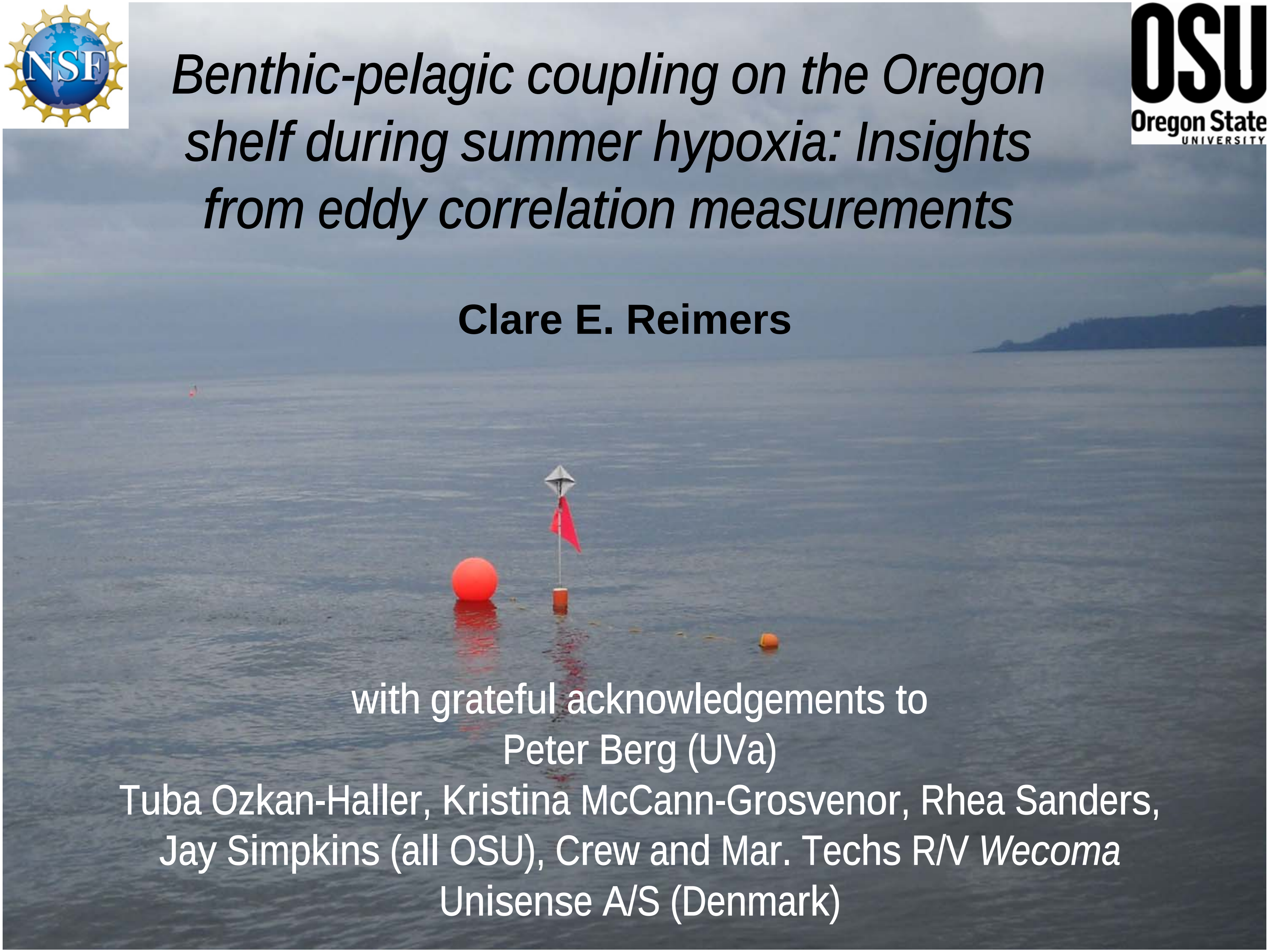


Benthic-pelagic coupling on the Oregon shelf during summer hypoxia: Insights from eddy correlation measurements

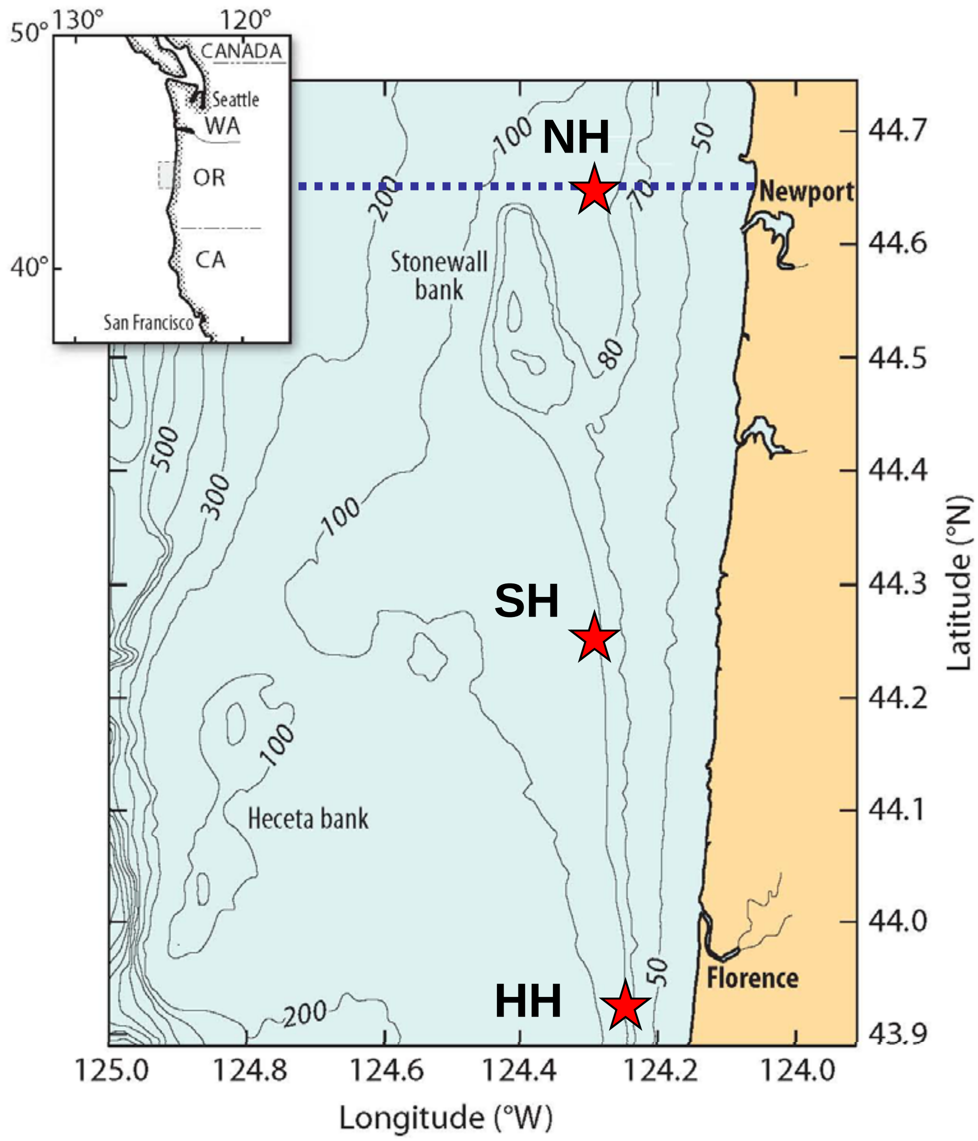
Clare E. Reimers

with grateful acknowledgements to
Peter Berg (UVa)
Tuba Ozkan-Haller, Kristina McCann-Grosvenor, Rhea Sanders, Jay Simpkins (all OSU), Crew and Mar. Techs R/V *Wecoma*
Unisense A/S (Denmark)

