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CPIES Data Collected Near Hydrostation S Southeast of Bermuda from June 2016 to June 2017

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CPIES Data Collected Near Hydrostation S Southeast of Bermuda from June 2016 to June 2017

Physical Oceanography Technical Report

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1 Setting and Experiment Design

1.1 Introduction

This report focuses on data collected from four current meter equipped pressure inverted echo sounders (CPIES), two with respectively two and one Popeye Data Shuttles (PDS) on them, and two dual-pressure CPIES each with a Paroscientific stable oceanographic sensor (SOS) and a 46K sensor that has a long track record of previous deployments with low-drift, deployed from June 2016 to June 2017 near Hydrostation S, 25 km southeast of Bermuda (Figure 1). The CPIES were moored at similar depths, ranging from approximately 3400 to 3600 m, at sites numbered clockwise around Hydrostation S as P1, P2, P3, and P4.

Serial hydrographic observations began at Hydrosation S in 1954. Currently, full water column CTD stations are taken twice-monthly within a radius of approximately 2 to 3 km of the nominal Hydrostation S position (32° 10‘N , 64° 30‘W). The CPIES sites were chosen to be close to Hydrostation S, but outside the approximate 3 km region of CTD casts. The CPIES were deployed with approximately 3 to 5 km site separation to investigate submesoscale and geostrophic pressure differences associated with eddy currents. The entire array is approximately 7 km by 7 km.

The measurements presented here were made with support provided by the National Science Foundation (Award number OCE-1358470). The one-year deployment was primarily an instrumentation-development test of the the two dual pressure CPIES and two CPIES with PDS. This report will document the standard CPIES data only, not the SOS nor the PDS data.

1.2 CPIES Description

A CPIES is a URI manufactured inverted echo sounder with a Paroscientific pressure sensor housed in a single glass sphere, and an Aanderaa Doppler Current Sensor (DCS) tethered 50 m above with additional flotation (Figure 2). The CPIES is kept stationary by an anchor stand to prevent movement from affecting the pressure measurement. Temperatures are measured by both the pressure sensor and the DCS.

For the Bermuda field work, two models of GSO/URI Model 6 CPIES were used, each with modifications to standard CPIES. The two model 6.1E2 IESs (SNs, 169 and 170) were modified to be PDS-enabled and the two model 6.2B IESs (SNs 229 and 230) included second pressure sensors, model SOS. All pressure sensors were 46K models (0–6000 psi full scale range). The primary pressure sensors in the CPIES had all been deployed previously and were chosen for their low drift rates. Two models of Aanderaa DCS were used during the field work: Model 3820R and Model 4930R (also known as ‘Zpulse’).

Measurements of vertical acoustic travel time (tau, τ), pressure and temperature and DCS u, v and temperature were made every 10 minutes. The SOS pressure sensors sampled on the same schedule as the standard pressure sensors. To avoid cross-talk between neighboring CPIESs, their sampling times were offset to begin 00, 02, 04, and 06 minutes after true UTC, respectively for sites P1 to P4. Our time-reference stopwatch was set to true UTC (within <1 sec) in accord with NIST time over the internet and the onboard GPS receivers, which we confirmed (by the stopwatch) were automatically corrected for the accumulated offset GPS-UTC=17 sec in years 2015-16.

1.3 Data Recovery

The Bermuda fieldwork consisted of deployment and recovery cruises (Table 1). CPIES locations, shown in Figure 1, are listed in Table 2 together with the duration of deployment and nominal depth. Serial numbers of the IES, pressure and current sensors, and Bliley crystal are also tabulated.

Cruise Number	Cruise Dates	Cruise Description
Atlantic Explorer AE1611	12-13 June 2016	Deploy CPIES
Atlantic Explorer AE1711	28-29 June 2017	Recover CPIES

Table 1: IES Cruises.

