Cruise plan
Ocean Perturbation Experiment (OPEREX), km_0814

VESSEL: R/V Kilo Moana, University of Hawaii
MASTER OF THE VESSEL: Captain Brian Wehmeyer
CHIEF SCIENTIST: Zbigniew Kolber, Monterey Bay Aquarium Research Institute
STAG electronic technicians: Tobin Chen and Timothy McGovern

Load: July 29, 2008
Departure: July 30, 2008, 0800 HST
Arrival: August 14, 2008, 0800 HST
Unload: August 14, 2008

1. SCIENCE OBJECTIVE
To explore the potentials and limitations of perturbation experiments at sea.
Goals:

1. Following local blooms and features
2. Eddy sampling experiments
3. Ship deck incubation experiments
4. Ship lab incubation experiments
5. pH shift experiments.

Rationale: To develop experimental tools for predicting responses of microbial communities to physical and chemical forcing.

Approach: We will try to observe and interpret natural perturbations such as local blooms and eddies. We will also perform, observe, and interpret artificial perturbations including ship-deck incubations, and lab-scale manipulation experiments.

1.1. SCIENTIFIC OPERATIONS

Transect/Stations	Time/Station	Activities
Hawaii 22.5N, 157.50W 100 nm, 10 hrs	July 30, 08:00 July 30, 18:00	Underway thermosalinograph, fluorometry, FRRf
22.50N, 157.50W	Station 1 Upwelling eddy	Min core CTD/ Science CTD, two casts for deep water enrichment, one cast for DOM incubation
22.50N, 157.50W 22.750N, 157.00W 31 nm, 3.0 hrs	July 31, 00:00 July 31, 03:00	Underway thermosalinograph, fluorometry, FRRf
22.75N, 157.00W	Station 2-18 BLOOM mapping July 31-Aug 08	Bloom location. Extensive sampling of bloom spatial characteristics, 40+ CTD casts (Min/Full core & Science), sediment traps deployment, SID deployment, pumping CTD operation, Deep water enrichment, Nitrogen fixation, Herve's floats deployment
22.75N, 157.00W 22.75N, 155.20W 99 nm, 10 hrs	Aug 08, 23:00 Aug 09, 09:00	Underway thermosalinograph, fluorometry, FRRf
22.75N, 155.20W	Station 19 Downwelling eddy	Full Core CTD/Science CTD
22.75N, 155.20W 23.50N, 154.00W 80 nm, 8 hrs	Aug 09, 12:30 Aug 09, 20:30	Underway thermosalinograph, fluorometry, FRRf
23.50N, 154.00W	Station 20 Upwelling eddy	Full Core CTD/Science CTD
23.50N, 154.00W 25.50N, 152.50W 145 nm, 14.5 hrs	Aug 10, 00:00 Aug 10, 14:30	Underway thermosalinograph, fluorometry, FRRf
25.50N, 152.50W	Station 21 Downwelling eddy	Full Core CTD/Science CTD
25.50N, 152.50W 25.50N, 154.00W 81 nm, 8 hrs	Aug 10, 18:00 Aug 11, 02:00	Underway thermosalinograph, fluorometry, FRRf
25.50N, 154.00W	Station 22 Downwelling eddy	Min Core CTD/Science CTD
25.50N, 154.00W 25.50N, 155.50W 81 nm, 8hrs	Aug 11, 04:00 Aug 11, 12:00	Underway thermosalinograph, fluorometry, FRRf
25.50N, 155.50W	Station 23 Upwelling eddy	Full Core CTD/Science CTD

