VENUS OCEAN OBSERVATORY MEASUREMENTS OF BENTHIC OXYGEN AND HEAT FLUXES

Rhea D. Sanders[1], Clare E. Reimers[1], Andrea Albright[1], Richard Dewey[2], Paul Macoun[2], and Rick Noel[3]

[1] College of Earth, Ocean and Atmospheric Sciences, Oregon State University, USA [2] Ocean Networks Canada, University of Victoria, BC [3] Rockland Scientific Instruments, Victoria, BC

INTRODUCTION

An eddy correlation (EC) system installed on the VENUS cabled subsea network has resulted in an unprecedented, 7-month time-series of high resolution (32 Hz) oxygen, temperature, and velocity data. The study site is located at 104 m depth in Saanich Inlet on the west coast of Canada. A natural sill exists towards the entrance to the inlet that restricts flow and causes seasonal hypoxia (Matabos et al. 2012).

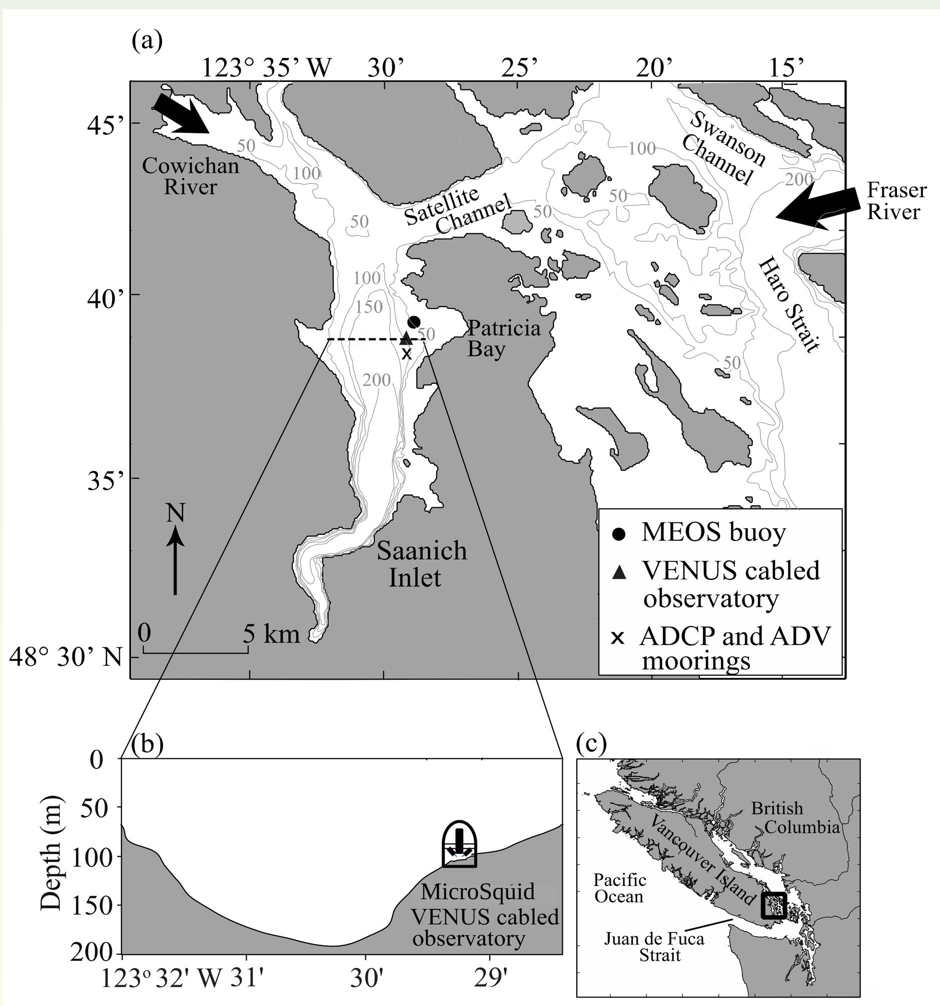

Figure 1. Location of the VENUS Saanich Inlet observatory on the south end of Vancouver Island, BC and the deployment site of the MicroSquid at ~104 m depth (note Squid is not to scale). Map revised from Sato et al. (in review).

