The Watts 1 mooring cruise program, which will be staged from the R/V R. Revelle from May 26 – June 14, 2005, will encompass the following tasks:

1. Recovery of 5 x 5500 m subsurface moorings.
2. Deployment 7 x 5500 m subsurface moorings.
3. Dragging operations for 3 x 5500 m subsurface moorings.
4. Recovery and re -deployment of a PMEL surface buoy and 500 m wire rope and instrumentation.
5. Deployment of second PMEL surface mooring
6. Deployment of 20 Argo floats - during transits between moorings

The positions and required operations of the KESS mooring array deployed R/V T. Thompson - May 04:
PMEL 2: 36 40.0000 N, 146 09.0000 E - surface mooring deployment
KESS 1: 37 04.1864 N, 147 22.7157 E - dragging operation
KESS 2: 36 18.3538 N, 146 53.6257 E – mooring turn around
KESS 3: 35 32.8362 N, 146 25.6193 E – mooring turn around
KESS 4a: 34 46.8583 N, 145 55.1504 E – recovery-possible dragging operation
KESS 4b: 35 10.7195 N, 146 12.6898 E – mooring turn around
KESS 5: 34 02.0140 N, 145 31.1000 E – recovery-possible dragging operation
KESS 6: 33 14.4913 N, 145 02.0164 E – mooring turn around
KESS 7: 32 23.9982 N, 144 33.2007 E – mooring turn around
PMEL 1: 32 30.0000 N, 144 50.0000 E – buoy and 700 m wire rope recovery and deployment

The proposed cruise track, illustrated in figure 1, for the WATTS 1 cruise is for the R/V R. Revelle to transit from Yokohama, Japan south-easterly to the KESS 7 and travel north east along the array line.

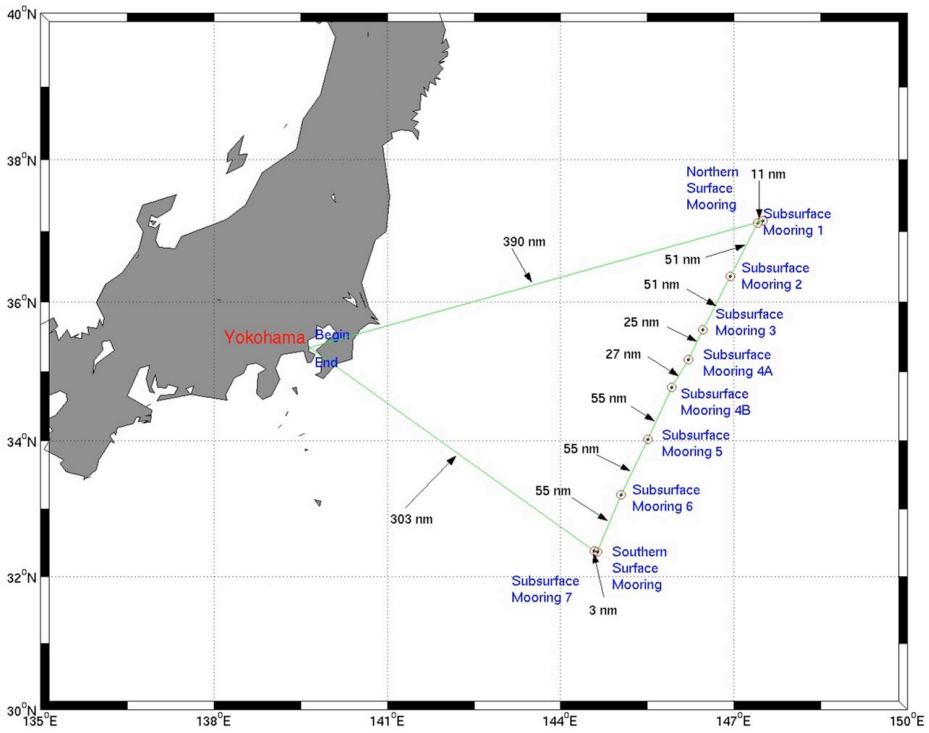
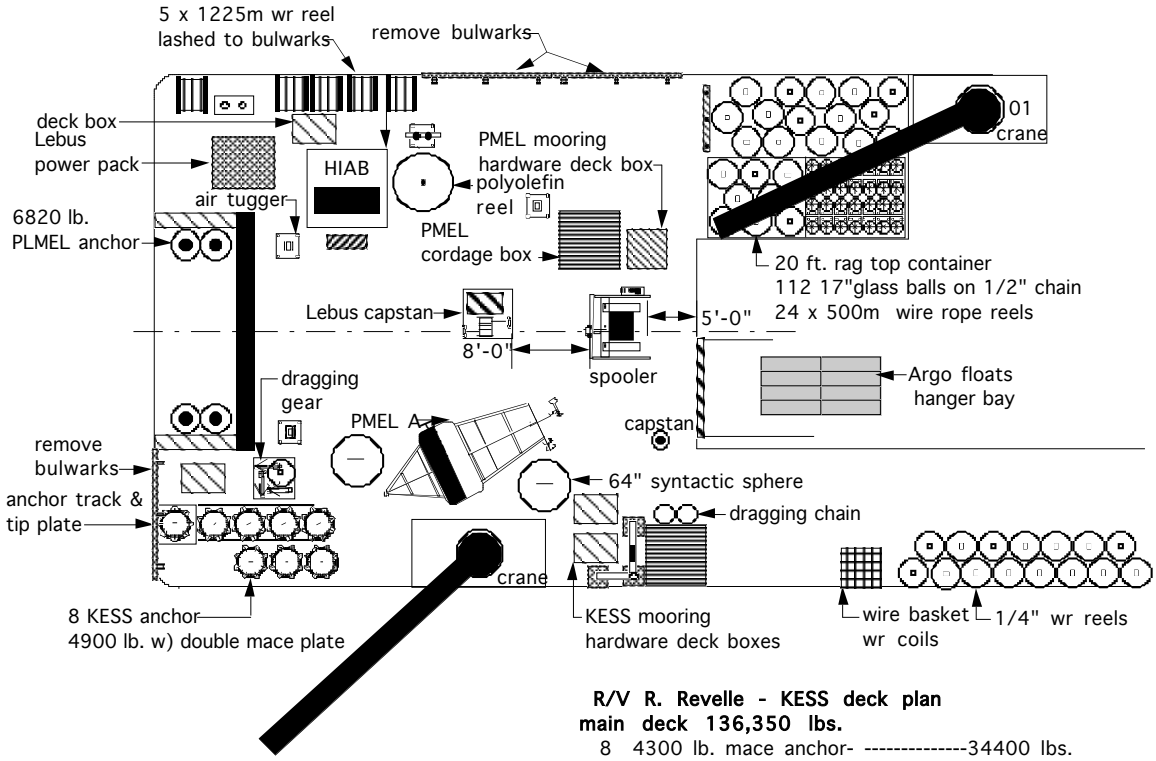


Figure 1. WATTS 1 cruise track

If sea conditions are favorable at this position, as an option, the PMEL 1 surface buoy and attached 700 m wire rope segment will be recovered and re-deployed before turning around the KESS 7 sub surface mooring. The Woods Hole Oceanographic Field Support Group has successfully utilized the procedures detailed in this report when working on the R/V Thompson, Atlantis and Brown. The deck layout (Fig. 2) illustrates the position and weights of the science deck load during the transit leg from Yokohama.



