Cruise Plan for R/V *Kilo Moana* KM-15-16: ALOHA Cabled Observatory Service 16 – 21 September 2015

14 September 2015

Version 1.1

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1. Introduction

The purpose of this NSF-funded cruise on the R/V *Kilo Moana* is to service infrastructure and instrumentation on the ALOHA Cabled Observatory (ACO). ACO is the deepest operating cabled observatory on the planet. Specifically, a new light (LIGHT4) and a basic sensor package (BSP2) will be installed, and three packages will be recovered (BSP1, CAM2, and LIGHT1). The remotely operated vehicle University of Hawaii ROV *Lu'ukai* is essential to performing the required tasks.

The cruise is 5 days long, from 0800 Wednesday 16 September – 0800 Monday 21 September 2015. The ship will depart Honolulu and proceed first to ROV test site 1 just off Honolulu for a test dive to 400 m, and then proceed directly to Station ALOHA, 100 km north, to perform the ACO work. If all goes according to this current plan, the work can be done during one ROV dive, approximately 28 hours. See Figure 1-1 for a map with nominal cruise lines. Table 1-1 gives coordinates of relevant points.

Figure 1-1 Map of area and nominal cruise lines.

	Depth m	Latitude deg	N minutes	Longitude deg	W minutes	Incremental distance (nmi)
UHMC, Snug Harbor		21	18.937	157	53.186	
Honolulu WP1		21	16	157	54	
Test Site 1, Connector frame	431	21	14.926	157	58.502	8
Barbers Point WP		21	16	158	09	14
Ka'ena Ridge WP		21	33	158	20	21
ACO Cable Termination Frame (TF)	4728	22	44.324	158	00.372	75
Station ALOHA		22	45	158	00	1

Table 1-1 Coordinates of waypoints and stations

In this Plan, we first describe the ACO system as it is now installed followed by a description of the new instrumentation to be installed. The ROV system is described, including the navigation system. The ship and deck configuration is described followed by a section on responsibilities. Finally, the operations are described with a timeline (some readers may wish to skip some of the preceding material). An even more detailed step-by-step plan is given in Appendix B. Other appendices have system diagrams and connections, personnel/contacts, berthing, and acronyms.

Information on the previous service cruise (KM-14-23) and installation cruise (KM-11-16) can be found in the respective cruise plans and reports, and the Oceans11 paper. See the list of references below and the ACO web site for this and other information including photographs and video, http://aco-ssds.soest.hawaii.edu/index.html. Because the ROV operations are so important for this cruise, this plan is written to emphasize those aspects.

All cruises such as this have some level of risk associated with completing the desired tasks. The most obvious two factors affecting risk here are weather and technical problems. In this case the cruise is taking place when weather is often not good. Working with the "one-body" ROV+TMS package and free-falling elevator and packages should let us work in a rougher weather and get the work done with a single ROV dive. The risk of technical problems with the ROV have been mitigated with the additional effort put into the system in the last month, since the 9-12 August test dive that reached 4726 m.

2. ACO Description

The ACO is a prototypical example of a deep ocean observatory system that uses a retired cable. The ACO uses a highly reliable existing transoceanic cable system to provide power and communications bandwidth to a "node" on the seafloor. In the simplest terms, we provide power and communications ports for users to plug into on the seafloor for arbitrary instrumentation. Here we include core instrumentation for scientific measurements of water properties (pressure, temperature, salinity, velocity, optics), video and acoustics, and acoustic communications.

The ACO node and instrumentation was deployed in May-June 2011 (see the KM-11-16 Cruise plan and report, and the Oceans11 article, Howe, et al., 2011). A subsequent service cruise in November 2014 removed a secondary node and added CAM2, LIGHT1, and BSP1. A composite photograph of the system deployed is shown in Figures 2-1 – 2-11; a plan view line drawing to scale is given in Figure 2-4.

Photographs of the equipment from the 2011 and 2014 cruises are shown in Figures 2-4 – 2-9. System block diagrams with interconnections are shown in Appendix A (along with the planned configuration).

Additional photographs and other system documentation can be found on the project wiki web site http://www.soest.hawaii.edu/acowiki/index.php/Main_Page. Also see the ROV *Jason* Virtual

Control Van videos for the two cruises (e.g., http://4dgeo.whoi.edu/webdata/virtualvan/html/VV-km1116/index.html).

Figure 2-1 shows an image taken by *Jason* of the seafloor equipment; from left to right, CAM2, CAM1, LIGHT1, OBS, and JBOX. The cable termination frame (TF) is to the right (Figure 2-2), and BSP1 farther still to the right (Fig. 2-3). The plan-view map is shown in Fig. 2-4 (this was the planned configuration; the actual is nearly the the same, other than the splice was left as is, straight to the CF). The current camera (CAM1) is working but the lights have failed, so we will be leaving it in place (though we may move it a little).

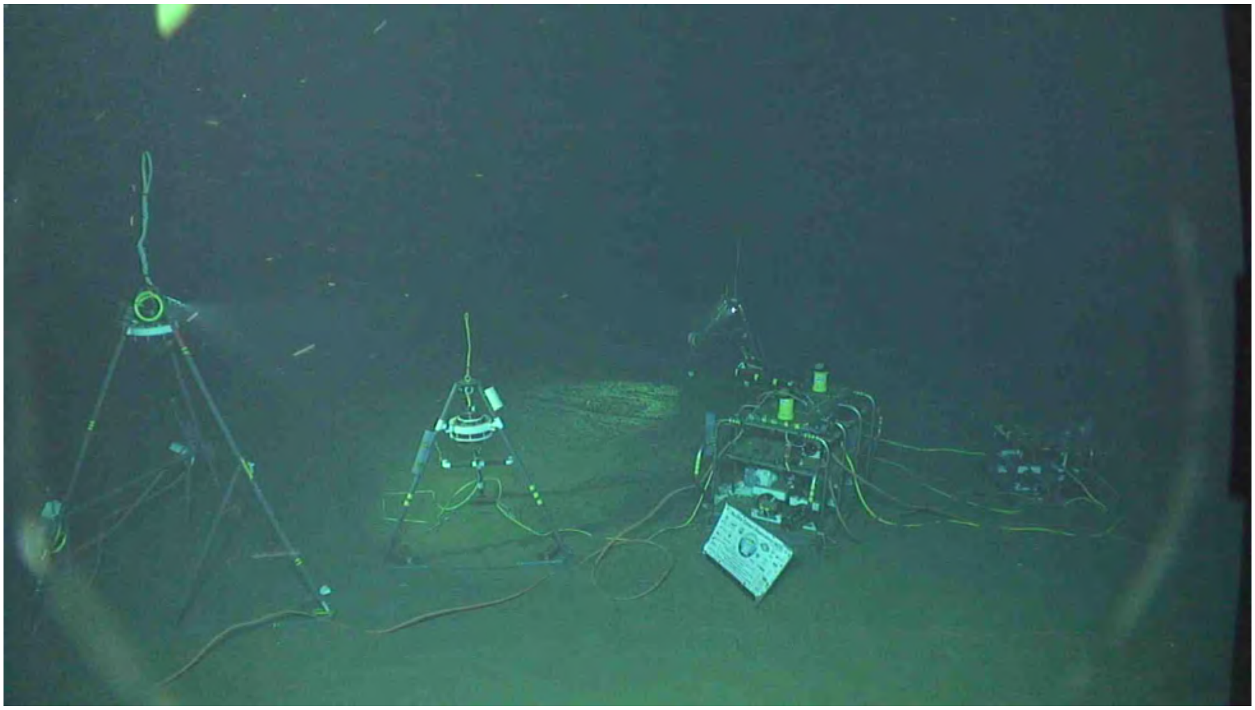


Figure 2-1 Image of present system. The BSP1 is off to the right 18 m.

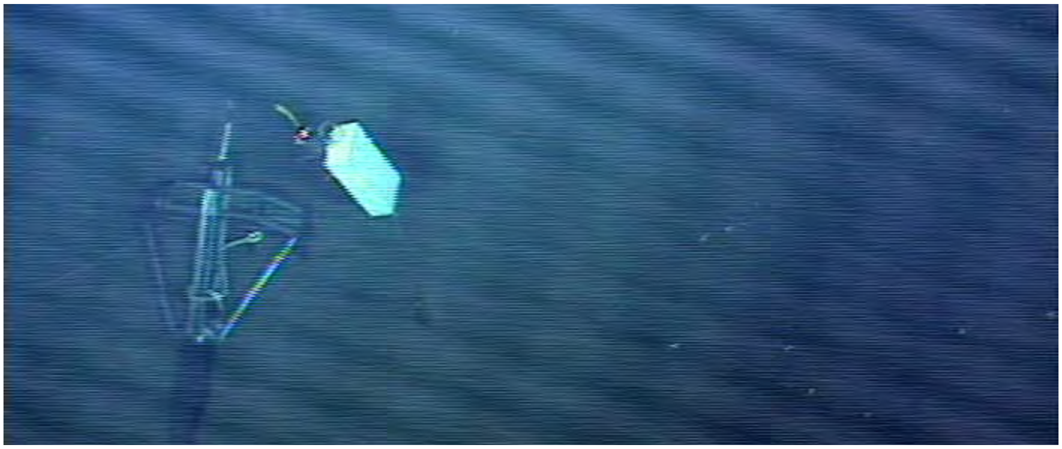


Figure 2-2 The cable termination frame on 24 May (top) and 6 June 2011 (bottom).

