Cruise Plan
Coastal Pioneer 4 Deployment
Leg 1: R/V *Atlantis* Cruise AT-27
28 April - 5 May 2015
Leg 2: R/V *Atlantis* Cruise AT-27
7 May - 14 May 2015

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Coastal and Global Scale Nodes
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Woods Hole Oceanographic Institution
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0-03	Updates/corrections	A. Plueddemann	

Table of Contents

1.0 Introduction 1
1.1. Overview 1
1.2. Operating Area 1
2.0 Cruise Plan 1
2.1. Background 1
2.2. Staging and De-Staging 3
2.3. Cruise Operations and Objectives 5
2.3.1. Release Tests 7
2.3.2. Mooring Operations 7
2.3.3. Glider Operations 7
2.3.4. AUV Operations 7
2.3.5. Anchor Surveys 7
2.3.6. CTD casts 8
2.3.7. Sensor Performance Evaluation 8
2.3.8. Shipboard Underway Data 8
2.3.9. Shipboard Multi-beam Bathymetry 8
2.3.10. Small Boat Operations 8
2.4. Potential Restrictions 8
3.0 Appendices 9
Appendix A – Cruise Timeline 10
Appendix B – Selected Waypoints and Maps 11
Appendix C – Deck Plan 14
Appendix D – Science Party 16
Appendix E – Mooring Drawings 18

List of Figures

Figure 2-1 – Map of the Pioneer Array region 2
Figure 2-2 – Pioneer Array mooring site locations. 3
Figure 2-3 – Pioneer Array glider lines. 4
Figure 3-1 – Example of “small scale” multibeam bathymetry survey. 12
Figure 3-2 – Example of “large scale” multibeam bathymetry survey. 13
Figure 3-3 – Deck plan for Pioneer-4, Leg 1. 14
Figure 3-4 – Deck plan for Pioneer-4, Leg 2. 15
Figure 3-5 – Pioneer Inshore Surface Mooring (ISSM). 18
Figure 3-6 – Pioneer Central Surface Mooring (CNSM). 19
Figure 3-7 – Pioneer Offshore Surface Mooring (OSSM). 20
Figure 3-8 – Pioneer Upstream Inshore Mooring (PMUI). 21
Figure 3-9 – Pioneer Central Inshore Profiler Mooring (PMCI). 22
Figure 3-10 – Pioneer Central Offshore Profiler Mooring (PMCO). 23
Figure 3-11 – Pioneer Offshore Profiler Mooring (OSPM). 24
Figure 3-12 – Pioneer Upstream Offshore Profiler Mooring (PMUO). 25
Figure 3-13 – Pioneer Coastal Surface Piercing Profiler (CSPP) 26

List of Tables

Table 2-1 – Pioneer-4 glider deployment plan. 6
Table 3-1 – Pioneer-4 station list 11

1.0 Introduction

1.1. Overview

This cruise represents the fourth 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 4 Leg 1 and Leg 2 deployment cruise (Pioneer-4) has 22 Primary Objectives (see Section 2.3) that include the recovery and deployment of Coastal Surface Moorings (CSMs), deployment and recovery of Coastal Profiler Moorings (CPMs), deployment of Coastal Surface Piercing Profiler (CSPP) moorings, deployment and recovery of gliders, operation of an AUV, and CTD casts with water sampling at the mooring sites. The Pioneer-4 cruise also has Additional Objectives, including CTD/ADCP surveys in the vicinity of the Pioneer moored array, meteorological comparisons between ship and buoys, and multi-beam bathymetry surveys of the Pioneer region.

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-4 operations will be focused on the Pioneer Moored Array centered near 40.15°N, 70.83°W (Figure 2-2) and the glider lines (Figure 2-3). Mooring site locations and water depths are provided in Appendix A.

2.0 Cruise Plan

2.1. Background

The Pioneer Array deployment plan, and the instrument configurations on each platform, assume that CSM and CPM moorings will be deployed for ~6 months and that gliders and CSPPs will be serviced at ~90 day intervals. The current status of Pioneer Array assets are as follows: The deployed moorings are the Offshore surface mooring (OSSM) and the Central Offshore (PMCO) and Offshore (OSPM) profiler moorings. The mooring risers from the Inshore surface mooring (ISSM) and the Upstream Offshore profiler mooring (PMUO) were left behind when the respective buoys went adrift. The mooring riser from the Inshore surface piercing profiler (ISSP) was left behind when the ISSP profiling body broke free. Two gliders remain operable, nominally on the EB and SS-1 lines, but require recovery as soon as possible – they will be recovered during the first few days of Leg 1.

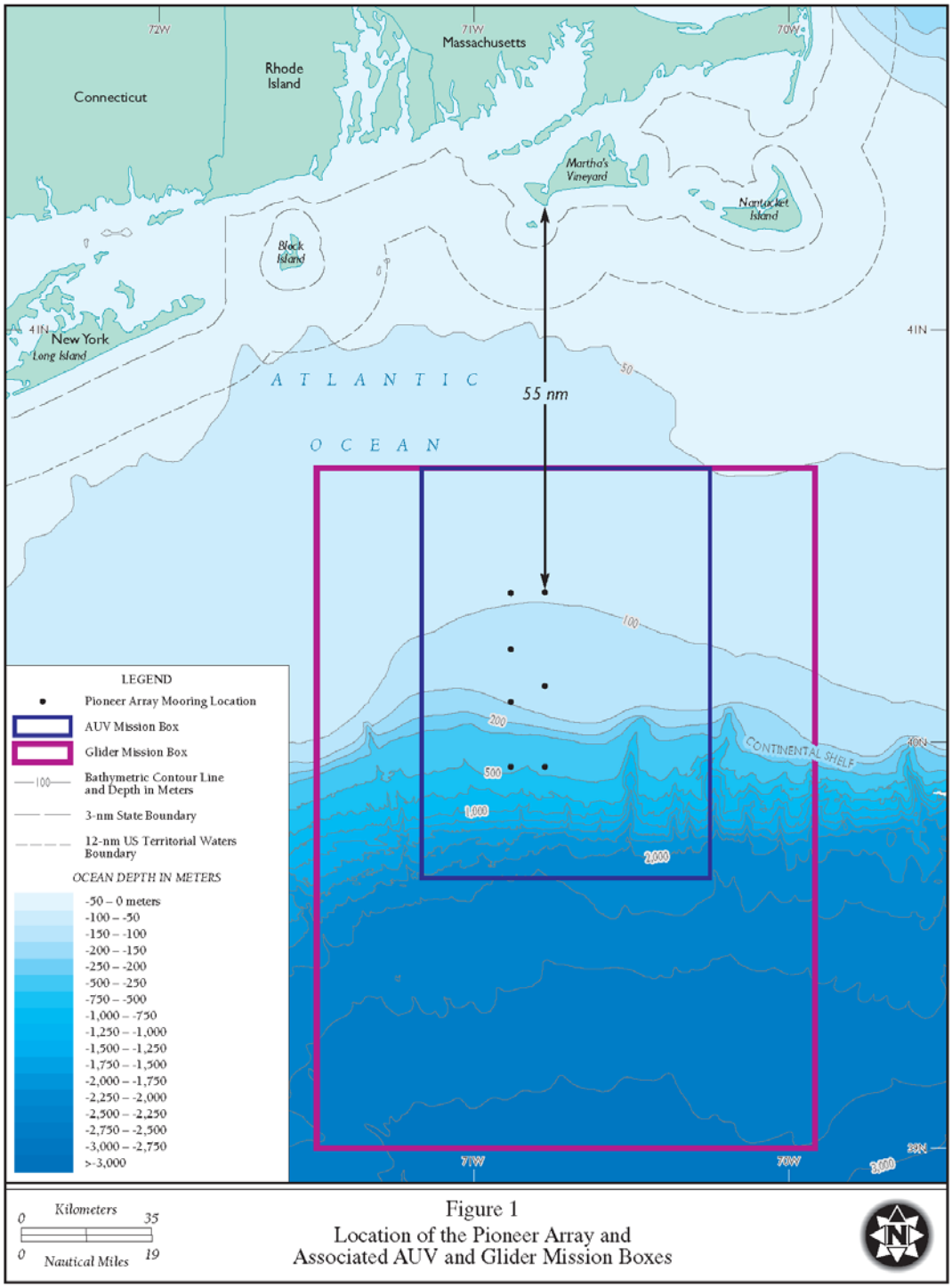

Figure 2-1 – Map of the Pioneer Array region over the southern New England continental shelf and slope. The seven sites of the moored array, the AUV operating region and the glider operating region are shown along with bathymetric contours.