Woods Hole Oceanographic Institution
Mooring Operations & Engineering Group
Title: R/V R. Revelle KESS -PMEL - transit
Date: 25 October 04
By: W.Ostrom
Scale: 1" = 15'
Version: 1

R/V R. Revelle - KESS deck plan
main deck 136,350 lbs.

8 4300 lb. mace anchor- ----------34400 lbs.
61 reels 1/4" wire rope @ 300 lb. ------18300 lbs.
2 66" syntactic sphere @ 2500 lb.-------7500 lbs.
3 Kess deck boxes @ 2000 lb.----------6000 lbs.
2 PMEL anchor @ 6800 lb.----------13600 lbs.
1 Lebus capstan winch----------4900 lbs.
1 Lebus spooler winch---------- -2000 lbs.
1 Lebus power pack----------4500 lbs.
5 1225m 1/4" wr reels @ 1000 lb.------8000 lbs.
1 PMEL surface buoy----------2000 lbs.
1 PMEL hardware deck box----------1000 lbs.
1 PMEL cordage box----------2400 lbs.
1 PMEL polyolefin line----------1100 lbs.
1 dragging gear box----------2100 lbs.
2 launch and recovey gear boxes---------2000 lbs.
3 air tuggers w) stands @ 350 lb.-------1050 lbs.
20 Argo floats - hanger bay @ 100 lb.----2000 lbs.
1 20 ft. rag top container----------18800 lbs.
112 x 17"glass balls
24 x 500m wr reels

01 port side 3000 lbs.
10 reels 1/4" wire rope spare----------3000 bs.

Hanger deck 1250 lbs.
5 collapsed wire baskets @ 250 lb--------1250 lbs.

Special Rigging and Ship Service Requirements

Three fairlead blocks and one vertical chain stopper will need to be hung in the A-frame. The blocks and chain stopper will be oriented in the A-frame in the following manner: a ship owned trawl wire block hung from the center bail, a WHOI owned Mckissick trawl block hung from a adjacent starboard bail, a 14 ft. length of ½" trawler chain hung adjacent to the Mckissick trawl block, and a WHOI Gifford block hung from the port side bail adjacent to the ship's trawl wire block. The Lebus winch power requirements are 100 amp 480v 3 phase. The three air tuggers will require 80 CFM with intermittent usage.

PMEL Surface Mooring Buoy Turn Around

The following procedure details how the PMEL surface buoy and attached 700 m wire will be recovered and redeployed. Figure #3 details the PMEL mooring design:

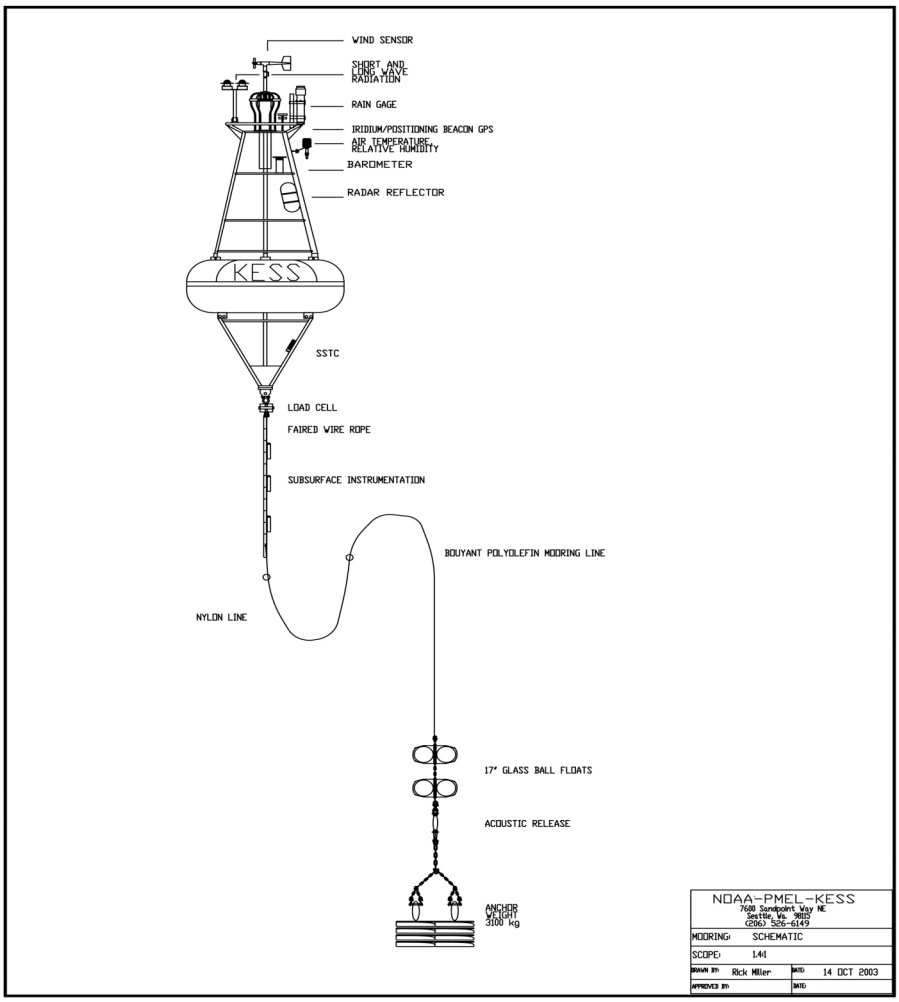


Figure 3. PMEL surface mooring

The ship's trawl winch, Lebus winch, fantail capstan, main crane, HIAB crane, and assorted stopper deck lines and hooks will be utilized during the recovery. The trawl wire with an attached WHOI designed lifting pennant will be fair lead through the starboard trawl block. The lifting pennant is a 45 ft. length of ¾" single braid Spectra line with a WHOI designed titanium pickup hook and a ¾" wire rope thimble sliced to either end of the line. This pennant was designed to improve the handling of the ½" trawl wire

during the hook-up of the buoy from a small boat. An Ingersoll-Rand air tugger is positioned on the fantail so that its tugger line can be fair lead to the center of the ship's transom. Figure #4 illustrates this fair lead.

