Cruise Plan
Coastal Pioneer 3 Deployment
Leg 2: R/V *Knorr* Cruise KN-224
10-16 December 2014

Control Number: 3204-00304
Version: 1-02
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Date: November 30, 2014
Approved:

Coastal and Global Scale Nodes
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Woods Hole Oceanographic Institution
Oregon State University
Scripps Institution of Oceanography

template number 3101-00045

Revision History

Version	Description	Originator	ECR No.	Release Date
0-01	Draft	A. Plueddemann	N/A	11/10/2014
0-02	Draft	A. Plueddemann	N/A	11/14/2014
1-00	Initial release	P. Matthias	N/A	11/15/2014
1-01	Revised for Knorr	A. Plueddemann	N/A	11/21/2014
1-02	Final draft for Knorr	A. Plueddemann	N/A	11/30/2014

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1.0 Introduction

1.1. Overview

This cruise represents the third major infrastructure deployment for the Pioneer Array of the National Science Foundation's Ocean Observatories Initiative (OOI; http://www.oceanobservatories.org). The Pioneer Array includes a network of moorings and autonomous robotic vehicles to monitor waters of the continental shelf and slope south of New England and, in particular, the shelfbreak front where nutrients and other properties are exchanged between the coast and the deep ocean. Data from the Pioneer Array will provide new insights into coastal ocean processes such as shelf/slope nutrient exchange, air-sea property exchange, carbon cycling, and ocean acidification that are important to the New England shelf and to continental shelf ecosystems around the world.

The Pioneer 3, Leg 2 deployment cruise (Pioneer-3 L2) has eight primary objectives (see Sec. 2.3) that include the deployment of three Coastal Surface Moorings (CSMs), the deployment of two uncabled Coastal Surface Piercing Profiler (CSPP) moorings, recovery and refurbishment of one Coastal Profiler Mooring (CPM), and CTD casts with water sampling at the mooring sites. The Pioneer-3 L2 cruise also has Additional objectives, including ship vs. buoy meteorological comparisons, and CTD/ADCP surveys in the vicinity of the Pioneer moored array.

1.2. Operating Area

The Pioneer operating area is the southern New England continental shelf and slope within a region bounded by approximately 39.0°- 40.7° N and 69.9° - 71.5° W (Figure 2-1). Pioneer-3 operations will be focused on the Pioneer Moored Array centered near 40.15°N, 70.83°W (Figure 2-2). Mooring site locations and water depths are provided in Appendix A.

2.0 Cruise Plan

2.1. Background

The Pioneer Array will be deployed in three phases, as described in the Pioneer Array Deployment Plan (CGSN 3101-00091: ECR 1303-01166). The deployment plans, and the sampling configurations on each platform, assume that CSMs will be deployed for ~1 year, whereas CPMs and CSPPs well be deployed for ~6 months (CSPPs are refurbished after ~90 days). Gliders will be deployed for ~90 days. The Pioneer Central Surface Mooring (CNSM) and the Upstream Inshore and Upstream Offshore Profiler Moorings (PMUI, PMUO) were deployed on the Pioneer-1 cruise. The surface mooring and two profiler moorings were recovered, and five profiler moorings were deployed (PMUI, PMUI, PMCI, PMCO and OSPM), on the Pioneer 2 cruise. Three gliders were deployed on Pioneer 2, occupying the EB, FZ and SS-1 lines. All gliders were recovered prior to the Pioneer 3 Leg 1 cruise. On the Pioneer-3 Leg 1 cruise, conducted in October 2014, the five Coastal Profiler Moorings were recovered, five replacement CPMs were deployed. Five gliders were deployed, occupying the EB, FZ, SS-1 and SS-2 lines.

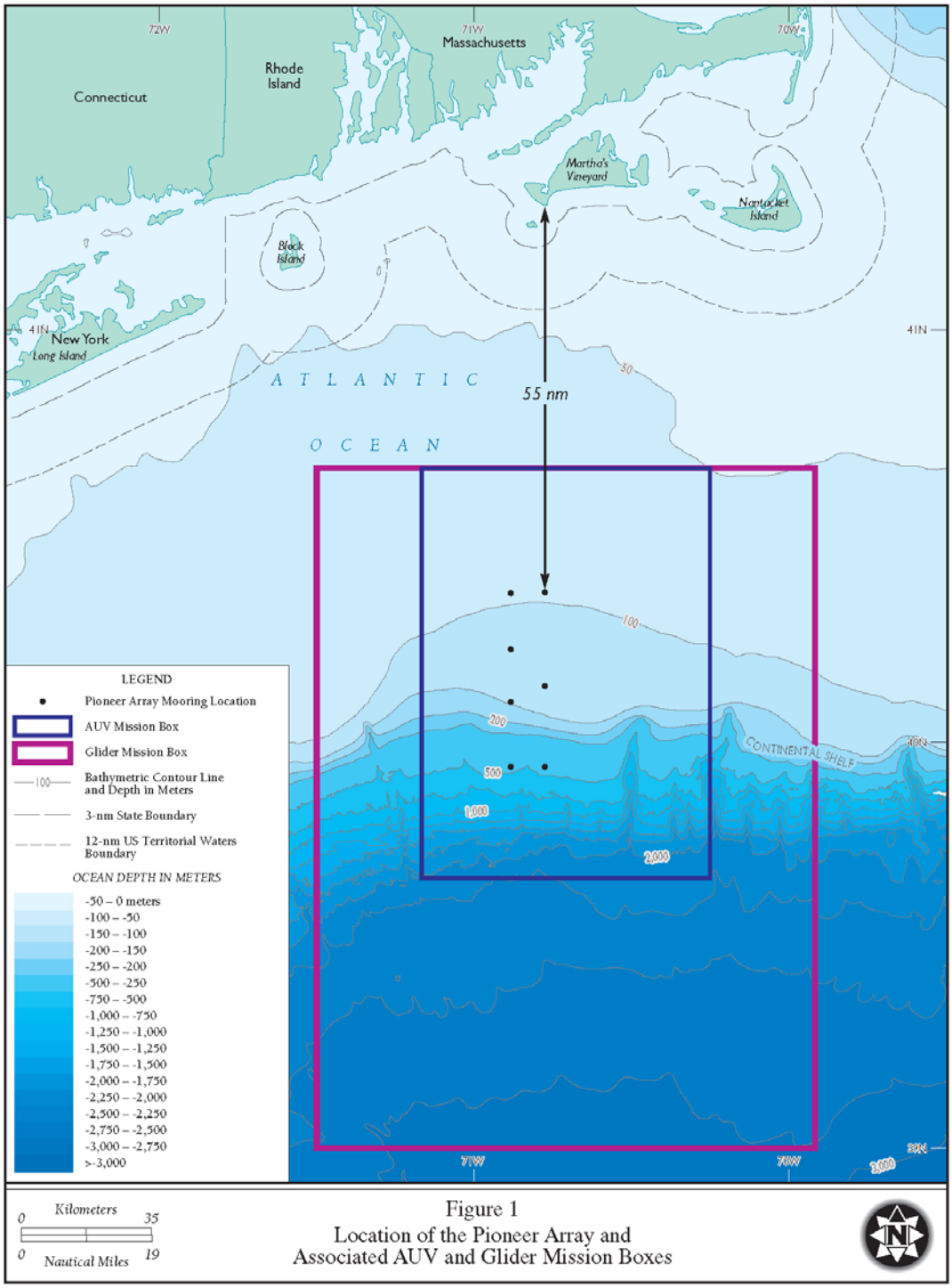

Figure 2-1 – Map of the Pioneer Array region over the southern New England continental shelf and slope. The seven sites of the moored array, the AUV operating region and the glider operating region are shown along with bathymetric contours.

