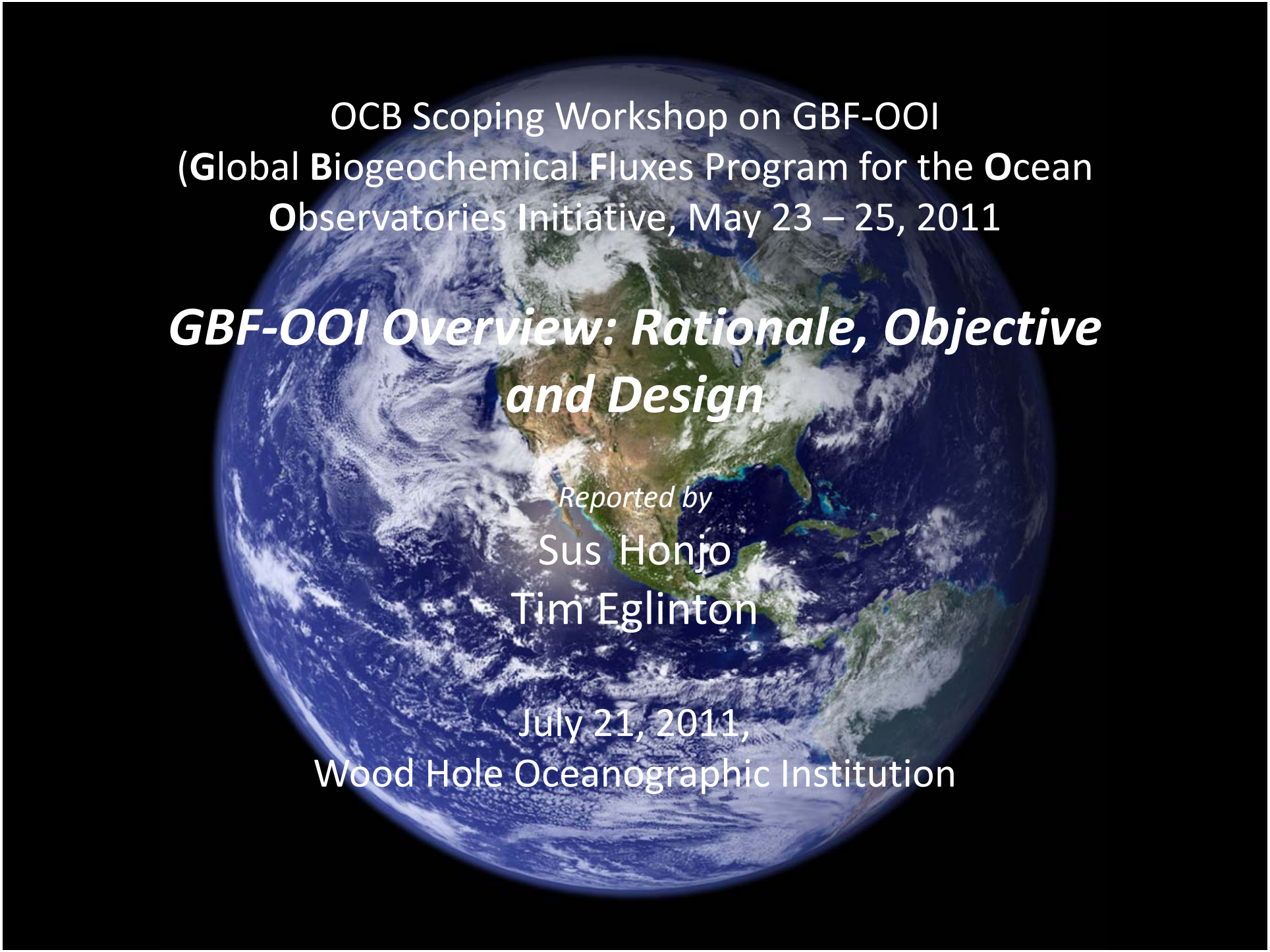


OCB Scoping Workshop on GBF-OOI
(**G**lobal **B**iogeochemical **F**luxes Program for the **O**cean **O**bservatories **I**nitiative, May 23 – 25, 2011

GBF-OOI Overview: Rationale, Objective and Design

Reported by

Sus Honjo

Tim Eglinton

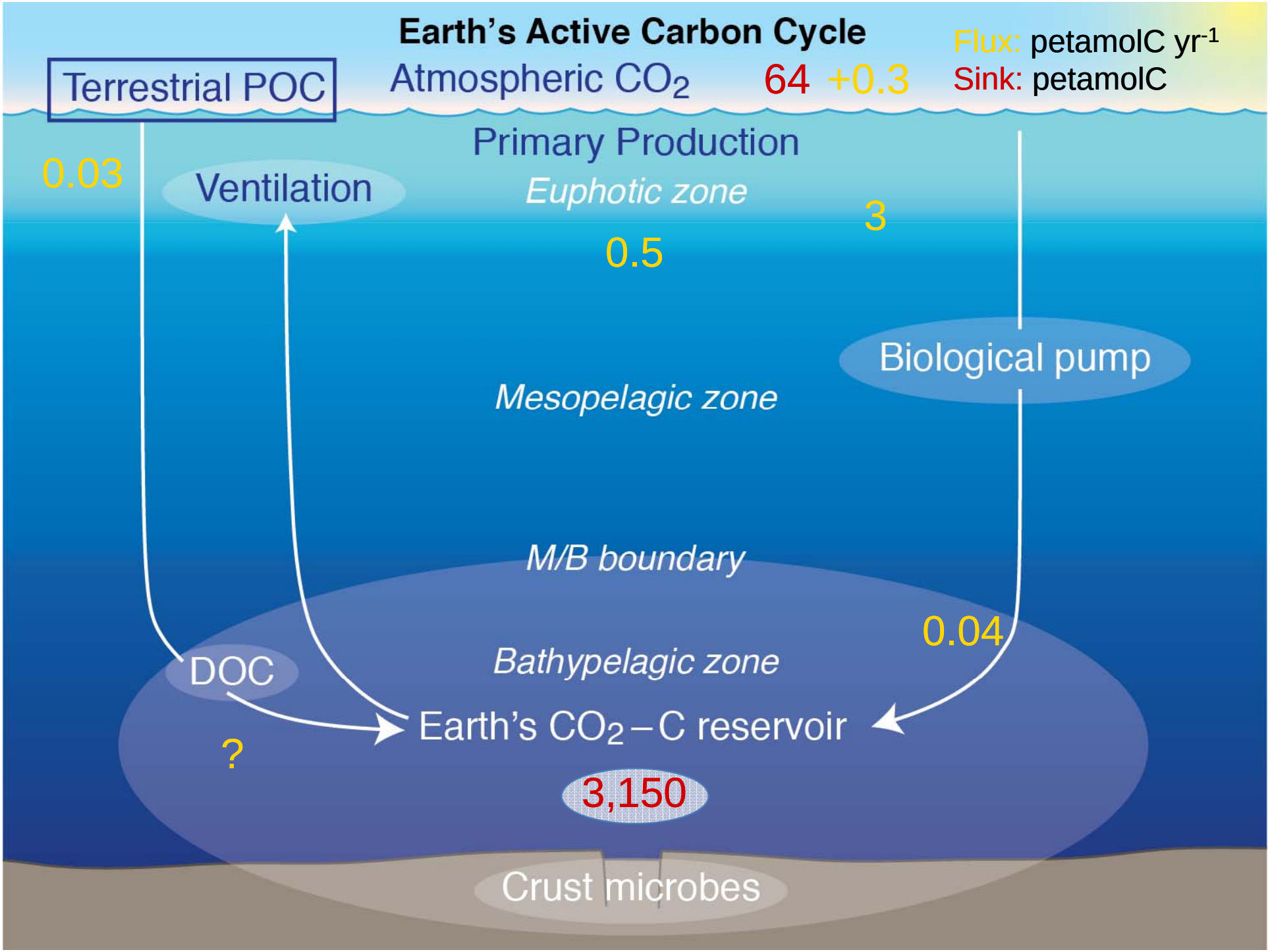
July 21, 2011,

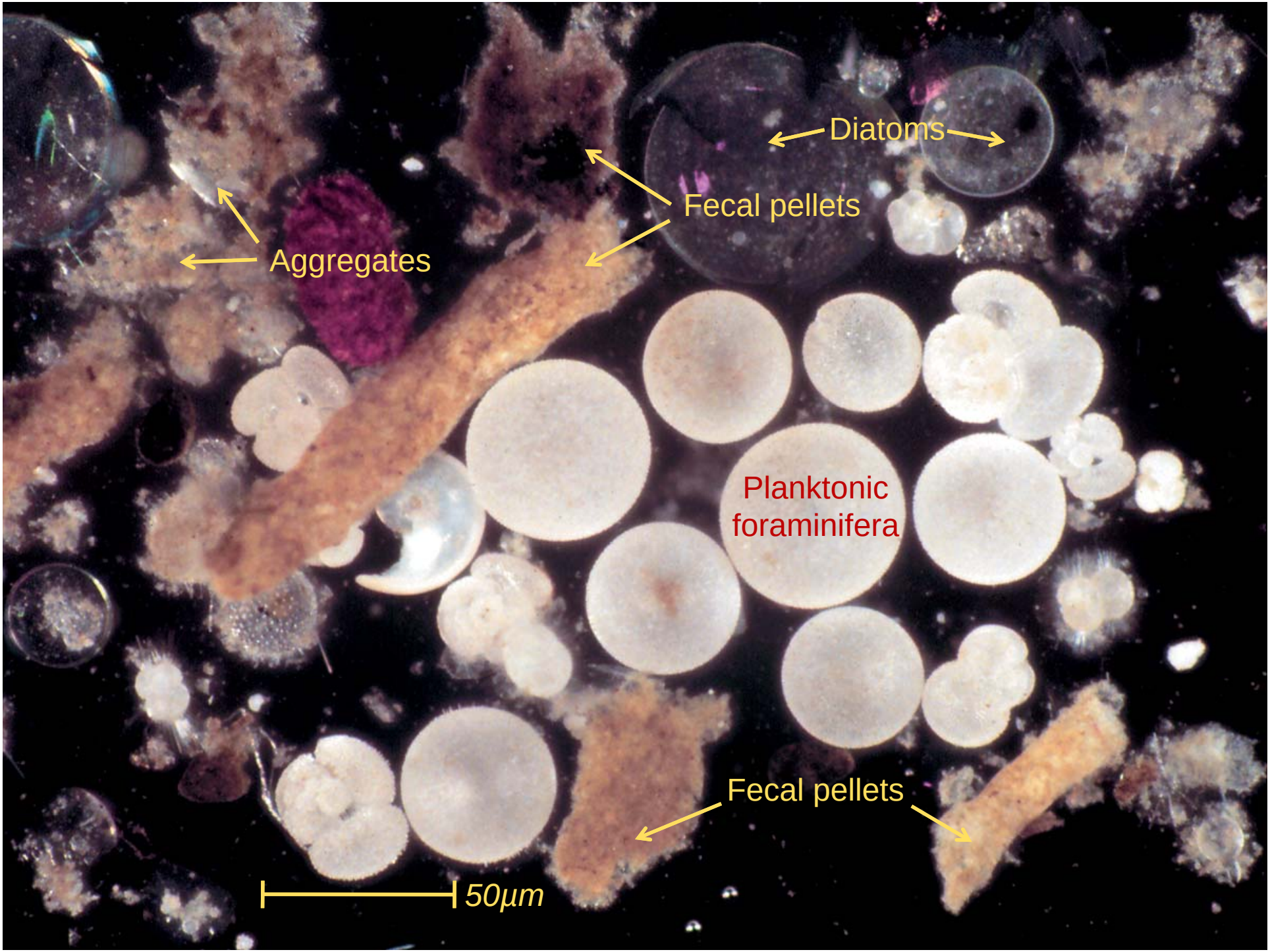
Wood Hole Oceanographic Institution

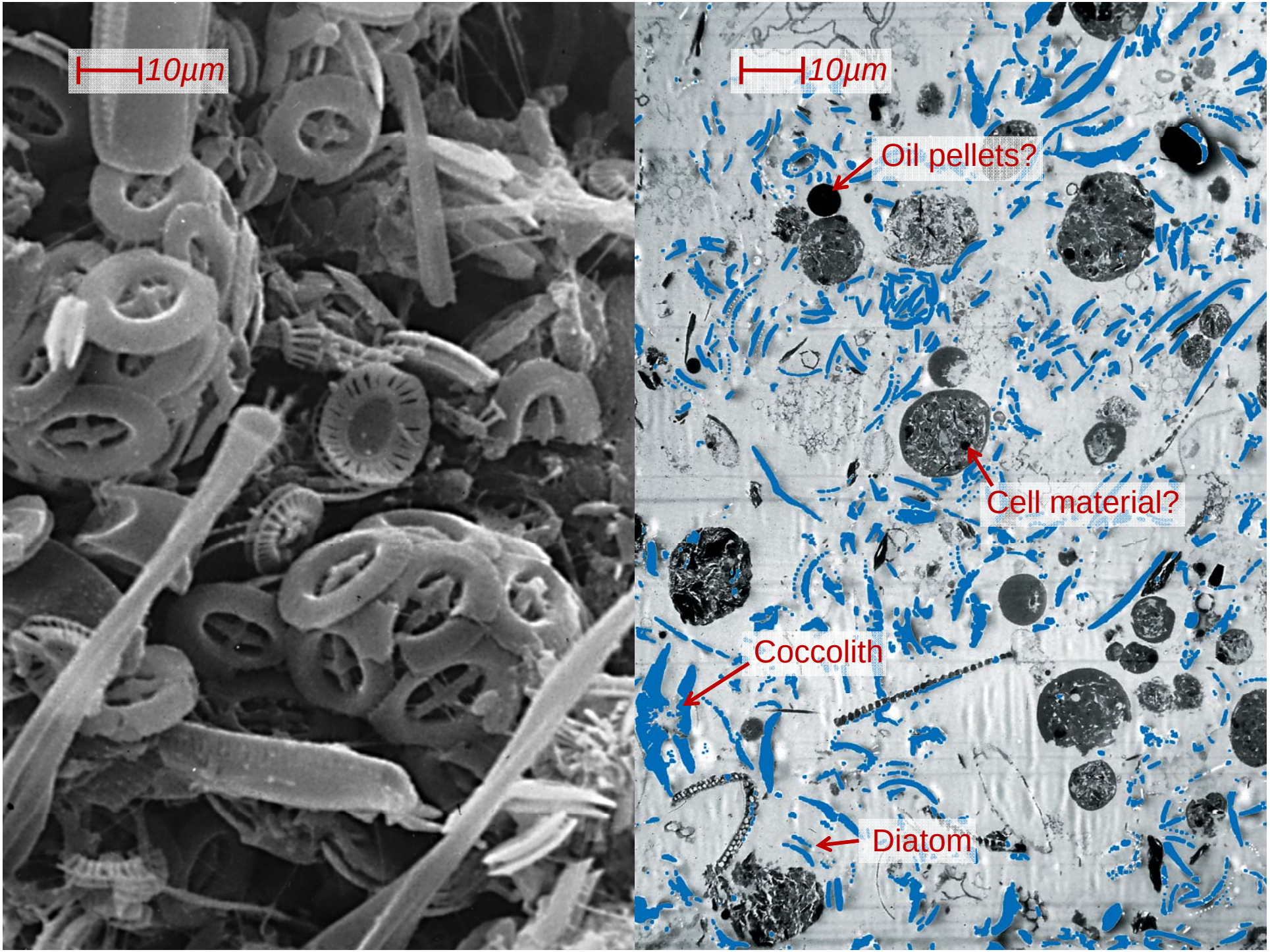
GBF-OOI Global Ocean Observatory

The Overarching Goal

To understand the global ocean carbon cycle, particularly the dynamics of **the *Global Biological Pump*** and its roles/effects over the ongoing ***Climate Change*** and radically improve our capacity to predict the Earth environment of the 21st century.


