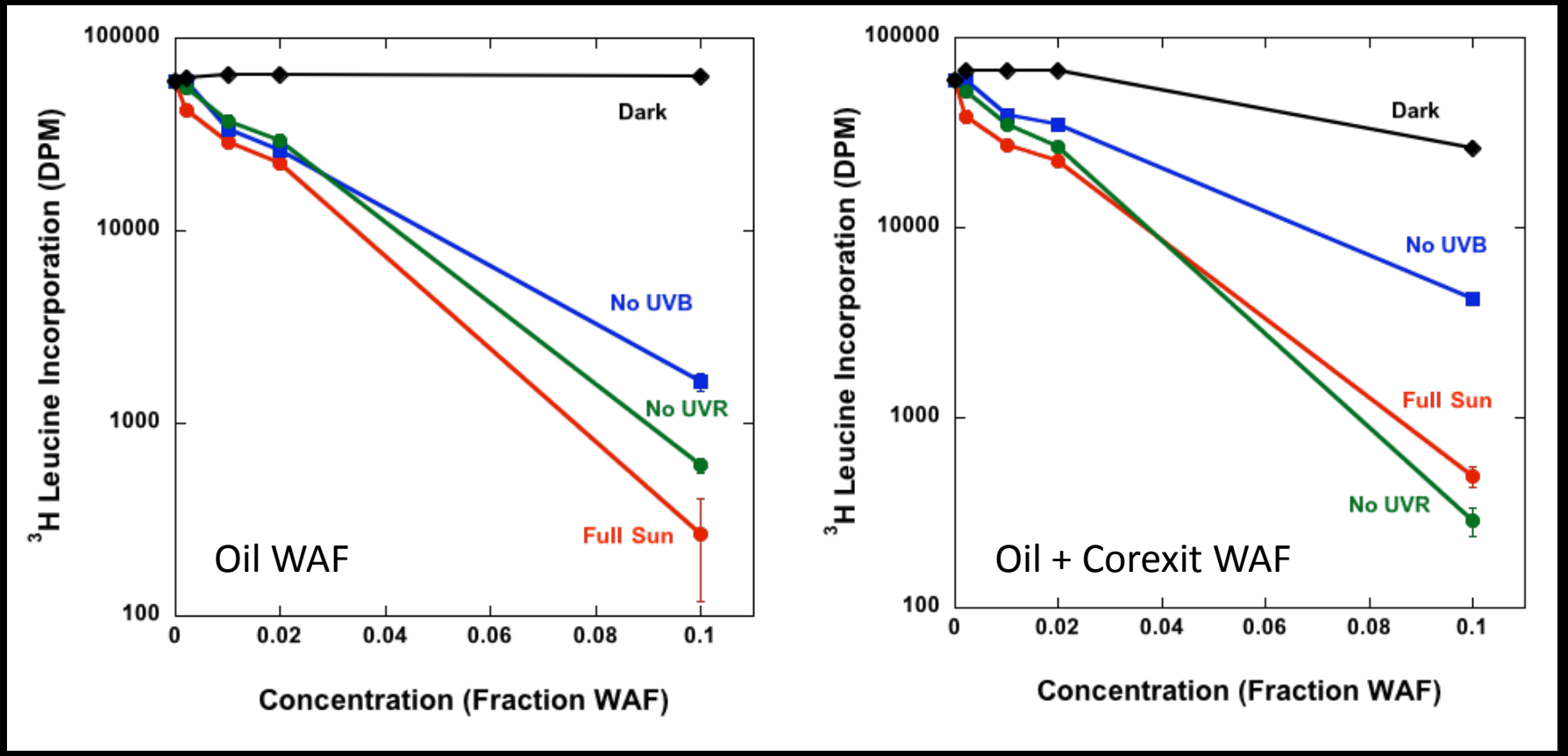
Production of WAF

Oil
+ Corexit

Oil

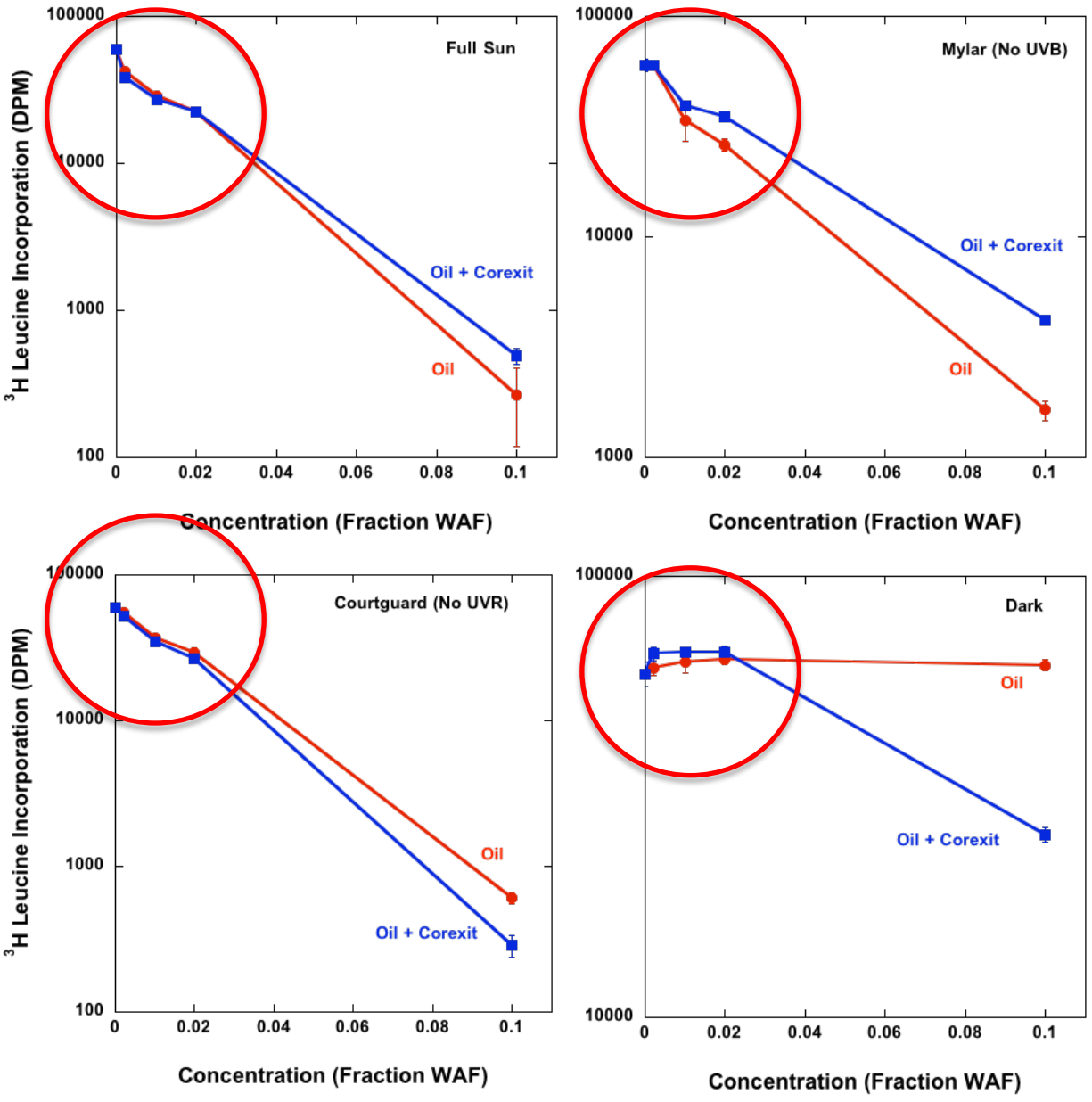
Does photooxidation of oil change the toxicity of the WAF to bacterioplankton?