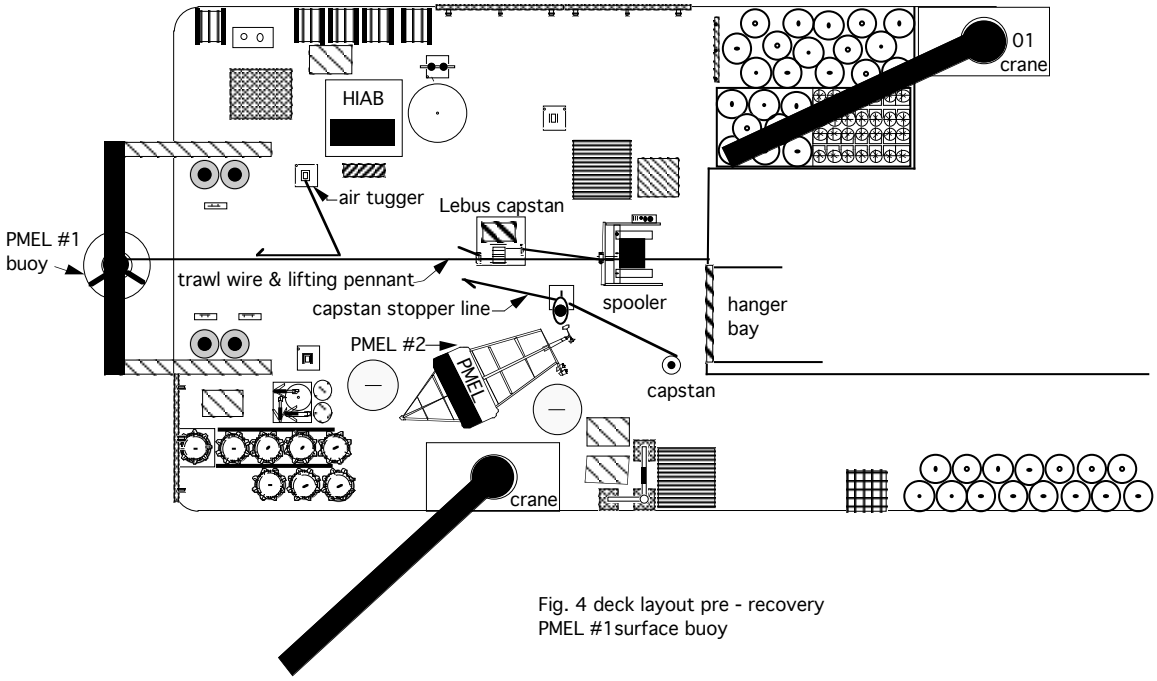


Fig. 4 deck layout pre - recovery
PMEL #1surface buoy

The R/V R. Revelle will be positioned ¾ of a mile down wind from the surface buoy's location. The ship would attempt to dynamically position at this location for approximately 30 minutes. The estimated period of holding time which will be required will be approximately 2 to 3 hours. Once the decision to proceed has been made, the ship would back slowly toward the surface buoy so that the buoy was approximately 8-10m from the stern of the ship. The ship's small boat is launched with a boat operator and two mooring technicians on board. The small boat would maneuver between the surface buoy and the stern of the ship. With the small boat in position, a polypropylene heaving line is passed from the ship to the small boat. Tied to the free end of the heaving line will be a WHOI designed lifting pennant and hook. The pick-up hook is attached to a pick up pole as the small boat approaches the surface buoy. The mooring technician, holding the pick-up pole and hook out across the small boat's bow, attaches the pick-up hook onto the buoy's lifting bail. The pole is removed and the lifting pennant is cast off from the small boat. The small boat returns to the ship to be hauled out of the sea. With the A-frame fully extended out board, the trawl winch hauls in the trawl wire causing the buoy to be lifted up. As the buoy tower rotates towards the ship's stern, the air tugger line, centered in the A-frame, is hooked onto a convenient bail on the opposite side of the lifting bail using a pick up pole. There will be approximately 2 meters of clearance between the tower's top and the ship during this phase of the recovery. Figure #5 shows the buoy hull's profile during the lifting phase of the recovery operation.

