Cruise Report

California Current Ecosystem LTER Program
CCE-P0810, Process Cruise #3
R/V MELVILLE, 29 September - 28 October, 2008

Compiled and submitted by: Michael R. Landry, Chief Scientist
Scripps Institution of Oceanography, Univ. California, San Diego

Cruise ID: CCE-P0810, aka BOLT01MV
Depart: 29 September 2008 at 0800 (PST)
Return: 28 October 2008 at 0700
Vessel: R/V MELVILLE
Operator: Scripps Institution of Oceanography
Master: Captain Christopher Curl
Chief Scientist: Michael R. Landry
Marine Technicians: Jim Dorrance, John Calderwood, Kris Weeks

Contents

Cruise Personnel ................................................................. 2
Science Objectives .............................................................. 3
Overview of the Science Plan ............................................... 3
Ship and Technical Support .................................................. 5
Additional Science and Support Operations ............................. 5
Information Management .................................................... 7
Daily Activity Schedule ....................................................... 7
CCE-P0810: CRUISE PERSONNEL

1. Michael Landry  mlandry@ucsd.edu  SIO Chief Scientist
2. Mark Ohman  mohman@ucsd.edu  SIO Project PI
3. Ralf Goericke  rgoericke@ucsd.edu  SIO Project co-PI
4. Tony Koslow  tkoslow@ucsd.edu  SIO CalCOFI Director
5. Alexander Chekalyuk  chekaluk@ldeo.columbia.edu  LDEO Researcher
6. Konstantin Semyanov  kas2187@ldeo.columbia.edu  Prog Sci (LDEO)
7. Marc Picheral  marc.picheral@obs-vlfr.fr  Visiting Sci. (Villefranche)
8. Kristen Buck  kbuck@ucsd.edu  Post-doc (Barbeau lab)
9. Ana Lara Lopez  analigia@yahoo.com  JIMO Post-doc (Koslow)
10. Qian Li  qian@coast.ucsd.edu  SIO Post-doc (Franks)
11. Ian Ball  gball@ucsd.edu  SIO Grad Student
12. Allison Cawood  acawood@ucsd.edu  SIO Grad Student
13. Moira Decima  mdecima@ucsd.edu  SIO Grad Student
14. Pete Davison  pdavison@ucsd.edu  SIO Grad Student
15. Jenna Losh  jlosh@princeton.edu  Grad Student (Princeton)
16. Ally Pasulka  apasulka@ucsd.edu  SIO Grad Student
17. Byron Pedler  bpedler@ucsd.edu  SIO Grad Student
18. Jessie Powell  jpowell@ucsd.edu  SIO Grad Student
19. Kelly Roe  kroe@ucsd.edu  SIO Grad Student
20. Ty Samo  tsamo@ucsd.edu  SIO Grad Student
21. Mike Stukel  mstukel@ucsd.edu  SIO Grad Student
22. Darcy Taniguchi  datanigu@ucsd.edu  SIO Grad Student
23. Andrew Taylor  agtaylor@ucsd.edu  SIO Grad Student
24. Megan Roadman  meroad@yahoo.com  SIO SRA (Goericke)
25. Haili Wang  HWang@spg.ucsd.edu  SIO SRA (Mitchell)
26. Brian Seegers  bseegers@spg.ucsd.edu  SIO SRA (Mitchell)
27. Dan Wick  dwick@ucsd.edu  SIO SRA (Landry)
28. Jean-Baptiste Romagnan  jbaptiste.romagnan@gmail.com  SIO SRA (Ohman)
29. Jian Liu  jianliu1961@yahoo.com  SIO SRA (Koslow)
30. Dave Jensen  dwjensen@ucsd.edu  Volunteer (Ohman)
31. Christy Millsap  cmillsap@powayusd.com  CCE Teacher-at-Sea
32. Jim Dorrance  jdorrance@ucsd.edu  MarFac STS Res Tech
33. John Calderwood  jcalderwood@ucsd.edu  STS MOC/CTD Tech
34. Kristopher Weeks  kweeks@ucsd.edu  STS Computer Tech
35. Andrew Taylor  agtaylor@ucsd.edu  SIO Grad Student
36. Laurie Guest  lguest@mitacademy.org  CCE Teacher-at-Sea

A. Chekalyuk, Q. Li, A. Cawood, K. Roe, and C. Millsap disembarked in Santa Barbara after leg #1

Leg #2
1. Mark Hafez  hafez@osb1.wff.nasa.gov  NASA Tech (Chekalyuk)
2. Ryan Rykaczewski  rrykacze@ucsd.edu  SIO Grad Student
3. Laurie Guest  lguest@mitacademy.org  CCE Teacher-at-Sea
SCIENCE OBJECTIVES