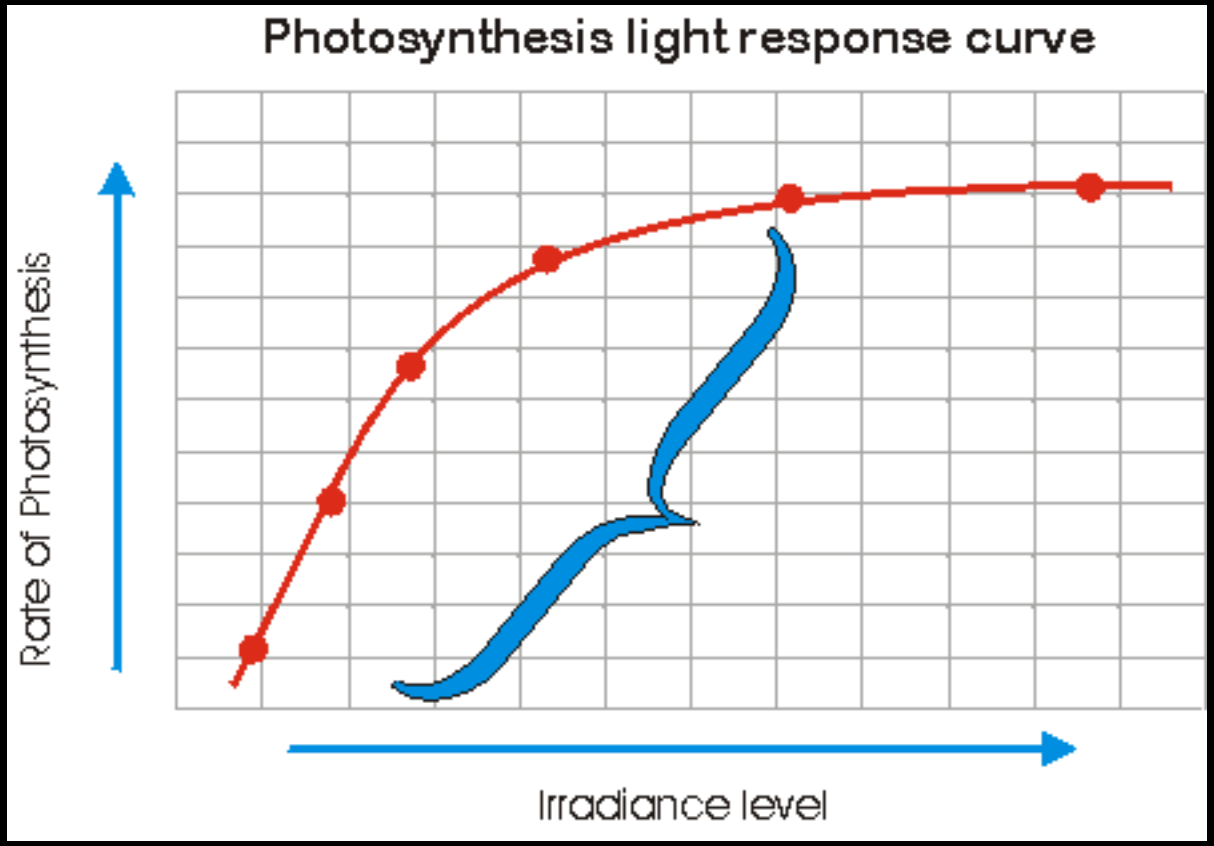
Make WAF in the dark and with exposure to sunlight

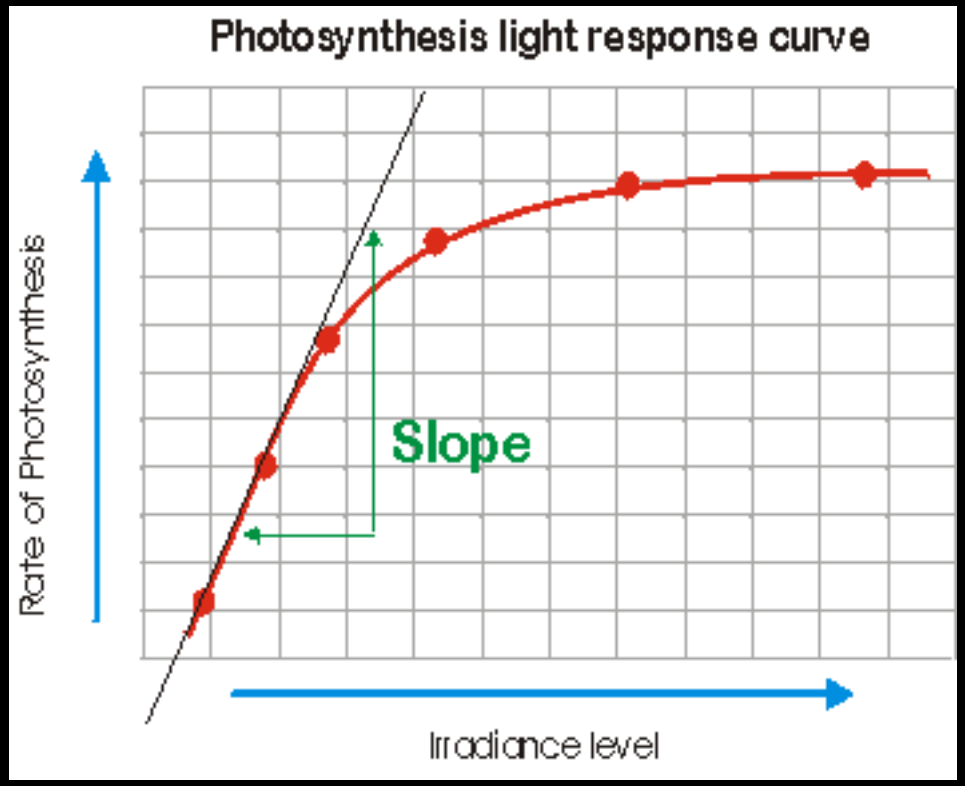


Sunlight increases the toxicity of the WAF

Does Corexit change the toxicity of the WAF?

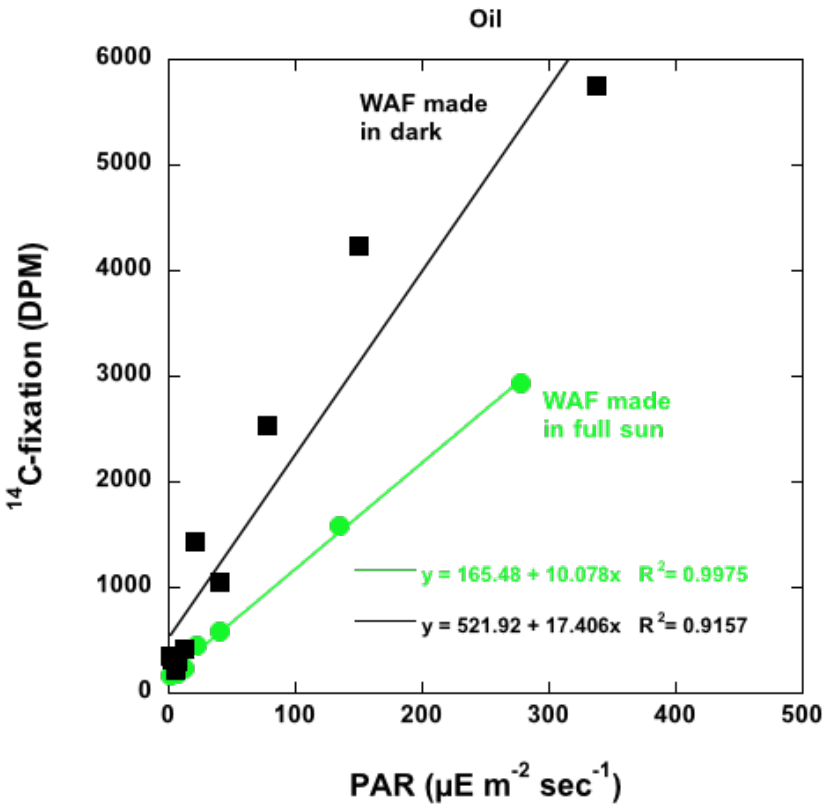


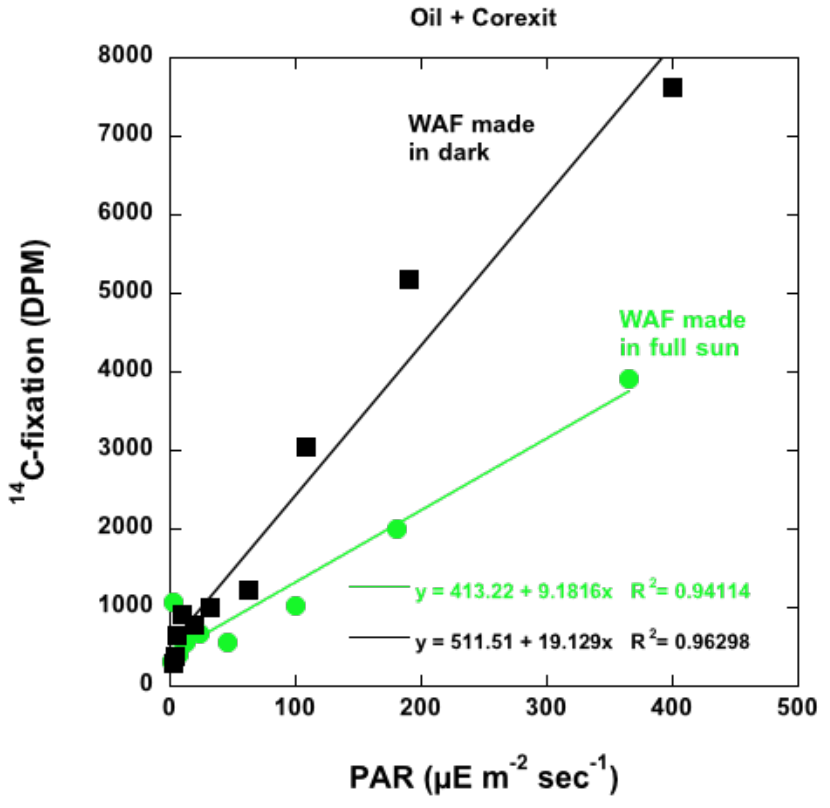

Photosynthesis light response curve
Rate of Photosynthesis
Irradiance level


Photosynthesis light response curve
Rate of Photosynthesis
Slope
Irradiance level

Does photooxidation of oil change the toxicity of the WAF to phytoplankton?