Outline

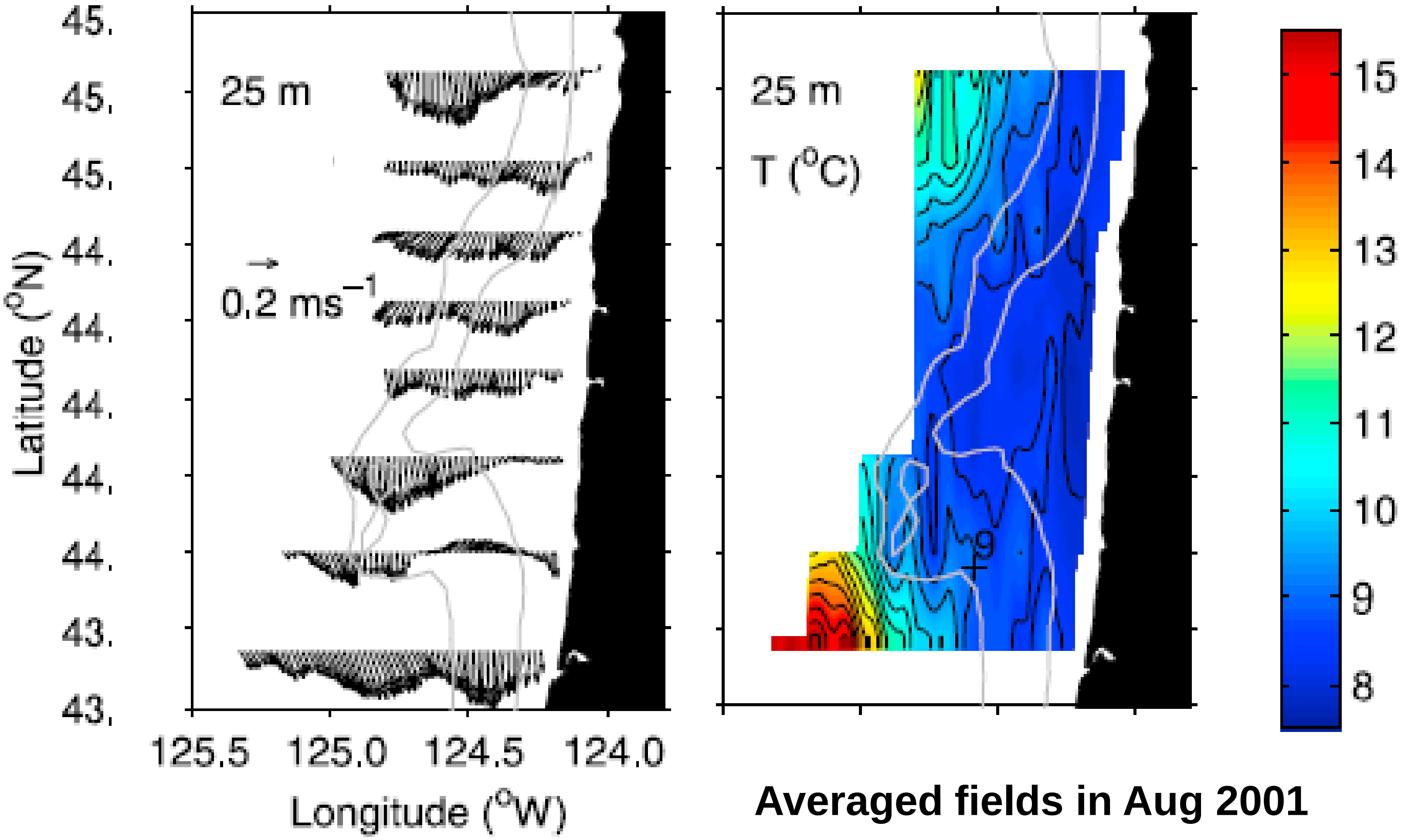
- Oregon Shelf: study sites and oceanography
  How important is benthic oxygen consumption to developing hypoxia?
- Eddy Correlation Lander: instrumentation and approach for shelf depth measurements
- Initial Results: time-series data
- Comparative oxygen exchange rates and sediment properties (3 sites)
- Conclusions and future directions

Study sites


50°
130°
120°
CANADA
Seattle
WA
OR
40°
CA
San Francisco
NH
SH
HH
100
50
200
70
Newport
Stonewall
bank
80
500
300
100
100
Heceta bank
50
Florence
200
44.7
44.6
44.5
44.4
44.3
44.2
44.1
44.0
43.9
Latitude (°N)
125.0
124.8
124.6
124.4
124.2
124.0
Longitude (°W)

Summer circulation and temperature

Shipboard ADCP **SeaSoar data**



Averaged fields in Aug 2001

Castelao and Barth 2005 *JGR*

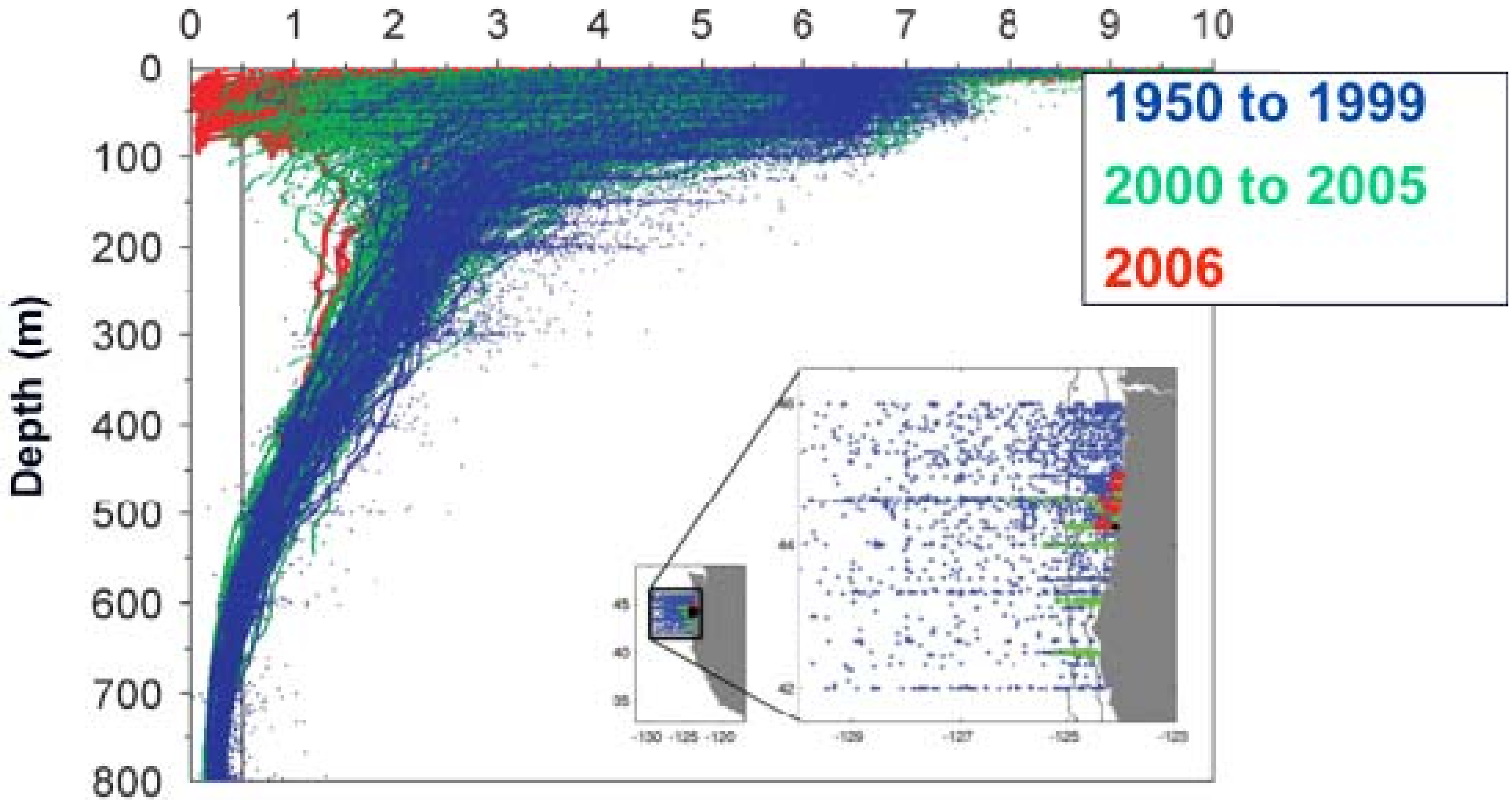
OR shelf hypoxia is recent

1 ml l^{-1} = 44.7 μM

Hypoxia <1.4 ml l^{-1} (62.5 μM)

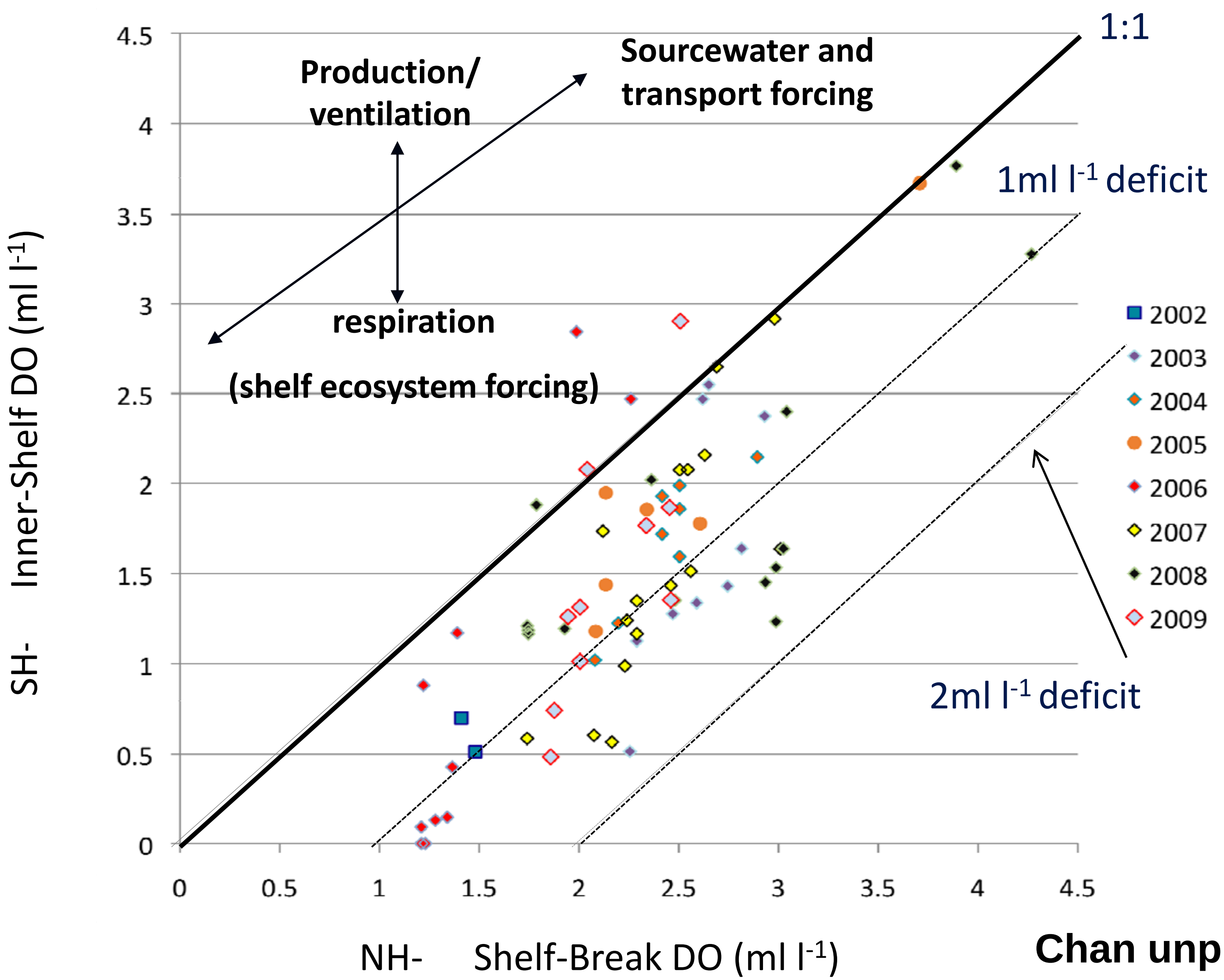
Severe hypoxia <0.5 ml l^{-1} (22.3 μM)

