ONR Inner Shelf Experiment

R/V Kalipi Cruise Report

Jim Lerczak – Oregon State University

1. Kalipi Personnel

Taylor Eaton	Boat Operator	IOP2 and IOP2	Oregon State University
Jim Lerczak	Chief Scientist	IOP1 and IOP2	Oregon State University
Jennifer Thomas	PhD Student	IOP1	Oregon State University
Una Savic	MS Student	IOP1	Oregon State University
Matthew Ball	Undergrad Student	IOP1	Oregon State University
Jacqueline McSweeney	Postdoc	IOP2	Oregon State University
Jenessa Duncombe	Science Writer	IOP2	Oregon State University
Dean Henze	MS Student	IOP2	Oregon State University

2. Mooring/Lander Operations:

09 September 2017: Deployed OC10N-T thermistor string and OC10N-A bottom lander

OC10N-T	15:42 UTC	35 00.245	120 38.790	Thermistor string deployed
OC10N-A	~16:00 UTC	35 00.251	120 38.771	Lander released to bottom

10 October 2017: Recovered OC10N-T thermistor string and OC10N-A bottom lander at ~16:30 UTC.

3. Survey Instrumentation and Data Processing

The principal instrumentation on the R/V Kalipi during the Inner Shelf Departmental Research Initiative (ISDRI) included a side-mounted acoustic Doppler current profiler (RDI workhorse sentinel ADCP, 1200-kHz, S/N 18238), a GPS unit (with its antenna located just above the ADCP mount pole), and a profiling CTD (RBR Concerto, 12 Hz, S/N 65816).

RBR CTD data and processing: The raw CTD data is saved as both *.rsk and *.mat files. For each survey day, the downcast of each profile is identified and saved to a matlab file with the naming convention: Kalipi_MMDD2017_RBRproc_01.mat, where MM and DD are the month and the day, respectively of that particular survey day. The downcast data are stored into a matlab structure (called CTD) and the following variables:

CTD.T	Temperature for each downcast
CTD.C	Conductivity for each downcast
CTD.S	Salinity for each downcast (RBR Ruskin software processing)
CTD.P	Pressure for each downcast (corrected for atmospheric pressure variations, though I found that this was no more than a 2 cm correction, usually less than 1 cm).
CTD.time_dnum	Matlab datenum for each sample of the downcast
CTD.lat	Latitude for each sample of the downcast
CTD.lon	Longitude for each sample of the downcast
CTD.x	Easting (m) for each sample of the downcast (I think in the same reference frame that everyone else is using.
CTD.y	Northing (m) for each sample of the downcast.
dnCTD	Matlab datenum for each cast (average over the period of the cast)
latCTD	latitude for each cast (average over the period of the cast)
lonCTD	longitude for each cast (average over the period of the cast)
xCTD	Easting (m) for each cast (average over the period of the cast)
yCTD	Northing (m) for each cast (average over the period of the cast)

The downcast data is then interpolated onto a uniform vertical grid (stored in matlab data files Kalipi_MMDD2017_RBRproc_01_gridded.mat). To grid the cast data onto a uniform vertical grid some smoothing must be done, but my choice was to use as small a scale that the data allows. I chose to use a LOESS filter, which has better spectral properties than a box car and can be easily implemented when data is non-uniform (as is the case for a CTD cast for which delta p is not uniform). The half-power cut-off filter I chose is tau = 0.25 dbars. With this tau, the filter doesn't work for about 1 percent of the grid points (because there are not enough data points close enough to that grid point for the filter to work). For these few grid points, I linearly interpolated from the points above and below. I think this is OK, but I could choose another tau. For example, if I use tau = 0.5 dbars, then the filter works at all grid points at the expense of some smoothing that may not be necessary.

For this processing, no attempt has been made to correct for 'salinity spiking'. For the ISDRI experiment, the salinity range is quite small. But there are clear indications of salinity spiking in the data at times with a strong temperature gradient is crossed. We should be able to play with lags between T and C to correct for some of the spiking. Another approach is to establish a T/S relationship (over an 'appropriate' period of time, and away from periods of obvious salinity spiking) and just use that to get salinity from temperature.

ADCP data and processing: While standard procedures were used to setup the ADCP and record data, some changes to the procedure were made during the experiment. These changes are noted in the table below.