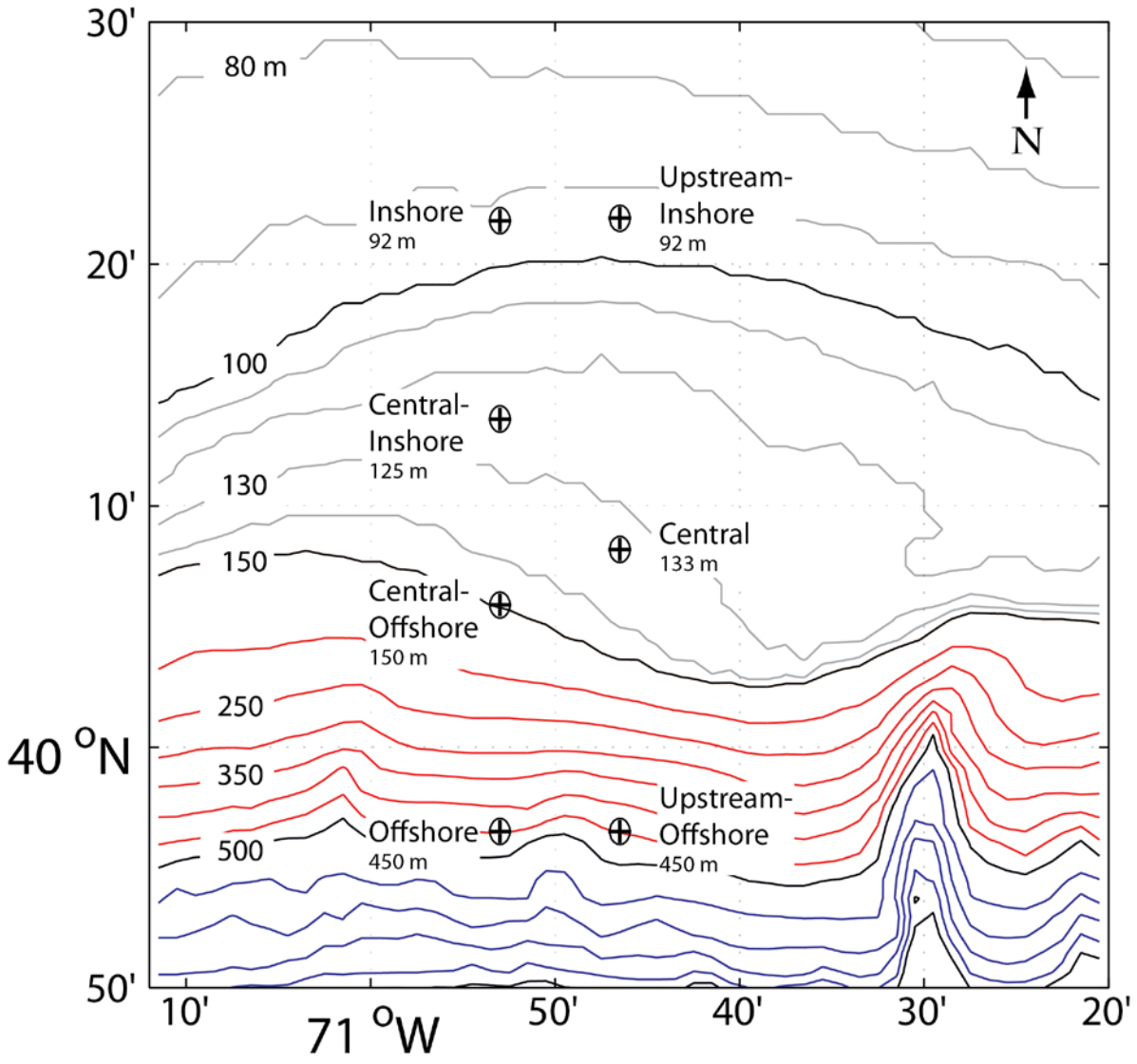

Figure 2-2 – Pioneer Array mooring site locations.
Site centers are marked by black "+" and encircled by approximate 0.5 nm radius buffer zones. Bathymetry is shown at 10 m (gray), 50 m (red) and 100 m (blue) intervals, respectively. Black contours are at 100 m, 150 m, 500 m and 1000 m.

2.2. Staging and De-Staging

Staging and loading will be done at the Woods Hole Oceanographic Institution (WHOI) dock during 25-27 April 2015. The ship's crane will be suitable for loading all science gear. At the discretion of the R/V *Atlantis*, partial loading and access to the ship may be possible before 25 April. 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 deck plan showing the location of major deck components is provided in Appendix A.

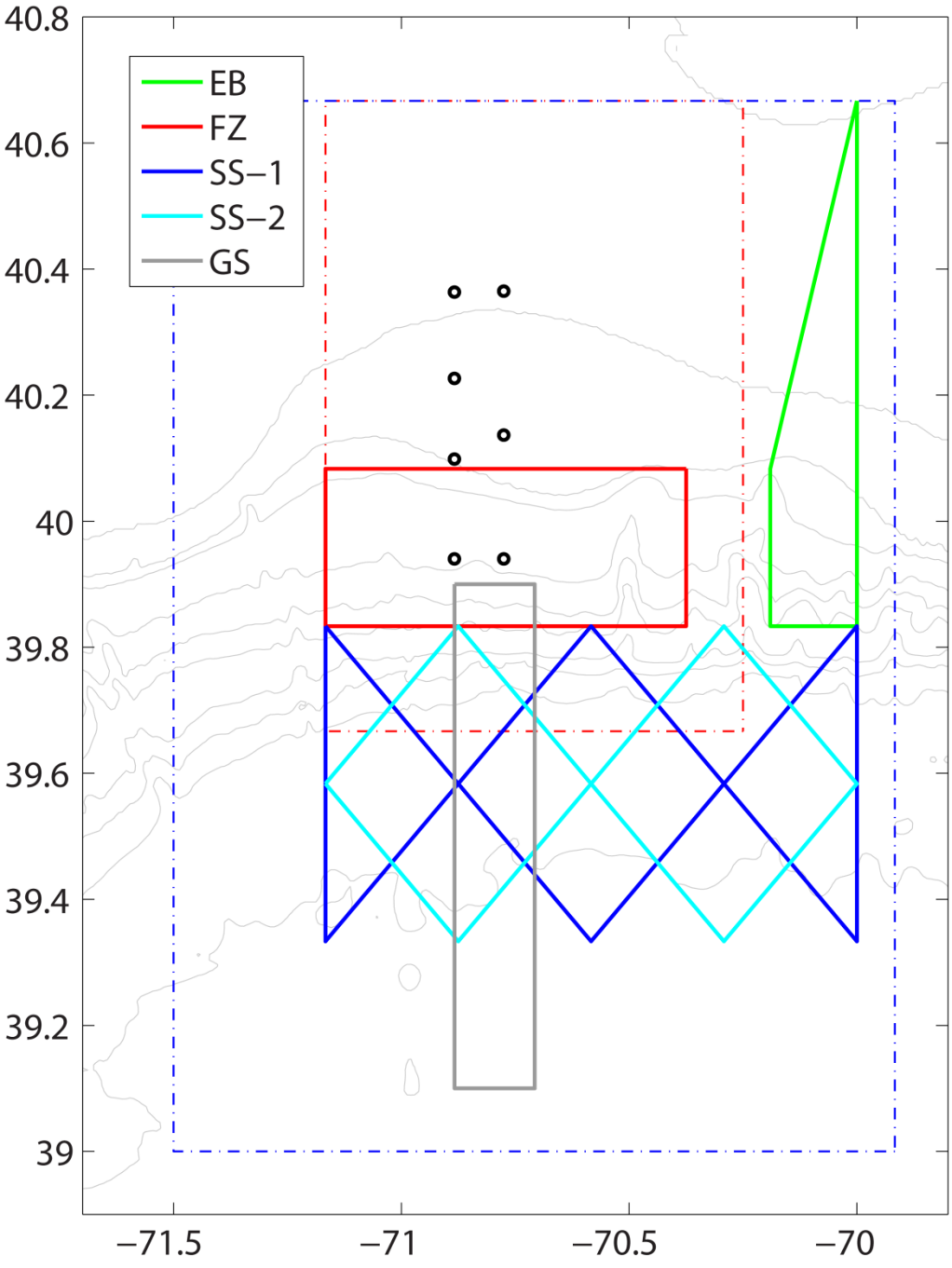

Figure 2-3 – Pioneer Array glider lines.
The Eastern Boundary (EB, green), Frontal Zone (FZ, red), Slope Sea (SS-1, blue; SS-2, cyan) and Gulf Stream (GS, gray) tracks are shown along with the Pioneer Array moorings (circles) and the glider and AUV operating areas (blue and red dashed lines, respectively).

Destaging and offloading of scientific equipment will be initiated at WHOI upon termination of the cruse on 14 May and will continue on 15 May as necessary. The ship's crane will be suitable for offloading all science gear.

2.3. Cruise Operations and Objectives

The R/V *Atlantis* will depart from Woods Hole and transit to the location of the first field operation. Successive cruise days will include a combination of activities, focusing on CSM and CPM mooring operations during Leg 1 and on CSM mooring operations, glider deployments, and AUV operations during Leg 2. CTDs with bottle samples will be done in conjunction with deployment and recovery operations. Glider deployments will be interspersed with mooring operations at times and locations chosen for efficiency. Multibeam surveys and ADCP surveys will be conducted in late evening after mooring and glider operations are completed.

The Primary Objectives (O1-O22) are listed below. Nominal times for these activities are given in the cruise timeline provided in Appendix A. Site locations are listed in Appendix B.

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

O2. Recover the Inshore Coastal Surface Mooring riser (CP03ISSM-00001).

O3. Recover the Upstream-Offshore Profiler Mooring riser (CP02PMUO-00004).

O4. Recover the Central Offshore Profiler Mooring (CP02PMCO)-00002).

O5. Recover the Offshore Profiler Mooring (CP04OSPM-00002).

O6. Recover the Inshore Surface Piercing Profiler Mooring riser (CP03ISSP-00001).

O7. Recover one shallow (200 m engine) coastal glider (EB).

O8. Recover one deep (1000 m engine) coastal glider (SS-1).

O9. Deploy the Central Coastal Surface Mooring (with fuel cell) (CP01CNSM-00003).

O10. Deploy the Inshore Coastal Surface Mooring (CP03ISSM-00002).

O11. Deploy the Offshore Coastal Surface Mooring (CP04OSSM-00002).

O12. Deploy the Upstream-Inshore Profiler Mooring (CP02PMUI-00004).

O13. Deploy the Upstream-Offshore Profiler Mooring (CP02PMUO-00005).

O14. Deploy the Central Inshore Profiler Mooring (CP02PMCI-00003).

O15. Deploy the Central Offshore Profiler Mooring (CP02PMCO)-00003).

O16. Deploy the Offshore Profiler Mooring (CP04OSPM-00003).

O17. Deploy the Inshore Surface Piercing Profiler Mooring (CP03ISSP-00002).

O18. Deploy the Central Surface Piercing Profiler Mooring (CP01CNSP-00001).

O19. Deploy two shallow (200 m engine) coastal gliders (EB, FZ-2).

O20. Deploy two deep (1000 m engine) coastal gliders (FZ-1, SS-1).

O21. Conduct multiple AUV missions in “attended mode”

O22. Conduct CTD casts with water sampling at the deployment/recovery sites.