INSTRUMENTATION

- A Rockland Scientific MicroSquid EC system was deployed by the ROV *Oceanic Explorer* from aboard the *CCGS Tully*.
- The EC system relies on two sensor units that send high resolution analog signals from oxygen and temperature microsensors to a Nortek Vector.
- The microsensors are an AMT galvanic oxygen electrode and a Rockland FP07 thermistor.

Figure 2. (a) EC system includes Nortek Vector, RSI temperature and oxygen sensor units mounted in a "birdcage" ROV-deployable frame. **(b)** close-up of microthermistor (left) and oxygen microelectrode (right).

OBSERVATORY & DATA PROCESSING

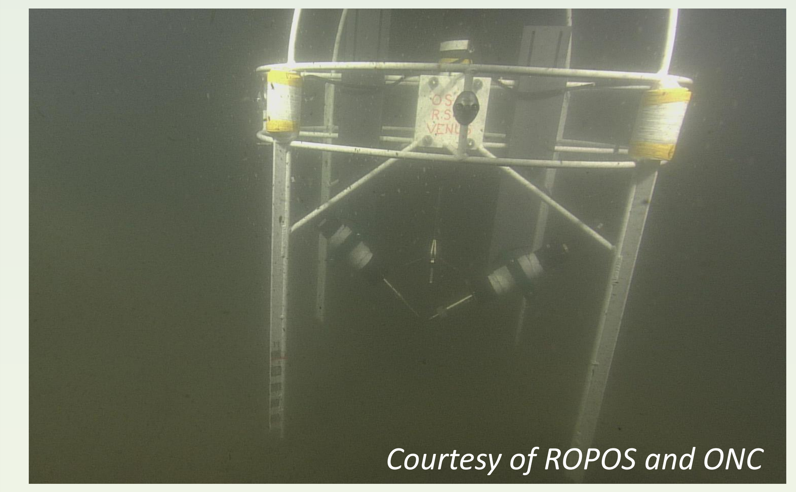

Figure 3. The MicroSquid deployed.

Figure 4. Example of an ONC Node.

- Ocean Networks Canada (ONC) VENUS coastal observatory includes permanent underwater cabled nodes with wet mateable ports to support scientific instrumentation. An interface layer, developed by ONC, communicates to the instruments. Commands sent and records received are UTC time stamped and stored in a HEX log file.
- Data is downloaded via the ONC web portal then processed following methods outlined in Berg et al. 2003, 2008, Crusius et al. 2007 and Reimers et al. 2012.
- The 32 Hz raw data is despiked, calibrated and reduced to 8 Hz.
- Each 30 min. burst is detrended in frequency domain with a 0.002 Hz frequency filter and the velocity coordinates rotated until the mean vertical velocity = zero.
- The eddy flux for each burst is derived as Flux = $\overline{V_z'c'} = \int_{0.002}^{\infty} Co_{V_z'c'}(f)df$ where V_z' is the fluctuating portion of the vertical velocity, c' is the fluctuating component of the oxygen concentration, $Co_{V_z'c'}$ is the cospectrum of these parameters, and f is the frequency.

HOW MUCH FLOW IS TOO SLOW?