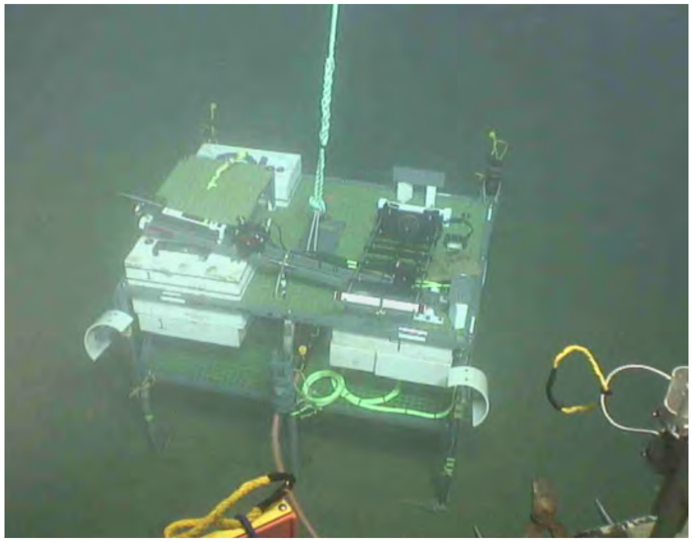


Figure 2-3 ACO Basic Sensor Package 1 (BSP1), just prior to raising masts.

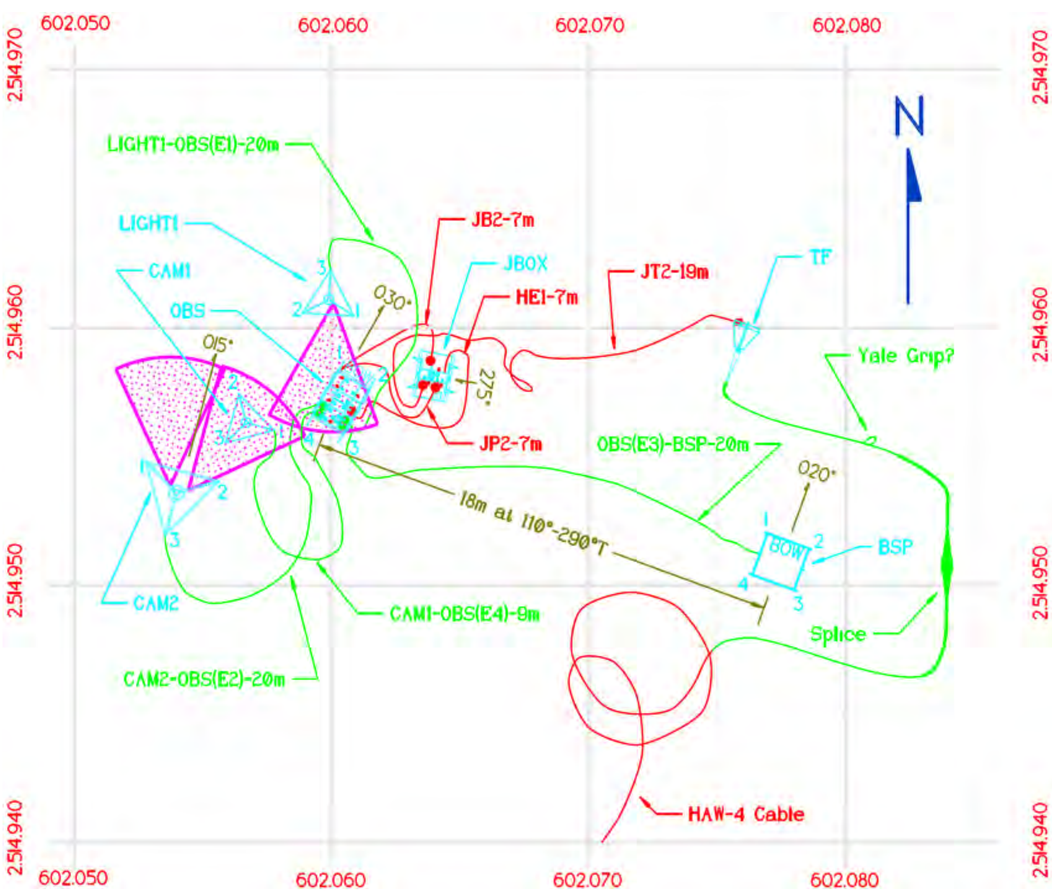


Figure 2-4 Present ACO seafloor configuration.

The ACO cable termination is connected to the junction box (JBOX) with an ODI hybrid optical-fiber/electrical hose assembly. An acoustic "homer" beacon is secured to the float on the neighboring short mooring (Fig. 2-3). The JBOX provides the fiber-to-electrical 100 Mb/s Ethernet and generates a precise pulse-per-second referenced to GPS on shore using IEEE-1588v2-PTP precise time protocol. On the JBOX frame is the hydrophone experiment module (HEM) with two hydrophones and a pressure sensor, Figure 2-5. Note the lowering bridle (this version has a mooring snubber).

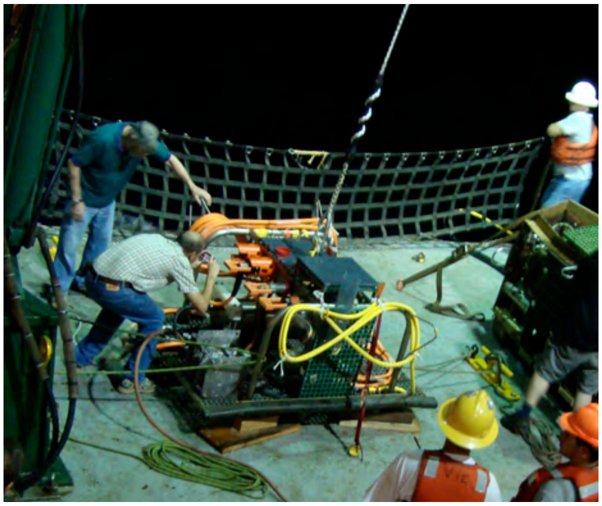
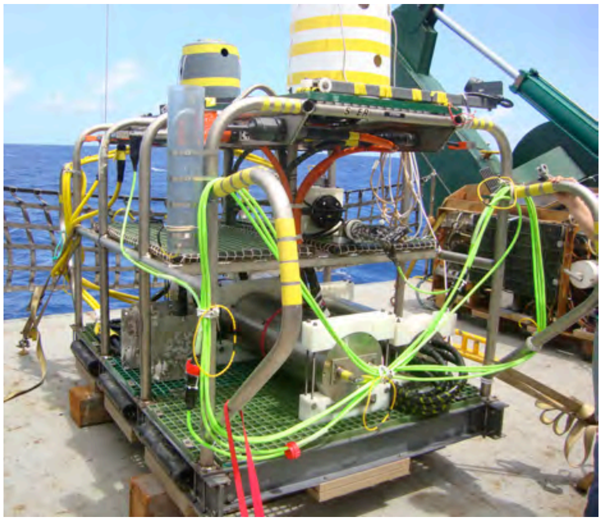
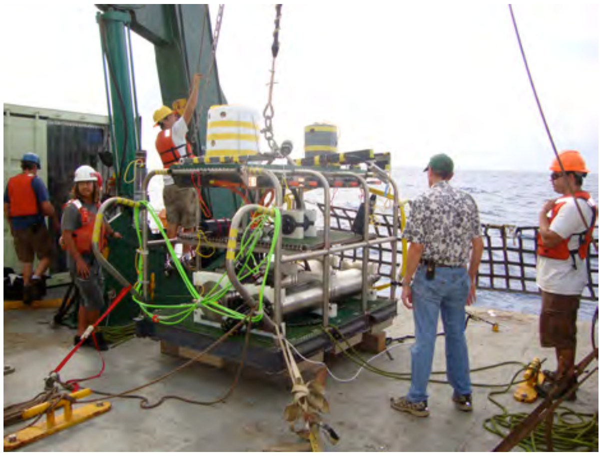


Figure 2-5 ACO JBOX

The observatory (OBS) is connected to the JBOX, Figure 2-6. The OBS converts the dc current on the cable to 48 V and 400 V, and distributes this, the Ethernet, and timing signals to eight user ports. On the observatory are two acoustic Doppler profilers (ADPs), a temperature/conductivity instrument (CT), and a light, that are connected to one “micro science experiment module” (µSEM) that is in turn connect to one OBS port, E6. Note the orientation guides: yellow tape on corners (1-4; 1 is port bow, 2 is starboard bow, …), and port numbers; see also Appendix A for a schematic of this including instrument port assignments. Deck pictures show the CTD and light in stowed positions; on the seafloor they have been rotated 180 degrees, so as to hang outboard of the OBS. Note the seawater return/ground plates on the bottom of the Observatory, port side. Also note the pin-protecting dummy at the stern on the middle deck; there is also one in the E6 position on the port quarter.