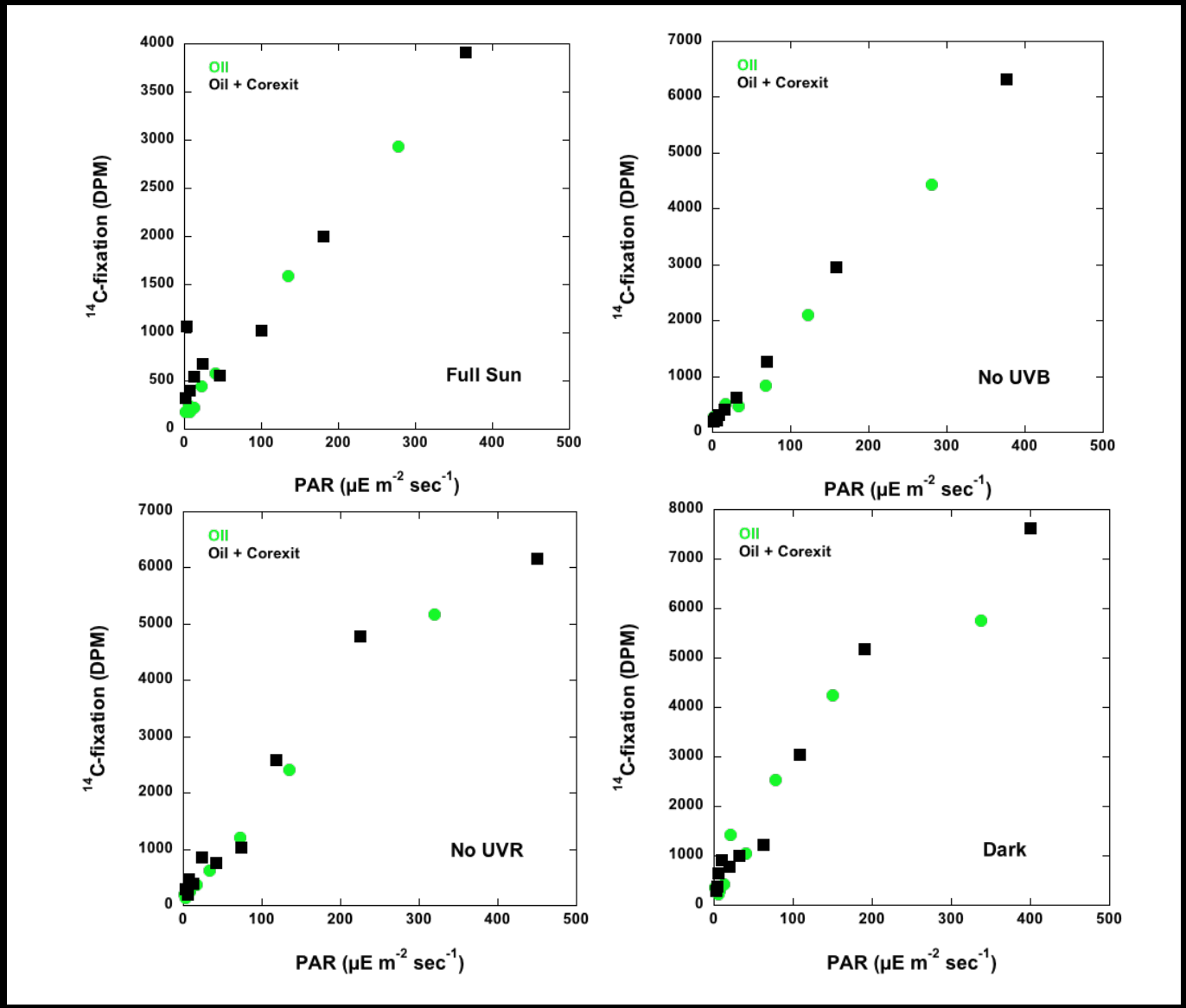
Make WAF in the dark and with exposure to sunlight