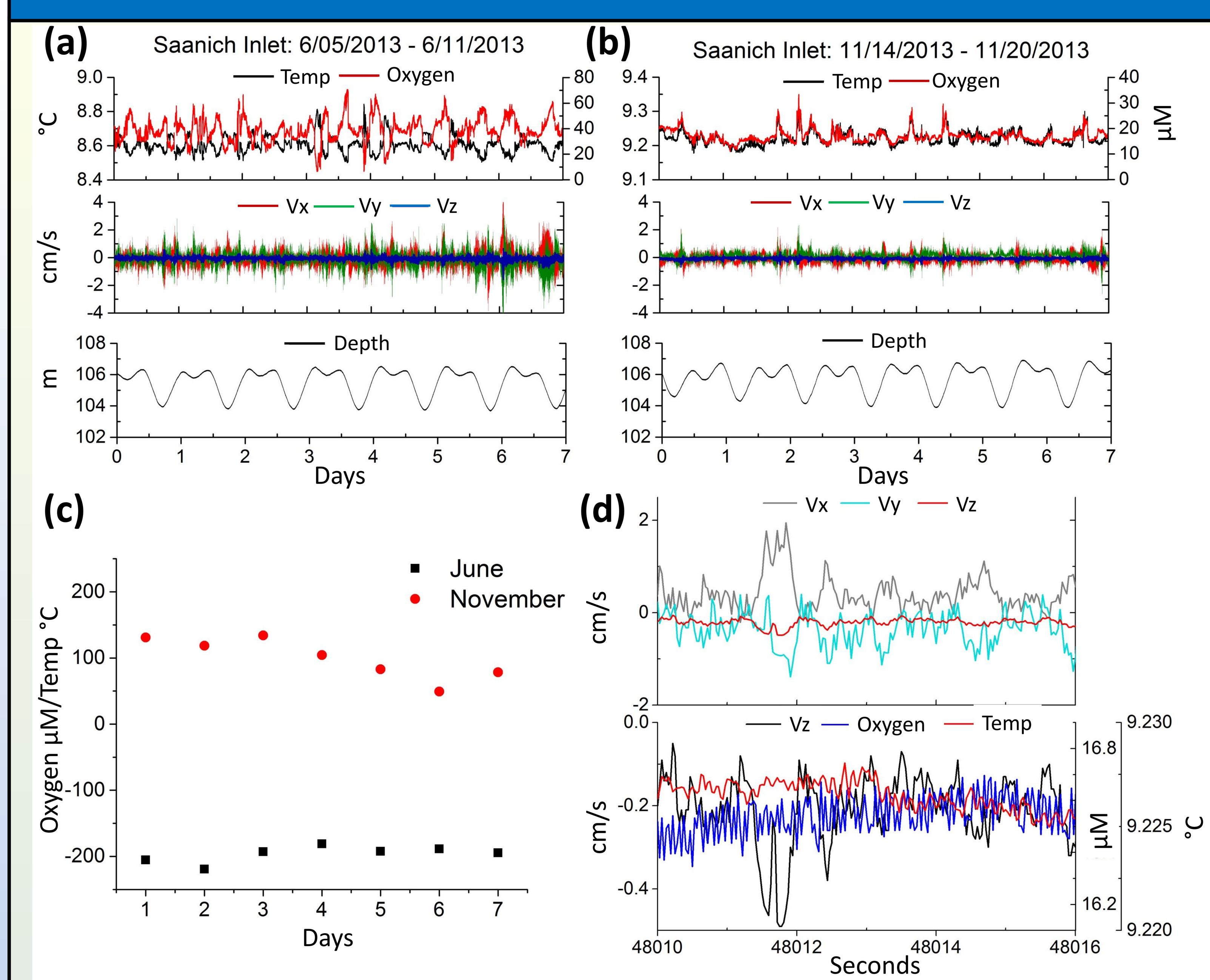

Figure 5. (a) and **(b)** illustrate two individual weeks of sensor data from the EC system while cabled in Saanich Inlet (1 Hz), **(c)** presents daily correlation slopes of O_2 and temperature that change seasonally, **(d)** shows a 6 second time interval demonstrating the absence of correlation between the vertical velocity, O_2 and temperature (32 Hz).

Table 1. Summary of the comparative O_2, temperature and velocity parameters for each of the seasonal weeks presented in Fig. 5 (n=329, 30 min. bursts).