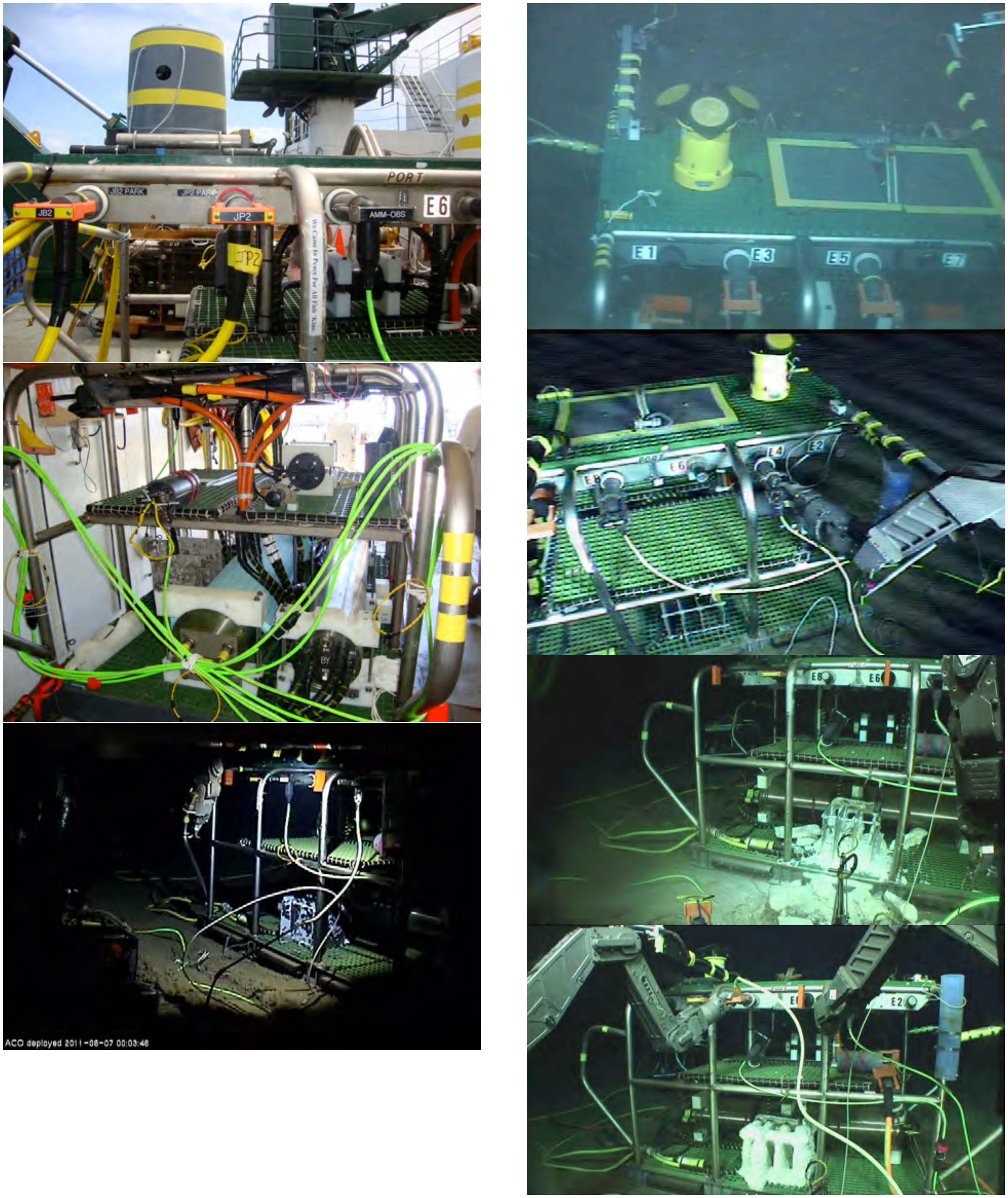


Figure 2-6 OBS frame (on deck and seafloor)

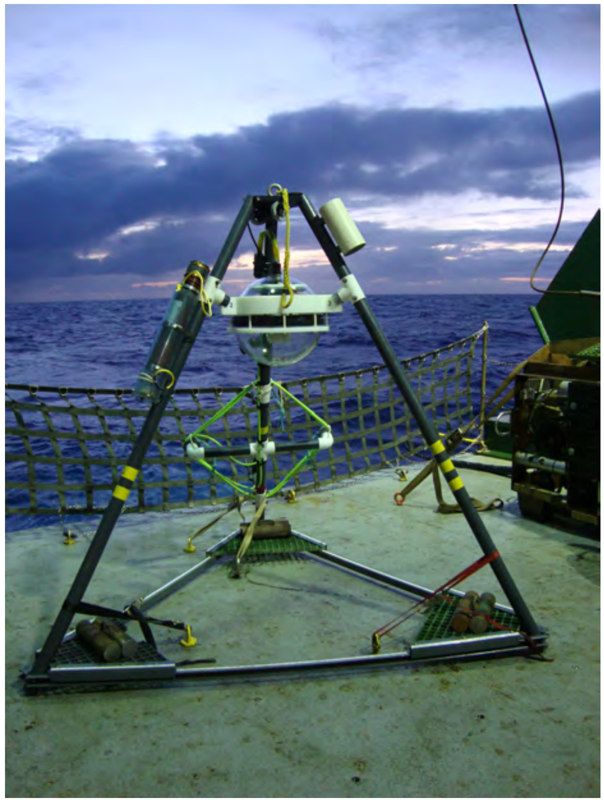


Figure 2-7 CAM1

The TAAM anchor sits 50 m off to the west. The mooring was recovered in December 2011, and the two ODI connectors and pin-protecting dummies recovered in 2014. We will use the TAAM anchor as a location for leftover weights, and other miscellaneous items being left on the bottom.

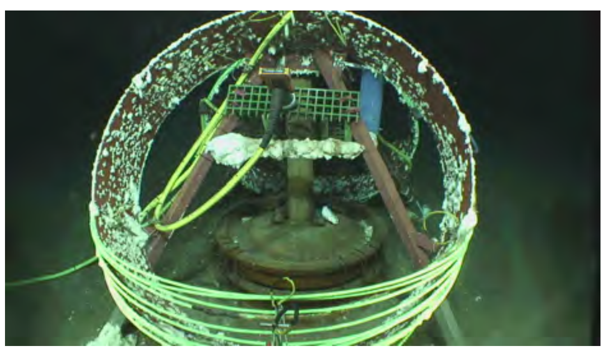


Figure 2-8 TAAM anchor 50 m to the west (connector was retrieved in November 2014)

The BSP1 is made up of a Science Instrument Interface Module (SIIM, from APL-UW), several science instruments, and a frame with syntactic foam buoyancy and ballast weights and provision for carrying navigation beacons (Figures 3-2 – 3-5). The BSP1 is connected to the OBS via a 20 m ODI pressure balanced oil-filled (PBOF) hose with a 12-pin flying connector, and a corresponding dry mate connector to the SIIM.

The SIIM aggregates multiple instruments so that only one standard 12-pin connect or is required to connect to the Observatory (OBS) or similar. The SIIM brings together the following sensors: Seabird conductivity, temperature, depth (pressure) and oxygen pumped (CTDO2), SBE- 37 SMP ODO; RBRduo bottom pressure recorder (BPR); WetLabs fluorometer/turbidity optical sensor, FLNTU; Woods Hole Oceanographic Institution (WHOI) acoustic micro-modem; and Teledyne RDI broadband 150 kHz acoustic Doppler current profiler (ADCP).

The BSP frame is roughly 4 x 4 x 6 ft (1.2 x 1.2 x 1.8 m). It is made from a combination of stainless steel tube (sandblast finish) and fiberglass unistrut and grating. The main frame will have zinc anodes. Stainless steel brackets and fasteners are used where necessary. Syntactic foam buoyancy blocks totaling 10 ft^3 are used (salvaged from retired deep tow mapping vehicles; 45 lb/ft^3 in air; –19.6 lb/ft^3 in seawater, using 64.4 lb/ft^3 for seawater).

The corners of the BSP are numbered and marked with yellow tape (ADCP is at the bow): port bow, 1 tape; starboard bow 2 tapes; starboard stern 3 tapes; port stern 4 tapes. This is the same convention as with the OBS.