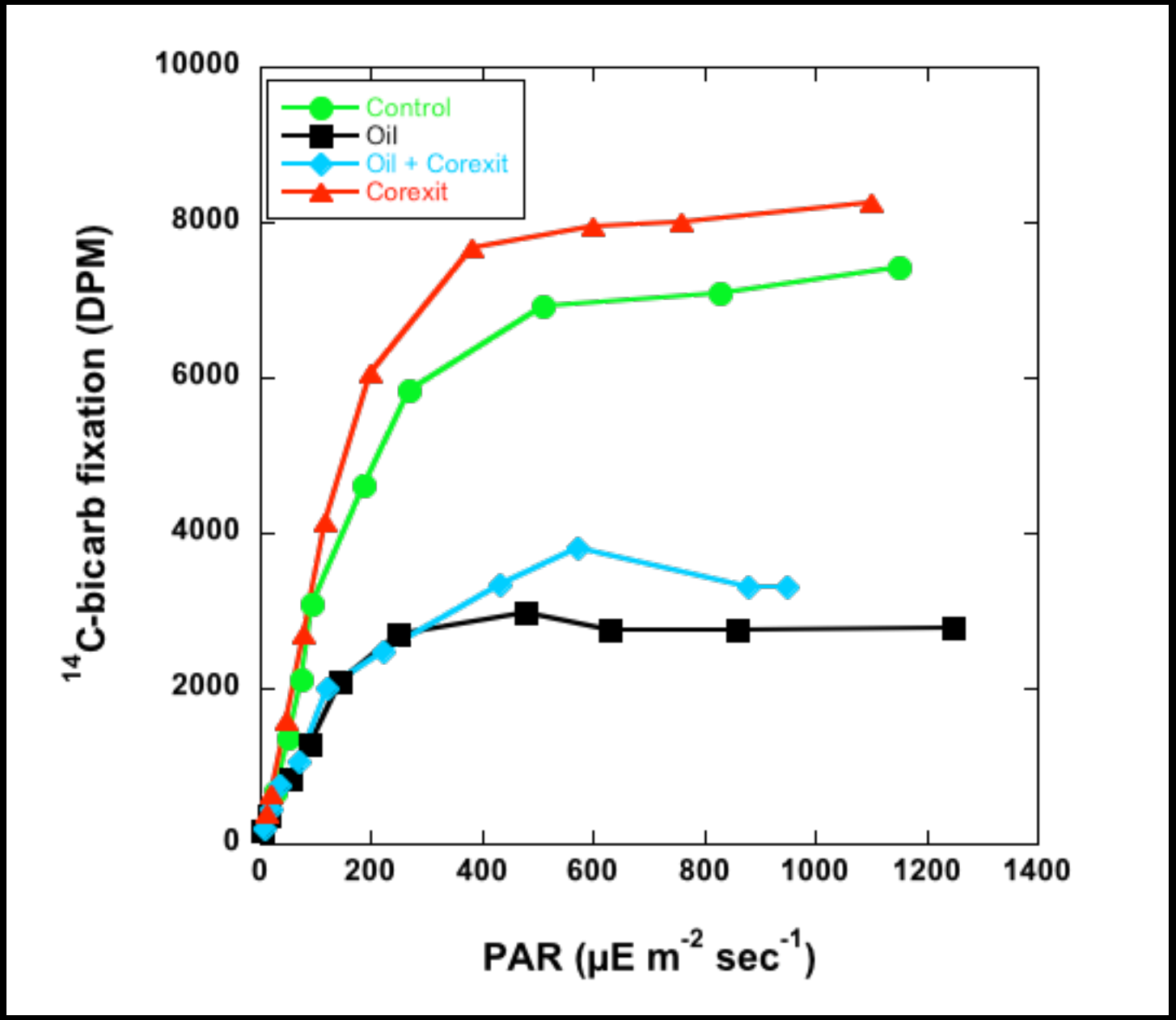


Sunlight increases the toxicity of the WAF

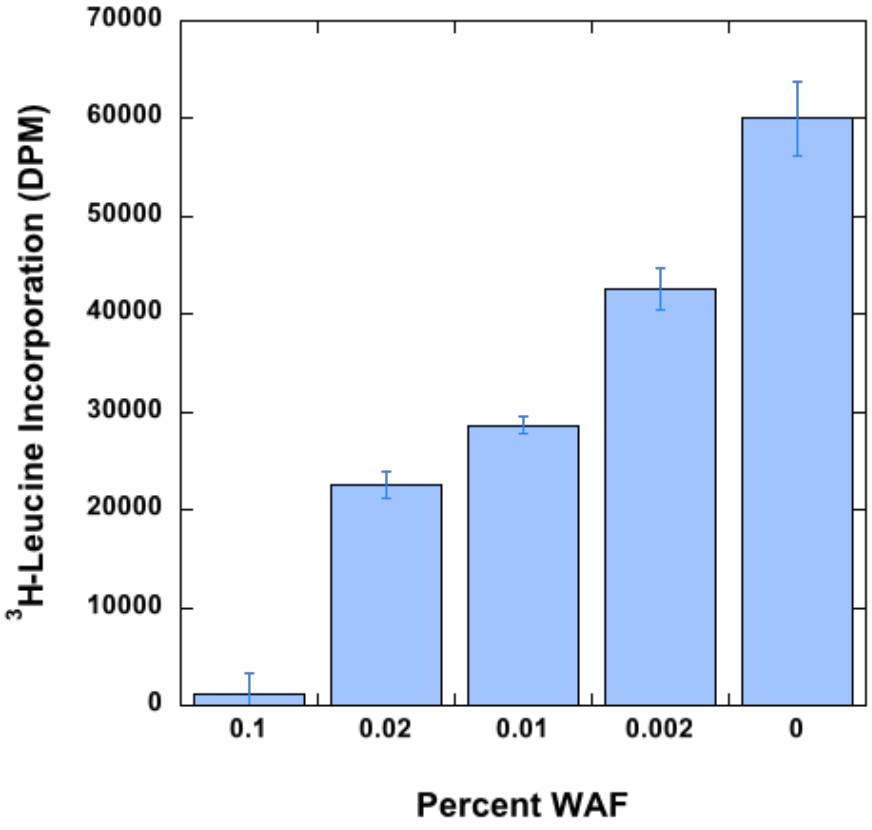
Does Corexit increase the toxicity of the oil WAF?