25.50N, 155.50W 25.50N, 156.00W 30 nm, 3 hrs	Aug 11, 15:30 Aug 11, 18:30	Underway thermosalinograph, fluorometry, FRRf
25.50N, 156.00W	Station 24 Eddy sampling 1	Min Core CTD/Science CTD
25.50N, 156.00W 25.50N, 156.50W 30 nm, 3 hrs	Aug 11, 20:30 Aug 11, 23:30	Underway thermosalinograph, fluorometry, FRRf
25.50N, 156.50W	Station 25 Eddy sampling 2	Min Core CTD/Science CTD
25.50N, 156.50W 25.50N, 157.00W 30 nm, 3 hrs	Aug 12, 01:30 Aug 12, 04:30	Underway thermosalinograph, fluorometry, FRRf
25.50N, 157.00W	Station 26 Eddy sampling 3	Min Core CTD/Science CTD
25.50N, 157.00W 25.50N, 157.50W 30 nm, 3 hrs	Aug 12, 06:30 Aug 12, 09:30	Underway thermosalinograph, fluorometry, FRRf
25.50N, 157.50W	Station 27 Eddy sampling 4	Full Core CTD/Science CTD
25.50N, 157.50W 25.50N, 158.00W 30 nm, 3 hrs	Aug 12, 13:00 Aug 12, 16:00	Underway thermosalinograph, fluorometry, FRRf
25.50N, 158.00W	Station 28 Eddy sampling 5	Min Core CTD/Science CTD
25.50N, 158.00W 25.50N, 158.50W 30 nm, 3 hrs	Aug 12, 18:00 Aug 12, 21:00	Underway thermosalinograph, fluorometry, FRRf
25.50N, 158.50W	Station 29 Eddy sampling 6	Min Core CTD/Science CTD
25.50N, 158.50W 25.50N, 159.00W 30 nm, 3 hrs	Aug 12, 23:00 Aug 13, 02:00	Underway thermosalinograph, fluorometry, FRRf
25.50N, 159.00W	Station 30 Eddy sampling 7	Min Core CTD/Science CTD
25.50N, 159.00W 23.75N, 159.00W 105 nm, 10.5 hrs	Aug 13, 04:00 Aug 13, 14:30	Underway thermosalinograph, fluorometry, FRRf
23.75N, 159.00W	Station 31 Eddy sampling 8	Full Core CTD/Science CTD
23.75N, 159.00W 21.30N, 158.80W 130 nm, 14 hrs	Aug 13, 18:00 Aug 14, 08:00	Underway thermosalinograph, fluorometry, FRRf
21.30N, 158.80W	Aug 14, 08:00	Arrive Snug Harbor, Unload ship

NOTE:

1. The bloom at 23N, 159W has faded away. There is another bloom developing at 22.75N 157.99W (Fig. 1). Ocean color data indicate that the bloom slowly moves north-west. The exact position of bloom experiment will be defined by FRR fluorometry survey once we arrive at the expected bloom location.
2. The remainder of the cruise track is defined by the most actual position of upwelling/downwelling eddies within 22N – 26N and 152W-160W positions (Fig. 2).

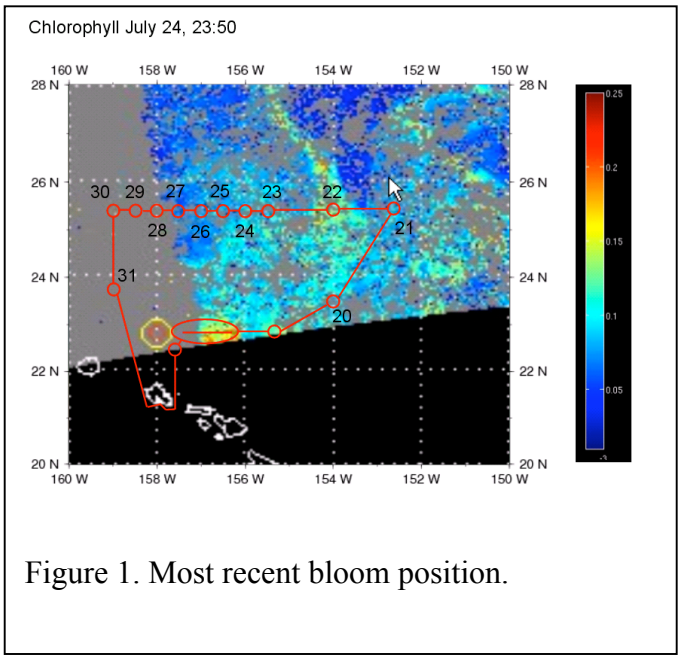

Figure 1. Most recent bloom position.