Earth's Active Carbon Cycle
Flux: petamolC yr-1
Sink: petamolC
Terrestrial POC
Atmospheric CO2
64 +0.3
Primary Production
0.03
Ventilation
Euphotic zone
3
0.5
Biological pump
Mesopelagic zone
M/B boundary
0.04
DOC
Bathypelagic zone
Earth's CO2 – C reservoir
?
3,150
Crust microbes


Diatoms
Fecal pellets
Aggregates
Planktonic
foraminifera
Fecal pellets
50µm


10µm
10µm
Oil pellets?
Cell material?
Coccolith
Diatom

Universal Biogeochemical Elements:
Expressed in molC, Si m^2 yr^{-1} in this paper

50µm

Organic Carbon Particles

C_{org}: Particulate organic-carbon PO**C**

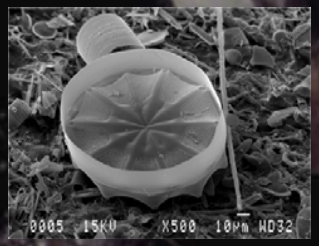
Woese et al., 1990

1µm

Ballast Particles

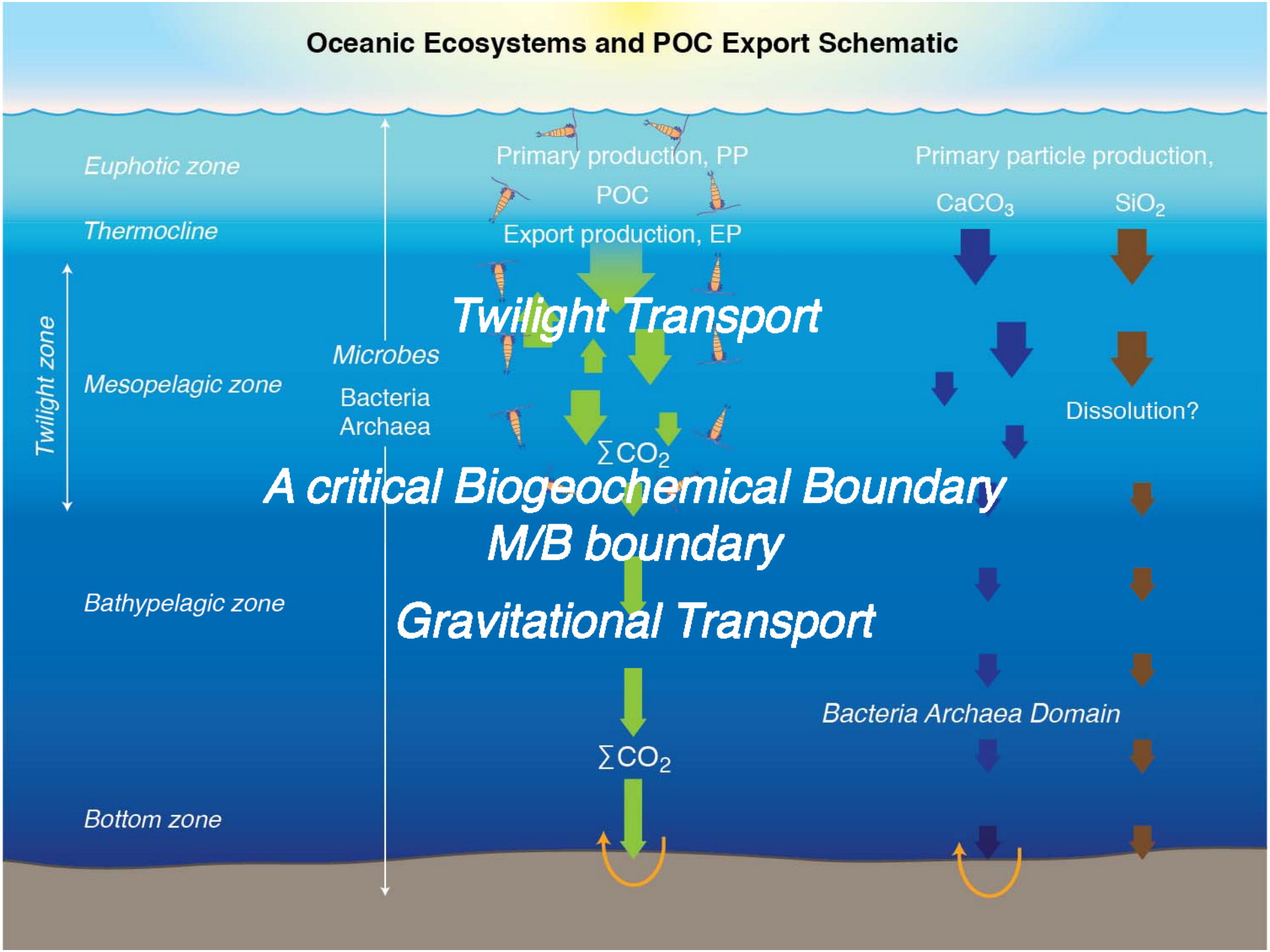
C_{inorg}: Biogenic Ca**C**O_3-carbon PI**C**

10µm

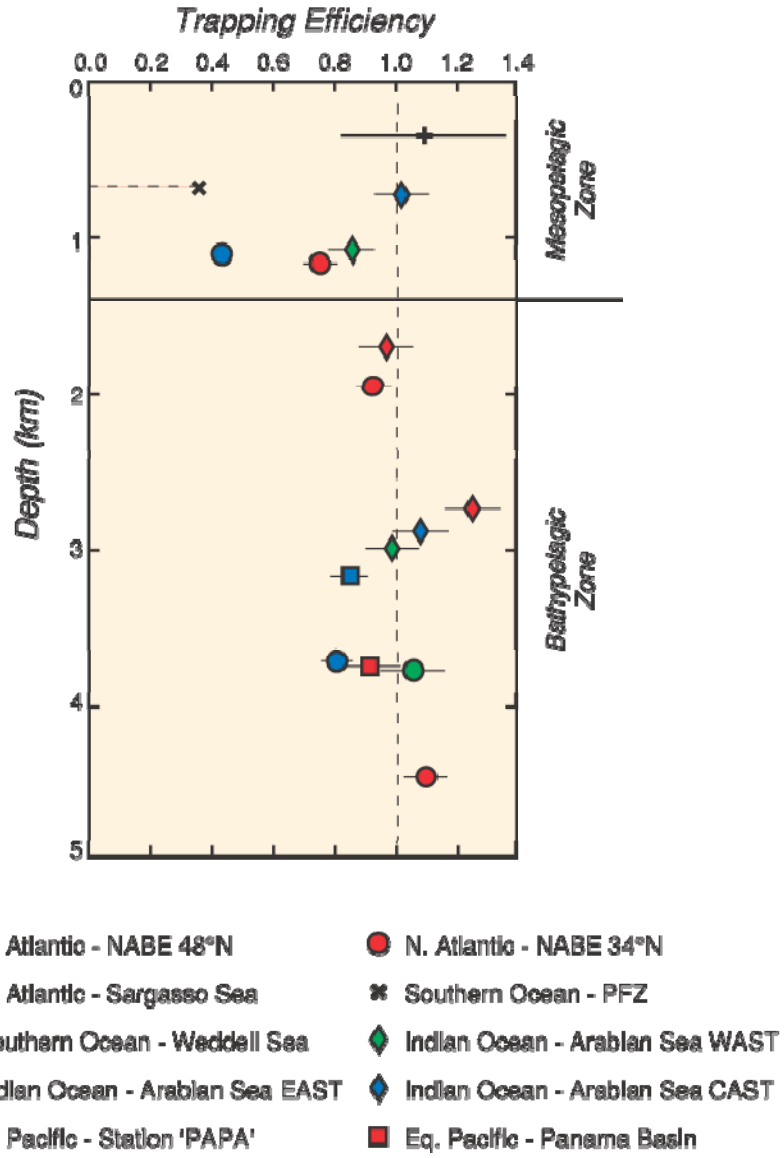


10µm

Si_{bio}: Biogenic opal **Si**O_2.mH_2O PSi_{bio}

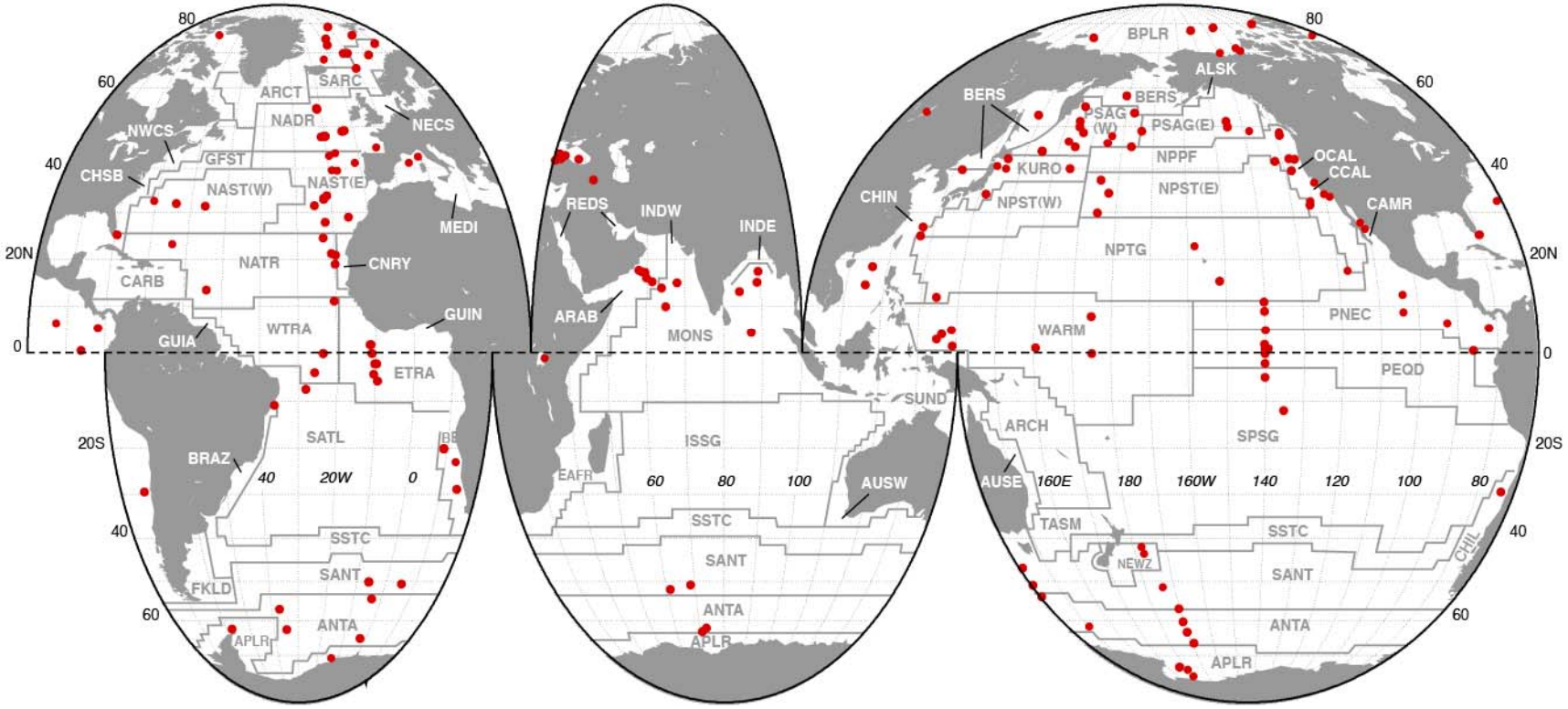

Oceanic Ecosystems and POC Export Schematic
Euphotic zone
Thermocline
Twilight zone
Mesopelagic zone
Bathypelagic zone
Bottom zone
Primary production, PP
POC
Export production, EP
Twilight Transport
Microbes
Bacteria
Archaea
∑CO2
A critical Biogeochemical Boundary
M/B boundary
Gravitational Transport
∑CO2
Primary particle production,
CaCO3
SiO2
Dissolution?
Bacteria Archaea Domain

Trapping Efficiency Correction
^{230}Th and ^{231}Pa



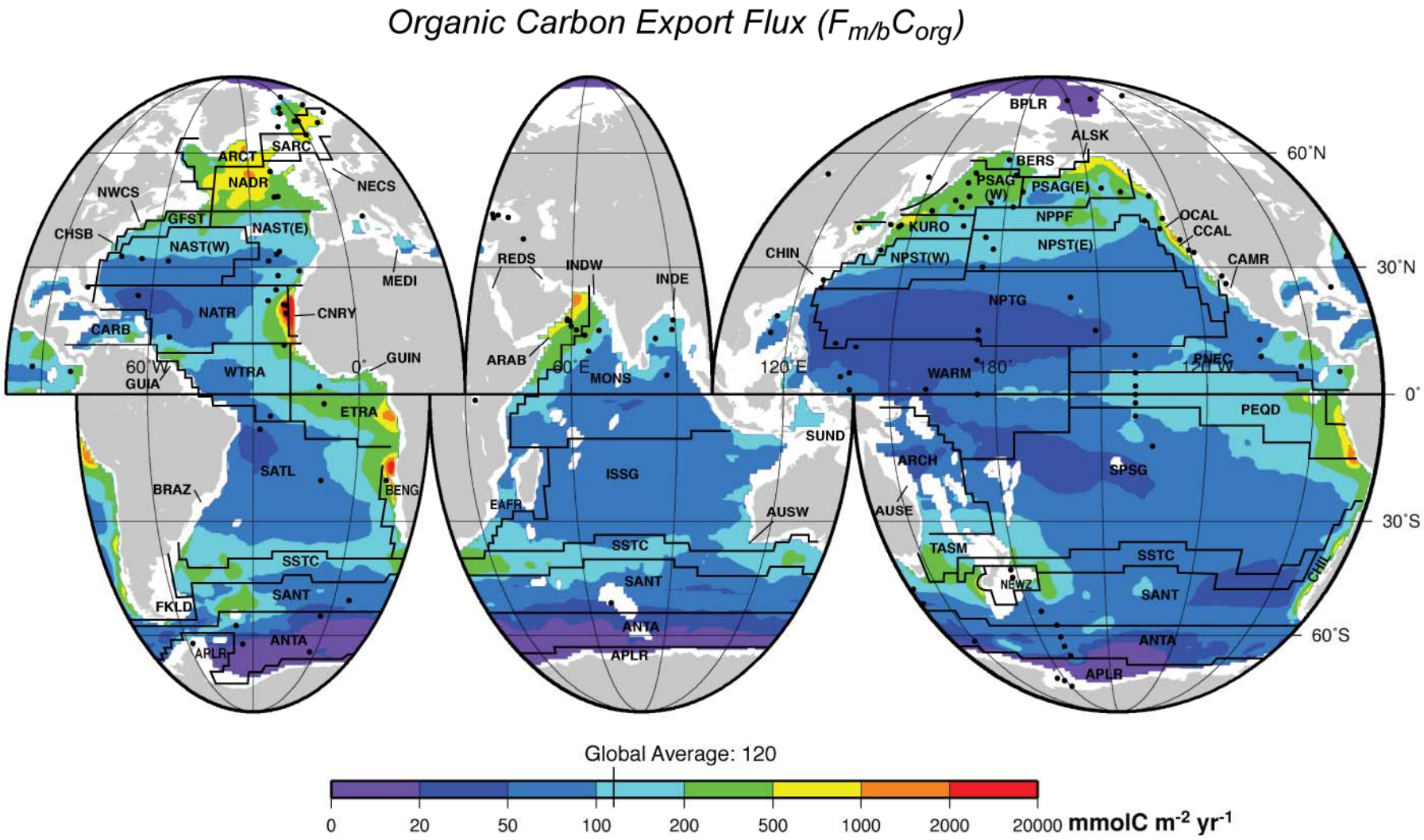
(Yu, et al., 2001, DSR)

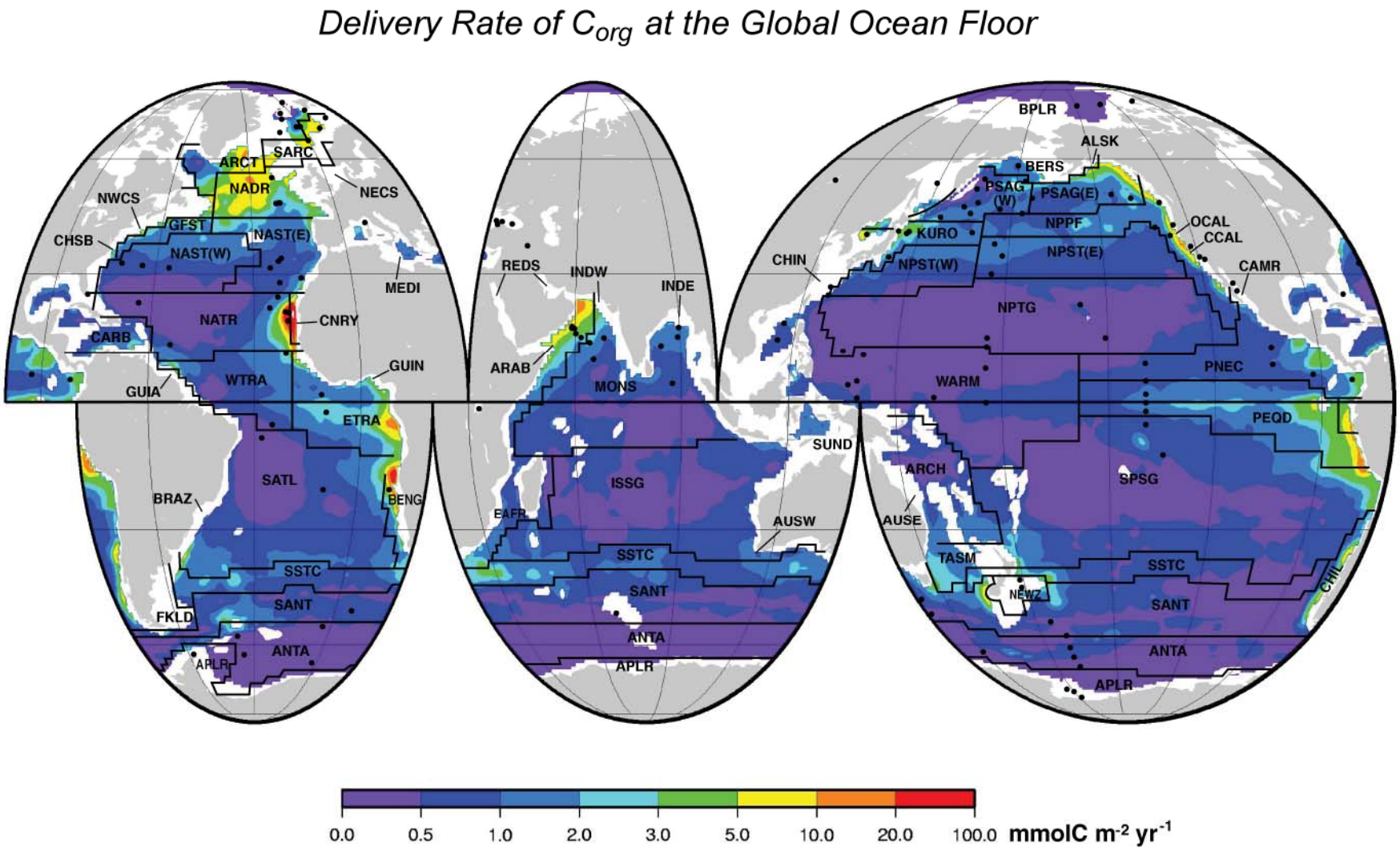
132 Annual Stations at M/B Depth, 1983-2008

