Coastal observation systems to monitor physical, chemical and biological parameters

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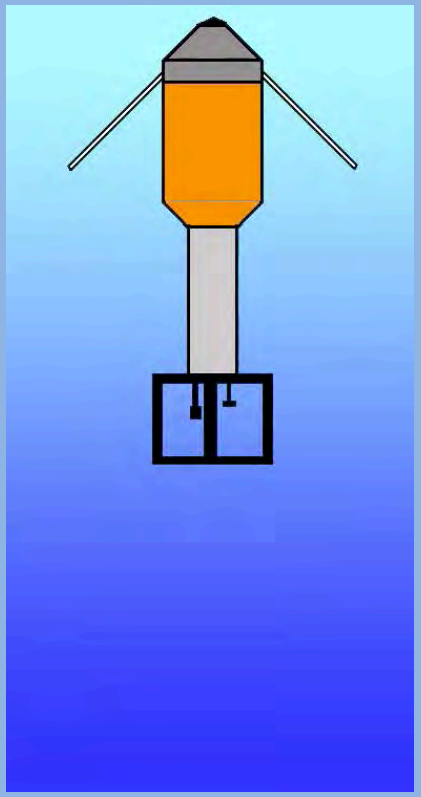
[2]Ibaraki University
[3]Woods Hole Oceanographic Institution
[4]Tokyo Metropolitan Government

PICES 2016 Session13 @ San Diego
November 7, 2016

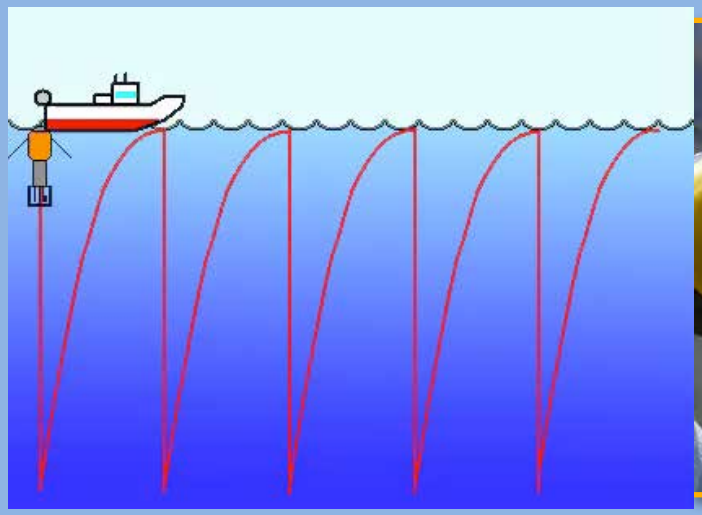
Topics

- YODA Profiler
- SUNTANS (Hydrodynamics model)
- JEDI System
- Cabled Observatory (OCEANS)
- A new AUV (MEMO-pen)

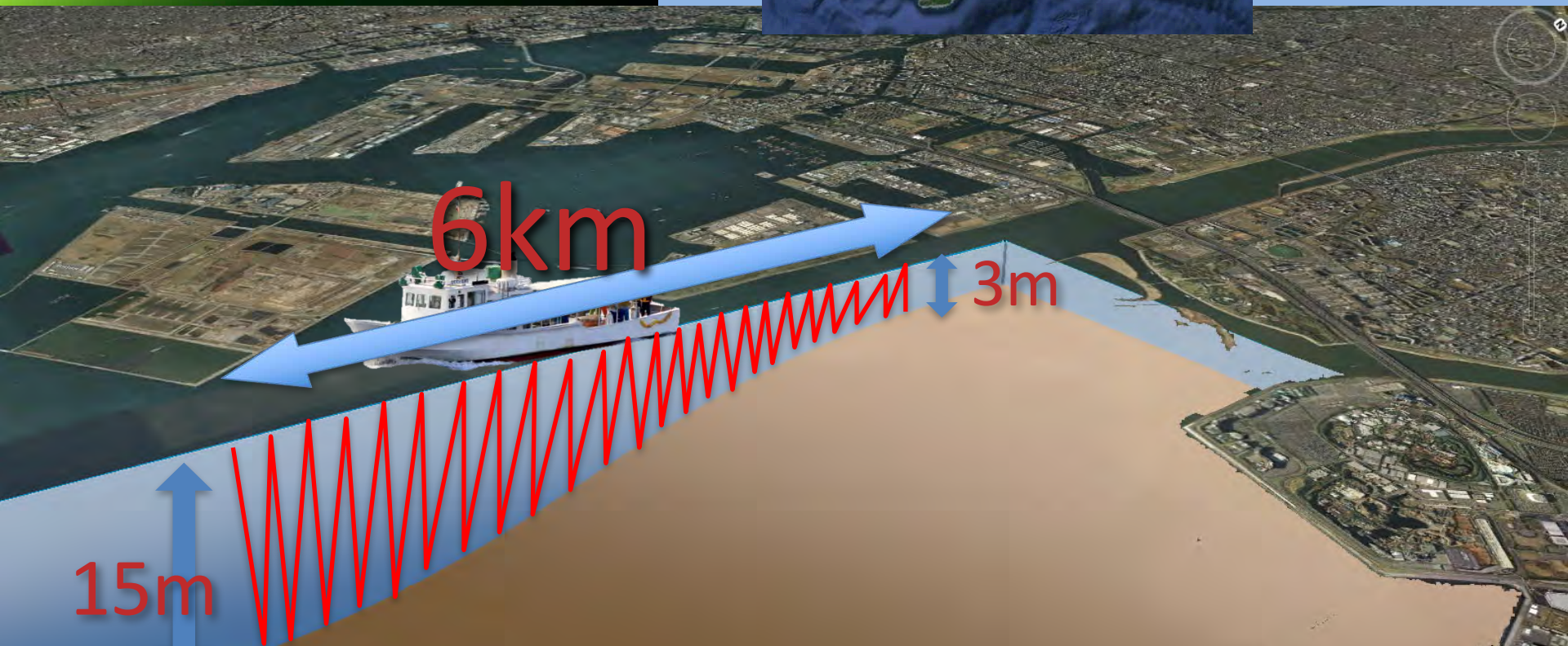
New tow-yo instrument designed for shallow areas



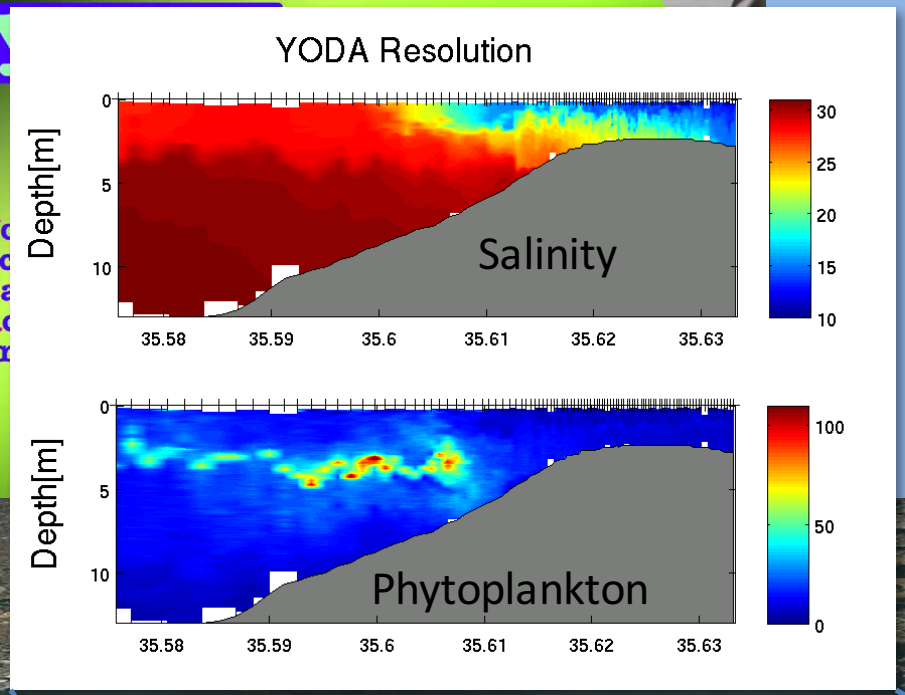
0.2m/s
Slowly

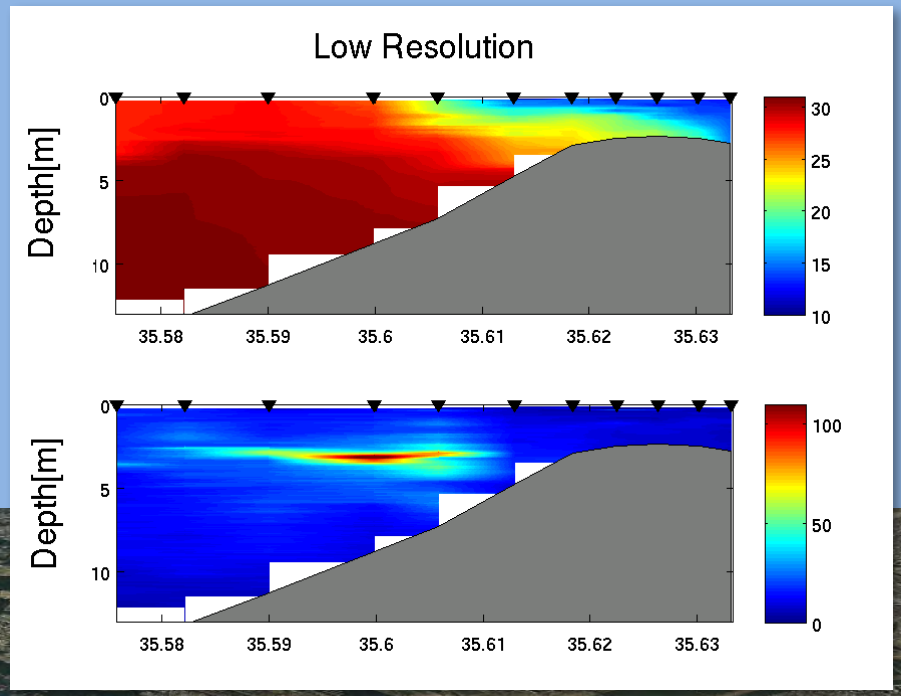


High resolution data from YODA



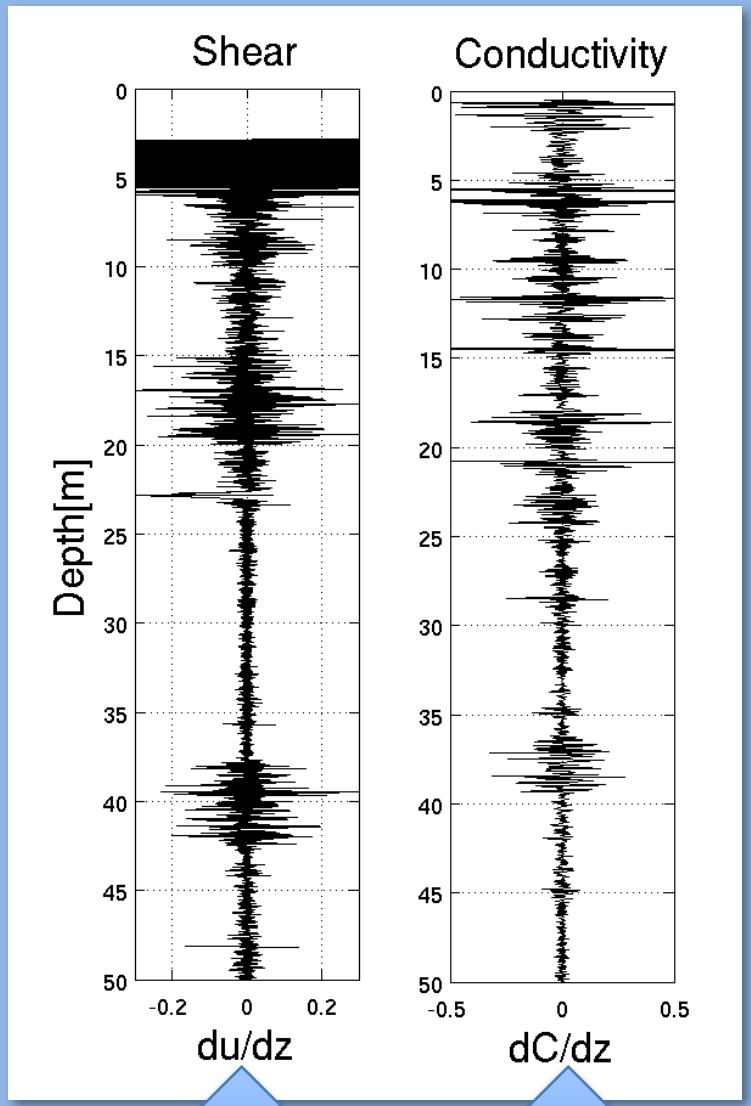
High resolution data from YODA



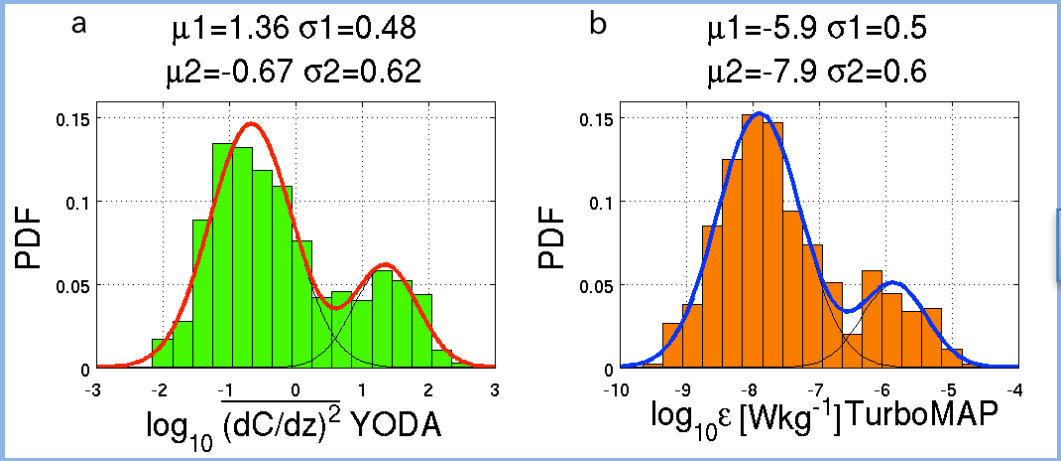


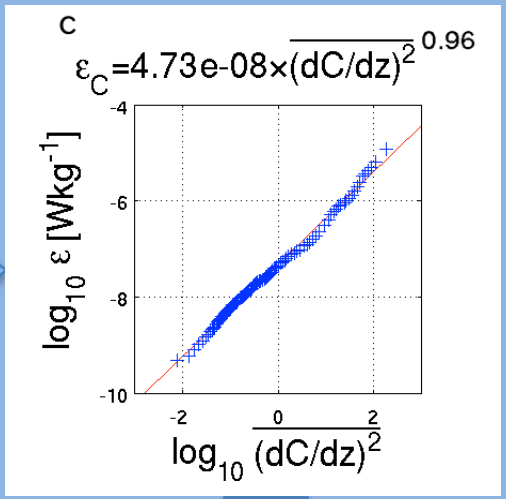
Turbulence from YODA

Conductivity → Turbulent intensity



dC/dz → ε W/kg



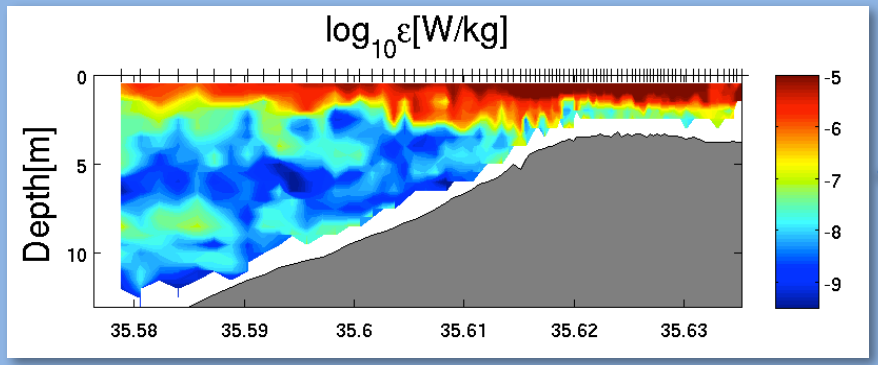


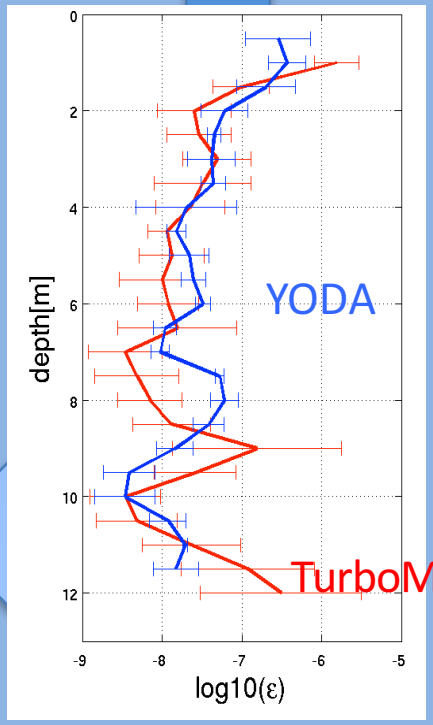
Assumptions:

1. The rate of turbulent kinetic energy dissipation and temperature gradient follows a joint lognormal pdf.

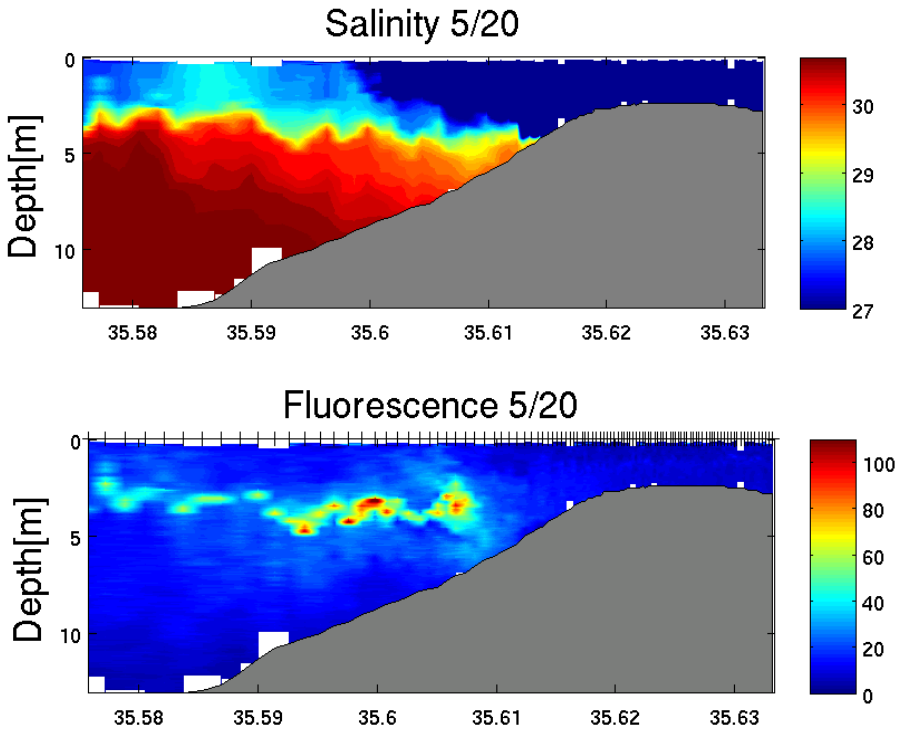
1. Conductivity signals follow temperature signals.

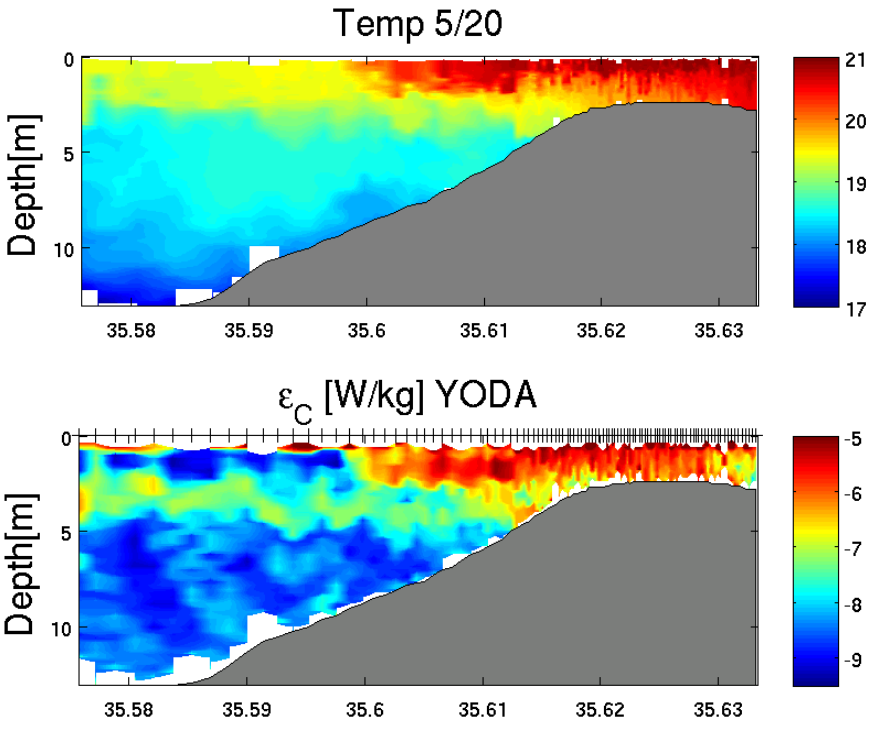
2. The rate of turbulent kinetic energy dissipation and conductivity gradient follows a joint lognormal pdf.