Additional activities are nominally scheduled in the cruise timeline (Appendix A), and will be fit in as time allows: Ship vs. buoy meteorological comparisons will typically be conducted from late evening, after mooring operations are completed, to early morning before the start

of the next operation. Specific bathymetric and oceanographic surveys may be conducted based on time constraints and weather conditions.

The Additional objectives (A1-A5) are listed in rough priority order below, and will be completed as time and conditions permit.

A1. Conduct a CTD surveys (no bottle samples) in the vicinity of the moored array.

A2. Evaluate the ability of a 1000 m engine glider to run the EB line.

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

A4. Conduct multibeam bathymetry surveys in the Pioneer region.

A5. Conduct shipboard ADCP surveys in the vicinity of the moored array.

Note that only four of 6 desired gliders will be available for the Pioneer-4 cruise. Of these four, two will have 200 m depth buoyancy engines and two will have 1000 m depth engines. Based on the glider line priorities and the mix of buoyancy engines, the available gliders will be assigned to lines as shown in Table 2-1.

Name	Region	Priority	Buoyancy Engine	Pioneer-4
EB	Eastern Boundary	Baseline	200 m	Planned deployment
FZ-1	Frontal Zone	Baseline	1000 m	Planned deployment
SS-1	Slope Sea	Baseline	1000 m	Planned deployment
SS-2	Slope Sea	Baseline	1000 m	Unoccupied
FZ-2	Frontal Zone	As-deployed	200 m	Planned deployment
GS	Slope Sea	As-deployed	1000 m	Unoccupied

Table 2-1 – Pioneer-4 glider deployment plan.

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 R/V *Atlantis*.

2.3.2. Mooring Operations

Mooring deployments and recoveries will be done in stages using the ship's crane and A-frame, plus 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 the ship's crane or A-frame, supplemented by air tuggers and handling equipment supplied by the science party. 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. AUV Operations

AUV deployments are expected to be done using the ship's EFFER crane supplemented by a handling gear supplied by the science party. AUV recoveries will also be done using the EFFER crane, but will require a small boat operation prior to lifting the vehicle aboard. Specifically, the ship's work boat will be used to secure tag lines and the crane hook to the vehicle, and to bring the vehicle abeam of the ship for recovery. Science party personnel will be familiar with AUV deployment and recovery, and will be capable of directing operations in cooperation with the ship's crew during all phases of AUV operations.

2.3.5. Anchor Surveys

Once the anchor has settled on the bottom, R/V *Knorr* 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.

2.3.6. CTD casts

CTD casts will be conducted using the ship's 9-11 CTD sensors, 24 bottle rosette frame, and deck box. Sensors requested in addition to C,T,D are dissolved oxygen, chlorophyll fluorometer, transmissometer, and PAR. CTD operations will be supervised by shipboard SSSG technicians – the science party will supply line handlers and a lab operator. Water sampling and analysis will be handled by the science party.

2.3.7. 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.

2.3.8. 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.

2.3.9. Shipboard Multi-beam Bathymetry

Bathymetric surveys will be conducted within the Pioneer Array region (e.g. within the AUV Mission Box of Fig. 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.

2.3.10. Small Boat Operations

The use of a work boat is requested for AUV recovery operations, and may be requested for other operations such as 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. It is recognized that such operations are weather dependent and would be conducted at the discretion 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 – Deck Plan

Appendix D – Science Party

Appendix E – Mooring Drawings

Appendix A – Cruise Timeline

25 – 27 Apr	Mobilization, LOSOS and WHOI pier
28 Apr – 14 May	Cruise dates, Leg-1 (8 DAS), 1 mob day, Leg-2 (8 DAS)
15 – 16 May	Demob, WHOI pier and LOSOS

Timeline

28 Apr	Complete loading, depart WHOI
29 Apr	Deploy CNSM, recover ISSM riser, seek ISSP riser, recover glider
30 Apr	Deploy PMUI, deploy PMCI, recover glider
01 May	Recover PMCO, deploy PMCO
02 May	Recover PMUO (riser only), deploy PMUO
03 May	Recover OSPM, deploy OSPM
04 May	Cross-shelf CTD survey and/or complete primary objectives
05 May	Arrive WHOI, offload
06 May	In-port WHOI, staging and loading for Leg 2
07 May	Complete loading, depart WHOI
08 May	Deploy OSSM, deploy glider(s)
09 May	Deploy ISSM, deploy ISSP
10 May	Recover OSSM, deploy CNSP
11 May	AUV testing, recover and reposition gliders
12 May	AUV operations, cross-shelf survey
13 May	Cross-shelf CTD survey and/or complete primary objectives
14 May	Arrive WHOI, offload

Appendix B – Selected Waypoints and Maps

Station List: Pioneer 4, R/VAtlantis, April-May 2015					
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	95 m	profiler mooring deployment, CTD
Inshore	IS	40 21.8	70 53.0	95 m	surface mooring recovery, surface and profiler mooring deployment, CTD
Central-Inshore	CI	40 13.6	70 53.0	127 m	profiler mooring deployment, CTD
Central	CN	40 08.2	70 46.5	134 m	surface mooring and profiler mooring deployment, CTD
Central-Offshore	CO	40 05.9	70 53.0	147 m	profiler mooring recovery and deployment, CTD
Offshore	OS	39 56.4	70 53.0	450 m	surface mooring and profiler mooring recovery and deployment, CTD
Upstream-Offshore	UO	39 56.4	70 46.5	450 m	profiler mooring recovery and deployment, CTD
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
gliders		various	various	various	glider recoveries and deployments, CTDs

Table 3-1 – Pioneer-4 station list

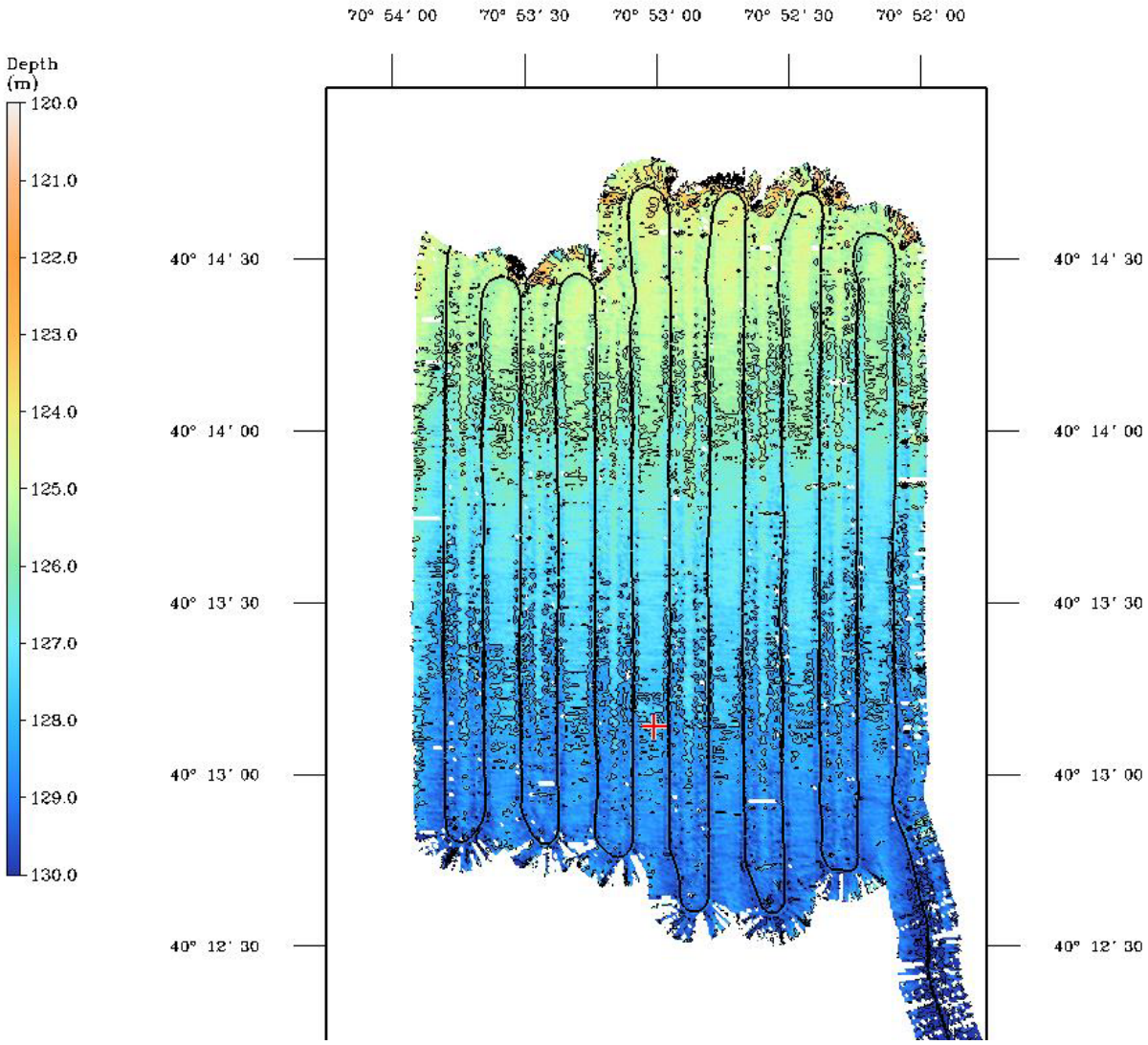

Figure 3-1 – Example of "small scale" multibeam bathymetry survey. This survey was conducted in the Pioneer Array region during the Pioneer 2 cruise, covering about 1.5 x 1.5 nm. The spacing between lines is about 0.1 nm. The total track distance is ~35 nm, which would take about 5 h to complete at 8 kt. Such a survey could be completed overnight.