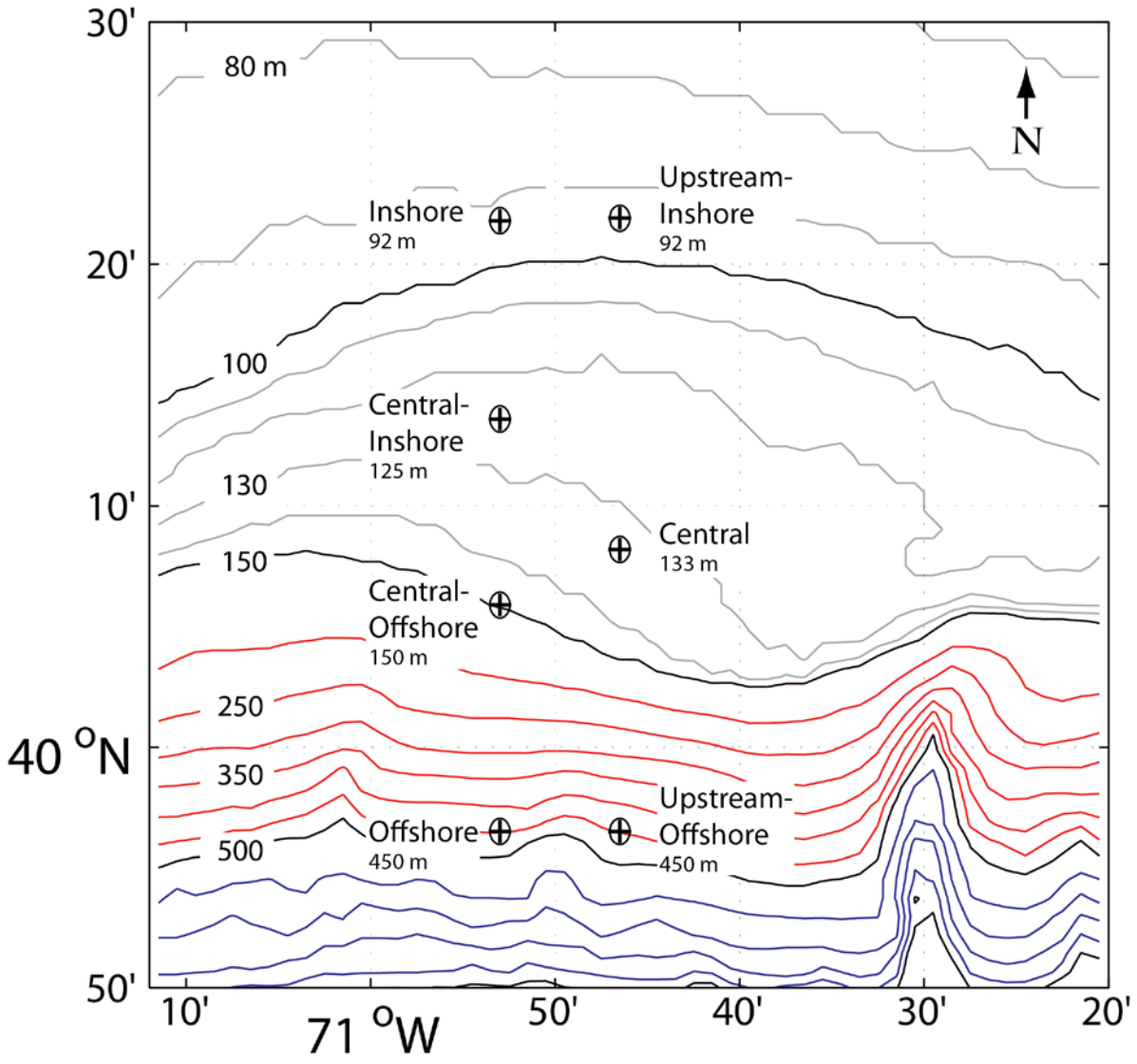

Figure 2-2 – Pioneer Array mooring site locations
Site centers are marked by black "+" and encircled by approximate 0.5 nm radius buffer zones. Bathymetry is shown at 10 m (gray), 50 m (red) and 100 m (blue) intervals, respectively. Black contours are at 100 m, 150 m, 500 m and 1000 m.

2.2. Staging and De-Staging

Staging and loading will be done at the Woods Hole Oceanographic Institution (WHOI). Staging will begin on the WHOI dock during 6-7 December. Gear will be loaded aboard the R/V *Knorr* during 8-9 December. The ship's crane will be suitable for loading all science gear. As part of the staging operation, it will be necessary to mount several antennas and run cables from these antennas to the main lab. Antenna mount locations and cable runs will be determined by consultation with the ship. A list of major equipment to be loaded and a deck plan showing the location of major deck components are provided in Appendix A.

Destaging and offloading of scientific equipment will be completed in Woods Hole upon termination of the cruse on 16 December, with the offloaded to be completed by 17 December. The ship's crane will be suitable for offloading all science gear.

2.3. Cruise Operations and Objectives

The R/V *Knorr* will depart from Woods Hole on 10 December and transit to the Pioneer Offshore site where operations will commence. Days 2-4 of the cruise will be primarily dedicated to Coastal Surface Mooring (CSM) deployments. One of these (the Central Site mooring, CNSM) contains a methanol fuel in the surface buoy. Coastal Surface Piercing Profilers (CSPPs) will be deployed at the Inshore and Central sites adjacent to the CSMs. The fifth day will focus on Coastal Profiler Mooring (CPM) recovery and re-deployment. If all activities are complete, the sixth day will focus on a cross-shelf CTD survey. In the more likely event that bad weather or other difficulties preclude completion of the primary objectives, they will be completed on the sixth day. The ship will depart station on day 6 and arrive at WHOI on day 7. Other activities that need to be conducted in conjunction with the mooring deployments include anchor surveys and CTDs with bottle samples. A detailed timeline is provided in Appendix A.

Additional activities are nominally scheduled in the cruise timeline (Appendix A), and will be fit in as time allows: A glider recovery will be conducted at a convenient time when the ship is near the glider location. Ship vs. buoy meteorological comparisons will be conducted from late evening, after mooring operations are completed, to early morning before the start of the next operation. A variety of surveys may be conducted.

The primary Objectives (O1-O8) are listed below. Nominal times for these activities are given in the cruise timeline (Appendix A). Site locations are listed in Appendix B.

