The C-MORE BAG-1 Post Cruise Summary:

Biogeochemistry and Genomes (BAG – 1) Mesocosm Experiment (Leg 1)
1 – 13 Dec 2011

Overview in Review:

C-MORE and IFM-GEOMAR (Kiel, Germany) partnered together to conduct an open ocean test of 3 free floating mesocosms (mechanical: frame ~3m dia x 9m H, 60cu meter bags) along with onboard carboy incubation experiments. The two overall objectives had both engineering and scientific components. The first part was to test the feasibility and logistics of utilizing three large-scale mesocosms in the open ocean, while the second part was to measure the surface response of the phytoplankton communities when deep-water macro and micronutrients are added.

The test & experiment was planned to take place, Dec 1st -15th, 2011 aboard the UH R/V *Ka'imikai-O-Kanaloa* (KOK) off the coast of either Oahu or the Big Island. Which location selected was primarily dependent on the weather conditions. The favored location was off the Waianae coast of Oahu, but it turned out that on the day of departure, on 1 Dec., the sea state conditions (primarily wind) on the Waianae side had "deteriorated" and was above the recommended range for safe deployment. Projections of the channel winds and sea state were unfavorable for launching the mesocosms or the small boats in this area, including the south end of Oahu. Therefore the decision was made to transit to the Big Island, off of the Kona side, which had current sea state values below(winds below ~<5kts) the recommended deployment range. The decision was also made in part, because the time of departure in the mid afternoon would have precluded the deployment of the mesocosms that afternoon (in any location) due to the fading daylight (3hrs minimum needed). Therefore the time was redeemed by transiting to Kona (~12-14hrs). Second to the wind speed concerns, and according to the models, Kona also had an anti-cyclonic eddy, it was thought, that would have helped constrained the drift track of the mesocosms.

Initial assembly and unpacking of the mesocosm frames was conducted at the University of Hawaii Marine Center pier side near the R/V KOK berth. This involved 2 IFM-GEOMAR and 2 -4 C-MORE colleagues from 14 -23 Nov 2011. After this, the 2 IFM-GEOMAR colleagues continued minor adjustments to the systems until the 29 Nov 2011. The mesocosms were loaded onto the KOK, 1 Dec., about noon and all was secure on the back deck by about 3pm.

Science Logistics:

<u>The Treatments of the mesocosm bags was the following</u>:

<u>BAG-1A</u> (mesocosm Frame 4, also called BAG-4, located in the middle of the deployed string)
This bag contained surface seawater only, serving as the negative control for the experiment.

<u>BAG-1B</u> (mesocom Frame 5, also called BAG-5, located at the free end of the string, non-drogue end)
This bag contained surface seawater plus nitrate/silicate/trace metals and vitamins (also ref '–P').
BAG-1B is predicted to drive phosphate to subnanomolar levels and will also use the bioavailable DOP over time
This treatment would match one possible treatment of deep seawater effluent in SWAC or OTEC facilities wherein phosphate is first scrubbed from the wastewater product prior to ocean disposal.

<u>BAG-1C</u> (mesocosm Frame 6, also called BAG-6, located at the end attached to the drogue)
This bag contained surface seawater plus nitrate/phosphate/trace metals and vitamins (also ref ' +P').
BAG-IC will stimulate a much more significant phytoplankton bloom that would last for a longer period of time, with estimates from similar carboy experiments predicting that in 5-6 days all the nutrients (within detectable limits) will be consumed. Note this BAG was pulled under water when the 150m drogue caught on the bottom on the 12th Dec., ~1am in the morning.

In addition, BAG-1B and BAG-1C were enriched with stable nitrogen isotopes (3-5umolar) that were added as sodium nitrate. This addition and other core measurements assisted in the calculations of the N mass balance, export, metabolic balance, and transformations.

Summary of the Deck Incubation experiments – BAG-1 Cruise:

In addition to the daily sampling (Day 1-7) of the in situ mesocosm BAGs, a series of simultaneous ship-board deck incubation experiments (in various size containers) were carried out. These experiments used the same treatments as were applied to the BAGs (Control, +P/N/Si/Trace metals/Vitamins and N/Si/Trace metals/Vitamins) plus an additional 4th treatment of deep-water collected from a 1000m at Station ALOHA (DSW). These smaller scale incubation experiments were intended to allow us to determine whether 'small-scale findings' of bottle or carboy incubations, manipulations match the 'large-scale' observations that were made in the mesocosm BAGS.

For this purpose, single 20L carboys of all 4 treatments (Control, ADSW+P, ADSW-P, DSW ALOHA) were incubated and sampled every other day (at day 2,4,6, and 7) for nutrients, size-fractionated Chl and PP, HPLC, FRRF, MIMS, LISST, FCM, ATP, DIC/TA, PC/PN, PPO_4, PSi as well as DNA/RNA. In addition to the 20L carboys, we also incubated 10L carboys and 1L bottles for one selected treatment, which was the +P/N/Si/Trace metals/Vitamins. The 10L carboys were incubated as singles and sampled daily for nutrients, size-fractionated Chl and PP, HPLC, FRRF, MIMS, LISST, FCM, ATP, DIC/TA, PC/PN, PPO_4 and PSi whereas the 1L bottles were incubated in triplicates and daily sampled for nutrients, total Chl, FRRF, FCM. All carboys and bottles were incubated in outdoor, light-shaded (~28 % surface irradiance), surface seawater-cooled incubators that simulated *in situ* light and temperature conditions.