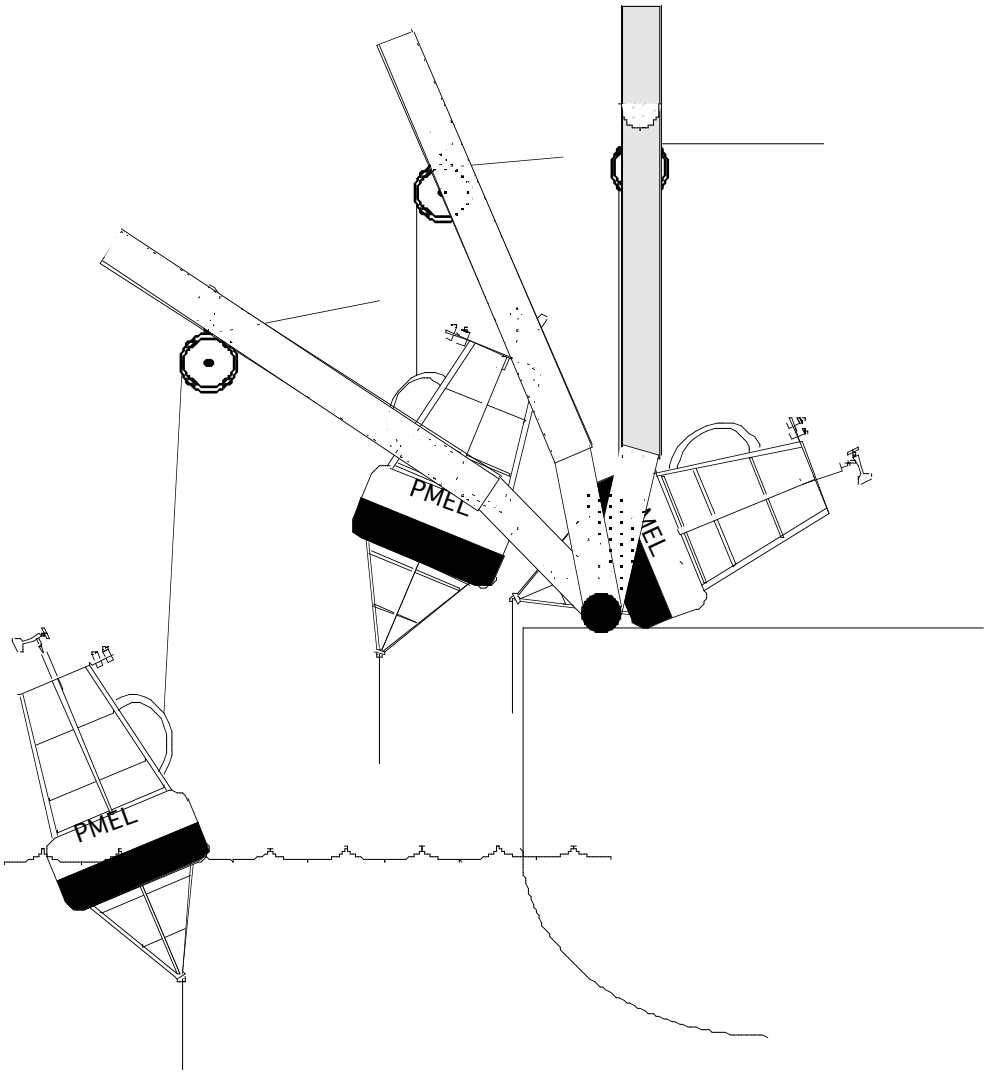


Figure 5. profile PMEL buoy recovery

The buoy is lifted until the buoy hull is approximately 1 meter above the ship's transom. The A-frame is shifted inboard causing the buoy hull to impinge against the ship's transom. The air tugger line is hauled in to stabilize and center the buoy as it is lifted towards the inboard side of the ship. Two 5/8" nylon tag lines will be tied to either side of the buoy and fair lead to A- frame cleats. With the tugger line and tag lines drawn up tight, the A- frame is shifted inboard as the trawl wire hauls in, lifting up and drawing the buoy inboard. Once the A-frame has been positioned completely inboard, the buoy is lowered and secured to the deck using aircraft straps and 2 large wooden wedges positioned on either side of the discus buoy hull. The Lebus tag line is than passed through the Gifford block and down to the apex of the buoy bridle. A 7/8" screw pin shackle is bent through the eye of the winch tag line and onto one of the two links of 1"chain connecting the buoy's load cell and 3/8" wire rope. The Lebus winch tag line is hauled in taking on the hanging mooring tension. The trawl wire is paid out and the lifting pennant is removed from the Mckissick trawl block. The A-frame repositions out board so that the Lebus tag line would hang just forward of the ship's transom. The Lebus winch then hauls in, taking the hanging mooring tension away from the buoy bridle so that the mooring wire can be disconnected from the buoy bridle. The inductive cable connector and 1" shackle are disconnected from the buoy. A 1" diameter Sampson double braid bull rope is fair lead from the ship's capstan through a 10" snatch block. This block is shackled to a WHOI fairlead plate located on the inboard starboard side of the A-frame. The free end of the bull rope will be

shackled to the stopped off 1" chain links. The bull rope, with six turns around the capstan, is hauled in taking the hanging mooring tension away from the Lebus winch line. The Lebus winch line is eased off and removed. The Lebus tag line is cleared away from the buoy tower. The buoy is then shifted forward up along the port rail using the IHAB crane with the assistance of air tugger lines to stabilize the buoy during the lift. Fig. 6 illustrates the position of the PMEL 1 buoy.

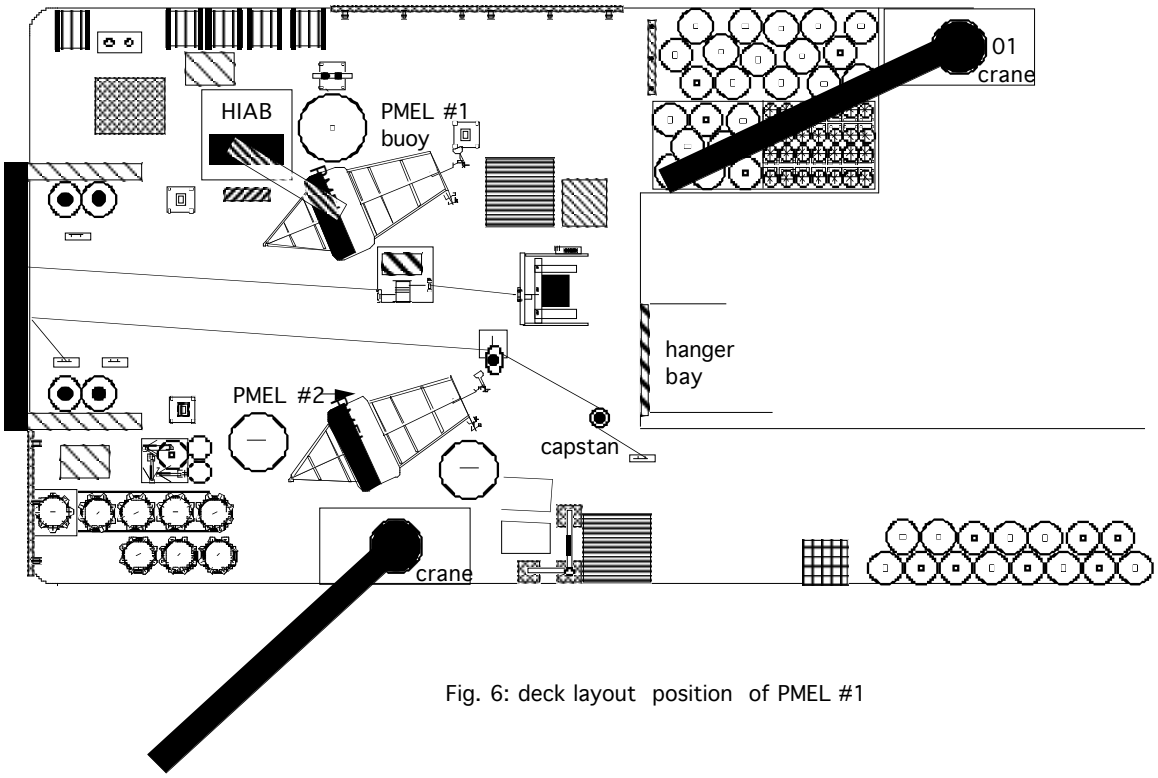


Fig. 6: deck layout position of PMEL #1

Once the buoy hull had been removed from the recovery area, the Lebus winch tag line will be reconnected onto the stopped off 1" chain. The winch will be hauled in transferring the hanging tension onto its tag line. The capstan bull rope would be eased off and removed. The removal of subsurface instrumentation and fairing, as the Lebus winch hauls in 500 m of the700 m long wire shot, will commence as the ship maneuvers so that the mooringcatenary is tending slightly aft. If the recovered 500 m wire rope is in a re-usable condition at the completion of the recovery, the wire will be re-deployed and paid out with the reattachment of new instrumentation and fairing. However, if the wire is not re-useable, it will be recovered and replaced. Once the wire has been redeployed, the bitter end of the wire will be stopped off using the capstan and bull rope. The main crane would be used to relocate the PMEL #2 into position inside the A-frame so that the apex of the bridle could be reattached to the stopped off mooring wire. The buoy hull would be temporarily secured to the deck once it had been shifted with the mooring wire shackled to the buoy's bridle. A 'Release-O–Matic' quick release hook, shackled to the Lebus tag line, will be hooked onto the buoy's lifting bail. Two slip lines will be rigged on either side of the buoy's tower. The A-frame will be shifted to its maximum inboard position and the temporary lashings are removed. The Lebus winch will than haul in, applying slight tension onto the buoy. A slip line will be rigged onto the 1" shackle connected to the wire rope termination. This slip line will be secured to a deck cleat positioned at the side of the buoy hull. The capstan line is eased off transferring the hanging mooring tension onto the slip line. The slip line is than eased off and cleared passing the hanging load onto the buoy bridle. The Lebus winch hauls in as the A-frame shifts outboard causing the buoy to be lifted up and outboard. The two buoy slip lines will be paid out together keeping the buoy tower centered in the A-frame. As the buoy clears the ship's transom, the Lebus winch will pay out lowering the buoy to allow one of the slip lines to be removed. The remaining slip line will be tended to orient the buoy so that the buoy's tower will rotate 45°away from the A-frame. The A-frame will continue to shift outboard while the slip line is being managed. The Lebus winch tag line

will pay out lowering the buoy into the sea and the quick release hook will be pulled, casting off the surface buoy. The remaining slip line will be removed immediately following releasing the buoy.