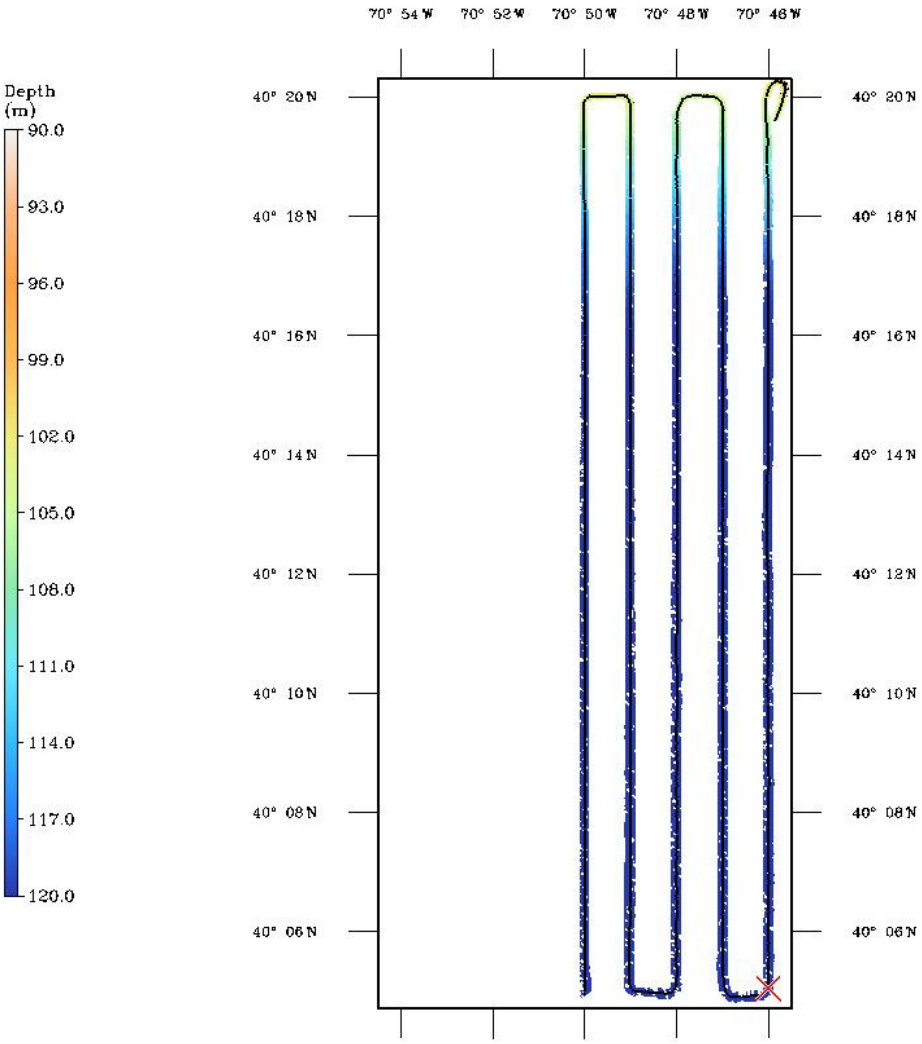

Figure 3-2 – Example of "large scale" multibeam bathymetry survey. This survey was conducted in the Pioneer Array region during the Pioneer 2 cruise, covering about 7 x 15 nm. The desired survey area is approximately 10 x 28 nm. The spacing between lines would be about 0.8 nm – it is recognized that successive tracks will not overlap. The total track distance for the desired survey is ~360 nm, which would take about 46 h to complete at 8 kt. Such a survey could be completed over multiple 8 h overnight periods (e.g. two track lines per night).

Appendix C – Deck Plan

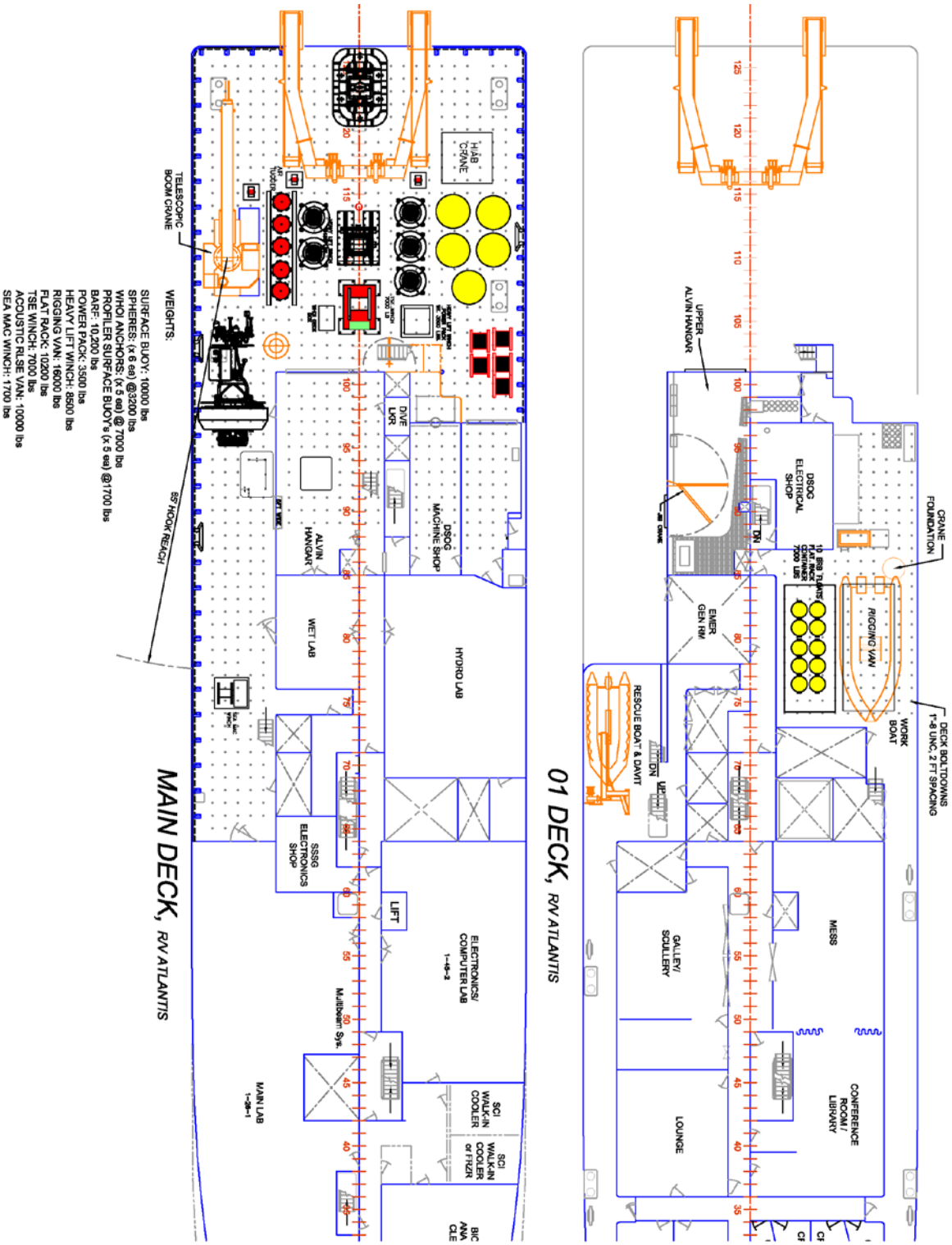

Figure 3-3 – Deck plan for Pioneer-4, Leg 1.
Nominal deck layout for the major components associated with Pioneer-4 Leg 1 operations.

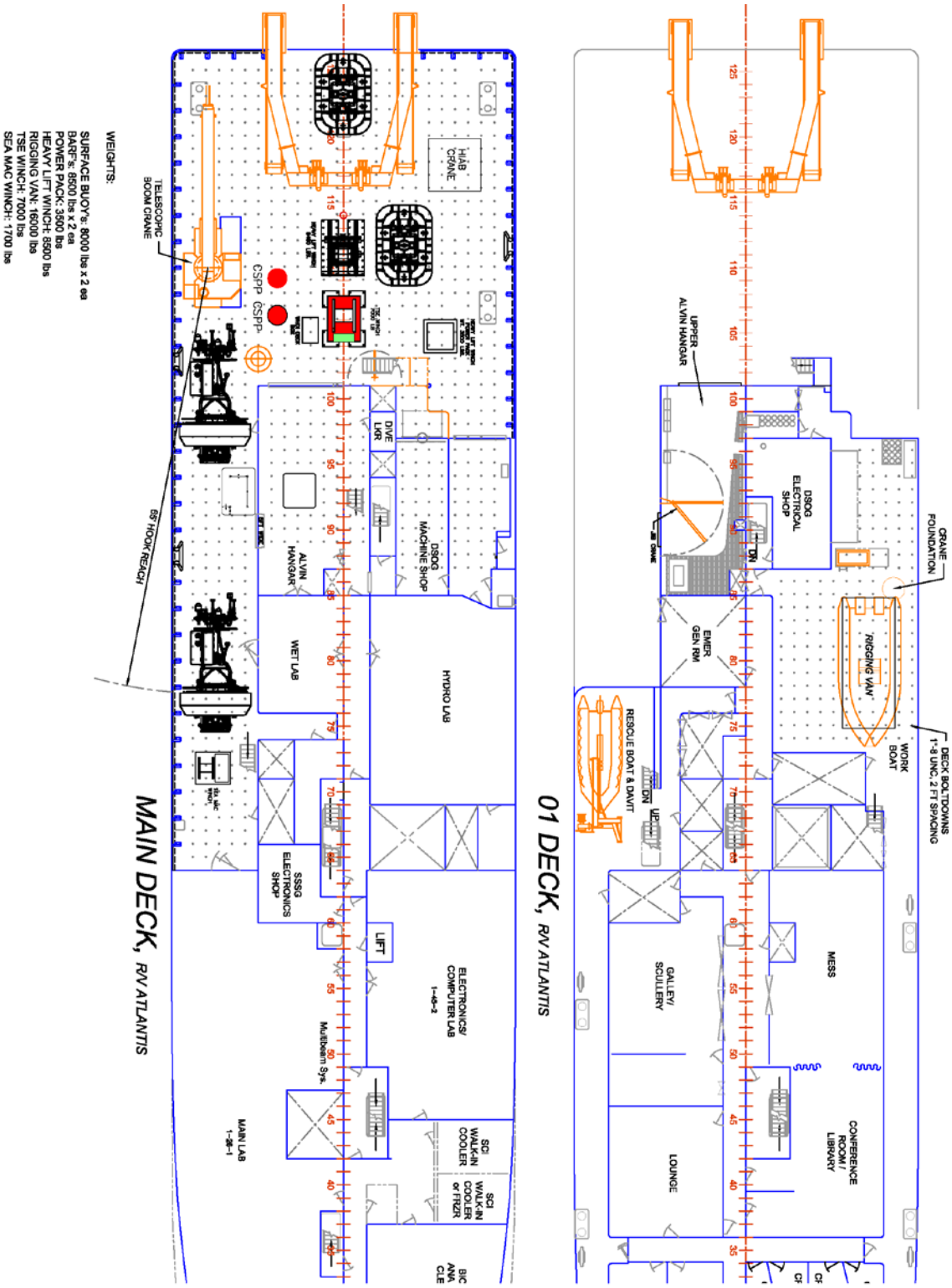

Figure 3-4 – Deck plan for Pioneer-4, Leg 2.
Nominal deck layout for the major components associated with Pioneer-4 Leg 2 operations.