Day	Bin width (m)	# Bins	Z_0 (m)[1]	Dis1 (m)[2]	Acquisition software
10 Sept	0.25	190	0.49	0.61	WinRiver
11 Sept	0.25	190	0.49	0.61	WinRiver
12 Sept	0.25	190	0.73	0.61	WinRiver
13 Sept	0.25	190	0.73	0.61	WinRiver
14 Sept	0.25	190	0.73	0.61	WinRiver
16 Sept*	0.25	120	0.73	0.53	VMDAS
17 Sept	0.5	65	0.73	1.03	VMDAS
11 Oct	0.5	60	0.73	1.03	VMDAS
13 Oct	0.5	60	0.73	1.03	VMDAS
14 Oct	0.5	60	0.73	1.03	VMDAS

[1]Distance from water surface to ADCP transducer head.
[2]Distance from ADCP transducer head to center of first ADCP bin (as reported in the fixed leader of each data ensemble.
*For the last transect on this day (and for all subsequent survey days), the processing mode in VMDAS was switched to 'low-resolution (long range)' from 'hi-resolution (short range)' in attempt to increase the profiling range of the ADCP. As a consequence, the data is somewhat noisier compared to the earlier surveys. It is not clear that this change increased the range significantly.

Three processed ADCP matlab files for each survey day were generated: Kalipi_MMDD2017_readrawadcp.mat, nav_Kalipi_MMDD2017.mat, and Kalipi_MMDD2017_procadcp.mat. As with the CTD data files, MM and DD are the month and the day, respectively for a particular survey day. For the first, the data from each raw data file for a particular data are put into the following structures (adcp, fl, vl, and fn):

```
adcp.time         ADCP time (decimal day, my convention, but time is in UTC)
adcp.year
adcp.head         magnetic heading
adcp.pitch        pitch
adcp.roll         roll
adcp.head_std     heading standard deviation
adcp.pitch_std    pitch standard deviation
adcp.roll_std     roll standard deviation
adcp.temp         temperature
adcp.v1           velocity 1 (coordinate frame dependent on acq. Software)
adcp.v2           velocity 2
adcp.v3           velocity 3
adcp.v4           velocity 4
adcp.stat1        beam 1 status data
adcp.stat2        beam 2 status data
adcp.stat3        beam 3 status data
adcp.stat4        beam 4 status data
adcp.echo1        beam 1 echo intensity
adcp.echo2        beam 2 echo intensity
adcp.echo3        beam 3 echo intensity
adcp.echo4        beam 4 echo intensity
adcp.perc1        beam 1 percent good
adcp.perc2        beam 2 percent good
adcp.perc3        beam 3 percent good
adcp.perc4        beam 4 percent good
adcp.btd          bottom track depth
adcp.btv          bottom track velocity

fl                fixed leader data for each raw adcp data file
```

```
vl                  variable leader data for each raw adcp data file
fn                  file name for each raw data file
```

The second file, nav_Kalipi_MMDD2017.mat, contains all the relevant gps data that was stored by the acquisition software. The following variables are stored:

```
ddnav       Time of each GPS data point (in UTC and matlab data format)
ltnav       Latitude in decimal degrees
lnnav       Longitude in decimal degrees
xnav        Easting (m) using the standard coordinate frame
ynav        Northing (m) using the standard coordinate frame
lon0, sclx  constants to convert from longitude to easting
            x = sclx*(lon – lon0)
lat0, scly  constants to convert from latitude to northing
            y = scly*(lat – lat0)
```

In the last file, Kalipi_MMDD2017_procadcp.mat, data from all raw files for a particular survey day are concatenated together. Currents are rotated into a fixed-earth (bottom track velocity is removed) true east, true north, and upward coordinate system. The rotation includes a heading correction. This rotation mostly accounts for local magnetic declination, but also corrects for slight magnetic errors about the compass rose (see Fig. 1 below). Data from each raw ensemble is saved (no averaging in time). The bottom depth (relative to sea level) is determined and data within 10% of the bottom and below is removed. The location for each ensemble is determined by interpolation from the navigation data described above. The adcp processed data file contains the following variables:

```
dna   time of each ensemble (in UTC and matlab data format)
z     depth (m) of each ADCP bin referenced to sea level, with downward
      negative
H     water depth (referenced to sea level), with downward negative
T     water temperature (degrees C) from ADCP thermistor
u     true east velocity
v     true north velocity
w     vertical velocity (upward positive)
e1    beam 1 echo intensity
e2    beam 2 echo intensity
e3    beam 3 echo intensity
e4    beam 4 echo intensity
eb    echo intensity average of four beams
hda   magnetic heading (raw, uncorrected from adcp compass)
pta   pitch
rla   roll
lona  longitude of each ensemble
lata  latitude of each ensemble
xa    easting (m) using the standard coordinate frame
ya    northing (m) using the standard coordinate frame
sclx, lon0  constants to convert from longitude to easting (see above)
scly, lat0  constants to convert from latitude to northing (see above)
```