Variable Mean	June	November
O_2 (µM)	38.6 ± 9.0	17.1 ± 2.3
Δ O_2 (µM/hr)	-0.1 ± 13.7	-0.4 ± 4.1
O_2 flux (mmol/m^2/day)	-0.3 ± 10.5	0.3 ± 4.7
Temp (°C)	8.60 ± 0.05	9.20 ± 0.02
Δ Temp (°C/hr)	0.00 ± 0.07	0.00 ± 0.03
Heat flux (W/m^2)	0.05 ± 2.32	0.15 ± 1.64
Current speed (cm/s)	0.54 ± 0.26	0.33 ± 0.13
Δ Current speed (cm/s/hr)	0.01 ± 0.67	0.01 ± 0.40
Vz (cm/s) (non-rotated)	-0.10 ± 0.42	-0.08 ± 0.07

- The depth of the EC system (~105 m) is below the natural sill (~75 m) of Saanich Inlet limiting deep basin tidal and wind mixing and creating a stratified water column. For the Benthic Boundary Layer (BBL) this results in (see Fig. 5):
  - very weak flow velocities averaging < 1 cms^{-1}
  - hypoxic (< 63 µM) bottom waters for most of the year
  - variations in velocities mainly caused by internal tides
  - a seasonally variable relationship between temperature and O_2
- During our EC observatory trial we learned that the galvanic AMT oxygen microsensor proved to be better suited for long duration deployments (months) than the standard Clark-type microsensor commonly used for EC measurements.

DISCUSSION & FUTURE WORK

- The Saanich Inlet initial test site is not well suited for application of the EC method because of low turbulence. Brand et al. (2008) have shown that without flow velocities >2 cms^{-1} and vertical variations greater than 0.1 cms^{-1}, bottom shear and associated turbulence are insufficient to transport DO through the BBL, even though periodic convective mixing may still be present.

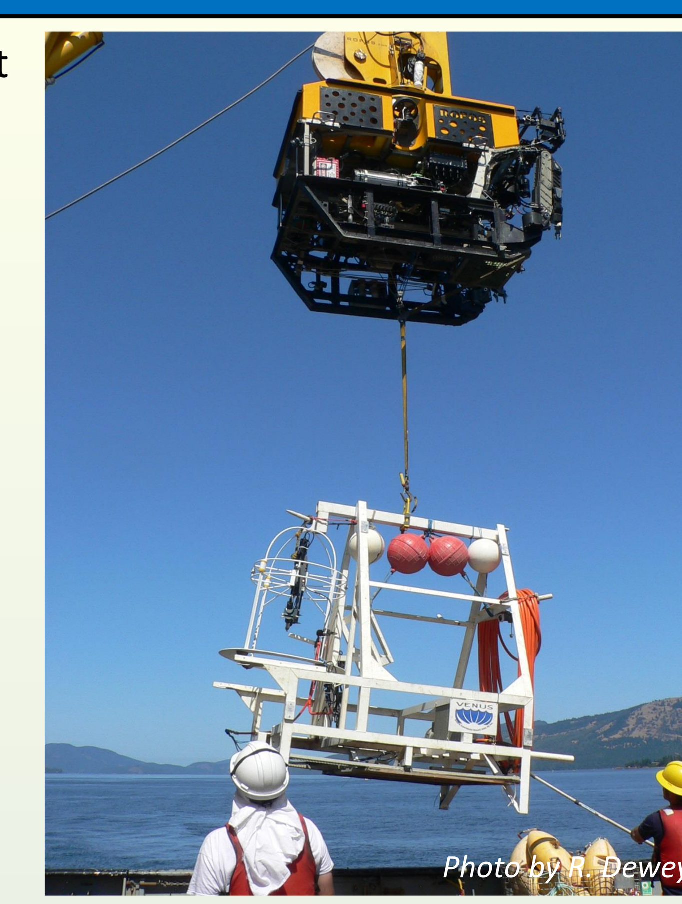

Figure 6. The EC system being deployed.

- This international collaborative study demonstrates the potential for the eddy correlation method to be a valuable addition to ocean observatories in areas characterized by greater velocities.
- For the next phase of our research we plan to deploy two EC systems on the ONC Straight of Georgia Central node located at 300 m depth where conditions are better suited for deriving benthic fluxes by the EC technique.

ACKNOWLEDGEMENTS

We thank our collaborators at the Ocean Networks Canada and the Rockland Scientific Instruments. Funding for this project was provided by the M. J. Murdock Charitable Trust.