DO (ml l^{-1})



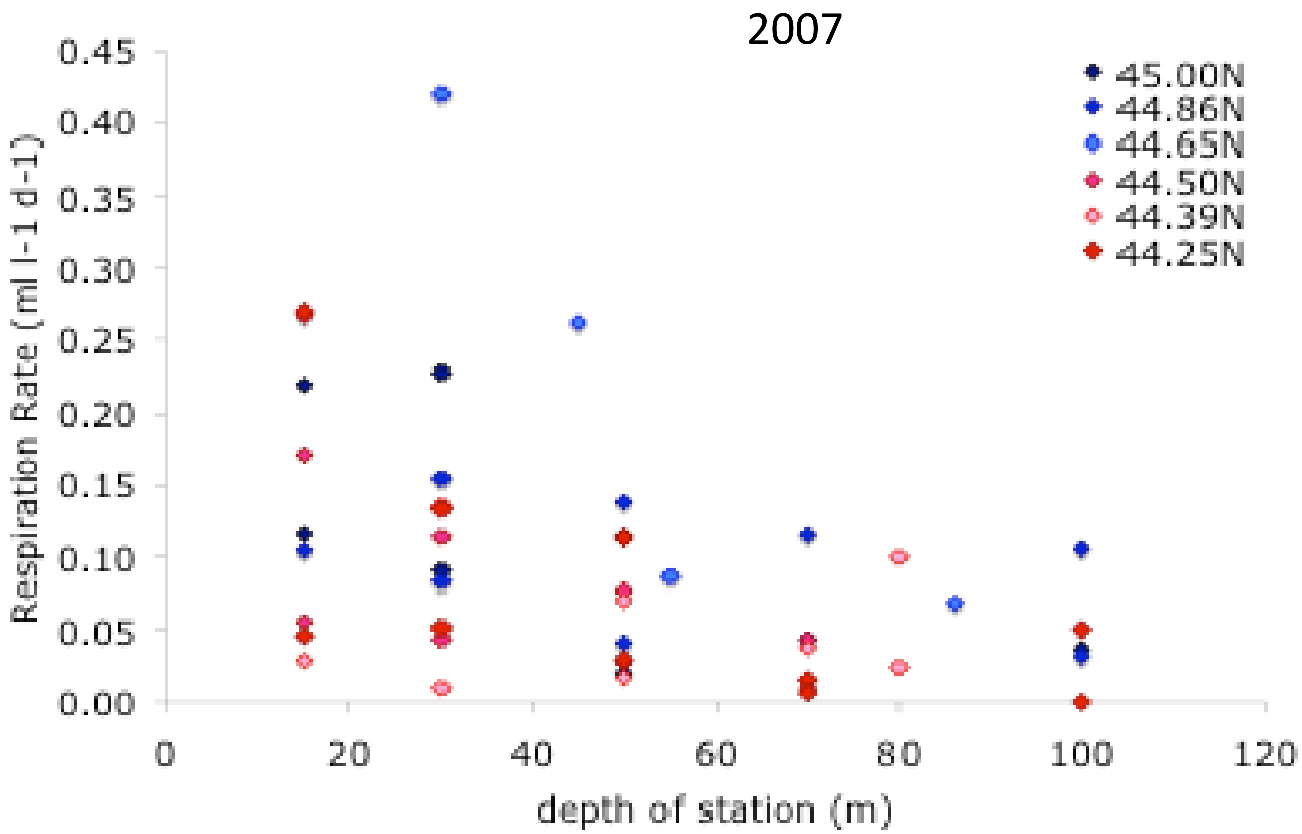
Chan et al. 2008 *Science* 319: 920

It is not all source-water



Chan unpublished

Water column respiration



Chan unpublished

Benthic environment OR shelf

Heavily bioturbated sand with phytodetritus
80 m; 10/04/04

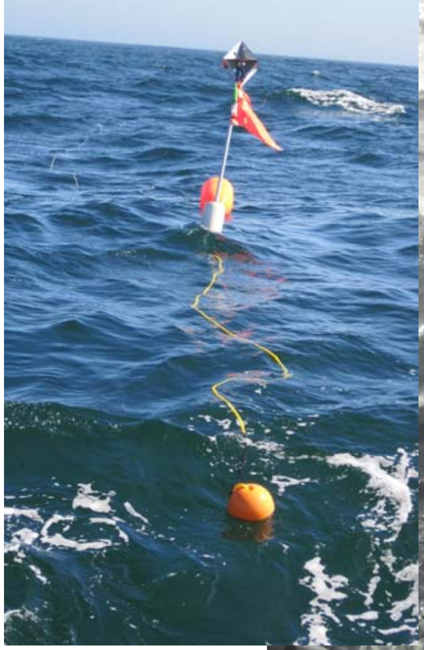
EC Lander Development

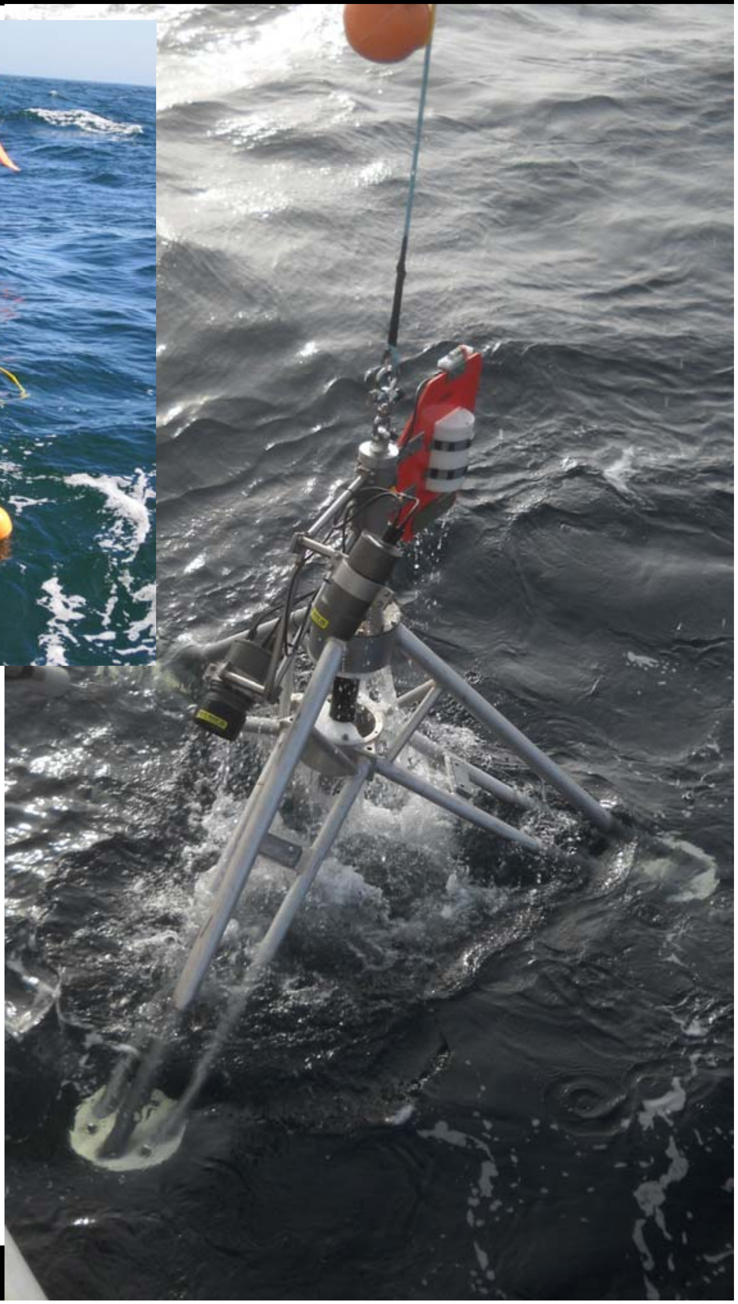
- to enable cross-shelf and time-series measurements of benthic total oxygen exchange rates (OE) by eddy correlation – especially in shelf regions with permeable sediments and wave motion