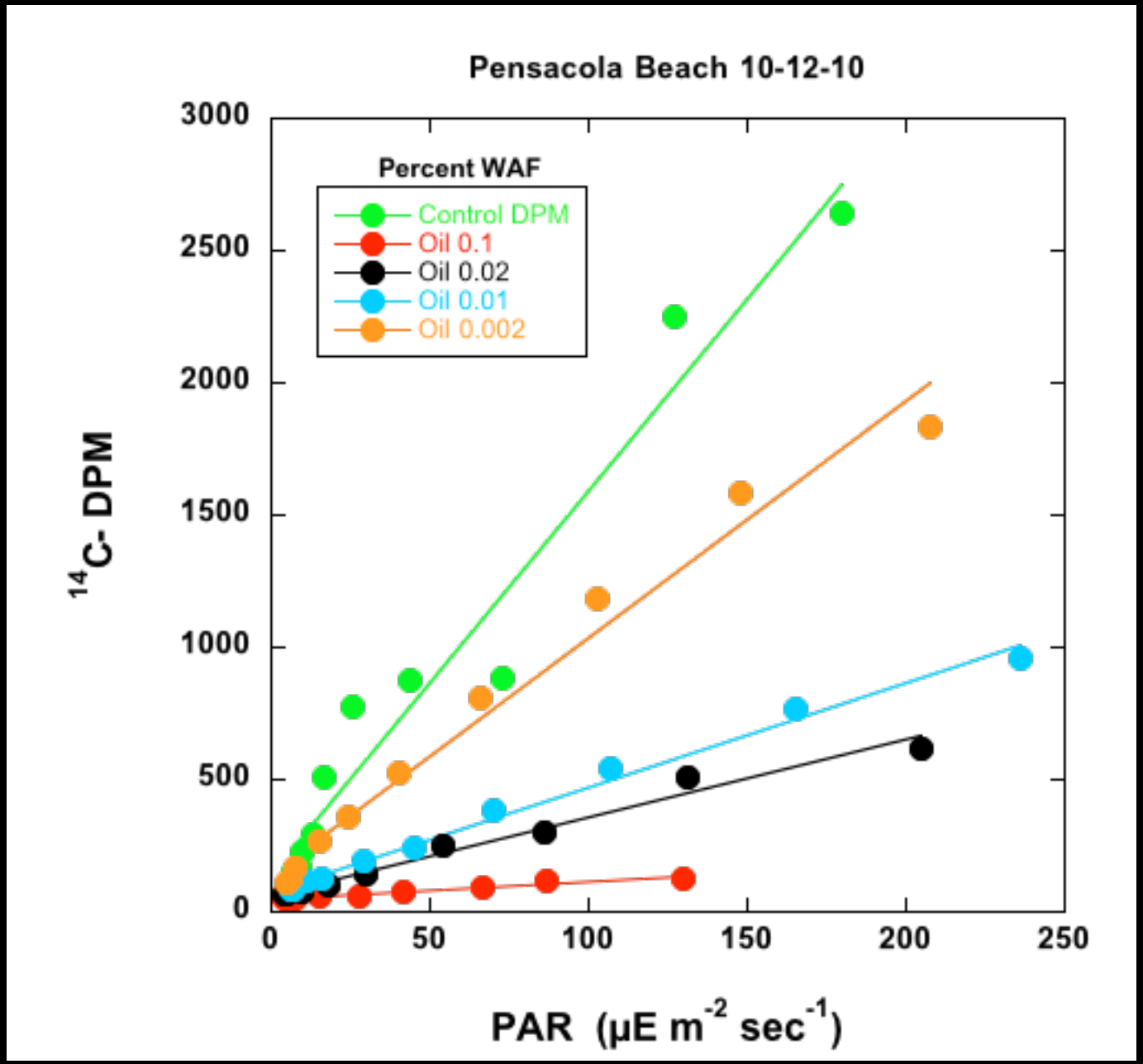


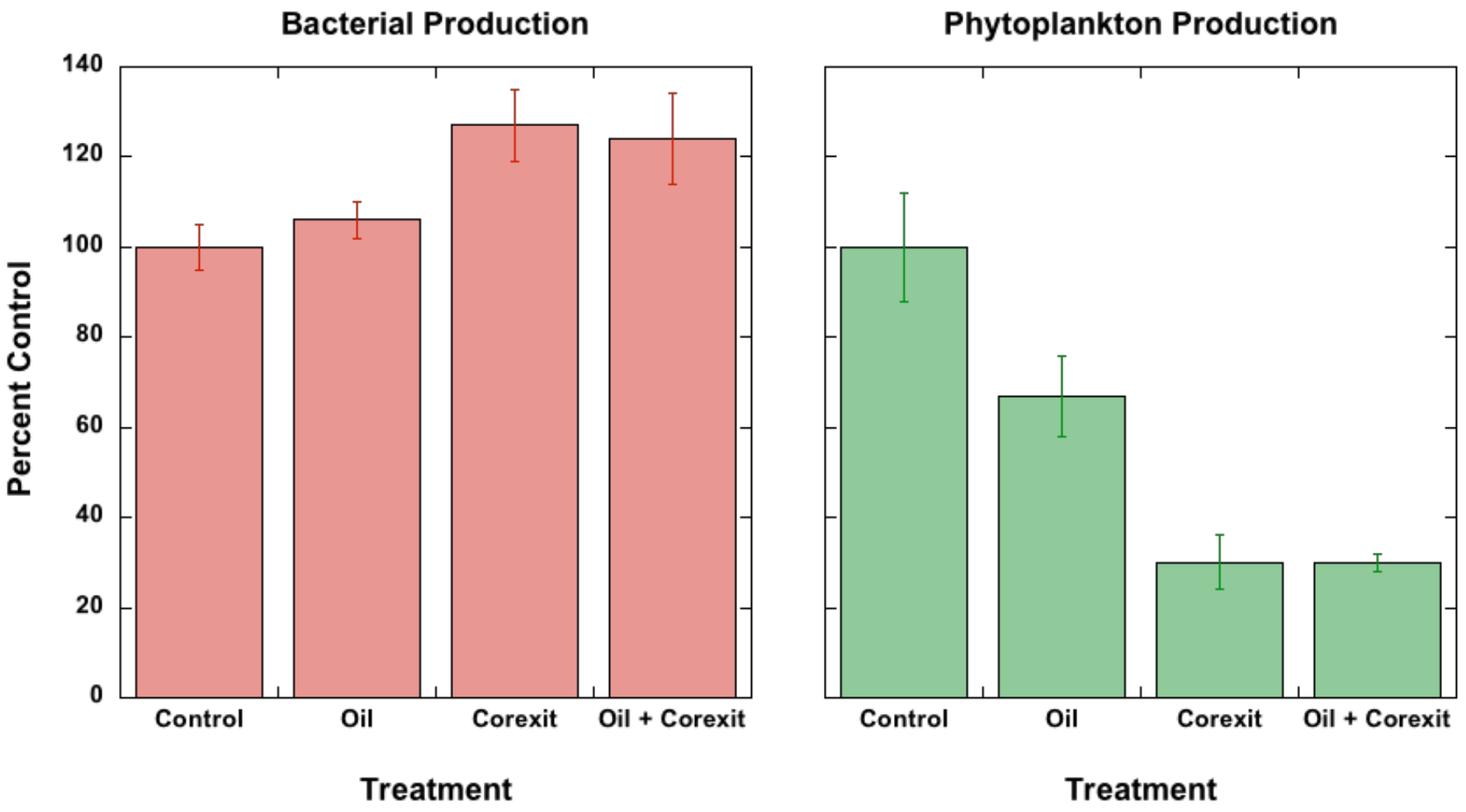
No


Control
Oil
Oil + Corexit
Corexit
10000
8000
6000
4000
2000
0
0
200
400
600
800
1000
1200
1400
14C-bicarb fixation (DPM)
PAR (µE m-2 sec-1)

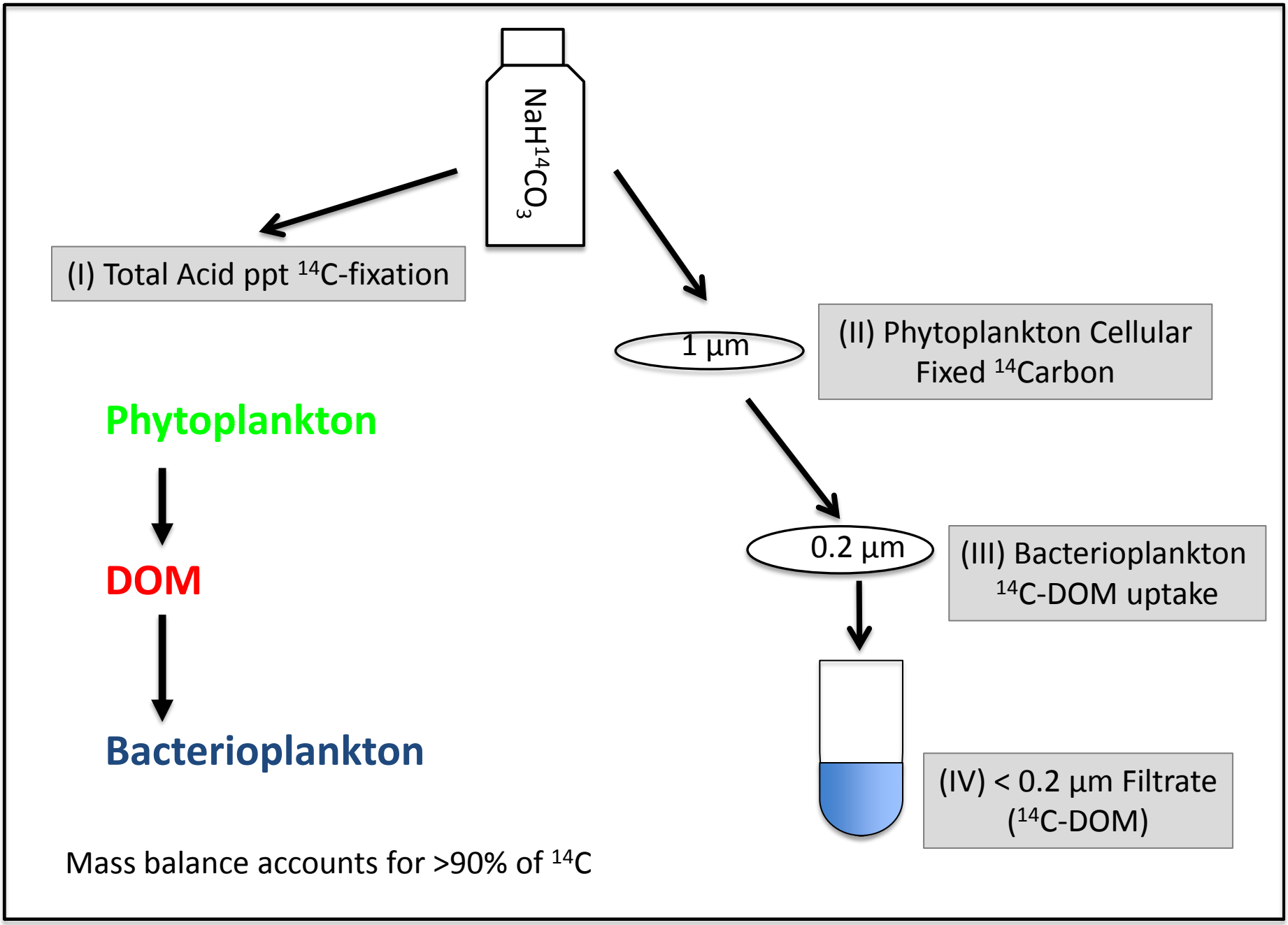
Bacterioplankton dose response to Oil WAF

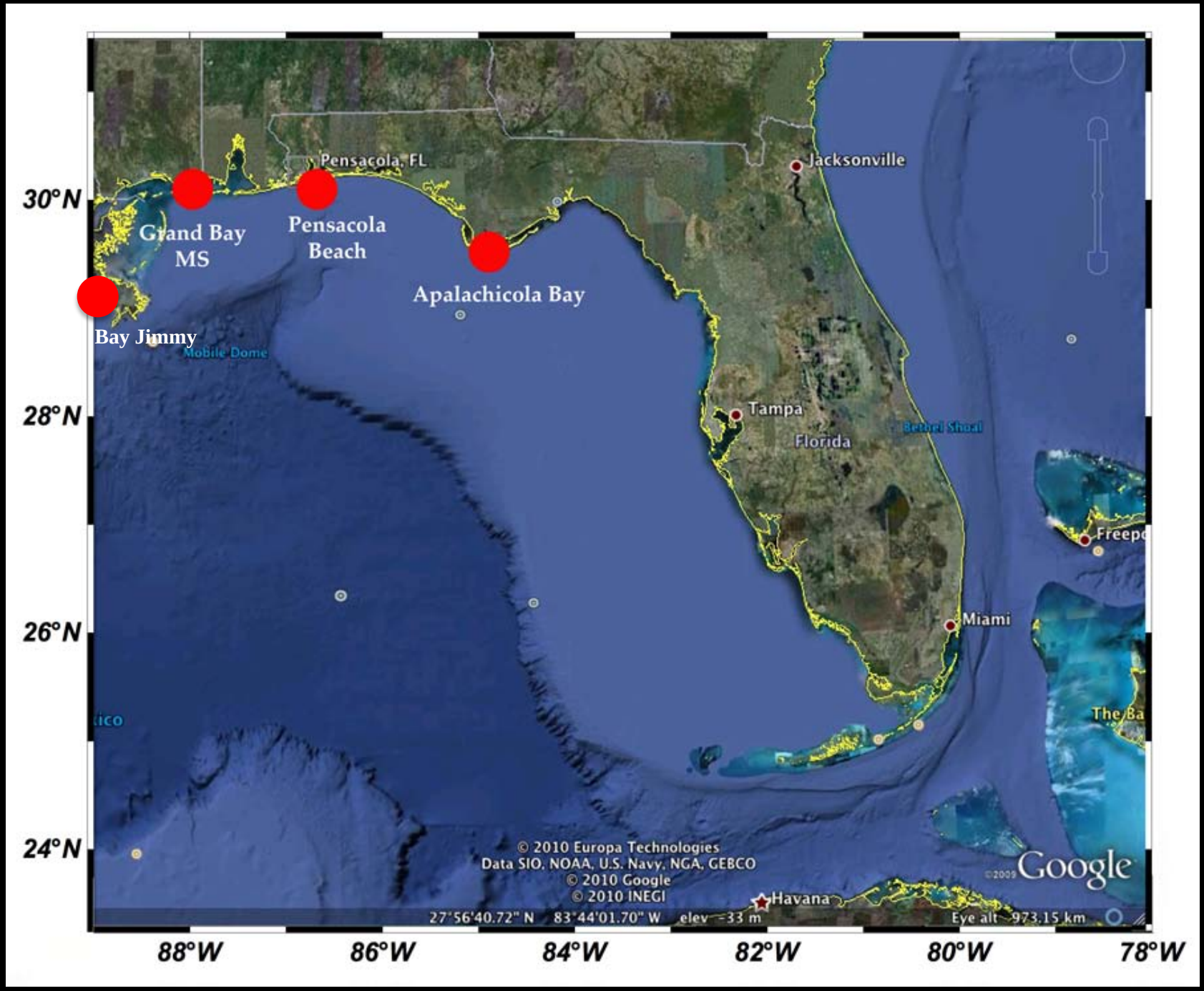



Pensacola Beach 10-12-10
Percent WAF
Control DPM
Oil 0.1
Oil 0.02
Oil 0.01
Oil 0.002
^{14}C- DPM
PAR (µE m^{-2} sec^{-1})
0
500
1000
1500
2000
2500
3000
0
50
100
150
200
250