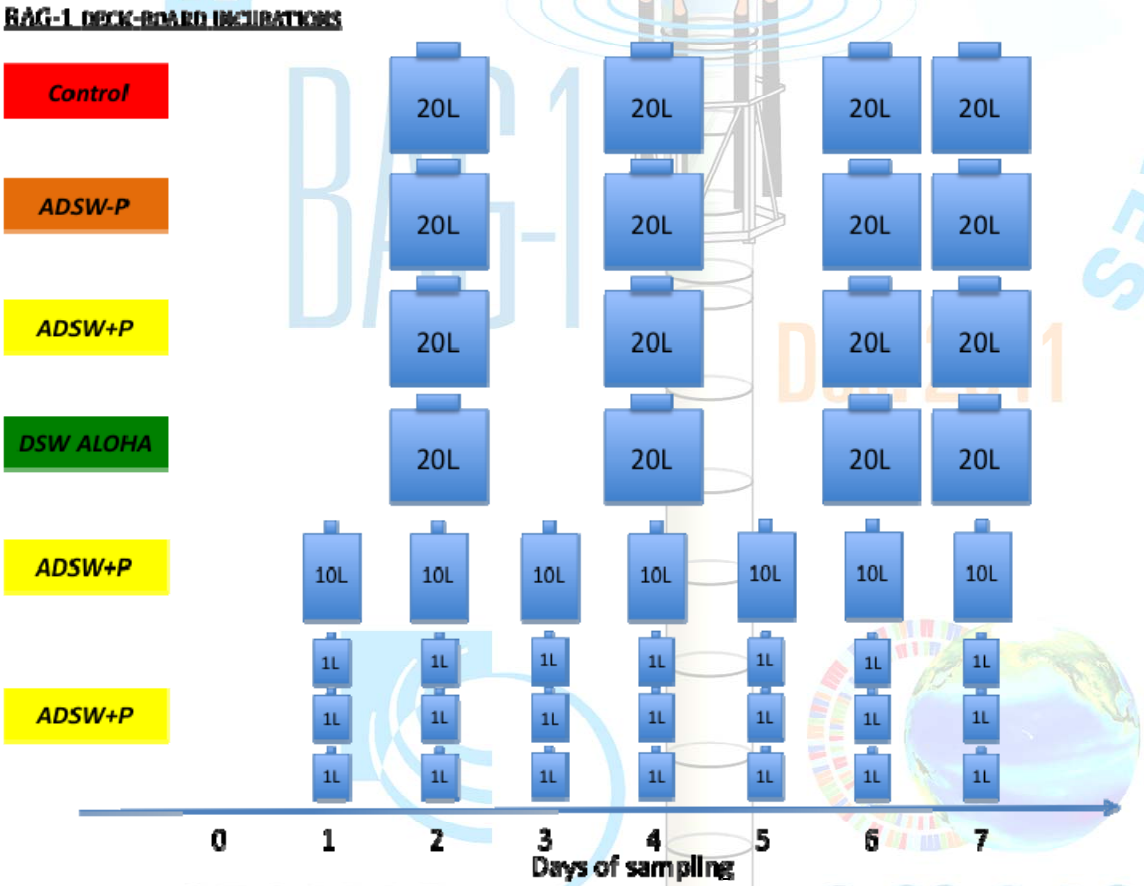


Fig.1 Summary of deck-board incubation experiments carried out during the BAG-1 cruise in December 2012.

R/V KOK Cruise - Daily Narrative

The time given below is listed as am/pm in general or using the 24hr ref for Hawaii Std Time (HST). Periodically a corresponding time will be given in UTC (with Julian day) or have a trailing 'z' because the underway ship's data is logged in this format. Therefore the logged data is easily linked to the following when the dual references are given.

Dec 1, Thursday -

~10:00 am (HST) - Begin Load; Finish ~03:00pm

Mesocosm Frames were arranged (5 4 6) ; fwd to aft respectively; OTG SAFEBoat in the hangar

Two vans topside, with the Flowcyto van fwd of the #23 Van

06:00pm - Depart Snug Harbor

Failure of Ship's propulsion; stbd shaft, Stbd SCR Bank #1 noted – not resetting when passing the Buoy

Night spent troubleshooting stbd shaft propulsion issues off Waikiki, Stbd SCR#1 failed

Dec 2, Friday –

Returned to Pier 45; Troubleshooting and talking to propulsion vendor – ref SCRs & stbd shaft turning checks

Dec 3, Saturday –

Fuses, etc., parts flown in. Pier side propulsion checks

15:00 (03:00pm) HST Depart UHMC-Transit to Kona based on still calm weather conditions, lee of Big Island.
(338) 4 Dec 01:00z (UTC) [Note: 3 Dec, Sat == Julian Day 337 for u/w data purposes]

15:40(03:40pm) HST (338) 4 Dec, 01:40z Fire Boat drill

16:00 (04:00pm) HST (338) 4 Dec, 02:00z Fire boat drill completed
(338) 4 Dec, 02:48z Winds typical 30kts 310 degs

Dec 4, Sunday -

Arrive West side of the Big Island

07:30am HST (338) 17:30z Arrived initial point of survey, Deploy the drogue polypro ~160m to let untangle/unhockle a bit out of the fish box.

08:00am HST (338) 18:00z recover polypro, and begin survey of area for wind abatement
Winds calm but shear came in kicking up white caps and wind 24-27kts
(338) 18:30z still transiting

09:30am HST (338) 19:30z <u>on station</u> , winds ~7kts about 80degs
Ship's small boat in the water, Mike H., Jan C., Ulf R., Eric G. filming

10:44am HST (338) 20:44z Drogue in water, all mesocosms drifting and initial deployment complete.
RF on drogue buoy Chan 74 or 156.725MHz

Deployment postion Lat = 19 d 38.1' N Lon = 156 d 11.1' W - about 7-8miles off Kona side

Winds still about 7kts 88degs T

Deployment Order [BAG-5]----[BAG-4] ----[BAG-6] ------- Drogue
\ \ \
-P Neg Control +P

01:34pm HST (338) 23:34z 1st Flange loaded onto OTG SAFEBoat

02:30pm HST (339) 00:30z All Flange loaded onto mesocosms,

02:57pm HST (339) 00:57z Ship's small boat recovered

04:20pm HST (339) 02:20z OTG SAFEBoat recovered, completion of flange bottom install(not closed)

Notes: Conclusion of Sunday eve meeting–

1) BAGs have the flanges attached in position ready to close
2) Nets are still protecting the top & bottom from fish
3) A tear in BAG-4 Flange – will be repaired Monday, frame bent a bit so will need to adjust
4) Suggestion subsequently was that BAG-4 becomes control – all agreed.
5) Lights are attached but in the evening it is discovered they flashed briefly and died. Analysis is that they might have been flashing in the 40ft container van during shipment and ran out of power.

Dec 5, Monday -

07:45am HST (339) 17:45z all dive equipment is in OTG SAFEBoat

08:15am HST SAFEBoat was deployed along side – divers entered.

SAFEBoat, with divers, were first going to investigate and fix a small tear in the plastic on BAG-4 (chosen as the control) Mesocosm. However, upon arrival and investigation evaluated it as a stretch and not a tear.

1st dive: a) Close Flanges (after removing bottom netting);~1hour b) BAGS topside pulled above water (Topside netting removed)

2nd dive: anti-chaffing material added & stabilization of the plastic bags(added weight to bottom flange)

08:45am HST Ship's Boat then was launched with Ulf, Andrea, & Klaus; This was to raise up the BAGs above the water simultaneous with the divers closing below(instead of in series) . This strategy was to keep the bags from either ballooning out or concaving inward. In both cases when bottom flange was closed and topside ring pulled up, the protective netting on both ends was removed.

"T-1" Nutrients were sampled,

The flashing lights on mesocoms were fixed -utilizing fresh batteries and another ARGOS unit was installed on the other end (BAG 5) of the array. So we have two ARGOS units, the first on the drogue –the 2nd on the other end, BAG-5 of the 'string'. REF ARGOS Info: 00739 084858 Mounted on BAG-5;
00739 084859 Mounted on Drogue – float

~11:00am HST Ship's small boat returned while the SAFEBoat continued with the 2nd dive (see above)

01:45pm HST SAFEBoat used to deploy the spider and T-0 samplers.

Spider recipe manipulation for the 2 BAGS: BAG-5 (-P) and BAG-6 (+P)

04:45pm HST (340) 02:45z SAFEBoat ops concluded, Boat brought on board.