This was the third Process Cruise of the CCE LTER (California Current Ecosystem, Long-Term Ecological Research) Program, the objective of which is to understand the coupling of physical, chemical and biological dynamics in the California Current ecosystem and, ultimately, the system responses to long-term climate variability. The cruise was designed to investigate the relationships among water-column light, temperature, nutrients, thermocline and nutricline depths, phytoplankton and zooplankton standing stocks, phytoplankton and bacterial growth and production rates, micro- and meso-zooplankton grazing rates, and active and passive contributions to organic export. Our aim was to have this cruise earlier, during the late summer period of maximum stratification. However, the science agenda was adjusted to fit the fall, storm-mixed conditions encountered. The results from this cruise will provide an empirical basis for modeling of CCE late summer/fall dynamics and for comparison to previous cruise studies of spring conditions.

OVERVIEW OF THE SCIENCE PLAN

The science plan was based around 3 long and 3 short activity cycles for which water masses of differing initial characteristics were marked with a drogued drift array and followed over the course of 2-5 days. The cycle sites were situated along the axis of CalCOFI sampling line 80, which extends seaward off Point Conception, California and in the area of biomass accumulation south of the point. We used satellite-tracked drift array for in situ experimental incubations (recovered/redeployed daily) and a drogued drift array with sediment traps at 100 m to assess passive vertical export (sinking particulates).

Daily CTD sampling at 0200 was conducted to assess changes in water mass characteristics due to growth, mortality and associated changes in community composition. Measured variables included: temperature, conductivity, density, nutrients (dissolved inorganic N, P, Si), total organic carbon and nitrogen (TOC, TON), particulate carbon and nitrogen (POC, PON), stable isotopes of C and N, particulate biogenic silica (BSi), thorium-uranium disequilibrium, fluorometric Chla and HPLC accessory pigments, microscopical and flow cytometric assessments of microplankton community composition, and samples for molecular analyses. The same water collection was also used experimentally to assess taxon-specific rates of phytoplankton growth, 14C-primary production and microzooplankton grazing impact by a combination of dilution and pigment labeling approaches. These incubations were conducted for 24 hours in net bags attached on a line below the drift array (therefore incubated under in situ conditions of temperature and light).

Using the drift array as a moving frame of reference, additional CTD sampling was conducted at mid-day for bio-optical parameters, shipboard assessments of primary production, and microbiological studies (bacterial production, bacteria particle interactions, enzyme activities and viral mortality impact), and typically in the evening for additional shipboard experimental studies of mesozooplankton grazing and reproduction. The latter were accompanied by short bongo net tows to collect live animals.
An Underwater Video Profiling system, operated by guest researcher Marc Picheral (Ville-Franche-sur-Mer), was integrated into the CTD package for this cruise, providing a unique data set of video images and quantitative depth profiles of zooplankton and aggregate distributions to 500 m on most casts.

Go-Flo samples were taken for iron (Fe) analyses and for grow-out experimental studies of Fe-limitation. MOCNESS net tows were taken at mid-day and mid-night to determine the depth structure and day-night variability of the meso-zooplankton community. Sampling of mesopelagic fishes and invertebrates was conducted with a large (6 m2) mid-water trawl net to assess the contribution of actively migrating mid-water animals to organic export from the euphotic zone. Bongo net tows were also taken around mid-day and mid-night to get depth-integrated assessments of the zooplankton biomass structure and gut fluorescence in the euphotic zone. One side of the paired nets from these collections was formalin preserved for species identification. The other was size-fractioned on shipboard for biomass (dry weight, C, N) and gut pigment analyses. During each long cycle, bongo net collections were taken at 3-4 h intervals over 24-h to better resolve the diel periodicity in feeding (gut fluorescence) and migration into the euphotic zone. At least twice during each cycle, McLane pumps were used to collect large volume samples from below the euphotic zone and 100 m for the C:Th ratios and the estimation of carbon export by the thorium disequilibrium method.

Daily activities also often included a 4-h bow-tie survey with a free-fall Moving Vessel Profiler (MVP) to determine the variability in water-column characteristics around the drift array, on a 10 x 10 naut mi pattern along and orthogonal to the direction of current flow. These surveys mapped to 200-m depth the 3-D fields of planktonic particles across a size spectrum of 150-6000 µm, Chl a fluorescence, temperature, salinity and density. The MVP was also used to identify major features of interest for the experimental cycles on 5 relatively long west-east sections, and on several crossings of a frontal system. In all, 700 MVP profiles were completed.