O1. Deploy the Offshore Coastal Surface Mooring (CP04OSSM-00001).

O2. Deploy the Central Coastal Surface Mooring (with fuel cell) (CP01CNSM-00002).

O3. Deploy the Inshore Coastal Surface Mooring (CP03ISSM-00001).

O4. Deploy the Central Surface Piercing Profiler Mooring (CP01CNSP-00001).

O5. Deploy the Inshore Surface Piercing Profiler Mooring (CP03ISSP-00001).

O6. Recover the Upstream Inshore Profiler Mooring (CP02PMUI-00003)

O7. Refurbish and redeploy the Profiler Mooring (CP02PMUI-00004).

O8. Conduct CTD casts with water sampling at the mooring sites.

There are also Additional objectives (A1-A4) that would be desirable to accomplish on the cruise. The Additional objectives are listed in rough priority order, and will be completed as time and conditions permit.

A1. Recover coastal glider SN 376, dedicated to the SS-1 line.

A2. Conduct ship vs. buoy meteorological comparisons at each CSM site.

A3. Conduct a CTD surveys (no bottle samples) in the vicinity of the moored array.

A4. Conduct shipboard ADCP and/or bathymetry surveys in the vicinity of the moored array.

The Chief Scientist (CS) will execute the cruise according to the direction of the Program Manager (PM) in order to accomplish, to the extent practicable, programmatic and scientific objectives as described above. The ship's Master and the CS have discretion to alter the order of operations as well as determine that some operations cannot be accomplished safely or effectively, based on conditions encountered at sea. The CS and PM have discussed tasks and responsibilities for the cruise, have reviewed likely at-sea failure modes and actions, have reviewed guiding principles for at-sea decision making, and have established communication pathways for both routine reporting (e.g. email) and emergency contact (e.g. satellite telephone).

The CS and PM will communicate frequently (typically daily by email) during the cruise to exchange status information and to assess the potential impact of at-sea decisions driven by weather or technical issues. Significant modifications to the cruise objectives (e.g. inability to deploy/recover a platform) or changes to the cruise plan anticipated to have significant financial impacts (e.g. additional ship days) will be communicated to the PM at the earliest opportunity. Incidents involving injury or damaged/lost equipment will follow established Program protocols (UNOLS policies, OOI Incident Reporting Process). Anomalies, suspected failures and confirmed failures will be handled according to the OOI Equipment Notification and Escalation Process.

2.3.1. Release Tests

At a convenient time prior to deployment of the moorings, the science party will to perform release tests. The release tests involve lowering multiple acoustic releases, to one or more depths between 500 m and the surface and held there while being interrogated acoustically. The science party will bring an acoustic transceiver than can be lowered over the rail with a cable run to the main lab and connected to a transceiver controller. Alternatively, the controller can be connected directly to a 12 kHz hull transducer on the ship.

2.3.2. Mooring Operations

Mooring deployments and recoveries will be done in stages using the ship's crane and winches supplied by the science party. Science party personnel will be familiar with mooring deployment and recovery, and will be capable of directing operations in cooperation with the ship's crew. Additional science personnel will assist with mooring operations, met watches, and other observation and data collection activities.

2.3.3. Glider Operations

Glider deployments and recoveries will typically be done using air tuggers and handling equipment supplied by the science party. It is also possible to use the A-frame and/or the ship's crane. Science party personnel will be familiar with glider deployment and recovery, and will be capable of directing operations in cooperation with the ship's crew during all phases of glider operations.

2.3.4. Anchor Surveys

Once the anchor has settled on the bottom, the ship will occupy three stations 0.3 to 0.5 nm from the anchor drop point in a triangular pattern. At each station the slant range to the acoustic release will be determined. Ranging from three stations will allow the release position, and thus the mooring anchor position, to be determined by triangulation.

2.3.5. CTD casts

CTD casts will be conducted using the ship's CTD sensors, 12 or 24 bottle rosette frame, and deck box. Sensors requested in addition to C,T, and D are dissolved oxygen, chlorophyll fluorometer, transmissometer, and PAR. An altimeter is desirable since cast depths will be within a few meters of the bottom. CTD operations will be supervised by shipboard technicians – the science party will supply line handlers and a lab operator. Water sampling and analysis will be handled by the science party.

2.3.6. Sensor Performance Evaluation

Sensor evaluation operations will be conducted with at each mooring deployment site and glider deployment site. The primary means of evaluation will be CTD casts obtained in near proximity (e.g. 0.25 nm) to the mooring or glider. For validation of meteorological and sea surface variables the ship may establish and hold a position, with bow into the wind, approximately 0.10 nm downwind of a buoy. This station will be held, and adjusted if necessary, while the science party evaluates data received from the buoy. During this period, the ships underway data will be continuously recorded. At a convenient time during the cruise, the ship may make a close approach to buoys to allow visual inspection, determination of the water line, and photographs.

2.3.7. Shipboard Underway Data

The ship's meteorological system will be used to continuously monitor weather conditions while underway and for evaluation of buoy meteorology during the intercomparison period. The ship's ADCP systems will be used to continuously measure the currents in the upper ocean while. Sea surface temperature and salinity will be recorded continuously, using the ship's thermosalinograph.

2.3.8. Shipboard Multi-beam Bathymetry

Bathymetric surveys may be conducted within the Pioneer Array region (e.g. within the AUV Mission Box of Figure 2-1). Nominal waypoints for each survey will be provided to the bridge and discussed with survey technicians. Cruising speed, leg length, and leg spacing can be adjusted as needed to ensure adequate data optimal system performance. The results of the bathymetry survey should be displayed immediately after completion for evaluation by the Chief Scientist.

2.3.9. Small Boat Operations

The use of a work boat may be requested, at the discretion of the ship, for glider recovery or attending to unforeseen problems that would require physical access to a buoy tower. Expected duration of use is approximately 0.5 to 1.5 hr. Work boat operations would be within 0.5-1.0 nm of the ship.

2.4. Potential Restrictions

Small boat activities may be restricted by weather. In the case of a recovery operation, the ship will maneuver to the item to be retrieved and grappling lines and/or pick up poles will be used. Mooring activities may be restricted by severe weather or equipment failure. Severe weather would result in postponement until conditions eased. Failure of a given piece of Project equipment (e.g. winch, air tugger) can typically be compensated by use of an alternative approach. Failure of ship's equipment (e.g. electrical or hydraulic system) would result in postponement of operations until the failure was addressed. Deployment and recovery activities may be restricted by the presence of multiple fixed objects (e.g. fishing gear) in the deployment area or along the deployment/recovery track. If possible, operations will be delayed until conditions are more favorable (e.g. change in prevailing wind direction allowing deployment approach along a different, unobstructed course).