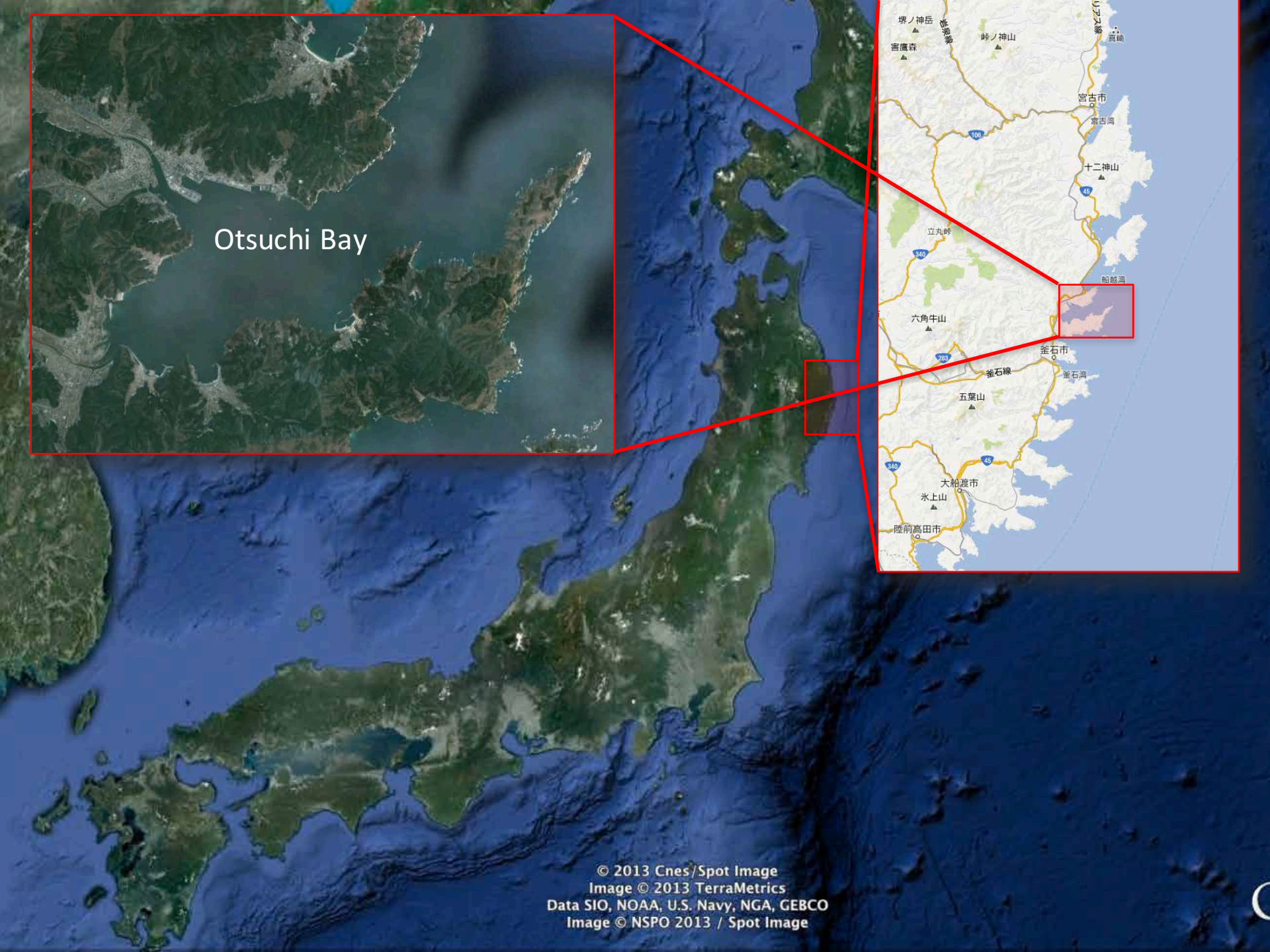


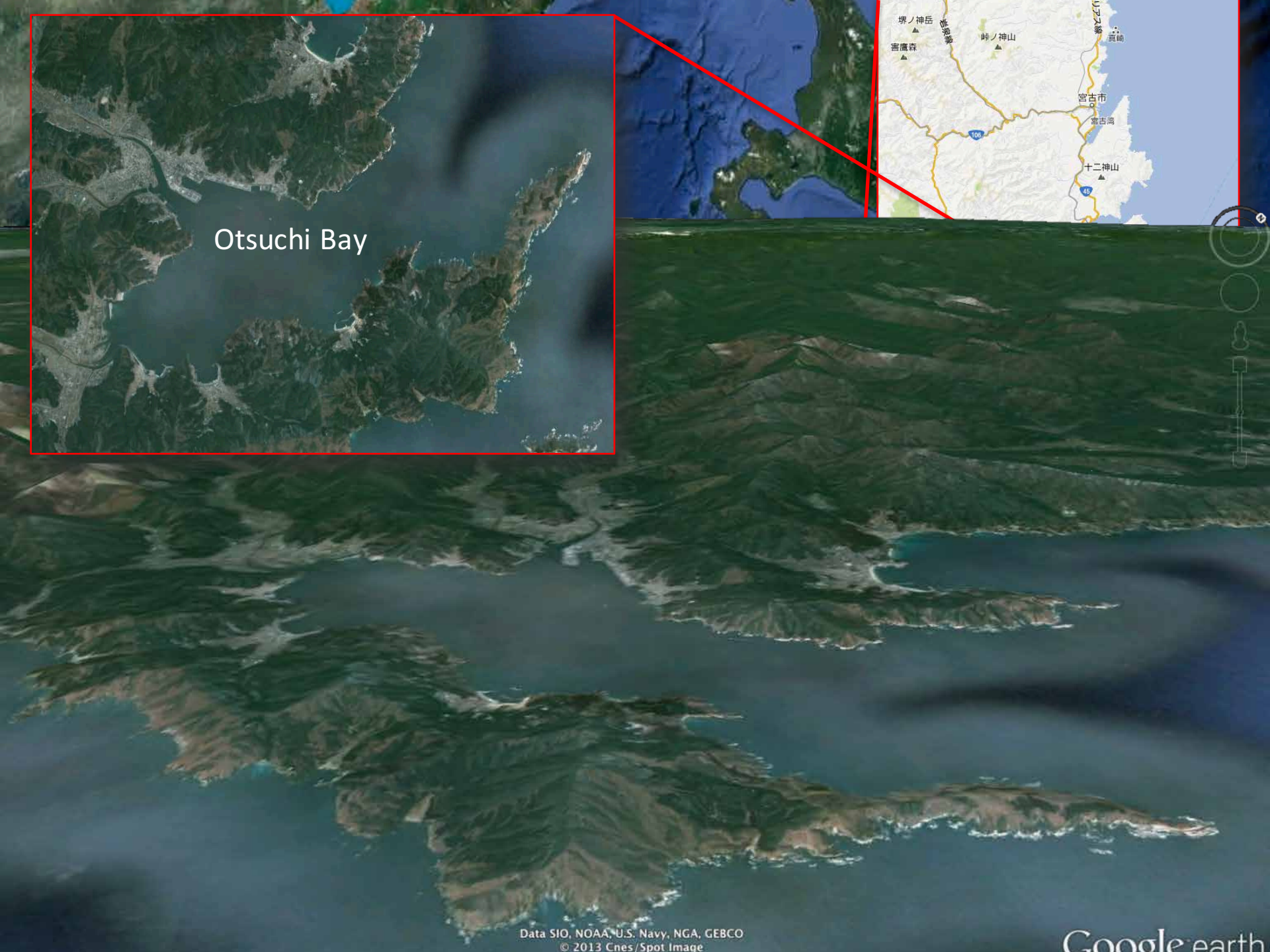


CTD + Phytoplankton + Turbulence






Otsuchi Bay
堺ノ神岳
害鷹森
峠ノ神山
宮古市
宮古湾
十二神山
立丸峠
船越湾
六角牛山
釜石市
釜石線
釜石湾
五葉山
大船渡市
氷上山
陸前高田市
© 2013 Cnes/Spot Image
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © NSPO 2013 / Spot Image

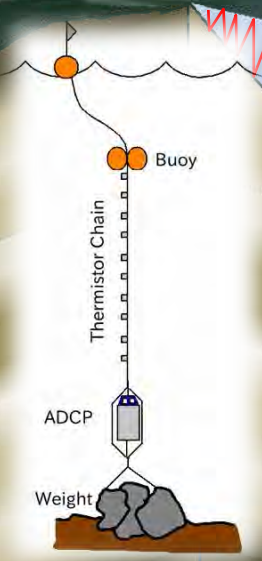

Otsuchi Bay
堺ノ神岳
峠ノ神山
宮古市
十二神山
106
45
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Cnes/Spot Image
Google earth

Masunaga and Yamazaki (2014)

Kotsuchi Riv.

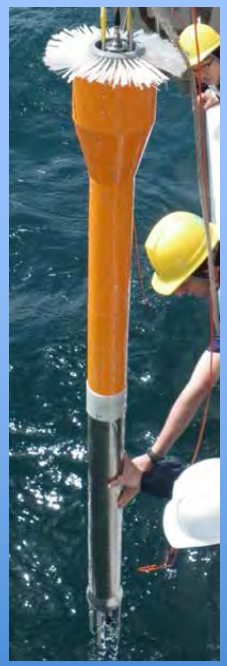
Otsuchi

Unosumai Riv.

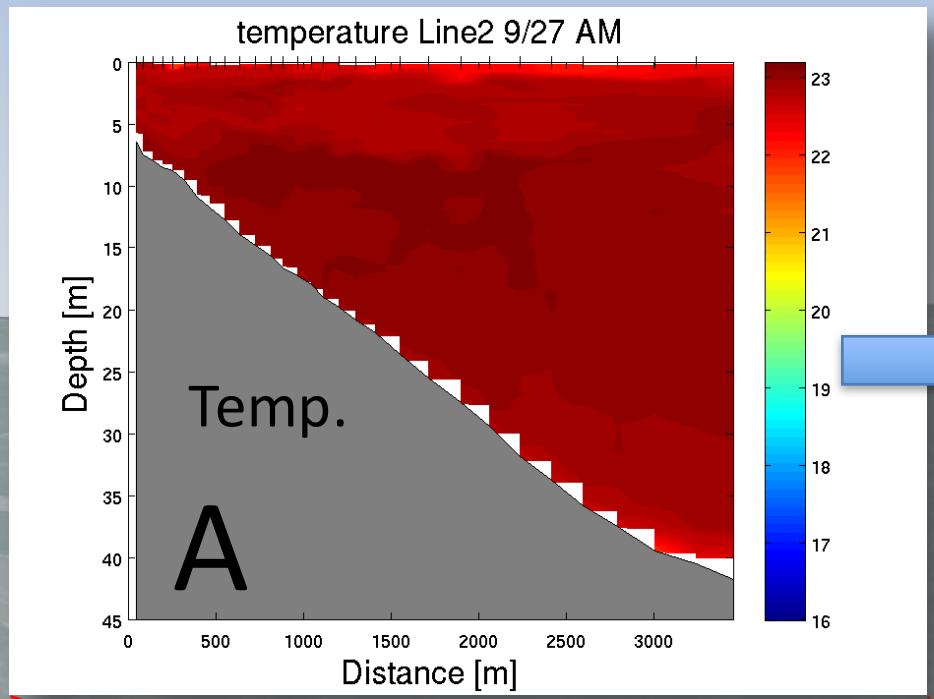


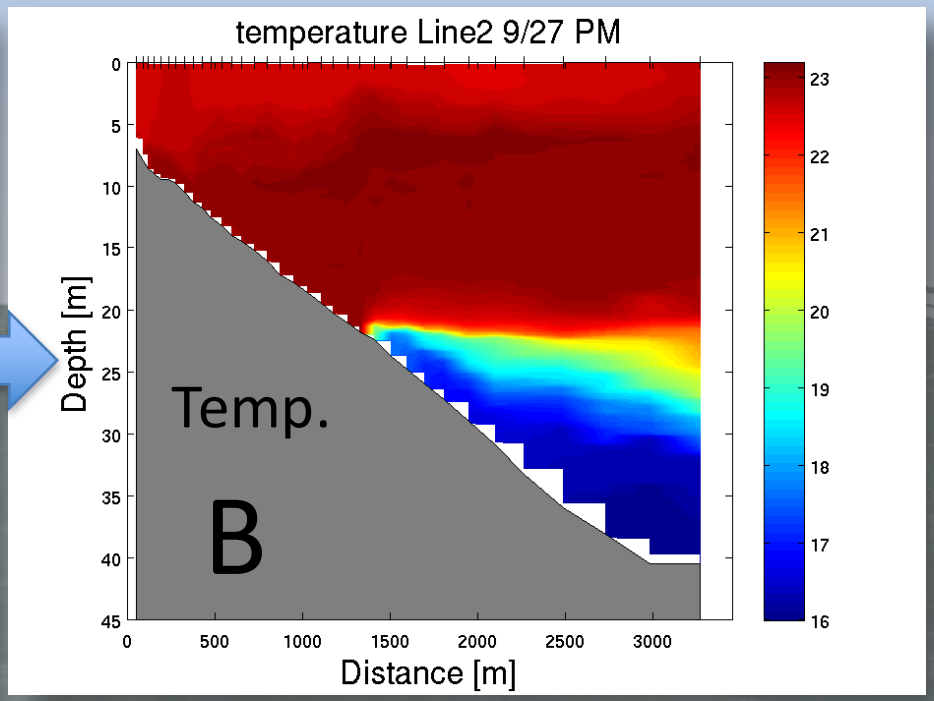
Mooring station

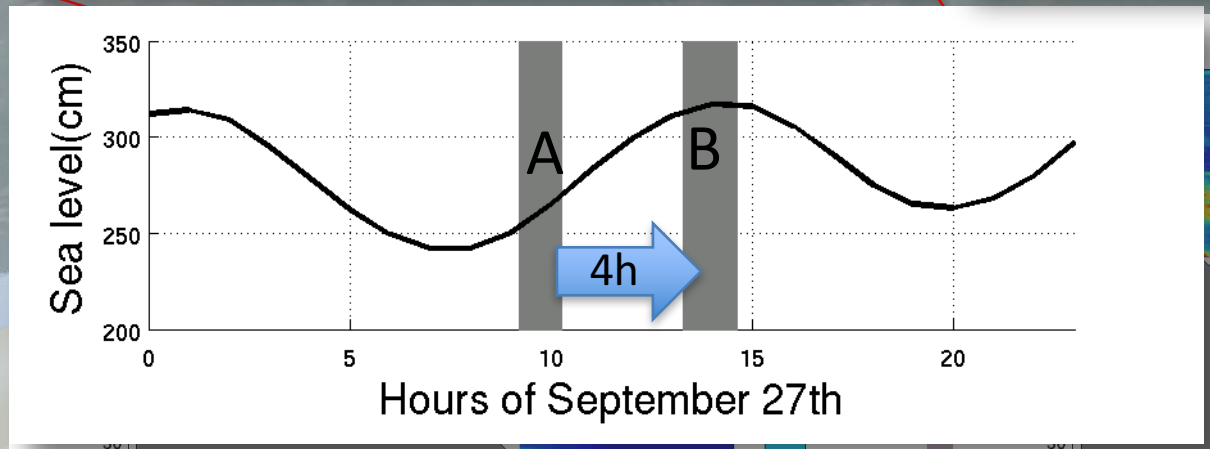
UCTD

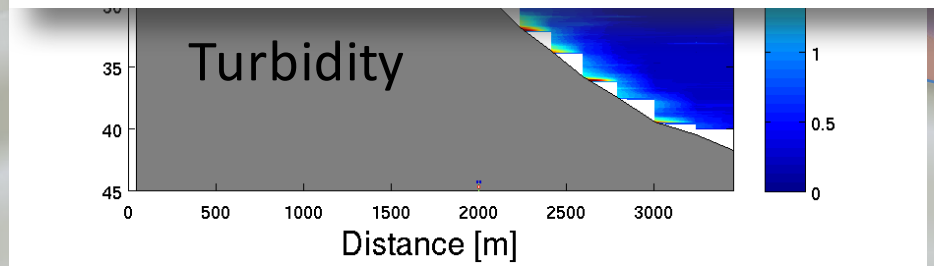


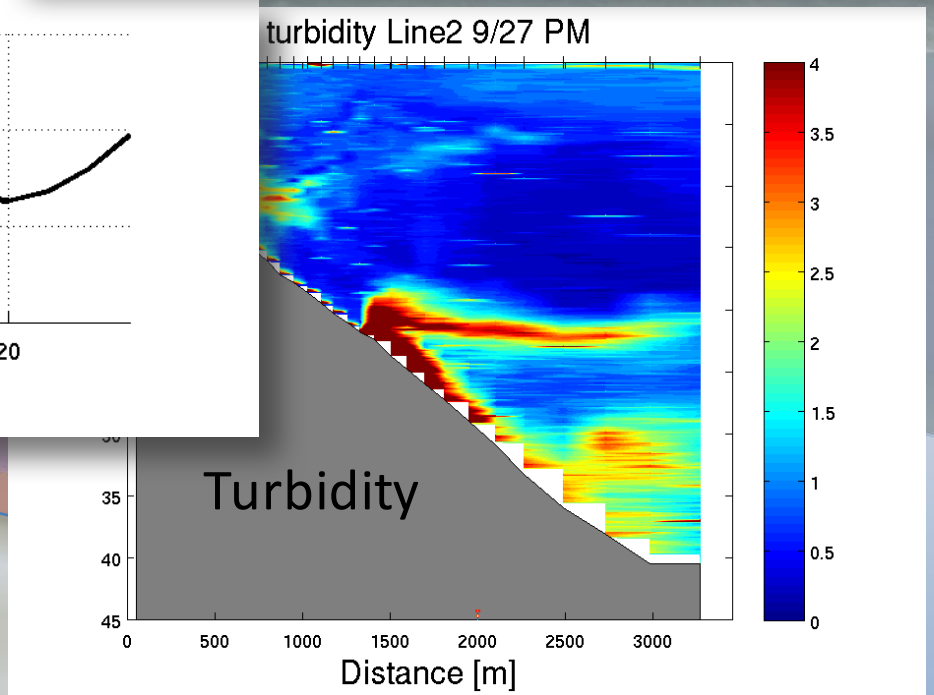
TurboMAP-L

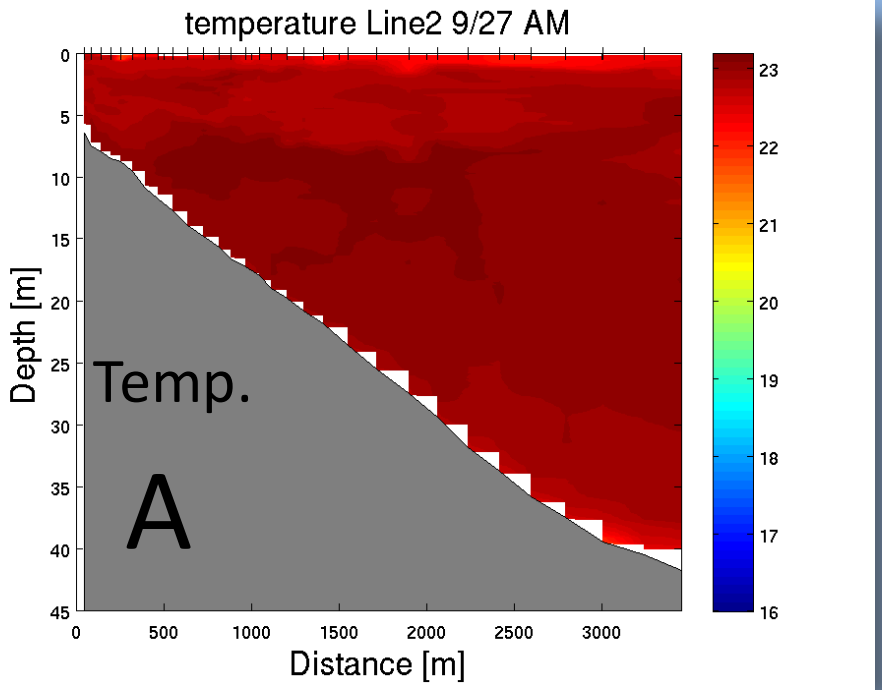

temperature Line2 9/27 AM
Depth [m]
Distance [m]
Temp.
A

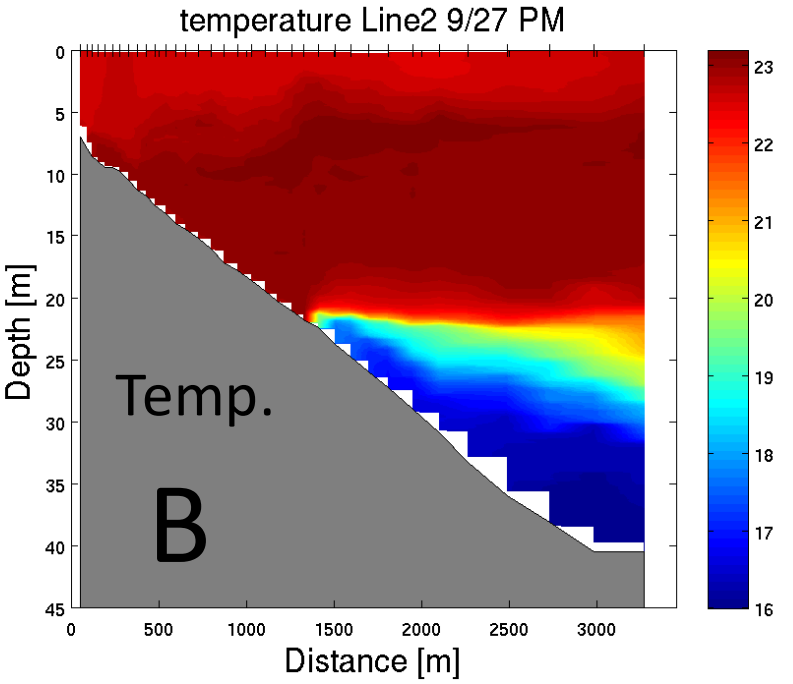

temperature Line2 9/27 PM
Depth [m]
Distance [m]
Temp.
B

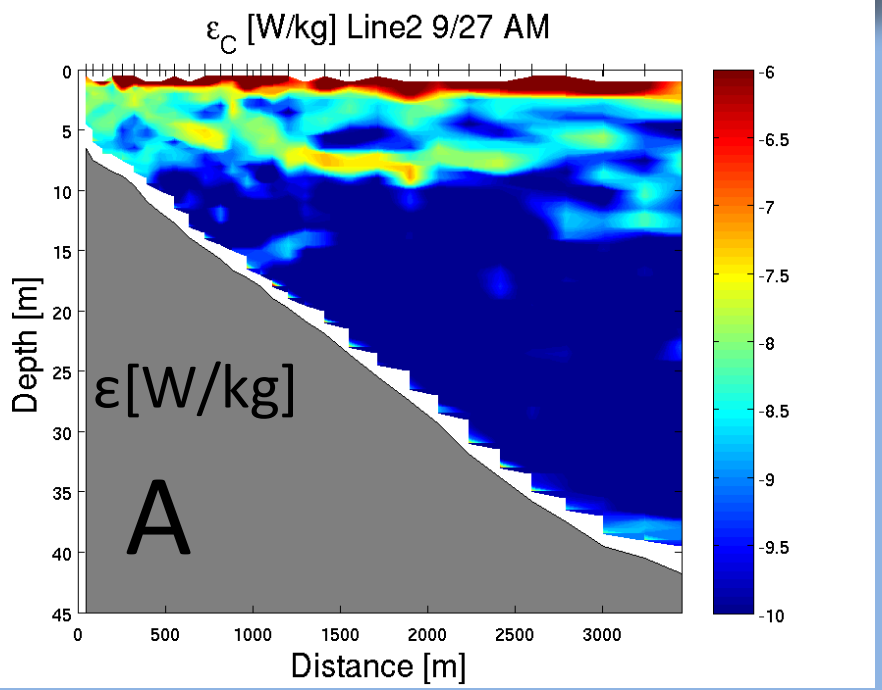

Sea level(cm)
Hours of September 27th
A
B
4h

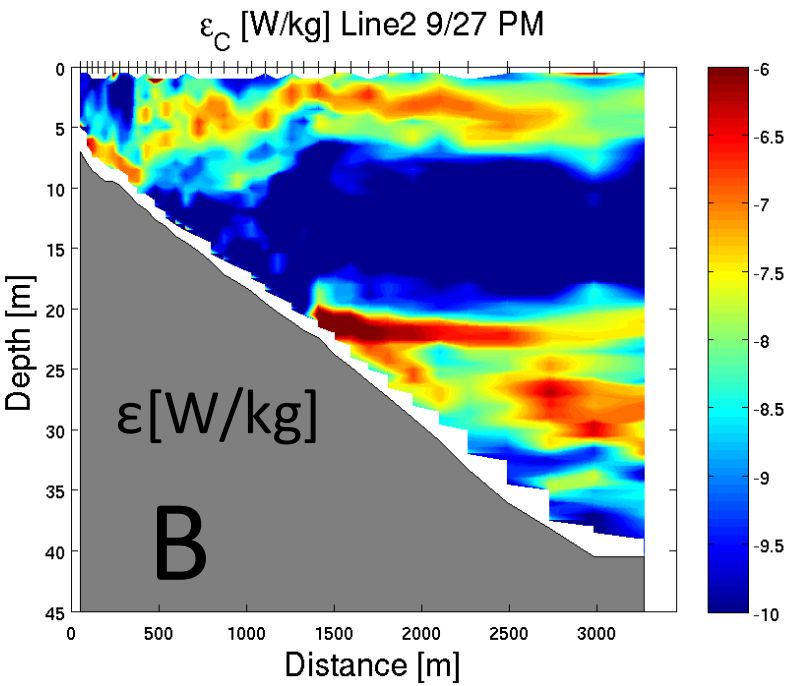

Turbidity
Distance [m]


turbidity Line2 9/27 PM
Turbidity
Distance [m]