- to provide bottom imagery and supporting sensor data to help interpret spatial and temporal variations in benthic OE

lander design features

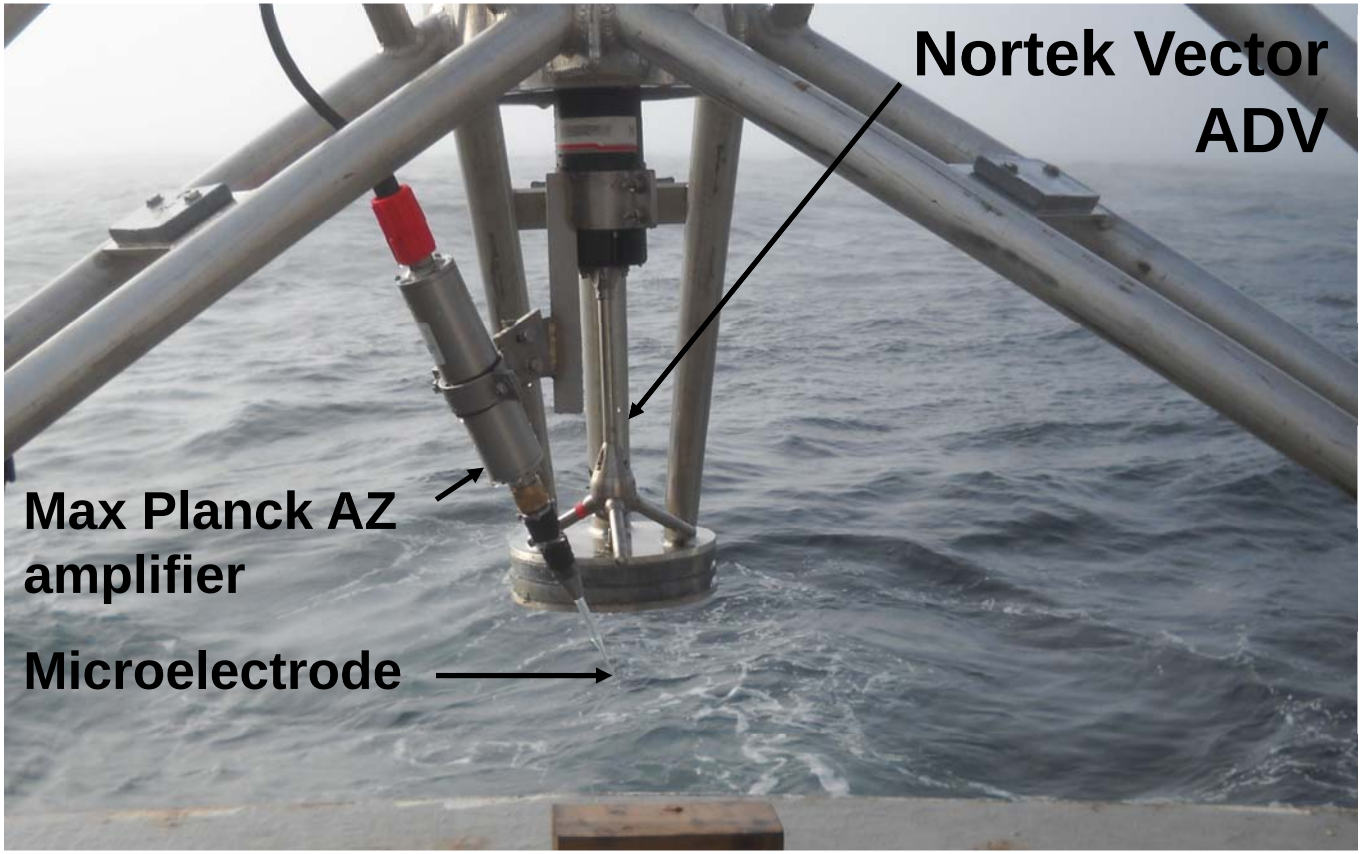
- Aluminum tripod (Height 1.8 m, width 2.3 m)
- Centered sensor mounts and adjustable brackets for easy sensor alignment
- Stable broad base (450 lbs Pb)
- Digital camera, strobe (Scorpio) and vane on rotating bearing assembly with Wildlife Computer Mk9 light, T, P sensor
- Moored deployment to depths of 200 m (spectra synthetic fiber rope 2:1 scope, surface buoys)





Eddy Correlation Systems

"Berg System"



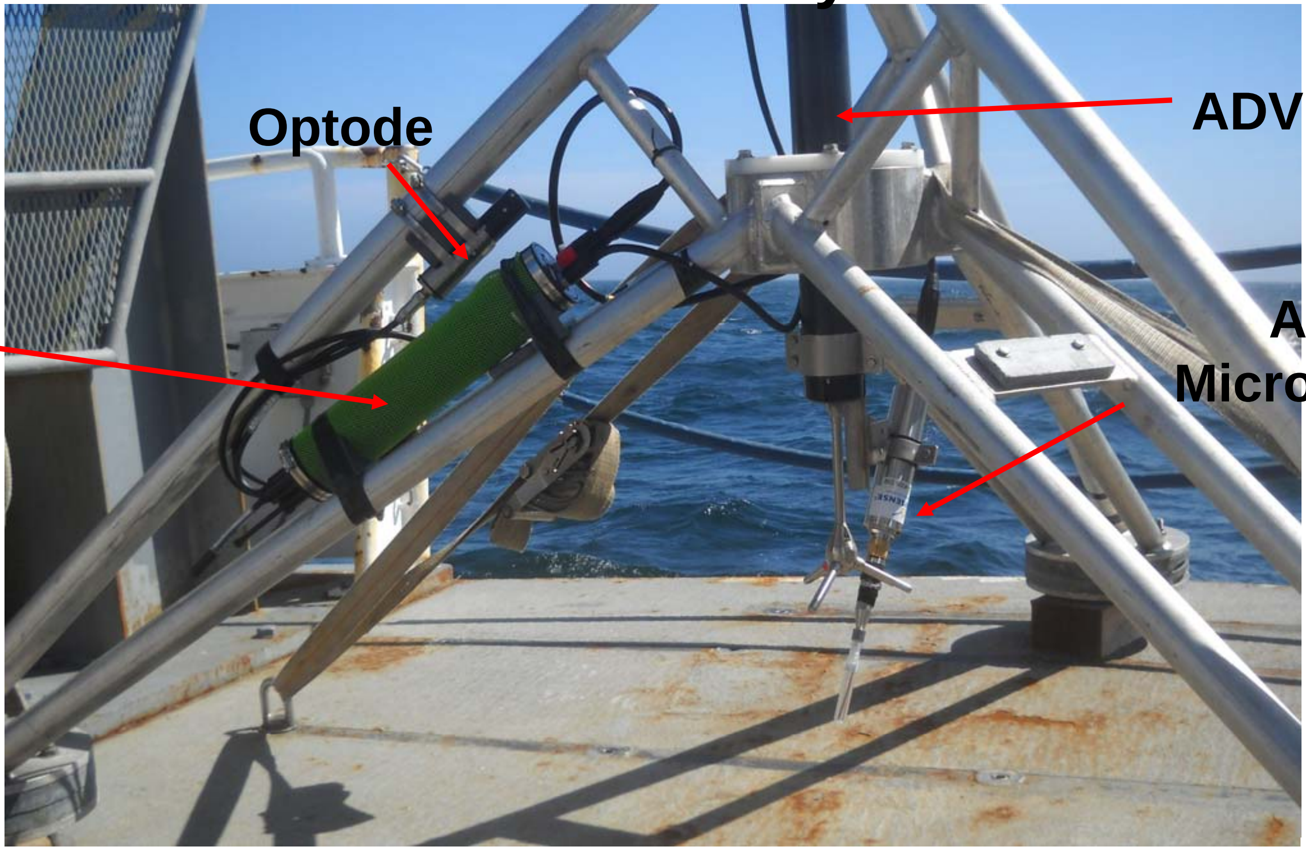
Vector serves as logger

EC Systems cont.

“Unisense EC Controller System”