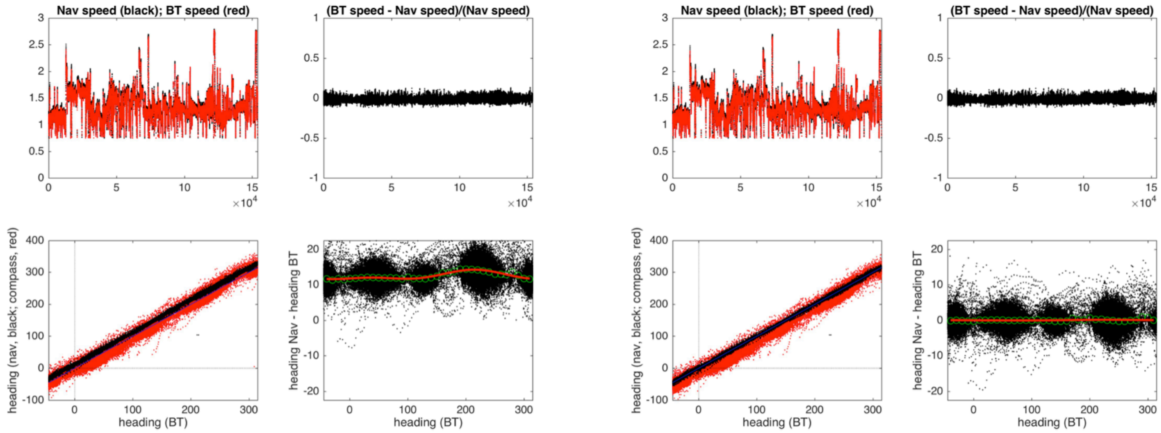

Figure 1. Heading correction for side-mounted ADCP on the R/V Kalipi based on all data from IOP1 and IOP2.

Left four panels are from analysis for uncorrected heading.

Upper left: Boat speed (course over ground) based on gps (black) and adcp bottom tracking (red). Only ensembles are used for which the boat speed (based on both gps and bottom tracking) exceeds 0.75 m/s and for which the difference in boat speed (between gps and bottom tracking) is less than 0.1 m/s.

Upper right: Difference between bottom track and gps based boat speeds normalized by gps boat speed.

Lower left: Boat heading based on gps (black) and based on the ADCP compass (red) vs. heading based on bottom track speed. Note that there is more scatter in compass heading vs bottom track heading (red), because the true heading of the boat (over ground) may differ from compass orientation because course-over-ground may differ from the direction the bow of the boat is pointing. The blue line is the one-to-one line.

Lower right: GPS heading minus bottom track heading ($\Delta\theta$) vs. bottom track heading (θ). The green circles are bin averages of $\Delta\theta$ over 10^{o} bins in bottom track heading. The red line is a harmonic fit to the bin averaged $\Delta\theta$, that includes a mean and two harmonics corrections about the compass rose, according to:

$$\Delta\theta = \theta_0 + a_1 \cos\left(\frac{2\pi}{T_1}\right) + b_1 \sin\left(\frac{2\pi}{T_1}\right) + a_2 \cos\left(\frac{2\pi}{T_2}\right) + b_2 \sin\left(\frac{2\pi}{T_2}\right)$$

where T_1 and T_2 are 180^{o} and 360^{o} respectively, and $(\theta_0, a_1, b_1, a_2, b_2)$ are (12.5043^{o}, 0.2079^{o}, 0.5845^{o}, -0.9415^{o}, -0.5844^{o}). The mean correction very closely matches the magnetic declination near Pt. Sal (12.57^{o} based on the NOAA magnetic declination calculator).

Right four panels are for the corrected heading. Here, the mean and harmonic corrections above are applied to the ADCP compass heading before the bottom track velocity (in Earth coordinates) is calculated. This heading correction is subsequently applied to all water column ADCP currents.

4. Summary of daily survey activities of the R/V Kalipi

The following figures summarize the survey activities conducted by the R/V Kalipi in coordination with other ISDRI vessels. For each day, a map of the survey tracks is shown. In addition, data from a particular transect on that day is shown to highlight some of the features observed.

10 September 2017 R/V Kalipi Operations

South to north transect along 10 m isobaths and north to south transect along 15 m isobath, both synchronous with R/V Oceanus.