06:15pm HST CTD test cast, Silicon tubing by itself problematic, 4 members worked to change out during the afternoon with Teflon springs. Successful test cast in general. Fluorometer responds to tests properly, but fluorescence in water low and linear? Will do checks with handheld mesocosm CTD mounted on Rosette at later time. Suggestion was to install 2nd fluoro if available.

Dec 6, Tuesday

06:30am HST (340) 16:30z Small boat away- Ulf , Andrea, Jan C., Alex driving, collect nutrients for incubation – motored back dropped off 2nd pumped sediment trap (normally done first due to stirring via sampling, but because of time/daylight and being careful reversed order)

07:45am HST Small boat dropped off the sediment material picks up handheld CTD (Mike, mattias, Jan B)

08:10am HST SAFEBoat away w/ sampling gear, 8samplers – 40 Liter sampling (kuhio, Ulf, Andrea, Sasha)

All Sampling wrapped up about noon – although, 1 boat op alone for 40L sampling takes too much time

Today, the small boat sampled one mesocosm BAG; SAFEBoat sampled 3 (2 BAGS & PacificO)

After lunch – SAFEBoat returned with divers checking the line and checking fasteners, to see if all was still secure.

02:00pm HST - (341) 00:00z Still on the mesocoms diving. Two vans handling the water filtration, etc.

Note: 3 photo synthetrons put out quite a bit of heat. Therefore quite warm in the flow cyto van.

Ship's Engineers rigged a "funnel" (used to vent hot air from Engine space) to redirect the A/C to where Ken's lab stool is. Concern is whether the flow cytometry data or stability will be impacted by the variable air flow nearer the instrument. Conclusion seemed to not impact the flowcytometer.

02:20pm HST , SAFEBoat back on deck- concluding todays boat ops

06:00-06:30pm HST Conducted Stn2Cast1 Ship's CTD to 300dbar - Profile only; now with Seapoint fluoro on which seemed to work fine in terms of proper trace.

08:00pm Captain explained we were 2.7nmiles from a FAD (Fish Aggregate Device, anchored to a subsurface buoy), began to discuss a strategy to keep the mesocosms off or from running into the FAD.

10:00pm mesocosms slowed from .5kts typical to about .3kts. Wind about 4kts at about 50degs. Standing by to see drift pattern and possible changes.

Dec 6, Tuesday (continued)

Note: Handheld CTD for mesocosms - Oxygen has depth limit of 100meters, therefore only test could be to 80meters checking corresponding CTD sensors on Rosette. May plug the hole of Oxygen sensor with a "bad" one - but question is what happens under pressure when going to 140m ? Mattias will check with vendor(s) etc., in determing the options. Thinking of doing cross calibrations with Shipboard CTD.

Dec 7, Weds (Setup sampling schedule & Starting to get more into Routine)

06:30am (341) 16:30z PP water Ship's small boat (Ulf , Andrea)
07:10am Small boat returns with PP
07:17am back to Sediment Sampling - Ship's small boat (Jan C., EricG.)
07:30am Ship's boat back to drop off sediments
07:45am OTG SAFEBoat - load for sampling (Kuhio : Andrea, Ulf, Jennie, Eric)
Preparation for 2 BAG sampling
07:40am Ship's small boat returns w/ sediment
07:45am small boat prepped for sampling/ (Mattias, Sasha)
Preparation for 2 BAG sampling; Note BAG samples are transferred from ship's small boat to SAFEBoat for Gas sampling while at the mesocosms;
small boat away from KOK prior to SAFEBoat departure (Mattias, Sasha)
08:15am SAFEBoat away to sample & also do Gas sampling
09:40-09:58am small boat, turn around: handheld CTD / Zooplankton 50ucron net (Jan B., Mattias)
~10:00am SAFEBoat returns, samples off load, and tethered to stbd side.
Break for SAFEBoat ops
10:57am small boat back, recovered, & stowed. Break for Small boat ops
11:00am Both Boats finished with sampling, CTD, Net collection
SAFEBoat - tethered for larger volume after lunch
11:15am Break for lunch
11:50pm SAFEBoat departs for larger volume sampling (Blake: Chris, Shimi, Daniela, Jan)
Chris - 50liters from each bag; Shimi, Daniela 100liters from BAG 4 & BAG6
12:00-12:45 pm Hyper - pro deployment off of back deck, N.American crane (hyper-pro instrument ~35lbs on deck, typically deployed stbd side utilizing the OTG Nylon block (Steve P., Angel)
02:00pm SAFEBoat returns - Crane on the Carboys? Line for larger, hand up for smaller.
02:15pm SAFEBoat stowed Note: it takes crane operator Plus 4 taggers to bring this aboard.

06:00pm Ship's Rosette/CTD sampling
07:00pm Science Meeting

Dec 8, Thursday

06:30am (342) 16:30z Depart ship's small boat for PP sampling (Alex: ULF, Andrea)
07:00am arrive
07:15am Depart ship's small boat, Sediment sampling (Alex: Jan C. Steve P.)
07:30am arrive - Prep for 2 BAG sampling
07:45am Prep OTG SAFEBoat for 2 BAG sampling and Gas sampling
08:00am Depart ship's small boat, sampling (Mike: Jan B., Steve P.)
08:15am Depart OTG SAFEBoat for 2 BAG & Gas sampling (Kuhio: Ulf, Andrea, (Tara-backup) Ken)
09:40am arrive ship's small boat
10:00am Depart ship's small boat Handheld CTD/ zooplankton net (Mike: Mattias, Sasha)
Arrive SAFEBoat - & tethered to the KOK
11:00am arrive/recover – ship's small boat
12:00pm OTG SAFEBoat away for Large Volume pumping (Blake: Chris, Eric)
12:10pm Hyper-Pro start Angel, Katie, Steve
01:00pm Arrive/Depart OTG SAFEBoat 2-Dives, (Blake: Eric DaveP, Jan C, Jan B., Jennie, Ulf)

Dec 8, Thursday (continued)

01:30pm Hyper-Pro finish
02:10pm arrive OTG SAFEBoat and recovery
06:00pm CTD cast 300m profile
07:00pm Science Meeting

Dec 9, Friday

06:30am (343) 16:30z Depart ship's small boat for PP sampling (Alex: ULF, Andrea)
07:00am arrive
07:15am Depart ship's small boat, Sediment sampling (Alex: Jan C. Jennie.)
07:30am arrive - Prep for 2 BAG sampling
07:45am Prep OTG SAFEBoat for 2 BAG sampling and Gas sampling
08:00am Depart ship's small boat, sampling (Mike: Jan B., Steve P.)
08:15am Depart OTG SAFEBoat for 2 BAG & Gas sampling (Kuhio: Ulf, Andrea, Tara, Eric)
09:40am arrive ship's small boat
10:00am Depart ship's small boat Handheld CTD/ zooplankton net (Mike: Mattias, Sasha)
Arrive SAFEBoat - & tethered to the KOK
11:00am arrive/recover – ship's small boat
12:30pm Hyper-Pro start Angel, Katie, Steve
01:00pm Hyper-Pro finish
01:30pm Depart OTG SAFEBoat Large volume pumping/ Filming (Blake: Chris, Eric, Shimi, Daniela)
02:45pm (344) 00:45z arrive OTG SAFEBoat and recovery
04:00pm CTD cast 300m profile
06:00pm Science Meeting