System Controller

& Logger



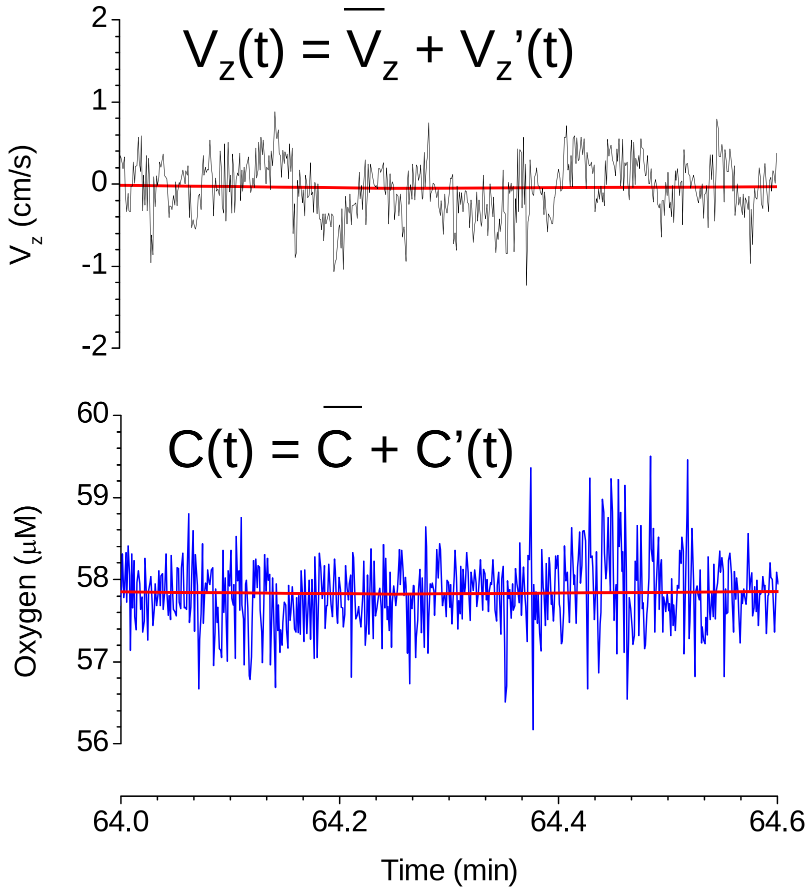
Optode

ADV

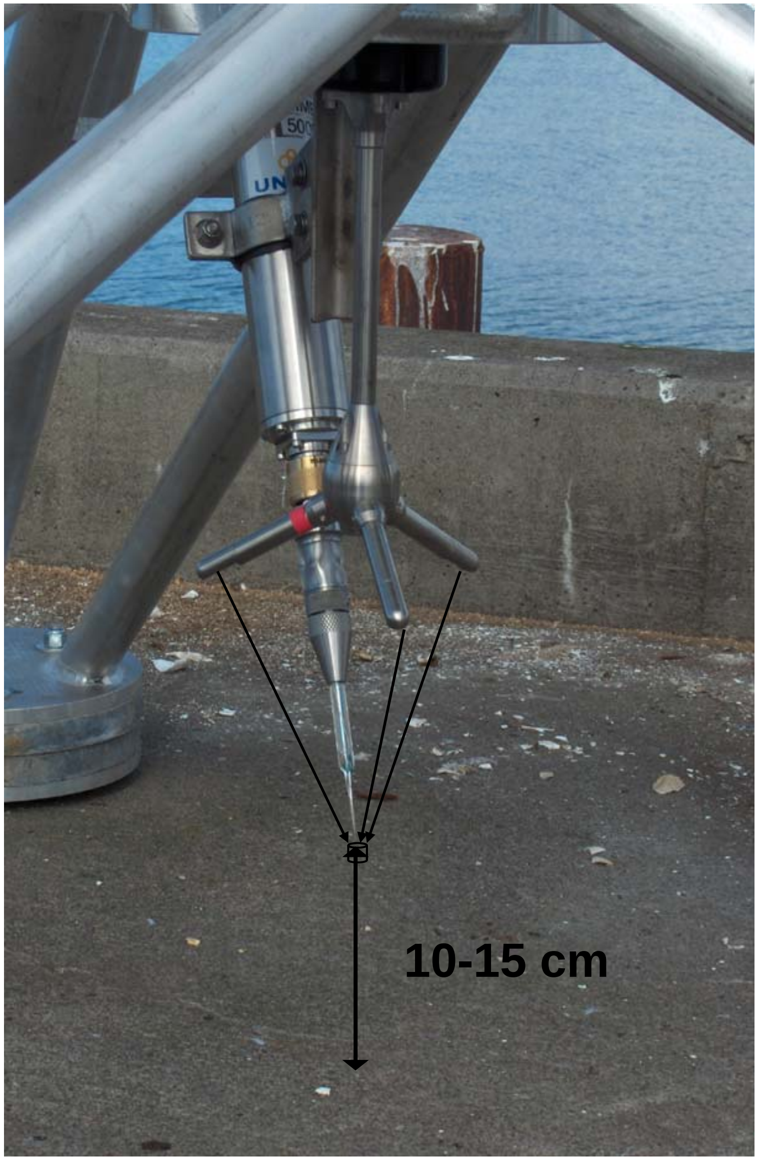
Amplifier & Microelectrode

Controller includes EC software package for calibration and data recovery

Eddy Correlation Method (after Berg et al. 2003)