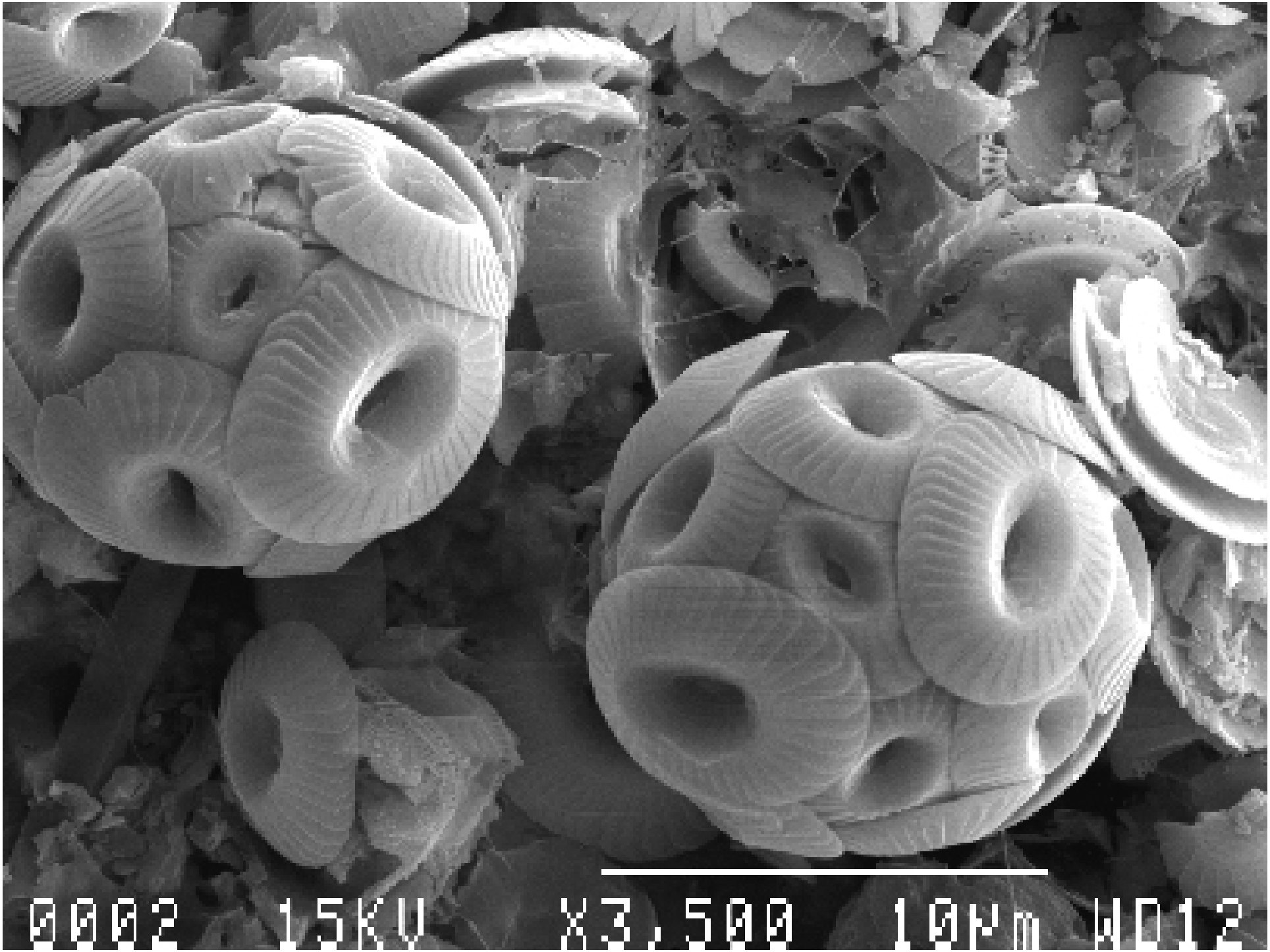


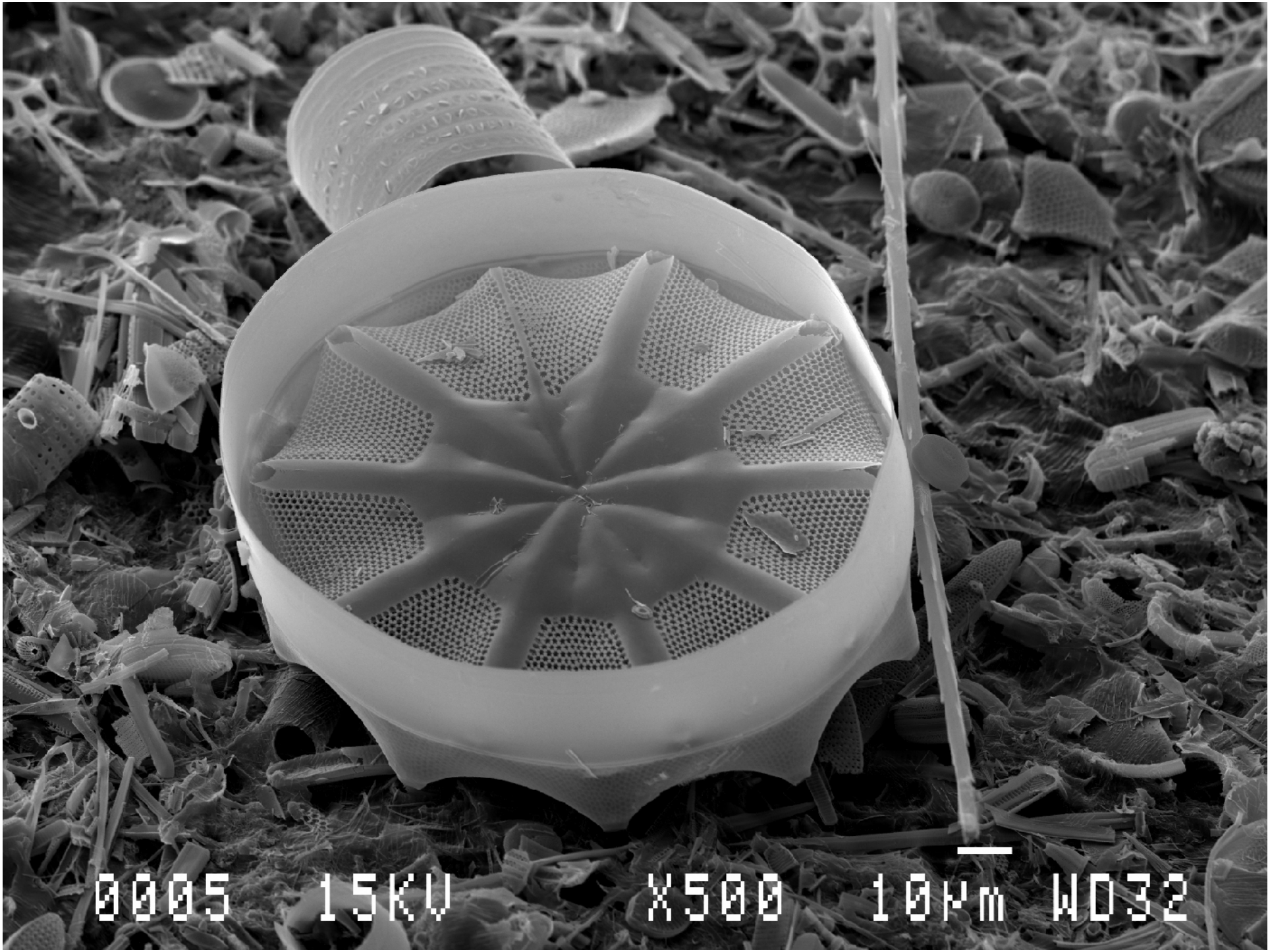
Biogeochemical Provinces: Longhurst, et al., 1994

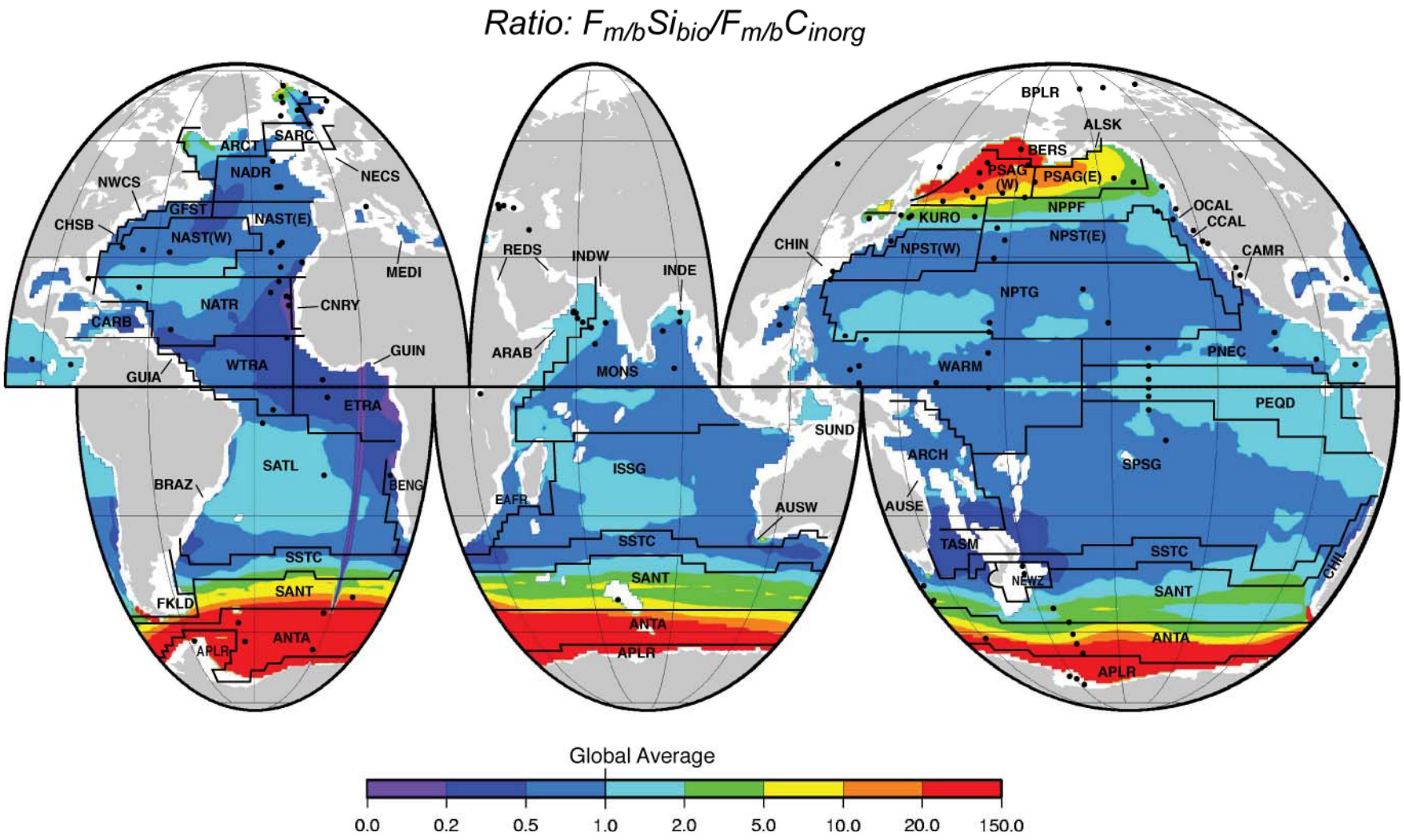
Over 1,700 elemental analyses (POC, PIC, Ca, Si, and lithogenic elements) are available.


Organic Carbon Export Flux ($F_{m/b}C_{org}$)
BPLR
ALSK
BERS
PSAG (W)
PSAG(E)
NPPF
KURO
OCAL
CCAL
CHIN
NPST(W)
NPST(E)
CAMR
NPTG
PNEC
WARM
PEQD
SUND
ARCH
SPSG
AUSE
TASM
NEWZ
CHIL
SSTC
SANT
ANTA
APLR
SARC
ARCT
NADR
NECS
NWCS
GFST
NAST(E)
CHSB
NAST(W)
MEDI
NATR
CNRY
CARB
GUIA
WTRA
GUIN
ETRA
SATL
BENG
BRAZ
FKLD
REDS
INDW
INDE
ARAB
MONS
ISSG
EAFR
AUSW
60°N
30°N
0°
30°S
60°S
60°W
0°
60°E
120°E
180°
120°W
Global Average: 120
0
20
50
100
200
500
1000
2000
20000
mmolC m-2 yr-1

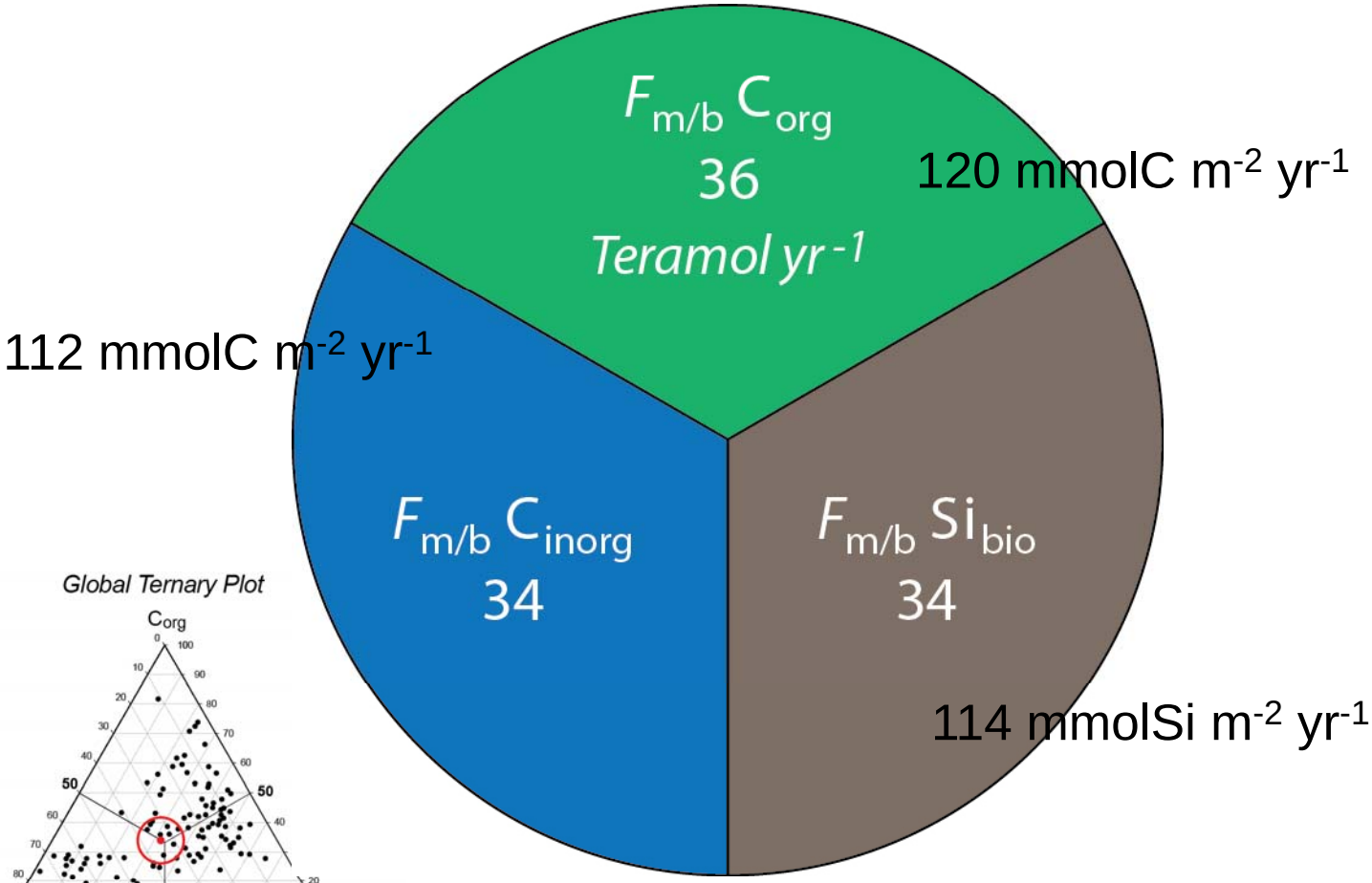

Delivery Rate of C_{org} at the Global Ocean Floor
ARCT
SARC
NADR
NECS
NWCS
GFST
NAST(E)
CHSB
NAST(W)
MEDI
NATR
CNRY
CARB
GUIN
WTRA
GUIA
ETRA
SATL
BRAZ
BENG
SSTC
SANT
FKLD
ANTA
APLR
REDS
INDW
INDE
ARAB
MONS
ISSG
EAFR
AUSW
SUND
SSTC
SANT
ANTA
APLR
BPLR
ALSK
BERS
PSAG (W)
PSAG(E)
KURO
NPPF
OCAL
CCAL
CHIN
NPST(W)
NPST(E)
CAMR
NPTG
PNEC
WARM
PEQD
ARCH
SPSG
AUSE
TASM
SSTC
NEWZ
SANT
CHIL
ANTA
APLR
0.0
0.5
1.0
2.0
3.0
5.0
10.0
20.0
100.0
mmolC m-2 yr-1

