June 2016

CORAL Carpenter calibration

Instrument name: MiniDOT logger (O_2 measurements), Nortek Aquadopp Acoustic Doppler Profiler (ADP), Sexton Corporation Water Sampler, Nortek Acoustic Doppler Velocimeter (ADV), Nobska Modular Acoustic Velocity Sensor, Biospherical PAR sensor, and Seabird Conductivity, Temperature, and Depth logger.

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I. Introduction

Two methods to measure reef metabolics were used: 1) Langrangian transect method that spanned an entire reef (~400 m), and 2) gradient flux method (~30-150 m^2).

Langrangian transect. The instruments deployed at the upstream station consisted of a SAMIpH (Sunburst Sensors, Missoula, MT) to measure pH, a Nortek (Boston, MA) Aquadopp acoustic Doppler profiler (ADP) to measure 3-D velocity of water flux at one minute intervals in10-cm bins from 10 cm above the instrument to the water surface, and an optical oxygen sensor (MiniDOT, PME, Vista, CA). The same instruments were deployed at the downstream station together with a Biospherical (San Diego, CA) 2π underwater irradiance sensor connected to a SeaBird (Bellevue, WA) 16Plus CTD, that recorded PAR values each minute. The oxygen sensors have an accuracy of 10 μmol/L and were factory calibrated.

Gradient Flux. Two (Top and Bottom) optical oxygen sensors (MiniDOT, PME, Vista, CA), two Nortek Vector Acoustic Doppler Velocimeter (ADV) and two Nobska MAVs.

Instruments:

MiniDOTs

MiniDOTs measure dissolved oxgen.

Fig. 1: MiniDOT O_2 logger.

Nortek Aquadopp Acoustic Doppler Profilers (ADP)

Aquadopps are placed at each end of our UPDN deployments and are "upward looking" (sensors are level and facing up). They are attached using SS hose clamps to the mobile instrument moorings. ADPs operate by sending sound waves from the instrument into the water column. As the sound waves are reflected by moving particles in the water, the frequency is shifted based on how fast the particles are moving. This Doppler shift is detected by the instrument and converted to a velocity. There are 3 sensors that detect the shift in different planes so that x, y, and z velocities are obtained. Further, the instrument detects the timing between the sound emission and the reflected sound detection so that it can sample velocities in bins at different distances from the instrument. The number of bins is determined by water depth and is entered during the setup.

Nortek Vector Acoustic Doppler Velocimeter (ADV)

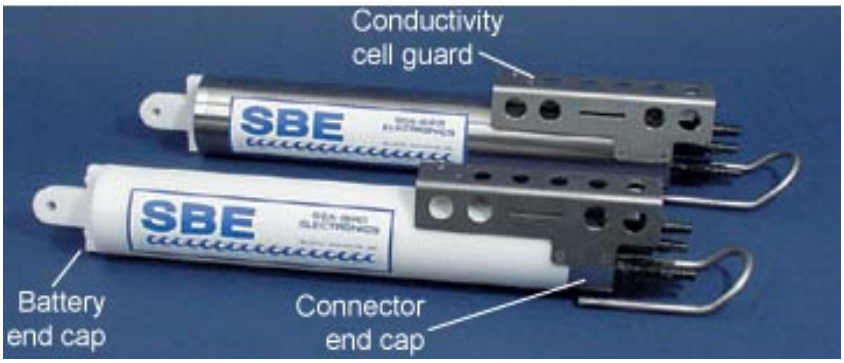
Vectors are placed at the top and bottom of the GF stand (GFA). ADVs operate by sending sound waves from the instrument into the water column. As the sound waves are reflected by moving particles in the water, the frequency is shifted based on how fast the particles are moving. This Doppler shift is detected by the instrument and converted to a velocity. There are 3 sensors that detect the shift in different planes so that x, y, and z velocities are obtained at a fixed distance from the central sensor (14.7 mm). The size of the box in which the velocities are sampled can be modified by the user.