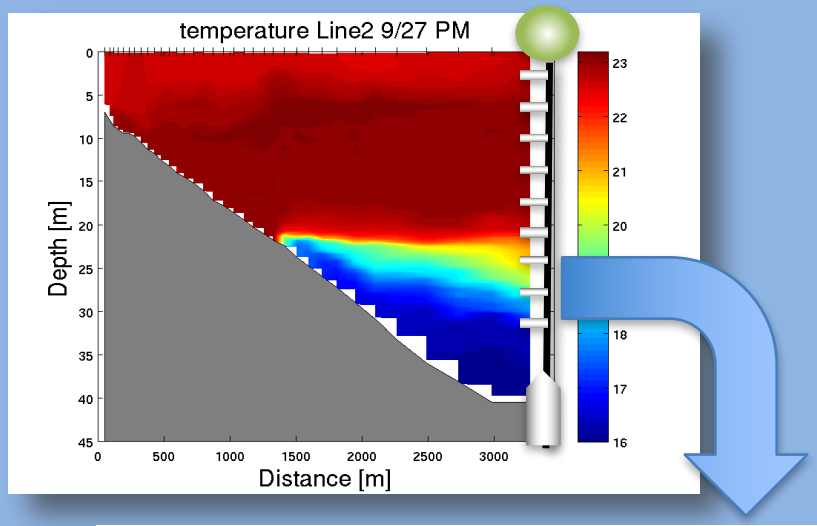

temperature Line2 9/27 AM
Depth [m]
Distance [m]
Temp.
A
0
5
10
15
20
25
30
35
40
45
0
500
1000
1500
2000
2500
3000
23
22
21
20
19
18
17
16


temperature Line2 9/27 PM
Depth [m]
Distance [m]
Temp.
B
0
5
10
15
20
25
30
35
40
45
0
500
1000
1500
2000
2500
3000
23
22
21
20
19
18
17
16

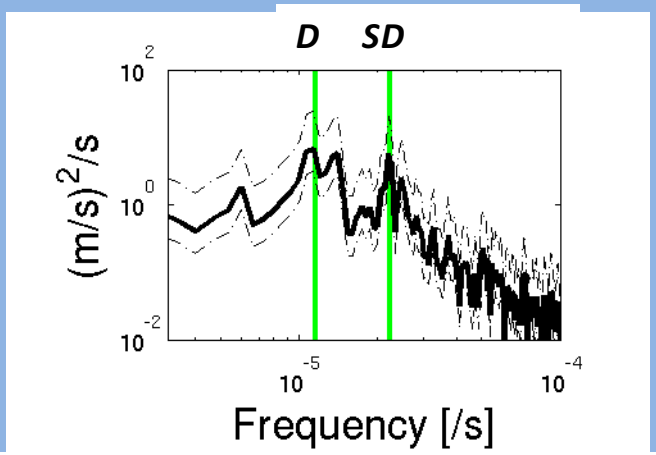

εC [W/kg] Line2 9/27 AM
Depth [m]
Distance [m]
ε[W/kg]
A
0
5
10
15
20
25
30
35
40
45
0
500
1000
1500
2000
2500
3000
-6
-6.5
-7
-7.5
-8
-8.5
-9
-9.5
-10

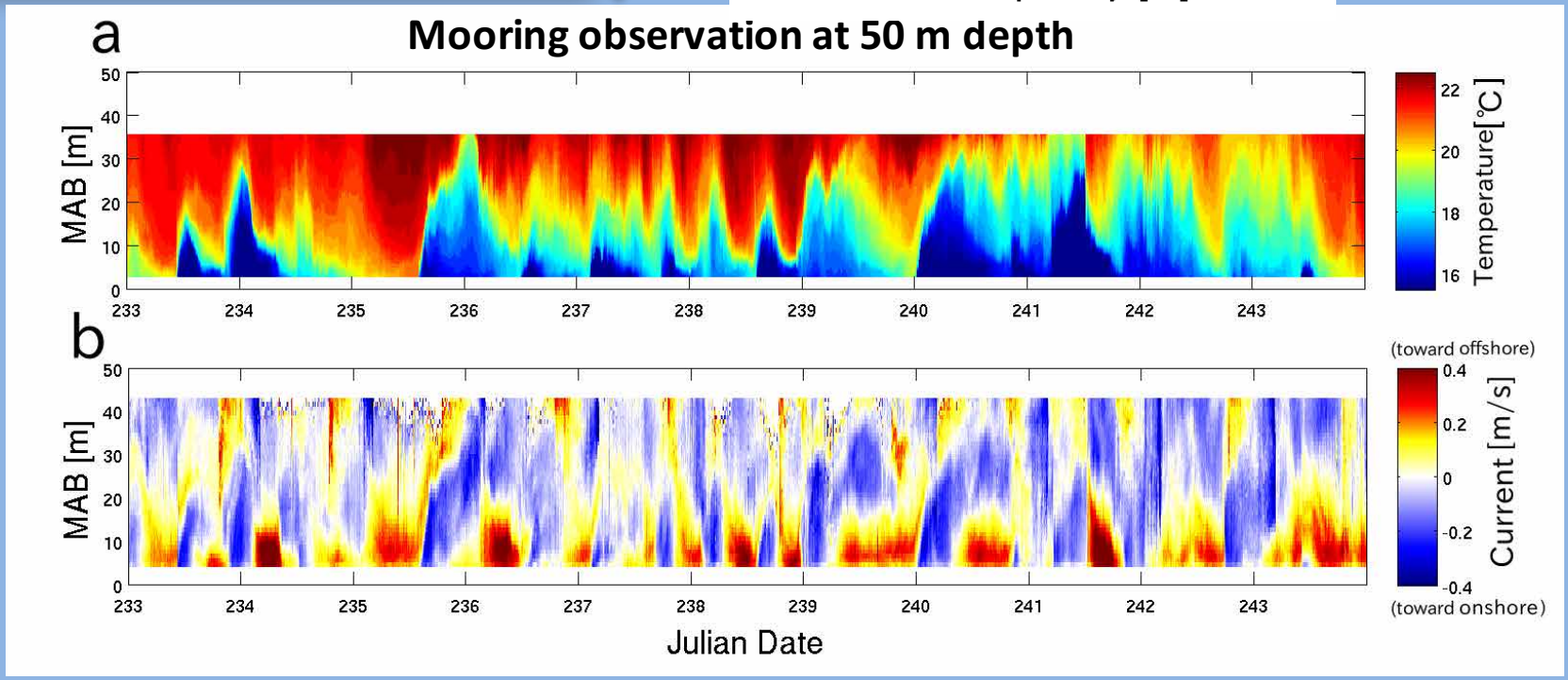

εC [W/kg] Line2 9/27 PM
Depth [m]
Distance [m]
ε[W/kg]
B
0
5
10
15
20
25
30
35
40
45
0
500
1000
1500
2000
2500
3000
-6
-6.5
-7
-7.5
-8
-8.5
-9
-9.5
-10

Internal bores

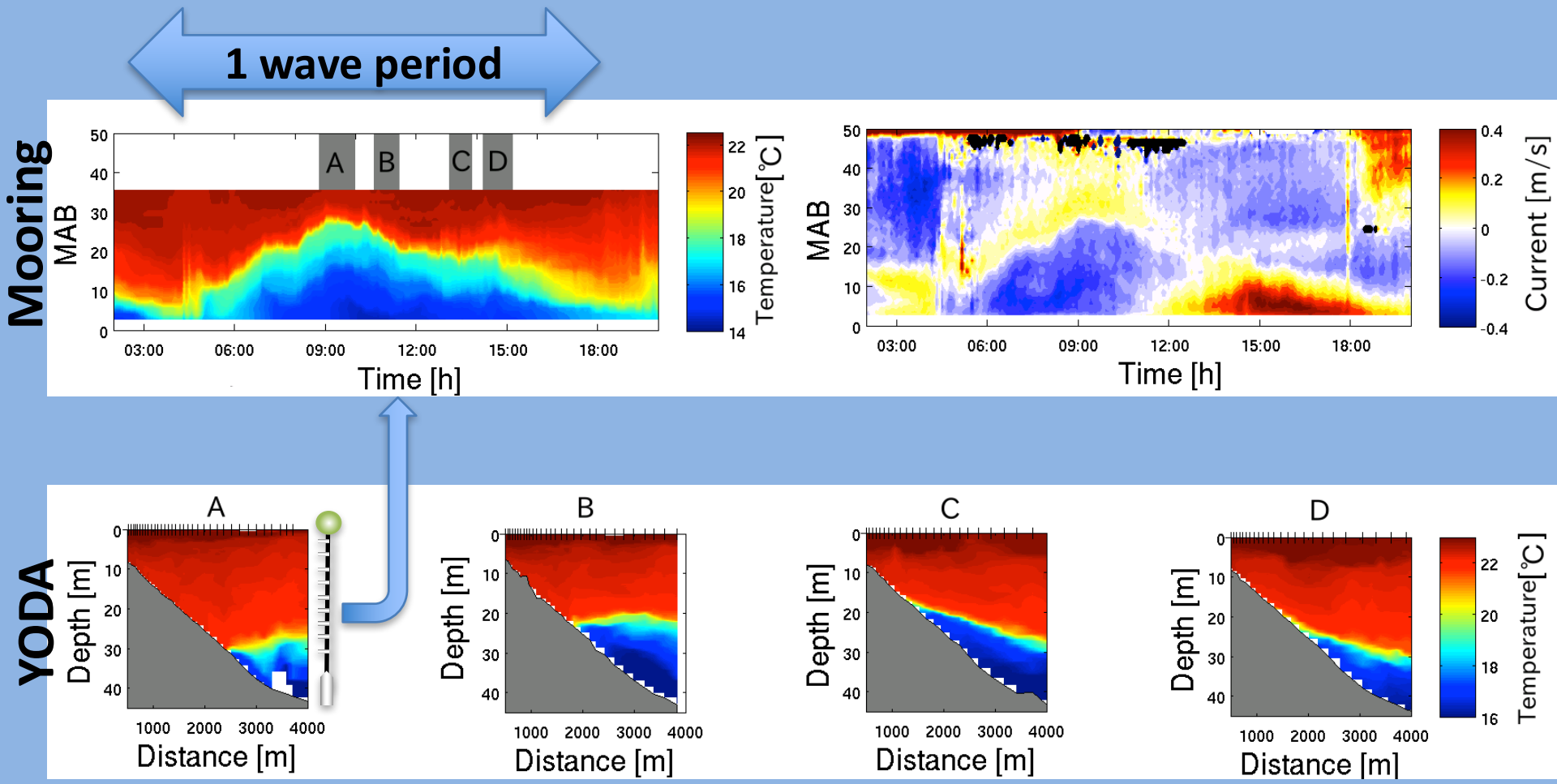


Diurnal and semidiurnal



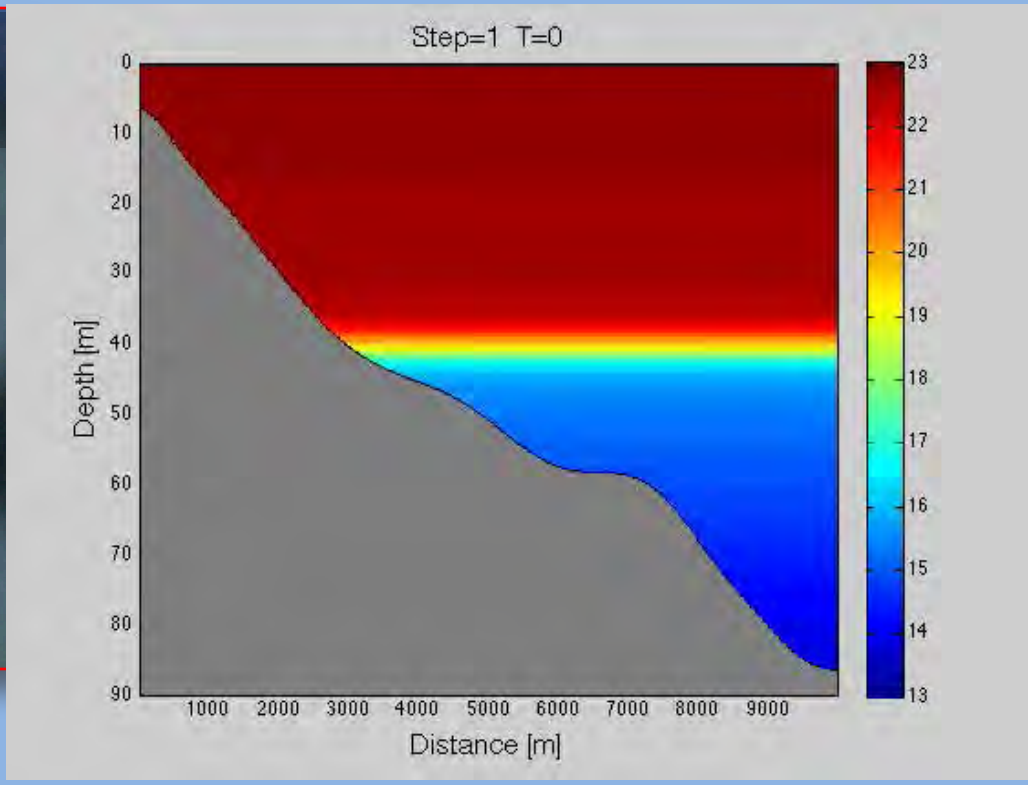


Internal bores



Numerical simulation: SUNTANS (Fringer et al., 2006)

2 dimensional SUNTANS



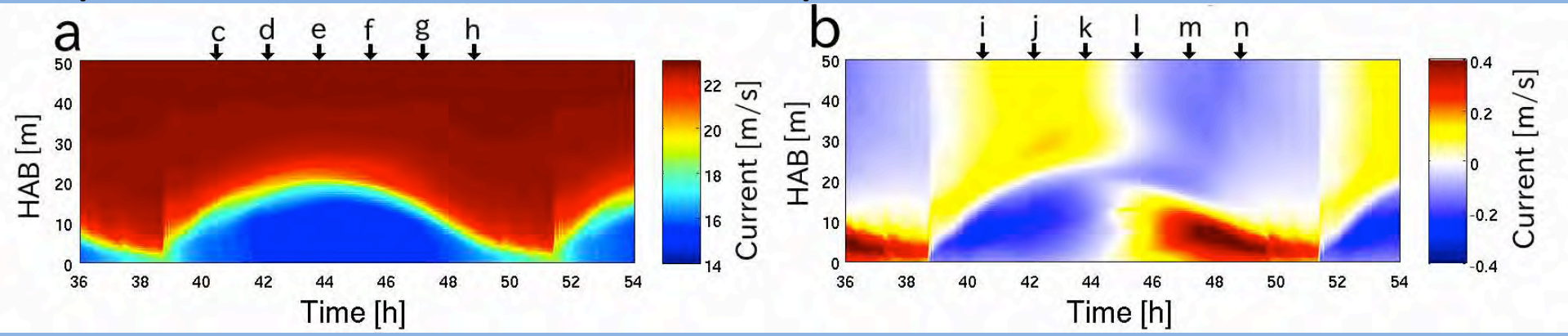
dt = 1s

σ = semidiurnal

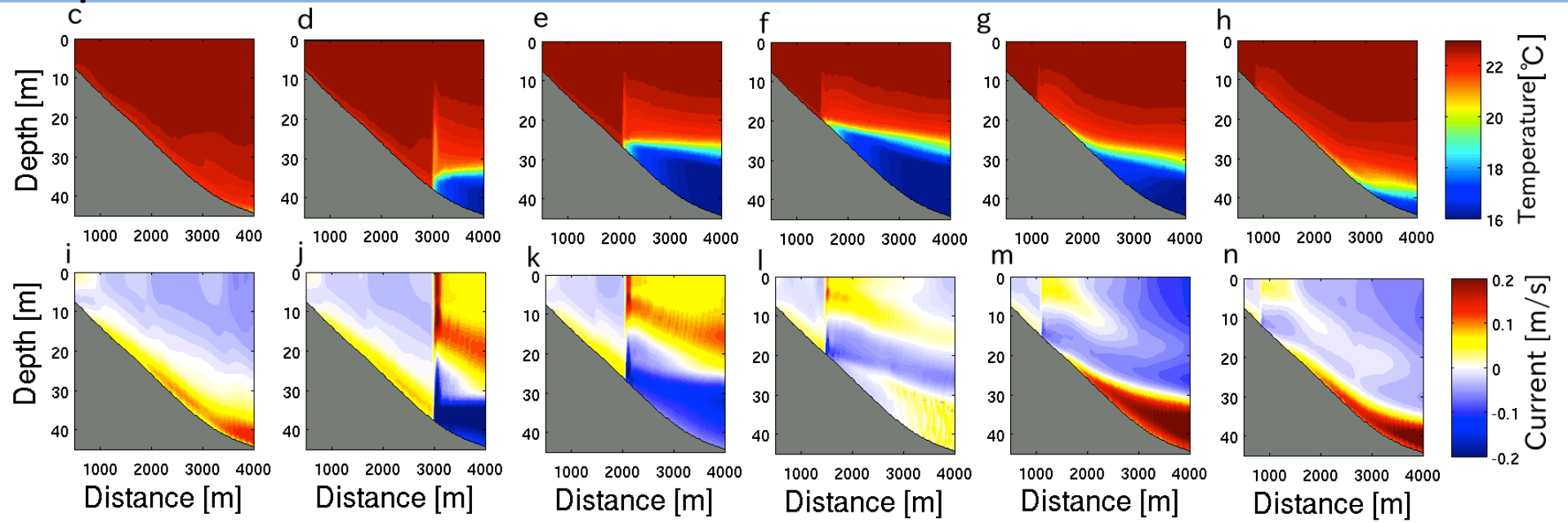
U = 0.2 m/s

Numerical Results

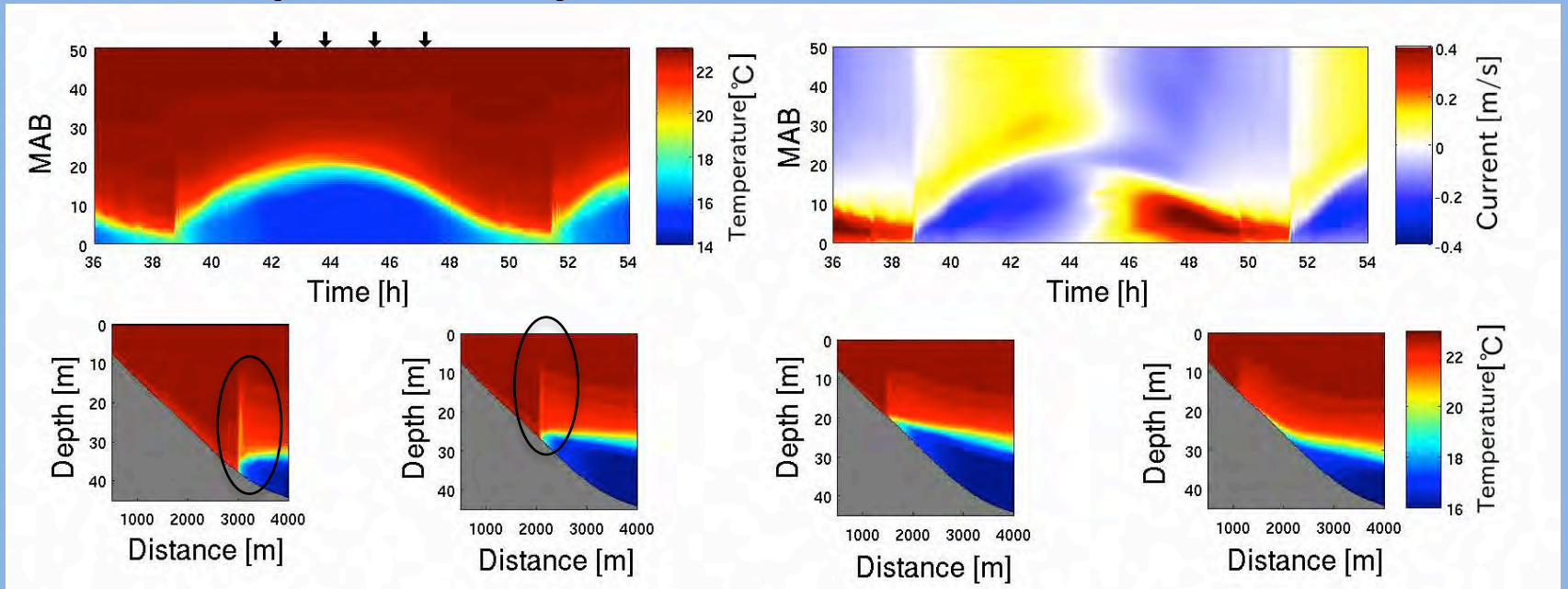
Temperature and current time series at 50 m depth



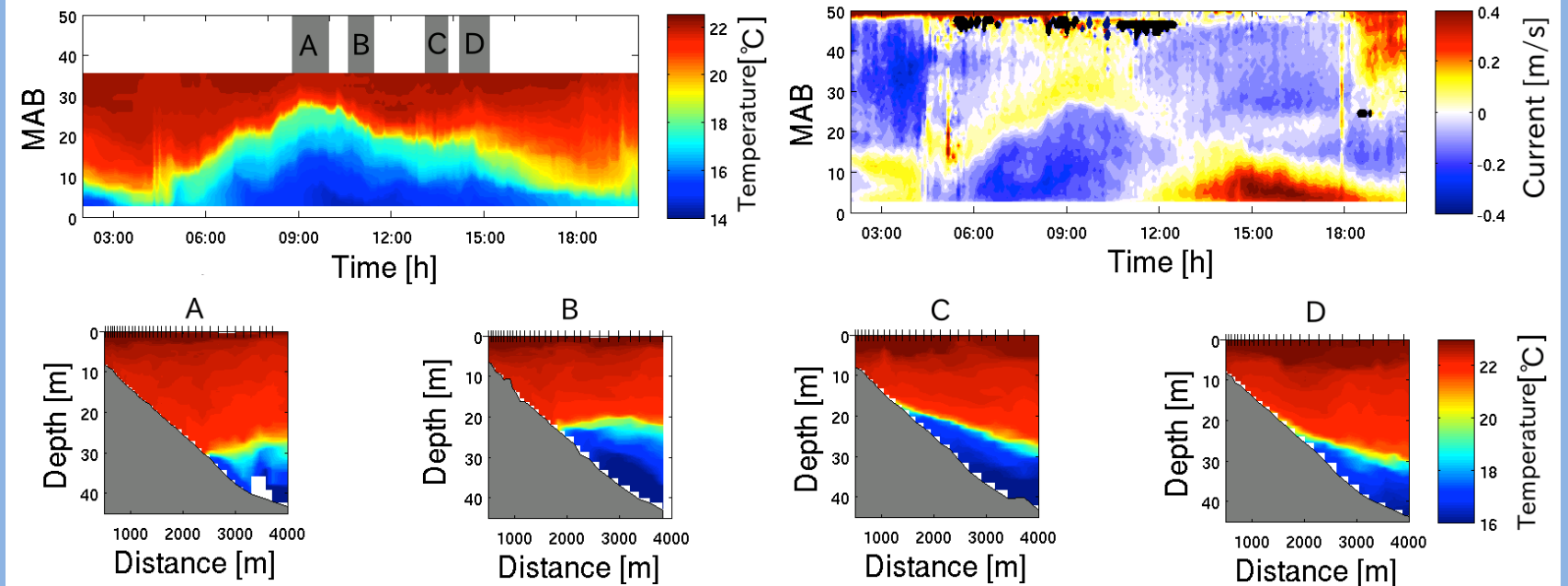
Temperature and current in the transect line