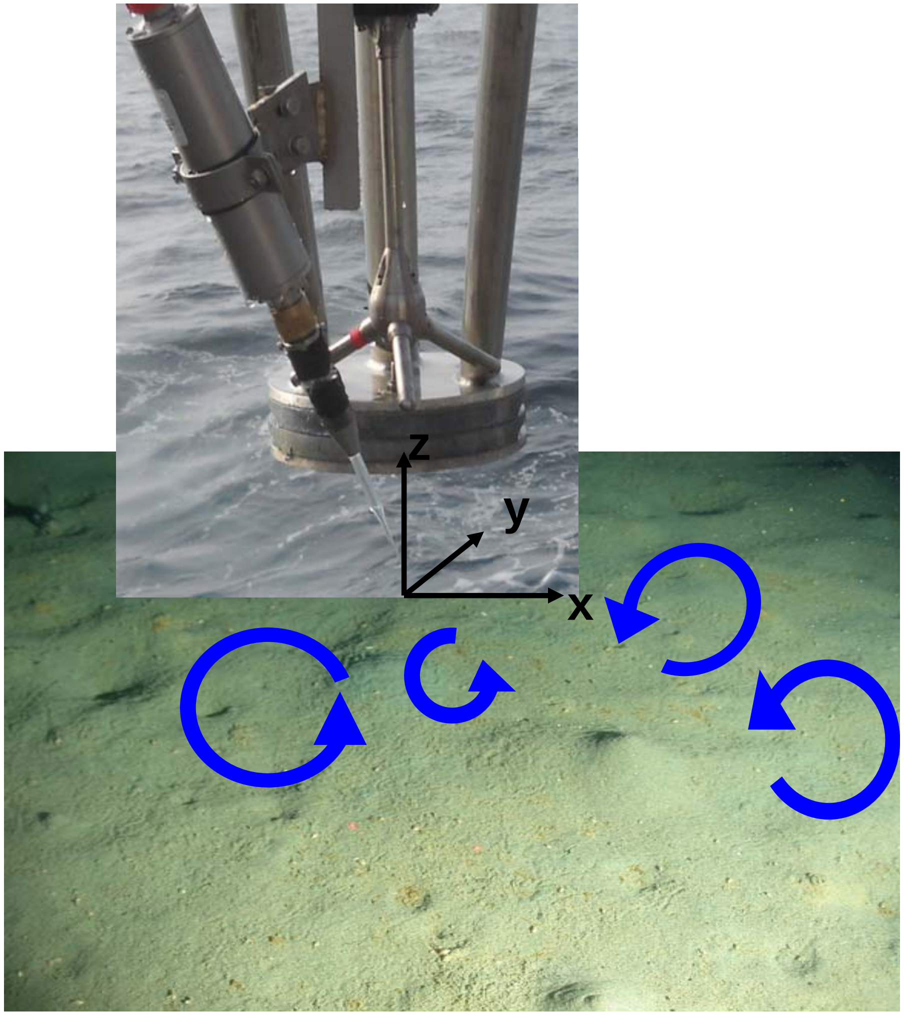


$$OE = \overline{V_z'C'}$$

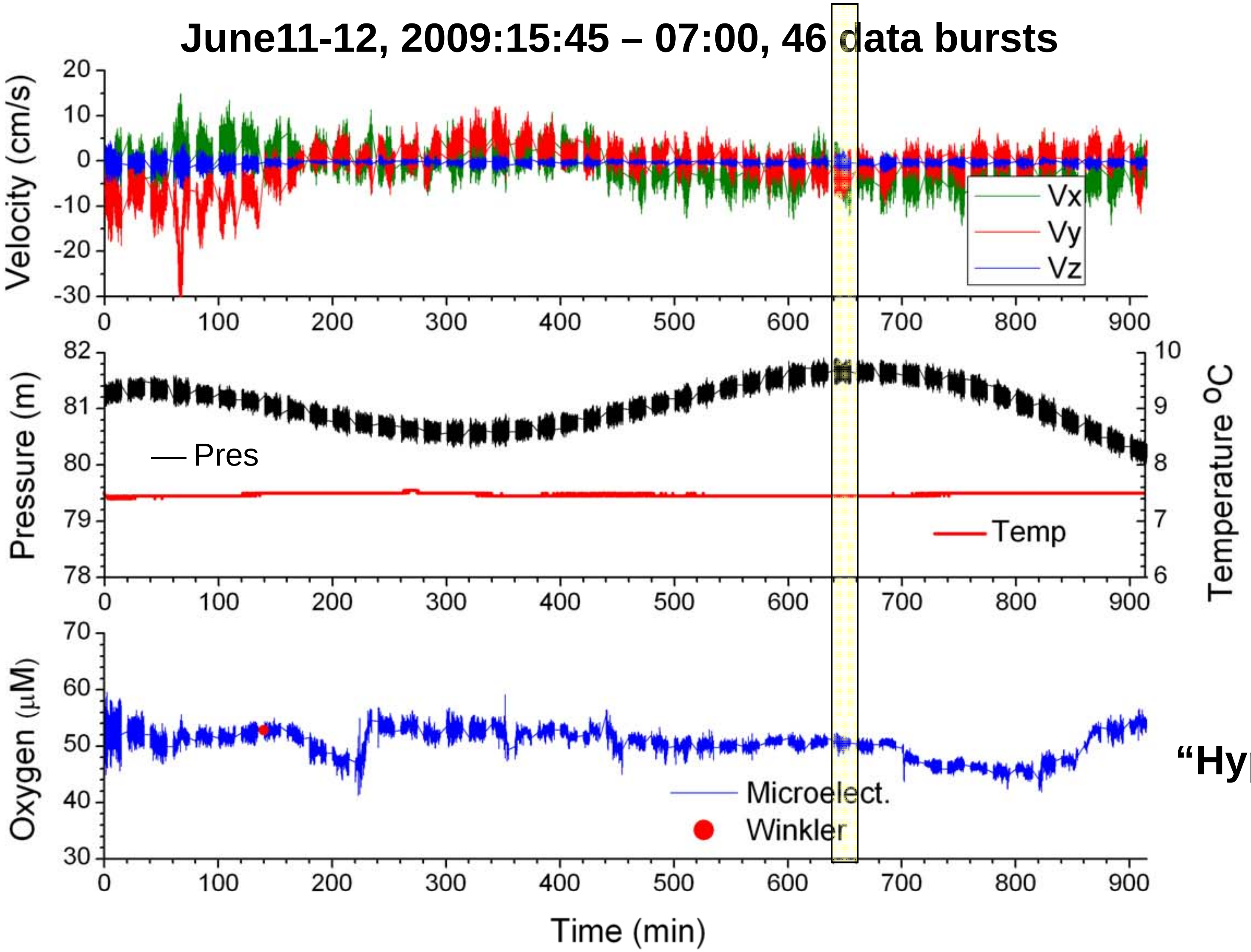


Critical Method Assumptions/Conditions

1. The seafloor is a horizontal homogenous local source or sink for O_2
2. There is no storage or loss of O_2 within bottom boundary layer
3. All O_2 exchange is due to turbulent eddies
4. Vertical and horizontal advective fluxes as well as horizontal divergence of the turbulent flux are negligible
5. Conditions representing all eddy sizes are sampled within each data burst

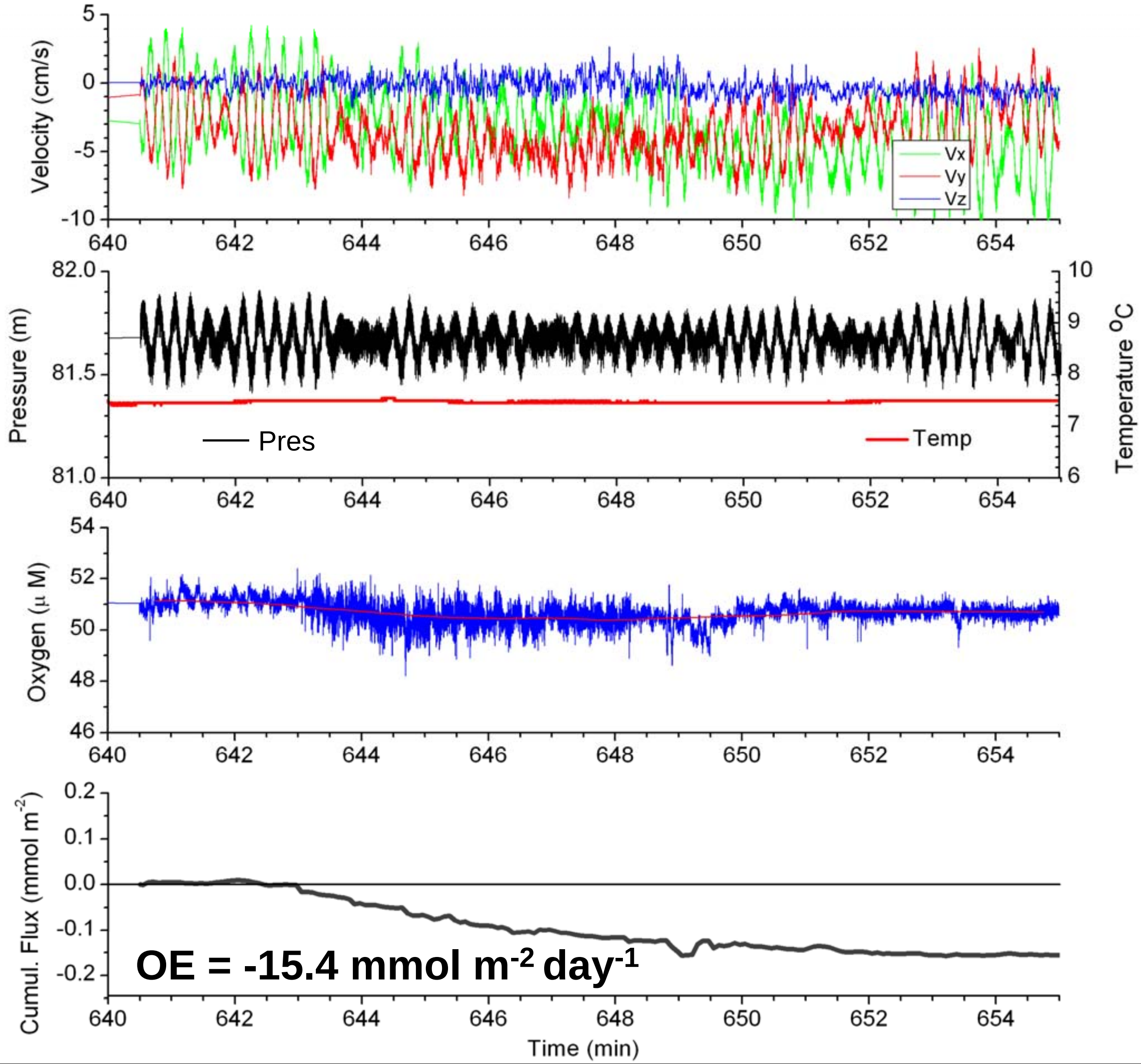


Results – HH site @ 43º 55.8N –Berg System



"Hypoxic"