Dec 10 Saturday

06:30am (344) 16:30z Depart ship's small boat for Primary Production water sampling (Alex: ULF, Andrea)
07:00am arrive
07:15am Depart ship's small boat; Sediment sampling (Alex: Steve P. Jennie.)
07:30am arrive - Prep for 2 BAG sampling
07:45am Prep OTG SAFEBoat for 2 BAG sampling and Gas sampling
08:00am Depart ship's small boat, sampling (Mike: Jan B., Blake.)
08:15am Depart OTG SAFEBoat for 2 BAG & Gas sampling (Kuhio: Andrea, Tara, Dave P., Jan C, Klaus)
09:40am arrive ship's small boat
10:00am Depart ship's small boat Handheld CTD/ zooplankton net (Mike: Mattias, Jan B., Eric-video)
Arrive SAFEBoat - & tethered to the KOK
11:00am arrive/recover – ship's small boat
12:00pm Depart OTG SAFEBoat; Large volume pumping, 100L BAG6 (Blake: Shimi, Daniela, Tara)
12:15pm Hyper-Pro start Angel, Katie, Steve
12:30pm Hyper-Pro finish
12:45pm arrive OTG SAFEBoat
01:15pm Depart OTG SAFEBoat Dive Ops – check Mesocosms /Filming (Blake: DaveP., Jennie, JanB, JanC, Eric Filming topside, Ulf, Mattias)
02:45pm (344) 00:45z arrive OTG SAFEBoat and recovery
04:00pm CTD cast 300m profile
06:30pm Brief Science meeting & review some raw video footage

Dec 11 Sunday - A change up in the Order to determine mixing from CTD possible.

06:30am Depart ship's small boat for Handheld CTD& Primary Prod & water sampling (Alex: Klaus, Mattias)
07:30am arrive/depart ship's small boat, Sediment sampling (Alex: Jan B., Jennie.)
07:45am Prep OTG SAFEBoat for 2 BAG sampling and Gas sampling

Dec 11 Sunday (continued)

08:00am arrive/ depart ship's small boat, regular sampling (Mike: Sasha., Blake.)
08:15am Depart OTG SAFEBoat for 2 BAG & Gas sampling (Kuhio: Karin, SteveP., Jan C, Klaus)
10:15am arrive ship's small boat & OTG SAFEBoat
11:50am Depart OTG SAFEBoat 2nd Handheld CTD (Blake: Mattias, Steve)
Arrive SAFEBoat - & tethered to the KOK
12:00pm Hyper-Pro start Angel, Katie
12:30pm Hyper-Pro finish
12:35pm arrive OTG SAFEBoat
01:00pm Depart OTG SAFEBoat Pull / Steer Mesocosm tests (Blake: Eric, Ulf ,)
Depart Ship's small boat taking the lead (Joe: Jan C., Steve)
Diving to monitor & film underwater, Dave P., Jennie, Jan B – topside
02:15pm (345) 00:15z arrive ship's small boat (recover) & OTG SAFEBoat
02:45pm Depart OTG SAFEBoat for Large volume 100L (Blake: Chris, Eric
03:45pm arrive & recover OTG SAFEBoat
06:20pm CTD cast 300m profile & sample Ken 2@150dbar & 2@15dbar

It was determined that we mesocosms were initially traveling at about .5kts and our taking under tow increased the speed to .6kts based on the ship's radar measurements. We added about a .1kt acceleration. Divers did note that the bags underneath seemed to respond in kind but no problems noted. The ship's small boat took on quite a bit of water over the transom even with additional weight of another person on the bow, thereby suggesting towing will be problematic for the small boats.

Dec 12, Monday

12:30am (345) 10:30z Mesocosm drifted into a northeast current traveling at about 1.7kts.
01:00am The current drifted the mesocosm system into approximately a 100m contour depth level.
01:30am The drogue (~150m depth) cage caught on something and held fast. The force of the current against the bags, submerged the drogue buoy (~3000lbs net buoyancy) and subsequently the attached BAG-6, such that the frame's blinking light was under water. The 10k lb drogue line from the cage parted ~3m from the buoy, allowing BAG-6 and the buoy to pop back to the surface. At this point experiment was halted and preparations were made to tether to and baby sit the mesocosms with the small boats until day light.
01:40am (345) 11:40z small ship's boat in water
02:45am OTG SAFEBoat in water and tow line was subsequently transferred from the ship's small boat
08:00am (345) 18:00z Began recovery of mesocosms, 1) flanges, 2) bags , 3) OTG SAFEBoat, 4) frames
04:00pm (346) 02:00z End Recovery
04:30pm CTD cast (Chris and Sasha water) 12bottles @ ~40dbar & 12 bottles @ ~ 5dbar
07:55pm CTD cast (Angel Cast) 24 bottles @~75 dbar

Dec 13, Tuesday

07:54am (346) 17:54 CTD cast (Tara & Karin water) 6bottles ea at 4 depths, 150 dbar, DCM, 45dbar, 15dbar
08:30am Transit to Snug Harbor
10:00am Arrive Pier 45 Snug Harbor. Partial offload – due to incubation experiments
Offload of Mesocosms – Begin disassembly of frames

Dec 14, Wednesday

Offload 20ft Vans and incubators, etc.,
Arrival of Empty 40ft container – begin loading the mesocosm system into the containers.

Dec 16, Friday

03:00-4:30pm Post Cruise Debrief – C-MORE Moore Conference Ctr, with Polycom broadcast

Dec 21, Wednesday

~10:30am Trucker picked up the loaded 40ft container for shipment back to Germany.