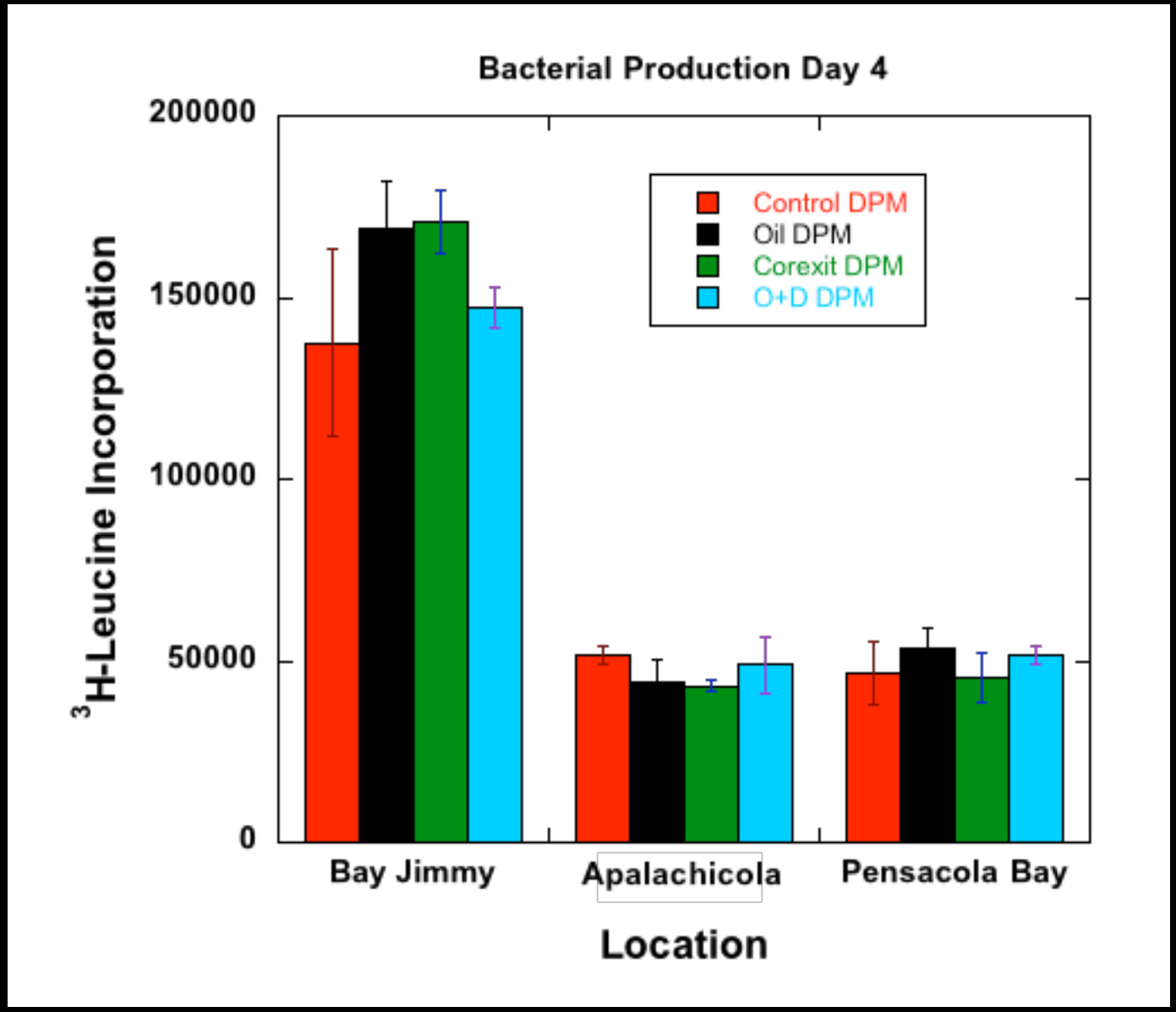

Bacterial Production
Phytoplankton Production
Percent Control
140
120
100
80
60
40
20
0
Control
Oil
Corexit
Oil + Corexit
Treatment
Control
Oil
Corexit
Oil + Corexit
Treatment

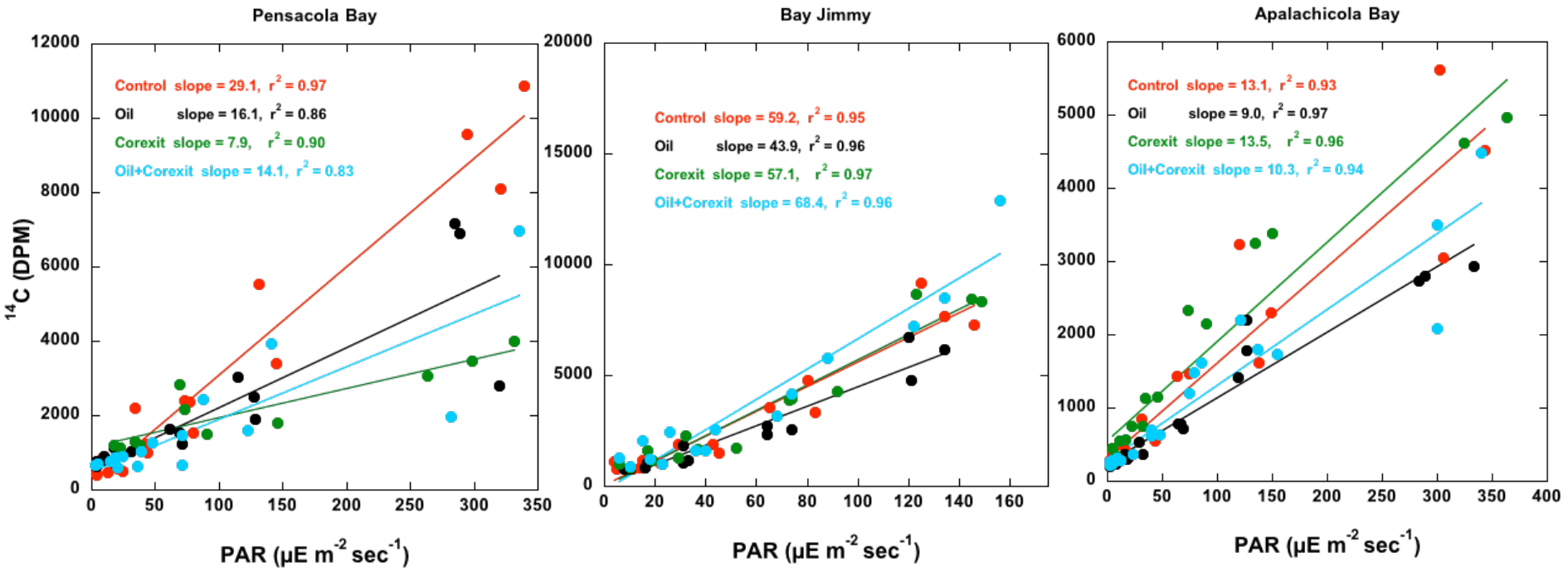
Oil at ~1 ppm


NaH14CO3
(I) Total Acid ppt 14C-fixation
1 µm
(II) Phytoplankton Cellular Fixed 14Carbon
Phytoplankton
DOM
Bacterioplankton
0.2 µm
(III) Bacterioplankton 14C-DOM uptake
(IV) < 0.2 µm Filtrate (14C-DOM)
Mass balance accounts for >90% of 14C


Pensacola, FL
Jacksonville
Grand Bay MS
Pensacola Beach
Apalachicola Bay
Bay Jimmy
Mobile Dome
Tampa
Florida
Miami
Havana
30°N
28°N
26°N
24°N
88°W
86°W
84°W
82°W
80°W
78°W
© 2010 Europa Technologies
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Google
© 2010 INEGI
27°56'40.72" N 83°44'01.70" W elev -33 m
Eye alt 973.15 km
Google


Swain's
ATHLETE'S CHOICE


Bacterial Production Day 4
200000
150000
100000
50000
0
^{3}H-Leucine Incorporation
Control DPM
Oil DPM
Corexit DPM
O+D DPM
Bay Jimmy
Apalachicola
Pensacola Bay
Location