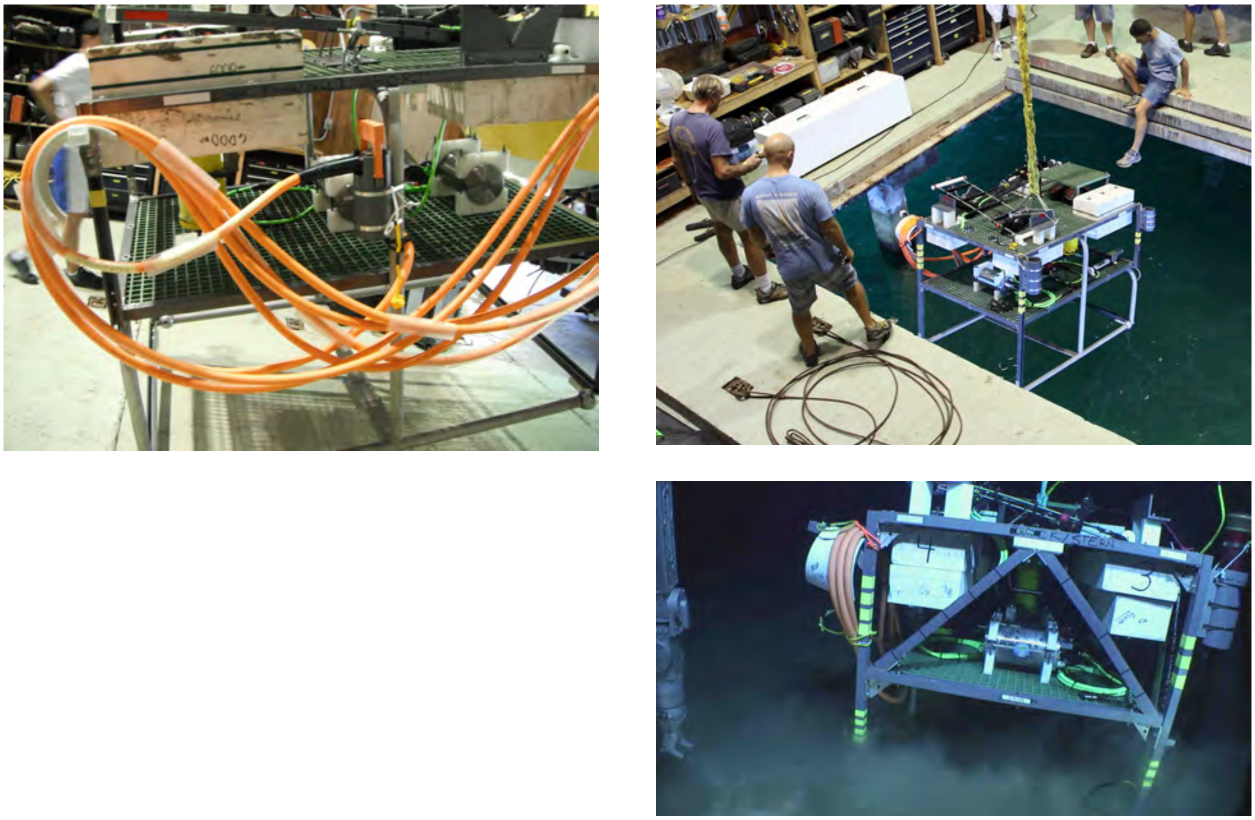


Figure 2-9 BSP1 at Makai Pier and on bottom.

The CAM2 has a similar configuration as the current CAM1, i.e., an AXIS Internet surveillance camera inside a Nautilus polished glass sphere with two lights and a hydrophone, Figures 3-6, 3-7, and 3-9.

The camera is ~8-ft (2.4 m) off the bottom. The length of a side on the bottom is 10 ft (3.0 m) and the length of the slant leg is 12 ft (3.6 m). The top of the frame is 11 ft 8 inches (3.6 m) high. The frame is made from the same fiberglass unistrut and grating as the BSP1. Stainless steel brackets and fasteners are used where necessary.

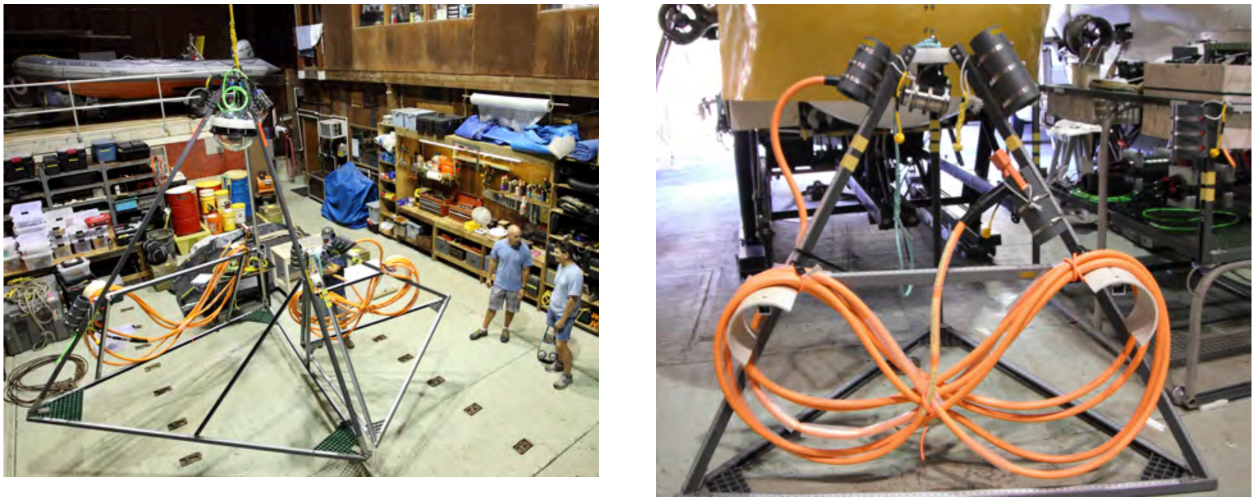


Figure 2-10 CAM2+LIGHT1, and LIGHT1 – stand alone

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Figure 2-11 BSP, LIGHT1 and CAM2 on seafloor at Makai Pier.

3. New ACO Equipment

Some equipment will be recovered and new equipment installed so that we end with a system layout as shown in Figure 8-1. A preview of tasks is useful here (more detail in Section 10 below). If all goes according to plan, only one ROV dive is required.

After testing the ROV at 500 m, the BSP2 and ELEVATOR with LIGHT4 attached will be free-falled. They will carry USBL beacons. The ELEVATOR+LIGHT4 will be moved to within 60 m of BSP1. LIGHT4 will be taken to the OBS, replacing LIGHT1, so that CAM1 will be functional. BSP1 will be removed and BSP2 moved and plugged in. Then the three packages to be recovered, LIGHT1, CAM2, and BSP2, will be attached to the ELEVATOR recovery line. Housekeeping will be done at this point (e.g., adjusting LIGHT4). Finally, the ELEVATOR with its packages will be released and recovered, while the ROV is ascending.

It is important to know the various in-air and in-water weights of the components, Table 3-1.

Weight, lb	Base in-air	Base in-water	Fixed added weight	Removable weight on frame	Weight on line hanging below for deploy	Total in-air deployment weight	Total in-water deployment weight	Total in-water weight final, on seafloor
CAM1	290	110	0?	0 (120?)				110
BSP1*	1152	161	0	0	100	1252	261	161
CAM2	272	56	0	0	100	372	156	56
LIGHT1	116	40	0	0	0	116	40	40
CAM2+LIGHT1	388	96	0	0	100	488	196	96
BSP2								
LIGHT4								
ELEVATOR								
ELEVATOR+ LIGHT4								

*Includes ADCP protective grating, 13 lb in air, 5 lb in water.

Table 3-1 ACO instrument package weights

The BSP2 is made up of a Science Instrument Interface Module (SIIM, from APL-UW), several science instruments, and a frame with syntactic foam buoyancy and ballast weights and provision for carrying navigation beacons (Figure x.). The BSP2 is connected to the OBS via a 50 m pressure balanced oil-filled (PBOF) hose with a 12-pin flying connector, and a corresponding dry mate connector to the SIIM.

The SIIM aggregates multiple instruments so that only one standard 12-pin connect or is required to connect to the Observatory (OBS) or similar. The SIIM brings together the following sensors: Seabird conductivity, temperature, depth (pressure) and oxygen pumped (CTDO2), SBE-52/43MP; Paroscientific nano-resolution pressure sensor; and WetLabs fluorometer/turbidity optical sensor (FLNTU).

The BSP frame is roughly 2 x 2 x 6 ft. It is made from a combination of titanium rod and syntactic foam. Syntactic foam buoyancy blocks totaling x ft^3 are used (salvaged from retired deep tow mapping vehicles; 45 lb/ft^3 in air; –19.6 lb/ft^3 in seawater, using 64.4 lb/ft^3 for seawater).

The stand-alone LIGHT4 is a copy of LIGHT1.

The elevator is basically a stack of flotation with a cage at the top for beacons and recovery lines, an acoustic release, and then a weight below that can be acoustically or with the ROV released.

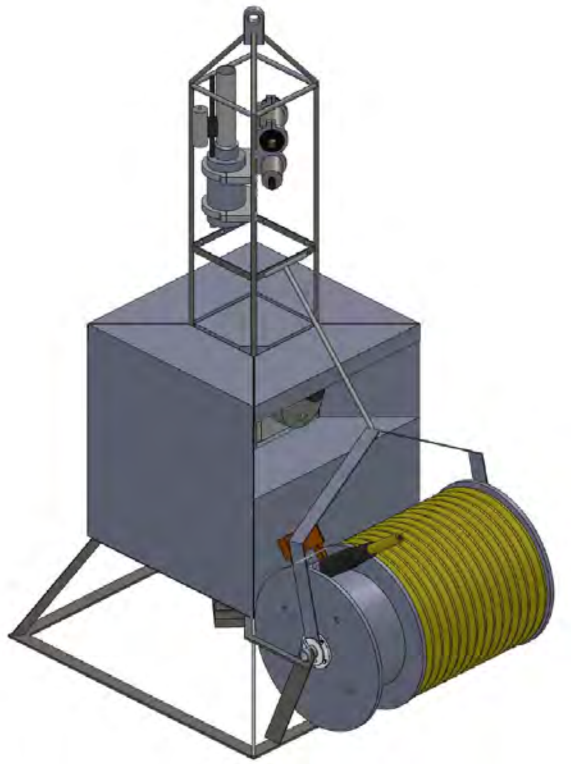

Figure 3-1 BSP2 with cable reel holding 50 m of hose.