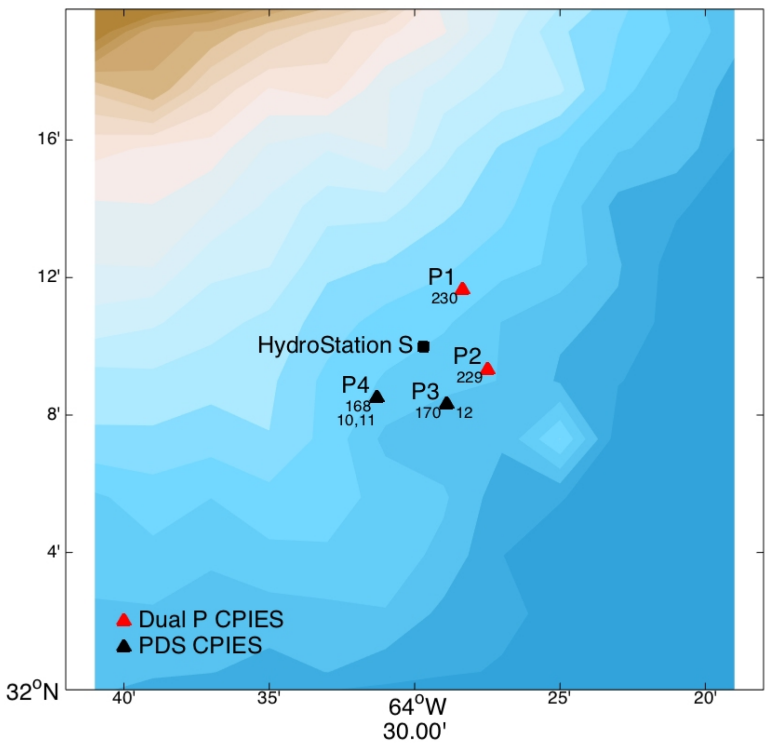

Figure 1: CPIES (triangles) site locations. Bathymetry derives from *Smith and Sandwell* [1997] contoured every 200 m depth: Colors transition from tans representing shallow depths to light and darker blues representing successively greater depths. The CPIES serial number is listed below the site designator. PDS serial numbers are listed with their respective PDS-enabled CPIES. Square denotes the location of HydroStation S.

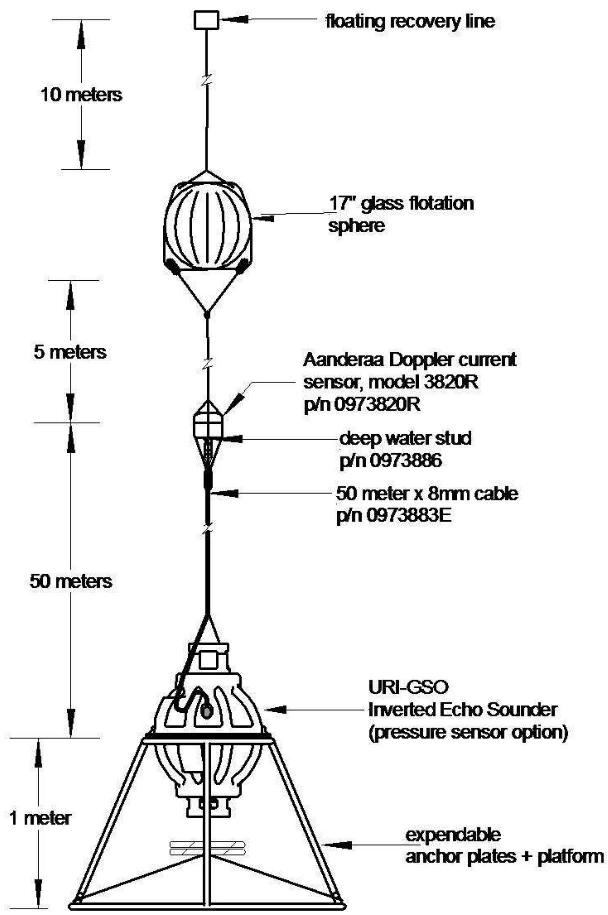

Figure 2: CPIES Schematic.

Table 2

Site	IES SN	Paros SN	SOS SN	DCS SN	DCS Model	Bliley SN	Latitude (°N)	Longitude (°W)	$\overline{p_{bot}}$ (dbar)	Clock Offset (min)	Launch Date	Recovery Date
P1	230	75157	132139	758	3820R	60801	32.19	64.47	3424	0	06/13/2016	06/29/2017
P2	229	36883	132137	25	4930R	50801	32.16	64.46	3675	-2	06/13/2016	06/28/2017
P3	170	90460	N/A	18	4930R	770245	32.14	64.48	3673	-4	06/13/2016	06/28/2017
P4	168	75157	N/A	16	4930R	710245	32.14	64.52	3498	-6	06/12/2016	06/28/2017

Table 2: CPIES Deployment log. Site designators, instrument serial numbers, clock offset from GMT, deployment and recovery dates, deployment locations and bottom depths. For each instrument package, serial numbers are tabulated for the IES, Paroscientific pressure sensor, Paroscientific stable oceanographic sensor (SOS), Aanderaa Doppler current sensor (DCS) and Bliley crystal. DCS Model type is also listed. Latitude and longitudes are from the deployment log sheets.