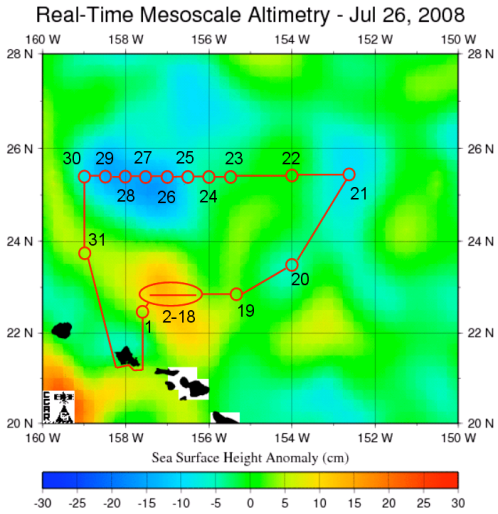

Figure 2. Km0814 cruise track

2. SCIENCE PERSONNEL

Participant	Title	Affiliation
1. Zbigniew Kolber	chief Scientist, CMORE faculty	MBARI
2. Miriam Sutton	teacher	Newport Middle School, NC
3. Allison Fong	student	UH
4. Lionel Guidi	postdoc	UH
5. Lars Stemmann	researcher	Obs. Ocean. Villefranche
6. Whitney Krey	student	WHOI
7. Craig Taylor	CMORE faculty	WHOI
8. Jamie Becker	student	WHOI
9. Mar Nieto Cid	postdoc	WHOI
10. Laure Anne Ventouras	student	MIT
11. Ryan Paerl	student	UCSC
12. Sasha Tozzi	CMORE postdoc	MBARI
13. Alan Foreman	CMORE intern	MBARI
14. Jennifer Brum	student	UH
15. Sam Wilson	postdoc	UH
16. Katie Watkins	student	OSU
17. Karen Breitlow	student	OSU
18. Solange Duhamel	postdoc	UH
19. Jason Hilton	student	UCSC
20. Paulo Calil	student	UH
21. Binglin (Ben) Li	student	UH
22. Donn Viviani	student	UH
23. Brett Updyke	technician	UH
24. Ken Doggett	technician	UH
25. Steve Paulos	technician	UH
26. Karin Bjorkman	researcher	UH
27. Tim McGovern	OTG	UHMC
28. Tobin Chen	OTG	UHMC

3. SUMMARY SCHEDULE (See the attached spreadsheet for detailed schedule)

3.1. Load ship on July 29, 2008

3.2. Leave Snug Harbor on July 30, 8:00, and transit to 22.50N, 157.50W.

a. Perform a double core/science casts 0-250m.
b. Perform two casts to get water for enrichment experiment.
c. Perform one cast for DOM incubation experiment.

3.3. Arrive at BLOOM location at 22.75N, 157.00W on July 31, 03:00. Map the bloom characteristics during next 9 days.

a. Alternatively occupy IN-BLOOM and OUT-BLOOM stations separated by approximately 10 nm, perform daily core/science CTD casts.
b. Deploy sediments traps, SID incubator, and N-fixation arrays.
c. Perform daily net tows.
d. Use pumping CTD in YOYO mode to map bloom characteristics during transects between IN-BLOOM and OUT-BLOOM stations.
e. Additional CTD cast at IN-BLOOM and OUT-BLOOM stations will be scheduled in the available open wire time.
f. Follow the evolution of biological signals.
g. Recover incubators and traps on August 8.
h. Deploy Herve's floats

3.4. Depart from area on August 8, 23:00, start an eddy hopping transect along cruise track described in section 1.1.
a. Perform 5 double CTD casts at the centers of five upwelling/downwelling eddies along the cruise track.

3.6. Start eddy mapping transect at 25.50N, 155.50W on August 11, 12:00
a. Perform 8 double CTD casts along the eddy mapping transect at stations separated by 25 nm.

3.7. Finish eddy mapping transect at 25.50N, 159.00W on Aug 12, 23:00.
3.8 . Perform last eddy station at 23.75N 159.00W on Aug 13, 14:30
3.9. Depart to Sun Harbor Aug 13, 18:00
3.10. Arrive at Snug Harbor August 14, 08:00
3.11. Unload the ship on August 14, 2008.

4. OPERATIONAL PLANS

4.1. *Phase I, Bloom experiment.*

4.1.1. Bloom mapping.

Evolution of biological signals within the bloom will be followed for nine days. Local blooms, if present, are likely to be driven by the confluence of eddies advecting westwards at average speed of 3-6 miles per day. The objective is to understand what sustain local blooms, which species are blooming, how the phototrophy/heterotrophy is affected, and what do these blooms leave in their wake.