3.0 Appendices

Appendix A – Cruise Timeline

Appendix B – Selected Waypoints and Maps

Appendix C – Equipment Inventory and Deck Plan

Appendix D – Science Party

Appendix E – Mooring Drawings

Appendix A – Cruise Timeline

08 – 09 Dec	Mobilization, LOSOS and WHOI pier
10 – 16 Dec	Cruise dates
16 – 17 Dec	Demob, WHOI pier and LOSOS

Timeline

10 Dec Depart WHOI

13:00 Depart Woods Hole (slack tide), steam to Offshore site (~10 h)

11 Dec Offshore site

07:00 – 08:00: Deck prep, ck weather, determine approach, steam line

08:00 – 10:00: Release tests, electronics prep, deck prep

10:00 – 15:00: Deploy surface mooring OSSM-00001

15:00 – 16:00: CTD with samples at Offshore site

16:00 – 17:00: Anchor survey, OSSM-00001

17:00 – 19:00: Recover glider

19:00 – 22:00: Monitor and evaluate OSSM function via telemetry

Overnight

Stand-off OSSM buoy for meteorological comparison

Transit to Inshore site to arrive 05:00

12 Dec Inshore Site

07:00 – 08:00: Deck prep, ck weather, determine approach, steam line

08:00 – 10:00: Release tests, electronics prep, deck prep

10:00 – 14:00: Deploy surface mooring ISSM-00001

14:00 – 16:00: Deploy surface piercing profiler ISSP-00001

16:00 – 17:00: CTD with samples at Inshore site

17:00 – 19:00: Anchor surveys, ISSM-00001, ISSP-00001

19:00 – 22:00: Monitor and evaluate ISSM, ISSP via telemetry

Overnight

Stand-off ISSM buoy for meteorological comparison

Transit to Central site to arrive 05:00

13 Dec Central site

07:00 – 08:00: Deck prep, ck weather, determine approach, steam line
08:00 – 10:00: Release tests, electronics prep, deck prep CNSM
10:00 – 14:00: Deploy surface mooring CNSM-00002
14:00 – 16:00: Deploy CNSP-00001
16:00 – 17:00: CTD with samples at Central site
17:00 – 19:00: Anchor surveys, CNSM-00002 and CNSP-00001
19:00 – 22:00: Monitor and evaluate CNSM, CNSP via telemetry

Overnight

Stand-off CNSM buoy for meteorological comparison
Transit to Upstream Inshore site to arrive 05:00

14 Dec Upstream Inshore site

06:00 – 07:00: Deck prep, ck weather, determine approach, steam line
07:00 – 08:00: Release tests, electronics prep, deck prep, PMUI
08:00 – 10:00: Recover PMUI-00003 mooring riser
10:00 – 11:00: CTD with samples
11:00 – 13:00: Steam to start point, prepare deck for deployment
13:00 – 16:00: Deploy PMUI-00004
16:00 – 18:00: Recover PMUI-00003 anchor and line pack
18:00 – 19:00: Anchor survey, PMUI-00004

Overnight

Transit to Upstream Offshore site

15 Dec Cross-Shelf CTD survey and/or Additional Activities*

08:00 – 09:00: CTD at UO
09:00 – 10:00: CTD at CS-4
10:00 – 11:00: CTD at CS-3
11:00 – 12:00: CTD at CN
12:00 – 13:00: CTD at CS-2
13:00 – 14:00: CTD at CS-1
14:00 – 15:00: CTD at UI
16:00: Depart station for WHOI

Overnight

Transit to WHOI

16 Dec Arrive WHOI (target is slack tide at ~11:00 AM)

* Additional activities may include:

    Address problems detected by shore station

    Complete unfinished anchor surveys

    Cross-Shelf CTD survey, UI to UO (~8 h)

    Steam cross-shelf AUV box (8 h @ 10 kt)

    Steam mooring box (6 h @ 10 kt)

Appendix B – Selected Waypoints and Maps

Station List: Pioneer 3 Leg2, R/VKnorr, November 2014					
See timeline for order of occupation; some sites are occupied more than once					
Name	**Code**	**Lat**	**Lon**	**water depth**	**comments**
Upstream-Inshore	UI	40 21.9	70 46.5	91.5 m	profiler mooring recovery and deployment, CTD
Inshore	IS	40 21.8	70 53.0	91.5 m	surface mooring and profiler mooring deployment, CTD
Central-Inshore	CI	40 13.6	70 53.0	125 m	no activities planned
Central	CN	40 08.2	70 46.5	133 m	surface mooring and profiler mooring deployment, CTD
Central-Offshore	CO	40 05.9	70 53.0	150 m	no activities planned
Offshore	OS	39 56.4	70 53.0	450 m	surface mooring deployment, CTD
Upstream-Offshore	UO	39 56.4	70 46.5	450 m	no activities planned
Cross-shelf 1	CS-1	40 17.6	70 46.5	115 m	part of cross-shelf CTD line
Cross-shelf 1	CS-2	40 13.2	70 46.5	125 m	part of cross-shelf CTD line
Cross-shelf 1	CS-3	40 04.3	70 46.5	140 m	part of cross-shelf CTD line
Cross-shelf 1	CS-4	40 00.4	70 46.5	270 m	part of cross-shelf CTD line