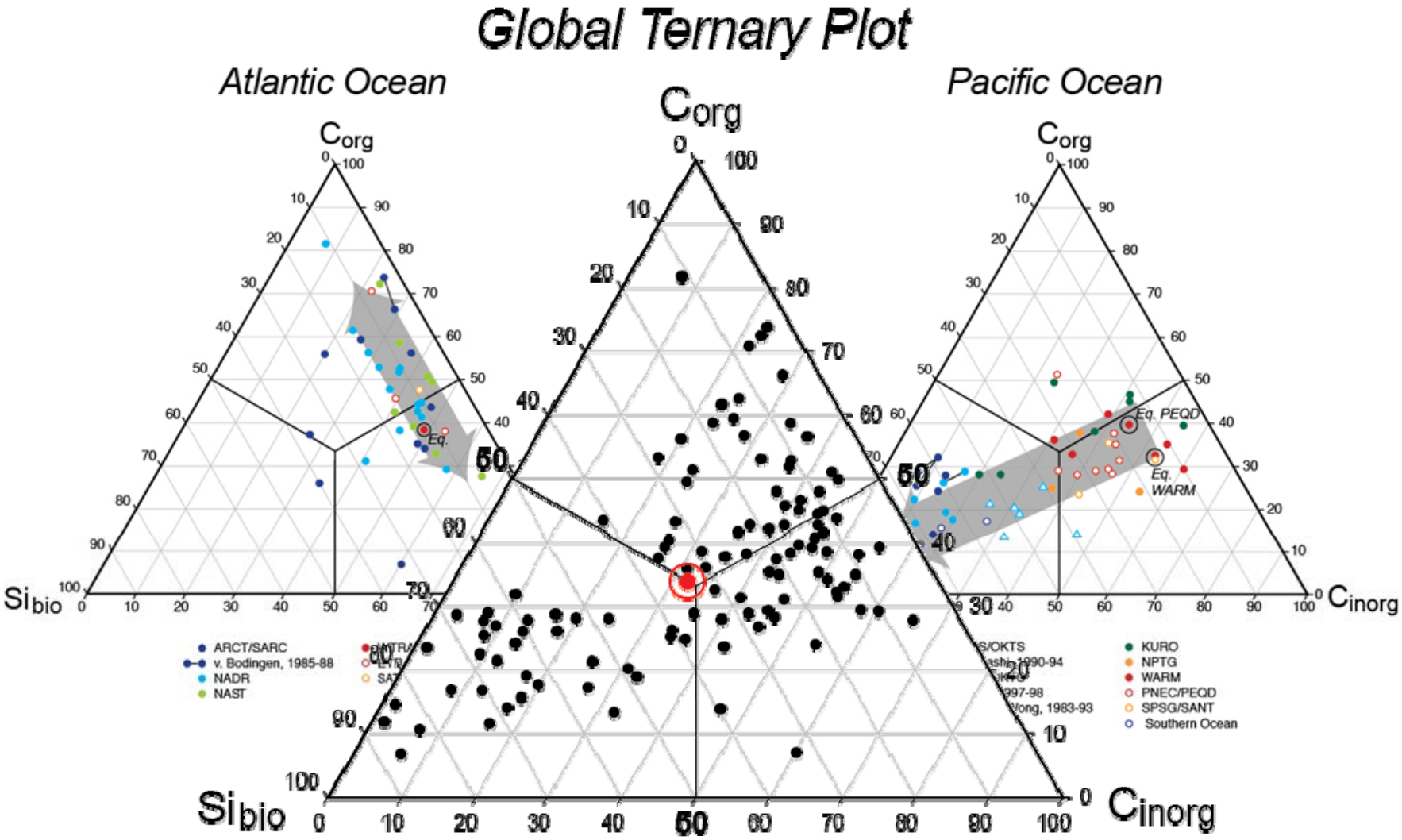

0002 15KV X3,500 10μm WD12


0005 15KV X500 10µm WD32

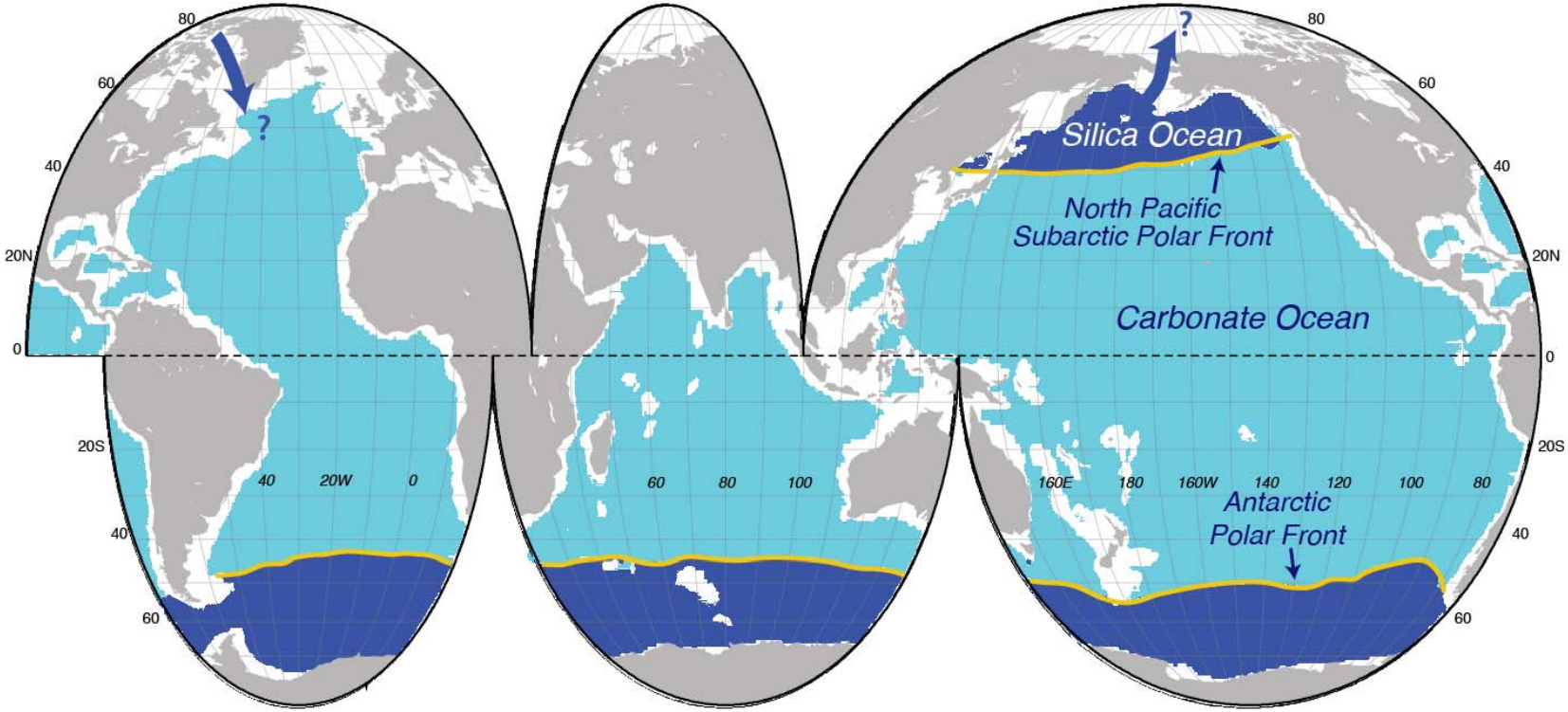

Ratio: $F_{m/b}Si_{bio}/F_{m/b}C_{inorg}$
ARCT
SARC
NADR
NECS
NWCS
GFST
NAST(E)
CHSB
NAST(W)
MEDI
NATR
CNRY
CARB
GUIN
WTRA
GUIA
ETRA
SATL
BRAZ
BENG
SSTC
SANT
FKLD
ANTA
APLR
REDS
INDW
INDE
ARAB
MONS
SUND
ISSG
EAFR
AUSW
SSTC
SANT
ANTA
APLR
BPLR
ALSK
BERS
PSAG (W)
PSAG(E)
NPPF
OCAL
CCAL
KURO
CHIN
NPST(W)
NPST(E)
CAMR
NPTG
PNEC
WARM
PEQD
ARCH
SPSG
AUSE
TASM
SSTC
NEWZ
CHIL
SANT
ANTA
APLR
Global Average
0.0
0.2
0.5
1.0
2.0
5.0
10.0
20.0
150.0

Global Total Fluxes of C_{org}, C_{inorg} and Si_{bio} at m/b (teramol C, Si, yr^{-1})



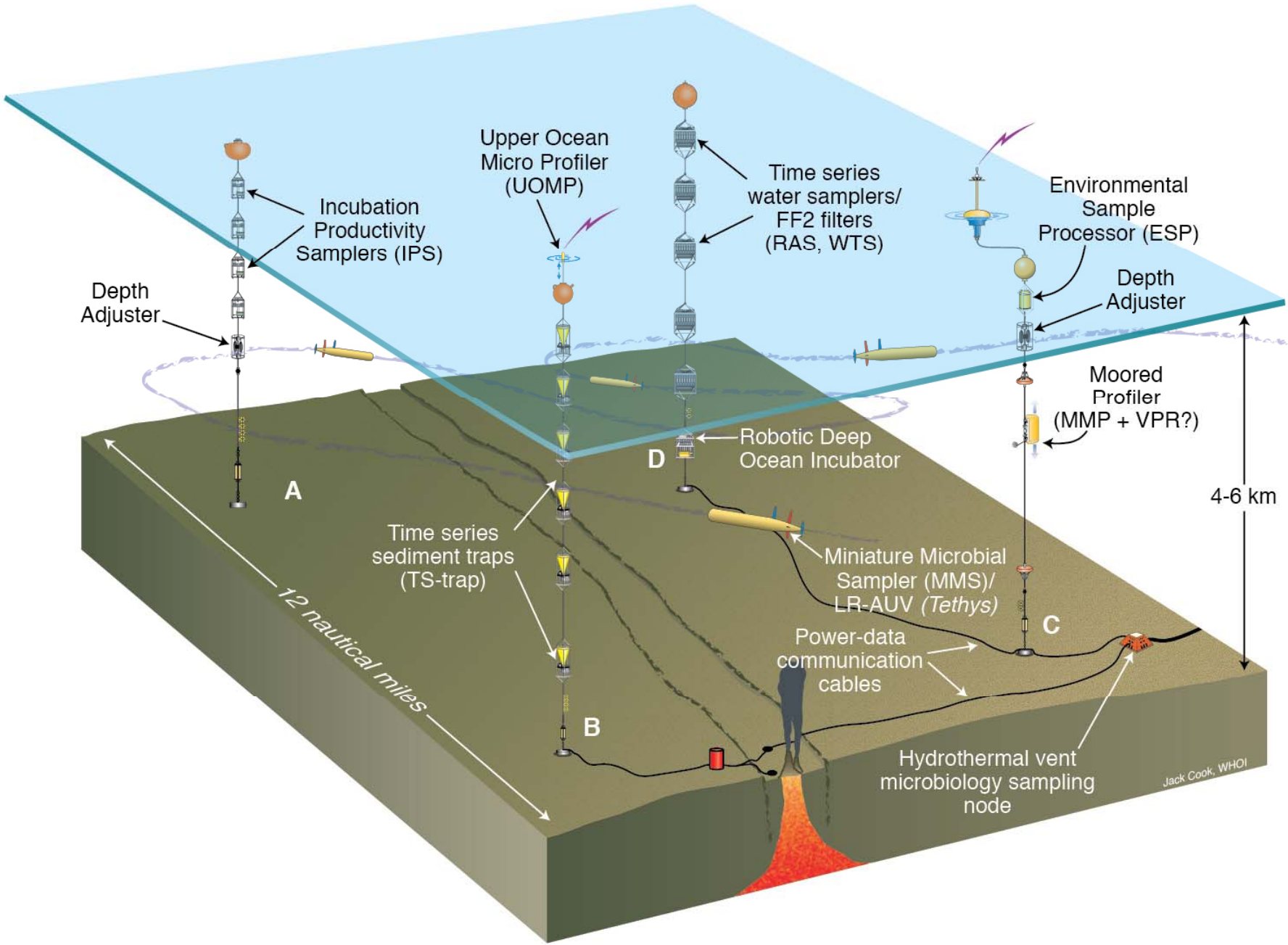

Global Ternary Plot
Atlantic Ocean
Pacific Ocean
Corg
Sibio
Cinorg
Eq.
Eq. PEQD
Eq. WARM
ARCT/SARC
v. Bodingen, 1985-88
NADR
NAST
KURO
NPTG
WARM
PNEC/PEQD
SPSG/SANT
Southern Ocean

Carbonate vs. Silica Ocean



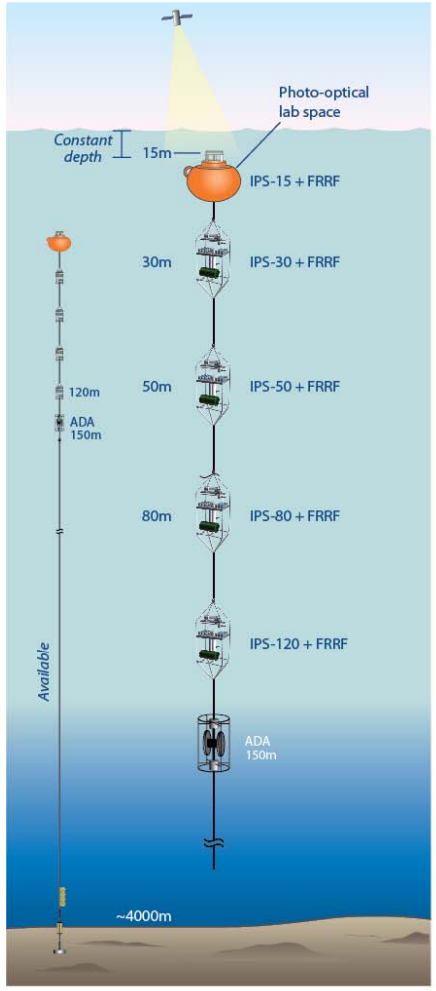
Silica Ocean: $F_{m/b}Si_{bio}/F_{m/b}C_{inorg} > 1$, and
$F_{m/b}C_{org}/F_{m/b}Si_{bio} \leq 1$

Carbonate Ocean: Rest of the pelagic ocean


Upper Ocean
Micro Profiler
(UOMP)
Time series
water samplers/
FF2 filters
(RAS, WTS)
Environmental
Sample
Processor (ESP)
Incubation
Productivity
Samplers (IPS)
Depth
Adjuster
Depth
Adjuster
Moored
Profiler
(MMP + VPR?)
Robotic Deep
Ocean Incubator
D
A
4-6 km
Time series
sediment traps
(TS-trap)
Miniature Microbial
Sampler (MMS)/
LR-AUV (Tethys)
C
Power-data
communication
cables
12 nautical miles
B
Hydrothermal vent
microbiology sampling
node
Jack Cook, WHOI

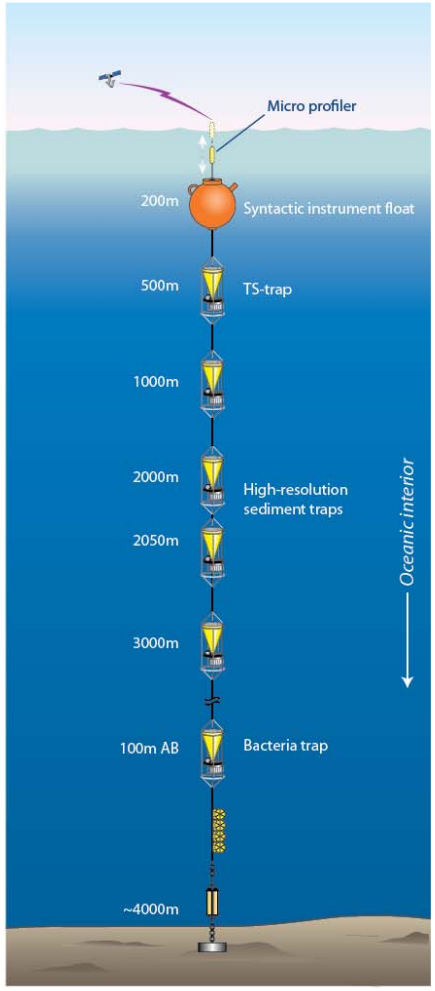
GBF-OOI Platform Configuration (Example)

A. Primary Productivity Platform



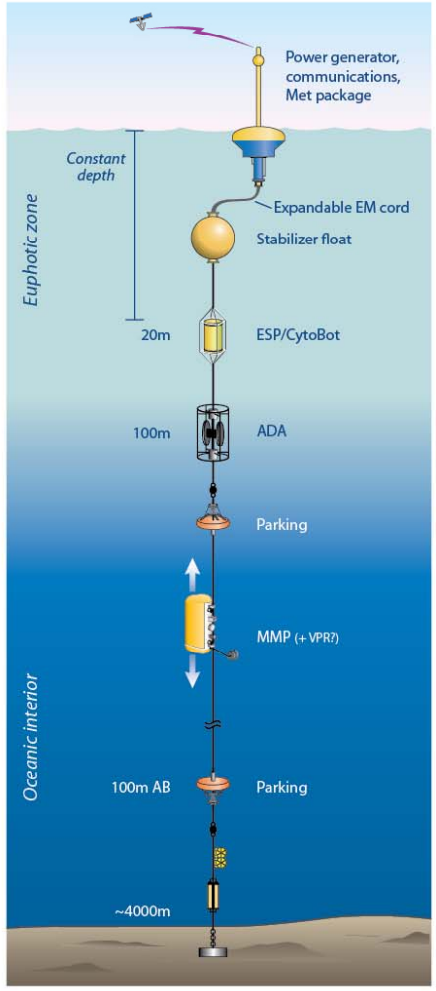
x5 IPS-FRRF combo
Surface water lab.
ADA-controlled.

B. Export Flux Platform



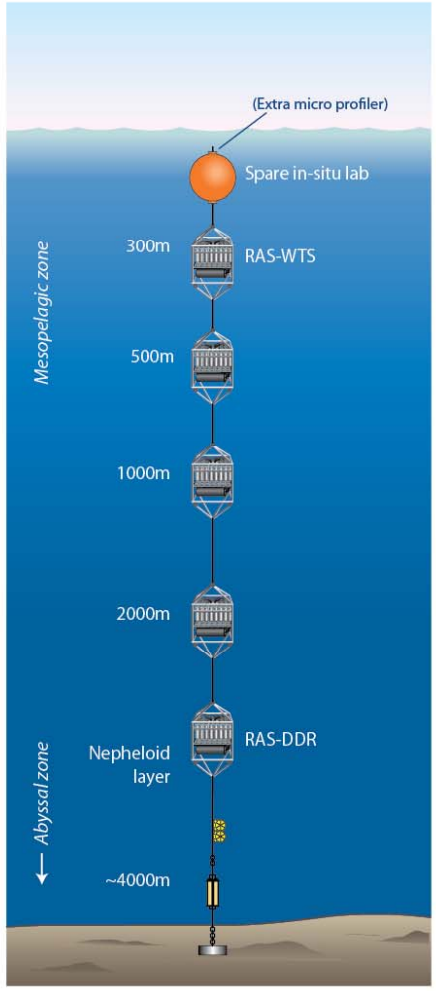
Micro profiler (upper 200m)
>6 TS-traps
Bacteria sampling units

C. ESP-MMP Platform



Power generator platform
ESP (and/or CytoBot)
MMP, 100m from bottom
ADA-controlled.

D. TS Water/Particle Sampler Platform



>5 PAS-PPS (FF-2)
Descrete DNA, RNA Samplers

http://www.whoi.edu/GBF-OOI

Basic Methodology Discussed:
Space-temporal Control of GBF-OOI Observatory

The Observatory covers entire water column (surface film to deep sea hydrothermal vent) with the equal emphasis on a depth of measurement:

Time-series control of measurement and sampling timings:

All timings to initiate "on-off" or "start-stop" of instruments at all depth, on any platforms or observatories, will be always *controlled by a single Grand-Time-Table. This concept must be more explained!*

Decision of Global locations of Observatories:

The first observatory will be deployed at a site with GBF significance and the location with significant technological advantage such as OOI's RSN N2, *the south edge of the Juan De Fuca Plate (post-Workshop suggestions; not a conclusion as yet).*

Total duration of GBF-OOI Observatory Program:

Many participants expressed duration must be in the order of a few decades.