Upon arrival at BLOOM location at 22.75N, 157.00W on July 31 03:00, FRRf survey will be performed to acquire information about the spatial characteristics of the bloom. Following the survey, double core/science CTD cast will be performed at the center of the local bloom, followed by deployment of sediment traps, SID incubator, and nitrogen fixation array. Bloom mapping will resume at 22:30 using pumping CTD operating in YOYO mode. The ship will then transit to OUT-BLOOM location where two CTD casts will be performed to collect water for incubations led by Jennifer Brum. Following that, a regular daily sampling schedule will be established with a pair of core/science casts at OUT-BLOOM location at 6:00, and at IN-BLOOM location at 20:00 (see the attached schedule spreadsheet). Pumping CTD will be deployed twice a day, during transects between OUT-BLOOM and IN-BLOOM locations. The IN-BLOOM and OUT-BLOOM

positions will vary from day to day to acquire the most complete description of the bloom biological properties. There will be open wire time at these two locations to be used for extra CTD casts.

Two-three casts will be performed at each of IN-BLOOM and OUT-BLOOM stations: the first cast will serve the needs of core measurements; the second 1-2 casts will serve the specific CMORE science needs. There will be 8 standard CTD depths (Table 1)

Table 1. Hydrocast depths/core

depth	**bottles**	**comments**
200 m	4	fixed
150 m	3	fixed
DCM	3	variable
100 m	3	fixed
75 m	3	fixed
45 m	2	fixed
25 m	3	fixed
5 m	3	fixed

There will be 13 core cast with full sampling schedule (approximately one full core sampling/day). The full core sampling schedule will include

- CHla and HPLC
- fluorescence properties (FRRf)
- particulate P, C, N, Si
- LLN/LLP
- dissolved nutrients (including Si)
- DIC/DOC
- pH
- PP
- oxygen
- FCM

The remaining casts will be performed with limited core sampling schedule. The minimal core sampling will include

- CHla
- fluorescence properties (FRRf)
- dissolved nutrients (including Si)
- DOC
- FCM

See the cruise schedule for the detailed description of full/minimal sampling.

Sediment traps will be deployed on the first day of the bloom mapping experiment. The traps will be deployed from the stern using the A-frame and the Sea-Mac winch. Power requirement for the winch is 440 VAC, three phase at 10 amps. After deployment we request that the Bridge verify that the radio transmitters are functioning and directionally correct. The TS-SID incubator will be deployed alongside of the sediment traps.

The array will drift for 8 days before recovery. The trap array is equipped with 2 ARGOS satellite transmitters (platform #s 01833, 03028, 60482, 60484), 2 strobe lights, and 2 radio transmitters (channel 72, 156.625 MHz). Daily positions of the array shall be transmitted by email directly to the ship, therefore the ship will **not** need to keep within site of the array until the time of the recovery. Assistance from the bridge is requested in plotting the drift track of the array. We request the use of the ship's radio direction finder for locating the array before recovery.

The TS-SID incubator is equipped with radio transponder and the flasher. Keeping track of this device may require more effort.

NOTES

1. We will transect between the IN-BLOOM and OUT-BLOOM locations (about 10 nm) twice per day.
2. The dumping area will have to be established at least 10 nm downward of the BLOOM location, outside of the IN-BLOOM location.

4.1.2. Ship-deck incubations.

Water for the first ship-deck incubation will be collected at Station 1 (22.5N, 157.50W, July 30, 18:00) prior to arrival to the bloom location. The incubation experiment will start shortly afterwards, and will be terminated on August 3, 20:00. Second incubation will be initiated on August 4 early morning, and will last till August 7, 20:00. Third incubation will be initiated on August 8 early morning, and will b terminated on August 13, 9:30. Water for all incubations will be collected in OUT-BLOOM stations.

There will be four large incubators on the upper deck, each with eight 20L carboys capacity, and two small incubators, with 4x20L carboy capacity. Two of the large incubators will be used to investigate responses of MLD water (45 meter depth) to 10% enrichment with 500m, 300m, and 200m water, at 40% and 16% light level. Remaining incubators will be used for other CMORE experiments. The deep water enrichment pattern is described in Table 2.

Table 2. Deck enrichment incubations.

	40% light (Incubator 1)	16% light (Incubator2)
10% 500 m	2 carboys	2 carboys
10% 300m	2 carboys	2 carboys
10% 200m	2 carboys	2 carboys
control	2 carboys	2 carboys

pH shift incubation will be performed in parallel to deep water enrichment incubations. Water from 45 m depth will be incubated at the ambient pH level (pH = 8.1), and at low pH level (pH = 7.8) induced by bubbling the water with 760 ppm CO_2/air mixture. Water

from 45 m depth enriched with 10% of 300m water will also be incubated at theses two pH levels (Table 3).