Burst 33 02:45-03:00



$\Sigma(V_z'C'dt)$

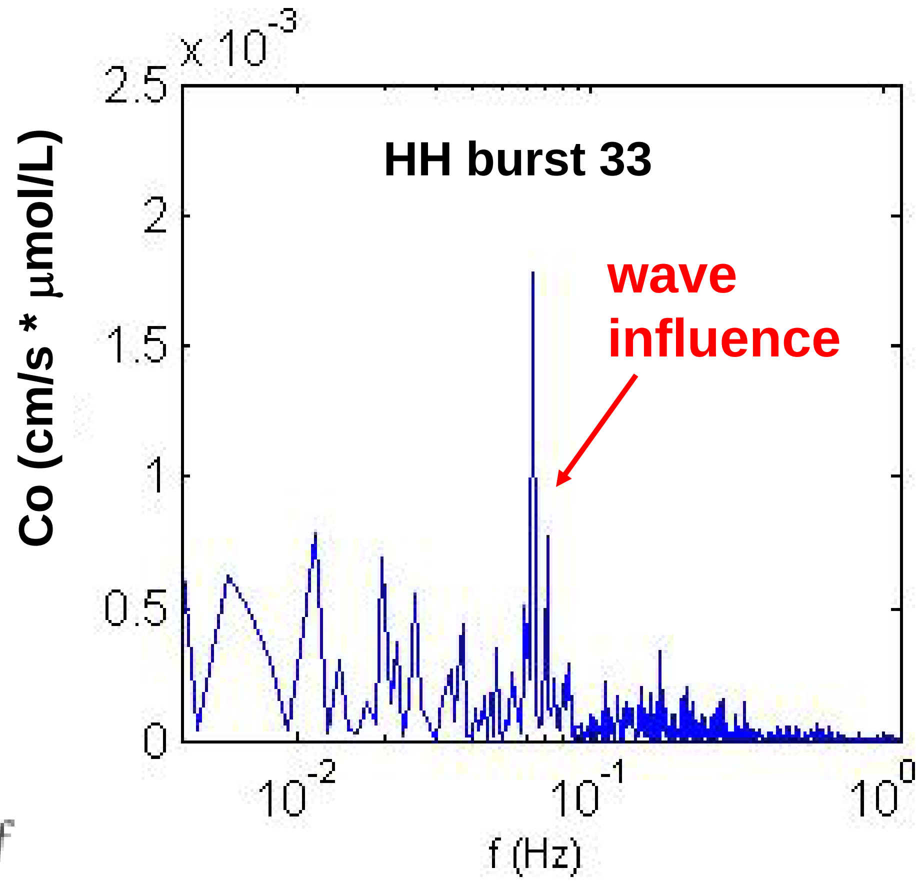
OE = -15.4 mmol m^{-2} day^{-1}

Co-spectra

From pressure record

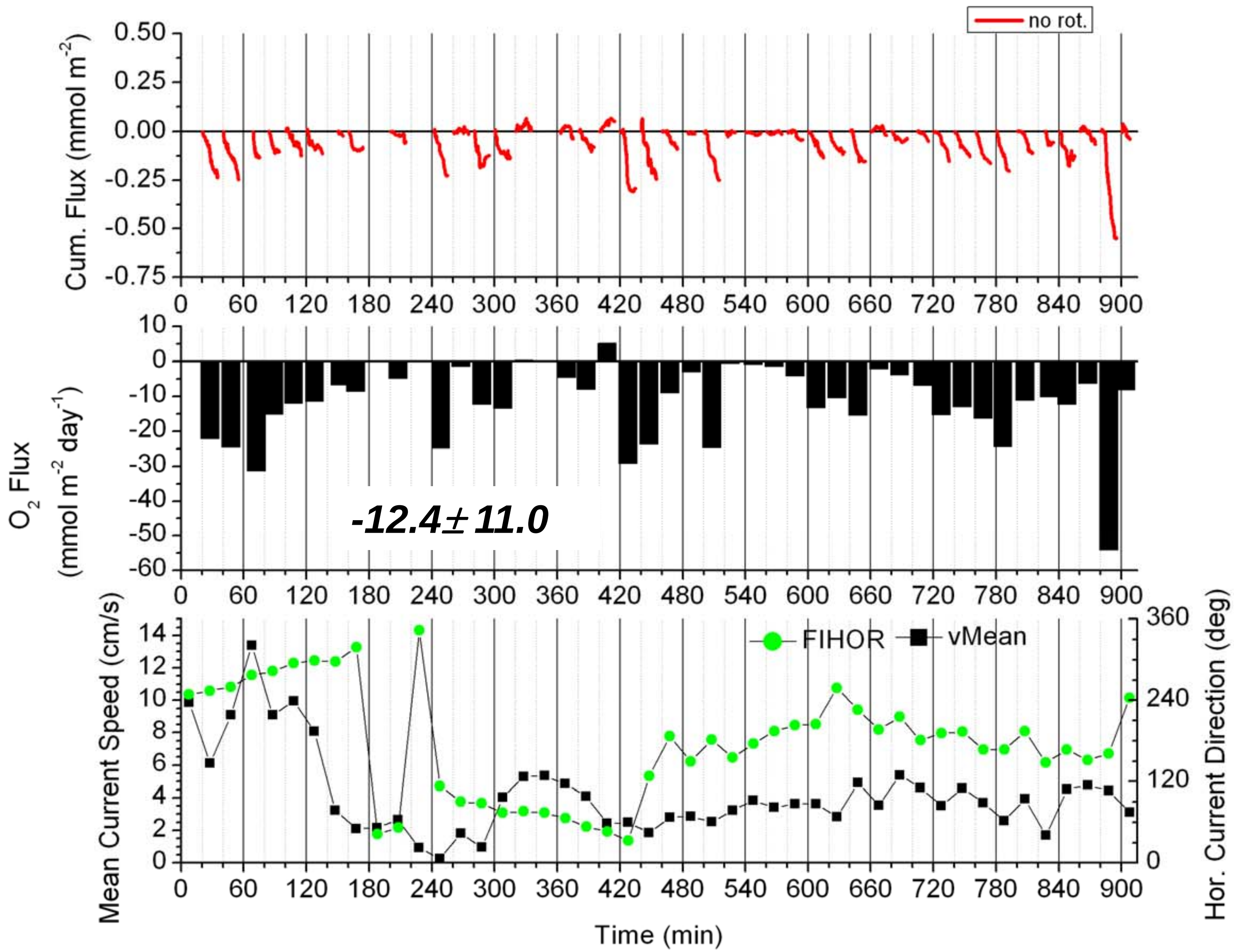
H_{sig} = 0.66 m

Tp = 15.5 s



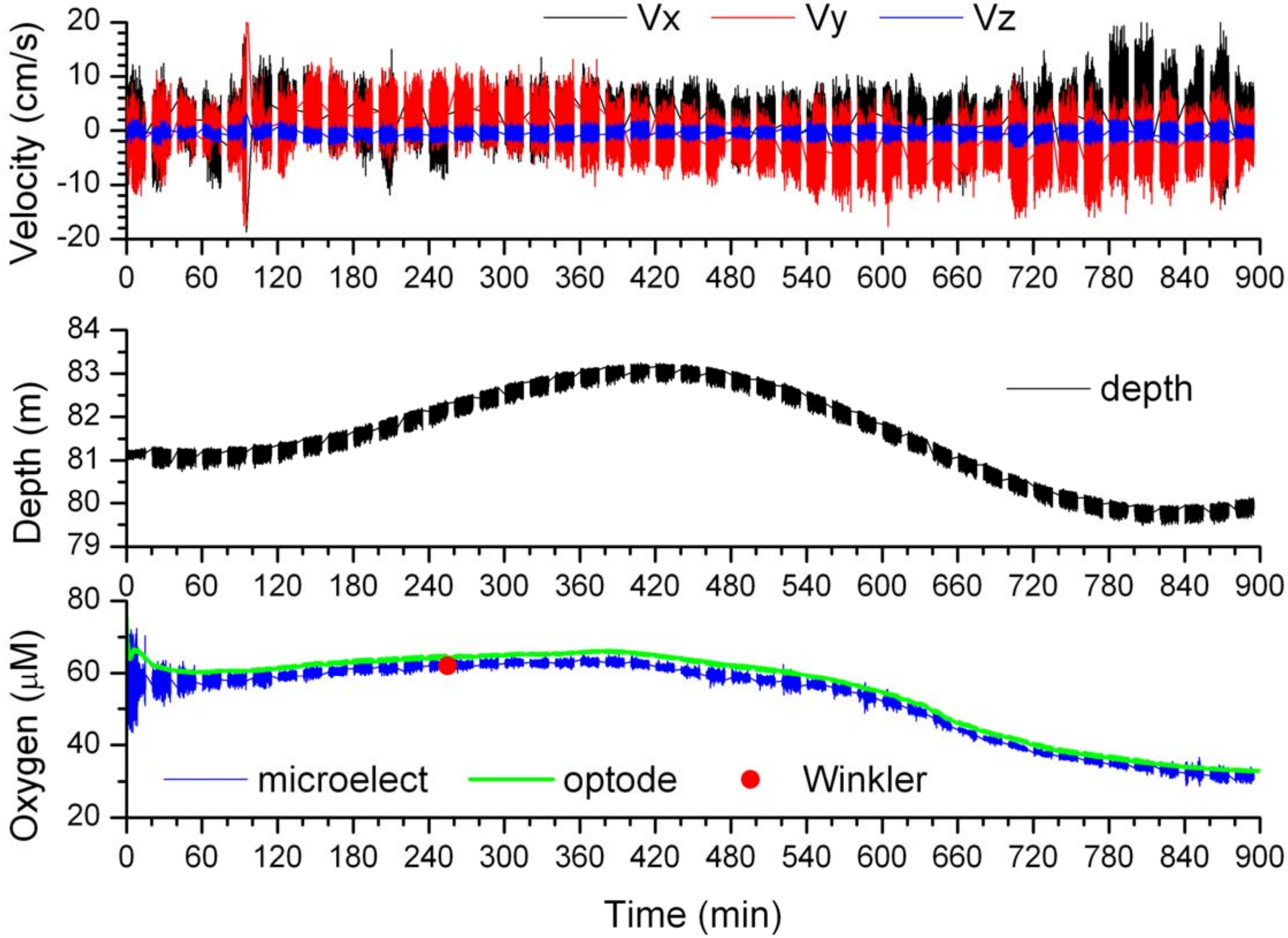
$$\overline{\text{Flux}} = \int_0^\infty Co_{u'_z c'}(f)\,df$$

Time-series Fluxes



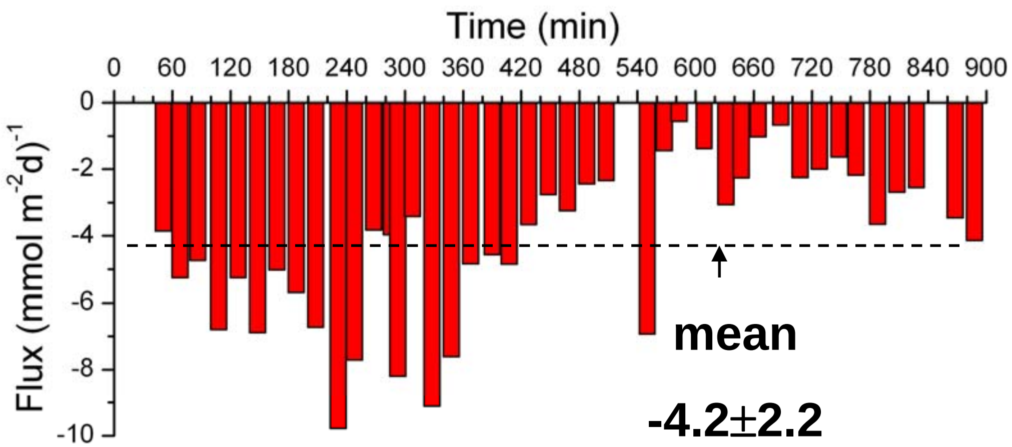
Results SH site @ 44º14.5N - Unisense Controller System