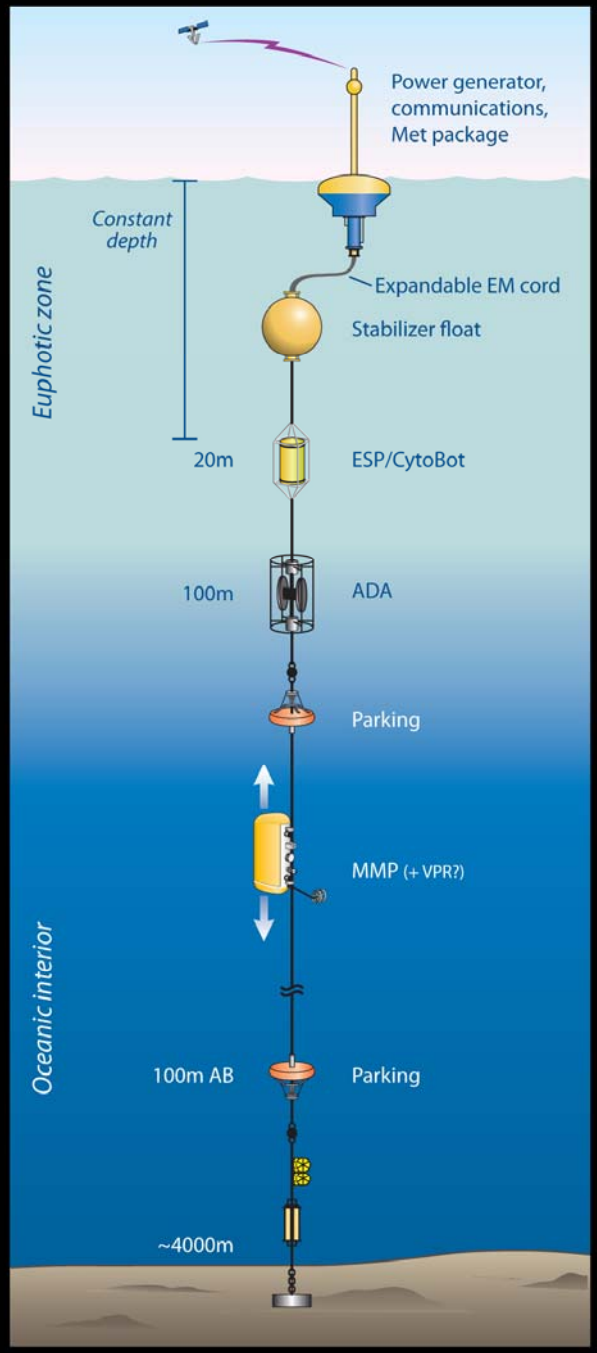
Hopefully: 40 years; "May enable us to resolve the anthropogenic forces (Hanson et al., 2011)." The balance between the data acquisition and the advancing computation speed was argued.

Table 2: Current status and risks of some long-term time-series instruments and performance goals

Mooring	*Device*	*Abbrev.*	*Endurance**	*Measurements/Activity*	*Status in 2010*	*Needs*	*Risks in 2012*	*R&D Funding*	*Status in 2017*
A	Incubation Productivity System	IPS	12	Time-series primary production via robotic multi-isotopic phytoplankton incubation	Used in field operations: Publications	More field tests	small risk	Mass spec. techniques	Routine 9-tracer incubation
A	Rapid Repetition Rate Fluorometer/Particle Transmissometer	FRR/PTM	12	Time-series primary production via advanced optical scattering/particle transmissometry	Used in field operations; Publications	Final development	small risk	Biofouling prevention for optimization	Early stage OOI data collection
B	Time-Series Sediment Trap	TS-trap	12	Export Flux	Stable technology: multiple publications	Accessory devices	no risk	No Additional	Video/still imaging in the cone
C	Environmental Sampler	ESP	12	In situ autonomous time-series micro-fluvial DNA/RNA assay collection	Successful field tests; publications	More field tests	some risk	Miniaturization; add PCR	PCR capacity; miniaturization
D	Remote Access Sampler/Water Transfer Sampler	RAS/WTS	12	Time-series discrete water/particle collecting device	Stable technology: multiple publications	Accessory devices	no risk	Perfection of bio-molecule preservation	Multiple adsorption columns
D	Autonomous microbial sampler	AMS	12	Uncontaminated samples of Eukarya/Bacteria/Archea	Used in field operations	sample preservation	modest risk	long-term preservation	Time-series sampling
A	Moored Profiler	MMP	12	Continuous profiling of water-column by CTD, vectors, optics.	Semi-stable technology; publications	Higher power	small risk	User specifications	Video plankton recorder
B	Euphotic Zone Micro-Profiler	EMP	12	Profiling of upper 200 m by CTD, optics, O2.	Under development	Under R&D	some risk	More sensors	Risk-free profiling up to 4 times/day
C	MicroGrid Buoy/Communication Tower	MG-Buoy	>24	Advanced, power-generating, communications bouy	Apply existing technology	More R&D w. EOM-MRL	small risk	More comms. capacity	More power
C	Communications	COM	12	Irridium statelite phone system to transmit ESP assay and other sensor data once a day	Apply current OOI exisiting technology	Fast development	small risk	More experts' participation in GBF	Radically improved
A, C	Automated Depth Adjuster	ADA	>24	Allows IPS and ESP to stay at 15-20 m.	Prototype testing; Patent application	High reliability	small risk	R&D for bi-directional depth	Bi-directional depth adjustment capacity

* months

C. ESP-MMP Platform

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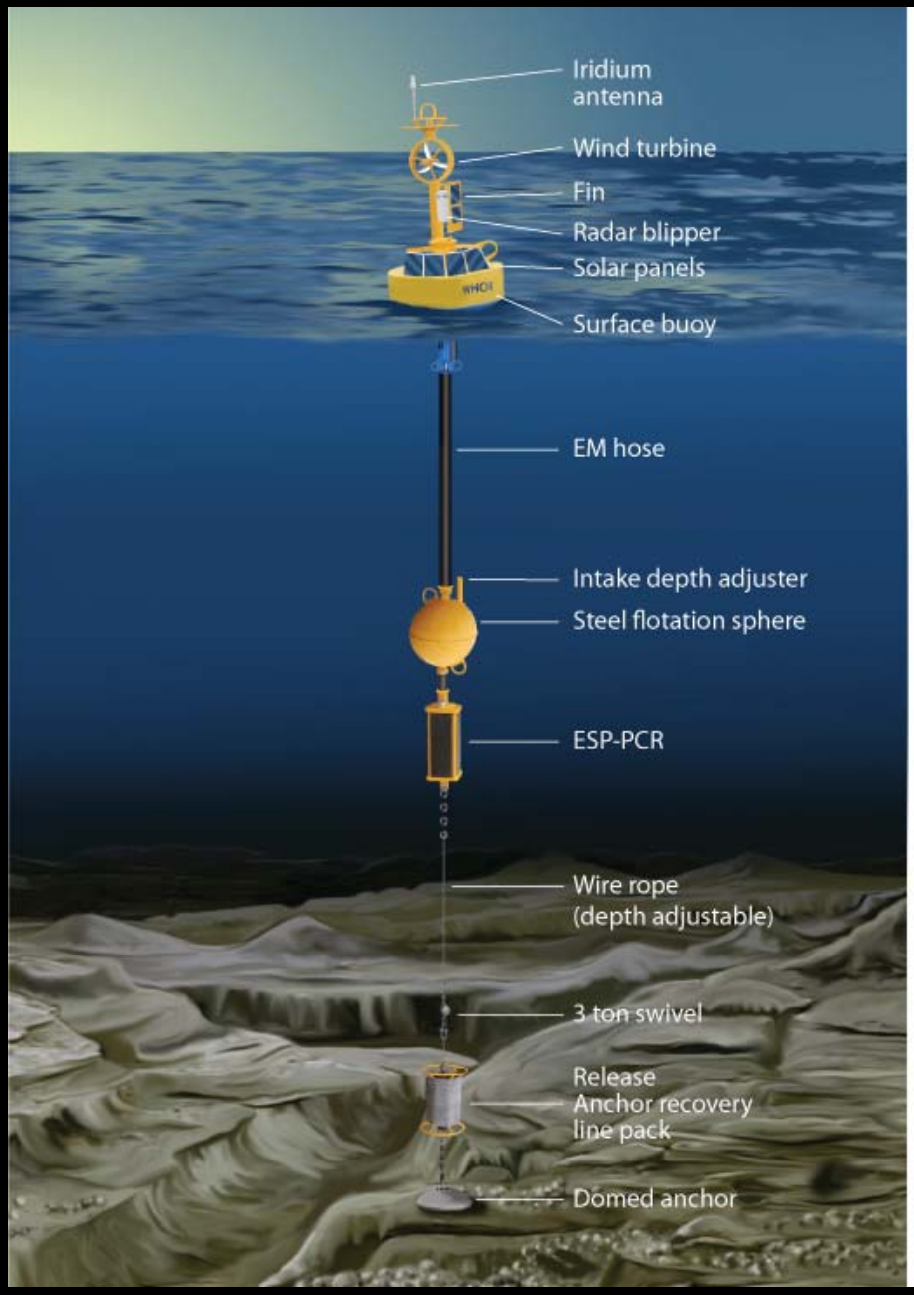
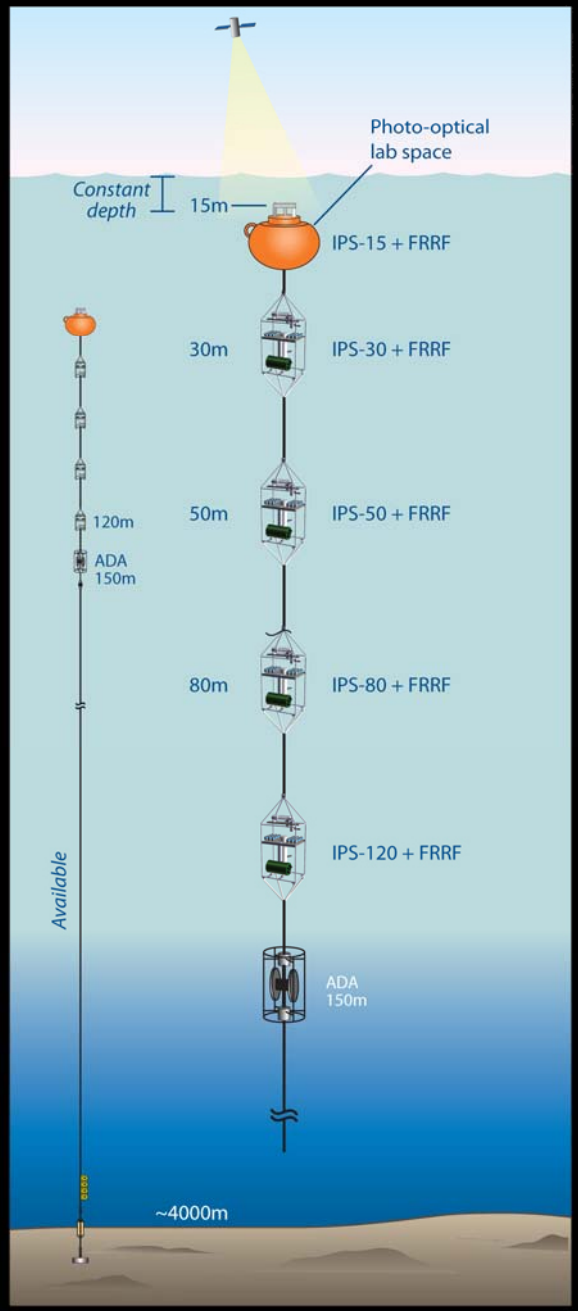
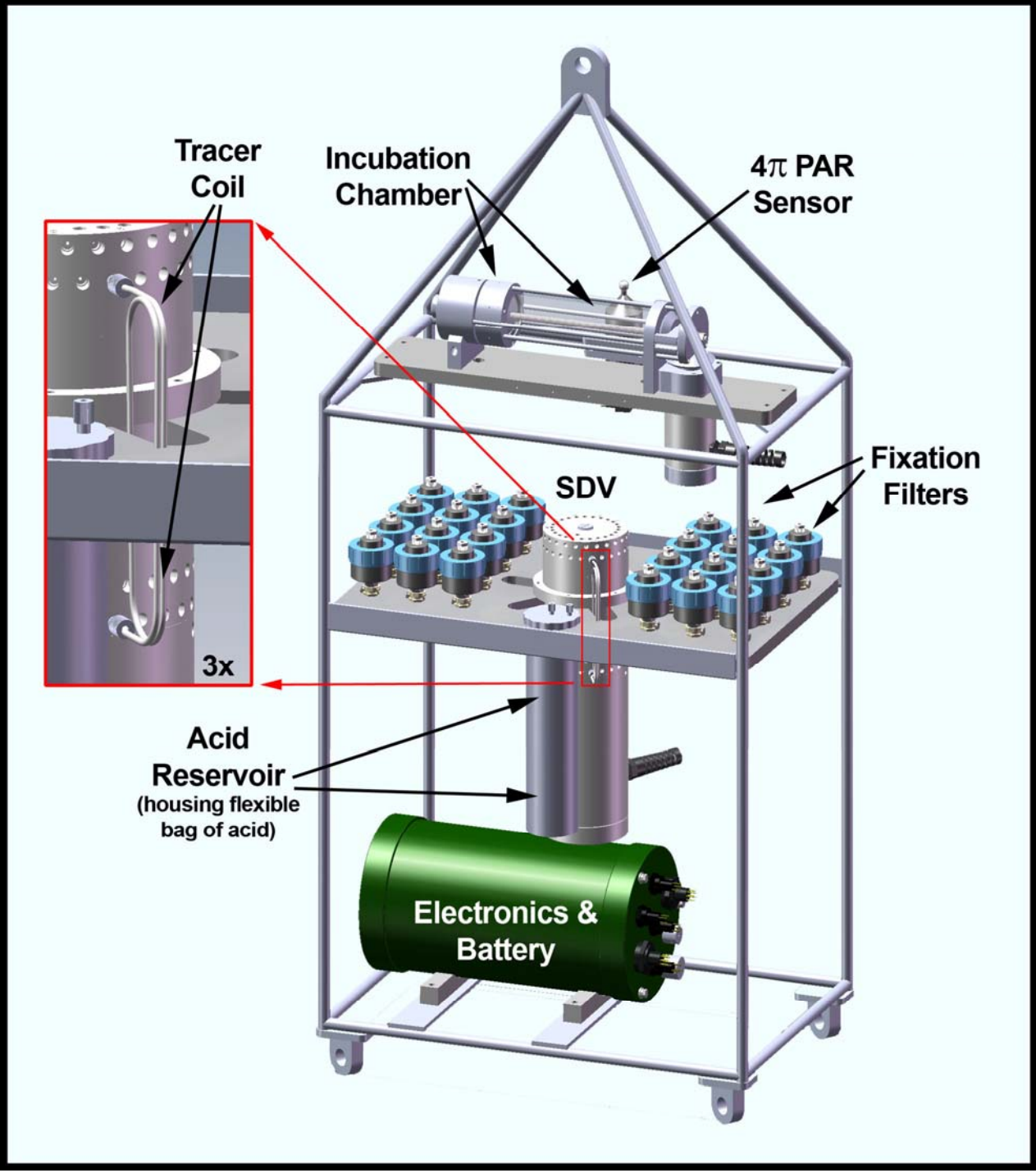
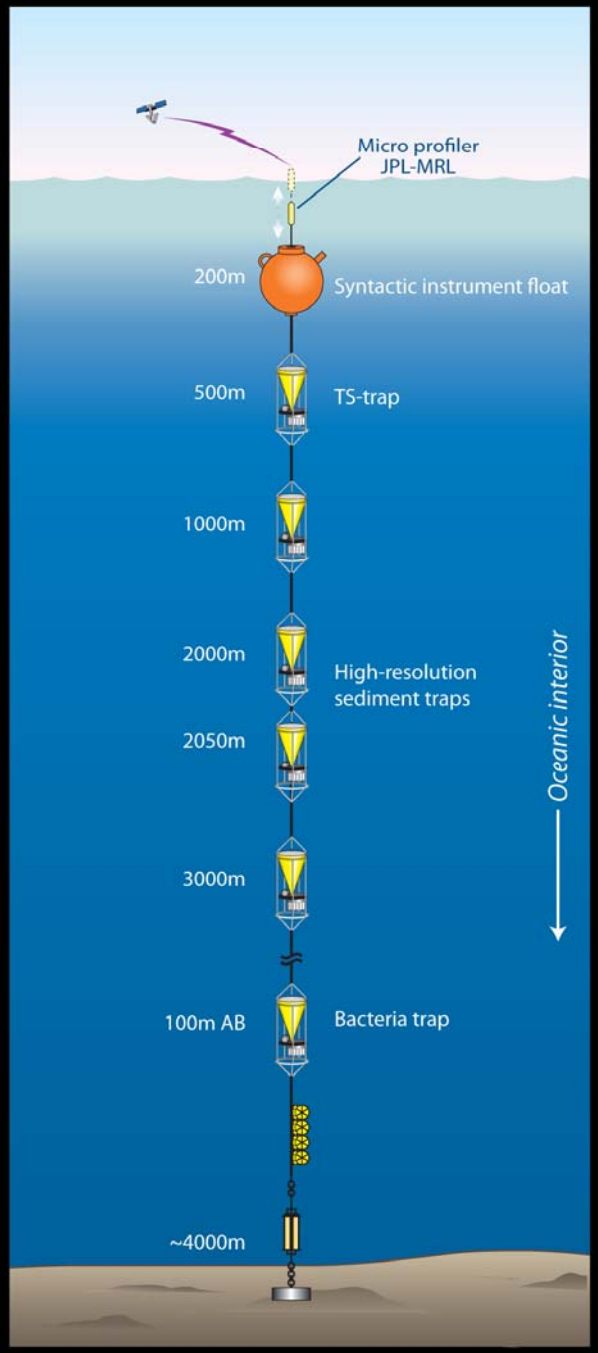