Appendix D – Science Party

There will be 12 participants in the science party for Leg 1. The Chief Scientist is Dr. Albert J. Plueddemann (WHOI). Cathy Bansmer is a volunteer, a teacher from Mildred L. Day School (Arundel, ME). An alphabetical list is given in the table below.

Participating Scientists

	Name	Gender	Nationality	Affiliation
1.	Alai, Aidan	M	USA	WHOI
2.	Bansmer, Cathy	F	USA	M.L. Day School
3.	Bogorff, Dan	M	USA	WHOI
4.	Caldwell, Steve	M	USA	WHOI
5.	Caporelli, Liz	F	USA	WHOI
6.	Donohue, Meghan	F	USA	WHOI
7.	Kemp, John	M	USA	WHOI
8.	Lund, John	M	USA	WHOI
9.	Murphy, Steven	M	USA	WHOI
10.	Palanza, Matt	M	USA	WHOI
11.	Plueddemann, Al	M	USA	WHOI/Chief Sci
12.	Wellwood, Dave	M	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, John Lund (profilers), Matt Palanza (surface moorings)
- Logistics, deck operations, mooring hardware, mooring operations
  - John Kemp, Steve Murphy, Meghan Donohue, Dan Bogorff
- Mooring control, power and telemetry systems
  - John Lund (profilers), Matt Palanza (surface mooring)
- Instrument configuration, preparation and pre-deployment checks
  - John Lund (profilers), Aidan Alai (surface mooring)
- Platform configuration and mission plan
  - John Lund (profilers), Matt Palanza, Steve Caldwell (surface mooring)
- Hydrographic sampling, including physical sample preparation
  - Dave Wellwood, Liz Caporelli, Steve Caldwell

There will be 16 participants in the science party for Leg 2. The Chief Scientist is Dr. Albert J. Plueddemann (WHOI). Aaron Rosenberg is a volunteer, a NOAA Fellow at NSF. An alphabetical list is given in the table below.

Participating Scientists

Name	Gender	Nationality	Affiliation
1. Brickley, Peter	M	USA	WHOI
2. Caldwell, Steve	M	USA	WHOI
3. Donohue, Meghan	F	USA	WHOI
4. Horn, Mark	M	USA	WHOI
5. Kelly, Brian	M	USA	WHOI
6. Kemp, John	M	USA	WHOI
7. Lund, John	M	USA	WHOI
8. Murphy, Steven	M	USA	WHOI
9. Plueddemann, Al	M	USA	WHOI/Chief Sci
10. Matthias, Paul	M	USA	WHOI
11. Mello, Richard	M	USA	Hydroid
12. Ryder, Jim	M	USA	WHOI
13. Sanger, Rick	M	USA	WHOI
14. Schwartz, Jared	M	USA	WHOI
15. Wellwood, Dave	M	USA	WHOI
16. White, Sheri	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
  - Sheri White, Brian Kelly (surface moorings), Peter Brickley (gliders)
- Logistics, deck operations, mooring hardware, mooring operations
  - John Kemp, Jim Ryder, Steve Murphy, Meghan Donohue
- Mooring control, power and telemetry systems
  - Brian Kelly, Rick Sanger (surface moorings), Mark Horn (CSPP), Peter Brickley (gliders)
- Instrument configuration, preparation and pre-deployment checks
  - Mark Horn, Jared Schwartz (surface moorings, CSPP), Peter Brickley, Steve Caldwell (gliders)
- Platform configuration and mission plan
  - Brian Kelly, Rick Sanger (surface moorings), Peter Brickley (gliders)
- Hydrographic sampling, including physical sample preparation
  - Dave Wellwood Sheri White, Steve Caldwell
- AUV mission planning and execution
  - Richard Mello, Al Plueddemann, Peter Brickley

Appendix E – Mooring Drawings

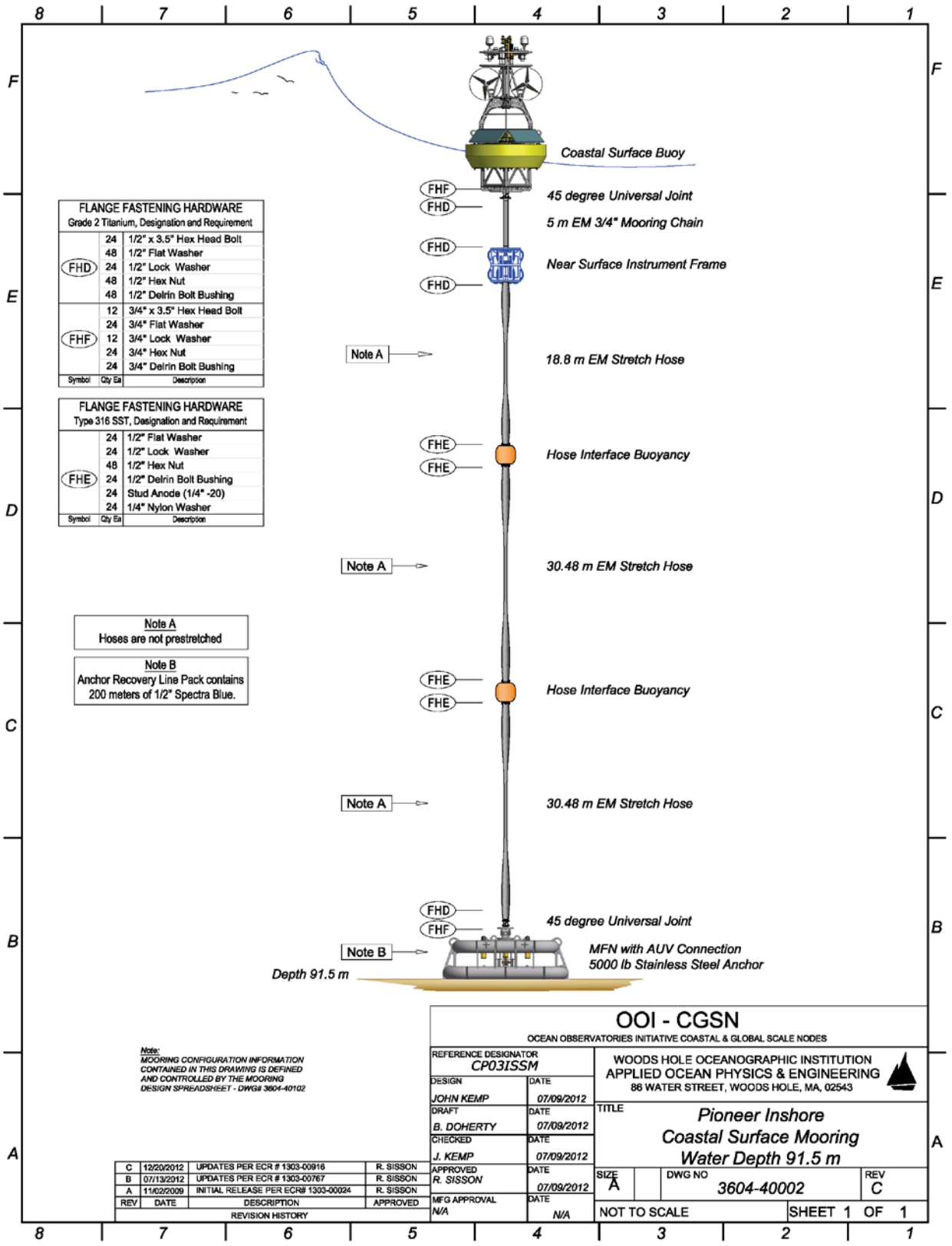

Figure 3-5 – Pioneer Inshore Surface Mooring (ISSM).