Table B-1 – Pioneer 3 Leg 2 station list

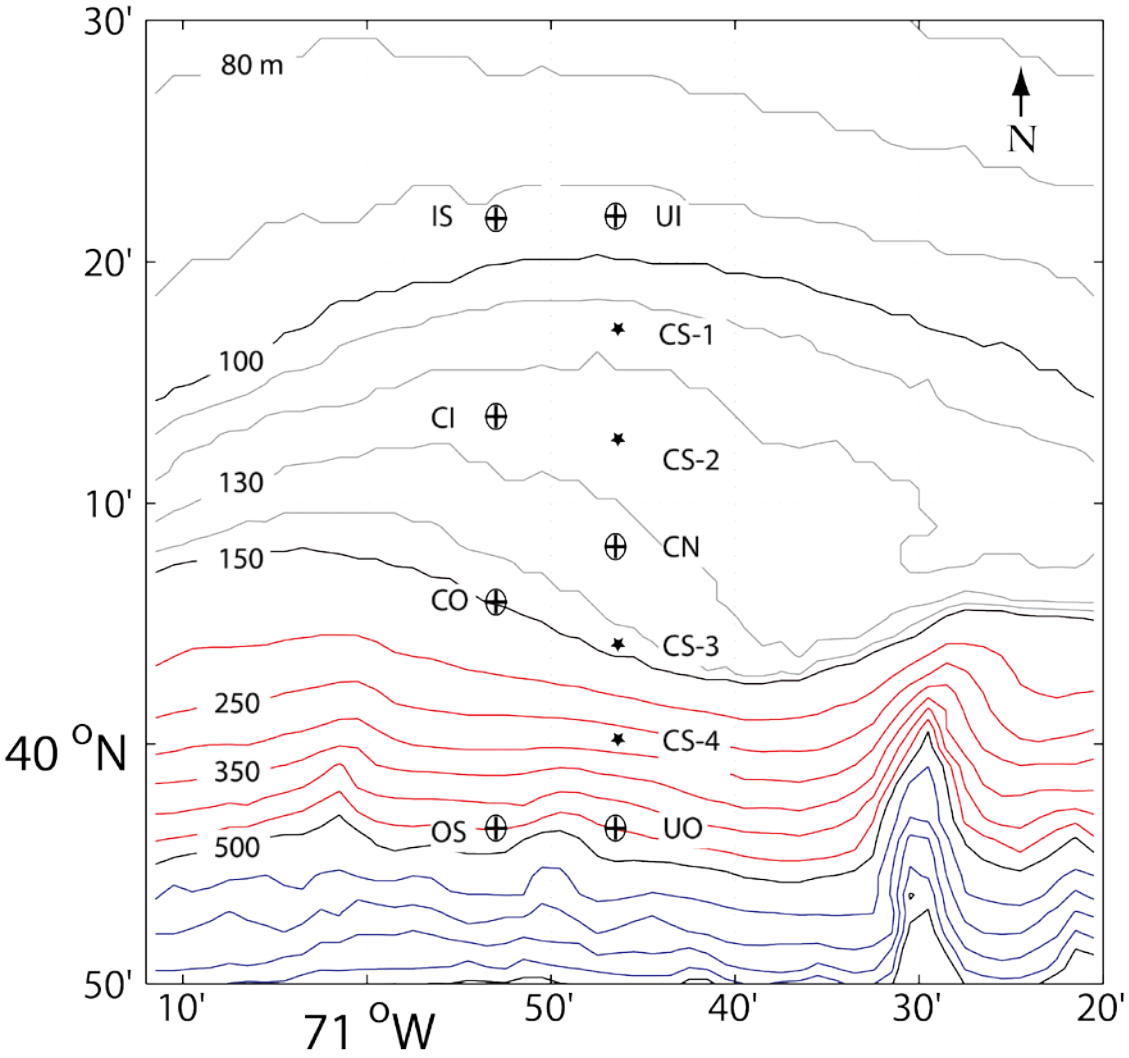

Figure B-1 – Pioneer 3 Leg 2 station map showing the seven mooring sites (IS, CI, CN, CO, OS, UO, UI) and four cross-shelf CTD stations (CS 1-4) that, along with the eastern mooring line, make up the cross-shelf CTD survey line from UI to UO.

Appendix C – Equipment Inventory and Deck Plan

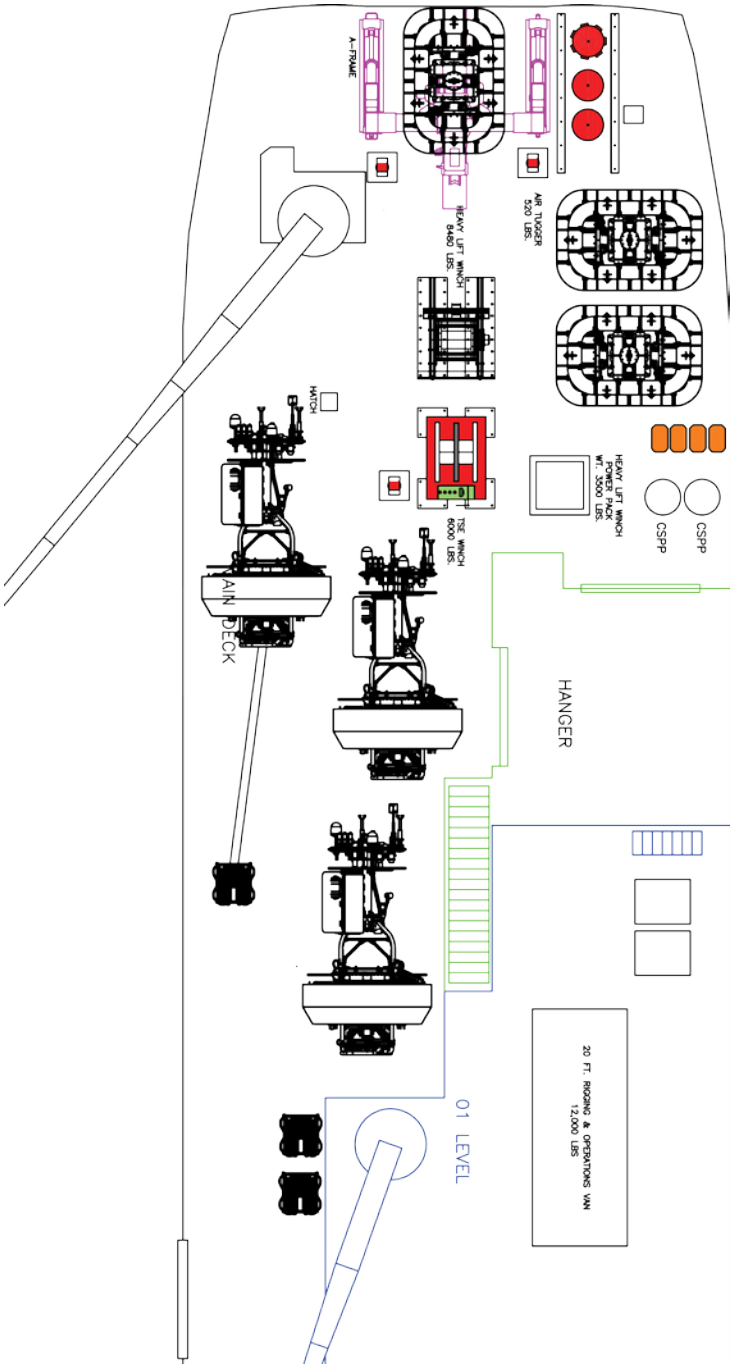

Figure C-1 – R/V *Knorr* Deck Layout. Nominal deck layout for the major components associated with Pioneer-3 Leg 2 operations. Proposed locations of major deck elements are shown. Estimated weights of major deck components are also documented in a table.

Ocean Observatories Inititve (OOI)
Pioneer 3 Deployment Cruise
Projected Deckload