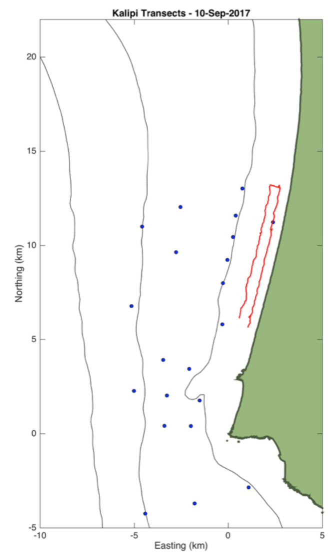

Fig 2. Map of Kalipi transects (red lines) on 10 September 2017.

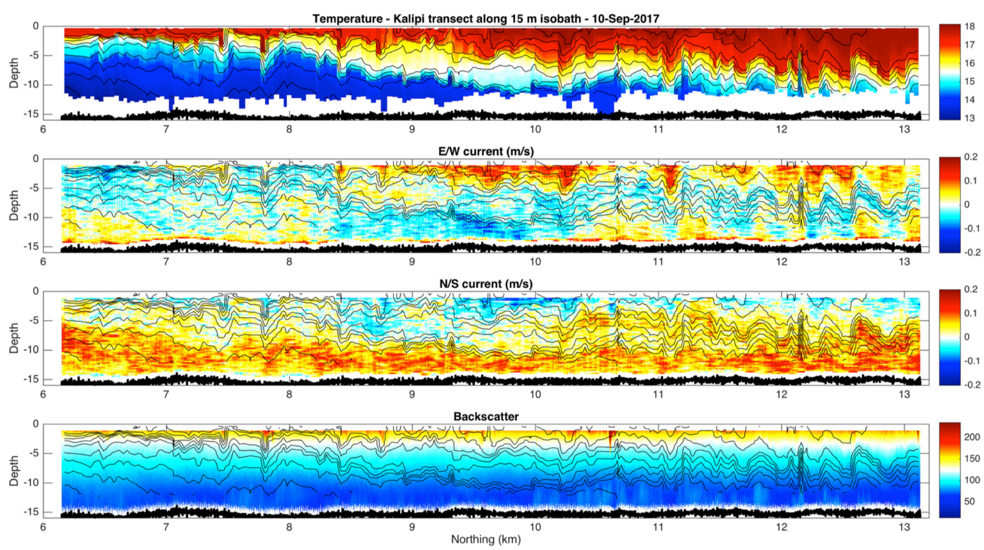

Fig 3. Temperature, E/W current, N/S current and ADCP acoustic backscatter along the transect along the 15-m isobaths on 10 September 2017. Current data is averaged over a 60-s running window.

11 September 2017 R/V Kalipi Operations

Transects along the 15-m isobaths with the R/V Oceanus and cross-shore transects sampling an onshore propagating NLIW with a strong surface convergence and foam line.

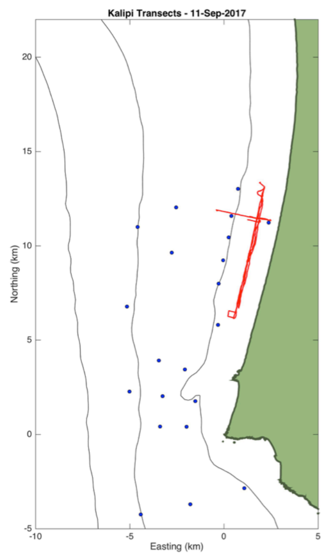

Fig 4. Map of Kalipi transects (red lines) on 11 September 2017.

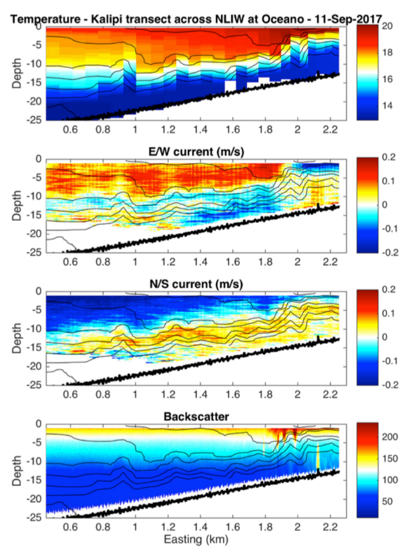

Fig 5. Temperature, E/W current, N/S current and ADCP acoustic backscatter along a cross-shore transect at Oceano crossing a NLIW (with strong foam line) on 11 September 2017. Current data is averaged over a 60-s running window.

12 September 2017 R/V Kalipi Operations

Pt Sal survey. Box pattern on the north side of the point. Four boxes were completed.