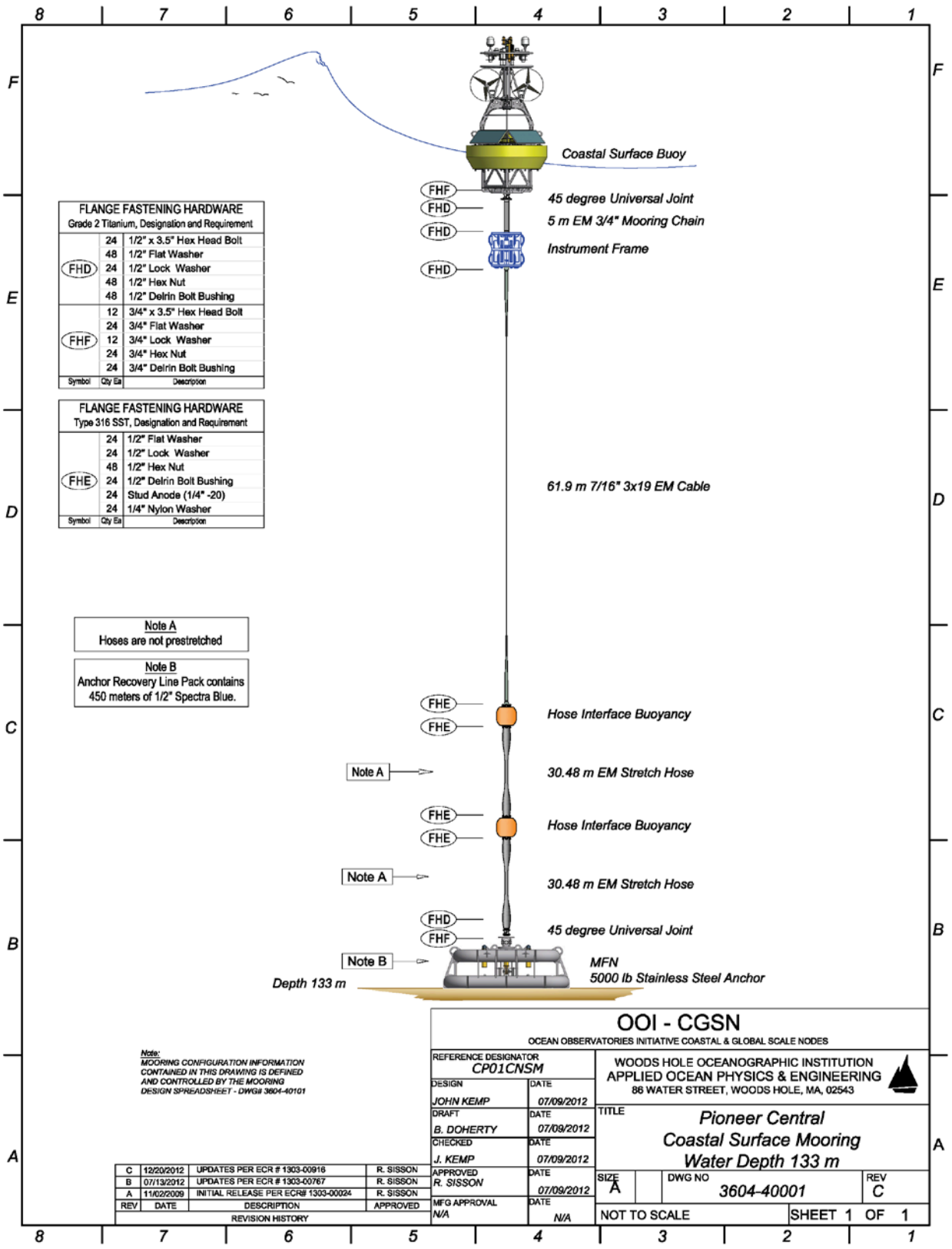

Figure 3-6 – Pioneer Central Surface Mooring (CNSM).

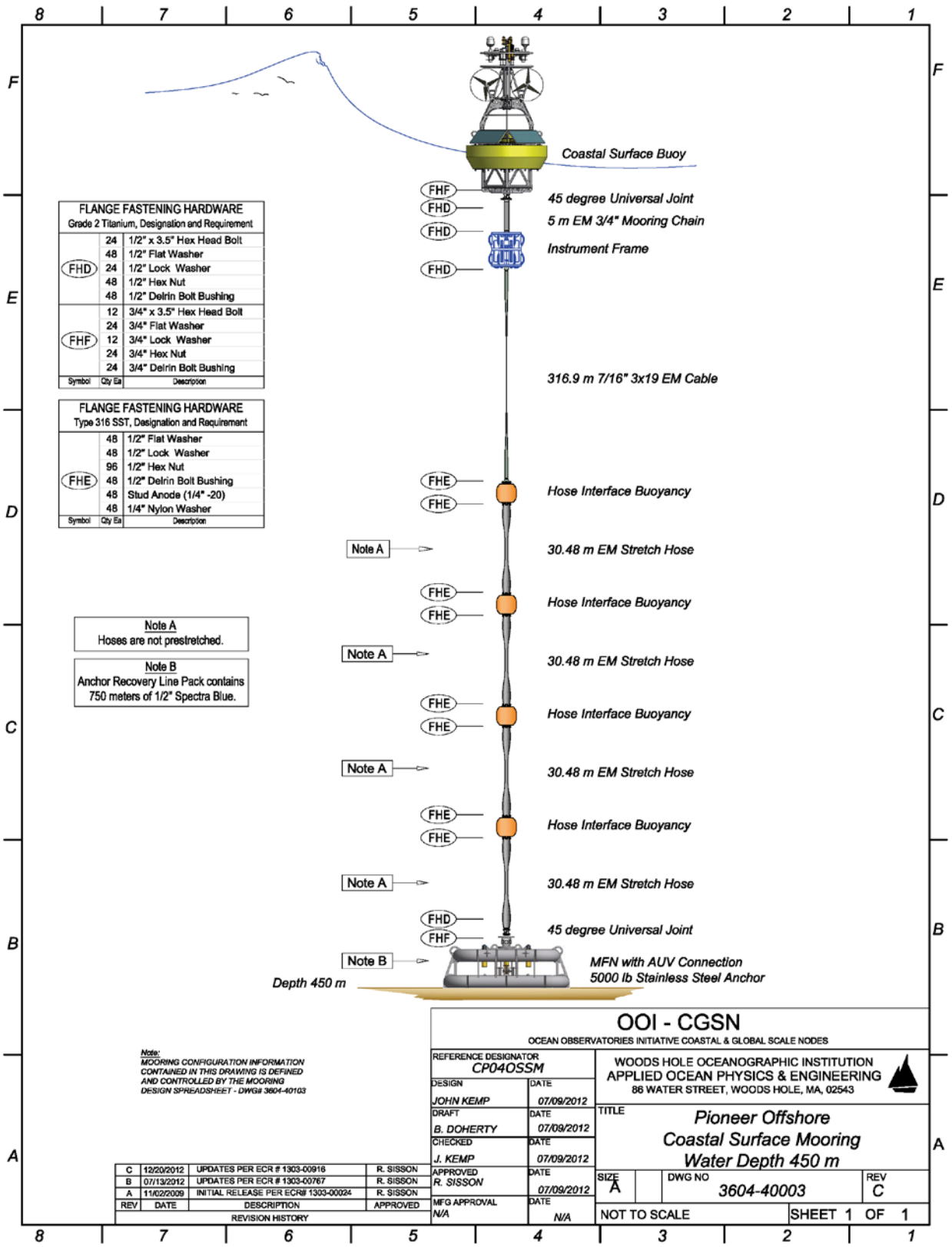

Figure 3-7 – Pioneer Offshore Surface Mooring (OSSM).

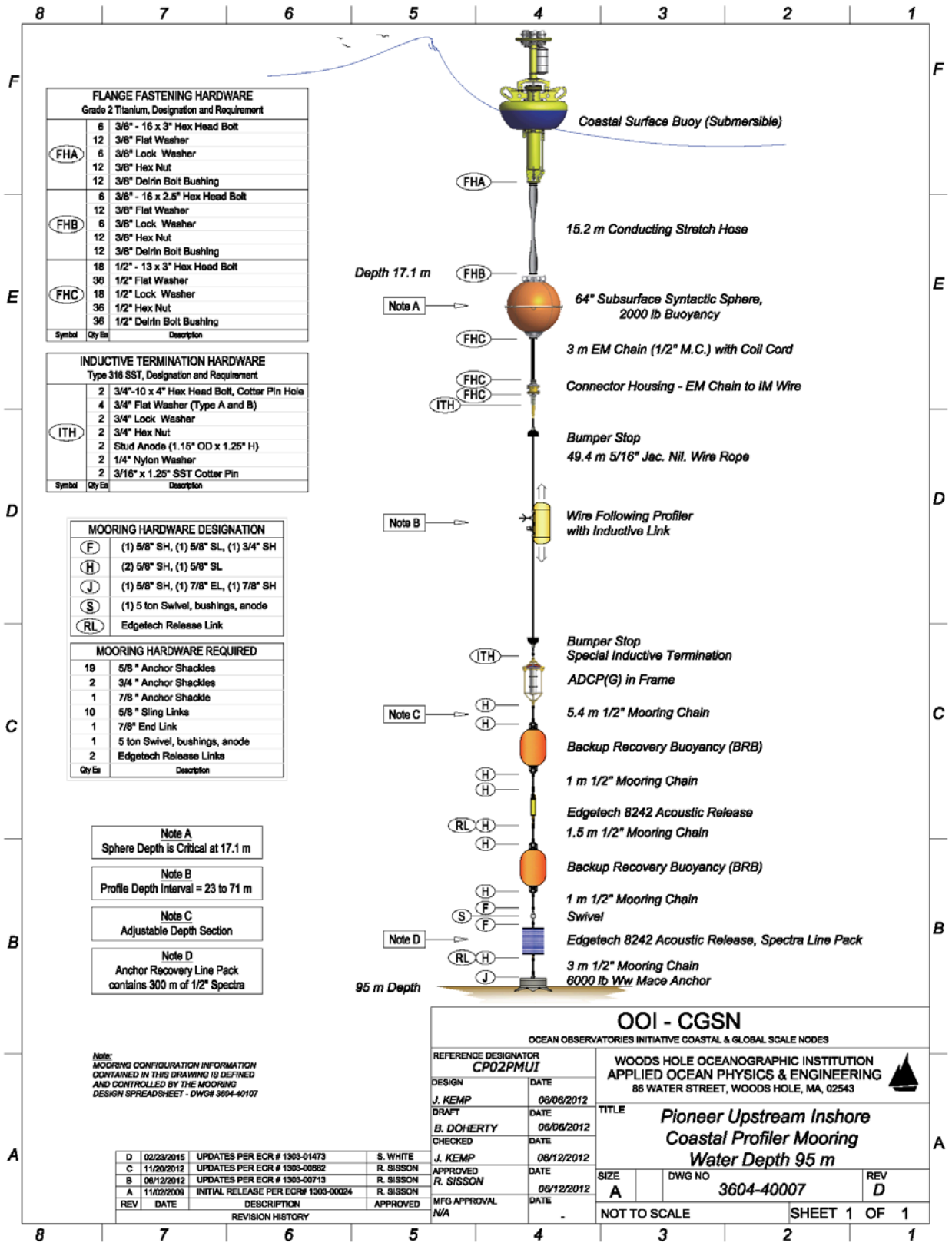

Figure 3-8 – Pioneer Upstream Inshore Mooring (PMUI).