Piece No.	Description of Items	Unit Dimensions L" x W" X H"	Weight in Lbs.
	Support Equipment		
1	20 Foot Rigging and Operations Container	240 x 96 x 96	16000
2	TSE Mooring Winch	108 x 98 x 72	7000
3	Heavy Lift Anchor Winch	48 x 48 x 30	8400
4	HLW Power Pack	72 x 48 x 50	3000
5	Air Tugger Winch on Stand	28 x 28 x 57	520
6	Air Tugger Winch on Stand	28 x 28 x 57	520
7	Air Tugger Winch on Stand	28 x 28 x 57	520
8	Air Tugger Winch on Stand	28 x 28 x 57	520
9	Galvanized Anchor Track (1 set)	151 x 8 x 9	500
10	Hydraulic Tensioning Cart	67 x 48 x 51	690
11	Fairlead Plate	28 x 28 x 7	170
	Offshore Surface Mooring - CP04OSSM		
12	Surface Buoy	102 x 102 x 156	8700
13	Electrical Mechanical Potted Chain	12 x 12 x 220	500
14	Near Surface Instrument Frame (NSIF)	48 x 24 x 24	300
15	Wooden Reel with EOM Cable	36 x 36 x 30	400
16	Plastic Bin Box with (2) EOM Stretch Hoses	56 x 45 x 45	900
17	Hose Interface Buoyancy (HIB)	24 x 30 x 30"	300
18	Hose Interface Buoyancy (HIB)	24 x 30 x 30"	300
19	Benthic Anchor Recovery Frame (BARF) with Mooring Anchor	60 x 60 x 40	10,700
	Inshore Surface Mooring - CP03ISSM		
20	Surface Buoy	102 x 102 x 156	8700
21	Electrical Mechanical Potted Chain	12 x 12 x 220	500
22	Near Surface Instrument Frame (NSIF)	48 x 24 x 24	300
23	Wooden Reel with EOM Cable	36 x 36 x 30	400
24	Plastic Bin Box with (2) EOM Stretch Hoses	56 x 45 x 45	900
25	Hose Interface Buoyancy (HIB)	24 x 30 x 30"	300
26	Hose Interface Buoyancy (HIB)	24 x 30 x 30"	300
27	Benthic Anchor Recovery Frame (BARF) with Mooring Anchor	60 x 60 x 40	10,700
	Central Surface Mooring - CP01CNSM - Fuel Cell		
28	Surface Buoy	102 x 102 x 156	9700
29	Electrical Mechanical Potted Chain	12 x 12 x 220	500
30	Near Surface Instrument Frame (NSIF)	48 x 24 x 24	300
31	Wooden Reel with EOM Cable	36 x 36 x 30	400
32	Plastic Bin Box with (2) EOM Stretch Hoses	56 x 45 x 45	900
33	Hose Interface Buoyancy (HIB)	24 x 30 x 30"	300
34	Hose Interface Buoyancy (HIB)	24 x 30 x 30"	300
35	Benthic Anchor Recovery Frame (BARF) with Mooring Anchor	60 x 60 x 40	10,700

Table C-1 – Estimated deck load.

	Offshore CSPP Mooring		
36	Coastal Surface Piercing Profiler	66 x 32 x 32	500
37	Syntactic Line Pack	28 x 29 x 29	260
38	Syntactic Buoyancy Recovery Module	42 x 20 x 20	190
39	Cast Iron Mooring Anchor	32 x 32 x 30	1167
	Inshore CSPP Mooring		
40	Coastal Surface Piercing Profiler	66 x 32 x 32	500
41	Syntactic Line Pack	28 x 29 x 29	260
42	Syntactic Buoyancy Recovery Module	42 x 20 x 20	190
43	Cast Iron Mooring Anchor	32 x 32 x 30	1167
	Surface Mooring with Profiler - CP04OSPM		
44	Surface Buoy Stand	48 x 48 x 60	220
45	Syntactic Sphere Stand	36 x 36 x 30	180
46	Backup Recovery Module (BRB)	56 x 44 x 44	490
47	Cast Iron Mooring Anchor	33 x 32 x 40	7000
		Total Weight (Lbs.)	**117264**
		Total Weight (Tons)	**58.632**

Table C-1 – Estimated deck load, continued.

Appendix D – Science Party

There will be 12 participants in the science party, all affiliated with the Woods Hole Oceanographic Institution (WHOI). The Chief Scientist is Dr. Albert J. Plueddemann (WHOI). WHOI Shipboard Scientific Services Group (SSSG) participants will be Robert Laird, Amy Simoneau and Ellen Roosen. An alphabetical list is given in the table below.

Participating Scientists

Name	Gender	Nationality	Affiliation
1. Caporelli, Liz	F	USA	WHOI
2. Donohue, Meghan	F	USA	WHOI
3. Horn, Mark	M	USA	WHOI
4. Kelly, Brian	M	USA	WHOI
5. Kemp, John	M	USA	WHOI
6. Lumping, Chris	M	USA	WHOI
7. Lund, John	M	USA	WHOI
8. Murphy, Steve	M	USA	WHOI
9. Pietro, Jeff	M	USA	WHOI
10. Plueddemann, Al	M	USA	WHOI/Chief Sci
11. Wellwood, Dave	M	USA	WHOI
12. Wickman, Diana	F	USA	WHOI

Roles and responsibilities will be delegated among individuals and groups per the following major categories. These assignments are representative, and not intended to be limiting – all participants will assist with multiple aspects of the cruise effort as warranted.

- Overall cruise coordination and execution
  - Al Plueddemann, John Kemp
- Cruise documentation, deployment records, platform and instrument metadata
  - Liz Caporelli, Mark Horn (CSPP), Brian Kelly (CSM)
- Logistics, deck operations, mooring hardware, mooring operations
  - John Kemp, Steve Murphy, Jeff Pietro, Meghan Donohue, Chris Lumping
- Mooring control, power and telemetry systems
  - Brian Kelly, John Lund (CSM), Diana Wickman, Mark Horn (CSPP)
- Instrument configuration, preparation and pre-deployment checks
  - Brian Kelly, John Lund (CSM), Diana Wickman, Mark Horn (CSPP)
- Platform configuration and mission plan
  - Brian Kelly, John Lund (CSM), Diana Wickman, Mark Horn (CSPP)
- Hydrographic sampling, including physical sample preparation
  - Dave Wellwood, Liz Caporelli
- Shipboard Scientific Services (CTD, ADCP, multibeam)
  - Robert Laird, Amy Simoneau, Ellen Roosen