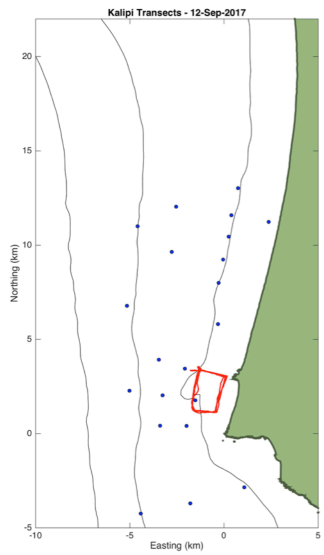

Fig 6. Map of Kalipi transects (red lines) on 12 September 2017.

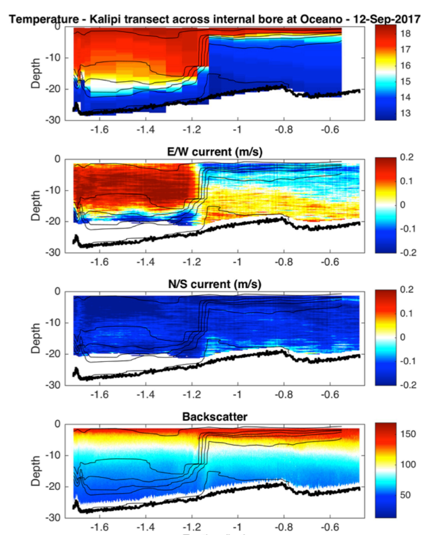

Fig 7. Temperature, E/W current, N/S current and ADCP acoustic backscatter along a cross-shore transect at Pt Sal on 12 September 2017. A sharp bore is crossed, indicated in both the temperature and E/W current structure. Along-shore flow is uniformly to the south (negative). Current data is averaged over a 60-s running window.

13 September 2017 R/V Kalipi Operations

The day began with box surveys at the north side of Pt. Sal. A little more than three boxes were completed. This was followed by an along-shore transect near Oceano along the 12-m isobaths with the R/V Sounder (6-m isobath), the R/V Sproul, and the UW aircraft. Finally, a cross-shore transect was conducted between OC17N-T and OC10N-T to sample a NLIW.

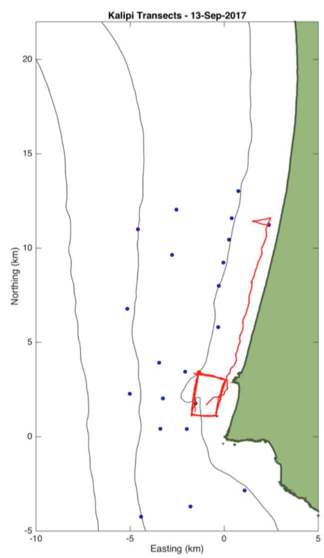

Fig 8. Map of Kalipi transects (red lines) on 13 September 2017.

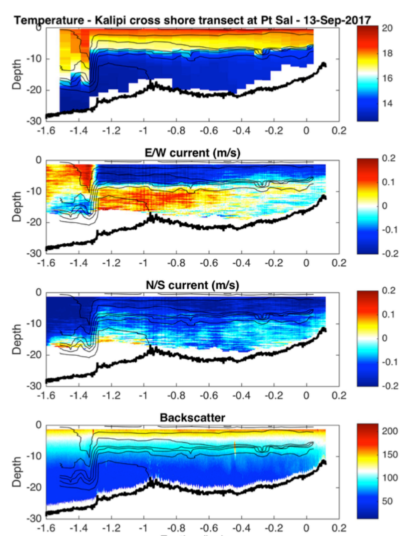

Fig 9. Temperature, E/W current, N/S current and ADCP acoustic backscatter along a cross-shore transect at Pt Sal on 13 September 2017. A sharp bore is crossed, indicated in both the temperature and E/W current structure. Current data is averaged over a 60-s running window.

14 September 2017 R/V Kalipi Operations

Box surveys at Oceano between the 20 m and 10 m isobaths. Five boxes were completed.

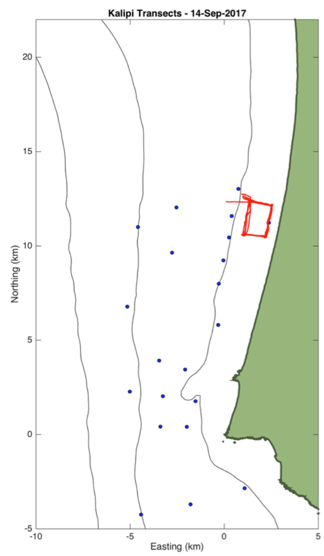

Fig 10. Map of Kalipi transects (red lines) on
14 September 2017.