KESS Sub - Surface-Mooring Recovery Procedure

The WHOI –KESS sub-surface moorings are 5500 m ¼" wire rope taught moorings. These moorings have several segments of buoyancy, 17" glass spheres, and a 2000 lb. air wt. 64 " diameter syntactic sphere at the top of the mooring . Figure 7 illustrates this mooring design.

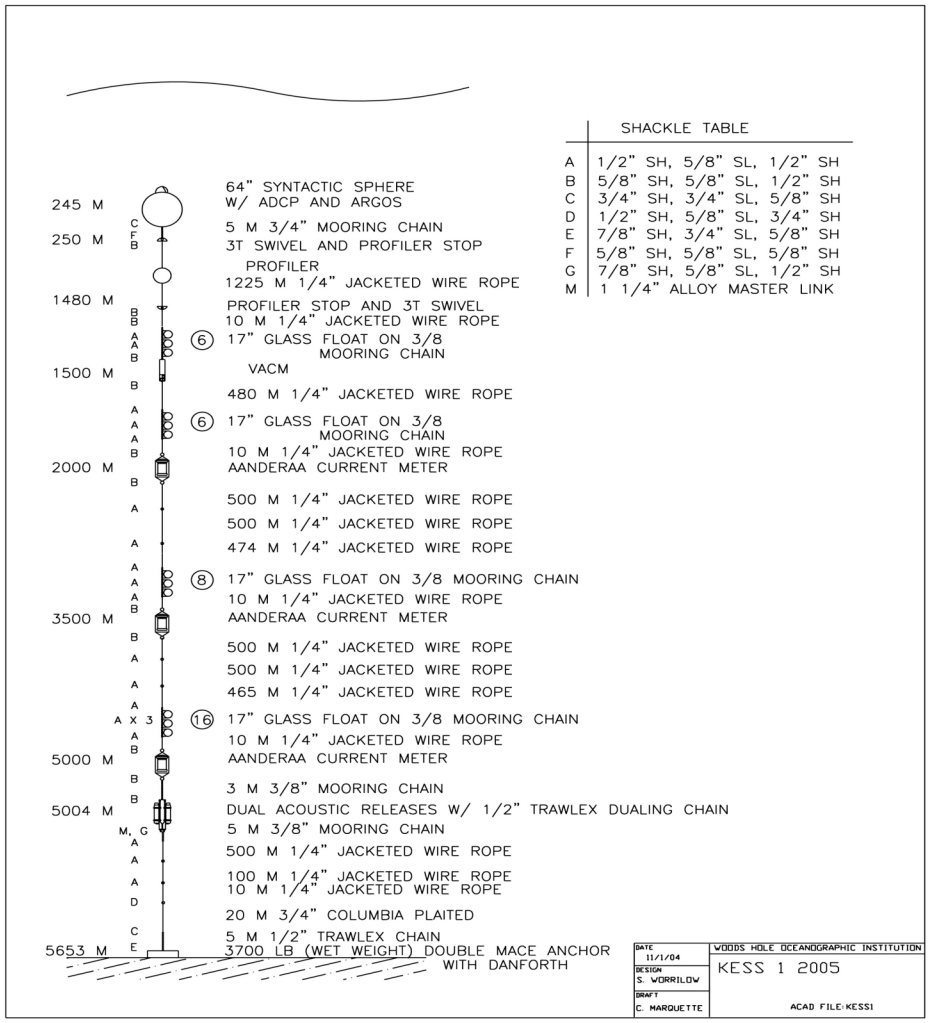


Figure7. KESS sub-surface mooring

The recovery of these sub-surface moorings will require the use of the following equipment: A-frame, Lebus winch, air tuggers, main crane, capstan, and assorted stopper line and hooks. Once the ship is positioned 1 mile horizontally down current from the mooring's anchor position, one of the two acoustic releases will be released. The syntactic sphere's light and RDF radio will be activated when the sphere reach's the surface. The ship will approach the sphere off the starboard aft quarter so that a pick-up hook and pennant can be attached to the sphere's lifting bail using a long pick-up pole. The Lebus winch tag line will be revved through the Gifford block and down to the deck. Once the pick up hook has been secured to the sphere, the end of the pennant will be shackled to the Lebus tag line. The A-frame will be positioned outboard and the Lebus will slowly haul the sphere out of the sea. As the sphere clears the sea surface, two pick-up hooks shackled to an air tugger line will be secured to bails on either side of the sphere using pick up poles. The tugger line will be hauled in controlling the sphere's swing as the A-frame shifts inboard. As

the sphere transits forward, inside the A-frame a bull rope with a ¾" chain grab will be hooked onto the3/4" chain then attached to the bottom sphere bail. The bull rope will be fair lead to the ship's capstan and bent around the capstan's barrel 6 times. The bull rope is hauled in slightly as the sphere is lowered into an aluminum stand taking the hanging mooring tension away from the sphere. The sphere is secured to the stand and the slack connection joint at the sphere's bottom bail is disconnected. The HIAB crane is swung over the sphere and the crane's hook secured to the sphere's lifting bail. The HIAB crane whip is hauled in taking tension on the sphere as the Lebus pays out its tag line. The Lebus tag line is removed and the sphere is shifted out of the recovery area and secured. The Lebus tag line is shackled to the stopped off mooring, then tension is applied, taking the mooring tension from the bull rope. The capstan is slowly paid out and disconnected from the ¾" chain. The remainder of the mooring is recovered through the A-frame.

KESS Sub-Surface-Mooring Deployment Procedure

The deployment of the sub-surface moorings will require the use of the following equipment: A-frame, Lebus winch, HIAB crane, main crane, and assorted handling lines and hooks. The second deployment mooring's design will be very similar to the first deployment in construction with changes in the several of lengths of wire rope and a smaller weight anchor. The entire mooring will be deployed through the A-frame, with the exception of the casting of the anchor. The anchor will be deployed using a tipping plate raised by the main crane's whip.

KESS Dragging Operations

One and possibly two additional subsurface moorings will need to be recovered using the following equipment: ship's trawl winch, Lebus winch, vertical chain stopper, A-frame, WHOI dragging chain and hooks, 12 kHz pinger, ship's dynamic positioning system, and a WHOI acoustic positioning program. The key element to a successful dragging operation is in the ability for the ship to hold position and transit as needed, as the trawl wire and bottom drag are being lowered and recovered. The trawl winch will need to be in excellent mechanical order along with all read outs functional, i.e.: tension and wire counter. I have had several unfortunate experiences on board other vessels where the ship's trawl winch has failed during a dragging operation.

Positioning the ship as the trawl wire is lowered and laid out on the bottom will require skill and patience. We would suggest that prior to starting a dragging operation that the ship complete a practice run along the dragging cruise track. Illustrated in Figure 8, is a cruise track used by the R/V R. Brown, during the NTAS/ Pluddemann Feb.04 to recover a failed surface mooring in 4988m of water. The planed ship track for the R/V R. Revelle will be similar with modifications made to lengths of each leg based upon the water depth, current, and sea state for each operation.