General Summary: The mesocosm deployment went smoothly and for the location chosen the weather was extremely cooperative. Modeling and data showed we deployed the mesocosm on the East edge of an anti-cyclonic eddy about 8nmiles SW of the Kona airport. The initial drift pattern was .5kts to the SSE. However, on Tues, Dec 6 about 8pm the drift track showed the drifting array to be leaving the eddy and moving to the east. It was about this time that the ship's RDI 150kHz NB ADCP started working which gave us a better indication of the 'why' of the array drift pattern. Early the next morning, Dec 7, it was clear that the drift track of the mesocosm array was turning back toward the north and was completely free of the SSE eddy. This impacted one engineering operational goal which was to observe the mesocosm behavior in higher sea states and large wind driven open ocean swells. With the U-turn to the north, the array drifted into even calmer seas riding a counter current north up the coast of the Big Island about 2-3miles offshore. As explained above in the narrative, the drogue consisted of a buoy and a wire cage tethered below about 150m. The drogue successfully put enough drag on the topside mesocosm string to keep them from entangling or bumping into each other as they drifted along. At one point it was considered a safety feature to have the drogue cage in a deeper mass of water not only for drag but to keep the array from running aground. This idea was tested, on the 12th of December, when it became apparent that the drogue had run aground. One can only speculate as to how close the mesocosms might have drifted to shore had the drogue not gotten caught. Now at the time of recovery it was noted that the mesocosms did experience some larger sea swells. These were in combo with higher winds (30kts) but this was not sustained enough to determine the open ocean response or chaffing action – plus the array was being tethered on the surface by one of the two smaller boats due to the drogue snag and this changed the characteristics of drift. Had the experiment not ended by the drogue getting caught and subsequently pulling BAG-6 under water, there was also concern that the drift at 1.7kts and drift direction might have quickly taken the array into the Alenuihaha channel with the channel sea state already unfavorable for a safe recovery. However, recovery went smooth and by the time the frames were lifted on to the deck, the sea state was mixed but the wind had fallen off from its higher peaks in the morning to about 8kts. Overall the ship's equipment for all deployments worked well and the procedure for lifting the OTG SAFEBoat on and off the back deck (into its cradle) went smooth but was labor intensive (1 crane operator, 4 tag lines) in comparison to the other operations, except for the deployment and recovery of the mesocosm frames. Utilizing the crew for the long hours of small boat operations impacted the crew staffing when it came to deploying the shipboard CTD. These CTD deployments were juggled at times to allow the necessary crew member to be rested and available for the launch and operation of the winch equipment. In view of this, we tried utilizing the OTG SAFEBoat far more than originally planned since it was being driven by the science party(Kuhio-OTG, Blake - C-MORE). The OTG CTD bottles (brand new), were modified underway to utilize the Teflon springs instead of the silicon tubing – due to 'nicking' being a factor of failure for the silicon tubing (attached to the end-caps). The Wetlabs ECO/AFL/Nephelometer (fluorescence & backscatter) initially installed on the CTD "worked", but its fluoro sensitivity range was too high for these waters. This Wetlab fluoro's lack of response is seen in the first few CTD casts. Therefore the Seapoint Fluorometer was subsequently installed and provided the typical traces and sensitivity needed. A working ADCP, with a depth range covering both the mesocosm and drogue depths is critical to these experiments, as it confirms or clarifies the surface currents in terms of direction and magnitude. It will be indispensible in the future as a pre-deployment or survey tool to confirm the presence of a modeled eddy (projecting drift). Also indispensible during the experiment to determine when a drifting mesocosm has left an eddy.

The OSU team had three collaborative cruise objectives that were achieved on the CMORE-BAG1 cruise.

(1) Flow-thru records of particle size (via LISST measurements of forward scatter) and whole water and dissolved absorption and attenuation were monitored from the ship's flow-thru. These data will be compared to UCSC-FRRF records of chlorophyll fluorescence and fluorescence yield. This data processing is still to be completed.

(2) Along with the UH and GEOMAR, OSU collected daily samples from the mesocosms for 12-hr 14C light response curves, HPLC, LISST and hyperspectral absorption and attenuation in order to capture potential changes in particle loading and productivity. These samples originated from the first daily collections from the mesocosms (generally at 7am LST) to allow initiation of productivity experiments as close to "local" dawn as possible.

(3) They collected daily samples from the on-deck incubation experiments for analysis of HPLC, LISST-derived particle size, hyperspectral absorption and attenuation and 12-hr 14C-productivity incubations. These data will ultimately be combined with the UH team effort in order to characterize the biological and chemical dynamics of on-deck incubations relative to in situ perturbation experiments.

All flow thru and filtration were conducted in the ship's wet lab. All photosynthetron experiments were conducted in the Flow Cyto/ Rad van. After initial trouble-shooting to ensure sufficient power was delivered to the van to allow 3 photosynthetrons and water baths to run concurrently for a 12-hr period, all experiments went smoothly.
Preliminary results from the 14C experiments revealed that overall net primary productivity was highest in response to deep seawater additions in the on-deck incubations and highest in the +PN treatment in the mesocosms. The preliminary results voiced so far suggest that these results matched the guiding hypothesis.

The diving aspects of this cruise were handled in a professional manner and at no time was there a lack of equipment or backup air, or interest in diving to check the status of the mesocosms or conduct video operations. Visibility under water from the video footage and discussions was clearly 50-100ft depending on the direction one viewed. Other science operations in terms of sampling both on board and at the mesocosms was fairly straight forward with the IFM-GEOMAR team taking on the bulk of the daily mesocosm sampling and training until the rest of the science complement came up to speed with the procedures. The Big Island, as a weather shield and in combo with low sea state, was a big help in giving C-MORE and its colleagues a good first impression working with the mesocosms. Even though this location was not typical and did thwart the objective to observe the mesocosm in wind driven open sea conditions it did provide the ability to conduct the pull-test and provide the underwater coverage. It also became obvious that sampling a greater number of mesocosms when deployed(replicates, etc.), will impact other parallel experiments onboard due to the increase of the number of staff (limited berths) required to tend to the mesocosms in a timely fashion. Alternatively, the experiment could be conducted in a fixed location nearer shore. The shuttling back and forth from shore would then allow more science personnel to handle the sampling aspects of a larger number of deployed mesocosms. In the future, increasing the number of mesocosms being deployed, also means that the ship's small boat and the OTG SAFEBoat would be the "minimum" number of small craft one could operate with, and suggests that with 9 mesocosms deployed, sampling in a timely fashion would necessitate the use of 3 smaller boats.

Ship to Shore communications was greatly enhanced due to the outcome of the drift direction. At all times the ship was well within most cell phone coverage and OTG had a Verizon WiFi Access point (5-6users at one time) available to use that had unlimited connectivity.

It was noted that in the 25L carboy addition to the bags, the hexafluorosilicate apparently did not go fully into solution by the time it was dispersed and some crystals were recovered in the sediment trap. The pre-BAG-1 incubation experiments showed complete solubility of the hexafluorosilicate; however, the silicate solution was prepared in a glass flask with a stirrer plate (~2h) where one could observe the solution. Therefore, it may be expedient in the future to verify all additions have gone into solution, especially when using opaque carboys.
The spider, integrated samplers, handheld CTD, and handheld BAG net tows all operated properly. We were unable to test the new design of the wiper (a ring that has silicon material to wipe down the inside of the bag – to collect all material for total production analysis) due to the premature halting of the experiment early on Monday. Samples of the inside of the bag were obtained by cutting parts of the plastic bag and freezing for later analysis.

The large volume sampling for samples of the viral community and grazing went relatively smoothly. Creating the vacuum with the polypropylene carboy worked efficiently for pumping water up from within the bags. This was in part due to the calmness of the seas and the wind, in contrast to the windy afternoons when the small boat would bump back and forth into the mesocosm frames making sampling, at those times, more difficult. The afternoon schedule allowed daily sampling to target for: virus abundance, viral nucleic acid extraction, frequency of visibly infected bacterial cells, and the performance of microzooplankton grazing experiments. Every other day, 40L was collected from each bag in preparation for later running viral community fingerprint gels.