Appendix E – Mooring Drawings

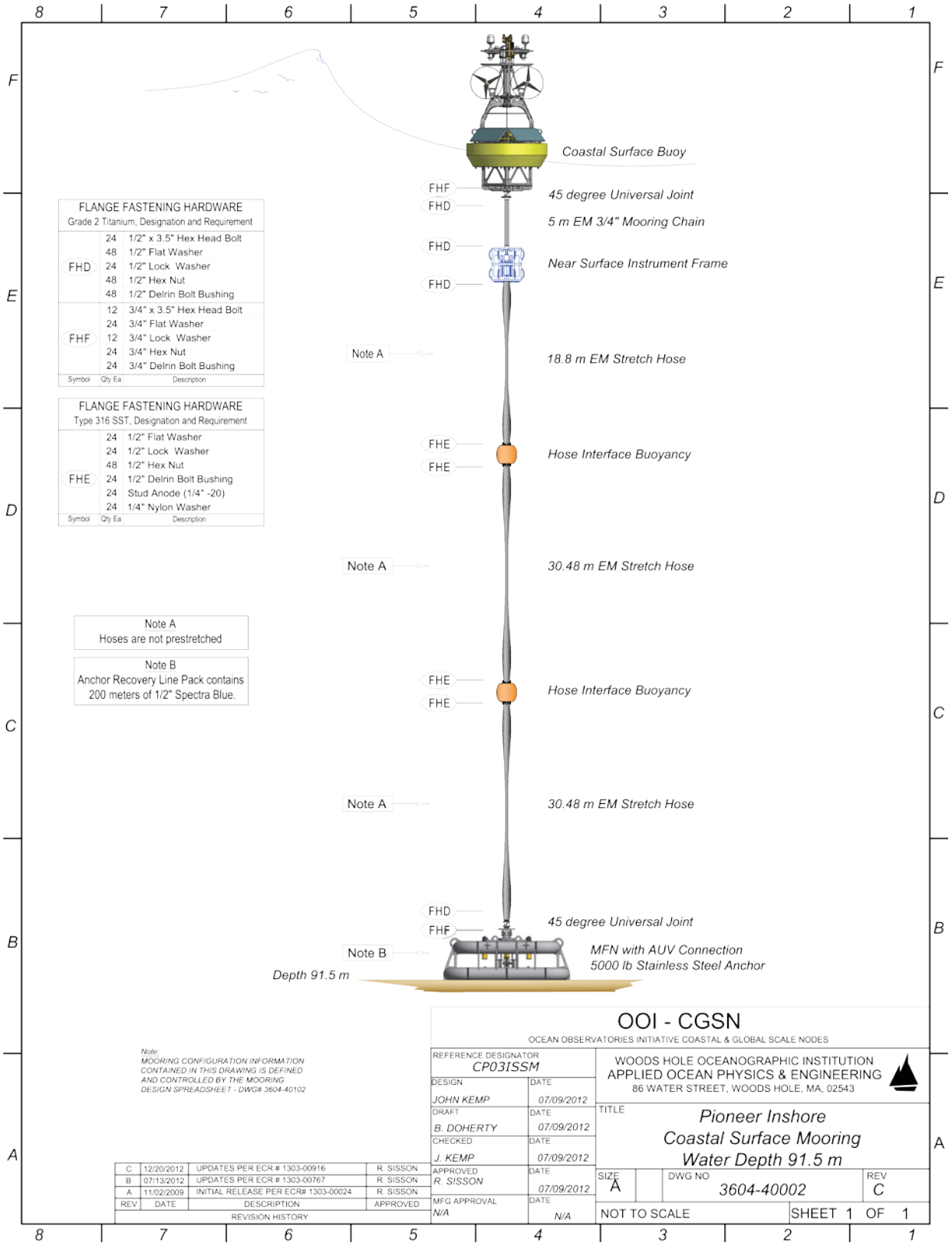

Figure E-1 – Pioneer Inshore Surface Mooring (ISSM).

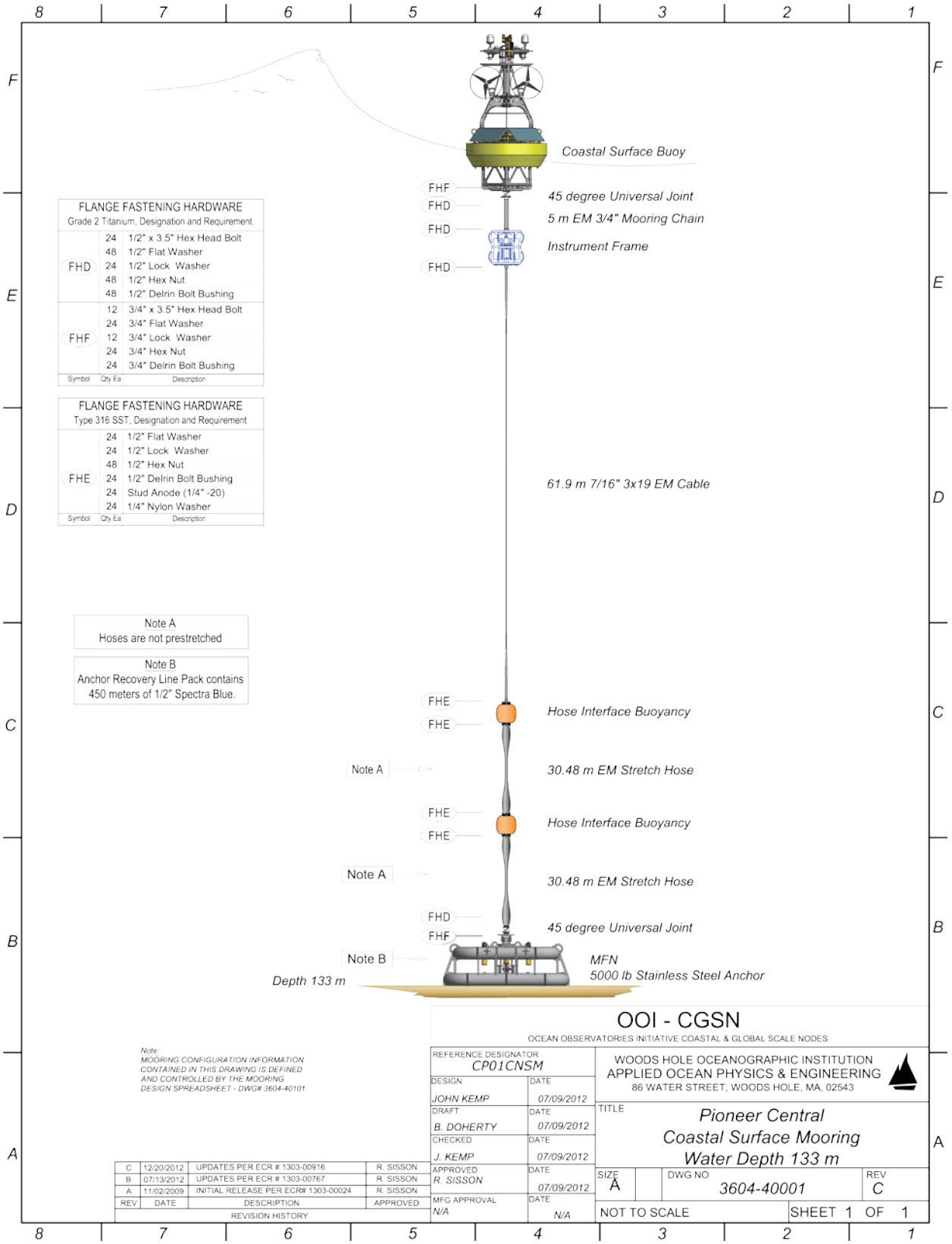

Figure E-2 – Pioneer Central Surface Mooring (CNSM).