In summary, each cycle of activity was designed to follow the temporal evolution of a marked parcel of water for 2-5 days (i.e., the net rates of change in the ambient physical and chemical environment and the biological community) while conducting experimental studies to assess the contributions of phytoplankton and bacterial growth, micro- and meso-zooplankton grazing and active vertical migrations to particle export and net community change. In addition, we investigated a major frontal system that separated the water types studied on two of the shorter experimental activity cycles (5 and 6). This part of the science plan included several daytime crossings of the frontal system with the MVP and surface flow through systems operating, followed by slow speed (6 kts) crossings in daylight and nighttime conditions with the MVP, flow and multi-frequency acoustical systems operating, followed by nocturnal sampling of 9 stations across the front with vertical bongo tows and CTD profiles.

ALL planned science objectives were completed successfully, despite the loss of a little time for specific operations. Some initial site survey and transect work with the MVP were not possible due to equipment problems. We lost ~2 days
initially when the drifters were damaged by faulty battery packs, and we had to make an unplanned stop in Santa Barbara for repairs. In addition, the weather was too rough for about 1.5 days for anything except CTD and drifter work. All drifters and sediment traps were deployed and recovered on schedule, regardless of weather. Some time was saved in planning subsequent transits to optimize the experimental cycles and front study. In the end, one small cycle was dropped with negligible impact on the science program.

**SHIP AND TECHNICAL SUPPORT**

The Resident and Computer Techs, led by Jim Dorrance and Kris Weeks, were superb on this cruise -- just the right amount of lecturing/advising the science party on the fine points of shipboard procedures and safety, combined with their direct participation in all critical deck operations and acquiring and processing ship system data.

The crew was friendly and very supportive of the science. Captain Curl's ship handling was superb, providing tight daily recoveries/redeployment of the drifter array despite occasional poor weather conditions (35-40 kt winds). Chief Engineer Paul Bueren was a huge help in trouble shooting issues with the MVP system (it was necessary to re-do both the electrical and mechanical terminations at sea due to intermittencies in data communications), and 2nd A/E Sabrina Tataboletti did an amazing job putting a badly damaged bongo net frame back into round. Without prior notice of a problem, A/B Cletus Finnell spotted a distressed drifter at dusk that had lost its light strobe and satellite-GPS communication, which led to its successful rescue and redeployment. The drifter and its experiments would likely have been lost during the night without this timely intervention. Engineering also provided two winch operators (CTD and hydro) for the duration of the front study to help run the station operations at a fast pace.

We had a few occasions when the wire read out for the CTD winch did not work in the winch house, which slowed those casts considerably. This however had no measurable impact on the science objectives.

**ADDITIONAL SCIENCE AND SUPPORT OPERATIONS**

We had excellent satellite image support from the SIO photobiology group during the cruise, notably from Mati Kahru. On a daily basis MODIS-Aqua and/or SeaWifs images were posted on a web site accessible to us at sea, permitting us to identify larger-scale near-surface features and processes of interest for our experimental work. This near-real time imagery was valuable in permitting us to follow the evolution of the Chl a and SST fields.

In addition, a Spray glider along CalCOFI line 80 provided recent subsurface ocean structure (T, S, density, chlorophyll a fluorescence, acoustic backscatter). These up-to-date glider data, combined with satellite imagery and vertical profiling by MVP, enabled us to carry out our experimental cycles in specific, pre-identified ocean features.
INFORMATION MANAGEMENT

Information management activities by Karen Baker, Mason Kortz and James Conners facilitated data handling and communication, including deployment of an event logger, support for the education outreach, and preparation of the cruise materials in on-line community interactions.

An event logger was set-up to provide an authoritative listing of each research activity, with an assigned event number, date time and location information. Pre-cruise preparations included incorporation of hardware/software updates on event logger laptops, set-up of logger stations on the bridge and in the lab, coordination of program decoding with the ship's GPS string, and logger training. A glossary of activity names incorporated as a configuration file serves as a controlled vocabulary list. Ship-to-shore communications permitted shore support for event logger issues that arose concerning display refresh, application restart, and latitude/longitude recording precision.

Infrastructure support was provided for a Teacher-at-Sea education/outreach activity. Preparations included evaluation, purchase, set-up, and testing of software and hardware to enable shipboard video recording and editing. Software was deployed and best practices were developed in support of a blog with input via the web shipboard that delivered text and associated photos daily. A configuration was established that allowed post-entry editing as well as input of comments by classroom participants.