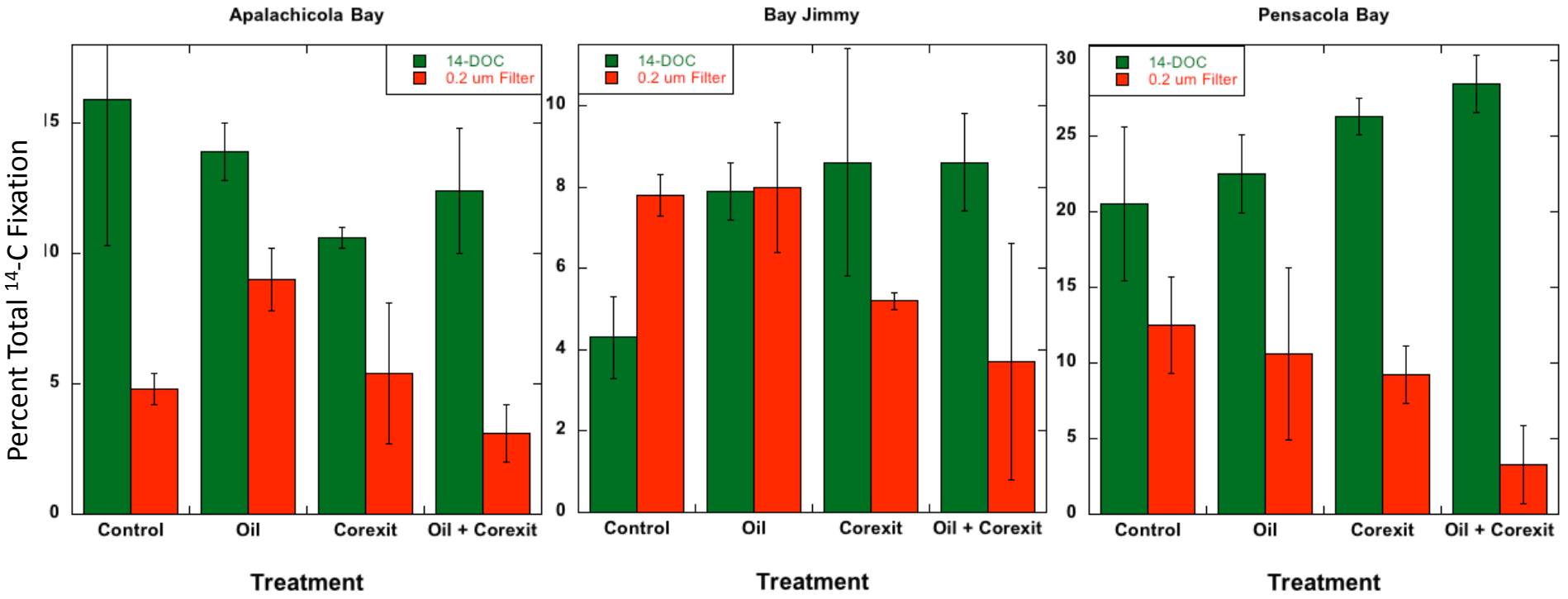


Heavily contaminated Jimmy Bay is minimally affected by the addition of oil

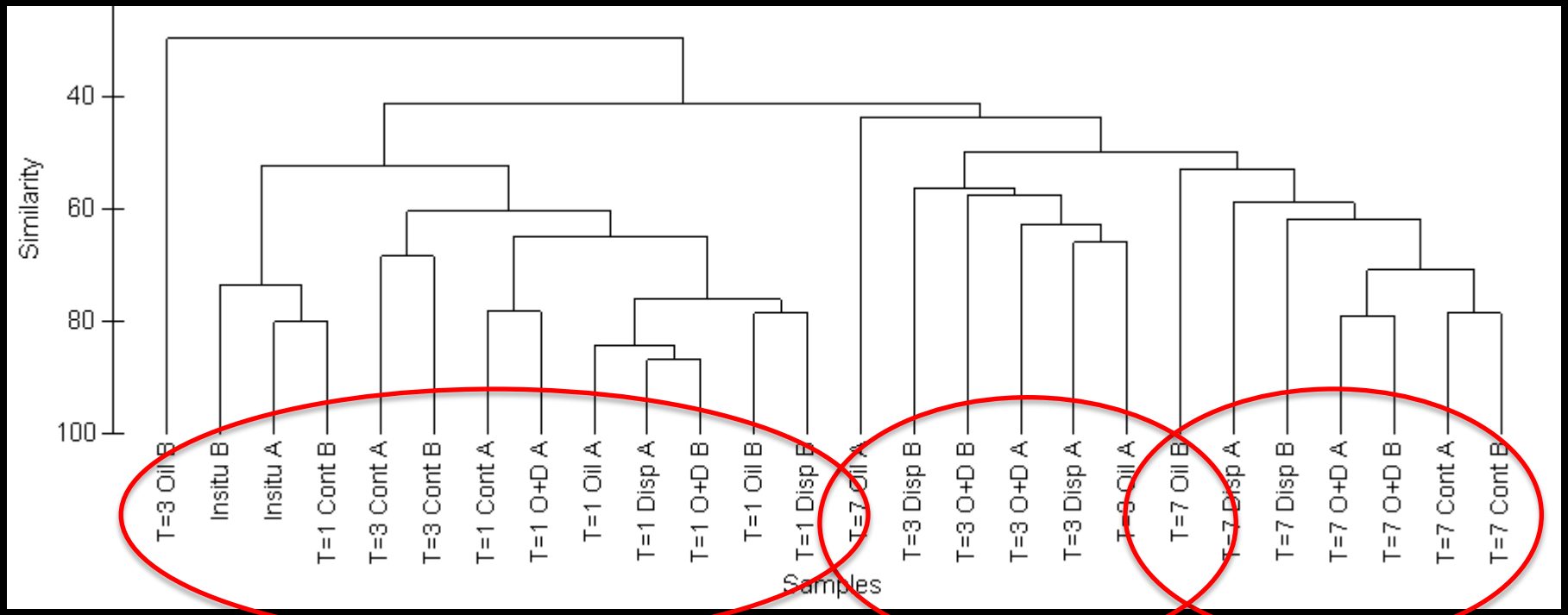
Percent of Total Bicarbonate Fixation

14-DOC is released by phytoplankton

0.2 um filter is carbon taken up by bacteria



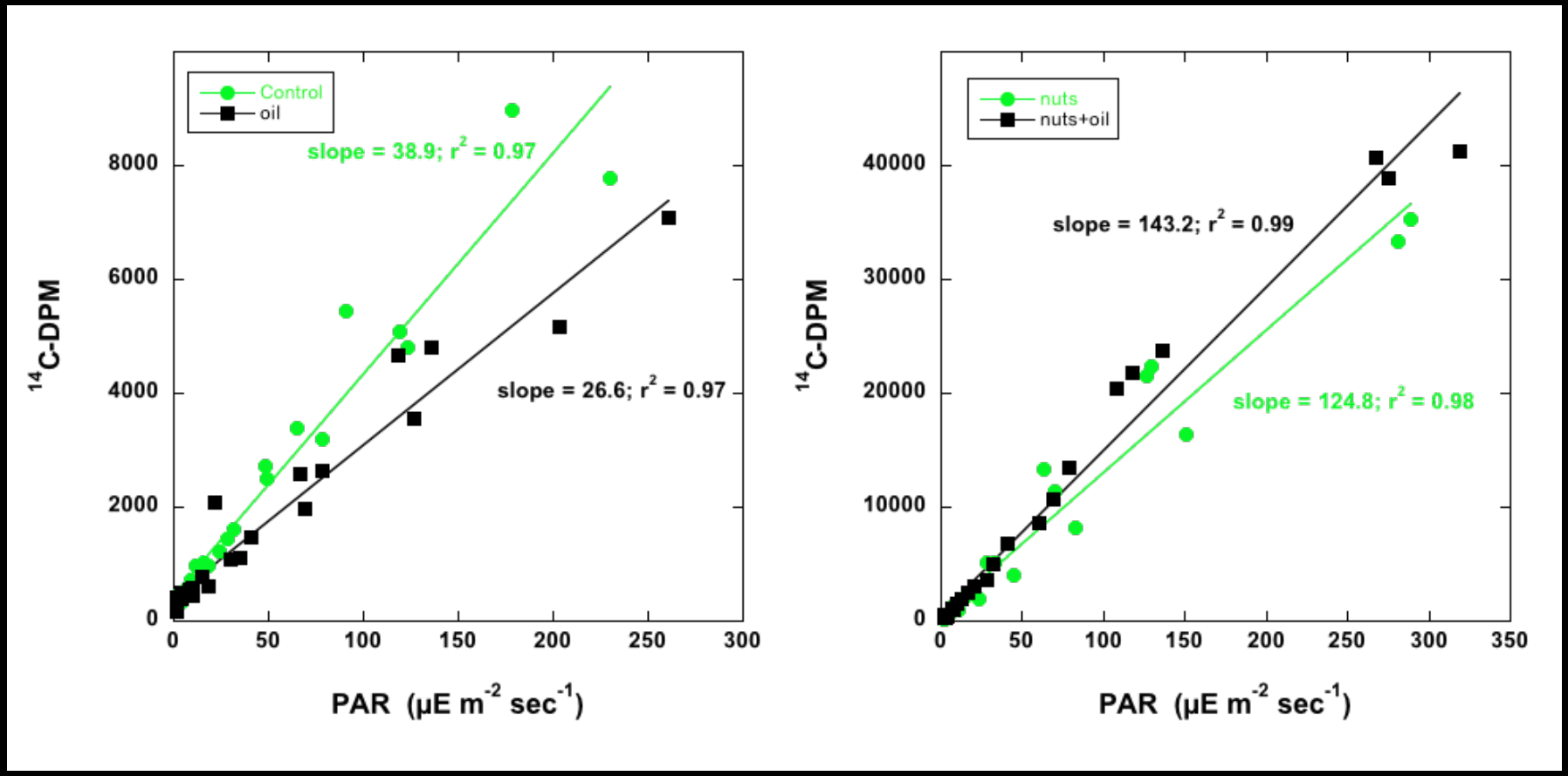
Oil and Corexit have little effect on production of DOC by phytoplankton but reduce the uptake of that DOC by bacterioplankton