16:00 Aug. 18 - 07:00 Aug 19, 2009, 45 bursts



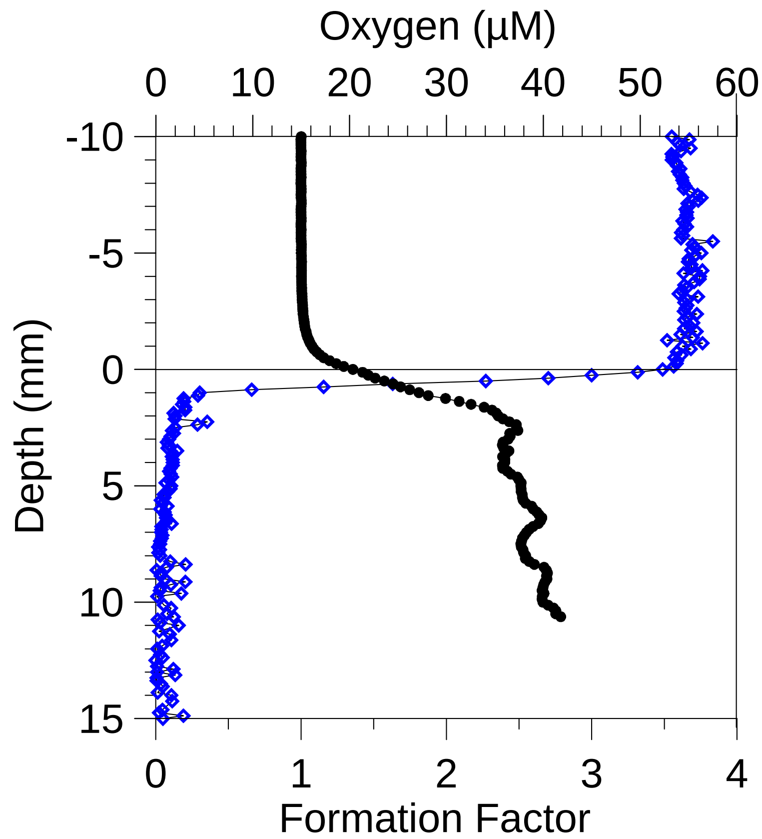
Eddy Flux vs. Diffusive

EC Fluxes



Using Fick's Law

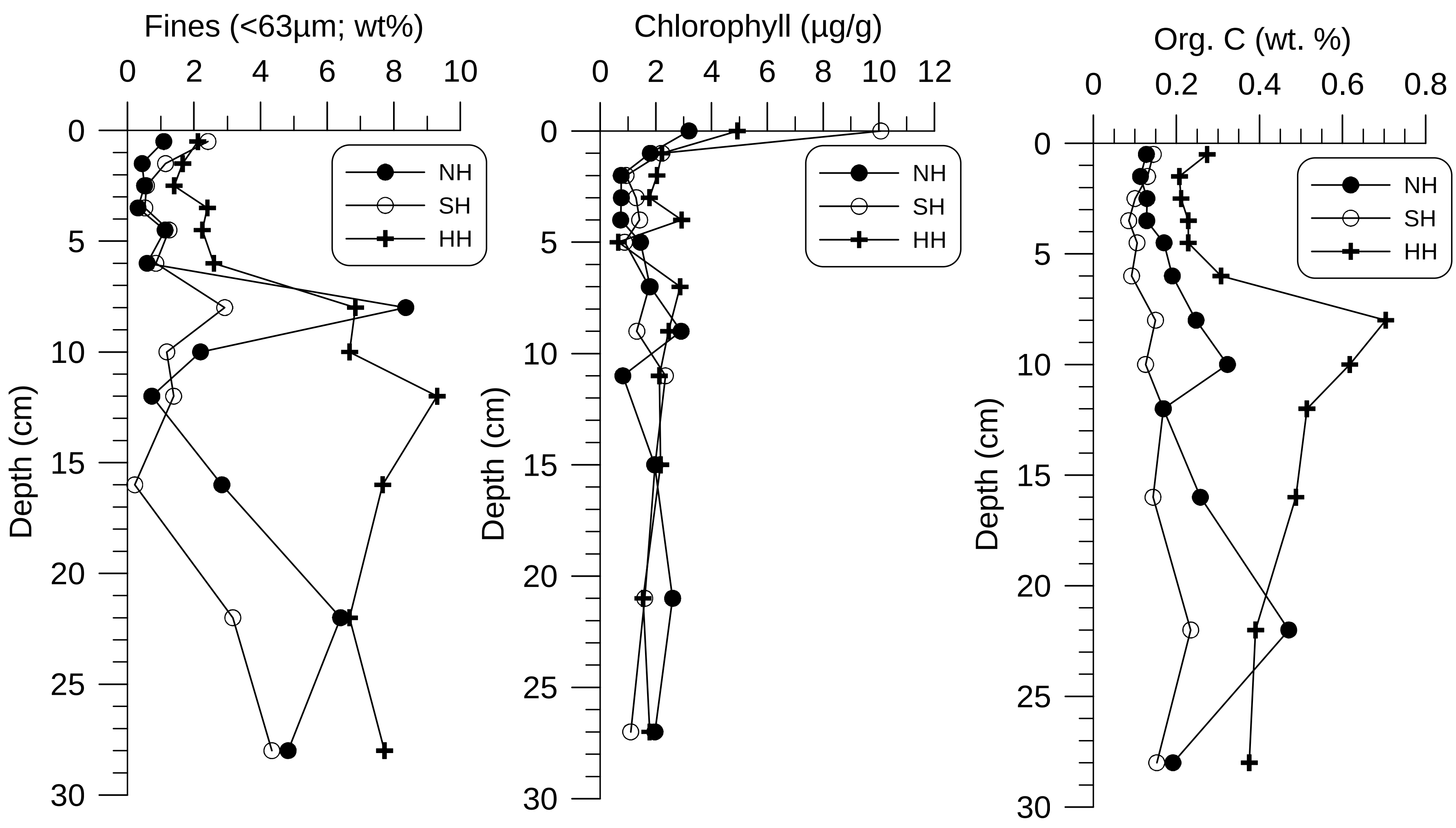
DOU = -3.2 mmol m^{-2} day^{-1}



Site Comparison

Deployment MMDDYYYY	Water Depth (m)	Vector Water Temperature (^oC)	Dissolved Oxygen (μM)	Time Weighted Mean Oxygen Flux (mmol m^{-2} d^{-1})
NH 06082009	84.8±0.9	7.14±0.03	58.2±0.9	-4.1±1.8
SH 08182009	81.6±1.1	7.96±0.05	52.9±11.4	-4.2±2.2
HH 06112009	81.1±0.6	7.57±0.01	50.5±2.3	-12.4±11.0

Sediment Properties



Conclusions

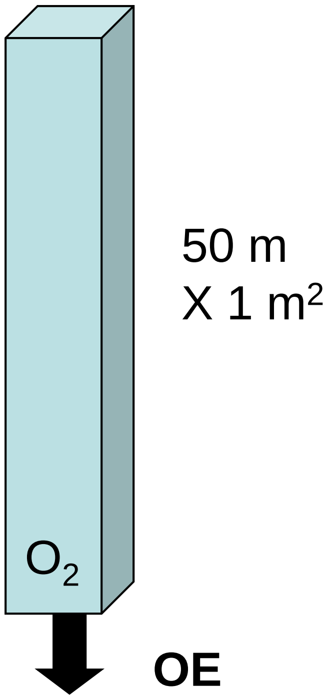
The measured benthic OE rates should create an oxygen deficient in a 50 m water column of

~0.002 - 0.006 ml l^{-1} per day**.**

This is not enough to create the respiration deficits Francis Chan and colleagues have documented.

We need to make more measurements under a wider range of conditions: *latitude, depth, DO, wave energy* to fully know the role of the benthos on the OR Shelf.

Considerable more work on the contributions of wave motions to oxygen exchange rates is needed.



Origin of Benthic-Pelagic Coupling Concept

Gilbert T. Rowe, C. Hovey Clifford, K.L. Smith Jr. and P. Lawrence Hamilton

***Nature* Vol. 255 1975**

Benthic nutrient regeneration and its coupling to primary productivity in coastal waters

SHALLOW, near-shore ocean waters support high primary production because of the availability of inorganic nutrients. The availability is usually attributed to the proximity of fresh-water runoff or to coastal upwelling and deep water advection[1,2].

The effects of nutrient regeneration from the ocean bottom have not, however, been estimated. We report here the first successful attempts to measure directly the nutrient flux from nearshore sediments. We contend that the continental shelf itself is a tightly coupled component of most near-shore ecosystems and that the function of the shallow sea floor in nutrient regeneration has been underestimated in previous investigations.

Benthic–pelagic coupling in the New York Bight

Gilbert T. Rowe, Kenneth L. Smith, Jr., and C. Hovey Clifford
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543

ASLO Special Symposium Vol. 2 1976

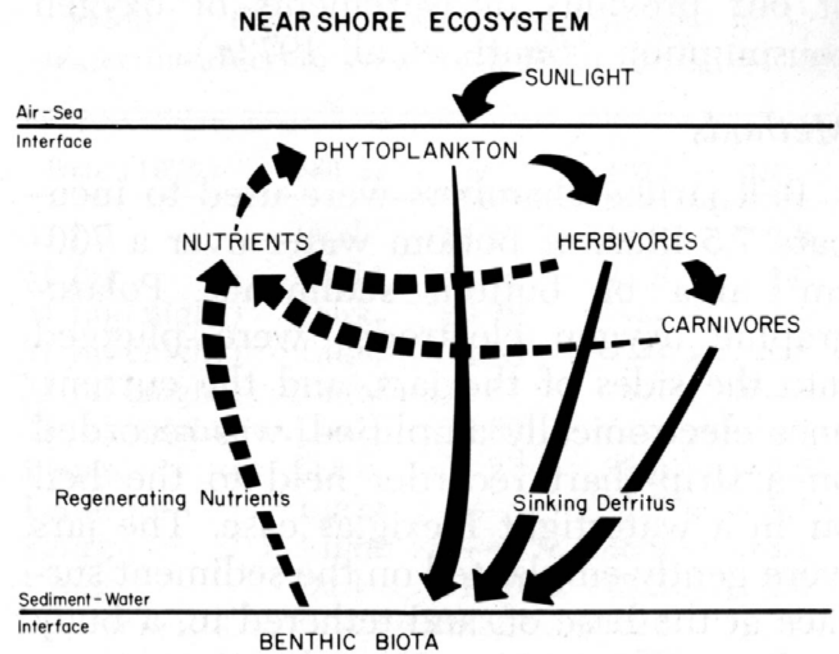


Fig. 1. Nearshore marine ecosystem components, with flows of matter represented by arrows. Dashed arrows are dissolved nutrients and solid arrows are organic matter.