Additional activities include input of cruise specifics to the information system study list and participant directory as well as upload of the cruise data CDs to a project shared disk. Since the event log serves as a key mechanism for post-cruise coordination of datasets, event log cleaning was initiated including checking for consistency and missing data. A web page was set up with cruise information and a dynamic mapper that makes station locations available visually and as a downloadable file. In addition, a Google earth mapping data file was produced to display the various activities by group and to animate the cruise track by time.

CCE-P0810 DAILY ACTIVITY SCHEDULE

30 September
0800 DEPART San Diego, various system tests in transit
1500 CTD test station
1600 Go-Flo bottle cast test/rinse
1730 MVP test
2000 Oozeki trawl test
2200 MOCNESS test

1 October
1900 MVP Bowtie survey to station, 33.64°N, 124.0°W
2 October
0200 CTD, setup *in situ* experiments (500 m)
0500 Deploy sediment trap array
0530 CTD, organics, bacteria, thorium (500 m)
0730 Recover sediment trap, station abandoned
0800 Begin transit to Santa Barbara for drifter repairs

3 October
0030 CTD, water for zooplankton experiments
0130 Bong tow (live), animals for experiments
0230 MVP deployed (2.5 h), transect sampling
0800 **Drifter repairs, Santa Barbara**
1700 MVP deployed (3 h), transect sampling to station
2200 CTD, water for evening experiments
2300 Net tows, animals for experiments

4 October
***** Begin CYCLE #1 (34.13°N 120.97°W) *****
0000 Deploy sediment trap array
0130 CTD, setup *in situ* experiments (500 m)
0400 Deploy *in situ* (drift) array
0430 CTD, organics, bacteria, thorium (500 m)
0600 MVP – small bow-tie survey
1030 Bongo, zooplankton biomass & gut pig sampling
1130 CTD (*¹⁴C-PP, PvsE), 500 m; Radiometer off stern
1230 IOP cast (hydrowire)
1330 MOCNESS, zooplankton sampling (800 m)
1600 CTD, water for evening experiments
1800 Thorium pump, simultaneous surface pump
2000 Net tows, animals for experiments
2100 Bongo, zooplankton biomass & gut pig sampling
2200 MOCNESS, zooplankton sampling (800 m)

5 October
0130 CTD, setup *in situ* experiments (500 m)
0300 Go-Flo trace-metal sampling (deep)
0430 Recover/redeploy *in situ* array
0500 Go-Flo trace-metal sampling (shallow)
0600 MVP – small bow-tie survey
1030 Bongo, zooplankton biomass & gut pig sampling
1100 Radiometer off stern
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1130</td>
<td>CTD ((^{14})C-PP, PvsE), 500 m</td>
</tr>
<tr>
<td>1230</td>
<td>IOP cast (hydrowire)</td>
</tr>
<tr>
<td>1330</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>1430</td>
<td>MOCNESS, zooplankton sampling</td>
</tr>
<tr>
<td>1730</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>1900</td>
<td>CTD, full dilution experiments &amp; thorium</td>
</tr>
<tr>
<td>2030</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>2230</td>
<td>MOCNESS, zooplankton sampling</td>
</tr>
</tbody>
</table>

**6 October**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0030</td>
<td>Bongo/LOPC, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>0130</td>
<td>CTD, setup <em>in situ</em> experiments (500 m)</td>
</tr>
<tr>
<td>0300</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>0430</td>
<td>Recover/redeploy <em>in situ</em> array</td>
</tr>
<tr>
<td>0600</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>0730</td>
<td>Oozeki trawl, deep (2 h)</td>
</tr>
<tr>
<td>1000</td>
<td>Bongo/LOPC, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>1100</td>
<td>Radiometer off stern</td>
</tr>
<tr>
<td>1130</td>
<td>CTD ((^{14})C-PP, PvsE), 500 m</td>
</tr>
<tr>
<td>1230</td>
<td>IOP cast (hydrowire)</td>
</tr>
<tr>
<td>1300</td>
<td>MOCNESS, zooplankton sampling</td>
</tr>
<tr>
<td>1500</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>1900</td>
<td>CTD, water for evening experiments &amp; new prod</td>
</tr>
<tr>
<td>2100</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>2300</td>
<td>Net tows, animals for experiments</td>
</tr>
<tr>
<td>2400</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
</tbody>
</table>