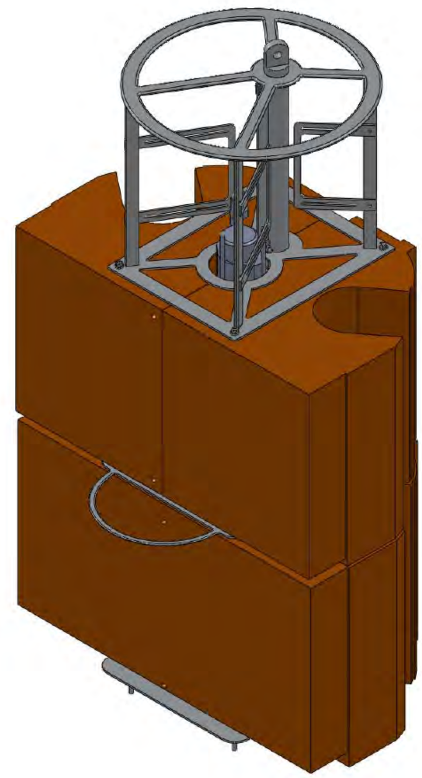

Figure 3-2 Elevator

4. ROV and TMS

ROV *Lu`ukai* is a two-body ROV system (Figure 4-1). A 0.681-inch electro-optic-mechanical (EOM) cable delivers electrical power and commands from the ship through the TMS and then to the ROV; both return data and live video imagery. The TMS serves as a dock for the ROV facilitating launch and recovery. When the ROV is swimming free of the TMS loosely tethered, the ROV is then decoupled from the movements (heave primarily) of the ship. While the tether is 100 m long, operationally, making effective use of this length requires further testing/practice. The TMS provides lighting and a bird's eye view of the ROV during seafloor operations. On this cruise, the ship's 0.681-inch electro-optical-mechanical cable is used as the main umbilical to TMS.

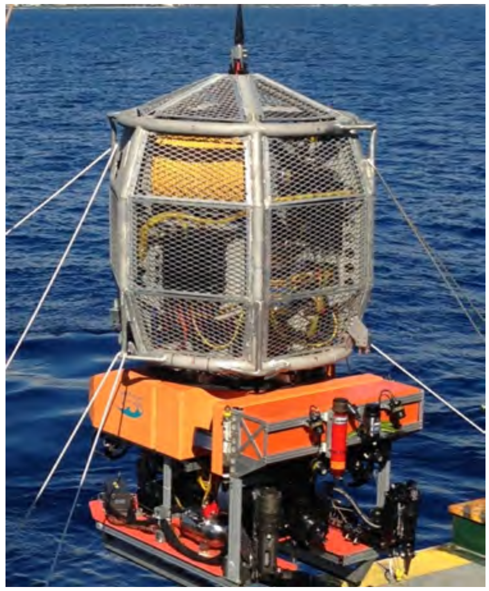

Figure 4-1 TMS and ROV.

5. Navigation

Lu'ukai will navigate in several ways. In addition to video, a scanning sonar will be used to detect targets/packages to a range of ~50 m. For large area coverage, the UH Sonardyne ultra-short-baseline (USBL) system will be used. The USBL transducer head will be installed on the retractable stem on the port side that can lower the sensor head 6-ft below the bottom of the hull. It will measure range and solid angle to beacons on the TMS and ROV, and our packages. The azimuthal orientation will have already been calibrated on the preceding cruise.

The ultra-short baseline transducer is a Sonardyne Marksman LUSBL Model 8023 with a 50° wide downward looking beam. The accuracy specification is 0.27 percent 1 Drms Slant Range, i.e., 63 per cent of fixes lie within 13.5-meter radius in 5,000 meters water depth. The transponder beacon is shown in Figure 5-3. The two beacons on the TMS and ROV will be configured as responders (triggered with an electrical signal from the deck unit). We are borrowing from MBARI two Sonardyne AvTrak2 beacons to use on the elevator and the BSP2. Absolute geographical position is provided by the ship using CNav GPS with decimeter accuracy.

Figure 5-1 USBL Wideband Mini Transponder (WMT) – 7000 m

6. Deck Layout

When on deck, *Lu`ukai* will sit on the centerline under the A-frame. The tool van and the ROV control van will sit on the O1 level, port side. The motor-motor generator will be placed on the O1 level, starboardside. The Connector Test Frame will be on the starboard quarter for use in the harbor. The ship's crane will be used to deploy this. The STU will be put in line between the traction winch and the A-frame, immediately adjacent to the bulkhead of the winch room. The STU weights 13,000 lb and the base plate 3,500 lb. The ELEVATOR+LIGHT4 will be placed on the aft port quarter for deployment with the crane. The BSP2 will reside forward in the staging bay prior to being deployed by the crane. The latter two items will be connected via their oil-filled hoses to the bench node in Lab2 for testing prior to launch.

Interior space is allocated as follows: The PI and the ROV crew share Lab2. ROV supplies will be in HydroLab. Hydraulic oil supplies will be in the WetLab. Personnel are free to use the rest of the lab space for personal computers, etc.

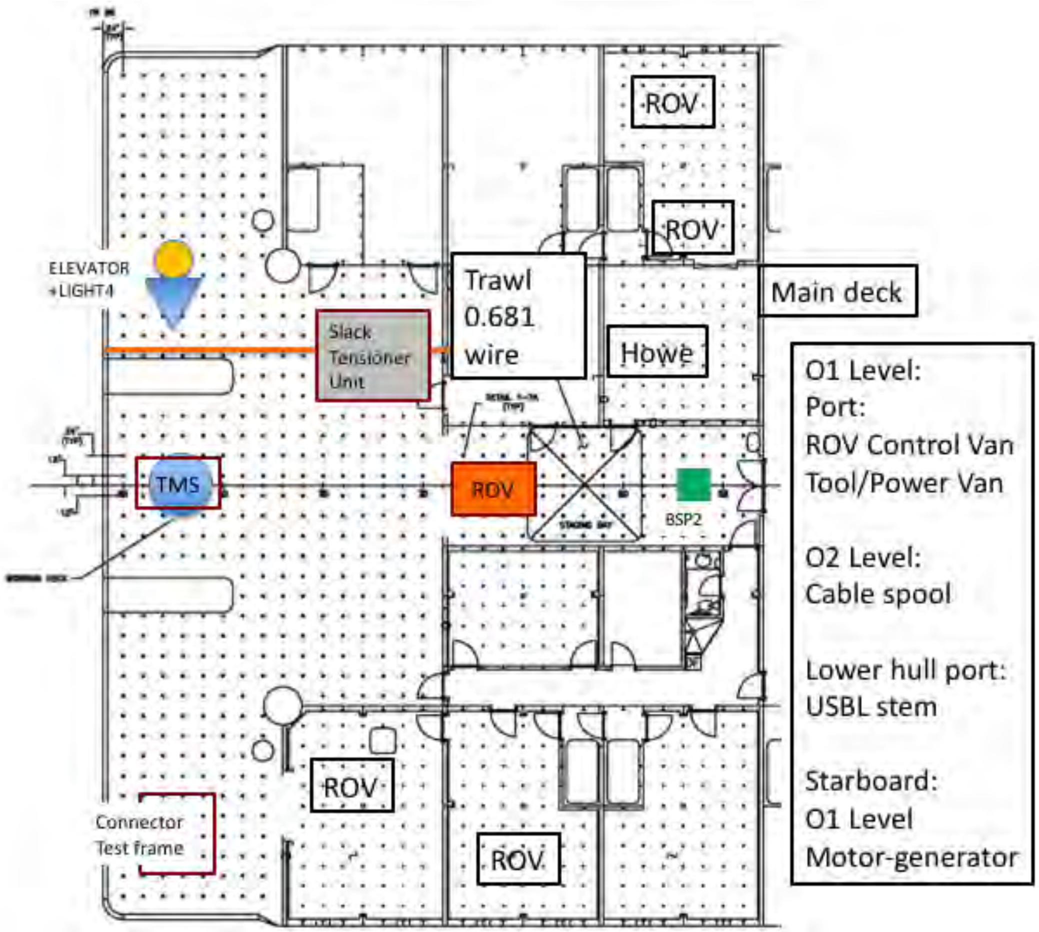

Figure 6-1 Main deck layout

7. Mobilization

Mobilization will start Saturday 12 September (see also Figure 7-1), with the loading of the motor-generator on the starboard side, O2. Further loading will be delayed by the emergency replacement of the electric motor running the winch/A-frame hydraulic power unit (HPU).

On Sunday morning the two ROV containers will be loaded on the O2 level, port side. Once the HPU work is done (estimating 1200 Sunday) the slack tension unit will be loaded and bolted down (new alignment pins will be available). After the cable is run from the spool on the O2 deck and through the STU (mid-Sunday afternoon), Steve Tottori can work on the cable termination, a critical path item. The ROV+TMS will be loaded together (connected by tether) in a multi-step operation. They will be set on the fantail on their respective carts. All additional ROV supplies, etc. will be loaded. A tent will be erected on the deck to protect against the sun and rain.

On Monday, the ACO lab and spare equipment and supplies will be loaded first, then BSP2, and finally ELEVATOR+LIGHT4. The bench-top test node will be installed immediately on a shelf to be installed immediately to the right of the Lab 2 door, so as to be close to the bulkhead access port for deck cables. GPS and Iridium antenna cables (100 ft) will be run from the lab up to the O2 level above, stern rail. An Iridium cable (50 ft) will be run from the ROV control van roof to the interior for real time comms to shore during operations. LIGHT4 and BSP2 will be connected with their yellow umbilicals (20 m and 50 m respectively) to the bench node in Lab2 and tested.

By the end of the Monday, all ACO gear should be on board and operational. In parallel, the cable termination will be completed and the ROV tested.