Iridium antenna
Wind turbine
Fin
Radar blipper
Solar panels
Surface buoy
EM hose
Intake depth adjuster
Steel flotation sphere
ESP-PCR
Wire rope (depth adjustable)
3 ton swivel
Release
Anchor recovery line pack
Domed anchor

A. Primary Productivity Platform




Tracer
Coil
Incubation
Chamber
4π PAR
Sensor
Fixation
Filters
SDV
3x
Acid
Reservoir
(housing flexible
bag of acid)
Electronics &
Battery

B. Export Flux Platform

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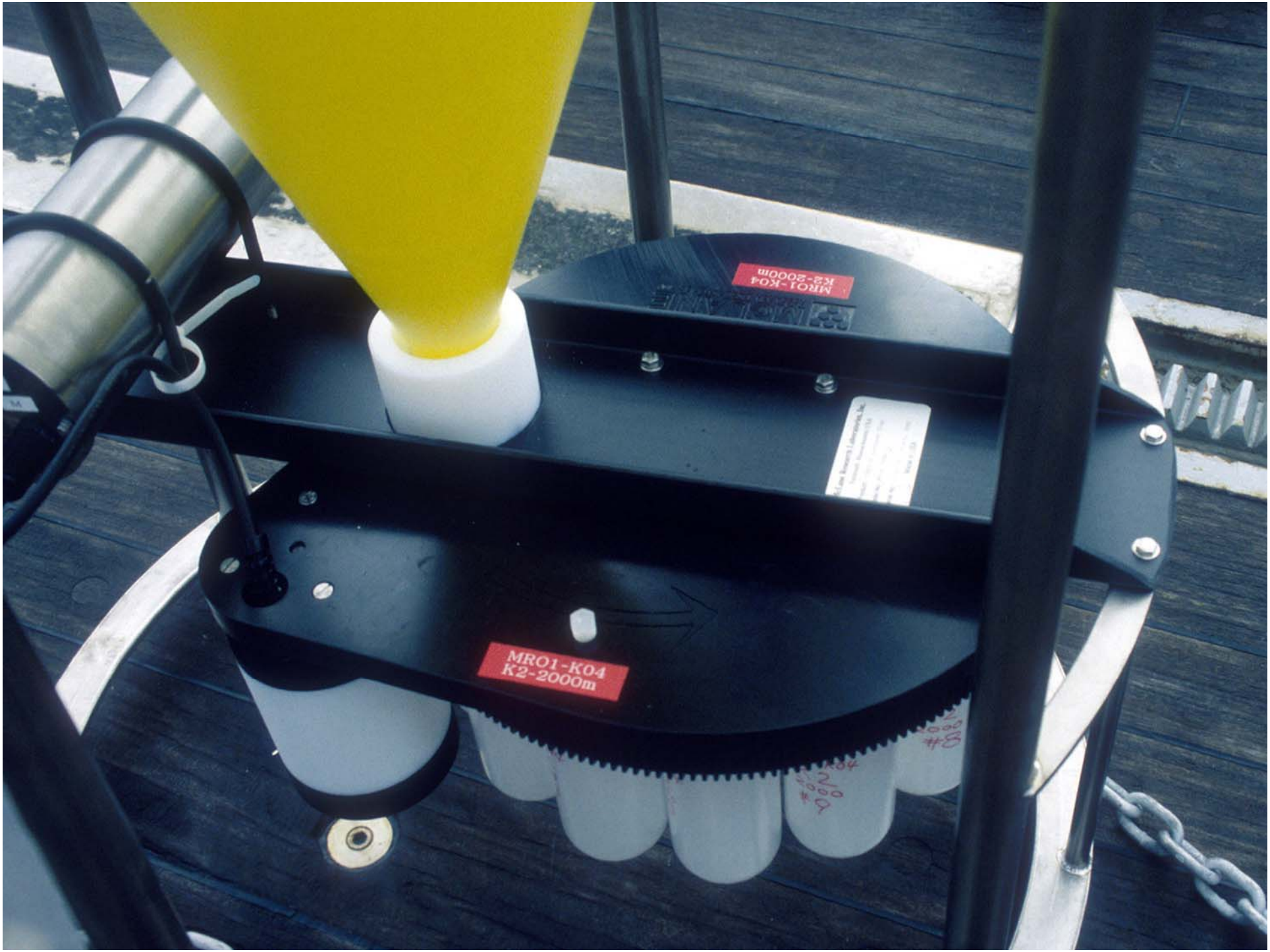
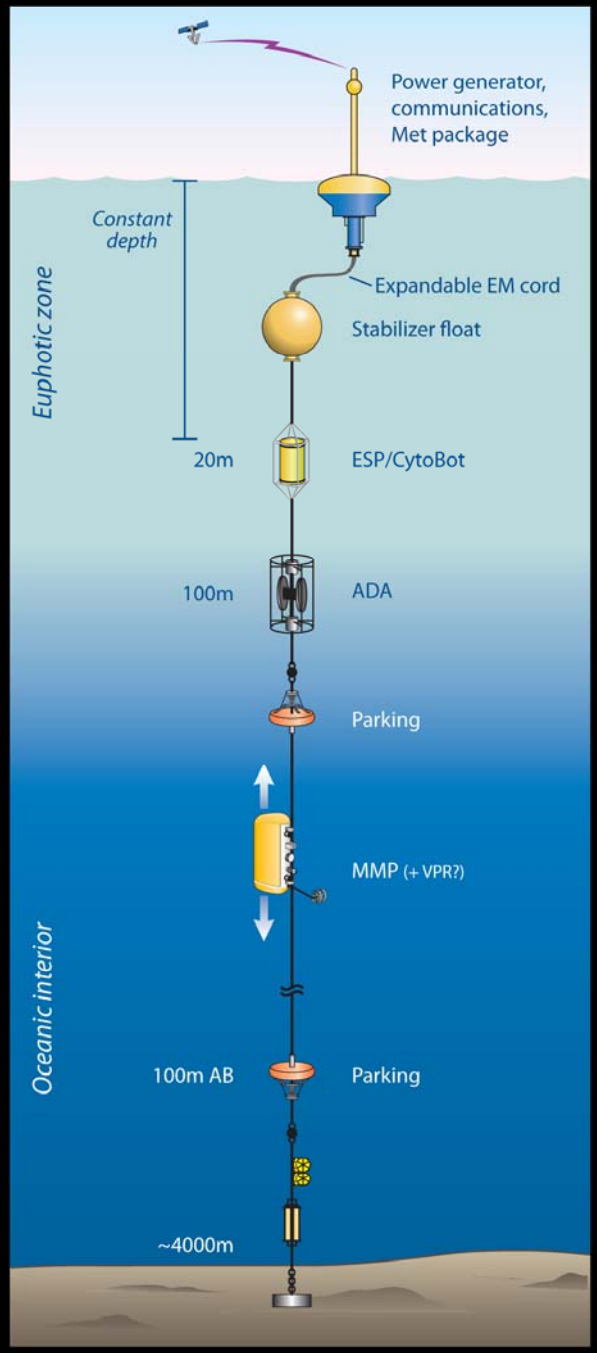
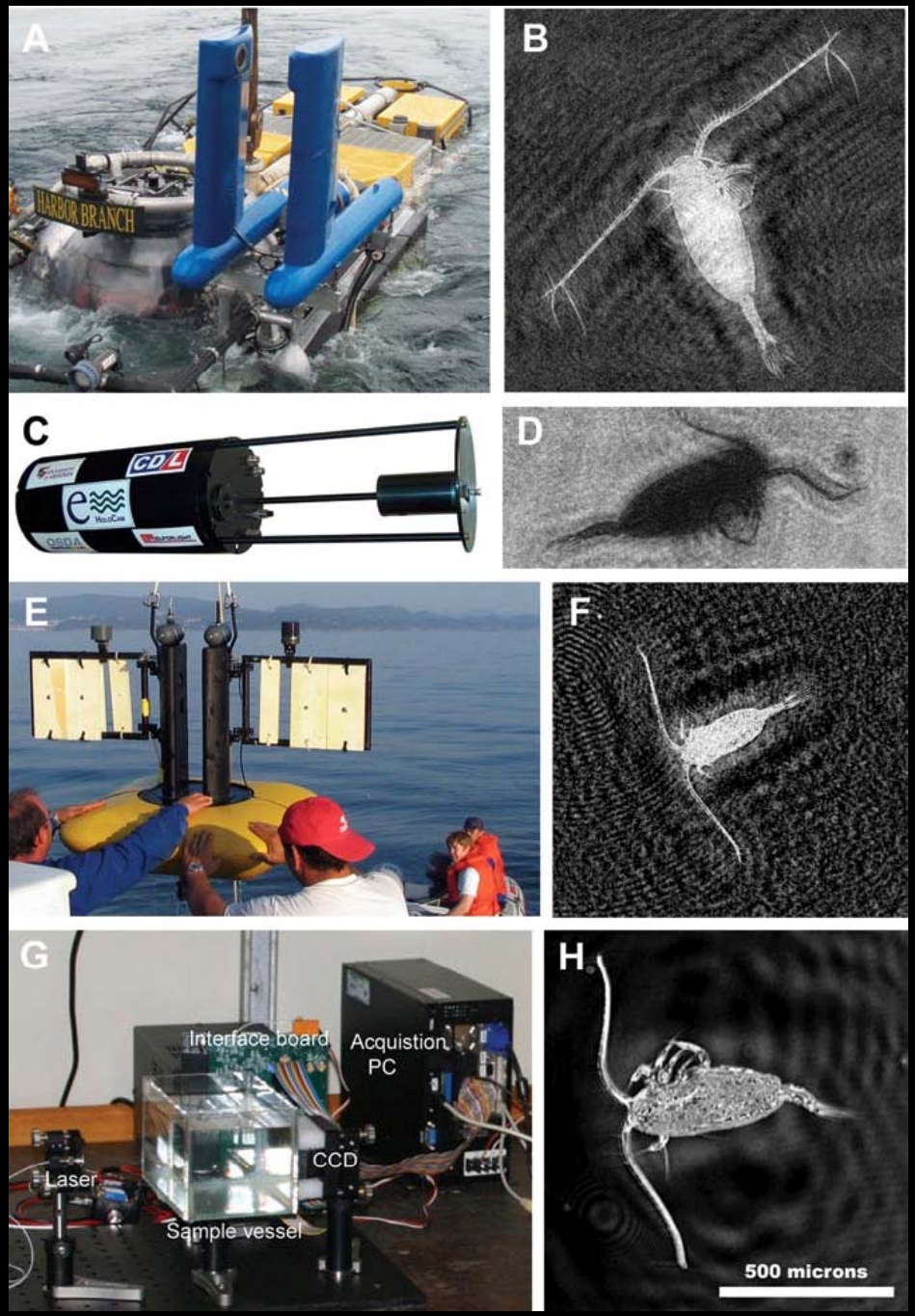
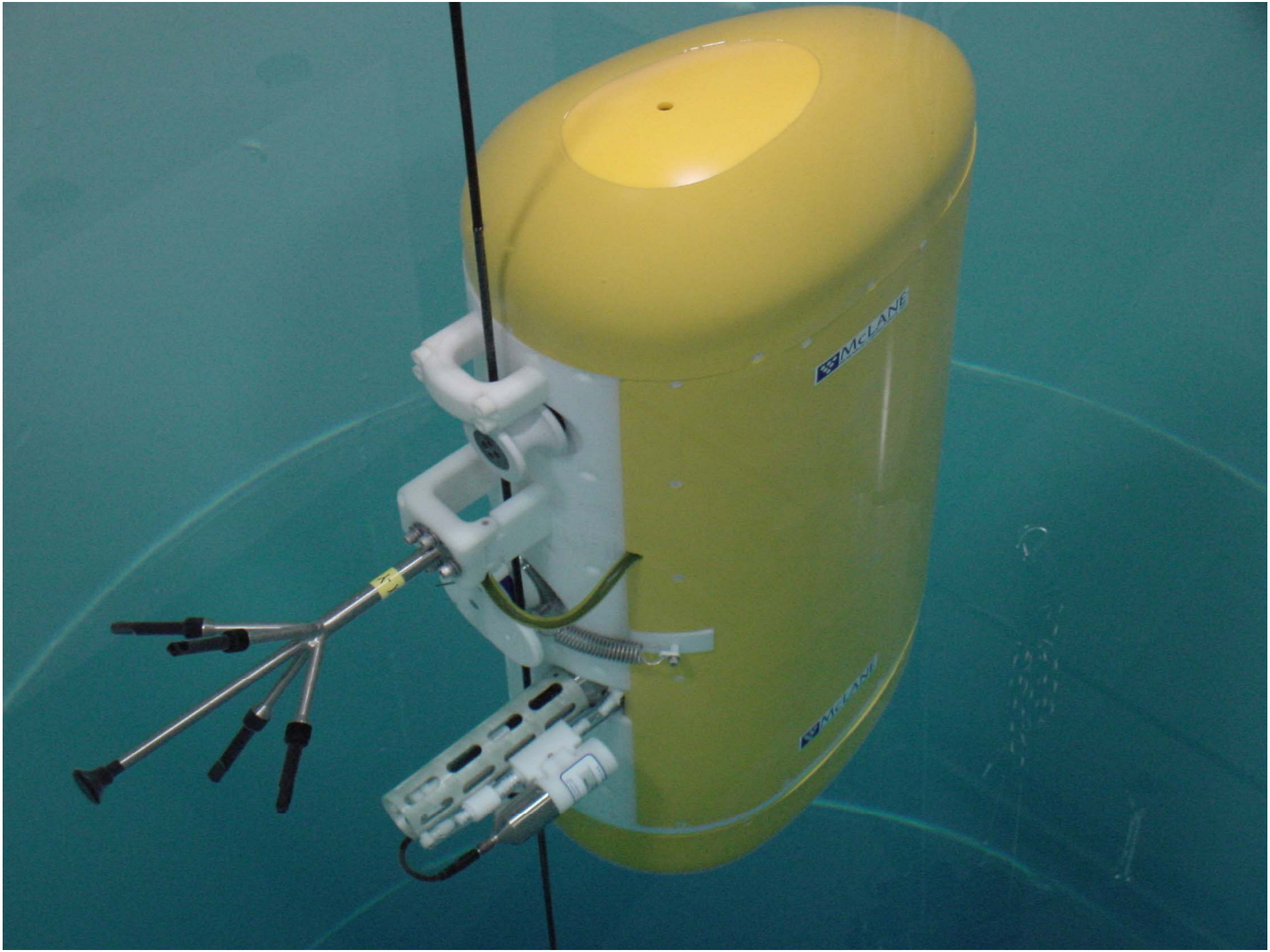