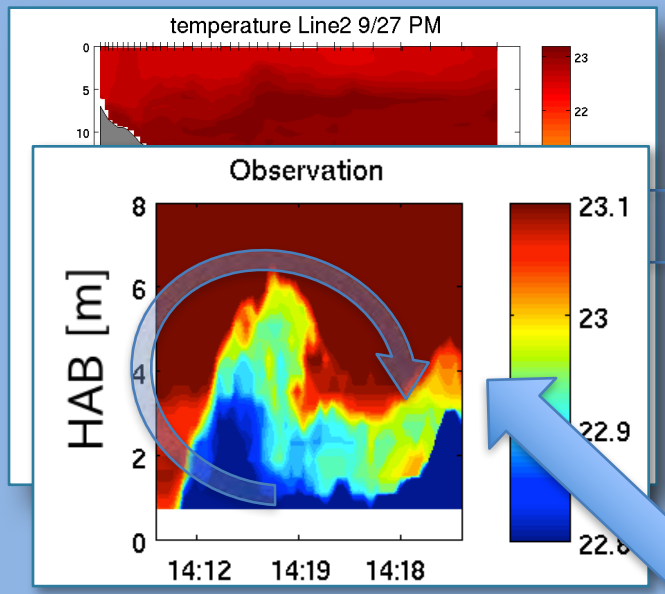
Simulation (SUNTANS)

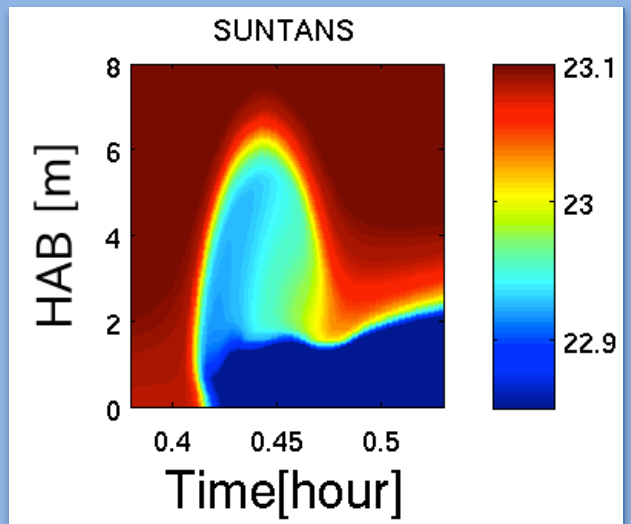


Observation



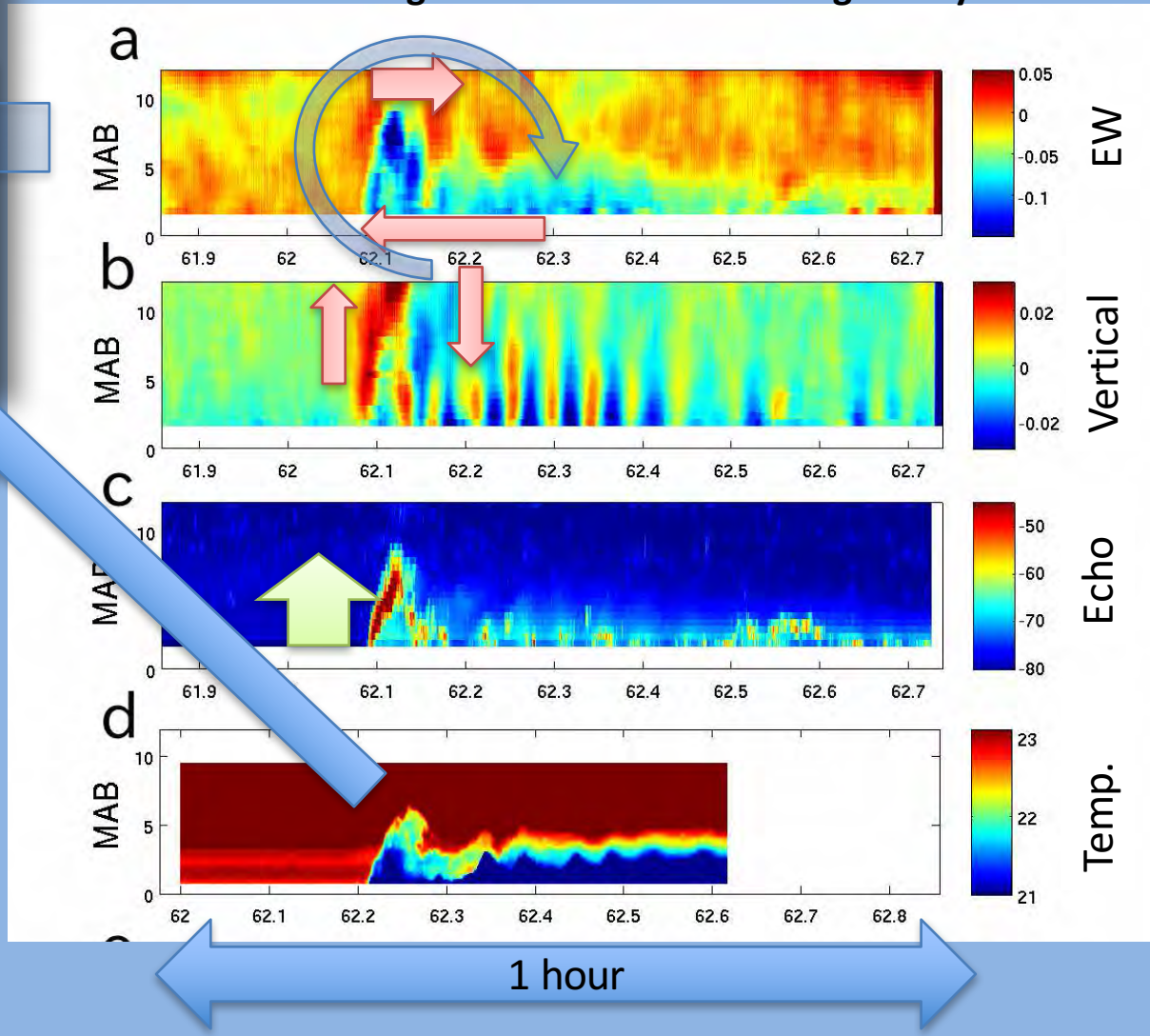
Vortex (observation)



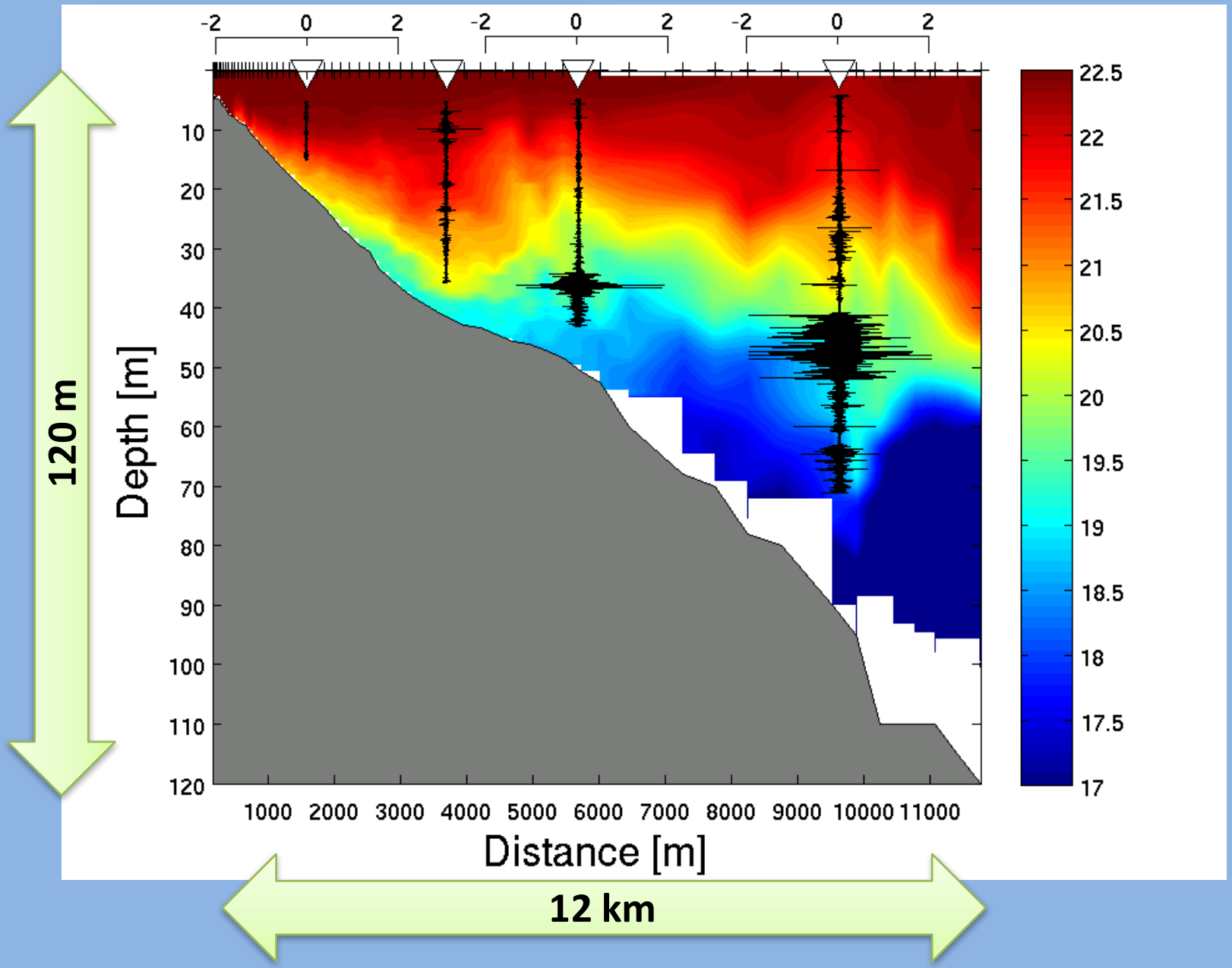


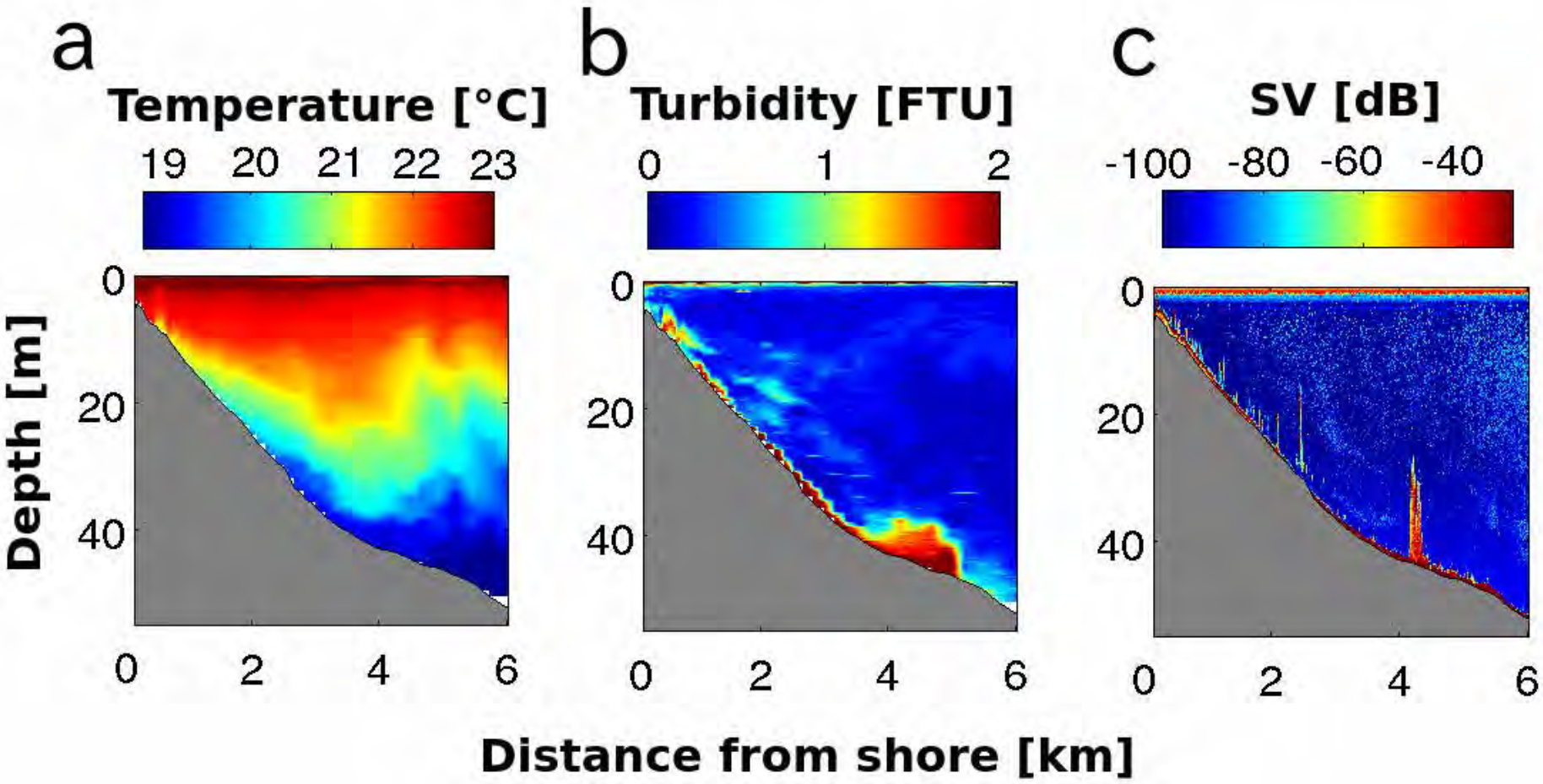
Vortex reproduced by SUNTANS

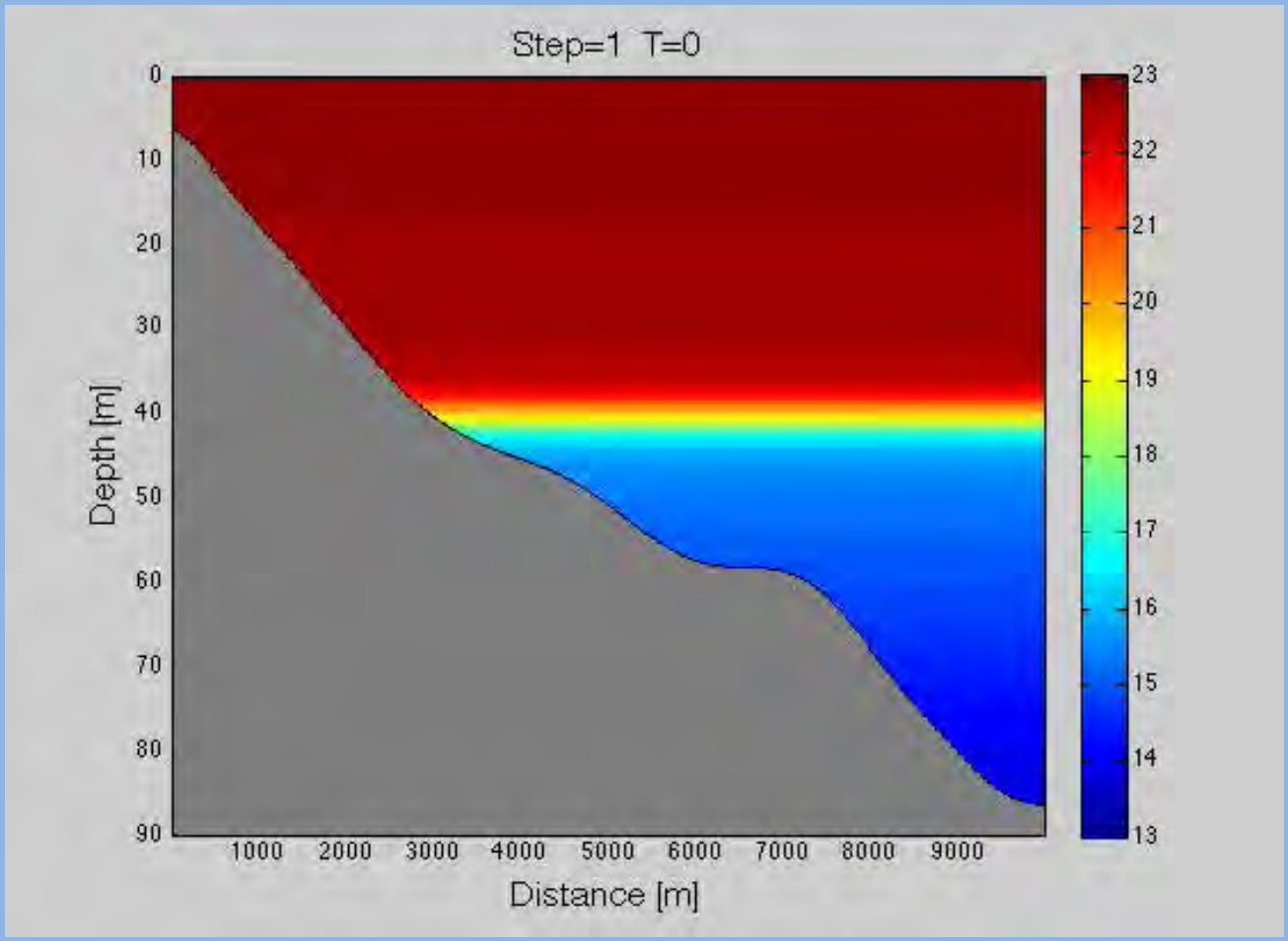
Data observed from high-resolution the mooring survey



Deeper area

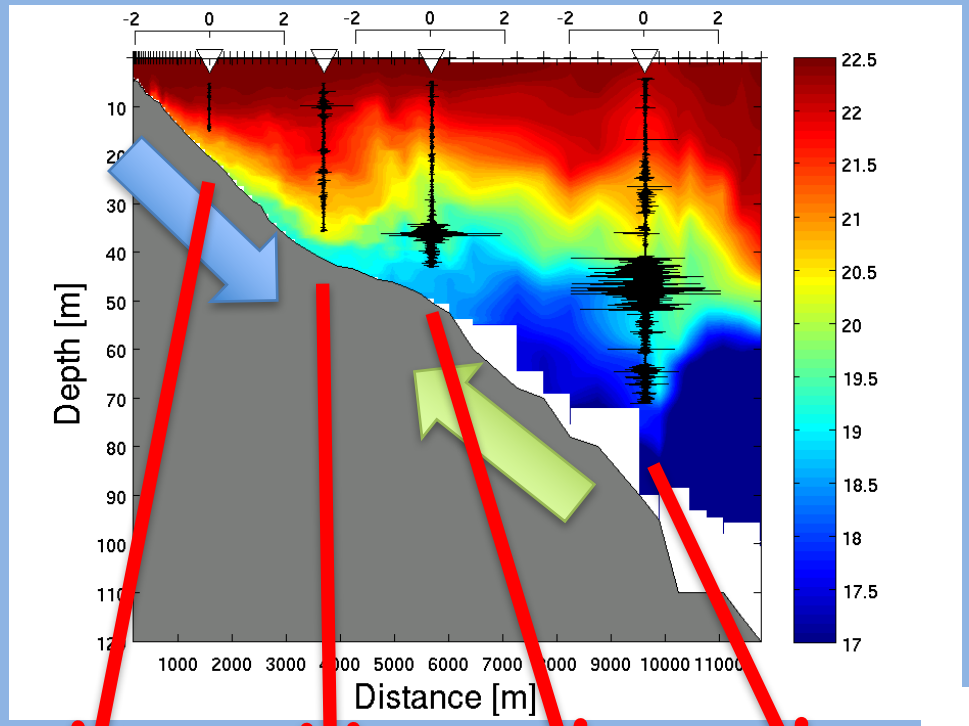

-2
0
2
-2
0
2
-2
0
2
10
20
30
40
50
60
70
80
90
100
110
120
Depth [m]
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
Distance [m]
22.5
22
21.5
21
20.5
20
19.5
19
18.5
18
17.5
17
120 m
12 km

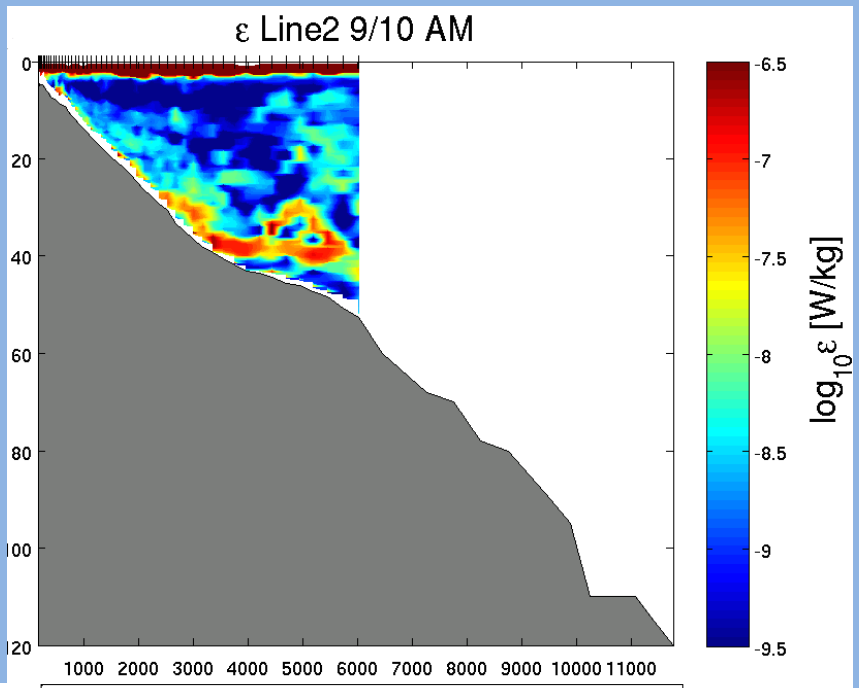

a
Temperature [°C]
19 20 21 22 23
b
Turbidity [FTU]
0 1 2
c
SV [dB]
-100 -80 -60 -40
Depth [m]
0
20
40
0 2 4 6
Distance from shore [km]

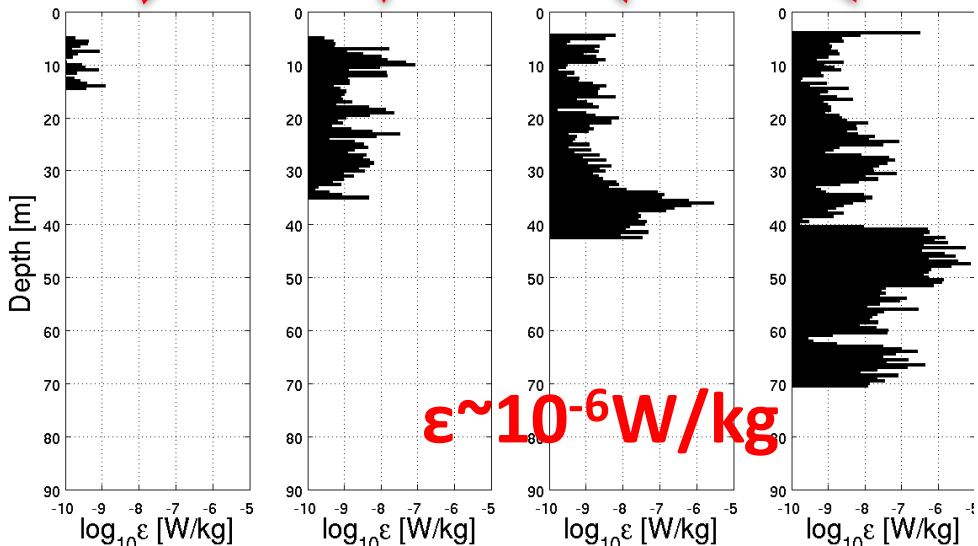


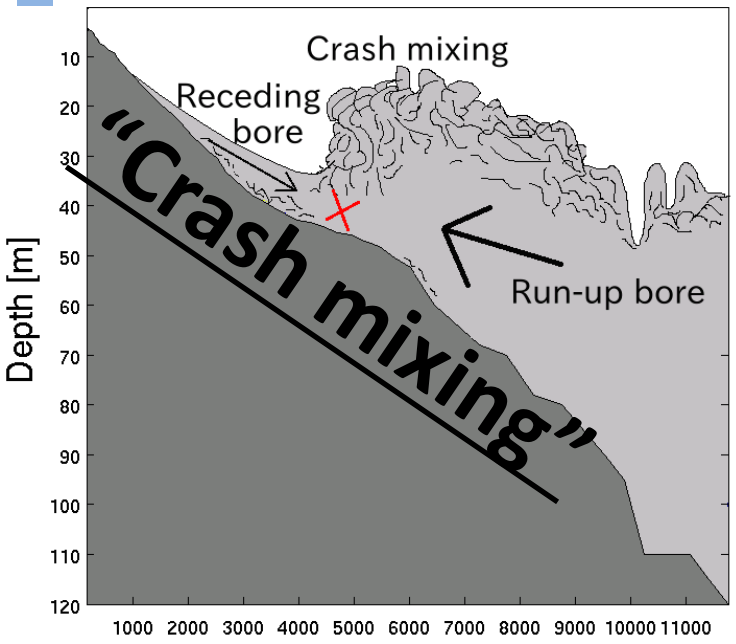
“What does happen when the receding bore runs into the next run-up bore?”