2 PIES Data Processing

2.1 Overview

Data from the Bermuda project were processed with the MATLAB routines described in *Kennelly et al.* [2007] to produce hourly values. τ, pressure and Paroscientific temperature are windowed and despiked similarly. Pressure is additionally detided and dedrifted. DCS u, v and temperature are processed separately.

2.2 Travel Time

A representative travel time for each hour was selected using a modified quartile method. Using this method, each hourly burst of 24 τ measurements was passed through two stages of windowing to eliminate outliers and to reduce noise. Details of this method can be found in *Kennelly et al.* [2007]. Large spikes were subsequently removed from the hourly travel time record.

2.3 Bottom Pressure

2.3.1 Detiding

Initial detiding removed the tidal contribution (semi-diurnal and diurnal constituents) from the pressure records (despiked but still containing drift) using a FORTRAN program called RESPO (Response Analysis of Tides), based on the work of *Munk and Cartwright* [1966]. After the pressure record has been dedrifted, it is customary to detide the record again to improve the tide prediction. This second pass adds the tides removed by initial detiding to the dedrifted pressure record and then recalculates the tides. The amplitudes and phases of the diurnal and semi-diurnal tidal constituents are listed in Table 3. The tides were added back to the dedrifted pressure for this submission.

Table 3

Site SN	Amp Phase	O1	K1	Q1	P1	M2	K2	N2	S2
P1	H(cm)	5.25	6.36	1.18	2.10	34.34	1.89	7.74	7.88
230	G(deg)	192.97	185.00	187.18	186.40	355.12	26.89	334.68	24.83
P2	H(cm)	5.26	6.37	1.19	2.10	34.39	1.89	7.74	7.88
229	G(deg)	192.10	185.06	186.97	186.51	355.15	26.90	334.65	24.84
P3	H(cm)	5.25	6.35	1.19	2.09	34.34	1.89	7.74	7.88
170	G(deg)	192.17	185.23	186.65	186.72	355.22	26.93	334.69	24.90
P4	H(cm)	5.27	6.38	1.19	2.10	34.30	1.88	7.72	7.84
168	G(deg)	192.36	185.37	186.31	186.94	355.25	27.03	334.76	24.96

Table 3: Amplitudes(H) and phases(G) of the major diurnal and semi-diurnal tidal constituents. IES serial number is listed below the site designator.

2.3.2 Dedrifting

The pressure records were dedrifted by least-squares fitting a linear-exponential curve to the detided measured pressures as described in *Kennelly et al.* [2007]. Real ocean signals may appear like instrumental drift [*Donohue et al.*, 2010]. Cross-verification of the drift curve using the current measurements was not performed, so it is possible that real ocean signals were misidentified as instrumental drift.

2.4 Currents

Anomalously high currents were noted at the beginning of the record for site P1, DCS SN 758, a Model 3820. Ping counts were low over part of the period. A stuck compass at deployment is suspected and current data for the first 350 hours (approximately 15 days) were excluded before the routine processing described next was done. Note the DCS were not tested onboard the ship with the halo prior to deployment. However, tests were performed in the lab on DCS SN 758 to confirm that its compass was working properly upon return to URI. The following tests were performed:

- The DCS test halo was placed on the DCS and several standalone DCS measurements were made to ensure that the device was reporting data back from the test halo. It performed as expected with the halo attached.
- A simple mission using a 10-minute sampling schedule for the DCS was run as it would in operational mode, again with the test halo installed on the device.

- The sample mission was run for approximately 5 hours, turning the DCS periodically so that the values for current speed and direction, as well as compass direction should change. After stopping the mission it was verified that the values for current direction and compass direction were changing in the data file as the device was rotated approximately 90 degrees each turn.

Hourly averages for the Aanderaa DCS velocity components were calculated. Large spikes were subsequently removed from u and v. Two corrections were applied: current directions were adjusted for the local magnetic variation and current speeds were multiplied by a sound speed scale factor, the ratio of the local in situ sound speed to the constant value (1500 m s^{-1}) used during data acquisition.

3 Acknowledgments

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