MRO1-K04
K2-2000m
MRO1-K04
K2-2000m

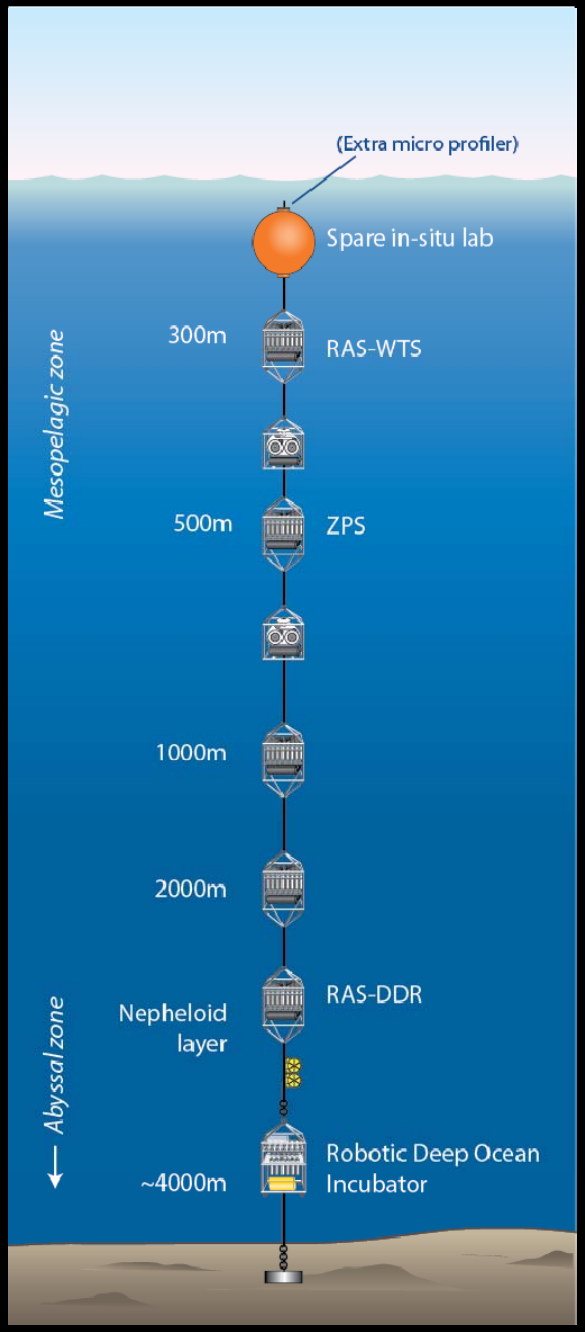
C. ESP-MMP Platform

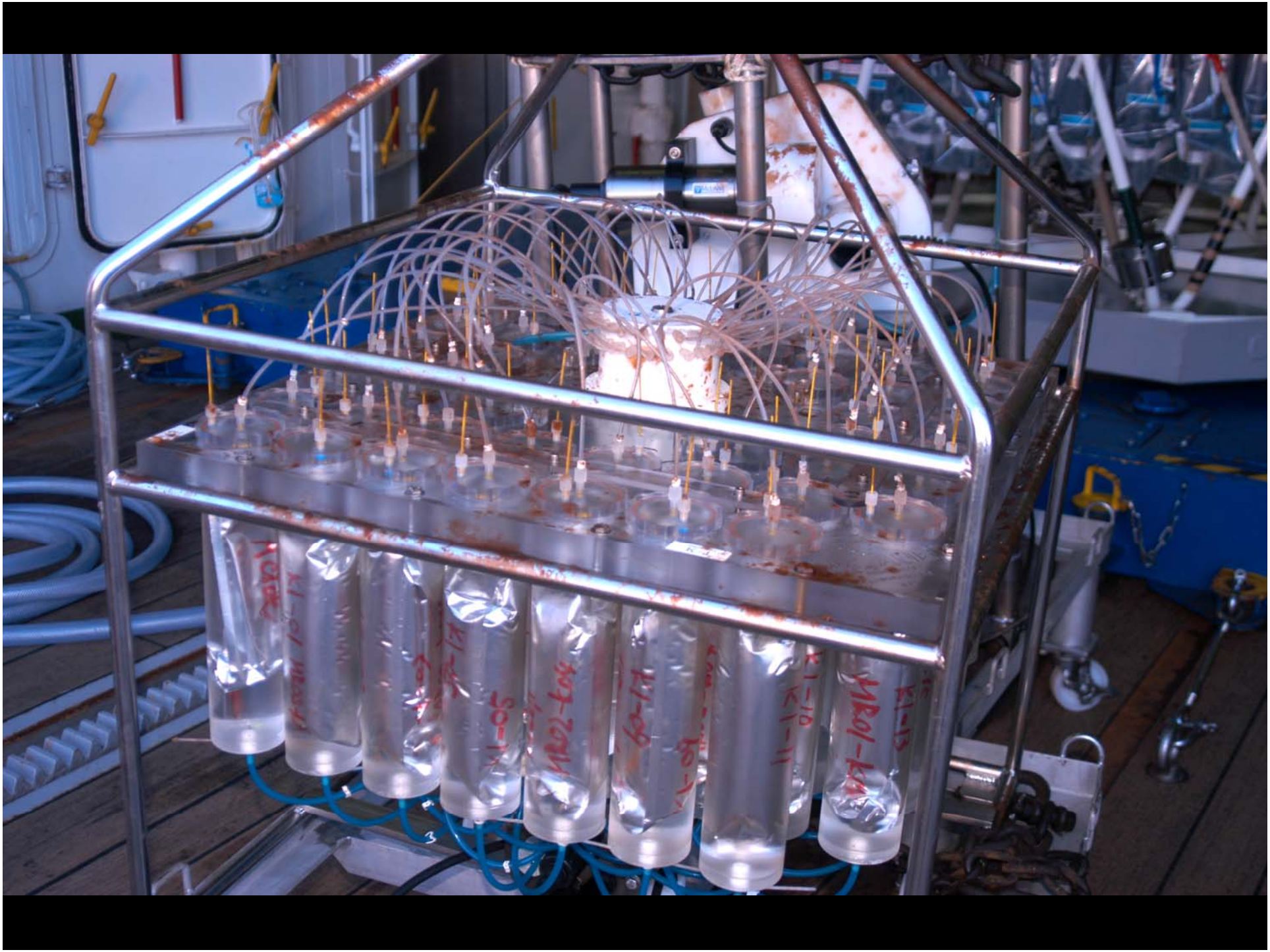


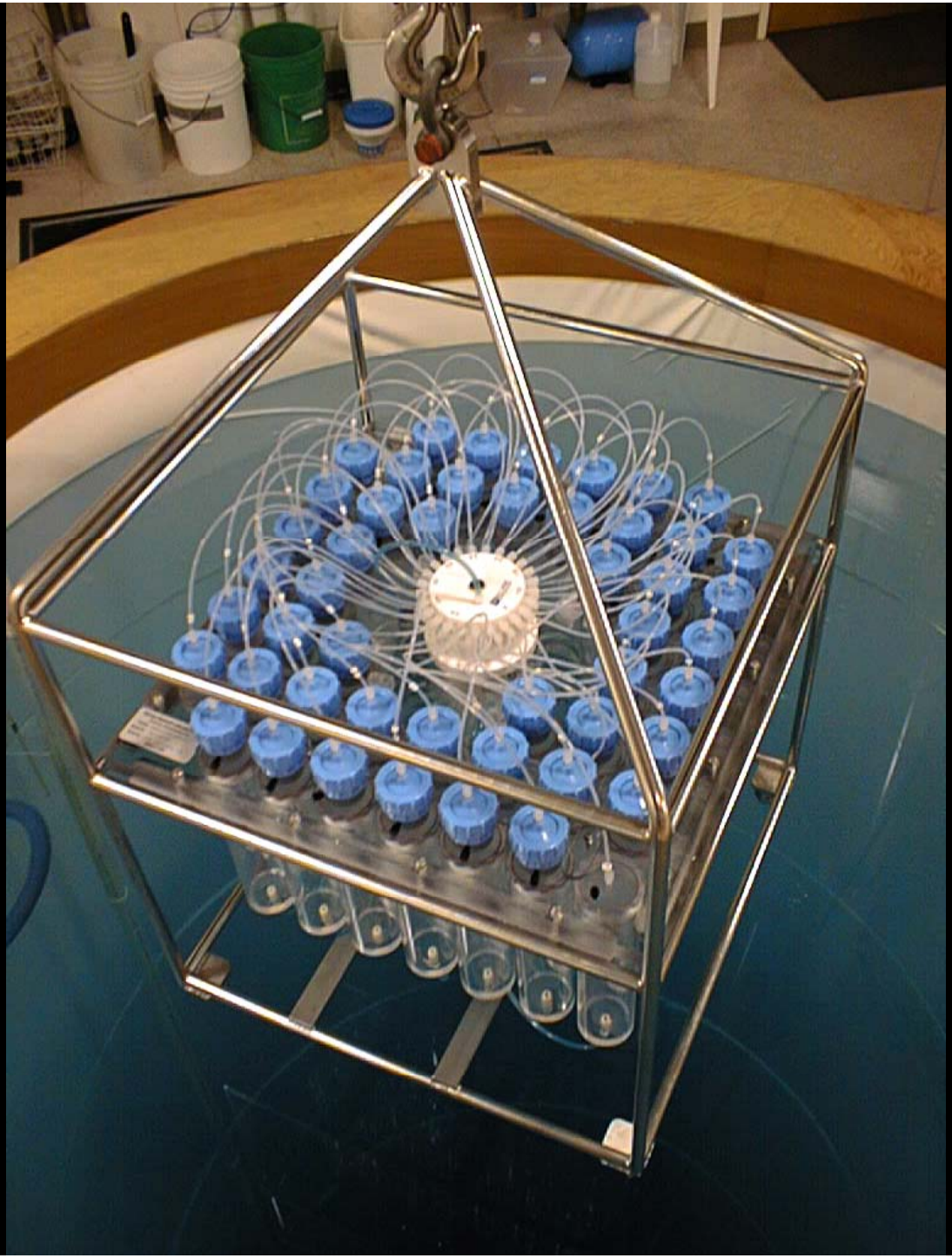

A
HARBOR BRANCH
B
C
CDL
D
E
F
G
Interface board
Acquistion PC
CCD
Laser
Sample vessel
H
500 microns