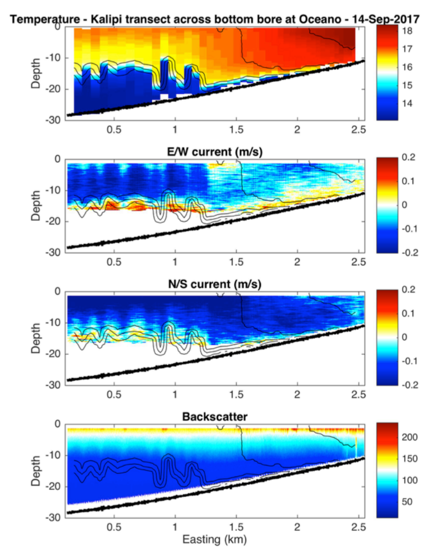

Fig 11. Temperature, E/W current, N/S current and ADCP acoustic backscatter along a cross-shore transect at Oceano on 14 September 2017. A bottom bore, indicated in both the temperature and E/W current structure, propagates toward the coast. Current data is averaged over a 60-s running window.

16 September 2017 R/V Kalipi Operations

Along-shore surveys on 17-m isobaths, coordinated with Sally Ride, Oceanus, Sounder and Sally Ann. Four transects completed.

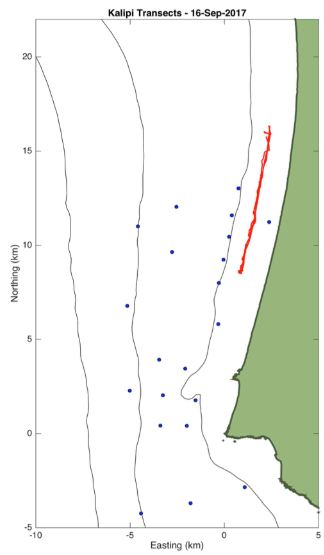

Fig 12. Map of Kalipi transects (red lines) on 16 September 2017.

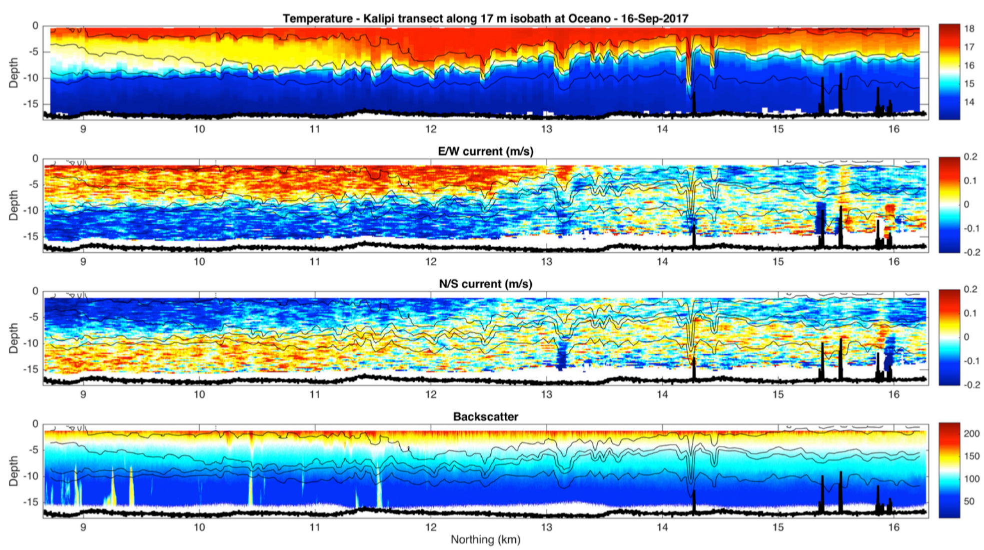

Fig 13. Temperature, E/W current, N/S current and ADCP acoustic backscatter from a transect along the 17 m isobath at Oceano on 16 September 2017. Current data is averaged over a 60-s running window.

17 September 2017 R/V Kalipi Operations

Surveys at Pt Sal with Sally Ride, Sounder and Sally Ann. Kalipi operations were cut short at 18:32 when its alternator belt broke.