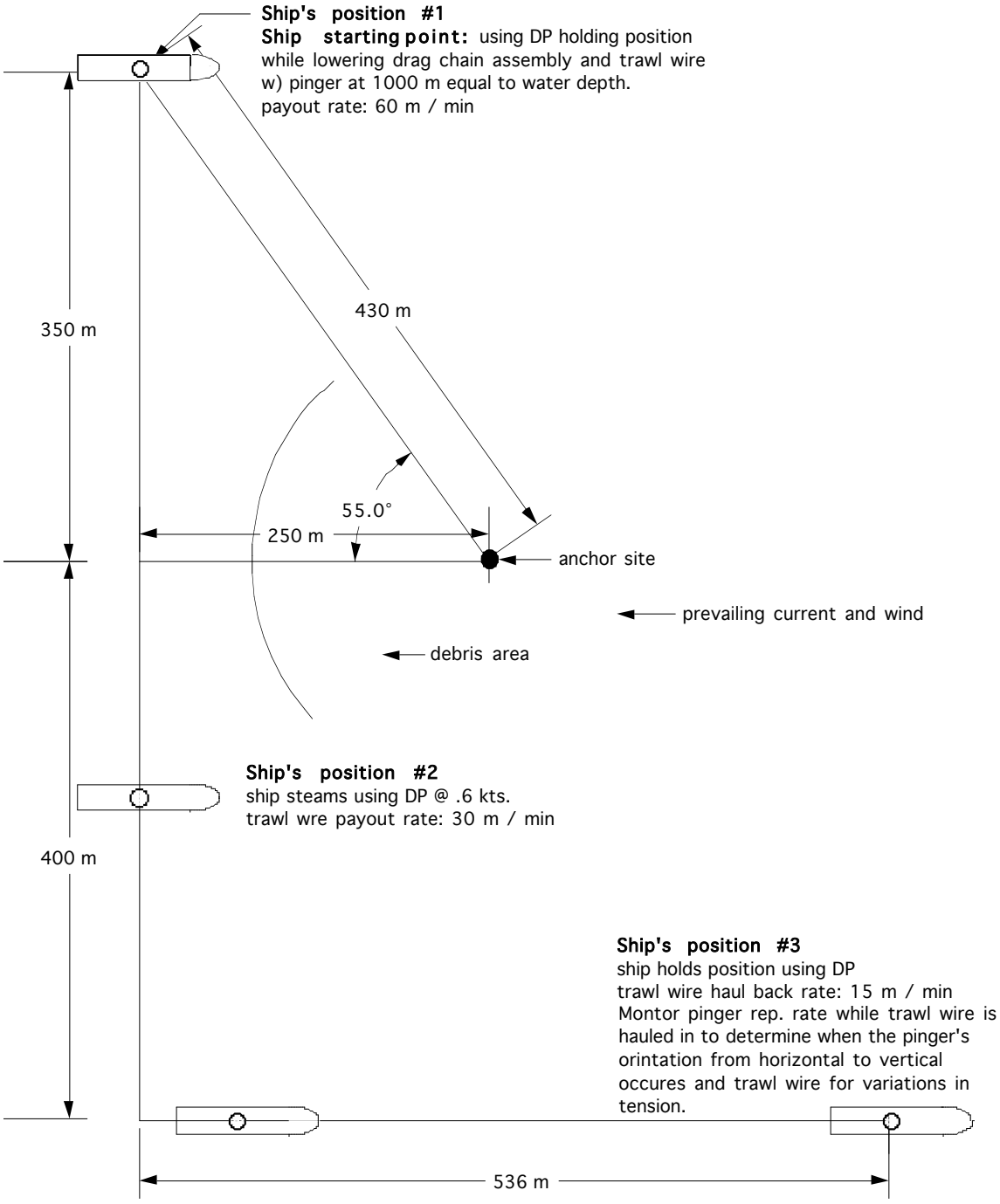


figure 8. example dragging cruise track

The procedure entails initially the lowering of a bottom drag segment, illustrated in figure 9.

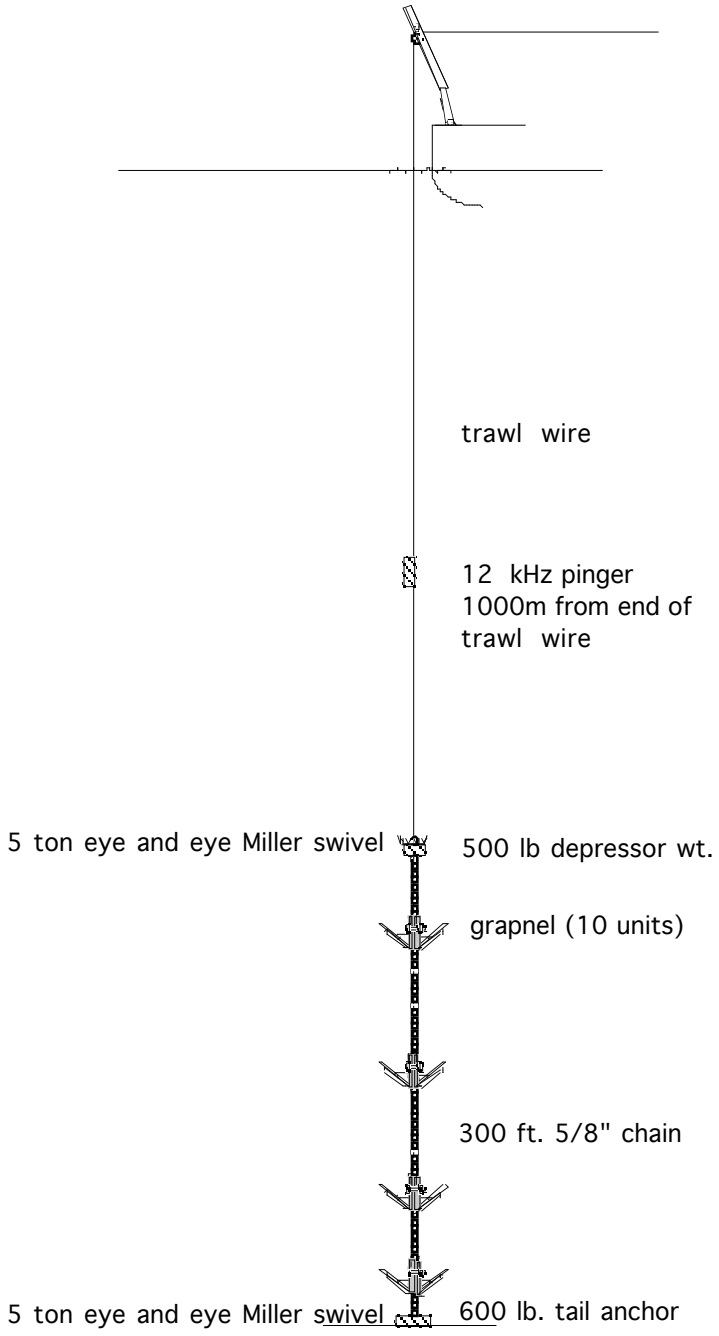


Figure 9. drag chain assembly

These bottom drag components are a 600 lb. tail anchor shackled to a 300 ft. length of 5/8" anchor chain with a 500 lb. depressor weight secured to the opposite end. Along the length of the chain there will be several WHOI designed bolt on grapnels attached to the 5/8" chain. The deployment of the bottom drag begins with the lowering of the tail anchor and 5/8" chain. The 5/8" chain is manually hauled out from storage drums secured to the forward main crane boom crotch. The free end of the chain is pulled aft up through the Mckissick block hanging in the A-frame and brought down to the deck. The end of this chain is shackled to the tailing anchor. Prior to starting the lowering of the tail weight and 5/8" chain over the stern, two distances will be measured to identify the correct location for attaching the trawl wire to the 5/8" chain