Tuesday should be devoted to final testing of the ROV and ACO gear described next. Given the tight schedule people should plan on sleeping aboard.

TASK	Saturday, September 12		Sunday, September 13		Monday, September 14		Tuesday, September 14	
	0800 - Noon	Noon - CoB	0800 - Noon	Noon - CoB	0700 - Noon	Noon - CoB	0700 - Noon	Noon - CoB
Full function shop tests	■							
Disconnect vans/vehicles		■						
Prepare ops equipment for move	■	■						
Load vans, vehicles, generator, STU			■					
Load ops equipment			■	■	■			
Set up equipment & work spaces			■	■	■			
Vans, electrical integration				■				
Generator, electrical integration				■				
681 cable & ROV tether termination				■	■	■		
System components, prep for ops, tests					■	■		
Integrate ship's handling system						■		
Full function deck tests							■	
Harbor tests								■

Figure 7-1 Mobilization Tasks

8. Dockside Operations

The objectives of the dockside ROV testing are:

- Verify functionality of the system and all subsystems in the water, reviewing all the items dealt with over the last month (ROV HPU, unloader valve, thrusters, arms, cameras and lights, etc.)
- Stress the system (e.g., cycle power, max thrusters, max electrical loads, max tether extension, sample basket, etc)
- Practice mating/unmating an ODI underwater mateable connector, high on the test frame
- Practice mating/unmating recovery lines with snap hooks.

The ACO packages must be weighed in air and water to adjust the buoyancy.

9. Responsibilities

The ACO science team is responsible for all the ACO packages, testing and preparing these for deployment, and providing science direction to the ROV crew during operations.

Good communications with the shore party will be essential. ACO will bring one Iridium phone (from Seaglider Lab). Two external antennas will be available. The ship will provide a second Iridium phone as a backup, as well as Satcom. In addition to HiSeasNet Internet, the ship/OTG will provide a dedicated Fleet Broadband satellite Internet connection in the ROV van for real time email and chat with the ACO shore party (ACO will bring wireless router). ACO will have a laptop in the control van for this purpose.

The ROV team will operate the ROV, and be in charge of the deck during all operations that involve their equipment.

ACO/OTG will be responsible for deploying the free-falling ELEVATOR+LIGHT4 and BSP2 and recovering the ELEVATOR with LIGHT1, CAM2, and BSP1.

ACO will supply all recovery lines, connecting lines associated with the use of the ELEVATOR.

ACO will supply pin-protecting dummies for ODI connectors (2 available), with ROV mating provision (i.e., T-Handle).

ACO will provide a "dumb" dummy/resistive load port test tool.

ROV will provide a cutting tool, i.e., sharp heavy knife and garden shears for line, bungies, tie wraps, in the "tool box" in the basket.

ACO provides one homer beacon, already mounted on the cable termination frame: code 61.

ACO will provide two USBL beacons for the ELEVATOR and the BSP2 packages, on loan from MBARI.

ACO will provide cleaning/scraping/brushing tools for cleaning the precipitate on the seawater return (SWR) on the OBS.

The ship will operate much of the time in dynamic positioning. This entire system must be checked out before this cruise and it must be fully operational with all backup and redundant systems tested and operational.

The ship and OTG will provide sub-bottom echosounders (3.5 kHz and 12 kHz), acoustic Doppler current profiler data/plots (using 38 kHz and 300 kHz instruments), two air tuggers, and pallet jack.

10. Operations and timeline

Some equipment will be recovered and the new equipment installed so that we end with a system layout similar to Figure 3-1. One ROV dive is required. As mentioned above, ELEVATOR+LIGHT4 and BSP2 will be free-falled . We will recover LIGHT1, CAM2, and BSP1 by attaching them to the ELEVATOR recovery line and free-floating it to the surface.

Figure 10-1 shows a cartoon of how a recovery line will be pulled out from the elevator for LIGHT1, CAM2 and BSP1 to be attached to.

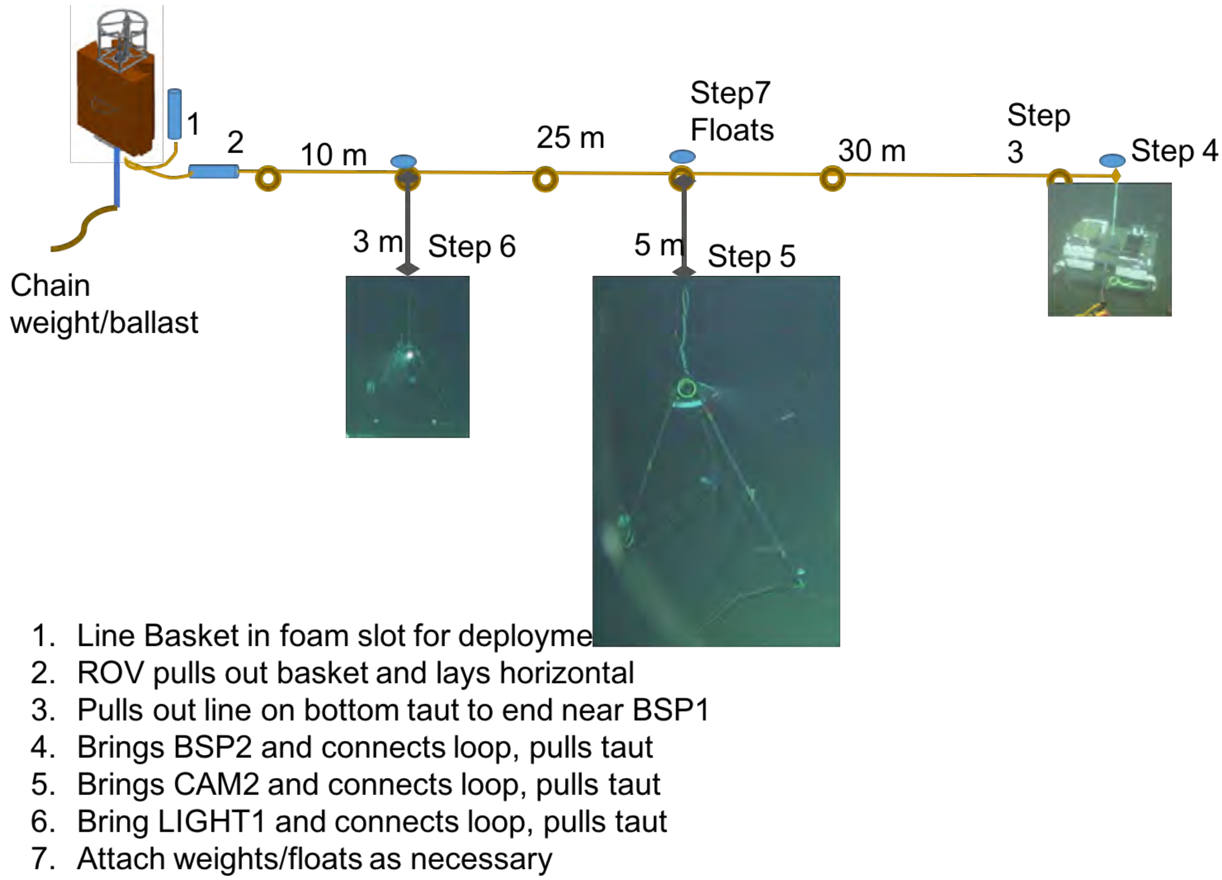

Figure 10-1 Package recovery process.

During operations UH ACO shore personnel will be available to turn instrument power on and off to individual ports, control the overall system, and test components as we add them. This command and control will be done at UH. The AT&T Makaha Cable Station will be notified of our activity, in case there is some need (not expected at this point) for the shore personnel to operate from there. Good communications is essential. A detailed checkout procedure for each package will be followed and results therefrom reported.

Most testing of the components will involve people on shore. They will report results to the ship in a timely manner. Two-way acoustic modem testing will use the shipboard transducer, as well as from shore.

If all goes according to the plan laid out in detail in Appendix B and in the schedule in Table 10-1, the entire operation should be completed in the allotted time, with ~60 hours of contingency in Task 10.

The following table gives the major tasks and associated times.

Table 10-1 Cruise tasks and times (local HST time)

	Task	Start	hh:mm	End
1	Transit to Station ALOHA and ACO	09/16 08:00	2:30	09/16 10:30
2	Dive 1 (LK-048)	09/16 10:30	2:25	09/16 12:55
3	Transit to Station Aloha	09/16 12:55	12:00	09/17 00:55
4	ROV Dive 2 (LK-049)	09/17 00:55	4:50	09/17 05:45
5	Deploy BSP2	09/17 05:45	5:30	09/17 11:15
6	Connect BSP2	09/17 11:15	4:25	09/17 15:40
7	Deploy ELEVATOR+LIGHT4	09/17 15:40	6:05	09/17 21:45
8	Connect LIGHT4	09/17 21:45	3:45	09/18 01:30
9	Move and Rig ELEVATOR with BSP1, CAM2, LIGHT1	09/18 01:30	10:10	09/18 11:40
10	Final steps	09/18 11:40	8:40	09/18 20:20
11	Ascent and Recovery	09/18 20:20	4:50	09/19 01:10
12	Contingency	09/19 01:10	41:50	09/20 19:00
13	Transit to Honolulu	09/20 19:00	13:00	09/21 08:00
			120:00	

References

2011 cruise plan
http://aco-ssds.soest.hawaii.edu/ACO/docs/20110515_KM1116_Cruise_Plan_Howe_lo-res.pdf

2011 cruise report
http://aco-ssds.soest.hawaii.edu/ACO/docs/20110515_KM1116_Cruise_Plan_Howe_lo-res.pdf

2014 cruise plan
http://aco-ssds.soest.hawaii.edu/ACO/docs/ACO_3_Cruise_Plan_2014.pdf

2014 cruise report
http://aco-ssds.soest.hawaii.edu/ACO/docs/ACO_3_Cruise_Report_2014.pdf

Oceans 11 paper
Howe, B. M., R. Lukas, F. Duennebier, and D. Karl, ALOHA cabled observatory installation, *OCEANS 2011*, 19-22 Sept. 2011, URL:
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6107301&isnumber=6106891
or
http://aco-ssds.soest.hawaii.edu/Howe_et_al_ACO_Oceans11.pdf

Additional photographs and other system documentation can be found on the project web site http://aco-ssds.soest.hawaii.edu/index.html. Also see the ROV *Jason* Virtual Control Van videos from the KM-11-16 June 2011 cruise and the KM-14-26 November 2014 cruise, http://4dgeo.whoi.edu/jason/.