All other science operations related to the BAGs and deck-board experiments as well as the Hyperpro casts, were satisfactory.

Assessments of the Cruise Based on the UNOLS Cruise Assessment Form:

Captain Clarey Gutzeit

R/V *KA ʻIMIKAI-O-KANALOA*
POST CRUISE REPORT

1. Cruise No. and/or Project Name: KOK 11-15, C-MORE
2. Dates of Cruise: December 1, 2011 to December 13 , 2011
3. Master: Clary Gutzeit
4. Chief Scientist: Steve Poulos, U. Riebesell
5. Marine Technician: Kuhio Vellalos , OTG,
6. Project funding agency: __X__NSF _____NOAA ____ONR____Navy ___Other
7. Area of Operations: NP-12
8. Name of person completing this form: Clary Gutzeit
9. E-mail address: kok-master@satellite-email.com
10. To what extent were the planned science objectives met?
    ___100%__X_75%-99%___50%-74%___25%-49%___0%-24%___N/A
    comment: 1 day 21 hrs lost due to propulsion failure.
    Returned to port two days early after loss of array drogue.

11. Please provide a brief description of the science objectives (ie. CTD casts, survey transects, mooring deployment)
    Mesocosm array deployment and recovery
    Small Boat operations in support of project.
    CTD casts
    Dive operations

12. Rate how well the science party contributed to achieving the scientific objectives of this cruise (pre-cruise planning, communication, adequate personnel, equipment, attention to safety, organization, etc.)___Excellent_X__Above average___Average_____Below average___Poor___N/A
    COMMENT: The science party contributed well to achieving the science objectives.
13. Rate how well ship operator pre-cruise activities and shore support (planning, coordination and logistics) contributed to achieving the scientific objectives of this cruise. ___Excellent___Above average__X__Average___Below Average___Poor___N/A
    COMMENT:
15. Rate how well the ship operator supplied scientific equipment and marine technicians supported this cruise (appropriate equipment, equipment operational and ready for cruise, calibrations, documentation, technicians trained and familiar with equipment).
    ___Excellent_X__Above average___Average___Below Average___Poor___N/A
    COMMENT:

16. Rate the level of safety in shipboard and science operations (safety briefing and instructions, procedures and equipment). ___Excellent__X__Above average____ Average ___Below average___Poor___N/A
    COMMENT: Safety brief was conducted and all safety procedures were followed.

17. Rate how well ship officers and crew and the manner in which the research vessel was operated contributed to achieving the scientific objectives of this cruise (communication, ship handling, deck procedures, attitude towards the science objectives, training, adequate number of crew, shipboard routine, etc.). ___Excellent _ _X__Above average___Average___Below average___Poor___N/A
COMMENT: Ship's officers and crew did a good job communication, ship handling and deck procedures.

18. Rate how well the research vessel and it's installed equipment contributed to achieving the scientific objectives of this cruise (material condition, readiness, living conditions and habitability, condition of lab spaces, deck equipment, winches, cranes). ___Excellent__X__Above average___Average___Below average___Poor___N/A
COMMENT: The ship's deck gear, lab spaces and living areas were in good condition.
Ship experienced propulsion failure on departure Dec. 1 ,2011 and repairs were delayed until Dec. 3, 2011 due to unavailability of parts.
19. Number of science days lost due to:
Weather: 0
Ship: 1 day 21 hours lost due to propulsion issues
Ship's scientific equipment: Returned to port 2 days prematurely due to loss of array drogue . Drogue was lost after it snagged on bottom.

UNOLS Cruise Assessment Form:
Chief Scientist Steve Poulos

1. Ship Name: R/V *Ka'imikai-O-Kanaloa*
2. Dates of Cruise: December 1, 2011 to December 13 , 2011
3. Chief Scientist: Steve Poulos
4. Master: Clary Gutzeit
5. Marine Technician: Kuhio Vellalos , OTG,
6. Cruise Number: KOK1115
7. Type of Work: C-MORE Collaboration with IFM-GEOMAR to utilize Open Ocean Mesocosms

7a Project funding agency: __X__NSF _____NOAA ____ONR____Navy ___Other

8. Area of Operations: NP-12
9. Name of person completing this form: Steve Poulos
10. Your Institution: University of Hawaii
11. E-mail address: poulos@soest.hawaii.edu
11a. PI Sci email dkarl@hawaii.edu
12. Your Position on Cruise: PI/Chief Scientist
13. To what extent were the planned science objectives met?
___100%__X_75%-99%___50%-74%___25%-49%___0%-24%___N/A
comment: 1 day 21 hrs lost, Dec 1-3, due to propulsion failure.
Dec 13, 10am, Returned to port two days early after loss of array drogue, and the experiment was halted due to BAG-6 being submerged when drogue snagged.

13a. Please provide a brief description of the science objectives (ie. CTD casts, survey transects, mooring deployment) 3 Mesocosm array deployment (surface-20m depth) with drogue (150m depth) and recovery Small Boat operations in support of project both for diving and sampling.
Mesocosm daily handheld sampling (CTD & depth integrated sampler) , Shipboard CTD casts
Diving operations - both IFM-GEOMAR & UH participants, Deck incubations

14. Rate how well the science party contributed to achieving the scientific objectives of this cruise (pre-cruise planning, communication, adequate personnel, equipment, attention to safety, organization, etc.)___Excellent_X__Above average___Average_____Below average___Poor___N/A
    COMMENT: Both parties prep and execution went well.
15. Rate how well ship operator pre-cruise activities and shore support (planning, coordination and logistics) contributed to achieving the scientific objectives of this cruise. ___Excellent_X__Above average_ __Average___Below Average___Poor___N/A
    COMMENT: Assitance shore side- very helpful with staging. Only unknowns to deal with – weather coordination with Ship's crew – very good.
16. Rate how well the ship operator supplied scientific equipment and marine technicians supported this cruise (appropriate equipment, equipment operational and ready for cruise, calibrations, documentation, technicians trained and familiar with equipment).
    ___Excellent __Above average_X__Average___Below Average___Poor___N/A
    COMMENT: Marine techs equipment worked well after startup issues. New Shipboard CTD bottles needed adjustment after initial install of silicon tubing –changed out for Teflon coated springs first day out. Orig Fluoro wrong sensitivity range so used 2nd fluoro unit. Also ADCP was not operational until a few days into cruise – both systems were needed and once operational, satisfactory. Flexible in substituting 1 tech for additional science person – very helpful.