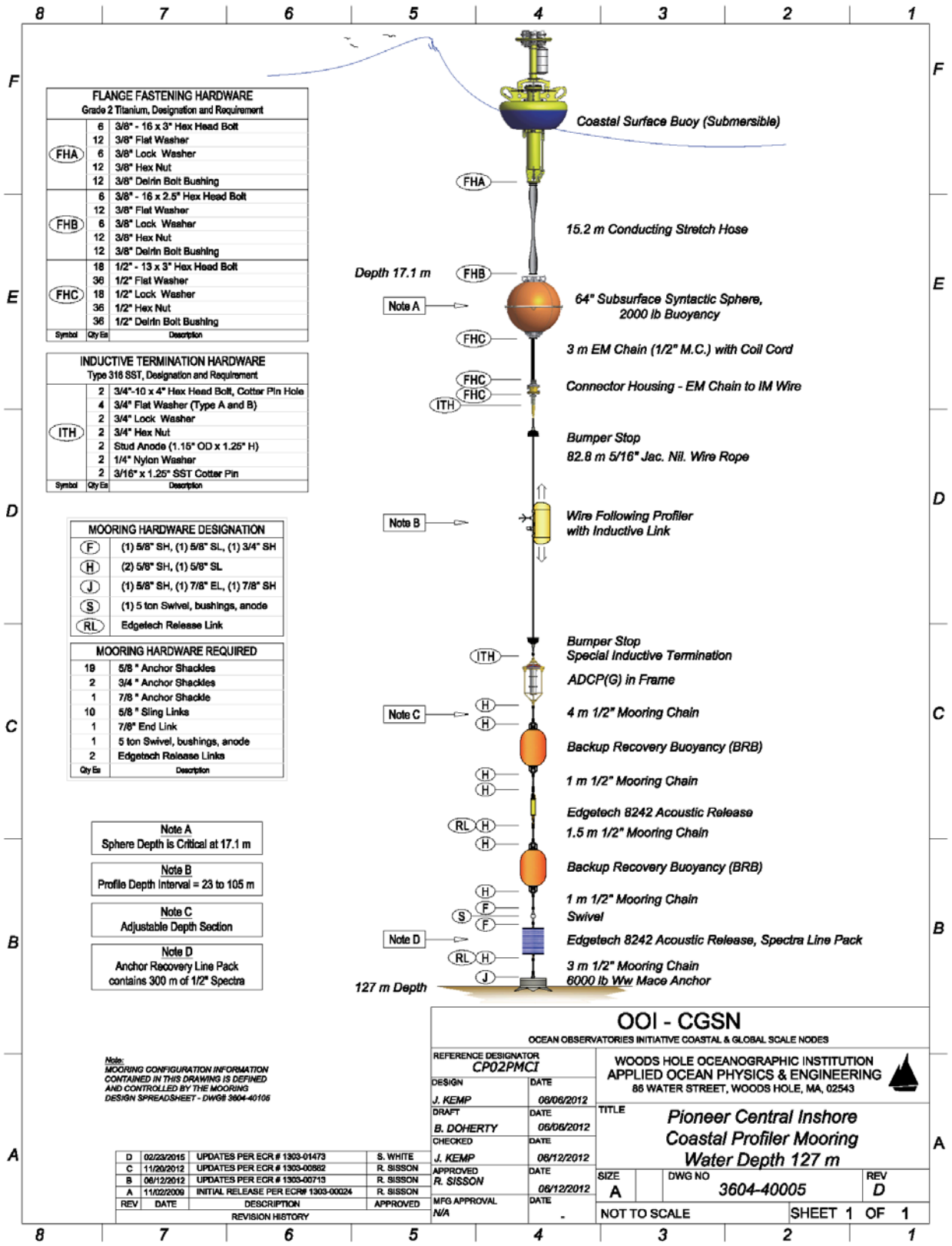

Figure 3-9 – Pioneer Central Inshore Profiler Mooring (PMCI).

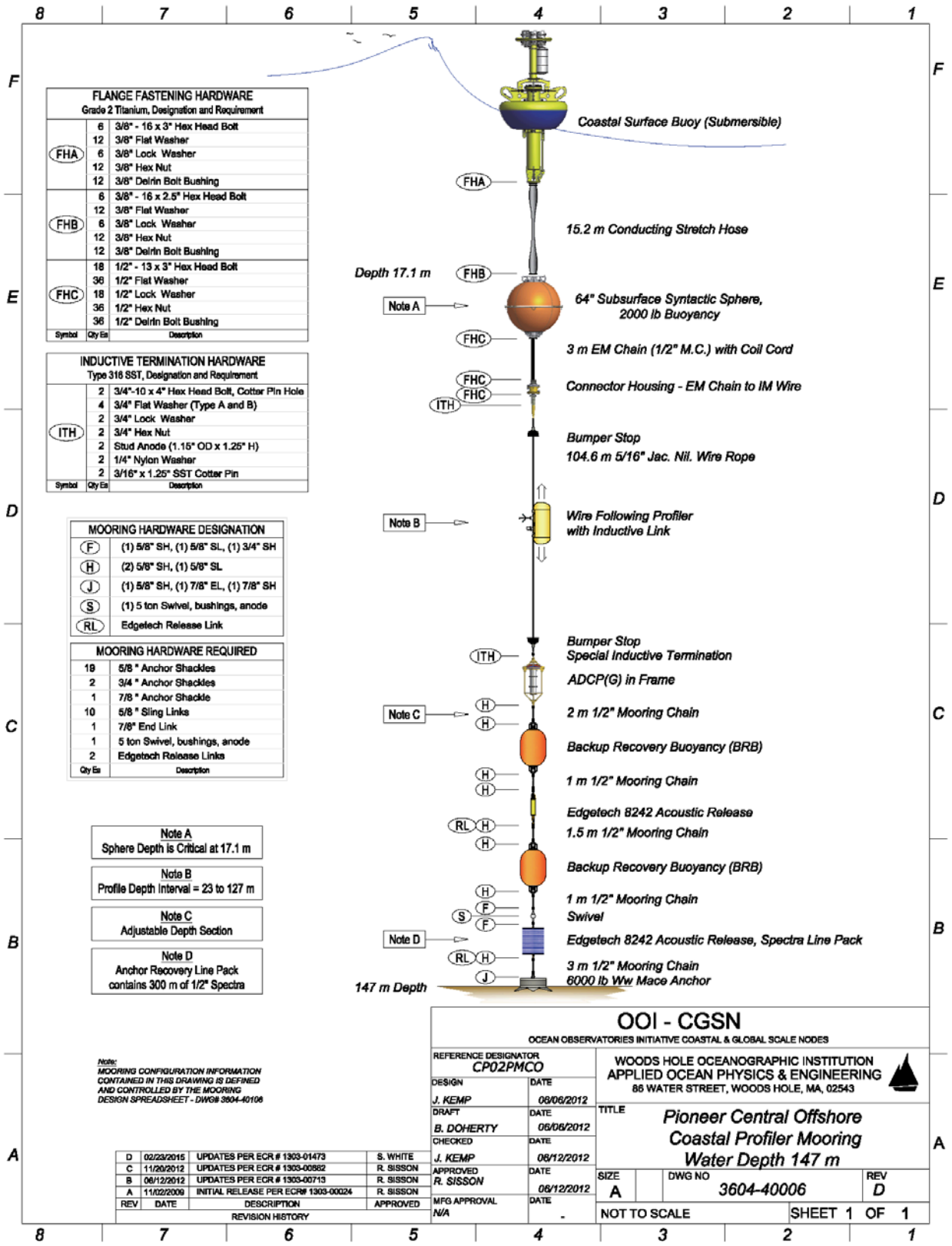

Figure 3-10 – Pioneer Central Offshore Profiler Mooring (PMCO).