Observation

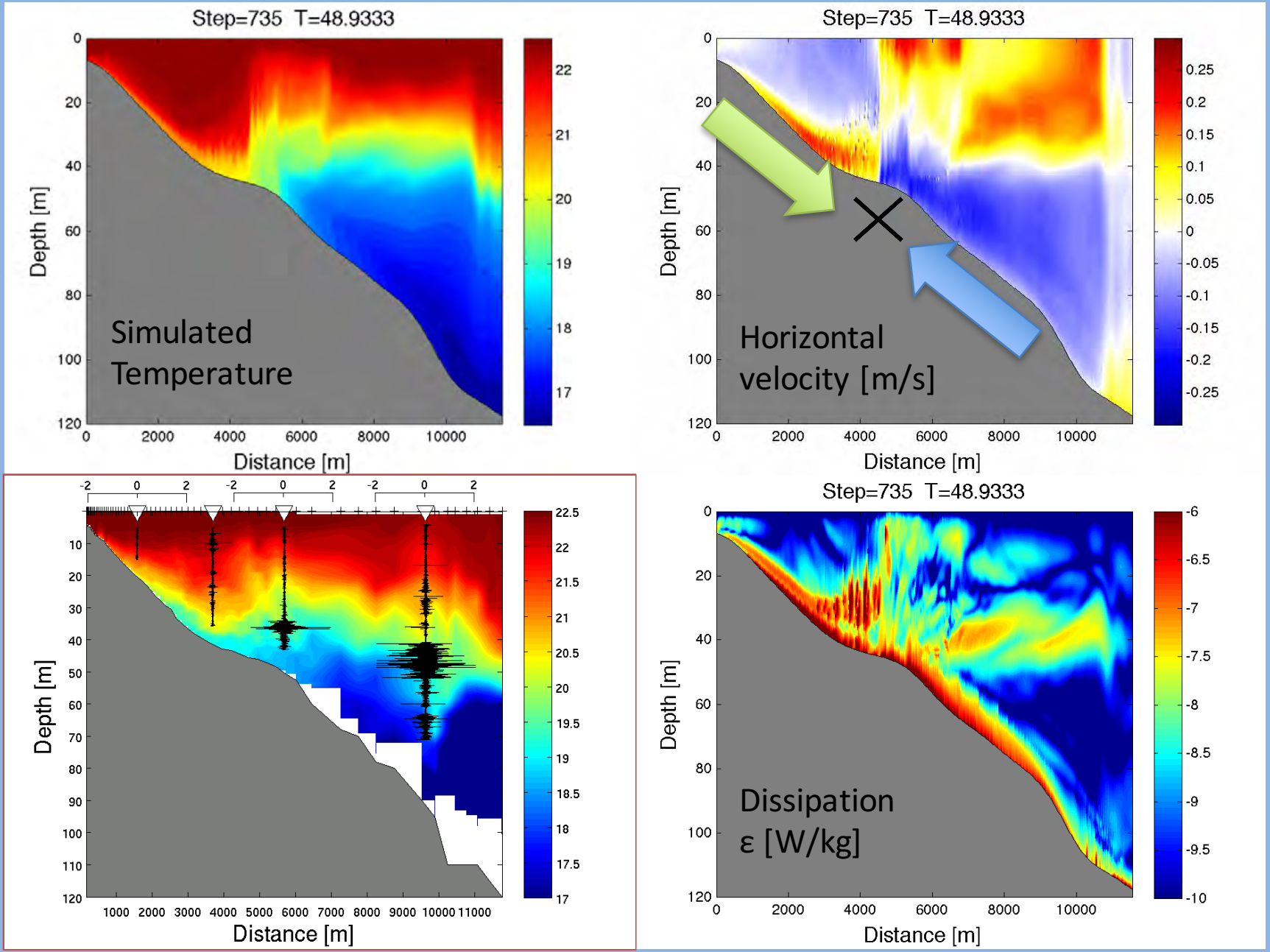




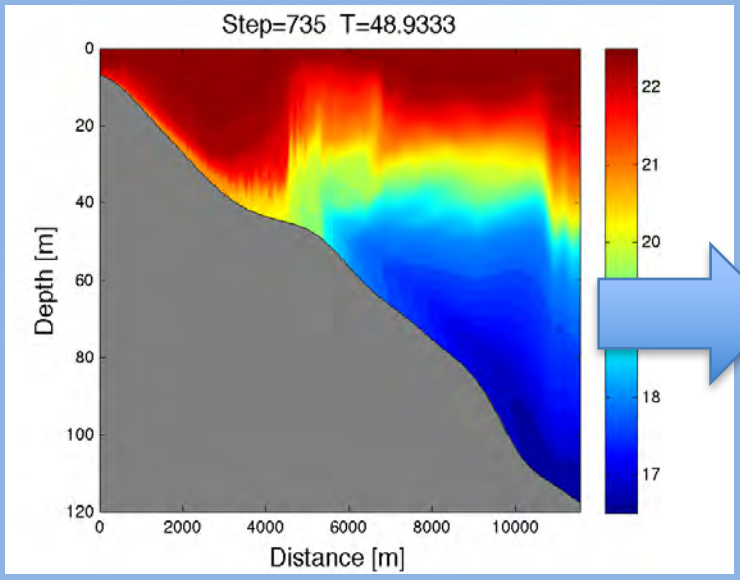




Numerical simulations



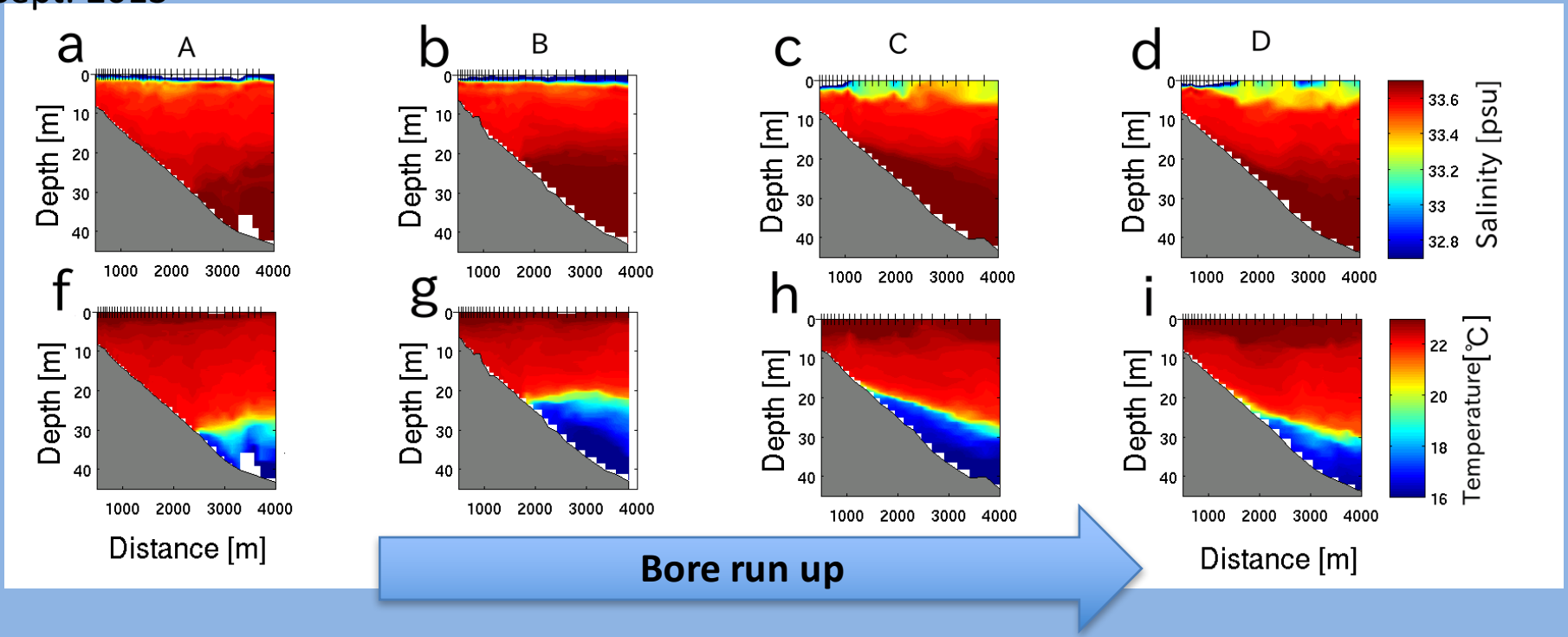
River plume mixing associated with internal bores.



"How internal bore influence surface river plume mixing?"

River plume and internal bores

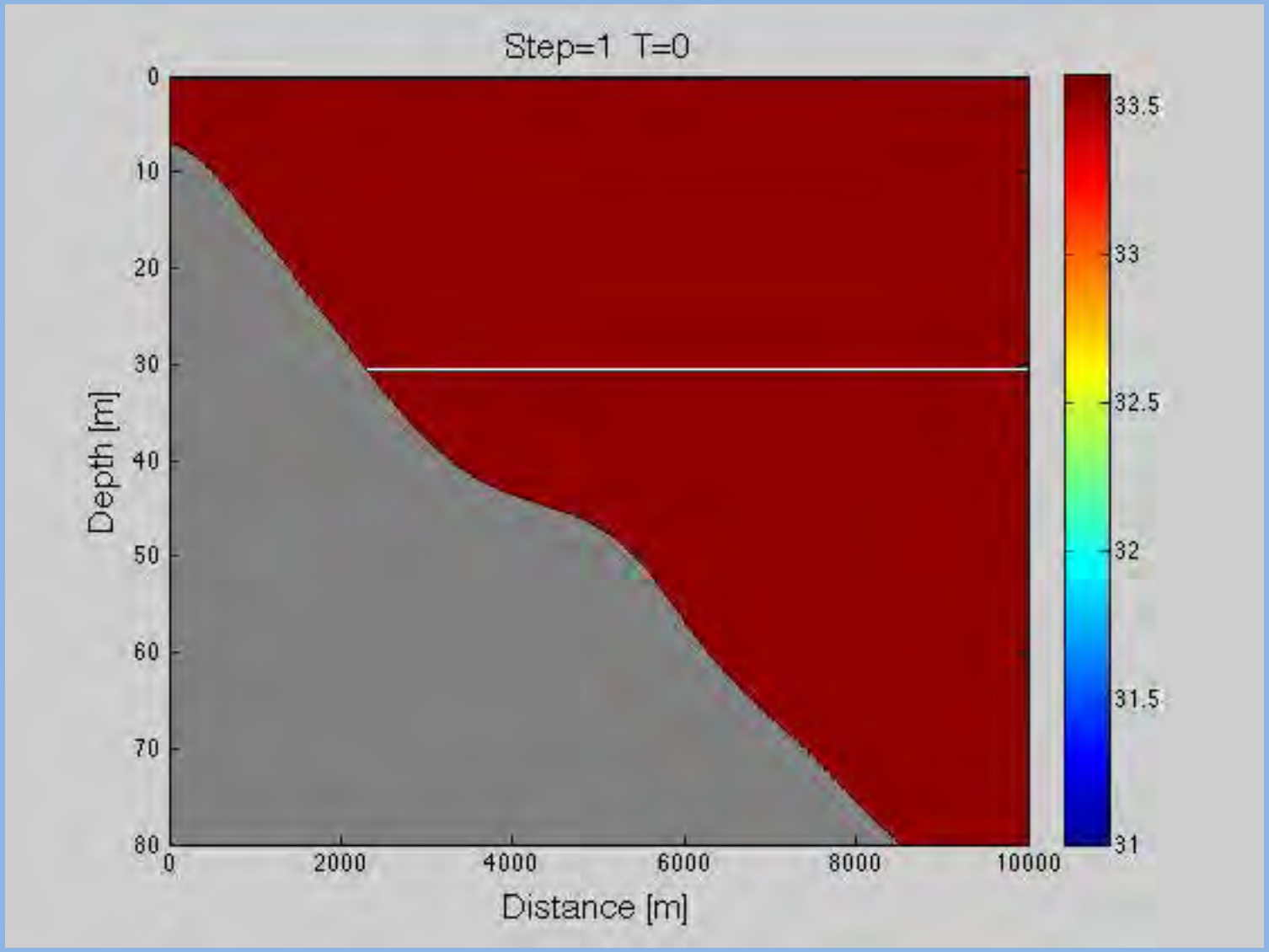
Sept. 2013



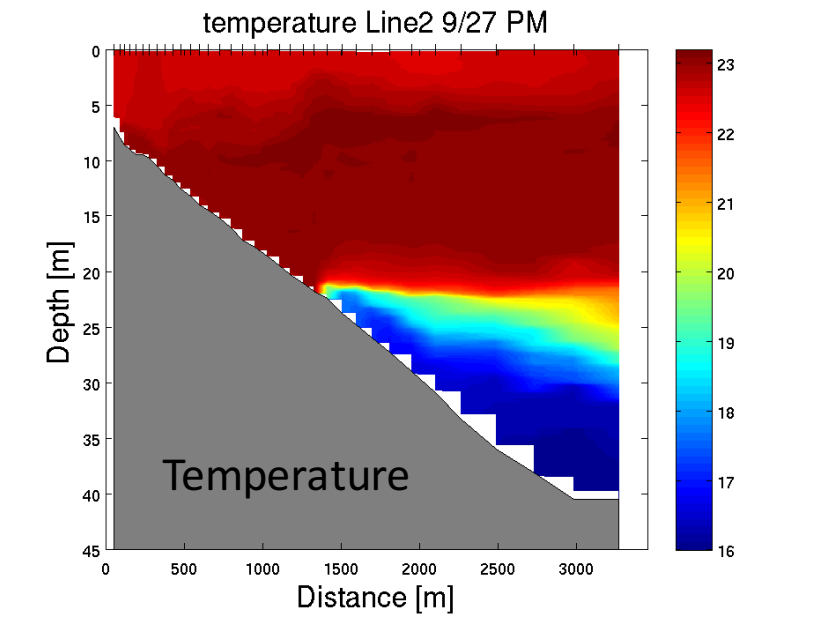
Vertical diffusivity *Kz*

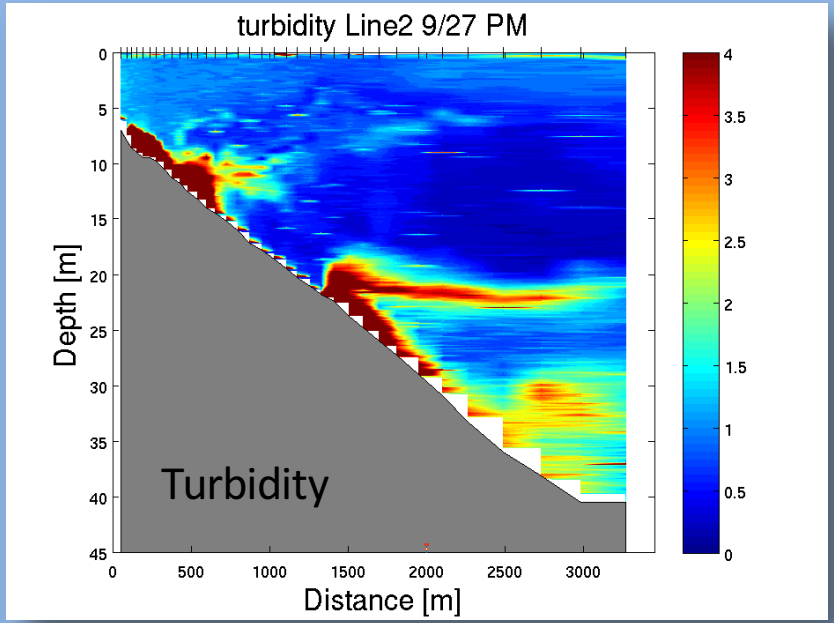
~ $O(10^{-4})$ m²/s

River plume and Crash mixing

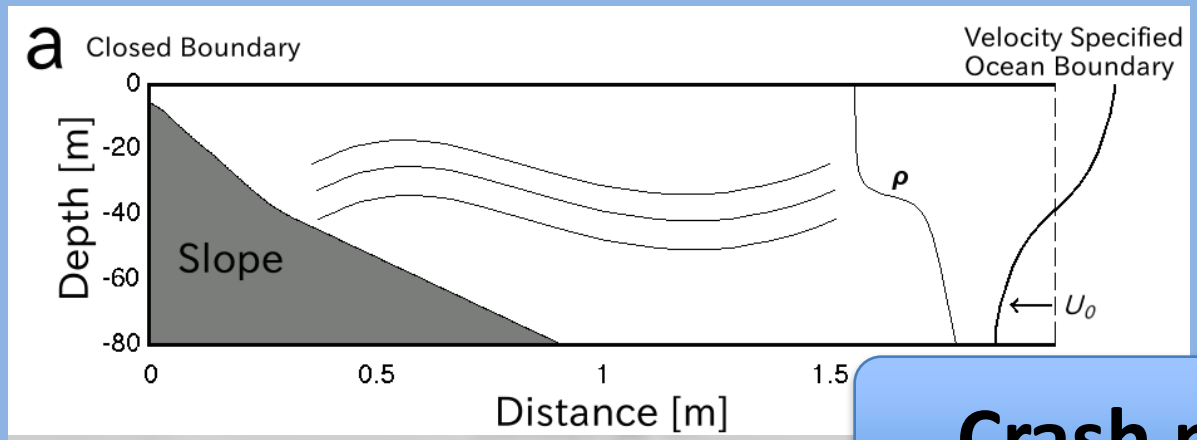


Mixing and sediment resuspension induced by internal bores





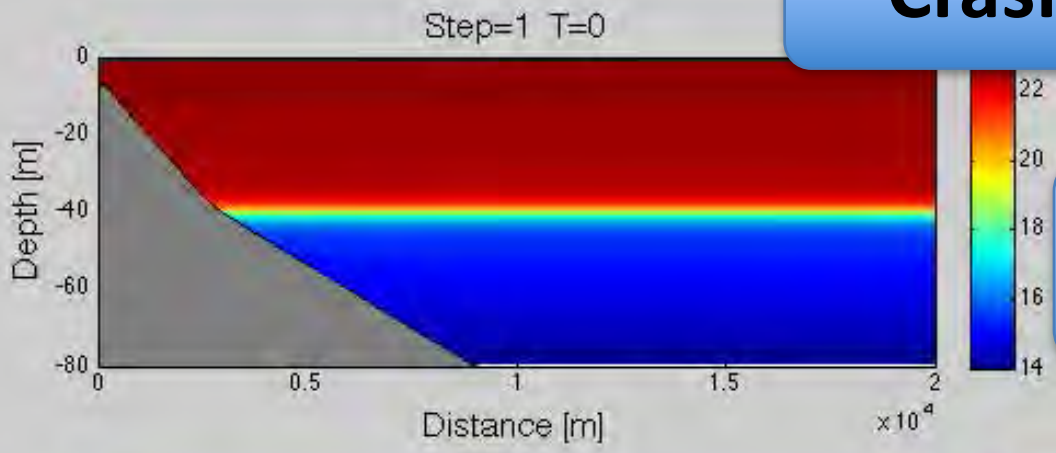
Numerical modeling



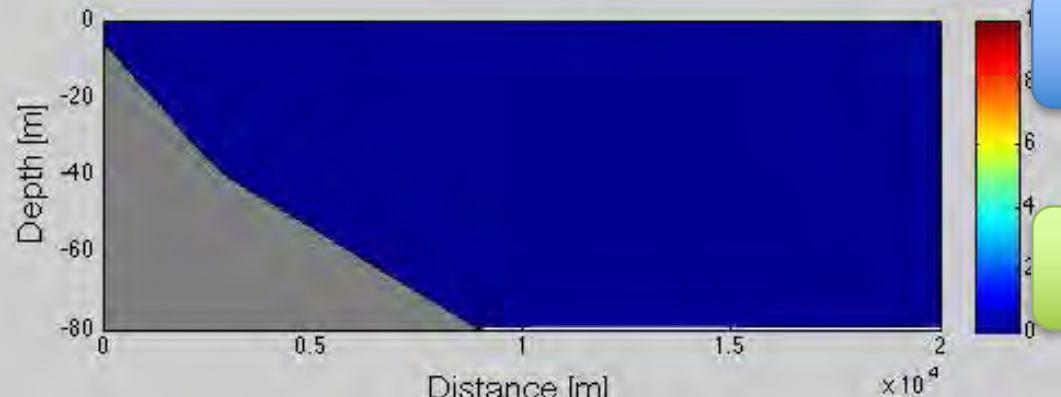
dx = 20 m
dz = 0.56 m
dt = 1 s

Receding bore

Crash mixing



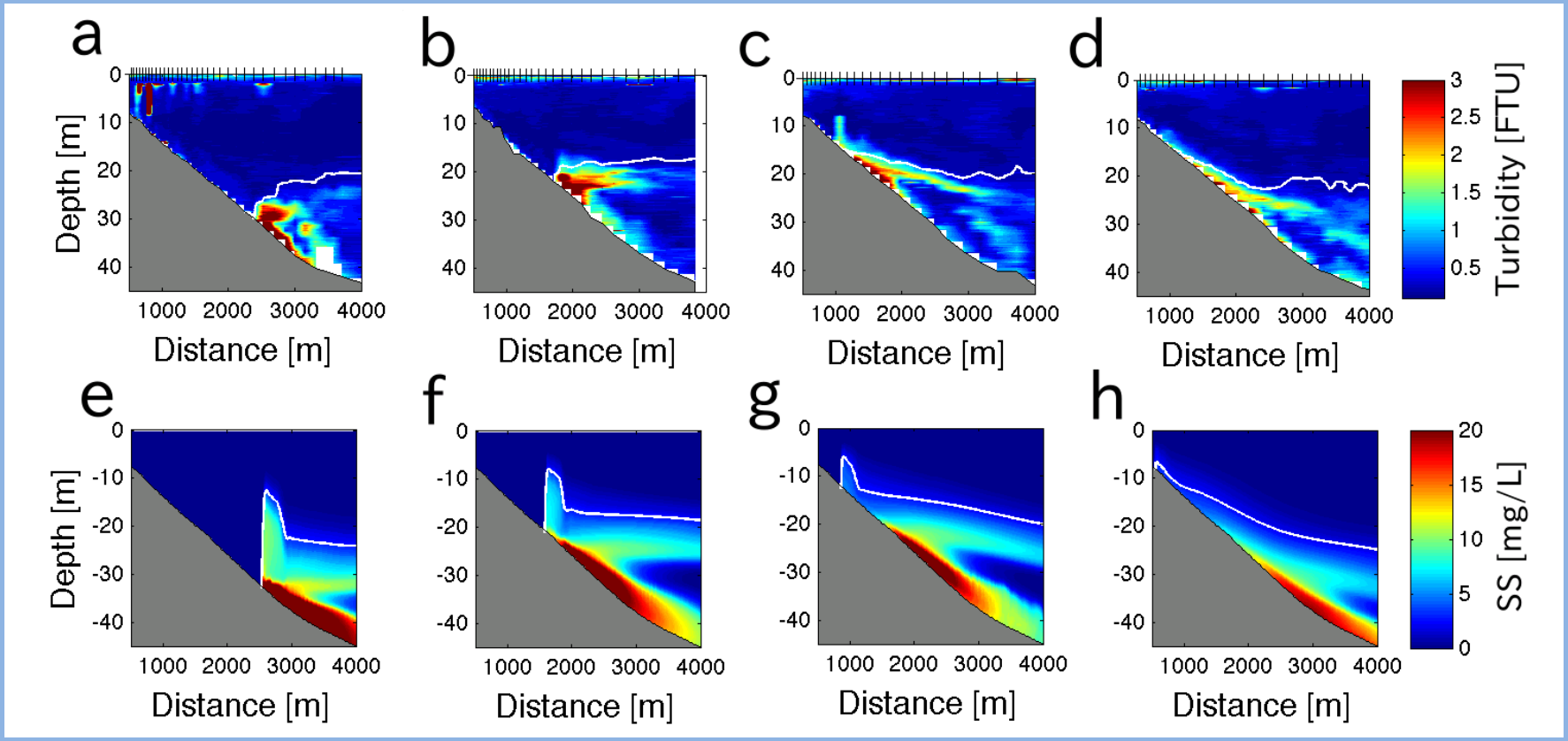
Strong resuspension



Repeated Bores

Turbidity Layer

Observational and Numerical results



Sediment resuspension model works very well.