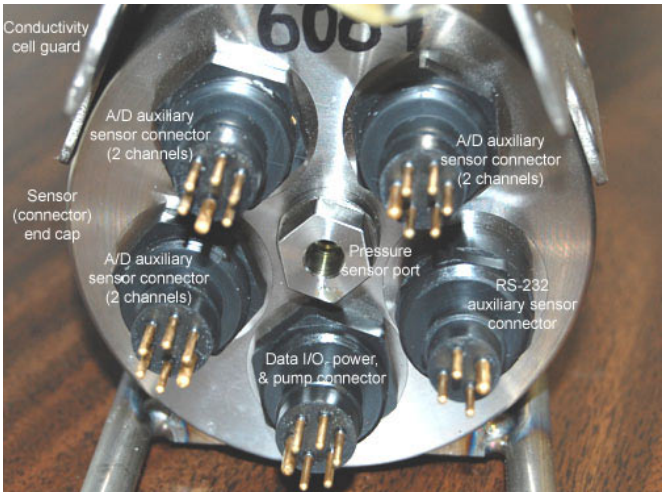
Nobska MAVs

MAVS (top and bottom) are deployed on Gradient Flux stand (GFB) and operate similarly to the ADVs.

Biospherical PAR Sensor/Seabird CTD

The cosine corrected PAR sensor is plugged into one of the voltage ports of the Seabird (top port). Connect the data/communications cable to the bottom port on the CTD and to the serial port on the computer.





SAMIpH

It records hourly values of pH. SAMI's sample on the hour and must have DI water bag connected to inlet during sample period. When not in the water is connected to a DI water bag.

II. Calibration / Maintenance

Before and after each deployment, the paired MINIDOTS (up and down for UPDN, top and bottom for GF) are deployed together over a >12hour period (usually overnight) at a dock. These cross calibrations (xcalib) are used to correct for small differences between instruments during the deployment. A regression with an r^2=1 indicates that there is no variability between the pair of O_2 loggers. The stated accuracy is 10 μmol/L so we want the paired instruments to be as close as possible, especially for the GF measurements. After data are downloaded (see below), plot the readings from each instrument against the other and fit a regression line. We will use the mean of those regressions (before xcalib, after xcalib) to correct the deployment data. Save the data files as: xcalibmonthdayyear(up/dn)(top/bot). An example might be: xcalib61016up.

III. Deployment / Sample Collection

Prior to deployment, the O_2 sensors were moored together overnight to provide cross-calibrations. The sensors recorded oxygen each minute over the course of the deployment.

To obtain estimates of large scale reef metabolism using the Langrangian method, 2 MiniDOTs were deployed simultaneously upstream and downstream to measure changes dissolved oxygen concentration as water flows over an entire reef flat. Differences in dissolved oxygen concentrations were used to detect periods of reef respiration and photosynthesis.

Smaller scale estimates of reef metabolism were determined using the gradient flux method. MiniDOTs were positioned 0.1 and 1.1 m above the seafloor on a gradient flux stand.

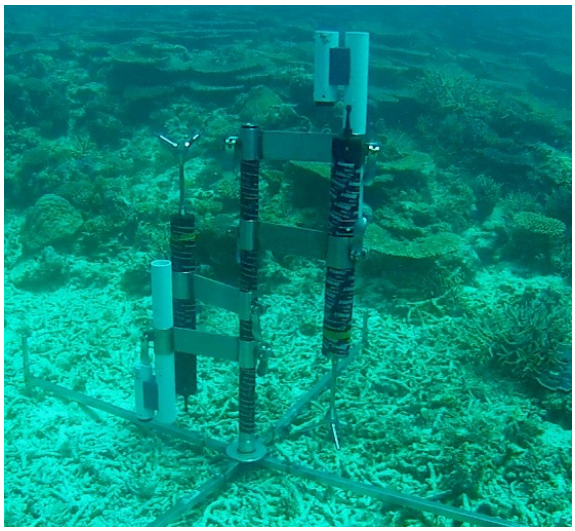


Fig. 2: Gradient flux instrument stand. MiniDOTs are positioned in 2 white pvc covers 0.1 and 1.1m above the seafloor.