**7 October**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0030</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>0130</td>
<td>CTD, setup <em>in situ</em> experiments (500 m)</td>
</tr>
<tr>
<td>0300</td>
<td>Go-Flo trace-metal sampling (deep)</td>
</tr>
<tr>
<td>0430</td>
<td>Recover/redeploy <em>in situ</em> array</td>
</tr>
<tr>
<td>0500</td>
<td>Go-Flo trace-metal sampling (shallow)</td>
</tr>
<tr>
<td>0600</td>
<td>MVP bow-tie survey</td>
</tr>
<tr>
<td>0930</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>1130</td>
<td>Radiometer off stern</td>
</tr>
<tr>
<td>1200</td>
<td>CTD ((^{14})C-PP, PvsE), 500 m</td>
</tr>
<tr>
<td>1230</td>
<td>IOP cast (hydrowire)</td>
</tr>
<tr>
<td>1330</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>1500</td>
<td>Oozeki trawl, deep (2 h)</td>
</tr>
<tr>
<td>1900</td>
<td>CTD, water for evening experiments &amp; Morel incubations</td>
</tr>
</tbody>
</table>
2000 Thorium pump (deep cast), simultaneous surface pump
2100 Net tows, animals for experiments
2200 Bongo, zooplankton biomass & gut pig sampling
2300 MOCNESS, zooplankton sampling

8 October
0200 CTD, in situ exp, Th & organics (500 m, final samples only)
0300 Recover in situ (drift) array
0400 Oozeki trawl, deep (2 h)
0800 Recover sediment trap array; End CYCLE #1
0900 Transit – MVP Transect (10 h) to next station

9 October
***** Begin CYCLE #2 (32.88°N 123.68°W)
0130 Deploy sediment trap array
0200 CTD, setup in situ experiments (500 m)
0400 Deploy in situ (drift) array
0430 CTD, organics, bacteria, thorium (500 m)
1030 Bongo, zooplankton biomass & gut pig sampling (non-quant)
2000 Net tows, animals for experiments
2200 Thorium pump, simultaneous surface pump

WEATHER DAY – 30-45 kt winds, heavy seas

10 October
0130 CTD, setup in situ experiments (300 m)
0430 Recover/redeploy in situ array
1900 CTD, full dilution experiments & thorium
2100 Net tows, animals for experiments

WEATHER DAY – 30-35 kt winds, heavy seas

11 October
0130 CTD, setup in situ experiments (300 m)
0430 Recover/redeploy in situ array
0730 MVP test transect
1000 Bongo/LOPC, zooplankton biomass & gut pig sampling
1130 Radiometer off stern
1230 CTD (¹⁴C-PP, PvsE), 500 m
1400 IOP cast (hydrowire)
1500 MOCNESS, zooplankton sampling
1800 CTD, water for evening experiments & new prod
1900 Go Flo cast, set-up incubation experiment
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Net tows, animals for experiments</td>
</tr>
<tr>
<td>2100</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>2200</td>
<td>MOCNESS, zooplankton sampling</td>
</tr>
</tbody>
</table>

**12 October**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0030</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>0130</td>
<td>CTD, setup <em>in situ</em> experiments (500 m)</td>
</tr>
<tr>
<td>0300</td>
<td>Go-Flo trace metal cast</td>
</tr>
<tr>
<td>0430</td>
<td>Recover/redeploy <em>in situ</em> array</td>
</tr>
<tr>
<td>0600</td>
<td>Go-Flo trace metal cast</td>
</tr>
<tr>
<td>1030</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>1130</td>
<td>Radiometer off stern</td>
</tr>
<tr>
<td>1200</td>
<td>CTD (\textsuperscript{14}C-PP, PvsE), 500 m</td>
</tr>
<tr>
<td>1330</td>
<td>IOP cast (hydrowire)</td>
</tr>
<tr>
<td>1400</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>1530</td>
<td>Oozeki trawl, deep (2 h)</td>
</tr>
<tr>
<td>1800</td>
<td>CTD, water for evening experiments</td>
</tr>
<tr>
<td>2000</td>
<td>Net tows, animals for experiments</td>
</tr>
<tr>
<td>2100</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>2200</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>2300</td>
<td>Oozeki trawl, deep (2 h)</td>
</tr>
</tbody>
</table>