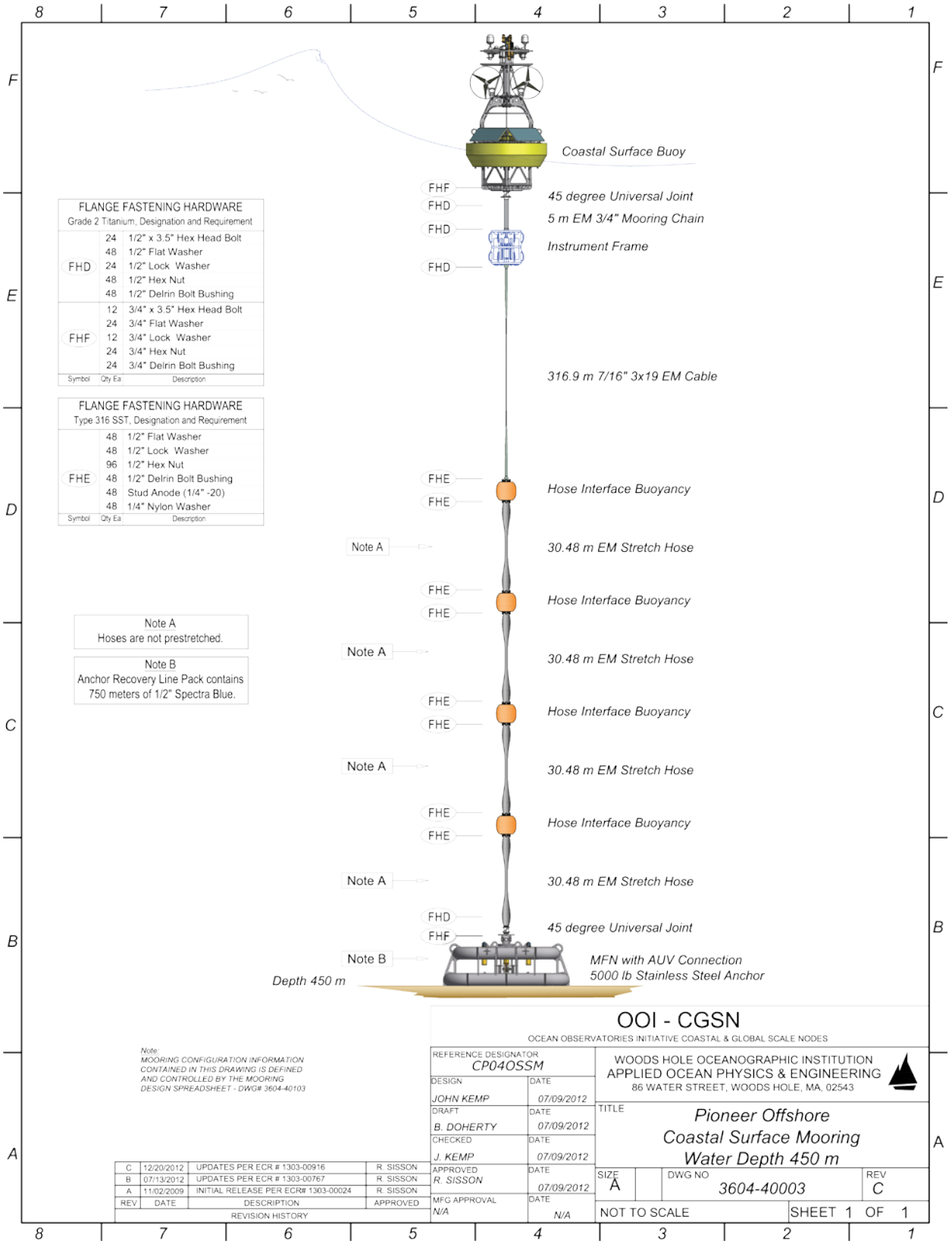

Figure E-3 – Pioneer Offshore Surface Mooring (OSSM).

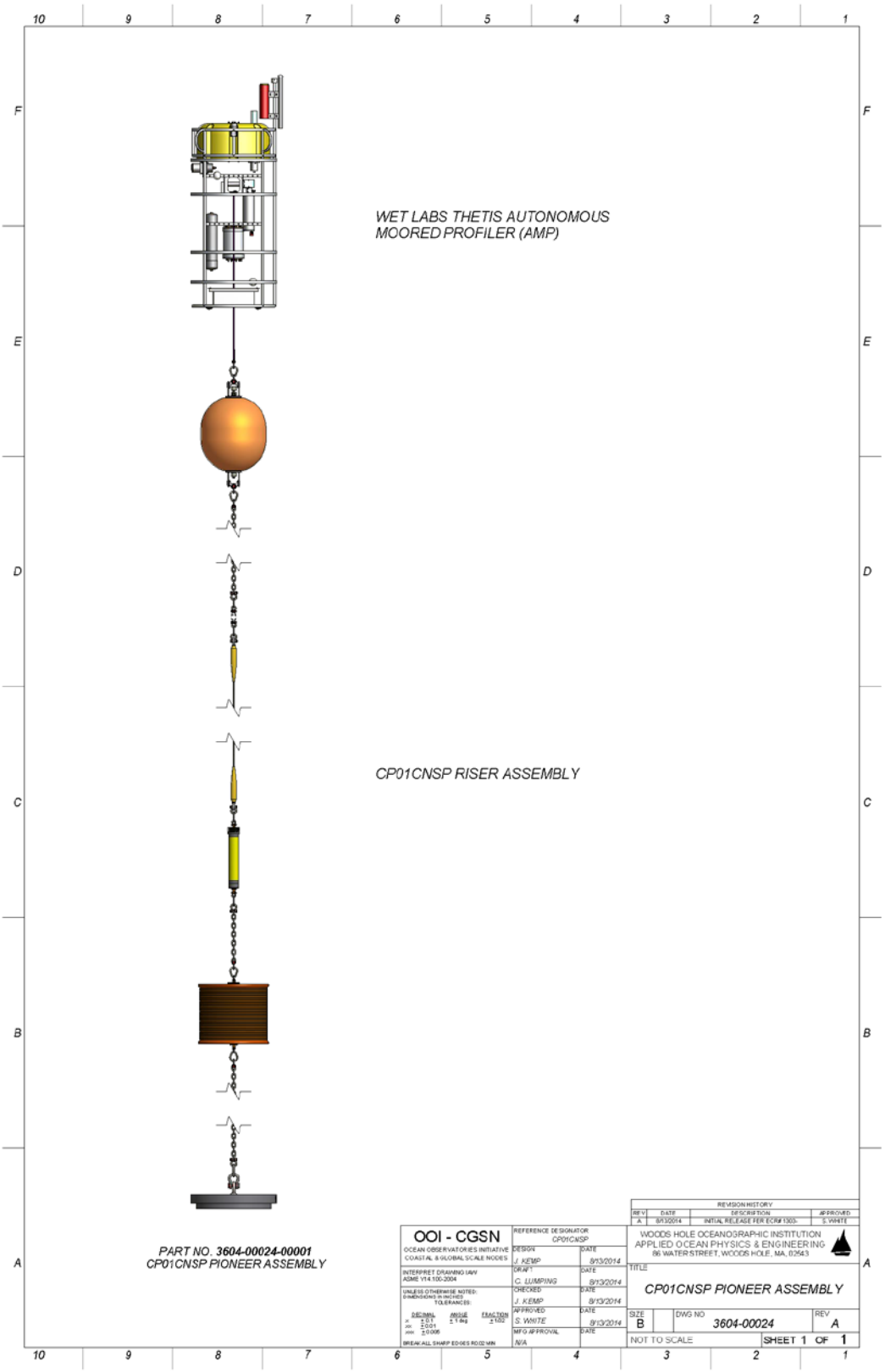

Figure E-4 – Pioneer Coastal Surface Piercing Profiler (CSPP).
The Central CSPP is shown. Central and Inshore moorings differ only in the length of the riser.