Similarity
40
60
80
100
T=3 Oil B
Insitu B
Insitu A
T=1 Cont B
T=3 Cont A
T=3 Cont B
T=1 Cont A
T=1 O+D A
T=1 Oil A
T=1 Disp A
T=1 O+D B
T=1 Oil B
T=1 Disp B
T=7 Oil A
T=3 Disp B
T=3 O+D B
T=3 O+D A
T=3 Disp A
T=3 Oil A
T=7 Oil B
T=7 Disp A
T=7 Disp B
T=7 O+D A
T=7 O+D B
T=7 Cont A
T=7 Cont B
Samples

What about nutrients?

Alaskan Beach before and after *Bioremediation*

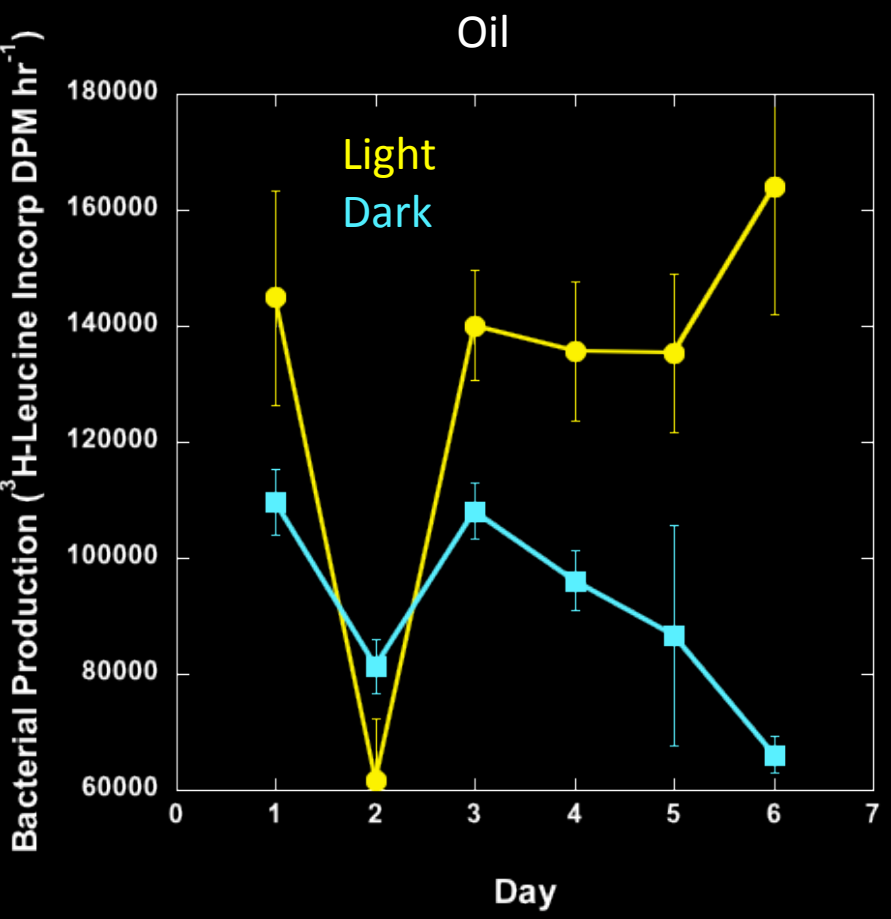
What about nutrients?

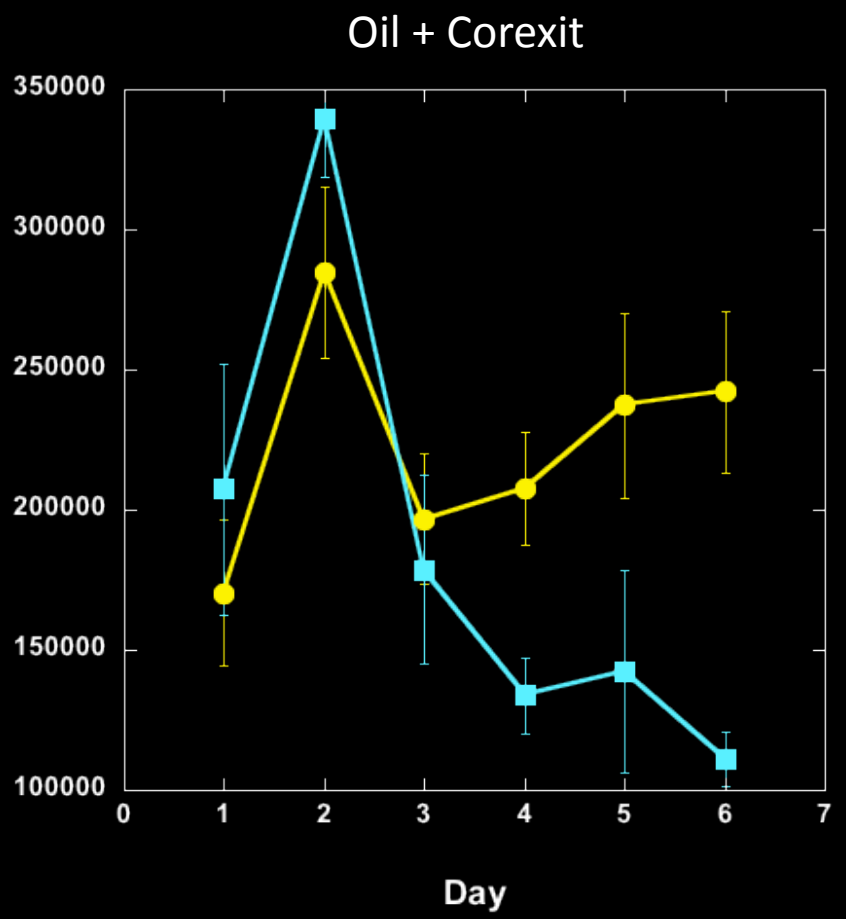


Addition of Inorganic nutrients reduces toxicity of oil to phytoplankton

(addition of N & P along with oil just makes bacterioplankton grow faster)

What controls bacterial growth and degradation of oil?





Oil (as naphthalene) degraded:
Light: 18 ppm
Dark: 0 ppm

Oil (as naphthalene) degraded:
Light: 15 ppm
Dark: 0 ppm

- **Phytoplankton production is more sensitive to oil than is bacterial production – while production declines, percent of fixed carbon released does not**
- **At relevant concentrations, dispersant has minimal effect on production**
- **Evidence suggests that bacterioplankton do consume oil as a carbon source – instead of phytoplankton carbon**
- **Bacterial growth on oil is enhanced by sunlight - probably photochemical reactions**
- **Dispersants to not appear to enhance biodegradation of oil**

Data still to come:

- Changes in nutrients, biogeochemistry

-Changes in bacterioplankton community structure
-– hot off the press

-Changes in phytoplankton community structure
--in progress, but larger cells seem to do better

Determine rates of oil biodegradation and factors that control it

Thanks to:

Dean Pakulski, Jason Kase, Jarah Meador, Amy Baldwin

Jessie Rosanbalm,Sandy McFarland, Pam Vaughan
Jennifer Cherrier, Tiffany Baskerville, Ashvini Chauhan
Melissa Hagy