and where to stop the pay out of trawl wire and attach the vertical chain stopper hanging in the A-frame. These locations are important to allow for adequate distance to haul in and take the hanging mooring tension at the flag block and scope to disconnect the trawl wire inboard of the A-frame. These locations are detailed in Figure 10.

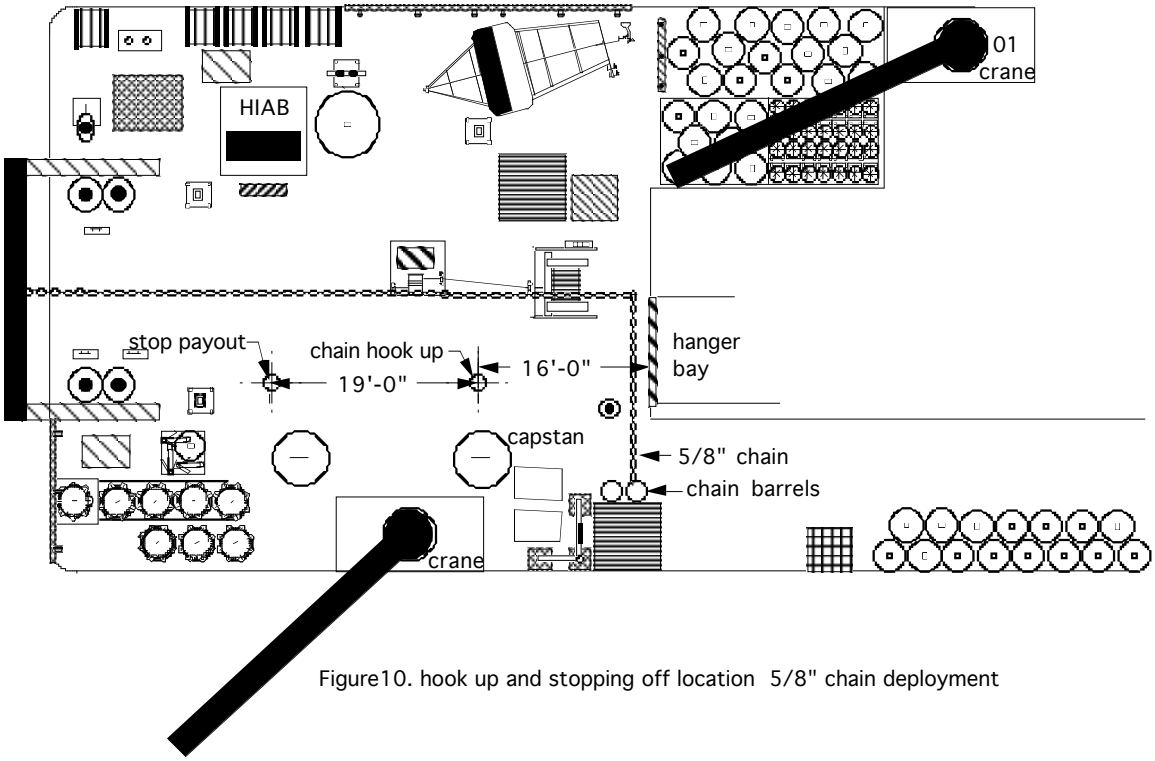


Figure10. hook up and stopping off location 5/8" chain deployment

The chain is laid on the deck behind the deckhouse and positioned underneath the trawl winch flag block. The free end of the trawl wire is shackled mid-span along the length of laid out chain a minimum of 16 ft. aft of the ship's deckhouse. The A-frame is shifted so that as the load is taken, lifting the tail anchor, the weight will swing out board over the transom. The trawl wire is hauled in lifting the anchor off the deck. The trawl wire is paid out lowering the anchor. Pay out will be stopped when the end of the trawl wire approaches the stop pay out mark, 35 ft. from the deckhouse. The vertical chain stopper is hooked across the 5/8" chain and the trawl wire is eased out slowly allowing the suspended catenary of chain to come down onto the deck. The shackle securing the end of the trawl wire is removed and the trawl wire is hauled in and re-secured to the chain at the chain hook-up location. This process, using the vertical chain stopper and trawl wire to deploy the bottom drag in bite, will be repeated 14 times at an approximate average rate of 10 minutes per lowering, taking 2.5 hours to deploy. The ship, while the bottom drag is being lowered, will be holding position over the starting point. Once the bottom drag has been deployed, the trawl wire is revved through the ship's trawl block and shackled to the stopped off 500 lb. depressor weight. The trawl wire hauls in and takes over the hanging load and starts to pay out at a rate of 60 mpm lowering the bottom drag to the bottom. Accurate bathymetry is crucial so that the combined trawl wire and bottom drag length when deployed is approximately 10m above the sea floor. Once the trawl wire and bottom drag have been lowered close to the sea bottom, the ship will crab along the cruise track and the trawl wire paid out at a rate of 1: 1.2 m/min. This rate allows for the trawl wire to be paid out at a faster rate relative to the horizontal distance made by the ship in the belief that the bottom drag will lay on the bottom and not be dragged. The goal is to lay down the bottom drag and an x length of trawl wire passing and turning this segment of the dragging wire around the failed mooring anchor location. When the ship has completed its track, the trawl wire is hauled up at a 40 to 60 m/min rate. The bottom drag is recovered in the reverse fashion it was deployed. Any salvaged mooring components that come up with the bottom drag will be recovered using the Lebus winch and A-frame.

PMEL #3 Surface Buoy Deployments

The equipment to be used in the deployment of the PMEL surface mooring includes: the Lebus winch, main crane, HIAB crane, and assorted deck lines and hooks. The personnel utilized during the first phase of the operation will be: a deck supervisor, 2 winch operators, 3 mooring wire handlers, crane-whip man, and a crane operator. Figure 11, illustrates the positioning of personnel and equipment prior to deployment of the surface buoy.