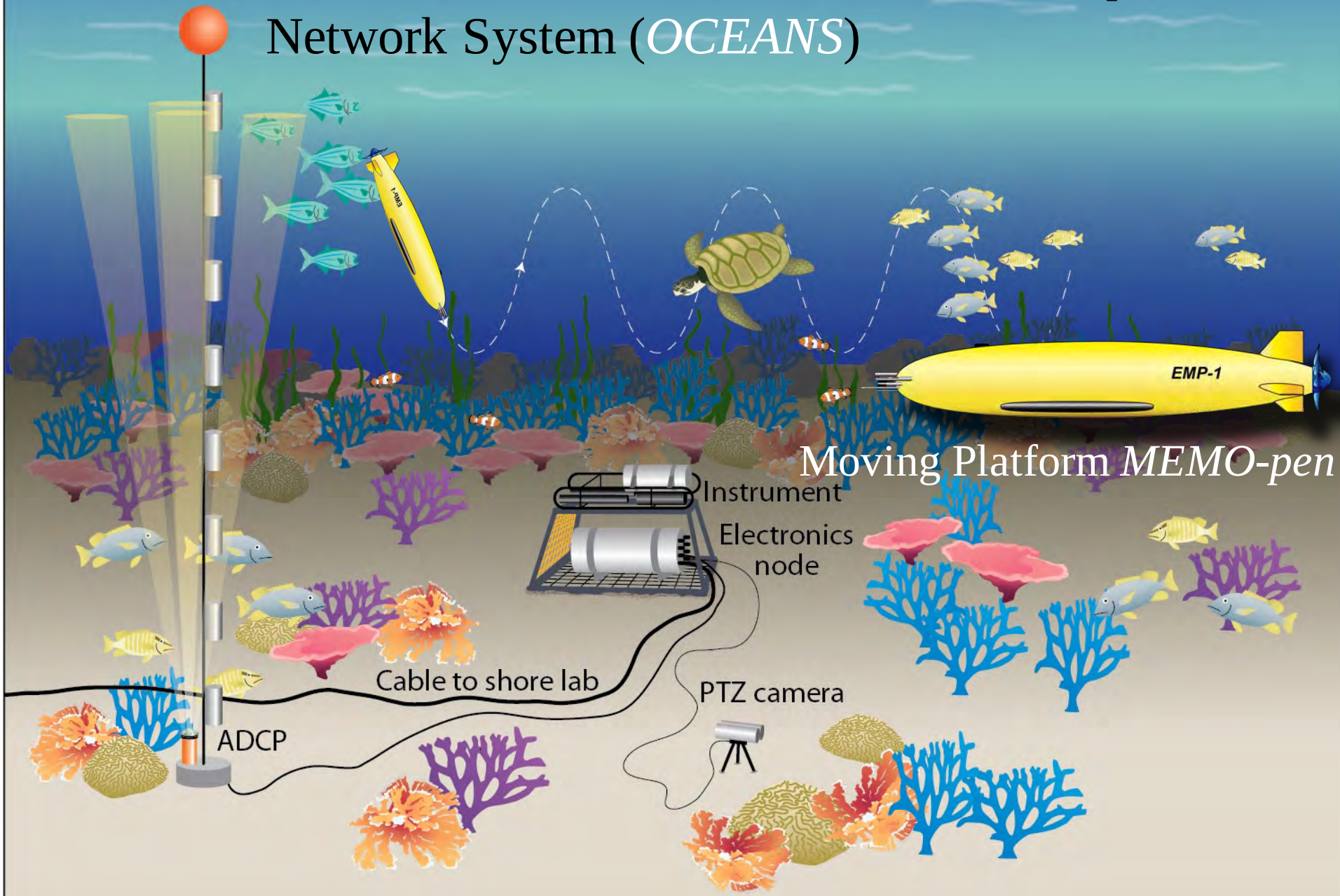
Joint Environmental Data Integration System: JEDI System

JEDI System HOMEPAGE http://www2.kaiyodai.ac.jp/~hide/JEDI/index.html

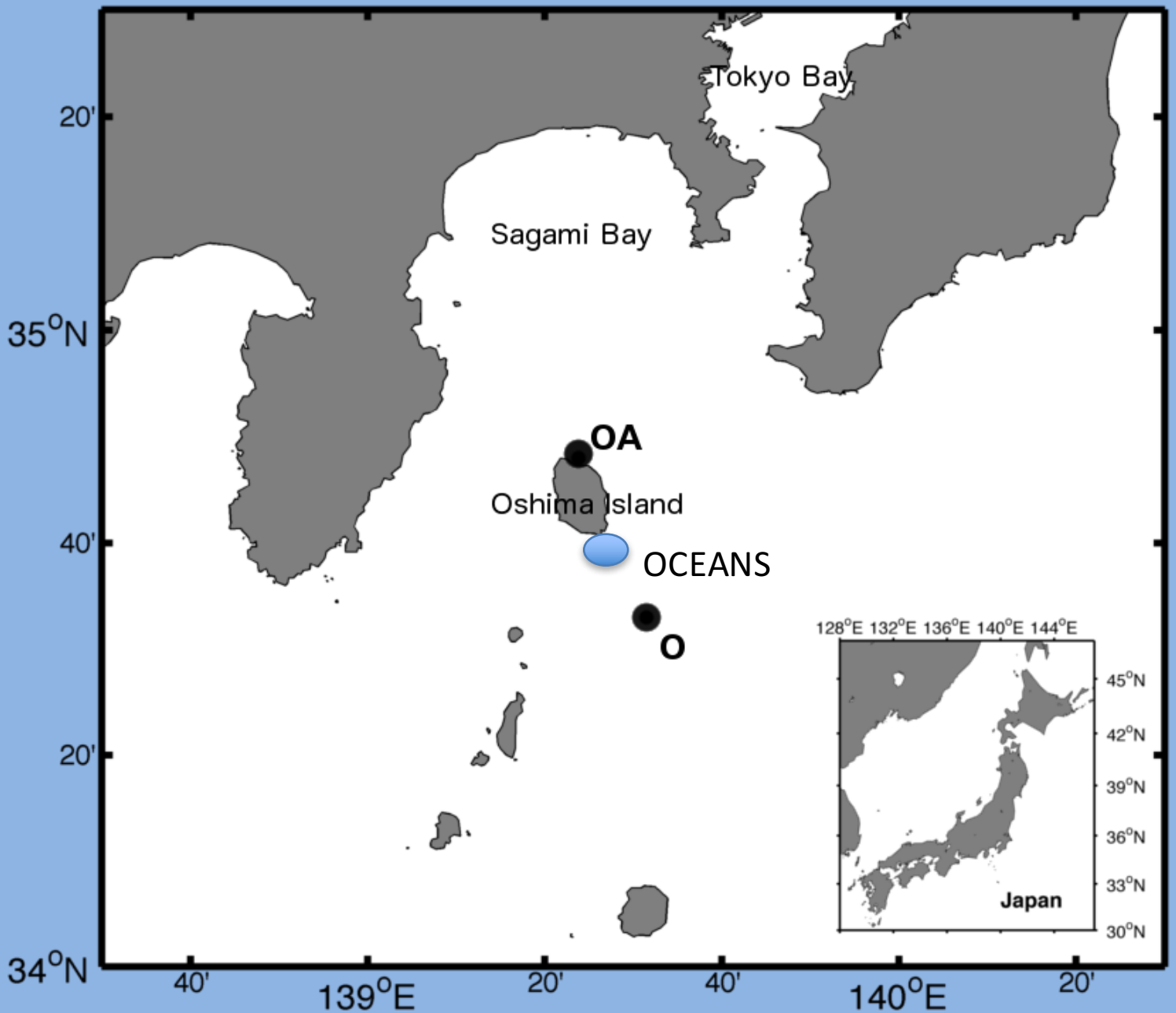
Specific Objectives:

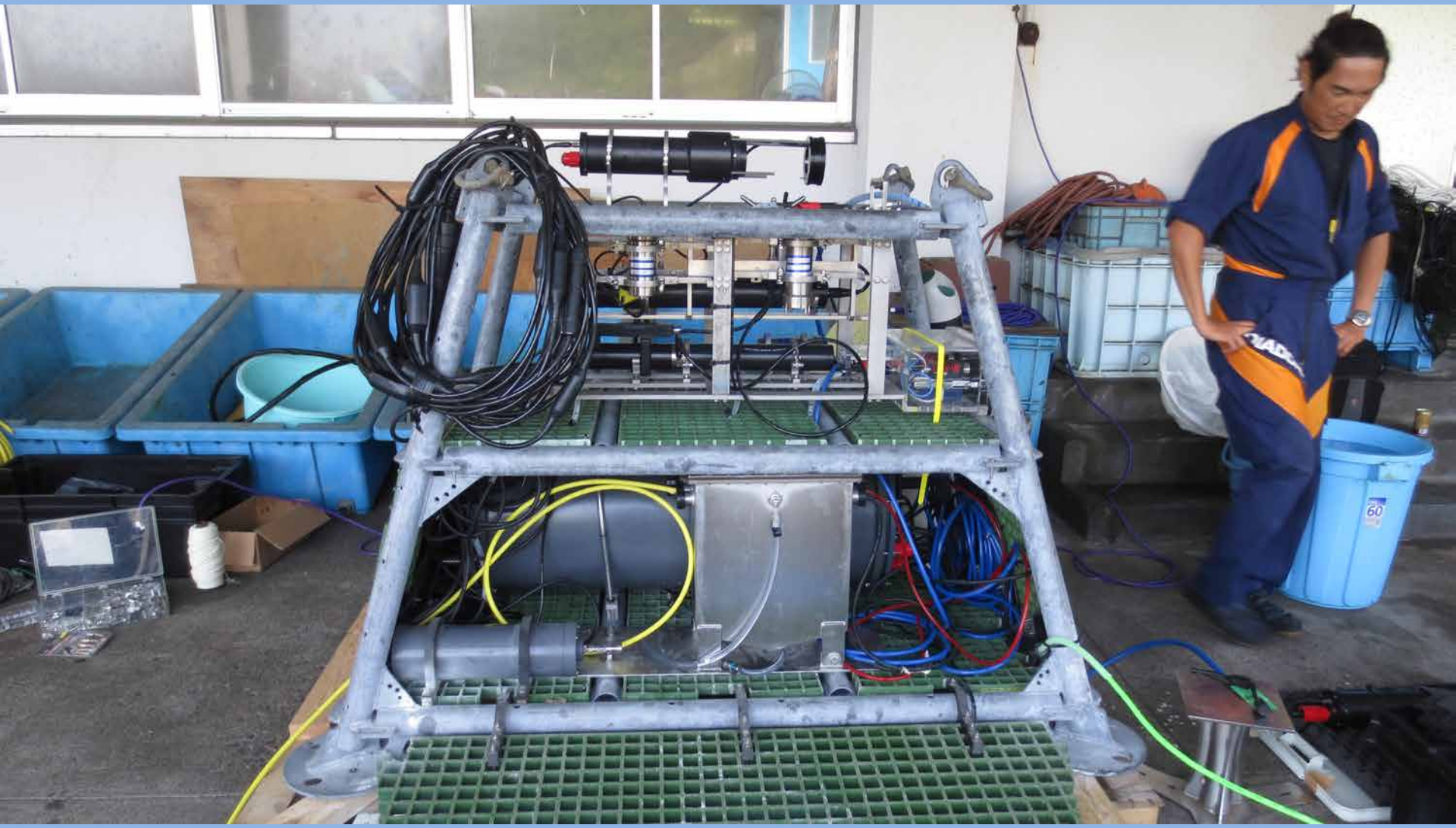
To characterize biodiversity dynamics of plankton in Kuroshio-affected habitats using a novel approach that combines numerical models with field observations obtained with advanced sensing technologies.

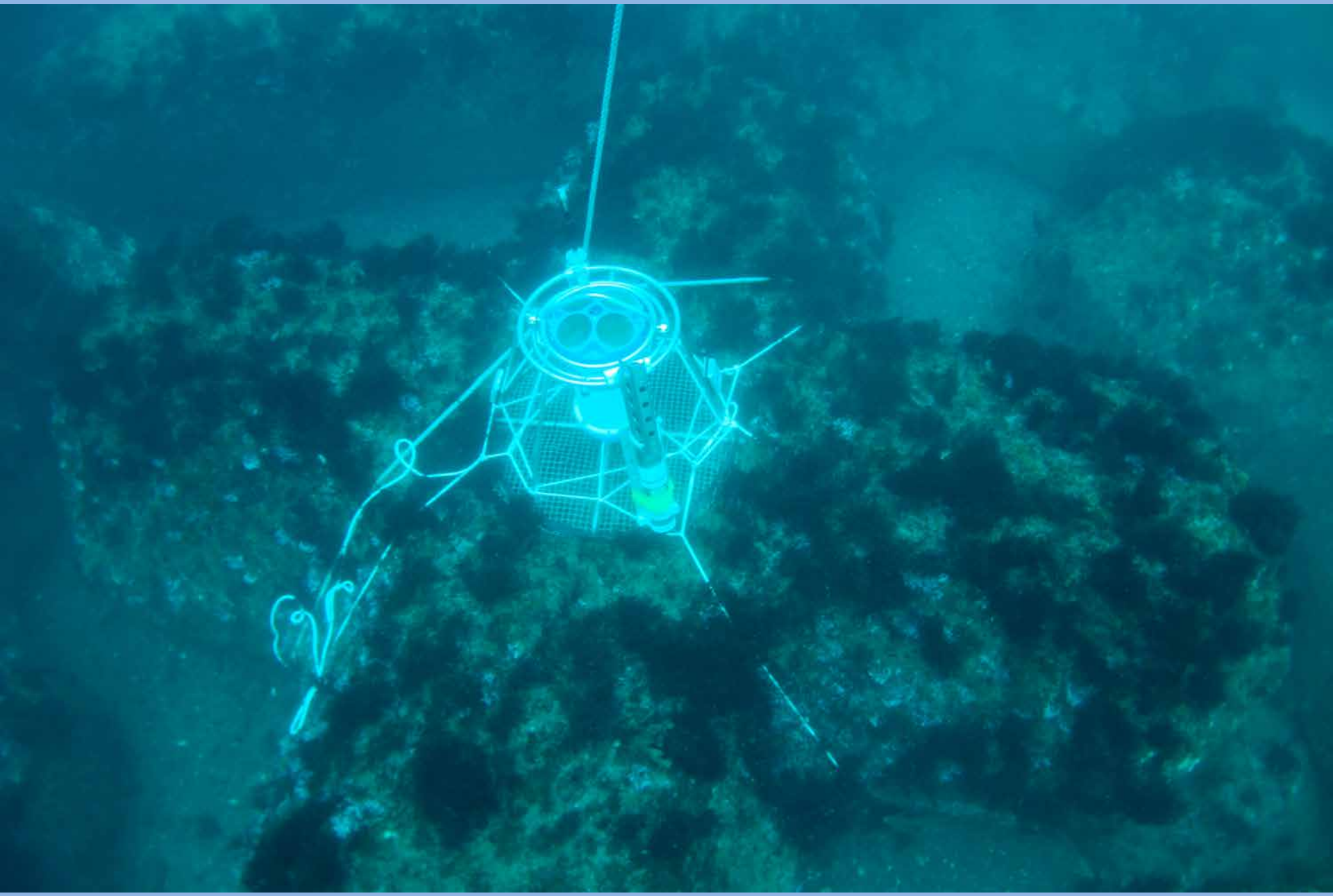
Oshima Coastal Environmental data Acquisition Network System (*OCEANS*)



The location of OCEANS



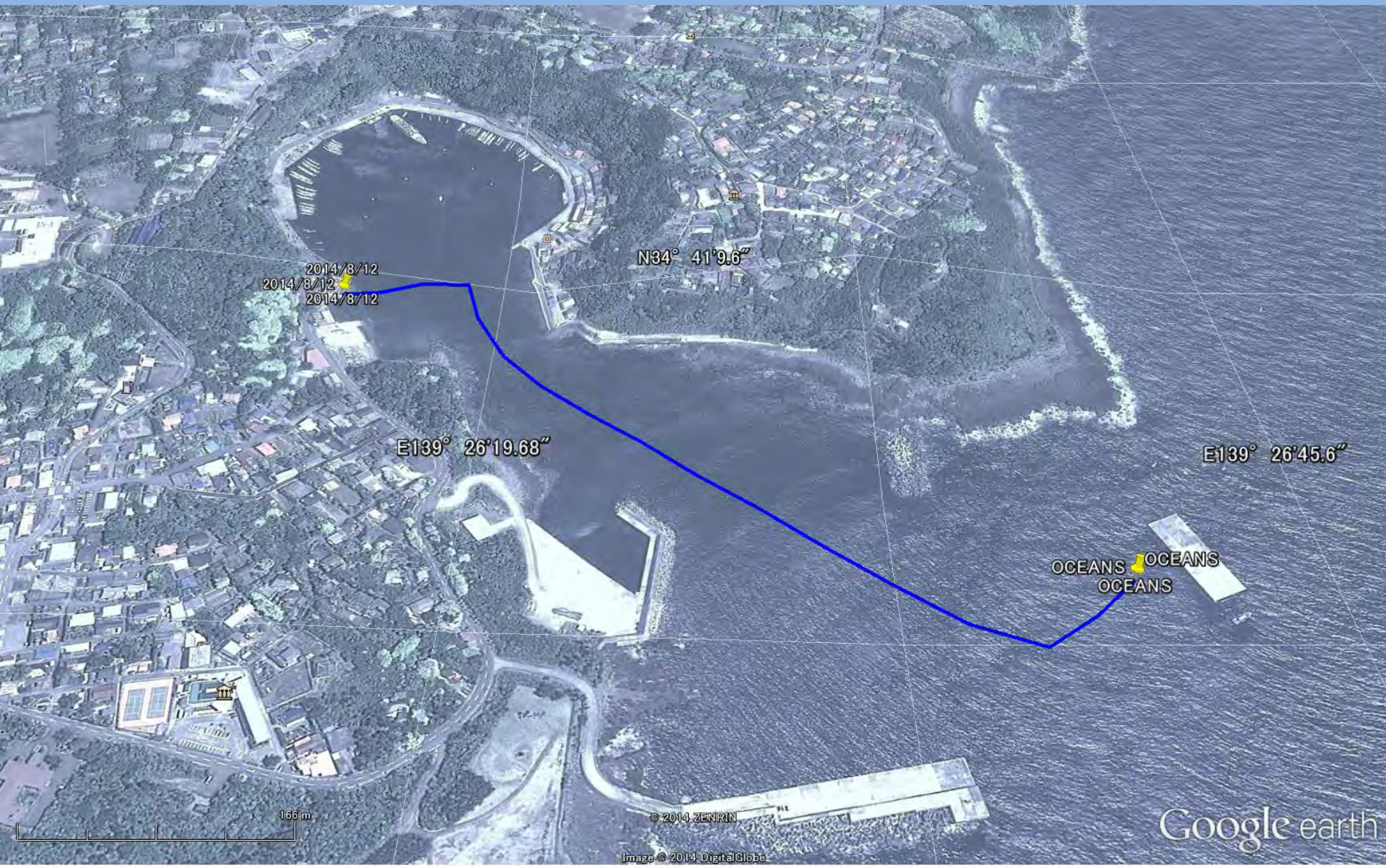





UNIC
大島町
第八潮丸
波浮港


UNIC
TK2-1876


第八潮丸

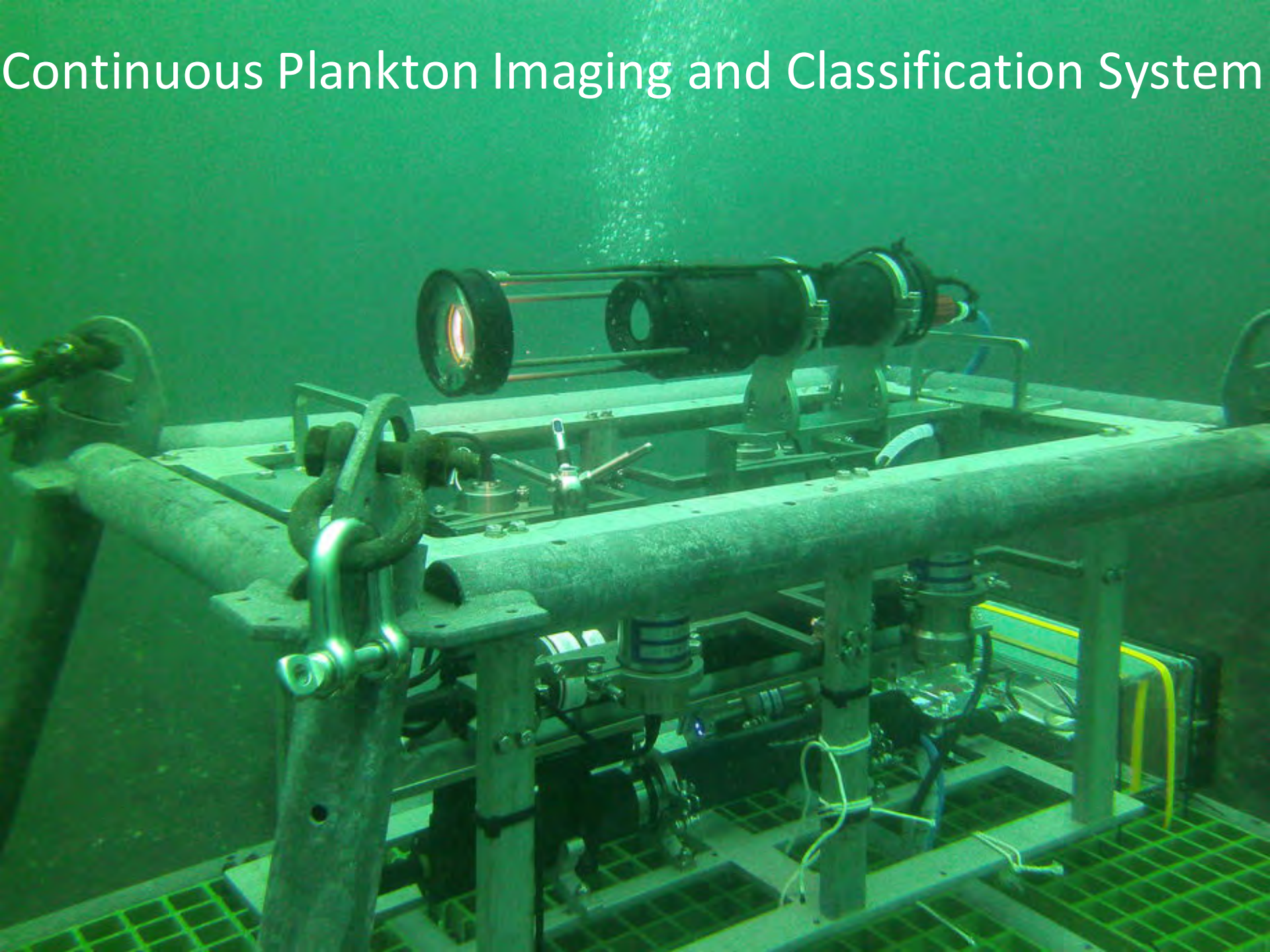

2014/8/12
2014/8/12
2014/8/12
N34° 41'9.6"
E139° 26'19.68"
E139° 26'45.6"
OCEANS
OCEANS
OCEANS
166 m
© 2014 ZENRIN
Image © 2014 DigitalGlobe
Google earth