**13 October**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0130</td>
<td>CTD, setup <em>in situ</em> experiments (500m)</td>
</tr>
<tr>
<td>0300</td>
<td>Go-Flo trace-metal sampling (deep)</td>
</tr>
<tr>
<td>0430</td>
<td>Recover/redeploy <em>in situ</em> array</td>
</tr>
<tr>
<td>0500</td>
<td>Go-Flo trace-metal sampling (shallow)</td>
</tr>
<tr>
<td>0600</td>
<td>MVP bow-tie survey</td>
</tr>
<tr>
<td>1030</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>1130</td>
<td>Radiometer off stern</td>
</tr>
<tr>
<td>1200</td>
<td>CTD (\textsuperscript{14}C-PP, PvsE), 500 m</td>
</tr>
<tr>
<td>1330</td>
<td>IOP cast (hydrowire)</td>
</tr>
<tr>
<td>1400</td>
<td>MOCNESS, zooplankton sampling</td>
</tr>
<tr>
<td>1800</td>
<td>CTD, water for evening experiments</td>
</tr>
<tr>
<td>1900</td>
<td>Thorium pump (deep cast), simultaneous surface pump</td>
</tr>
<tr>
<td>2100</td>
<td>Net tows, animals for experiments</td>
</tr>
<tr>
<td>2200</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>2300</td>
<td>MOCNESS, zooplankton sampling</td>
</tr>
</tbody>
</table>

**14 October**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0130</td>
<td>CTD, in situ exp, Th &amp; organics (500 m, final samples only)</td>
</tr>
</tbody>
</table>
0300 Recover *in situ* (drift) array
0400 Oozeki trawl, deep (2 h)
0630 Recover sediment trap array; **End CYCLE #2**
0800 Transit – MVP Transect (8 h) to next station
2300 Bongo net tow (live), animals for experiments

**15 October**

***** Begin CYCLE #3 (33.95°N 121.81°W) *****

0000 Deploy sediment trap array
0130 CTD, setup *in situ* experiments (500 m)
0400 Deploy *in situ* (drift) array
0430 CTD, organics, bacteria, thorium (500 m)
0600 Oozeki trawls, deep/shallow
1030 Bongo, zooplankton biomass & gut pig sampling
1130 Radiometer off stern
1200 CTD (*¹⁴C-PP, PvsE), 500 m
1300 MVP vertical profile (test)
1330 IOP cast (hydrowire)
1430 MOCNESS, zooplankton sampling
1700 CTD, water for evening experiments
1800 Thorium pump, simultaneous surface pump
2000 Net tows, animals for experiments
2130 Bongo, zooplankton biomass & gut pig sampling
2230 MOCNESS, zooplankton sampling

**16 October**

0130 CTD, setup *in situ* experiments (500 m)
0300 Go-Flo trace-metal sampling (deep)
0430 Recover/redploy *in situ* array
0500 Go-Flo trace-metal sampling (shallow)
0600 Oozeki trawls, deep/shallow
1000 Bongo, zooplankton biomass & gut pig sampling
1100 Radiometer off stern
1130 CTD (*¹⁴C-PP, PvsE), 500 m
1300 IOP cast (hydrowire)
1400 Bongo, zooplankton biomass & gut pig sampling
1500 Oozeki trawl, deep (2 h)
1730 Bongo, zooplankton biomass & gut pig sampling
1830 CTD, full dilution experiments & thorium
2000 Bongo, zooplankton biomass & gut pig sampling
2100 Oozeki trawl, deep (2 h)
2330  Bongo/LOPC, zooplankton biomass & gut pig sampling

**17 October**

0030  Oozeki trawl, shallow (1 h)
0130  CTD, setup *in situ* experiments (500 m)
0300  Bongo, zooplankton biomass & gut pig sampling
0430  Recover/redeploy *in situ* array
0500  Bongo, zooplankton biomass & gut pig sampling
0600  MVP – small bow-tie survey
1000  Bongo/LOPC, zooplankton biomass & gut pig sampling
1100  Radiometer off stern
1130  CTD (\(^{14}\)C-PP, PvsE), 500 m
1300  IOP cast (hydrowire)
1400  MOCNESS, zooplankton sampling
1700  CTD, water for evening experiments & new prod
1800  Thorium pump (deep cast), simultaneous surface pump
2000  Net tows, animals for experiments
2130  Bongo, zooplankton biomass & gut pig sampling
2200  MOCNESS, zooplankton sampling

**18 October**

0100  CTD, *in situ* exp, Th & organics (1000 m, final samples only)
0300  Recover *in situ* (drift) array
0500  Recover sediment trap array; **End CYCLE #3**
0600  Transit – PERSONNEL TRANSFER, Santa Barbara
2230  MVP transect (3.5 h) to next station