17. Rate how well the scheduling of this supported the scientific objectives of this cruise
    _X__Excellent __Above average___Average___Below Average___Poor___N/A
    The interactions with the Ch Sci prior and post with Port Captain was excellent in arriving at the sched.
18. Rate the level of safety in shipboard and science operations (safety briefing and instructions, procedures and equipment). ___Excellent__X__Above average_____ Average ___Below average___Poor___N/A
    COMMENT:

19. Rate how well ship officers and crew and the manner in which the research vessel was operated contributed to achieving the scientific objectives of this cruise (communication, ship handling, deck procedures, attitude towards the science objectives, training, adequate number of crew, shipboard routine, etc.). _X__Excellent _ __Above average___Average___Below average___Poor___N/A
    COMMENT: Ship's officers and crew very flexible and capable – fit well with the experiment being a first of its kind. Ship's officers had excellent attitudes -

20. Rate how well the research vessel and it's installed equipment contributed to achieving the scientific objectives of this cruise (material condition, readiness, living conditions and habitability, condition of lab spaces, deck equipment, winches, cranes). ___Excellent__X__Above average___Average___Below average___Poor___N/A
    COMMENT: Staterooms, labs, installed equipment The ship's deck gear, lab spaces and living areas were in good condition. Ship's propulsion SCRs had problems that delayed departure, until parts were flown in on Dec. 3, 2011.
21. Number of science days lost due to:
    Weather: 0 Note: inside West Hawaii coast area from 2mi-8miles very calm for this leg
    Ship's Propulsion : 1 day 21 hours lost due to propulsion issues
    Ship's scientific equipment: Returned to port 2 days prematurely due to loss of array drogue and submergence of one of the mesocosms . Drogue was lost after it snagged on bottom.

Assessment IFM-GEOMAR: Chief Scientist- Ulf Riebesell

Resumé of BAG-1 mesocosm campaign off Hawai'i, Dec. 1-13, 2011 on board R/V *Ka'imikai-O-Kanaloa*

(1) The crew of the KOK is very well capable of handling the mesocoms. They did an excellent job in deploying, sampling and recovering the mesocosms. They were competent and extremely helpful during the entire campaign.

(2) The boats and sampling equipment available during this cruise were appropriate to carry out the sampling needed for a normal mesocosm campaign. Sampling of the mesocoms was possible at all times during this campaign, including times with 3-4 feet swell.

(3) The location chosen for mesocosm deployment (in the wind shade west of Hawai'i) was optimal to keep them in relatively calm waters. Deploying the mesocosms in the eddy west of Hawai'i seems like a useful strategy to ensure that they stay in protected waters for extended periods of time. The surface currents in the vicinity of the island (5-6 nm off shore) did not follow the eddy's meso-scale current pattern indicated in the available current charts. Operation of the ADCP is helpful to obtain information on the current patterns surrounding the mesocosms.

(4) The mesocosm array (3 mesocosm units with a buoy and drogue) behaved well in currents with often changing directions. The drogue was sufficient to keep the mesocosms apart.

(5) The mesocosms are well capable to handle swell or wind waves up to 5-6 feet (max. probably 6-7 feet). We have not experienced strong winds and high swell in combination, so not sure yet what would be the limits for this.

(6) An attempt to pull the mesocosm array with the small boats (ship's boat and OTG boat) demonstrated that (a) it is possible to steer them away from any obstacles (e.g. FADs), (b) it is impracticable to pull them for long distances (e.g. 1 mile or more). As a consequence, the strategy of repositioning the mesocosms in order to keep them in an eddy when they are at risk to be kicked out or to move them into a more favorable current does not seem viable. Underwater filming during this test indicated that the bags were tilted, but not at risk to be damaged.

(7) An avoidable problem (the drogue hitting the ground and getting stuck) led to an early termination of the experiment. Because of high currents (1.7 knots) the buoy and the mesocosm next to it got pulled under water when the drogue got stuck. After about 25 minutes the line between drogue and buoy ripped and the buoy and mesocosm resurfaced. The problem could have been prevented by lifting the drogue while passing the shallow waters. No damage occurred to the mesocosm frames. The bags in two of the mesocosms were damaged substantially.

(8) The experiment (6 days) was too short to go through the entire plankton succession after nutrient addition. It is important to note, however, that this campaign was intended primarily as a technical test.

Future perspectives:

(1) The captain and chief-mate, Clary and George, both had ideas on how to transport and deploy 6 or 9 of these mesocosms on the KOK. The suggested options seem reasonable and feasible to us.

(2) Considering the difficulty to pull the mesocosms over some distance, it may be difficult to conduct a longer-term (5-6 weeks) experiment in free-floating mode without risking to be exposed to unfavorable waters. The preferred mode of operation would therefore be a moored deployment in sheltered waters on the lee side of Oahu or Hawai'i. Surface currents of up to 0.5 knots should not be a problem. Higher currents should be avoided. We are still lacking experience on the combination of substantial swell/wind waves and strong surface currents in terms of possible chaffing damage on the ropes. A longer-term experiment of this kind would need regular inspections by divers for possible wearing of the materials.

(3)

(4) Options for a full 9-mesocosm C-MORE – GEOMAR joint experiment: all 9 mesocosms will be needed for the upcoming campaign off Finland in June-July 2012. They would be available for a joint experiment after this

campaign, i.e. late summer/fall 2012. An alternative time window would be the second half of 2013. More flexibility in 2014 and the following years.

(5) It would be worthwhile discussing areas of mutual scientific interest for future experiments. Possible options for mesocosm manipulation are: (i) deep-water injection to simulate upwelling; (ii) CO_2 enrichment to simulate ocean acidification; (iii) a combination of deep-water injection and CO_2 enrichment.

Science Personnel:

The *RV* KOK accommodates up to 21 scientists (typically 19 + 2 OTG). List of participants was as followed:

#	Participant	Institution
1	Kuhio Vellalos	OTG
2	Ulf Riebesell	IFM GEMOAR
3	Andrea Ludwig	IFM GEMOAR
4	Jan Czerny	IFM GEMOAR
5	Jan Büdenbender	IFM GEMOAR
6	Klaus von Bröckel	IFM GEMOAR
7	Matthias Fischer	IFM GEMOAR
8	Steve Poulos	UH
9	Daniela Böttjer	UH
10	Karin Björkmann	UH
11	Tara Clemente	UH
12	Blake Watkins	UH
13	Shimi Rii	UH
14	Eric Grabowski	UH
15	Shasha Tozzi	UCSC
16	Chris Schvartz	UH
17	Ken Doggett	UH
18	Angel White	OSU
19	Katie Watkins	OSU
20	David Pence (diver)	UH
21	Jennie Mowatt (diver)	UH

REFERENCE MATERIAL

IFM – GEOMAR 'spider' Procedure for additions: (rate of dispersement)

The spider is composed of a membrane pump (12 v car battery a 25 m rubber hose ½ ' and a dispersing part. It injects and distributes evenly the nutrients over the entire water column of the mesocsom. The Spider pumps 7l/min (dispersion rate) so amounts of 25L to 300L are practical for manipulation. Mixing bottles were 25L size, and GEOMAR provided the bottles for mixing the nutrient solution. Future planning should utilize this quantity to determine solutions that can be added volumetrically (to ~ 25L of milliQ or sea water) prior to addition.