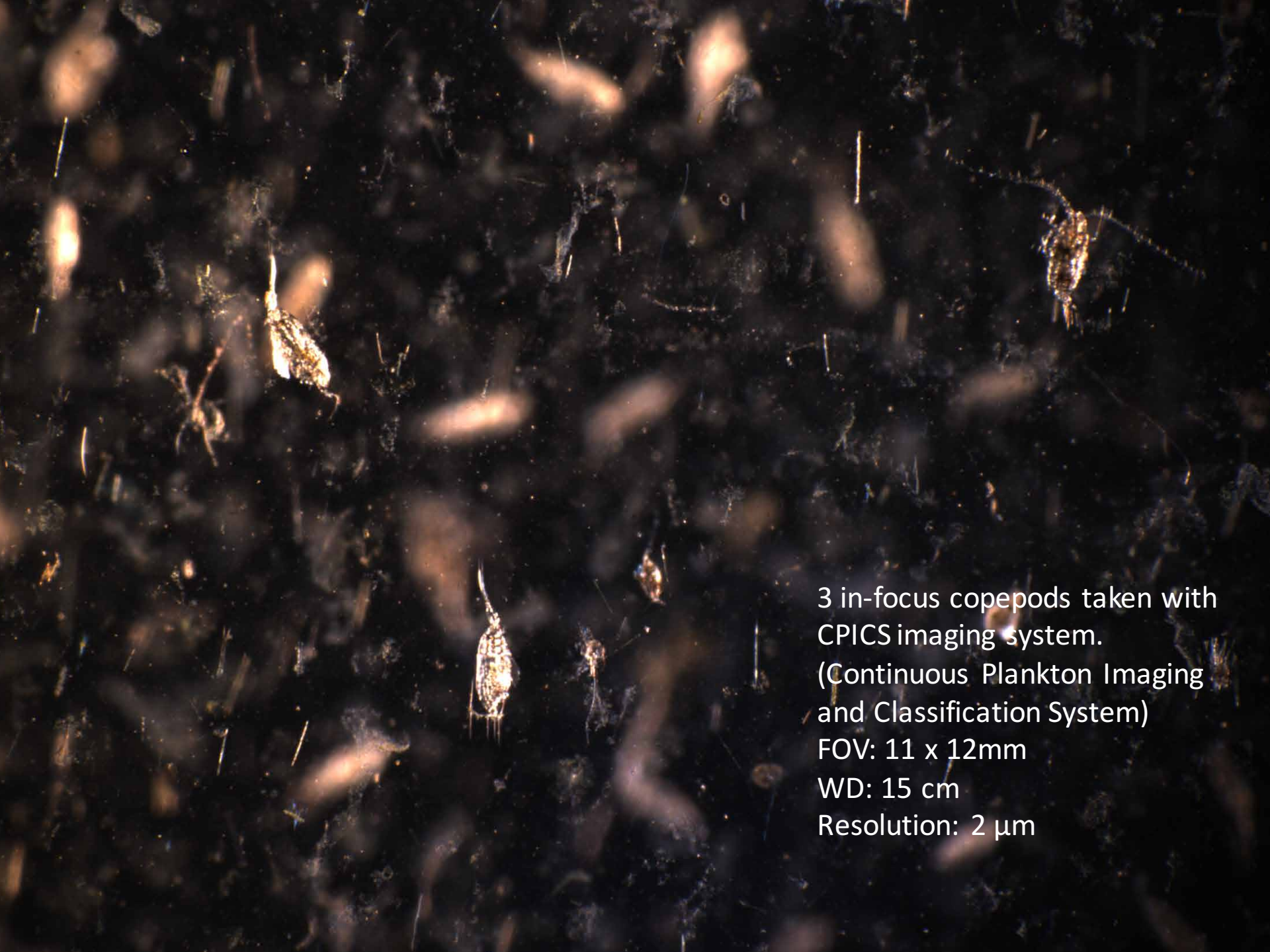
Select Instrument: All | ADCP1 | ADV | CPICS1 | ChlorTurbid | CondTemp | DO | Env Board | IBTHX | PAR | Pan-Tilt Camera | SUNA | Stereo Cam1 | TString1 | WaveHeight

Cable Pwr: ON Current: 5.93 ma
Shore GFD: 50 MΩ Node GFD: 50 MΩ

Node: Temp: 39.8 degC Humid: 24.7 % Press: 1085 mbar
Shore: Temp: 28.2 degC Humid: 47.8 % Press: 1012.7 mbar

Continuous Plankton Imaging and Classification System

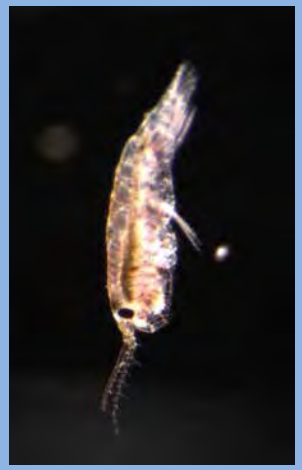


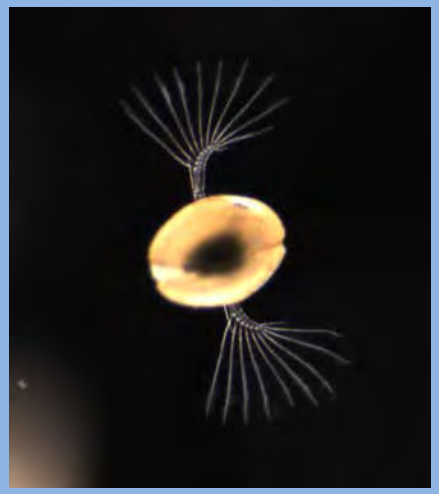


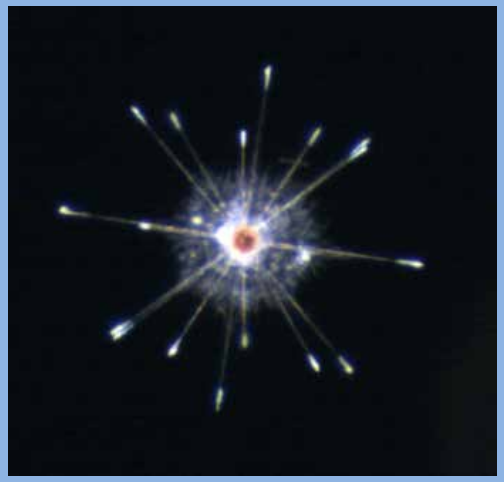
3 in-focus copepods taken with CPICS imaging system.
(Continuous Plankton Imaging and Classification System)
FOV: 11 x 12mm
WD: 15 cm
Resolution: 2 µm

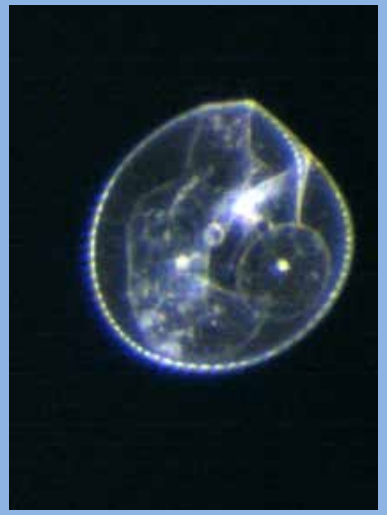
Three copepods with yellow Region of Interest (ROI) pixels extracted in real-time by FPGA (frame programmable gate array)


PLEASE LEAVE
ALL COMPUTERS
ON
R
BUCK ISLAND
ST. CROIX





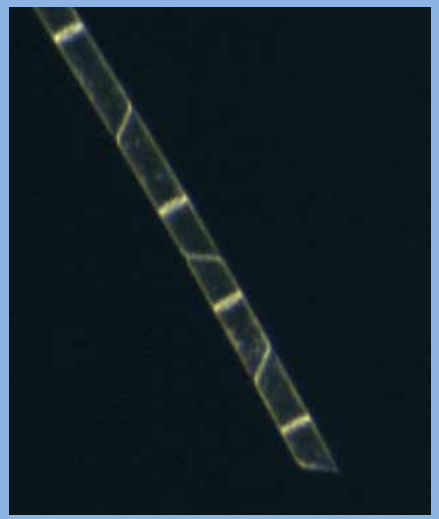
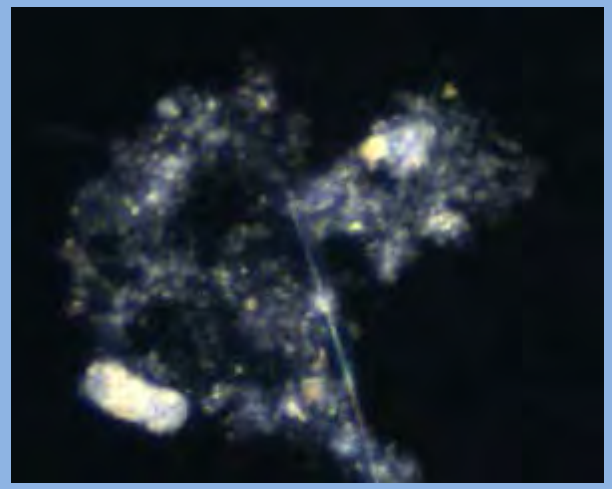


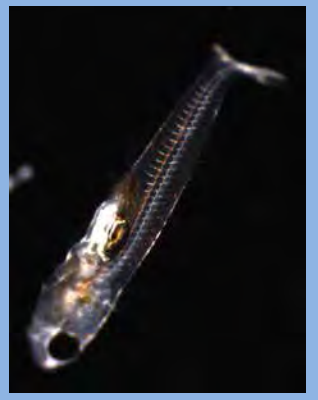




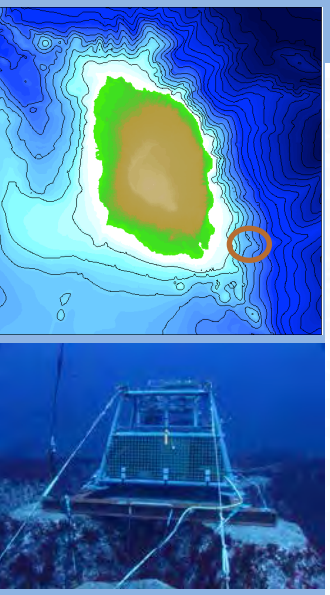




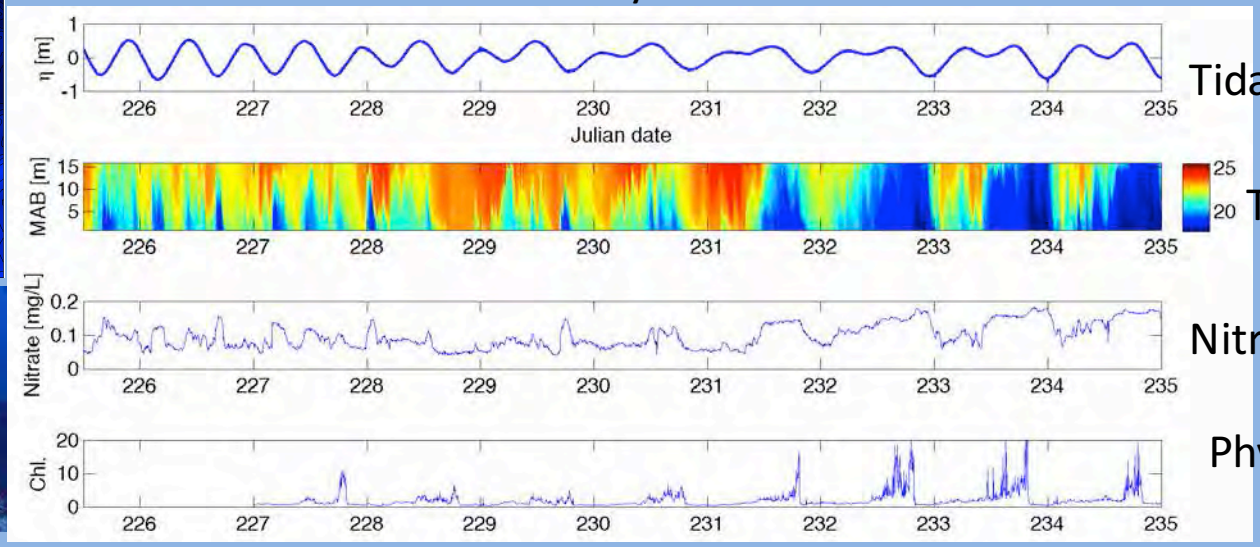






Example data



Data from OCEANS observatory

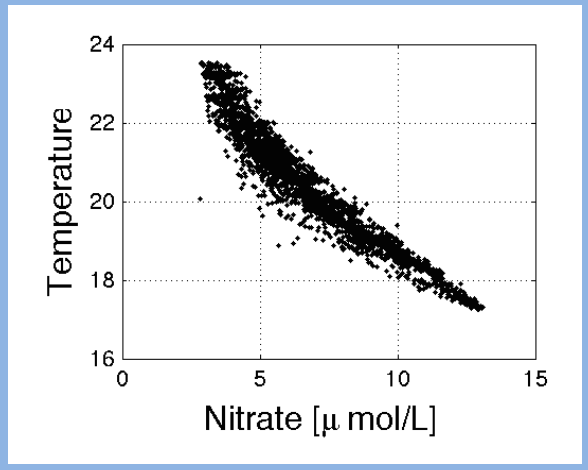


Tidal elevations

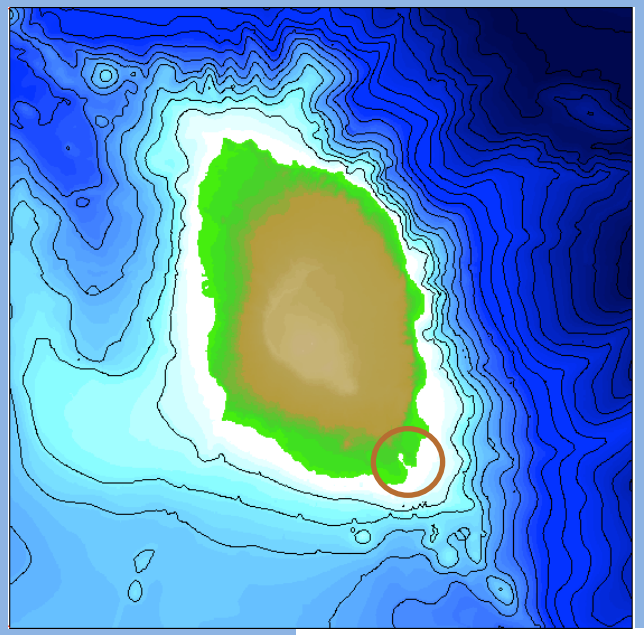
Temperature

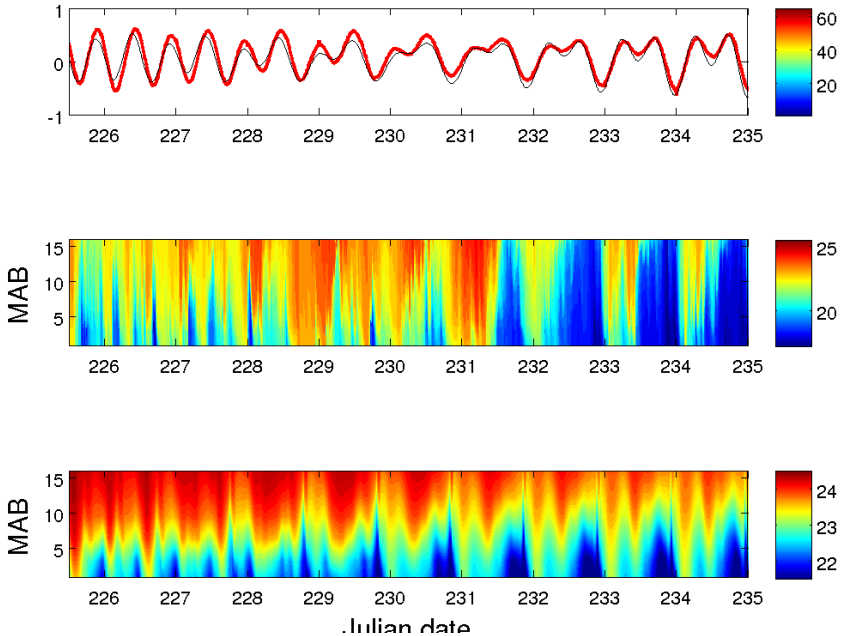
Nitrate

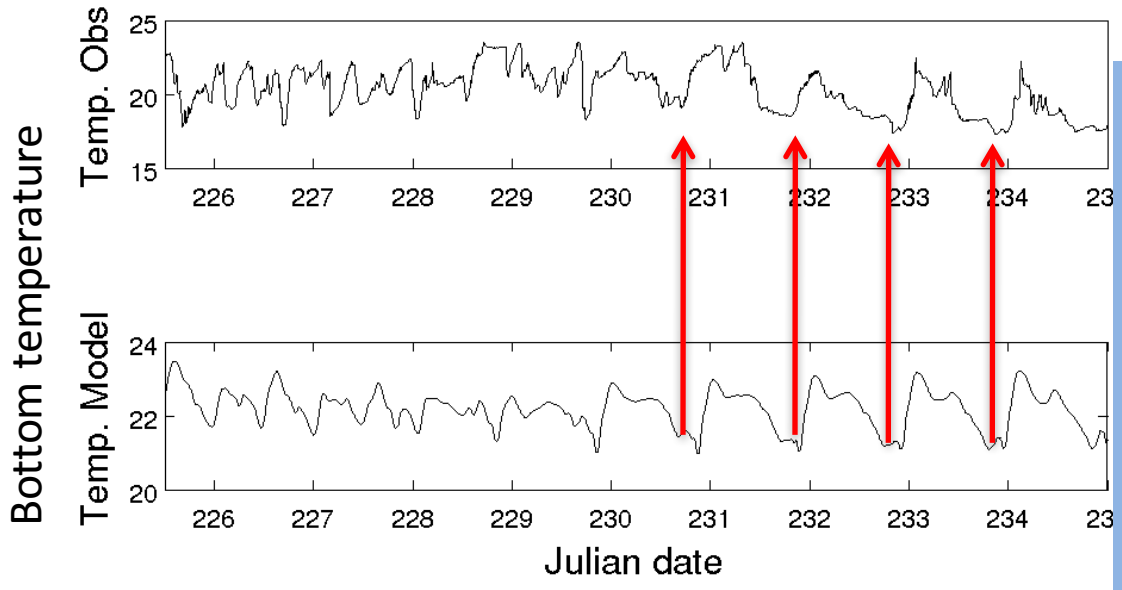
Phytoplankton



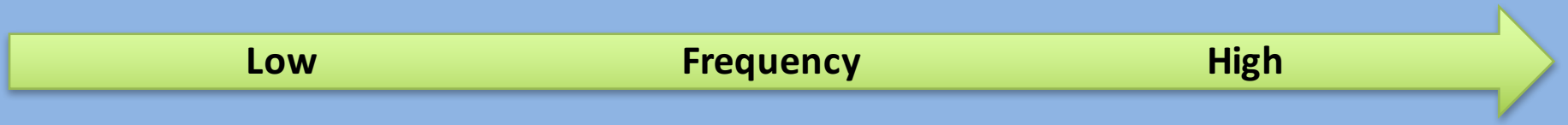
Observed data vs. SUNTANS







Oscillation of waves



$$D < f < SD << N$$

Diurnal tides

1/24 cph

Inertial frequency

1/20 cph

Semi-diurnal tides

1/12 cph

Buoyancy Frequency

Separated numerical simulations using diurnal and semidiurnal frequencies with constant tidal elevations.