Table 3. Deck pH shift incubations.

	pH = 8.1	pH = 7.8
10% 300m	2 carboys	2 carboys
control	2 carboys	2 carboys

4.1.3. Small-scale lab incubations.

Two small scale (2L) incubators with computer-controlled temperature, light, and pH will be used in the lab to study physiological responses of phytoplankton to temperature, light, and pH shift. These incubations will be run through the length of the cruise.

4.2. Phase II: Eddy hopping.

The objective of this phase is to determine whether local biogeography is affected by the presence of upwelling/downwelling eddies. To investigate that, CTD stations will be performed at the centers of five eddies along the cruise track as described in section 1.1. The actual transect during this phase will be defined by the end of the Phase I, based on the most actual SSH/Ocean Color data.

4.3. Phase III. Intensive eddy mapping

The objective is to determine the variability of biological signals across an upwelling eddy. After completion of Phase II on August 11, 21:00 the ship will transect through a single eddy (presently centered at 25.50N, 157.50W) with 8 stations separated by 30 nm. Intensive sampling schedule (double casts CTD every 5 hours) will be initiated. This will be the most demanding sampling schedule with double CTD casts very 5 hour. By this time most of the cruise participants should become familiar with the details of core measurements, and should be able to assist the BEACH team in this their effort. The eddy mapping transect will end at 25.50N, 159.00W on August13, 04:00. Upon completion of this transect, the ship will transit to 23.75N 159.00W to perform last CTD cast in the upwelling region. On August 13, 18:00 the ship will start transit to Snug Harbor (ETA August 14, 08:00).

NOTE: The location, and the orientation of this transect will be defined by the end of the Phase I, based on the most actual SSH/Ocean Color data.

5.0 EQUIPMENT

5.1 The UH science party shall be bringing the following:

1. Three laboratory vans with assorted equipment for radioisotope and general use
2. All required chemicals and isotopes
3. Large vacuum waste containers

4. Liquid nitrogen dewar and transfer hose
5. Drifting sediment trap array with strobe lights, satellite and radio transmitters, floats, weights
6. Kevlar line, polypropylene line
7. Sediment traps and crosses
8. Drifting primary production array and gas array with light and radio transmitter, floats, weights, polypro. Line, spare buoy, etc
9. PRR, AC-9/FRRf and other optical measuring instruments.
10. Oxygen titration system
11. Plankton nets and towing lines
12. Desktop and laptop personal computers
13. Assorted tools
14. Waste containers to contain all generated hazardous waste.
15. All required sampling bottles
16. Pertinent MSDS
17. compressed gas cylinders
18. Clean air compressor
19. Four large incubators, 3 small temperature controlled incubators and the chilling unit
20. One pH incubator (will be assembled by the MBARI group).

5.2. We will need the use of the following ship's equipment:

1. A-frame
2. A-frame block assembly
3. Appleton crane and winch with conducting wire for CTD
4. Electric power for winches (440 VAC, 3 phase, 60 Amp breaker) and vans (208 VAC single phase at 60 amps for lab van, 110 VAC 10 amps for equipment van)
5. Radio direction finder
6. Space on upper deck for two lab vans port side, one van starboard side
7. Space on upper deck for incubators
8. Hand-held VHF transceivers
9. Precision depth recorder
10. Shackles, sheaves, hooks and lines
11. Shipboard Acoustic Doppler Current Profiler
12. Thermosalinograph, *p*CO2 system, and Fluorometer
13. Copy machine
14. Grappling hooks and line
15. Navlink2 PC or equivalent
16. Running fresh water and seawater, hoses
17. Electronic mail system
18. GPS system
19. Uncontaminated seawater supply
20. Small capstan (~ 10 m/min)
21. Underway/on-station data acquisition system for meteorological instruments, ADCP, thermosalinograph, fluorometer, *p*CO2

22. OTG's 24-place rosette, and 24 12-l water sampling bottles (to be used as primary system)
23. Pinger (to be used as spare)
24. 1000 lb weight.
25. Remote CTD decibar pressure display in the winch operator cabin.
26. Large Sea-Mac winch (Mod. 1025 EHS). 60 Amp Hubbel plug/connector (440 VAC, 3 phase, 60 Amp breaker)
27. 2 Freezers -20 ^{o}C (Science hold)

NOTE: OTG's 24-place rosette, and 24 12-l water sampling bottles will be used as primary system.

Ship: R/V *KILO MOANA* km0841 CTD CASTS (See the attached spreadsheet).

6. KM0841 WATCH SHEDULE

The intense CTD sampling schedule may require three 8-hours watches.