**19 October**

*****  **Begin CYCLE #4 (33.61°N 121.15°W)**

0300  Deploy sediment trap array
0400  CTD, setup *in situ* experiments (500 m)
0530  Deploy *in situ* (drift) array
0600  CTD, organics, bacteria, thorium (300 m)
0700  MVP – small bow-tie survey
1030  Bongo, zooplankton biomass & gut pig sampling
1130  Radiometer off stern
1200  CTD (\(^{14}\)C-PP, PvsE), 500 m
1330  IOP cast (hydrowire)
1430  MOCNESS, zooplankton sampling
1600  Repair multi-freq sonar system
1900  CTD, water for evening experiments

12
2000  Thorium pump, simultaneous surface pump
2130  Net tow, animals for experiments
2230  Bongo, zooplankton biomass & gut pig sampling
2330  MOCNESS, zooplankton sampling

**20 October**
0230  CTD, setup *in situ* experiments (500 m)
0400  Go-Flo trace-metal sampling (deep)
0530  Recover/redeploy *in situ* array
0600  Go-Flo trace-metal sampling (shallow)
0630  MVP – small bow-tie survey
1030  Bongo, zooplankton biomass & gut pig sampling
1130  Radiometer off stern
1200  CTD (*¹⁴C-PP, PvsE), 500 m
1330  IOP cast (hydrowire)
1430  Oozeki trawl, deep (2 h)
1730  Thorium pump (deep cast), simultaneous surface pump
1900  CTD, water for full dilution & evening experiments
2000  Oozeki trawl, shallow (1 h)
2100  Oozeki trawl, deep (2 h)
2300  Net tow, animals for experiments
2330  Bongo, zooplankton biomass & gut pig sampling

**21 October**
0030  Oozeki trawl, shallow (1 h)
0200  CTD, in situ & Th & organics (1000 m, final samples only)
0400  Recover *in situ* (drift) array
0430  Oozeki trawl, shallow (1 h)
0700  Recover sediment trap array; **End CYCLE #4**
0600  Transit to next station, MVP testing/repair enroute
2300  Bongo net, live animals for experiments

**22 October**
*****  **Begin CYCLE #5 (32.90°N 120.93°W)**
0000  Deploy sediment trap array
0130  CTD, setup *in situ* experiments (500 m)
0300  Bongo net, live animals for experiments
0430  Deploy *in situ* (drift) array
0500  CTD, organics, bacteria, thorium (1000 m)
0600  Oozeki trawl, deep (2 h)
0900  Oozeki trawl, shallow (1 h)
1030  Bongo, zooplankton biomass & gut pig sampling
1130  Radiometer off stern
1200  CTD ($^{14}$C-PP, PvsE), 500 m
1330  IOP cast (hydrowire)
1430  MOCNESS, zooplankton sampling
1600  Go-Flo trace-metal sampling
1730  Thorium pump, simultaneous surface pump
1900  CTD, water for evening experiments
2000  Net tow, animals for experiments
2130  Bongo, zooplankton biomass & gut pig sampling
2230  MOCNESS, zooplankton sampling

23 October
0200  CTD, setup in situ experiments (500m)
0430  Recover/redeploy in situ array
0500  MVP – small bow-tie survey
1030  Bongo, zooplankton biomass & gut pig sampling
1130  Radiometer off stern
1200  CTD ($^{14}$C-PP, PvsE), 500 m
1330  IOP cast (hydrowire)
1430  Oozeki trawl, deep (2 h)
1730  Thorium pump (deep cast), simultaneous surface pump
1900  CTD, water for full dilution & evening experiments
2000  Oozeki trawl, shallow (1 h)
2100  Oozeki trawl, deep (2 h)
2300  Net tow, animals for experiments
2330  Bongo, zooplankton biomass & gut pig sampling