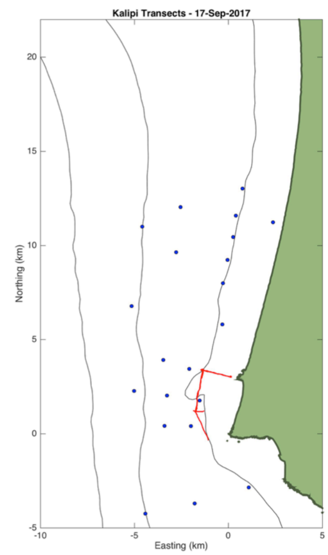

Fig 14. Map of Kalipi transects (red lines) on 17 September 2017.

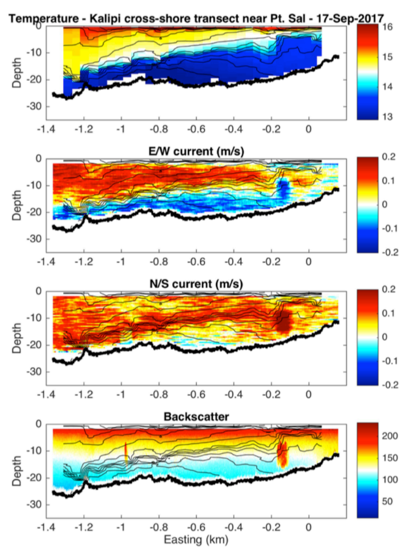

Fig 15. Temperature, E/W current, N/S current and ADCP acoustic backscatter from a cross-shore transect near Pt. Sal on 17 September 2017. Current data is averaged over a 60-s running window.

11 October 2017 R/V Kalipi Operations

Alongshore surveys from alongshore points N8 to N15 with Sally Ann (6 m isobaths), Sounder (12 m), Kalipi (17 m), and Oceanus (23 m). The Kalipi completed three surveys and just started a fourth as wind and wave conditions increased.

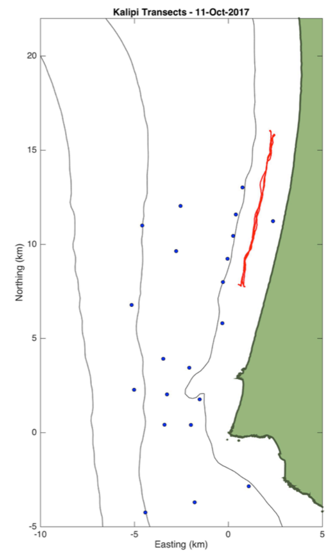

Fig 16. Map of Kalipi transects (red lines) on 11 October 2017.

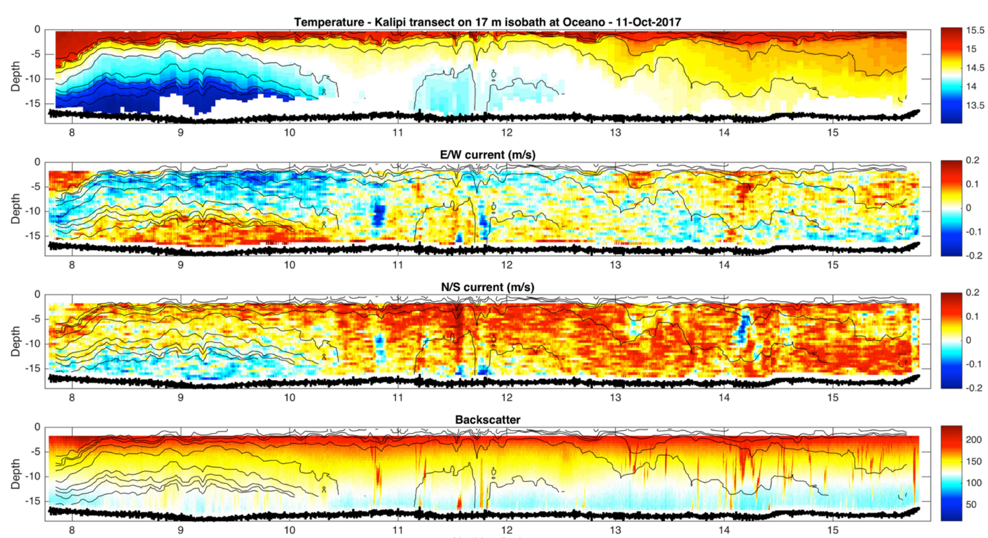

Fig 17. Temperature, E/W current, N/S current and ADCP acoustic backscatter from a transect along the 17 m isobath at Oceano on 11 October 2017. Current data is averaged over a 60-s running window.

13 October 2017 R/V Kalipi Operations

Along-shore surveys at Oceano with other vessels. One line along the 17 m isobaths waw completed. Then a short line along the 12 m isobath (from N13 to N17) was completed.