Appendix A – ACO Diagrams

The following diagrams show the OBS port assignments, current and planned.

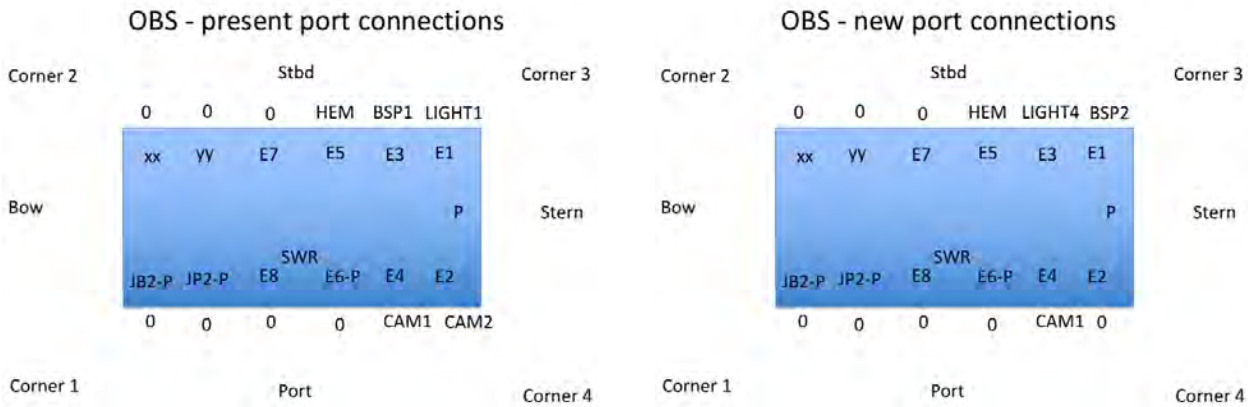

Figure A-1 ACO Observatory port connections – present and new (P = parking)

Appendix B – ACO Operations

The following table gives the detailed ACO tasks associated with deploying and recovering the instrumentation.

Table B-1 ACO tasks for deployment

		Task	Start	hh:mm	End
1		**Transit to Site 1, 430 m**			
	1	Transit	09/16 08:00	2:00	09/16 10:00
	2	Load ROV basket: weighs, knife, brushes and chisels for cleaning sea water return (SWR), 1 ODI Environmental Cover (EC), snap-hook-lines, 1 ODI pin-protecting dummy with T-handle	09/16 10:00	0:00	09/16 10:00
	3	Establish ship in DP mode at Site 1, Connector Test Frame, Bottom depth 431 m.	09/16 10:00	0:30	09/16 10:30
2		**Dive 1 (LK-048)**			
	1	Deploy ROV. USBL Beacon 1 on ROV, Beacon 2 on TMS.	09/16 10:30	0:20	09/16 10:50
	2	Test systems at 50 m, 100 m, 200 m, 415 m, 431 m on bottom. Test Beacons 3 and 4 over the side (? Or in ROV basket?). Work with bridle.	09/16 10:50	0:20	09/16 11:10
	3	Operate on bottom	09/16 11:10	1:00	09/16 12:10
	4	Ascend, test at 50 m	09/16 12:10	0:30	09/16 12:40
	5	Recover	09/16 12:40	0:15	09/16 12:55
3		**Transit to Station Aloha**			
	1	Transit	09/16 12:55	11:30	09/17 00:25
	2	Establish DP position (A-frame of ship) 100 m S of Cable Termination (CT)	09/17 00:25	0:30	09/17 00:55
4		**ROV Dive 2 (LK-049)**			
	1	Deploy ROV. Beacon 1 on ROV, Beacon 2 on TMS.	09/17 00:55	0:30	09/17 01:25
	2	Test ROV periodically all the way to bottom. Periodically add gas to the STU. Stop 15 m above bottom and undock	09/17 01:25	3:00	09/17 04:25
	3	Move north to find sea cable, and then cable termination (CT); interact with shore using CAM1 to watch ROV	09/17 04:25	0:30	09/17 04:55
	4	Look around area, establish nav references	09/17 04:55	0:20	09/17 05:15
	5	Move ship 100 m N and put in DP (A-frame)	09/17 05:15	0:30	09/17 05:45
5		**Deploy BSP2**			
	1	Deploy BSP2 free fall, with USBL Beacon 3	09/17 05:45	0:20	09/17 06:05

	2	Move ship and ROV south as BSP2 falls, up to 100 m S of CT following sea cable	09/17 06:05	2:00	09/17 08:05
	3	As appropriate move ship and ROV back to intercept BSP2 (conservatively!)	09/17 08:05	1:00	09/17 09:05
	4	After BSP lands, go to it	09/17 09:05	0:30	09/17 09:35
	5	Cut bottom weight from BSP2	09/17 09:35	0:20	09/17 09:55
	6	Lift BSP2 and move to desired location 47 m due E of OBS	09/17 09:55	1:00	09/17 10:55
	7	Remove hose reel from BSP2	09/17 10:55	0:20	09/17 11:15
6	**Connect BSP2**				
	1	Move ROV toward OBS unspooling hose from reel	09/17 11:15	0:20	09/17 11:35
	2	Fly up above OBS (to side) until all hose off reel and connector free (let reel fall to bottom for later retrieval)	09/17 11:35	0:10	09/17 11:45
	3	Take BSP2 connector to port E1 on SE corner 3 of OBS	09/17 11:45	0:10	09/17 11:55
	4	Set down BSP2 connector on mid-deck of OBS under E1	09/17 11:55	0:10	09/17 12:05
	5	Confirm from shore that LIGHT1 port E1 is off	09/17 12:05	0:10	09/17 12:15
	6	Remove pin protecting dummy from BSP2 connector	09/17 12:15	0:15	09/17 12:30
	7	Remove LIGHT1 connector from port E1	09/17 12:30	0:15	09/17 12:45
	8	Plug BSP2 connector into port E1	09/17 12:45	0:20	09/17 13:05
	9	Have shore turn on BSP2 and test	09/17 13:05	0:30	09/17 13:35
	10	Place pin protecting dummy on LIGHT1 connector	09/17 13:35	0:15	09/17 13:50
	11	Take LIGHT1 connector to LIGHT1 and place in holster	09/17 13:50	0:30	09/17 14:20
	12	Go to BSP2 and adjust position	09/17 14:20	0:30	09/17 14:50
	13	Remove USBL Beacon 3 from BSP2 and place in basket	09/17 14:50	0:20	09/17 15:10
	14	Move ship to 100 m N of OBS	09/17 15:10	0:30	09/17 15:40
7	**Deploy ELEVATOR+LIGHT4**				
	1	Deploy ELEVATOR+LIGHT4 free fall, USBL Beacon 4	09/17 15:40	0:20	09/17 16:00
	2	Move ship and ROV south as package falls, up to 100 m S of CT (original starting point)	09/17 16:00	2:00	09/17 18:00
	3	As appropriate move ship and ROV back to intercept package (conservatively!)	09/17 18:00	2:00	09/17 20:00
	4	After package lands, go to it	09/17 20:00	0:30	09/17 20:30
	5	Remove LIGHT4	09/17 20:30	0:30	09/17 21:00
	6	Lift LIGHT4 and move to desired location next to CAM1	09/17 21:00	0:30	09/17 21:30