24 October
0030  Oozeki trawl, shallow (1 h)
0200  CTD, in situ & Th & organics (1000 m, final samples only)
0400  Recover in situ (drift) array
0430  Oozeki trawl, shallow (1 h)
0630  CTD profile & Chl a at sediment trap
0800  Recover sediment trap array; End CYCLE #5
*****
Begin MVP transects through FRONT STUDY area
1000  MVP South transect through front 12 nm
1130  MVP North transect through front 24 nm
1400  MVP South transect through front 18 nm
1600  MVP slow (6 kts) North transect through front 12 nm
1830  MVP slow (6 kts) South transect through front 12 nm
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2100</td>
<td>Vertical bongo tow (100 m) – Stn AF1; 32.67°N, 120.71°W</td>
</tr>
<tr>
<td>2120</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>2200</td>
<td>Vertical bongo tow (100 m) – Stn AF2; 32.70°N, 120.71°W</td>
</tr>
<tr>
<td>2220</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>2300</td>
<td>Vertical bongo tow (100 m) – Stn AF3; 32.72°N, 120.71°W</td>
</tr>
<tr>
<td>2320</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>25 October</td>
<td><em>Begin A Front transect sampling, Bongo &amp; CTD</em></td>
</tr>
<tr>
<td>0000</td>
<td>Vertical bongo tow (100 m) – Stn AF4; 32.75°N, 120.71°W</td>
</tr>
<tr>
<td>0020</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>0100</td>
<td>Vertical bongo tow (100 m) – Stn AF5; 32.78°N, 120.71°W</td>
</tr>
<tr>
<td>0120</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>0200</td>
<td>Vertical bongo tow (100 m) – Stn AF6; 32.80°N, 120.71°W</td>
</tr>
<tr>
<td>0220</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>0300</td>
<td>Vertical bongo tow (100 m) – Stn AF7; 32.83°N, 120.71°W</td>
</tr>
<tr>
<td>0320</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>0400</td>
<td>Vertical bongo tow (100 m) – Stn AF8; 32.85°N, 120.71°W</td>
</tr>
<tr>
<td>0420</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>0500</td>
<td>Vertical bongo tow (100 m) – Stn AF9; 32.89°N, 120.71°W</td>
</tr>
<tr>
<td>0520</td>
<td>CTD (300 m)</td>
</tr>
<tr>
<td>0700</td>
<td><strong>End A Front sampling</strong>; Transit south to CYCLE #6 area</td>
</tr>
<tr>
<td>1600</td>
<td>Go-Flo trace-metal sampling</td>
</tr>
<tr>
<td>1800</td>
<td>CTD, water for thorium, evening experiments</td>
</tr>
<tr>
<td>1900</td>
<td>Deploy sediment trap array</td>
</tr>
<tr>
<td>2030</td>
<td>Net tow, animals for experiments</td>
</tr>
<tr>
<td>2200</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>2300</td>
<td>MOCNESS, zooplankton sampling</td>
</tr>
<tr>
<td>26 October</td>
<td><strong>Begin CYCLE #6 (33.60°N 120.56°W)</strong></td>
</tr>
<tr>
<td>0100</td>
<td>IOP, Bio-optics cast</td>
</tr>
<tr>
<td>0200</td>
<td>CTD, setup <em>in situ</em> experiments (500 m)</td>
</tr>
<tr>
<td>0430</td>
<td>Deploy <em>in situ</em> (drift) array</td>
</tr>
<tr>
<td>0500</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>0630</td>
<td>Oozeki trawl, deep (2 h)</td>
</tr>
<tr>
<td>0900</td>
<td>Oozeki trawl, shallow (1 h)</td>
</tr>
<tr>
<td>1030</td>
<td>Bongo, zooplankton biomass &amp; gut pig sampling</td>
</tr>
<tr>
<td>1130</td>
<td>Radiometer off stern</td>
</tr>
<tr>
<td>1200</td>
<td>CTD (*¹⁴C-PP, PvsE), 500 m</td>
</tr>
<tr>
<td>1300</td>
<td>MVP stationary vertical cast</td>
</tr>
</tbody>
</table>
1330  IOP cast (hydrowire)
1430  MOCNESS, zooplankton sampling
1730  Thorium pump, simultaneous surface pump
1900  CTD, water for full dilution & evening experiments
2000  Oozeki trawl, shallow (1 h)
2100  Oozeki trawl, deep (2 h)
2330  Bongo, zooplankton biomass & gut pig sampling

**27 October**
0030  Oozeki trawl, shallow (1 h)
0200  CTD, setup *in situ* experiments (500 m)
0430  Recover/redeploy *in situ* array
0530  MVP – small bow-tie survey
1030  Bongo, zooplankton biomass & gut pig sampling
1130  Radiometer off stern
1200  CTD (\(^{14}\text{C}-\text{PP}, \text{PvsE}\)), 500 m
1330  IOP cast (hydrowire)
1430  Oozeki trawl, deep (2 h)
1900  Thorium pump (deep cast), simultaneous surface pump
2030  Net tow, animals for experiments
2130  Oozeki trawl, shallow (1 h)
2300  MOCNESS, zooplankton sampling (1000 m?)

**28 October**
0200  CTD, *in situ* & Th & organics (1000 m, final samples only)
0400  Recover *in situ* (drift) array
0430  Oozeki trawl, shallow (1 h)
0630  CTD adjacent to sediment trap
0730  Recover sediment trap array; **End CYCLE #6**
0900  Transit – Head for the barn, sonar test speed, Oozeki trawls enroute
1300  Oozeki trawl, deep (2 h)
1500  CTD, water collection
2100  Live Bongo tow