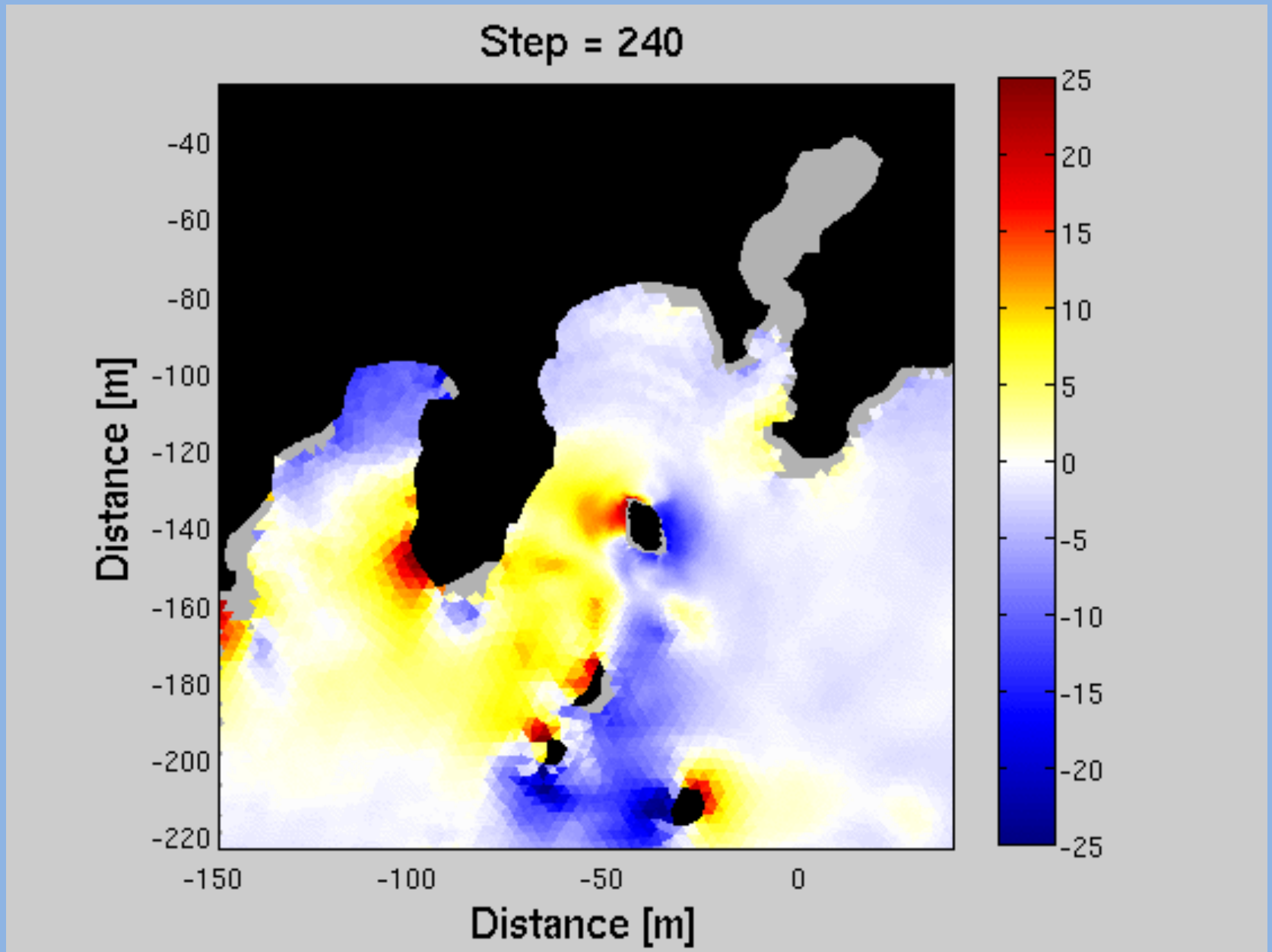
1. Run with K1 tides
$\sigma = 7.3 \times 10^{-5}$ rad/s
a = 0.5 m

2. Run with M2 tides
$\sigma = 1.4 \times 10^{-4}$ rad/s
a = 0.5 m

Submitted to *Journal of Physical Oceanography*

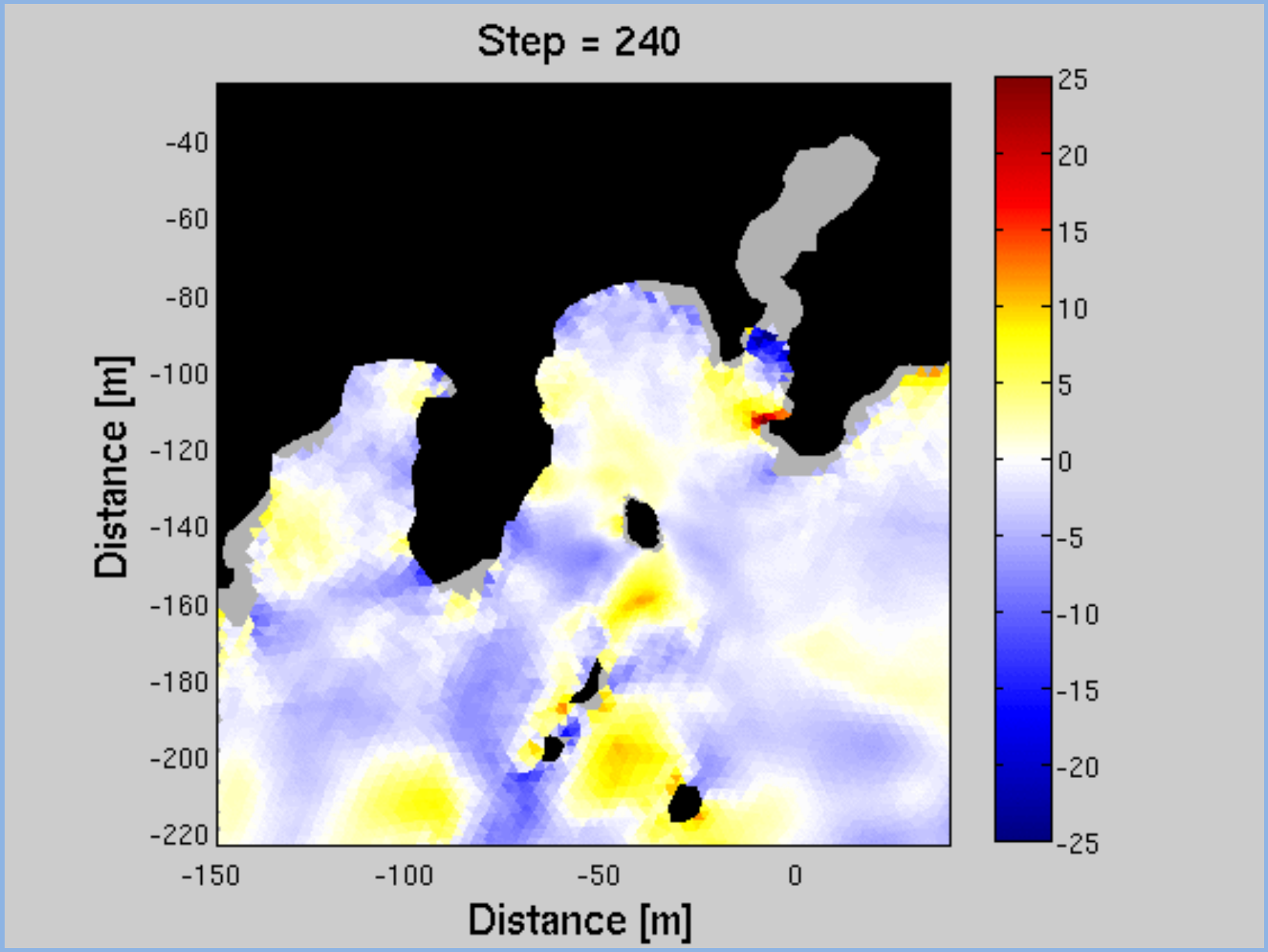
SUNTANS Results: K1 forcing

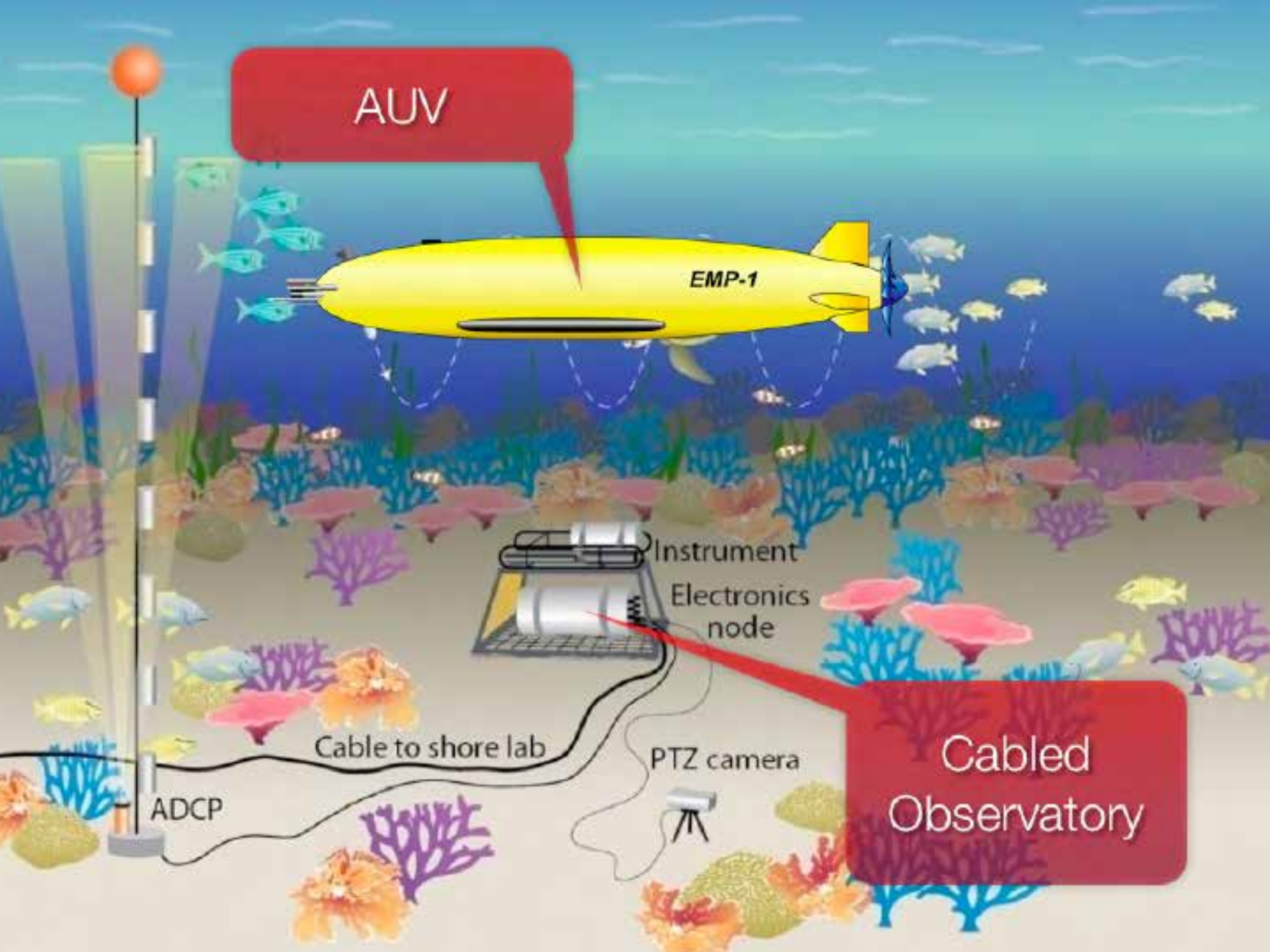
21 degrees isothermal displacement



SUNTANS Results: M2 forcing

21 degrees isothermal displacement




AUV
EMP-1
Instrument
Electronics
node
Cable to shore lab
PTZ camera
ADCP
Cabled
Observatory

Design Concept of the AUV

Cruising-Style

Slow Cruising Speed

Plankton Microscope Camera

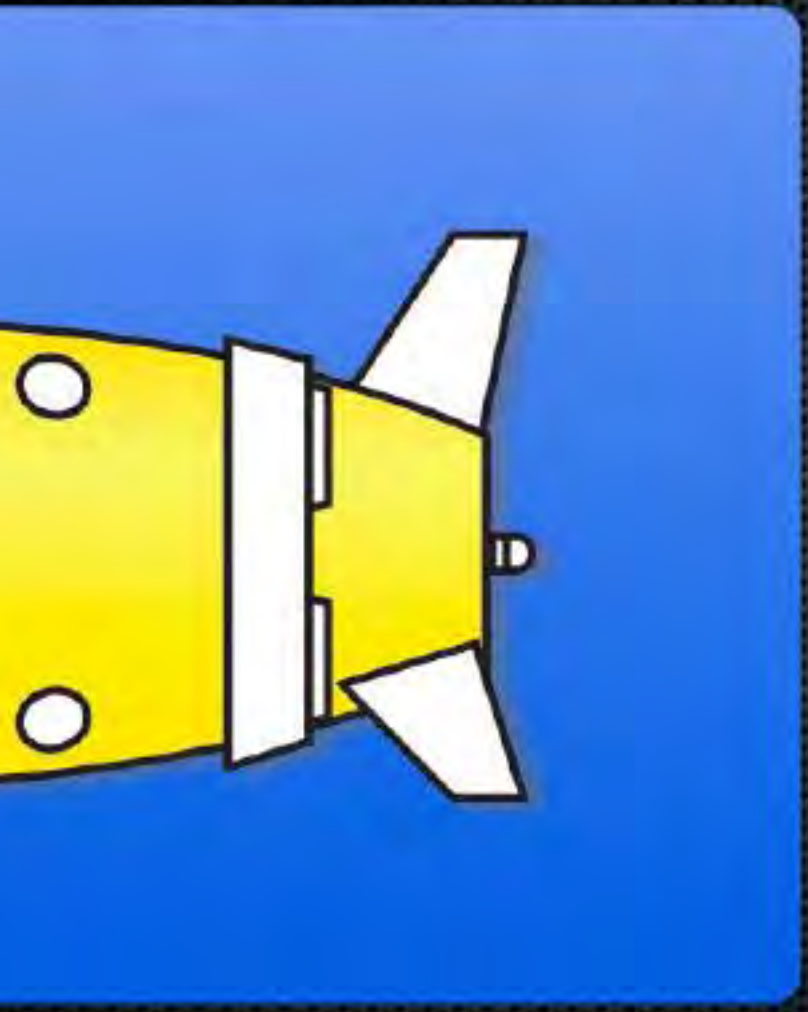
Operation with CO

Microstructure Measurement System

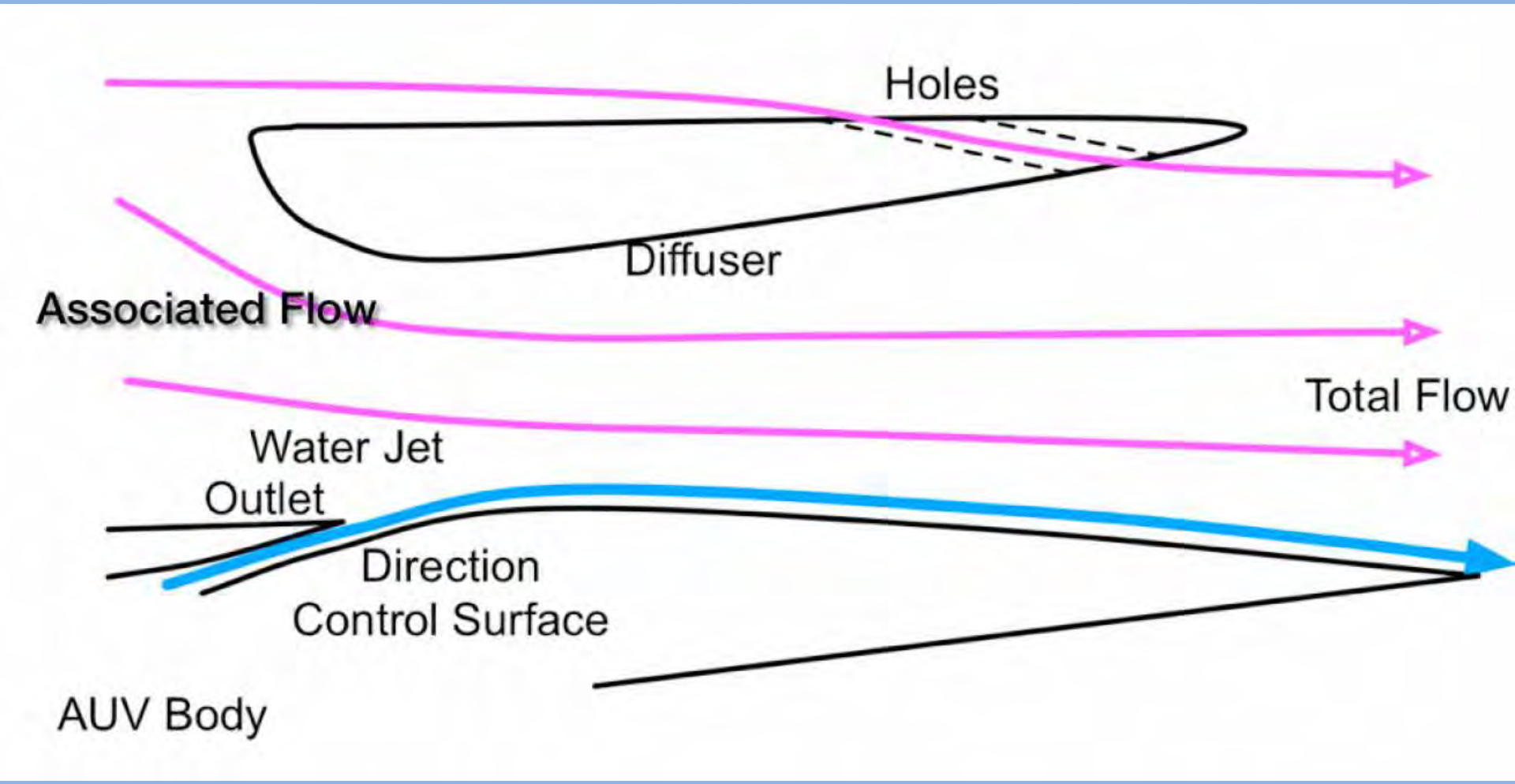
Low-Vibration

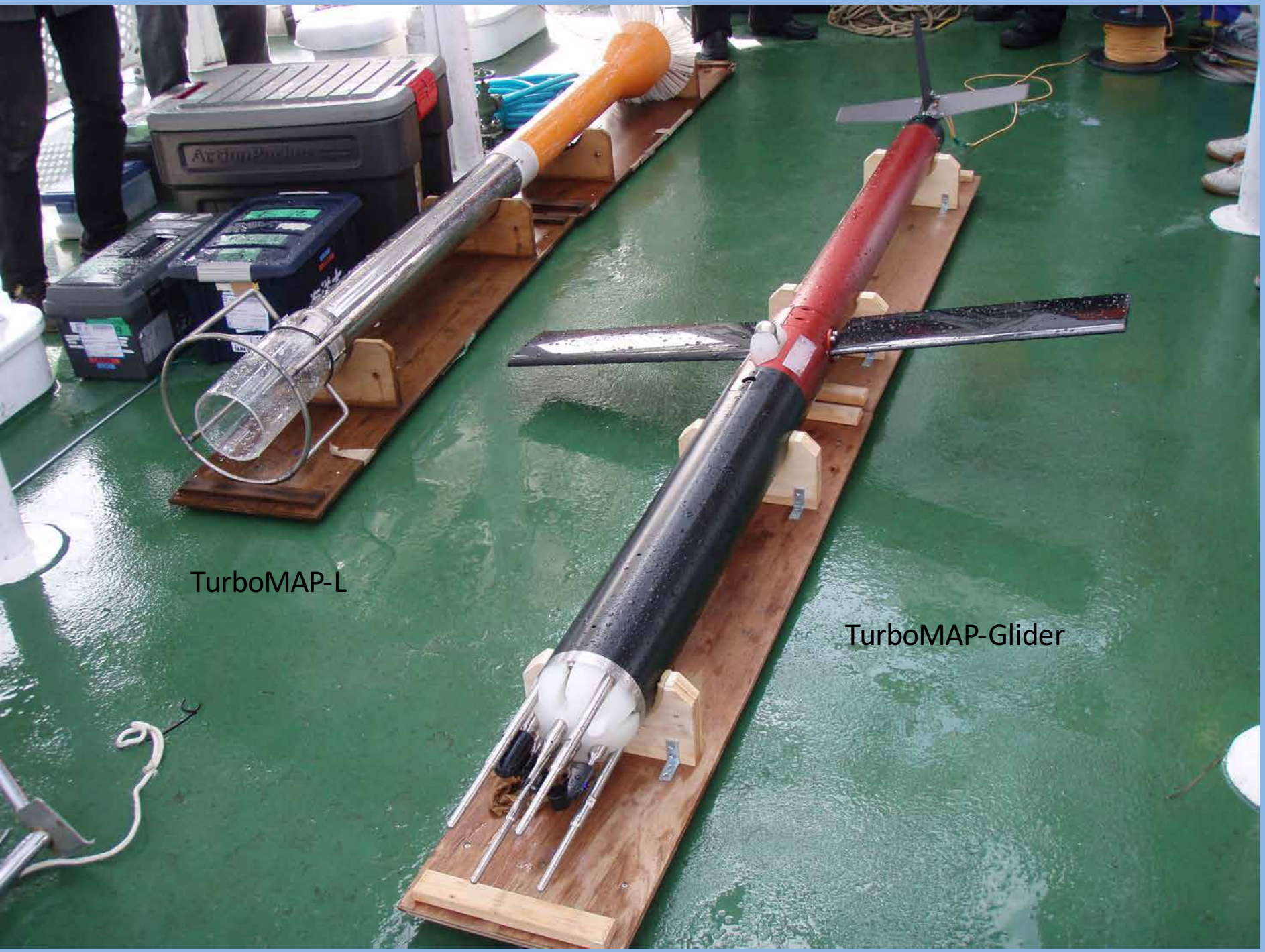
Low-Vibration Propulsion System

Low-Vibration Propulsion System

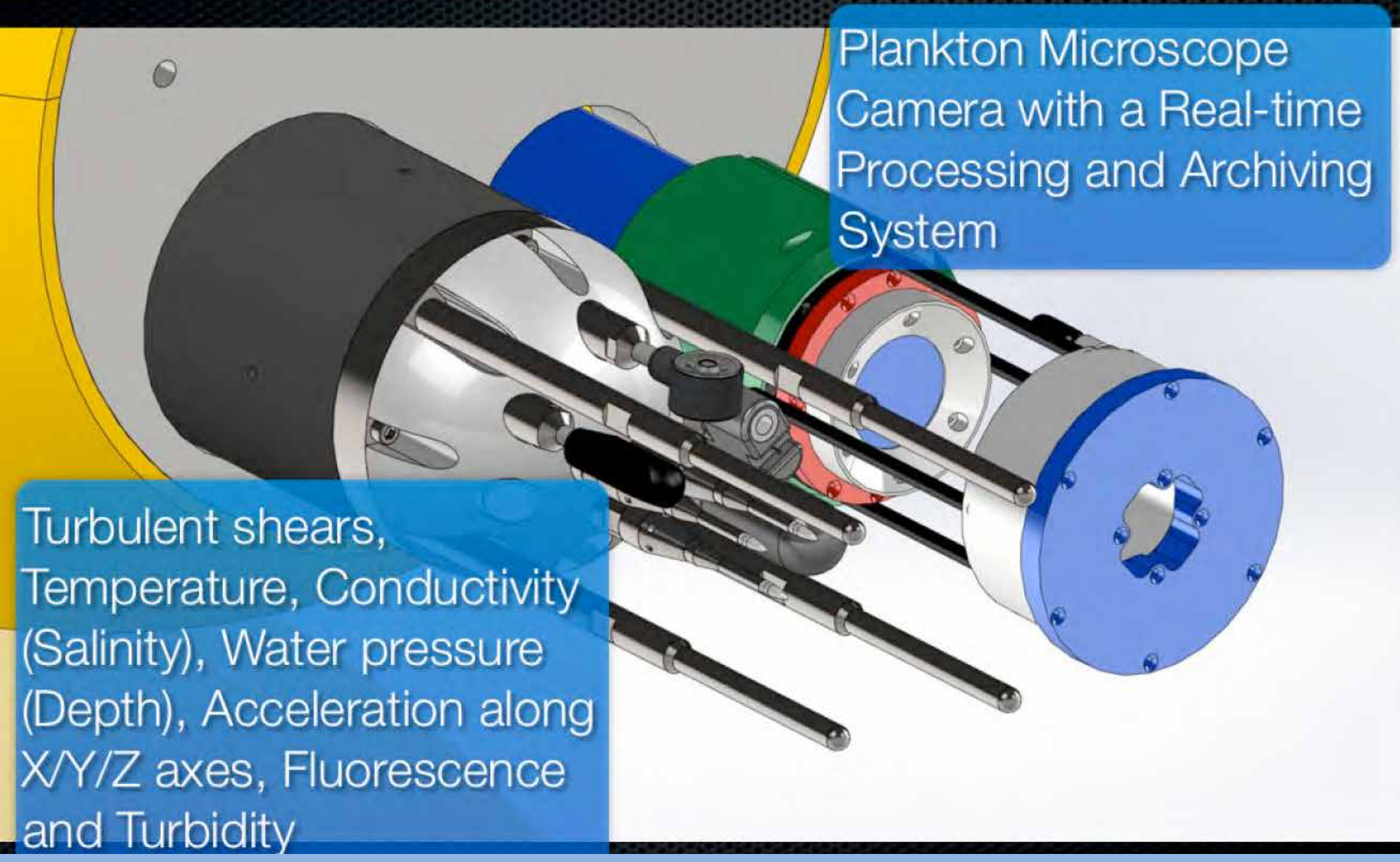


- Pump Jet System
- High Rotation Rate Small Motor
- Avoid Low Frequency Vibration from a Rotating Propeller and a Motor
- Eliminate the Spiral Stream by a Rotating Propeller
- Drawing Surrounded Water to Increase the Thrust Efficiency
- Introduce Direction Control Surface (DCS)


Holes
Diffuser
Associated Flow
Total Flow
Water Jet
Outlet
Direction
Control Surface
AUV Body


TurboMAP-L
TurboMAP-Glider

CPICS and TurboMAP



Plankton Microscope Camera with a Real-time Processing and Archiving System

Turbulent shears, Temperature, Conductivity (Salinity), Water pressure (Depth), Acceleration along X/Y/Z axes, Fluorescence and Turbidity

Take home messages

- New observational systems are uncovering new processes.

- A combination of observation and numerical model is a powerful tool to study coastal ocean processes.

Thank you for your attention!