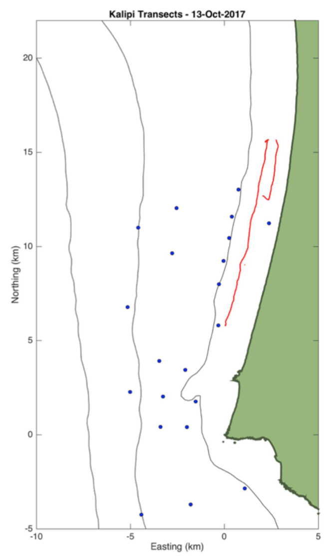

Fig 18. Map of Kalipi transects (red lines) on 13 October 2017.

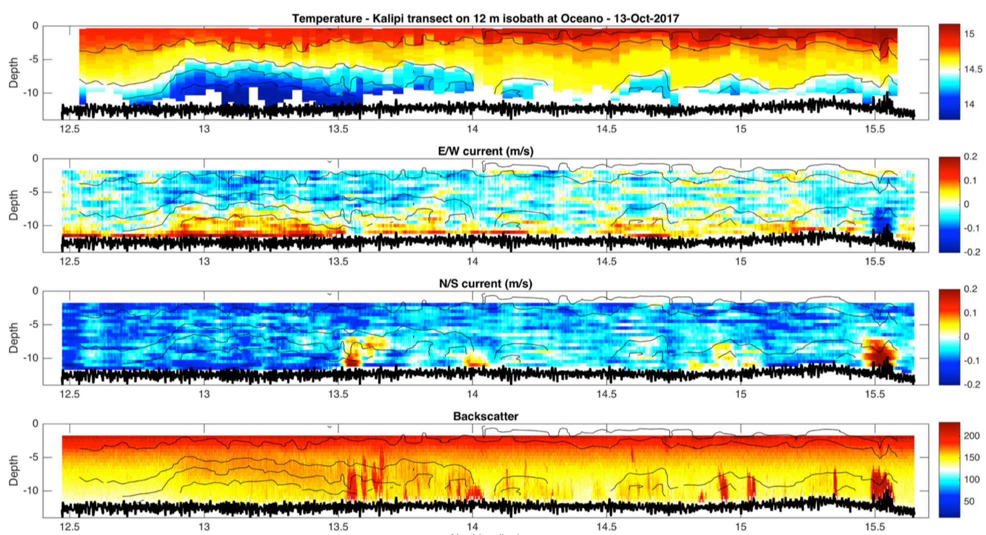

Fig 19. Temperature, E/W current, N/S current and ADCP acoustic backscatter from a transect along the 12 m isobath at Oceano on 13 October 2017. Current data is averaged over a 60-s running window.

14 October 2017 R/V Kalipi Operations

"C" transects around Pt Sal. Three C-transect surveys were completed.

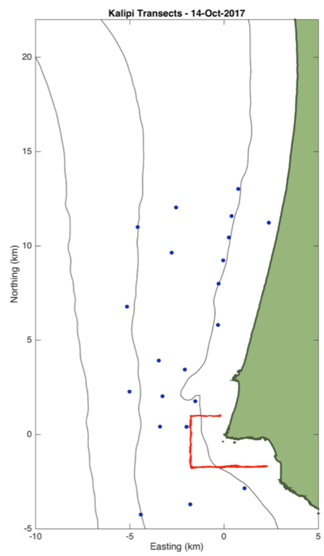

Fig 20. Map of Kalipi transects (red lines) on
14 October 2017.

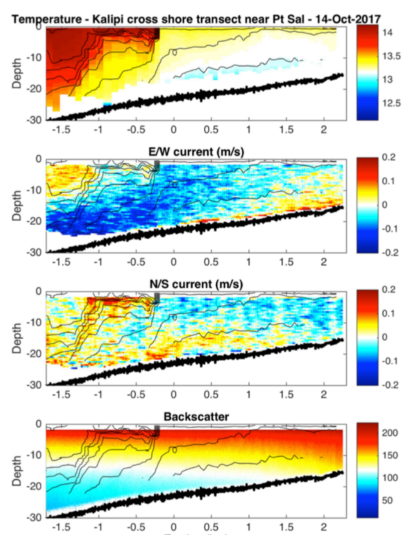

Fig 21. Temperature, E/W current, N/S current and ADCP acoustic backscatter from a cross-shore transect to the south of Pt Sal. on 14 October 2017. Current data is averaged over a 60-s running window.