	7	Remove connector and hose from LIGHT4	09/17 21:30	0:15	09/17 21:45
8	**Connect LIGHT4**				
	1	Move to OBS port E3 with LIGHT4 hose and connector	09/17 21:45	0:20	09/17 22:05
	2	Land next to OBS port E3	09/17 22:05	0:20	09/17 22:25
	3	Remove pin-protecting dummy from LIGHT4	09/17 22:25	0:20	09/17 22:45
	4	Confirm power to port E3 is off.	09/17 22:45	0:20	09/17 23:05
	5	Remove BSP1 connector from port E3	09/17 23:05	0:15	09/17 23:20
	6	Plug LIGHT4 into port E3	09/17 23:20	0:20	09/17 23:40
	7	Turn on LIGHT4 and test	09/17 23:40	0:30	09/18 00:10
	8	Connect pin protecting dummy to BSP1 connector	09/18 00:10	0:20	09/18 00:30
	9	Take connector to BSP1 and place in holster	09/18 00:30	0:30	09/18 01:00
	10	Move to OBS port E2	09/18 01:00	0:30	09/18 01:30
9	**Move and Rig ELEVATOR with BSP1, CAM2, LIGHT1**				
	1	Unplug CAM2 from port E2; connect pin-protecting dummy, place EC on port E2	09/18 01:30	0:30	09/18 02:00
	2	Take CAM2 connector to CAM2 and place in holster and secure with bungie	09/18 02:00	0:20	09/18 02:20
	3	Move to BSP1	09/18 02:20	0:10	09/18 02:30
	4	Lower and latch CTD mast; same for WHOI micromodem.	09/18 02:30	0:40	09/18 03:10
	5	Go to ELEVATOR	09/18 03:10	0:40	09/18 03:50
	6	Move ELEVATOR to ~58 m ESE of BSP1	09/18 03:50	0:40	09/18 04:30
	7	Remove line basket from ELEVATOR and set on bottom	09/18 04:30	0:10	09/18 04:40
	8	Pull out recovery line to BSP1	09/18 04:40	0:30	09/18 05:10
	9	Connect Snap-hook-line between end of recovery line and BSP1	09/18 05:10	0:30	09/18 05:40
	10	Go to ELEVATOR and move to pull recovery line near-taut	09/18 05:40	0:30	09/18 06:10
	11	Move to CAM2	09/18 06:10	0:15	09/18 06:25
	12	Move CAM2 to recovery line	09/18 06:25	0:40	09/18 07:05
	13	Connect Snap-hook-line between recovery line loop and CAM2	09/18 07:05	0:45	09/18 07:50
	14	Go to ELEVATOR and move to pull recovery line taut	09/18 07:50	0:30	09/18 08:20
	15	Move to LIGHT1	09/18 08:20	0:40	09/18 09:00
	16	Move LIGHT1 to recovery line	09/18 09:00	0:40	09/18 09:40
	11	Connect Snap-hook-line between recovery line loop and LIGHT1	09/18 09:40	0:30	09/18 10:10
	15	Dress connecting lines	09/18 10:10	0:30	09/18 10:40

	16	Inspect ELEVATOR and packages, move packages to tauten line, ping on release to test	09/18 10:40	1:00	09/18 11:40
10	**Final steps**				
	1	Adjust LIGHT4 and CAM1 as necessary based on directions from shore	09/18 11:40	1:00	09/18 12:40
	2	Move BSP2 to remove slack in hose	09/18 12:40	0:40	09/18 13:20
	3	Re-adjust ACO sign	09/18 13:20	1:00	09/18 14:20
	4	Dress all cables	09/18 14:20	1:00	09/18 15:20
	5	Take bait from ELEVATOR and place by CAM1	09/18 15:20	2:00	09/18 17:20
	6	Clean SWR	09/18 17:20	1:00	09/18 18:20
	7	Photo op - coordinate Luukai and camera control on shore	09/18 18:20	2:00	09/18 20:20
11	**Ascent and Recovery**				
	1	Acoustically release ELEVATOR with packages daisy chained (ROV watching on from a distance)	09/18 20:20	0:30	09/18 20:50
	2	ROV ascends	09/18 20:50	2:00	09/18 22:50
	3	Recover ELEVATOR and packages with crane, small capstan/winch	09/18 22:50	1:30	09/19 00:20
	4	Recover ROV	09/19 00:20	0:30	09/19 00:50
	5	Final deck checks	09/19 00:50	0:20	09/19 01:10
12	**Contingency**				
	1	Contingency - ROV testing and operation	09/19 01:10	41:50	09/20 19:00
13	**Transit to Honolulu**				
	1	Transit	09/20 19:00	12:00	09/21 07:00
	2	Holding off Honolulu for entry	09/21 07:00	1:00	09/21 08:00
	3	Arrive	09/21 08:00	0:00	09/21 08:00
			09/16 08:00	**120.0 5.00**	**09/21 08:00**

Appendix C – Cruise Participants and Contacts List

	Name	Position	Email	Phone
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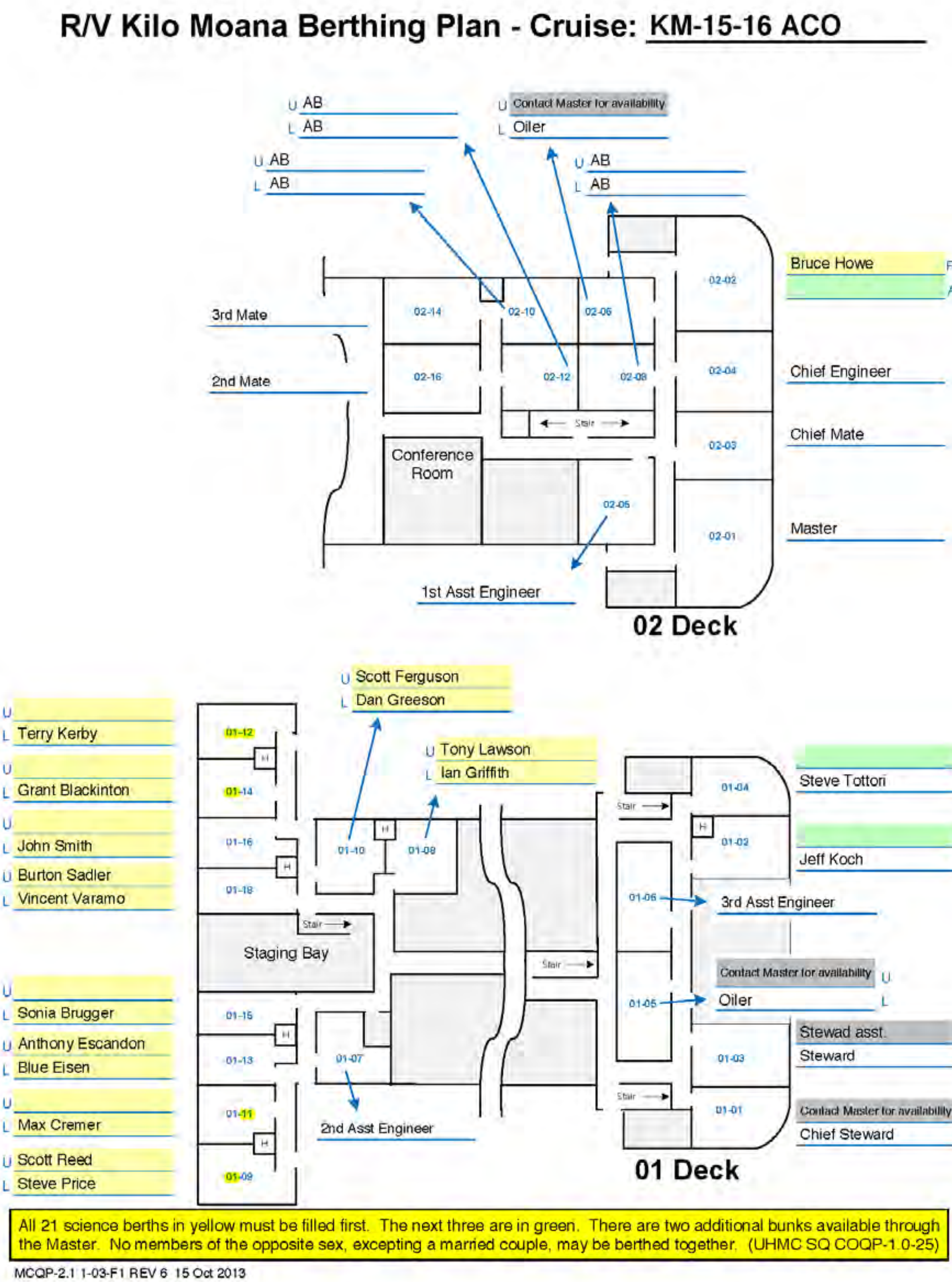
Appendix D – Berthing Plan



Appendix E – Acronyms and abbreviations

12E	Electrical connector with 12 electrical circuits
2E	ODI NRH Connector with 2 electrical circuits and 4 optical circuits
4E	Electrical connector with 4 electrical circuits
ACO	ALOHA Cabled Observatory
ACP	Acoustic current profiler
ADCP	Acoustic Doppler current profiler
AMM	Aloha Mars Mooring Secondary Node
BSP	Basic Sensor Package
CAM	Camera Tripod
$CTDO_2$	Conductivity, temperature, depth, oxygen sensor package
DMAS	Data Management and Archiving System
DP	Dynamic positioning
EC	Environmental Cover – protective cap for unconnected ODI bulkheads
EM	Electrical-Mechanical
EO	Electrical-Optical
EOM	Electrical-Optical-Mechanical
HEM	Hydrophone Experiment module, resides on JBOX
HOT	Hawaii Ocean Timeseries
μSEM	micro Science Experiment Module
JBOX	Frame with junction box and HEM with cables and connectors
MARS	Monterey Accelerated Research System
MBARI	Monterey Bay Aquarium Research Institute
NRH	Nautilus Rolling Hybrid – optical and electrical ODI connector
NTP	Network Time Protocol
OBS	Observatory package
ODI	Ocean Design, Inc. wet mateable connector
PBOF	Pressure balanced, oil filled
PMACS	Power Management and Control System
PPS	Pulse Per Second (GPS-derived precise timing signal)
PTP	Precise Time Protocol
PTT	Port Test Tool
ROV	Remotely Operated Vehicle
SIIM	Science Instrument Interface Module
SMF	Single mode fiber
TF	Termination Frame