The sample interval for each measurement is 1 minute for both Langrangian and gradient flux methods.

MINIDOTS Downloading Data

After a deployment, retrieve, rinse in FW, and dry the instrument before opening (again not contacting the sensing foil). Open the instrument and move the switch to Halt to stop recording. Connect to instrument and open the data folder. Data files are stored for each day; insure that there is the correct number of files. Return to the main instrument window and select Concatenate. This program will append all the files into a single file. To do this, you have to choose and enter the barometric pressure (in millibars) for the depth of deployment. Also enter the salinity (we can always use 35 psu). Select Concatenate and a single file (called Cat.txt) will be saved in the data folder.

AQUADOPPS DEPLOYMENT

Frequency:	2 MHz
Current profile:	60 s

Number of cells-	this is depth-dependent, cell size is 0.1 m (see below), so for a 3 m water column you would have 30 cells; it is better to overestimate, it is ok if the last cells are above the water surface
Cell size (m)-	0.1
Average interval (s)-	30
Blanking distance (m)-	0.1

ADV Deployment

Sampling rate-	16 Hz
Nominal velocity range-measured	0.3 or 1 m/s: this needs to be chosen carefully; the velocities cannot exceed this value or ALL of the data will be garbage. So choose a value that you are sure will not be exceeded (within reason). The higher this value, the lower the accuracy of the measurements. In most of our environments, 0.3 m/s should be ok, but occasionally in higher flows, 1 m/s should be chosen.
Burst interval-	600 s; the instrument will record a burst every 10 min at 16 Hz
No. of samples/burst-	480; this will be a 30 s burst at 16 Hz that will record 480 samples

IV. Data analyses :

Data are extracted from the logger using miniDOTPlot software that is included with each logger. Output data are .txt files.

.txt files are converted into .xls files to be read by R script.

To calculate net primary productivity (NPP) from the Langrangian transect method, we use the following equations, where DO = dissolved oxygen

$$NP\ (R)\ =\ \frac{(DO_{DN} - DO_{UP})}{L}\ \frac{(U_{UP}H_{UP} + U_{DN}H_{DN})}{2}\ -\ J_{air-sea}$$

To calculate NPP from the gradient flux method, we use the following equation, where DO = dissolved oxygen:

$$\mathrm{NPP} =\ \rho * \mathrm{Ustar} * \chi * \frac{\mathrm{DO}_{bottom} - \mathrm{DO}_{top}}{\ln(\mathrm{Z2} - \mathrm{Z1})}$$

Calibration files (described previously) are used to correct for differences between deployed pairs of miniDOTs.

Data from when the instruments were out of water were not included for most instruments. All data were submitted raw.
Oxygen data were recorded as mg/L, to convert milligrams (mg) to milliliters (ml), the number of milligrams was multiplied by the density of seawater (1.024), which equals the volume in liters, and then divided by 1,000 to convert liters to milliliters.
PAR data was recorded in uE/m^2/s and then converted to uE/cm^2/s by dividing by 10000.

For the ADP data a R-script code was used to exclude data that should be above the surface according to the depth reading. All Bins were averaged to obtain three Velocities.

```
#V Data
XDN_RM<-
data.frame(DateTime=Vel1DN$DateTime,Means=rowMeans(Vel1DN[,1:BIN],na.rm=TRUE))
YDN_RM<-
data.frame(DateTime=Vel2DN$DateTime,Means=rowMeans(Vel2DN[,1:BIN],na.rm=TRUE))
ZDN_RM<-
data.frame(DateTime=Vel3DN$DateTime,Means=rowMeans(Vel3DN[,1:BIN],na.rm=TRUE))
```

For the ADV, time data and velocity data are at different sampling intervals, so a single data frame with a TimeStamp and Velocity data was created.

V. Additional Information

All the instruments were programmed to record data at the local time (Hawaii, Australia AEST, Guam and Palau), however in Seabass data were reported in UTC.