IFM – GEOMAR 'integrated sampler'

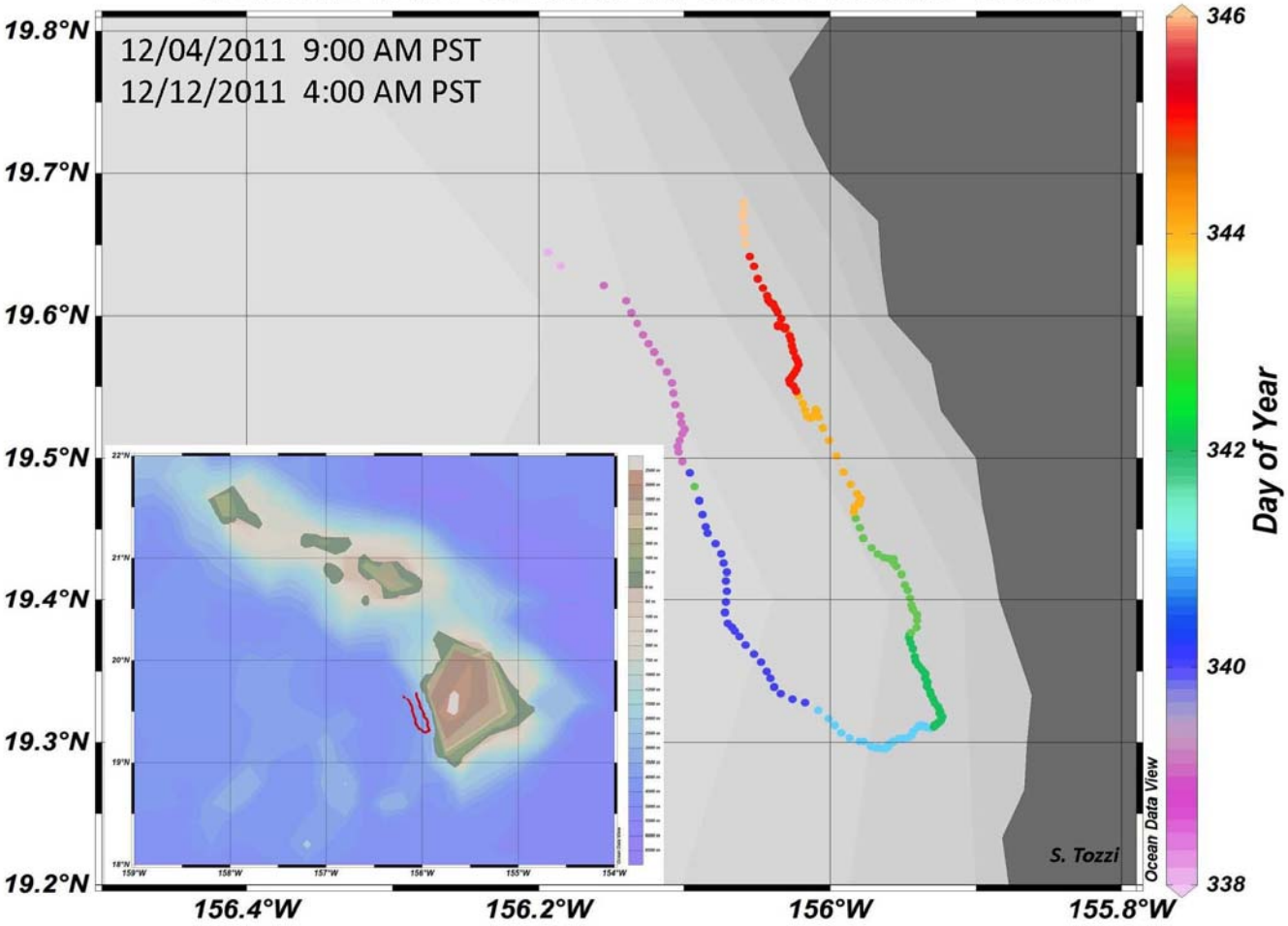
An Integrated depth sampler was used daily for routine measurements as well as a handheld data logger probe, equipped with several sensors (temperature, salinity, turbidity, pH, fluorescence, oxygen etc.). Integrated sampler is set to "on" and then utilizes a depth sensor to determine its rate of sampling.

The Instruments were lowered by hand over a davit into the mesocosm. In the current configuration, this also speaks to having taller scientists able to reach up from the small boat (bobbing up and down) over the top of the BAG to deploy or recover the samplers.

Equipment (brief):

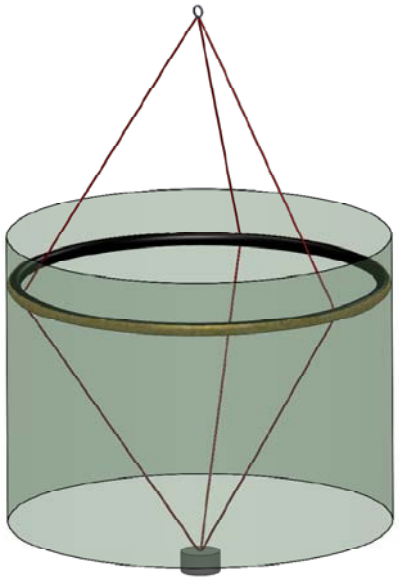
OTG CTD; Dual SBE sensors; fluorescence; (see Std HOT config for OTG CTD/Rosette) deck boxes etc.
OTG 150kHz Narrow Band ADCP – very useful
OTG Rosette and 24 -12 liter water sampling bottles, all spare parts
Did use the KOK Sub drum for some recovery ops – so future space should be made for a small capstan or open ended winch drum for drogue line retrieval and recovery of line for BAGs.
KOK/OTG standard underway sampling (THSL, fluoro), met, ADCP, and navigation information/ logging
Hyperpro (hyperspectral radiometer, a WET Labs ECO-BB2F triplet: Chlorophyll-a fluorescence & backscattering: blue & red wavelengths, temp & conductivity sensors) and associated optical measuring instruments
UCSC - FRRF –Benchtop Fast Rate Repetition Fluorometer
UH – Inverted Microscope (with Digital Camera)
GEOMAR - 5L bottles
OTG SAFEBoat in the Hangar
HOT Van & Flow Cyto Van both on top of Hangar
Incubation systems on top of hangar (for subscale process studies)
KOK - RDF
KOK – Comms (VHF) , email, Verizon WiFi Access point; F77 used sparingly
KOK – Depth Indicators
Pertinent MSDS

Mesocosm Drift Track:



Mesocosm Net (was not utilized due to abrupt project ending) :

Can be used to assist in seeing what microbes are growing on the interior bag wall. It is mounted to a ring sealing to the walls with silicone rubber seal. Note: this device is the same as used to remove wall growth in long-lasting experiments on a regular basis.



Reference Drawing for mesocosm Net

Reference Model or Drawing for a Mesocosm Drogue