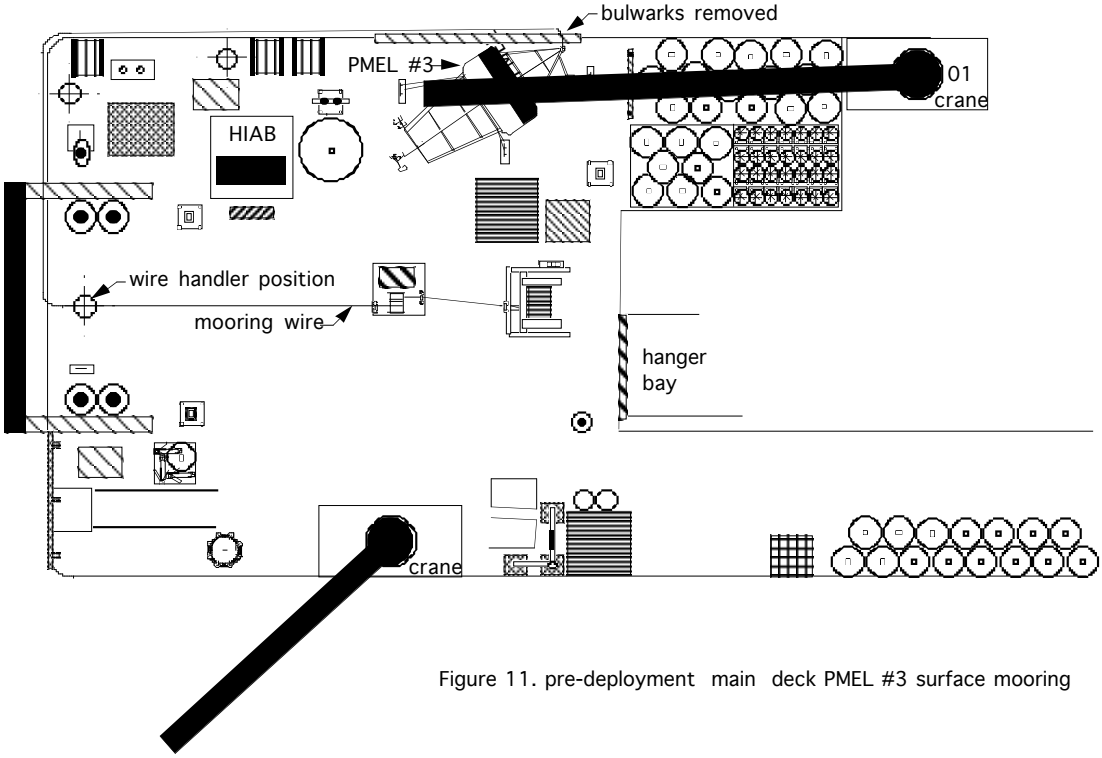


Figure 11. pre-deployment main deck PMEL #3 surface mooring

Before starting the deployment of the surface buoy, the top of the 700-meter length of 3/8" diameter wire rope will be revved around the Lebus winch and paid out to allow its bitter end to be passed out around the aft port quarter and up forward along the port rail to the buoy's bridle attachment point. Three hauling wire handlers will be positioned around the aft port rail to tend this wire manually, outboard of the rail. Their positions are in front of the Lebus winch, the aft port quarter, and one personnel approximately 5 meters forward along the port rail. The wire handler's responsibility is to keep the mooring wire from fouling in the ship's propellers and passing the mooring wire around the stern as the deployed surface buoy drifts aft.

The second phase of the operation is the launching of the surface buoy. The ship is positioned hove to with the wind slightly off the port bow. There will be three slip lines rigged on the buoy: the buoys bridle, buoy hull, and tower, which will maintain constant swing control during the lift. One additional line called the whip tag line will be tied to the headache ball. This tag line will help in pulling the crane whip away from the tower's meteorological sensors once the quick release hook has been released and the buoy cast adrift.

The personnel utilized for this phase of the operation included a deck supervisor, 2 Lebus winch operators, three hauling wire handlers, three slip line handlers, a 01 crane operator, a crane whip tag line handler, and quick release hook handler. With all three-slip lines in place, the crane is directed to swing over the surface buoy. The extension of the crane's boom will be approximately 60 ft. The crane's whip is lowered to the buoy and the quick release hook attached to the main lifting bail. Slight tension is taken up on the whip to take hold of the buoy. The chain lashings, binding the buoy hull to the deck, are removed. The buoy is raised up and swung outboard as the slip lines keep the hull in check. The bridle slip line is removed first, followed by the tower bail slip line. Once the discus had settled into the water (approximately 15 ft. from the side of the ship and the release hook had gone slack), the quick release hook handler pulls the trip line and clears the whip away from the buoy (forward) with the assistance of the whip

tag line handler. The slip line to the buoy deck bail should be cleared at about the same time the quick release hook is tripped or slightly before in order to prevent the buoy from rotating and fouling the quick release hook. The ship then maneuvers slowly ahead to allow the discus to pass around the stern of the ship while the wire handlers, along the port rail, cast off the bite of mooring wire they have been tending as the buoy drifts past their position.

The Lebus winch operator is instructed to slowly haul in the mooring wire once the buoy has drifted behind the ship. The ship's speed is increased to 1 kt. The mooring wire is recovered up to the point that the pre-attached fairing can be seen behind the ship. The HIAB crane is than swung over the mooring wire. A 'Skookum Rope Master 508' block is hooked onto the crane whip and the wire bent through the block. The HIAB crane boom positions the block so that the mooring wire fleet angle is approximately 1 m clear of the deck. The remaining fairing and subsurface instrumentation are attached to the mooring wire and deployed. The ship's speed will be adjusted based upon sea conditions and current. The long lengths of wire and nylon will be paid out approximately 10% slower than the ship's speed through the water. This is accomplished by using a digital tachometer, 'Amertek model #1726', to calculate the mooring pay out speed verses the ship's speed through the water. The mooring anchor will be deployed thru the A-frame using the trawl wire and a 'Brailer' vertical tripping hook.

Scientific personnel participates

Dr. Nelson Hogg (Chief scientist) -WHOI
Dr. Steve Jayne - WHOI
Mr. William Ostrom - WHOI
Mr. Scott Worrilow – WHOI
Mr. Brian Hogue – WHOI
Mr. Kris Newhall - WHOI
Dr. Megan Cronin – PMEL
Mr. Mike Strick – PMEL
Dr. Peter Hatcker – Univ. of Hawaii
Mr. Pierre Dutrieux – Univ. of Hawaii
Dr. Genta Mizuta – Univ. of Hokaido (Japanese)
Dr. Humio Mitsudera – Univ. of Hokaido (Japanese)
Mr. Yuka Ikumi – Univ. of Hokaido (Japanese)
Mr. Yuusuke Kawaguchi – Univ. of Hokaido (Japanese)
TBA (US Navy)
TBA (US Navy)

Cruise time budget

Estimated total	Task
115 hr. = 23 hr. @	5 sub - surface mooring turnarounds
72 hr. = 24 hr. @	3 dragging operations
24 hr. = 12 hr. @	2 sub-surface mooring deployment
8 hr. = 8 hr. @	1 PMEL buoy turn around
12 hr. = 12 hr. @	1 PMEL surface mooring deployment

Will Ostrom
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Mooring Operations and Field Support Group
Woods Hole Oceanographic Institution
November 4, 2004