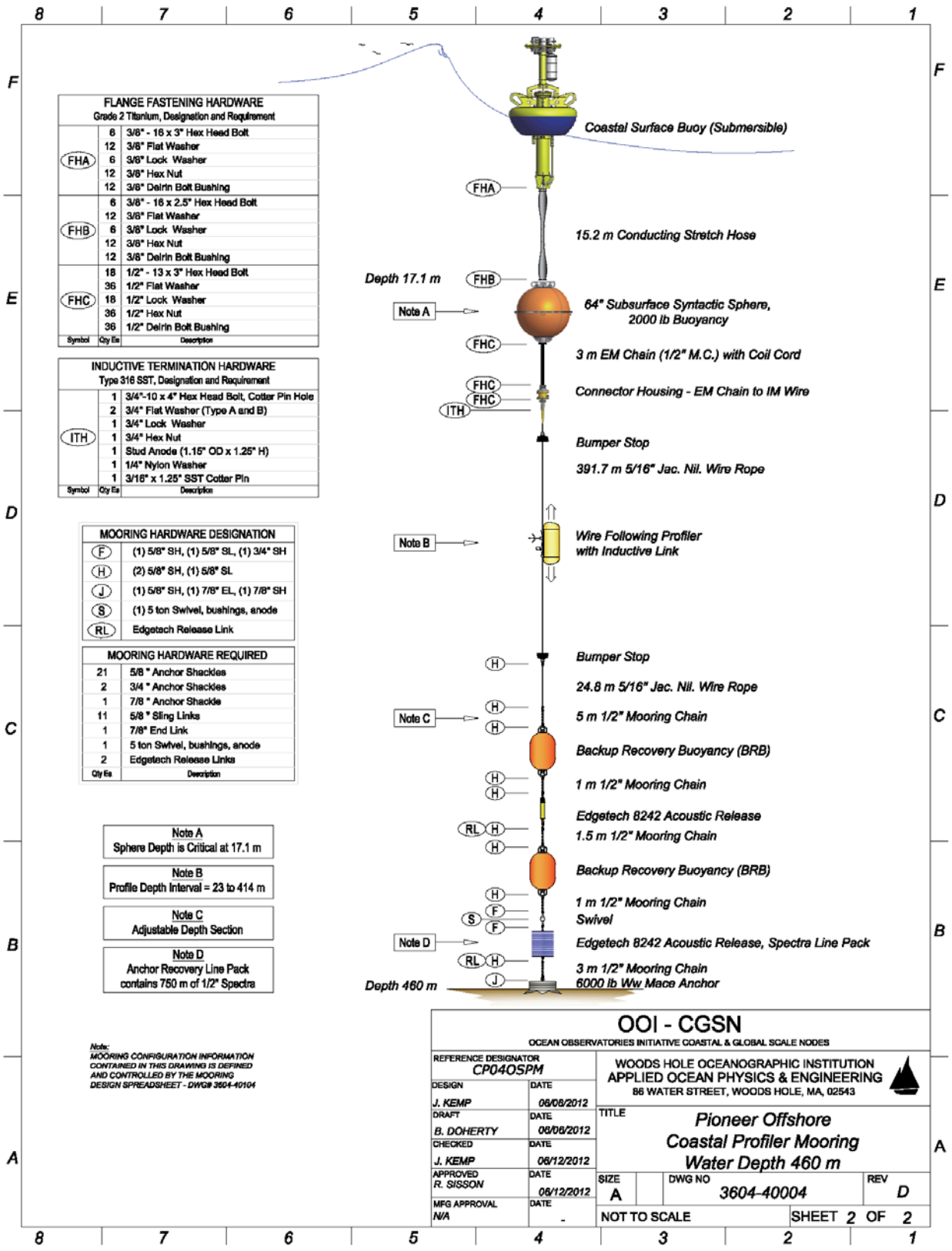

Figure 3-11 – Pioneer Offshore Profiler Mooring (OSPM).

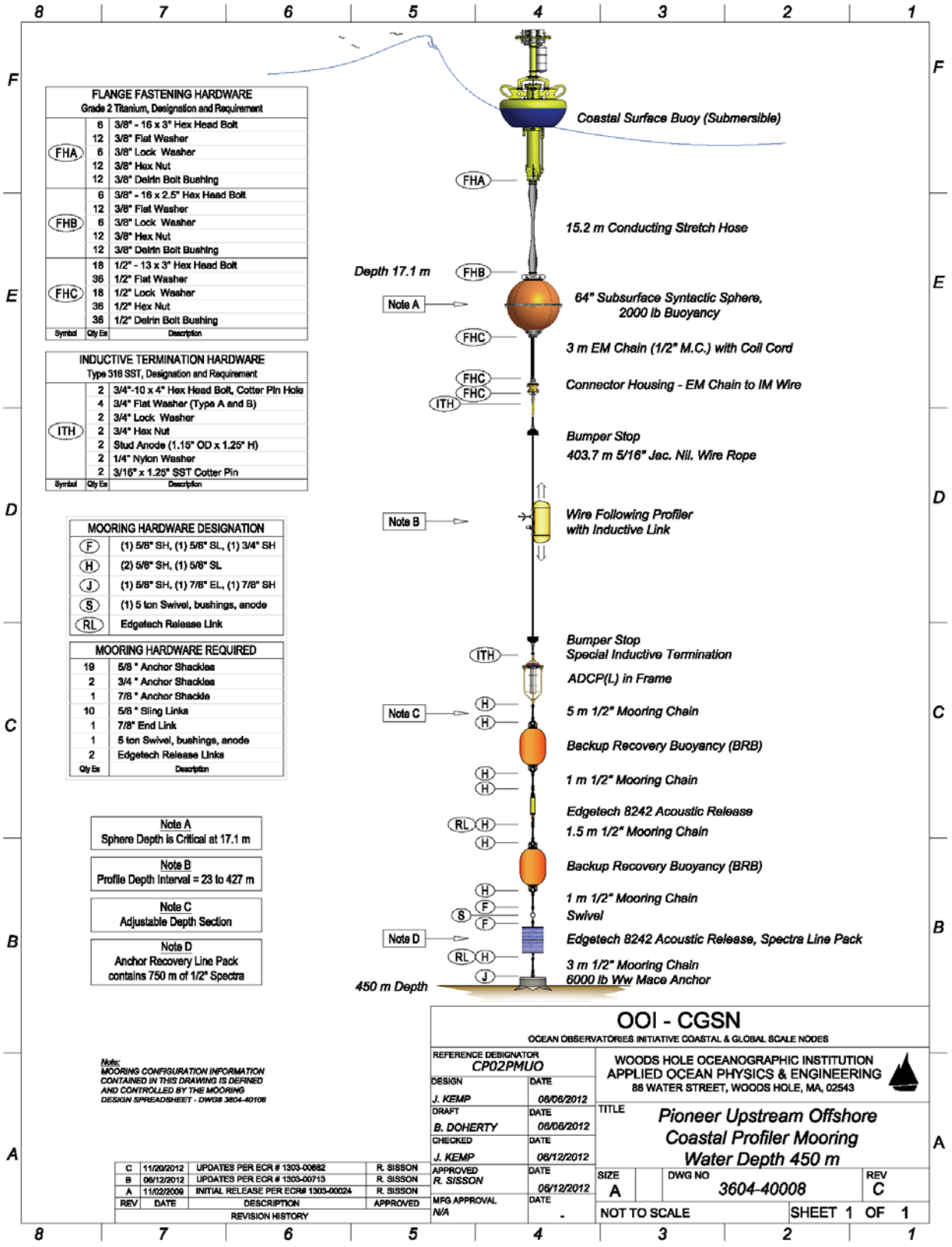

Figure 3-12 – Pioneer Upstream Offshore Profiler Mooring (PMUO).

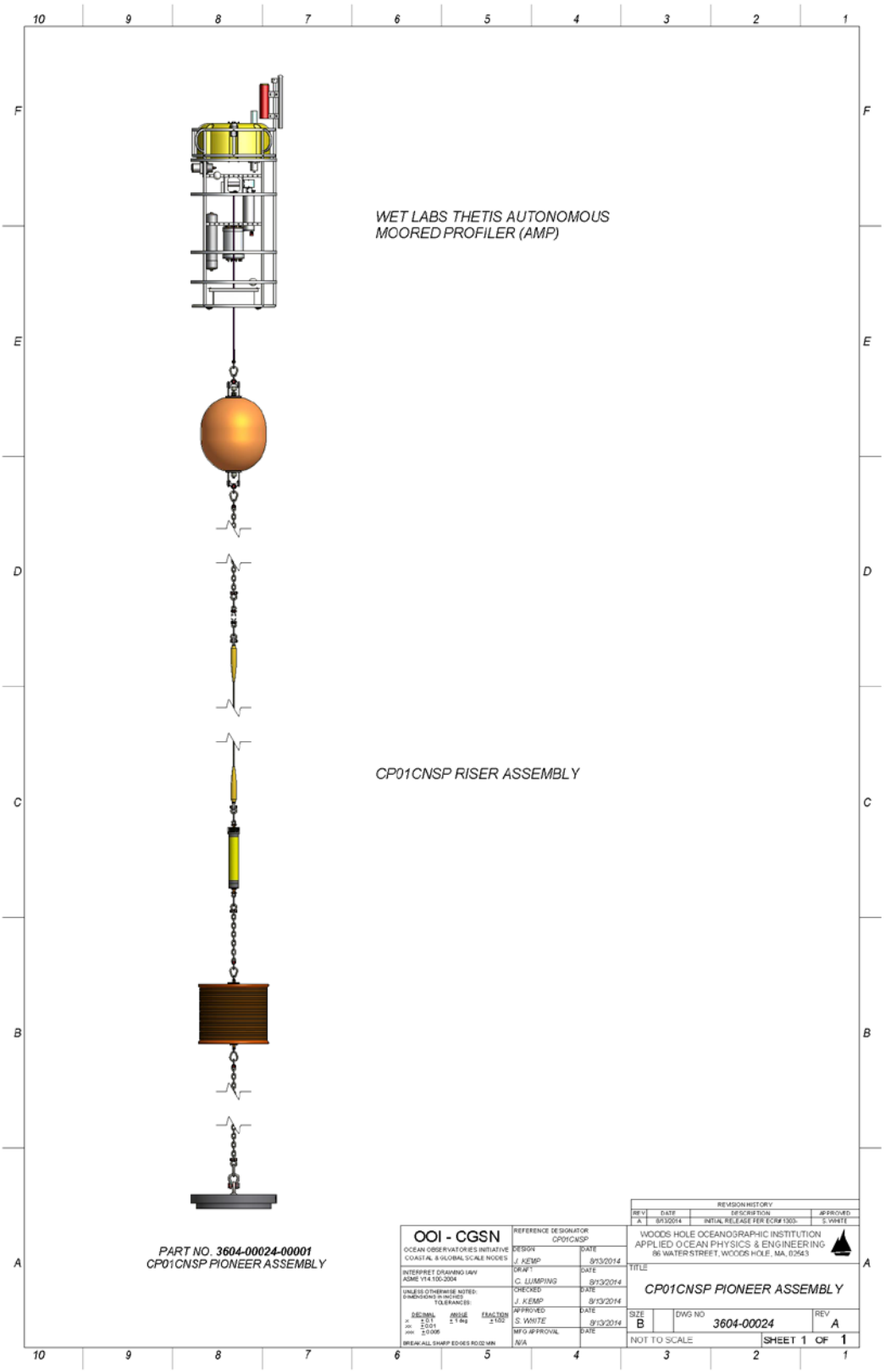

Figure 3-13 – Pioneer Coastal Surface Piercing Profiler (CSPP).
The Central CSPP is shown. Central and Inshore moorings differ only in the length of the riser.