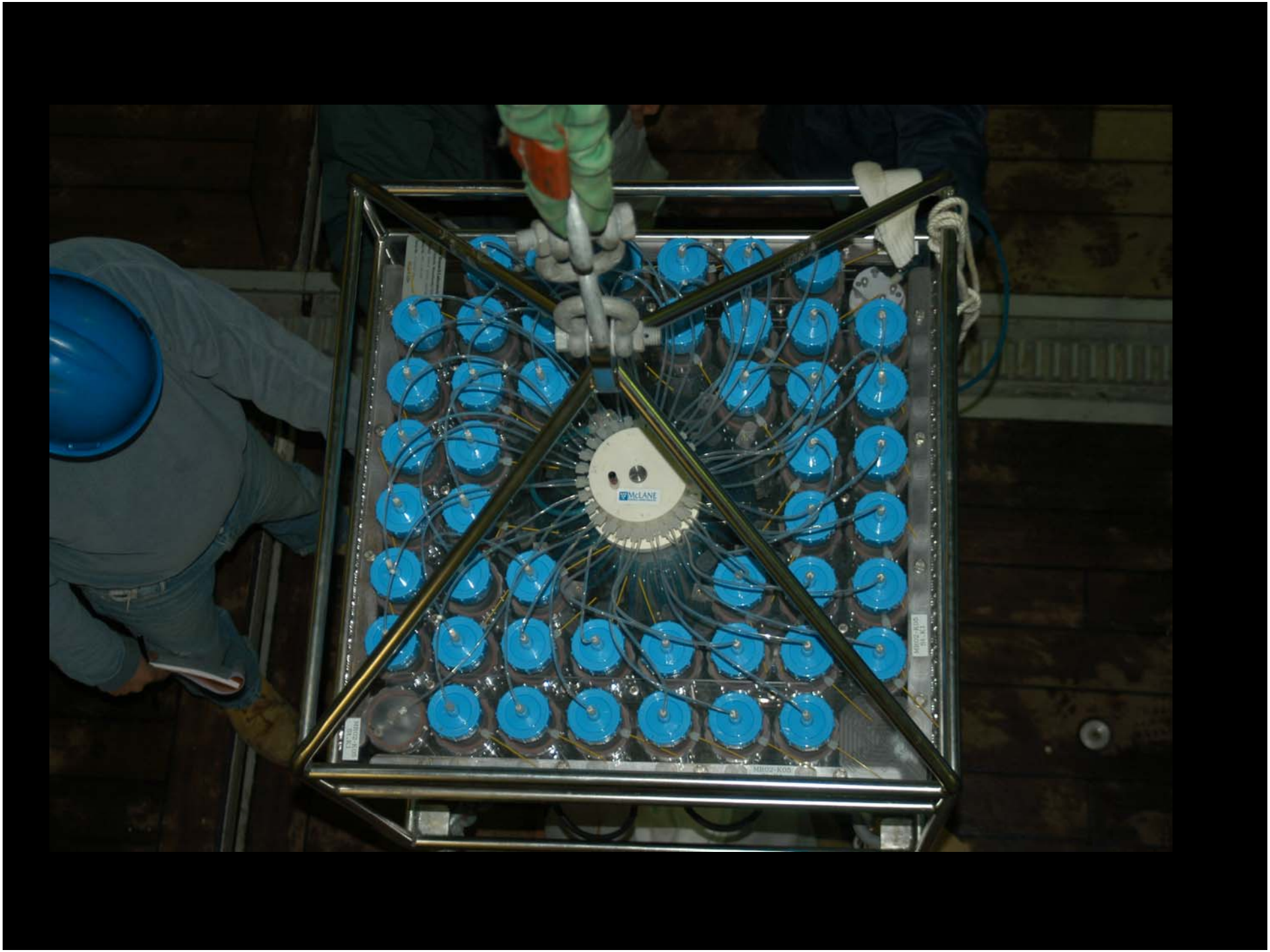

McLANE
McLANE

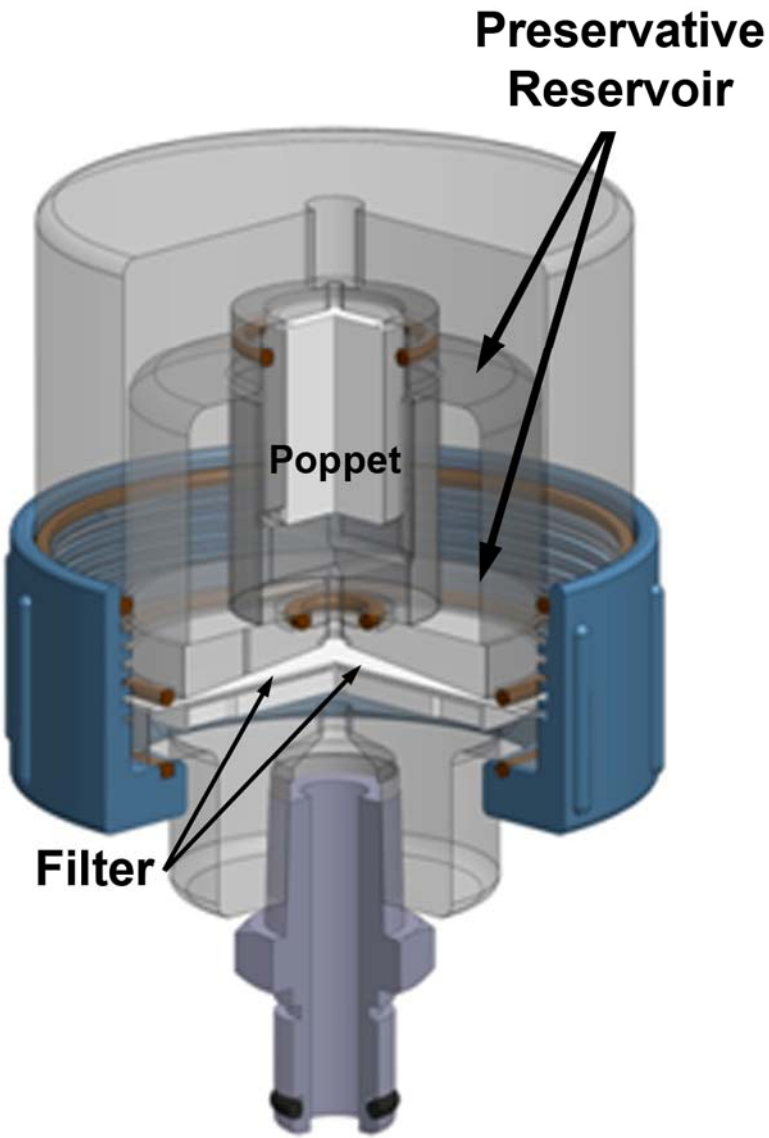
D. TS Water/Particle Sampler Platform



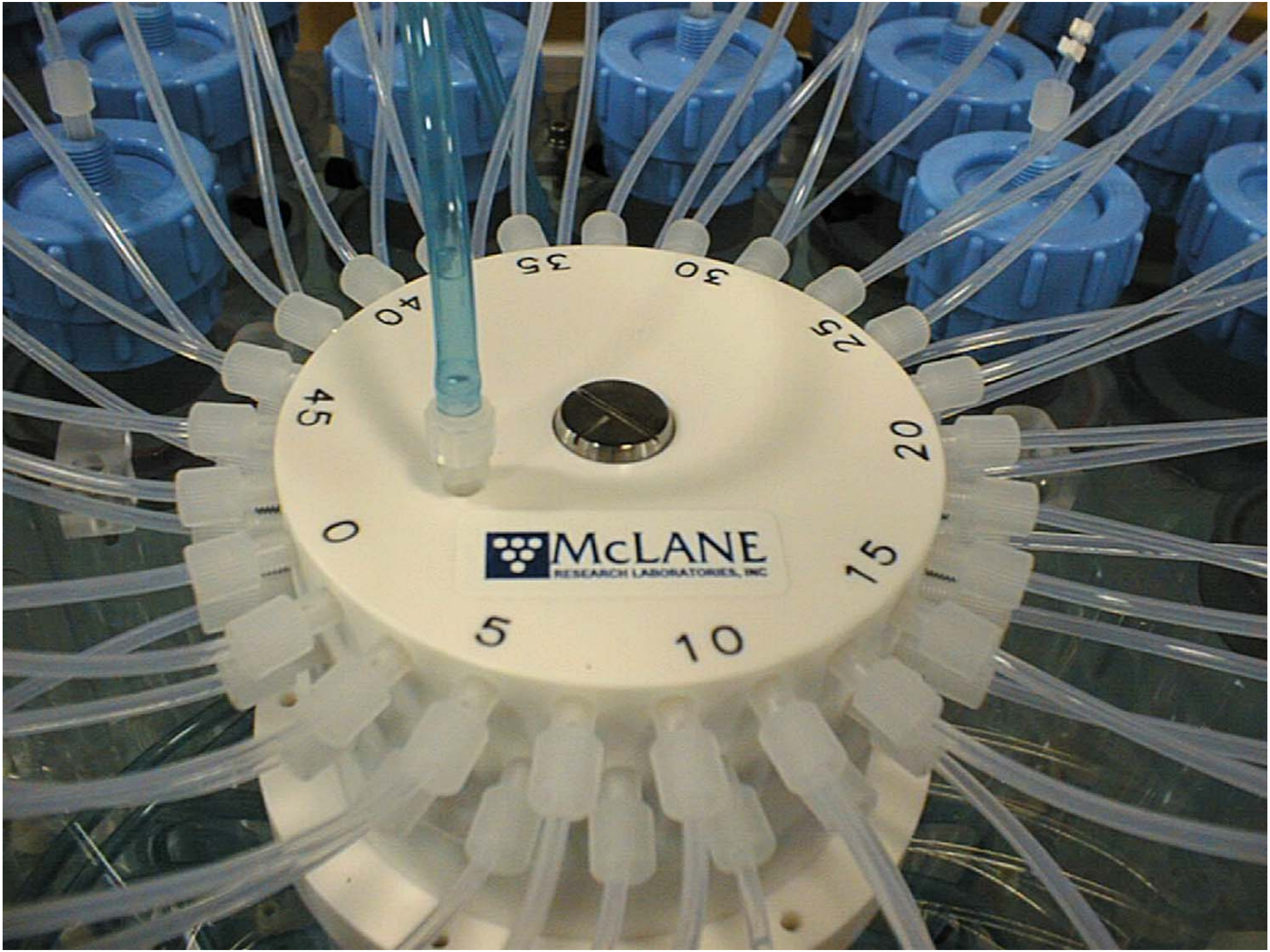




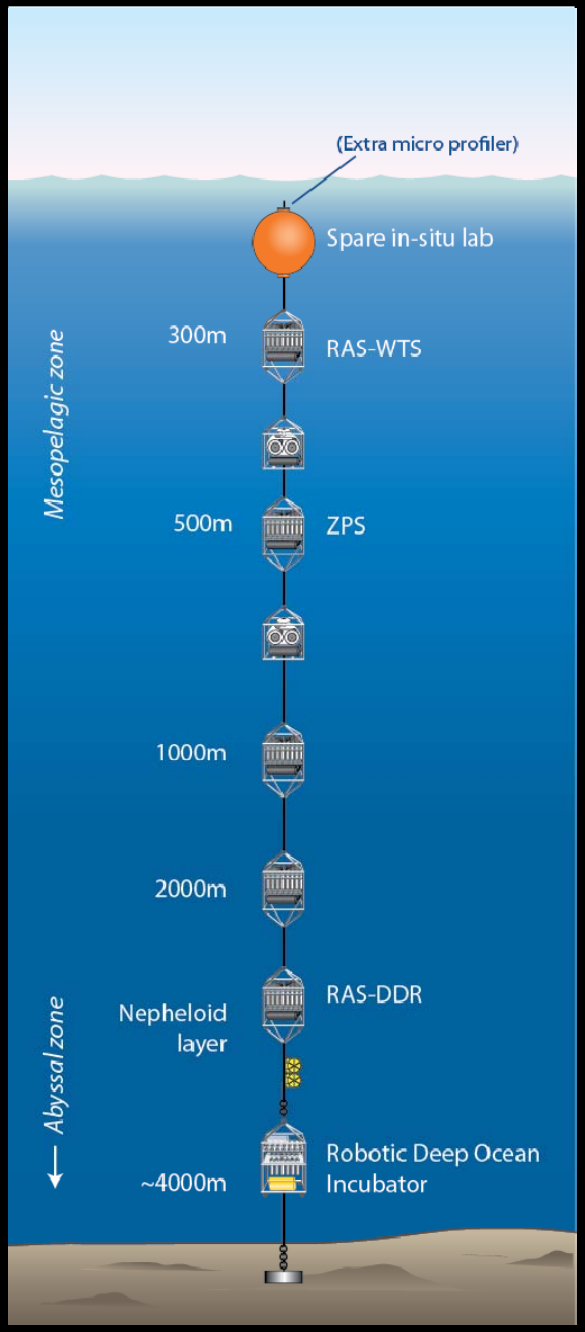

McLANE



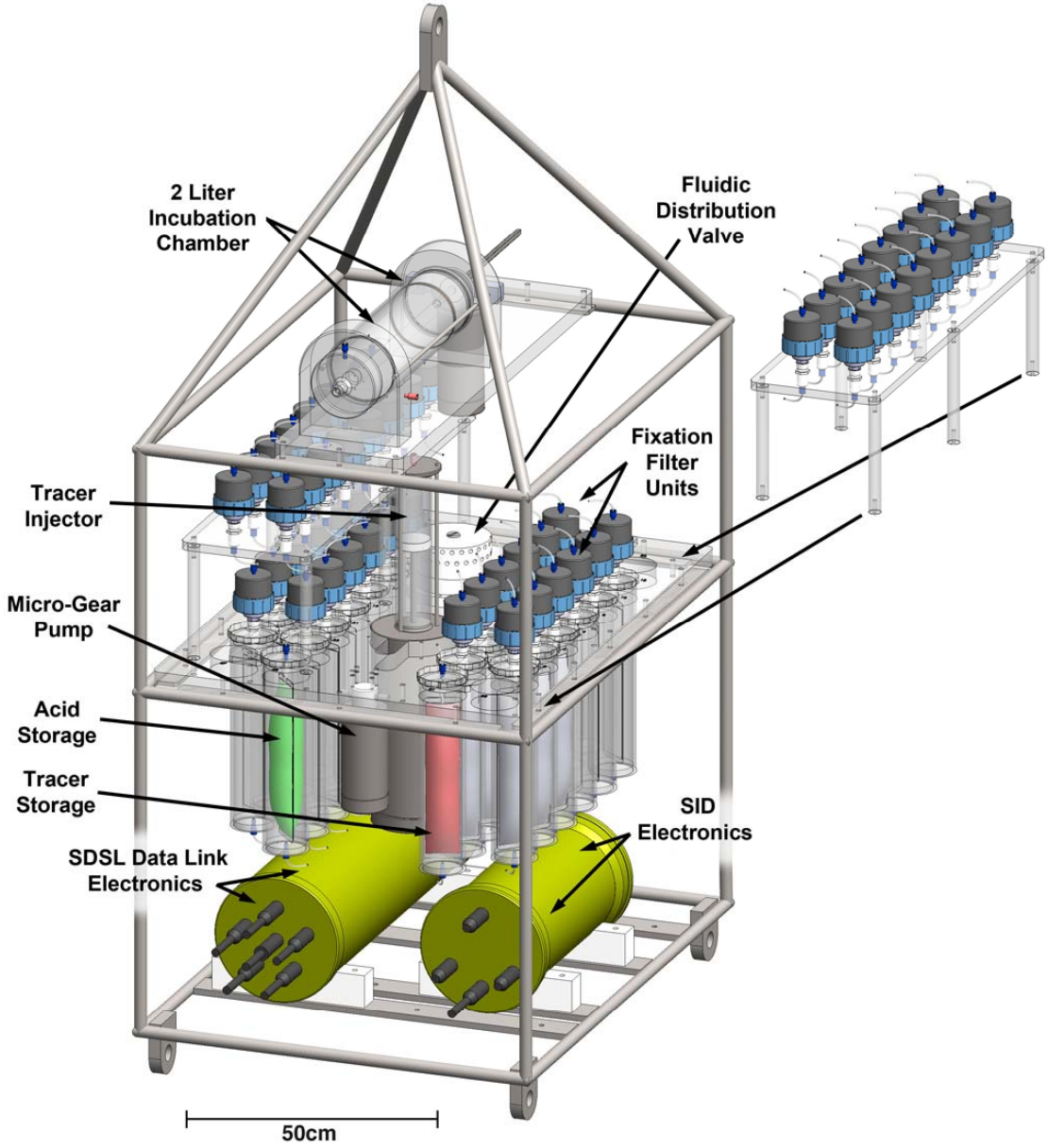
RNA Fixation Filter Unit

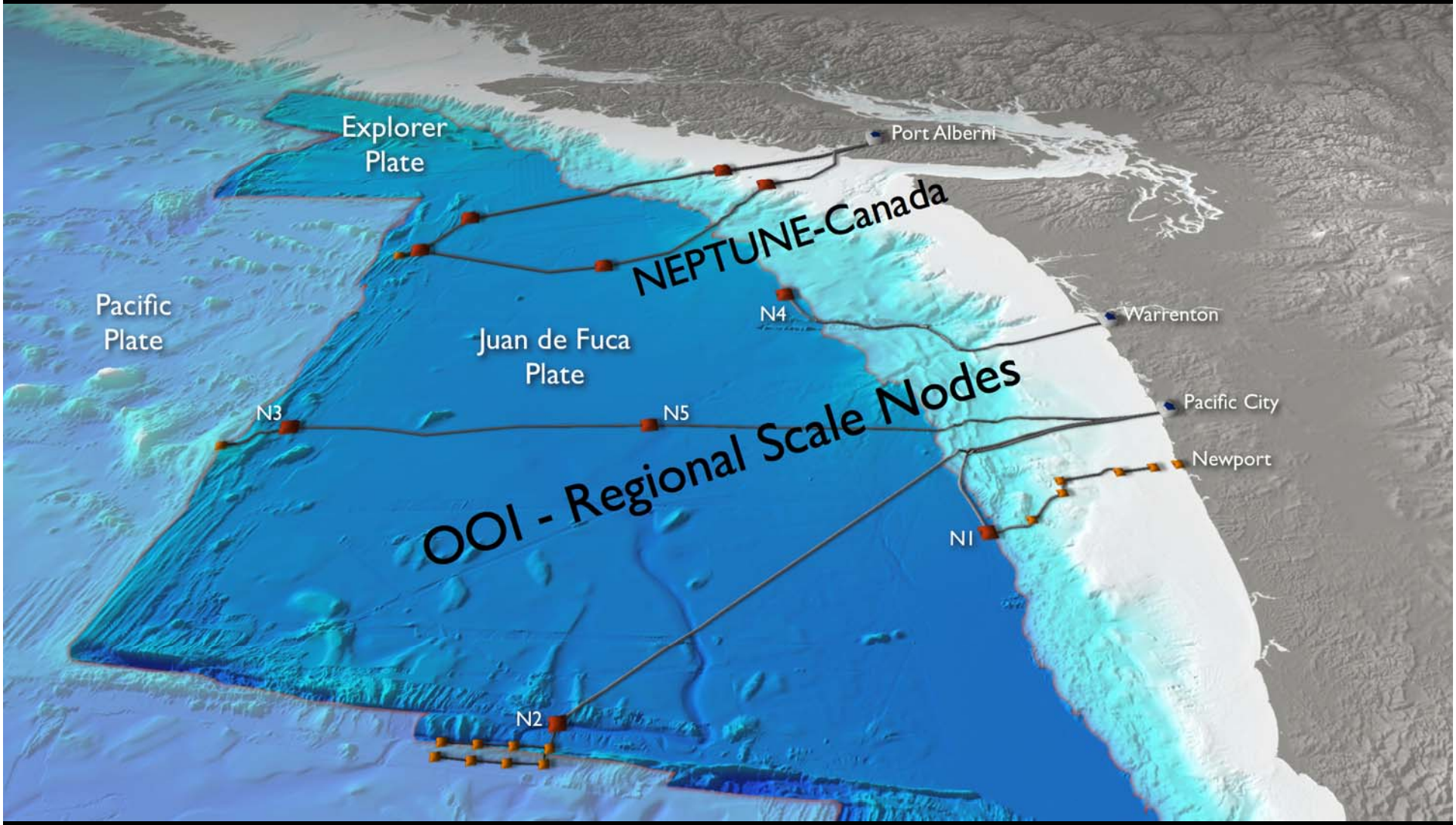

0
5
10
15
20
25
30
35
40
45
McLANE
RESEARCH LABORATORIES, INC

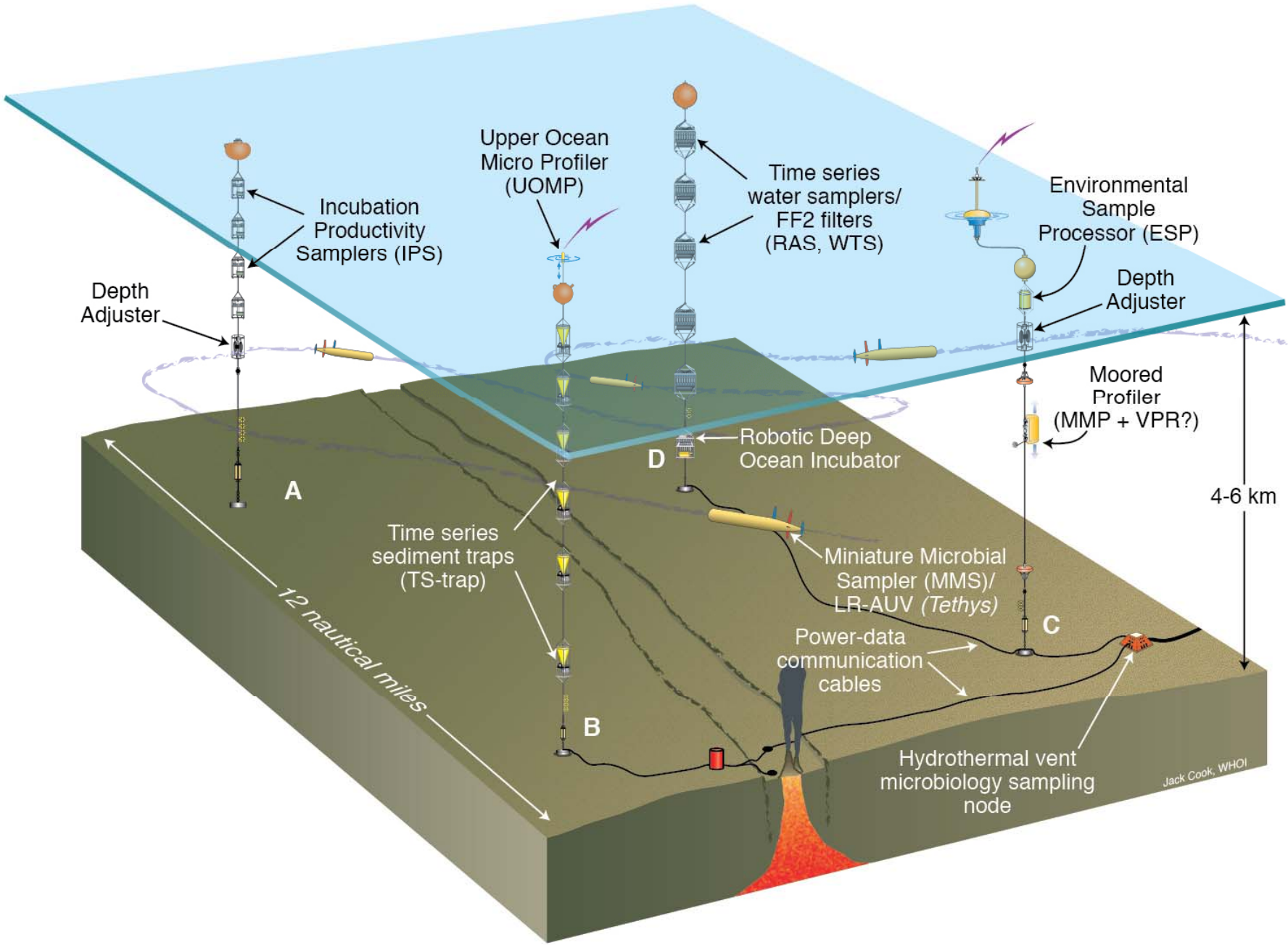
D. TS Water/Particle Sampler Platform

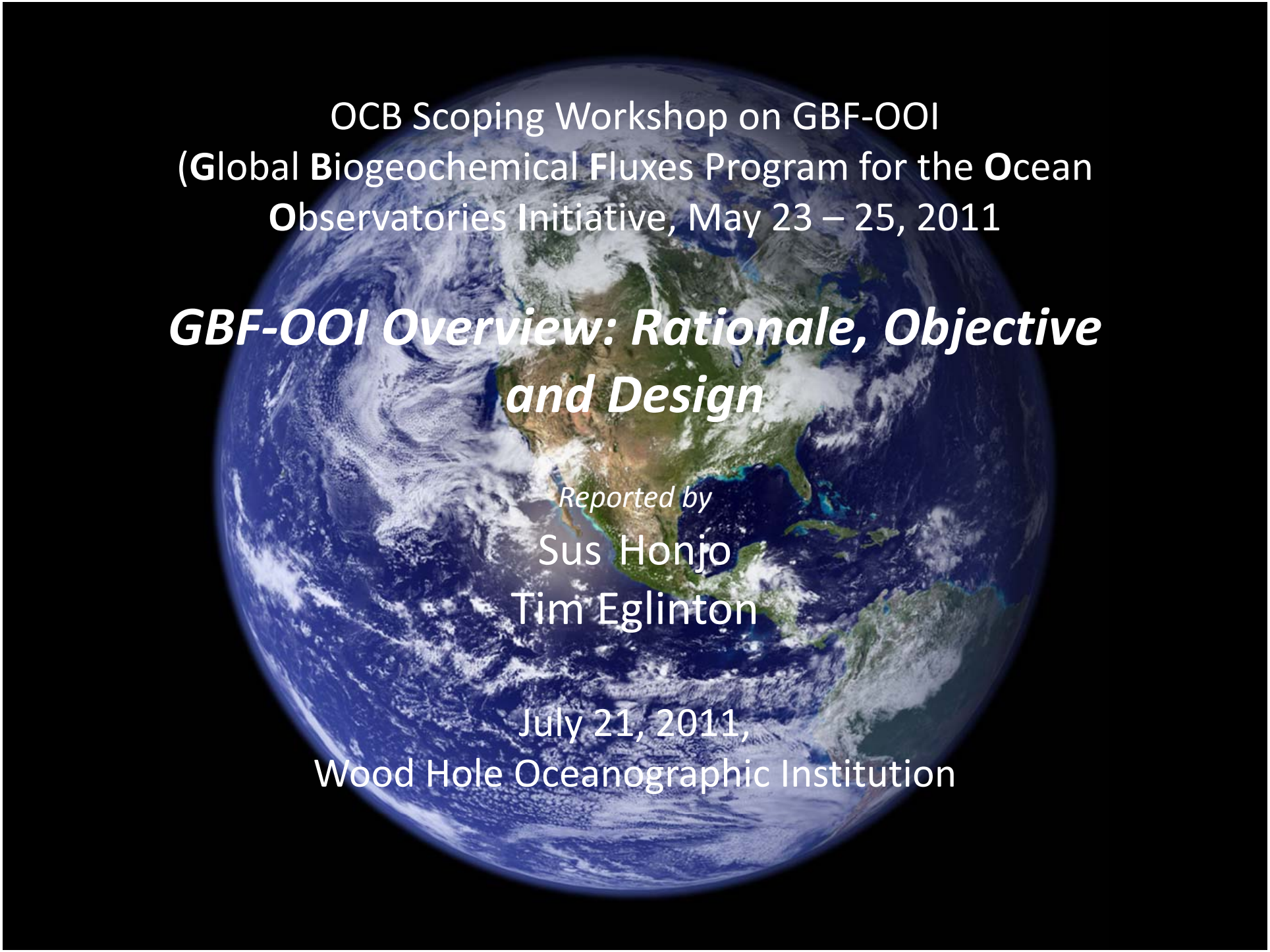


Submersible Incubation Robot (SID-ISM)




Explorer
Plate
Port Alberni
NEPTUNE-Canada
Pacific
Plate
N4
Warrenton
Juan de Fuca
Plate
N3
N5
Pacific City
OOI - Regional Scale Nodes
Newport
N1
N2


Upper Ocean
Micro Profiler
(UOMP)
Time series
water samplers/
FF2 filters
(RAS, WTS)
Environmental
Sample
Processor (ESP)
Incubation
Productivity
Samplers (IPS)
Depth
Adjuster
Depth
Adjuster
Moored
Profiler
(MMP + VPR?)
Robotic Deep
Ocean Incubator
D
A
4-6 km
Time series
sediment traps
(TS-trap)
Miniature Microbial
Sampler (MMS)/
LR-AUV (Tethys)
C
Power-data
communication
cables
12 nautical miles
B
Hydrothermal vent
microbiology sampling
node
Jack Cook, WHOI



OCB Scoping Workshop on GBF-OOI
(**G**lobal **B**iogeochemical **F**luxes Program for the **O**cean **O**bservatories **I**nitiative, May 23 – 25, 2011

GBF-OOI Overview: Rationale, Objective and Design

Reported by

Sus Honjo

Tim Eglinton

July 21, 2011,

Wood Hole Oceanographic Institution