Cruise Plan
Coastal Pioneer 7 Deployment
Leg 1: R/V *Armstrong* Cruise AR-08A
27 Sep – 04 Oct 2016
Leg 2: R/V *Armstrong* Cruise AR-08B
06 Oct - 14 Oct 2016

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Coastal and Global Scale Nodes
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Woods Hole Oceanographic Institution

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Revision History

Version	Description	Originator	Release Date
0-01	Draft for IRR 2016-09-15	A. Plueddemann	
0-02	Formatting updates	S. White	
0-03	Final edits	A. Plueddemann	
1-00	Initial release	P. Matthias	2016-09-19

Table of Contents

List of Figures

List of Tables

1.0 Introduction

1.1. Overview

This is the seventh major infrastructure deployment and servicing cruise 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 7 array service cruise (Pioneer-7) has 24 Primary Objectives (see Section 2.3) that include the recovery and deployment of Coastal Surface Moorings (CSMs), recovery and deployment of Coastal Profiler Moorings (CPMs), recovery and deployment of gliders, operation of AUVs, and CTD casts with water sampling at the mooring sites. The Pioneer-7 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-7 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, assumes that CSM and CPM moorings will be deployed for ~6 months, and gliders will be serviced at ~90 day intervals. The current status of Pioneer Array assets are as follows: Three Coastal Surface Moorings (CSMs) are deployed. Five Coastal Profiler Moorings (CPMs) are deployed. The Central Offshore Profiler Mooring Buoy (CP02PMCO) stopped reporting to shore on 4 September 2016; the buoy may have been damaged and/or parted from the mooring. One glider is operating, on the Slope Sea (SS-1) line.

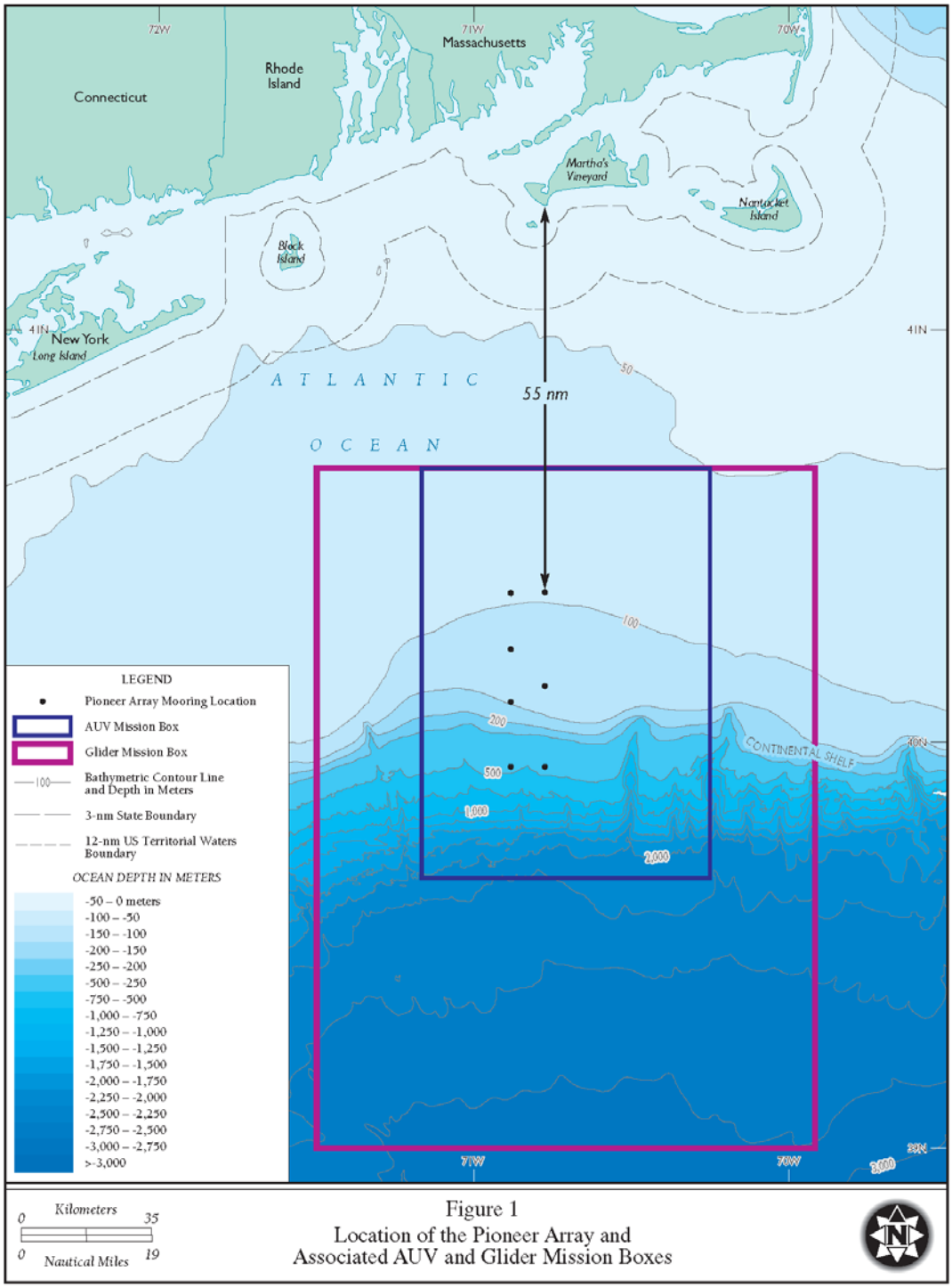

Figure 2-1 – Map of the Pioneer Array region.
The seven sites of the moored array, the AUV operating region and the glider operating region are shown along with bathymetric contours.

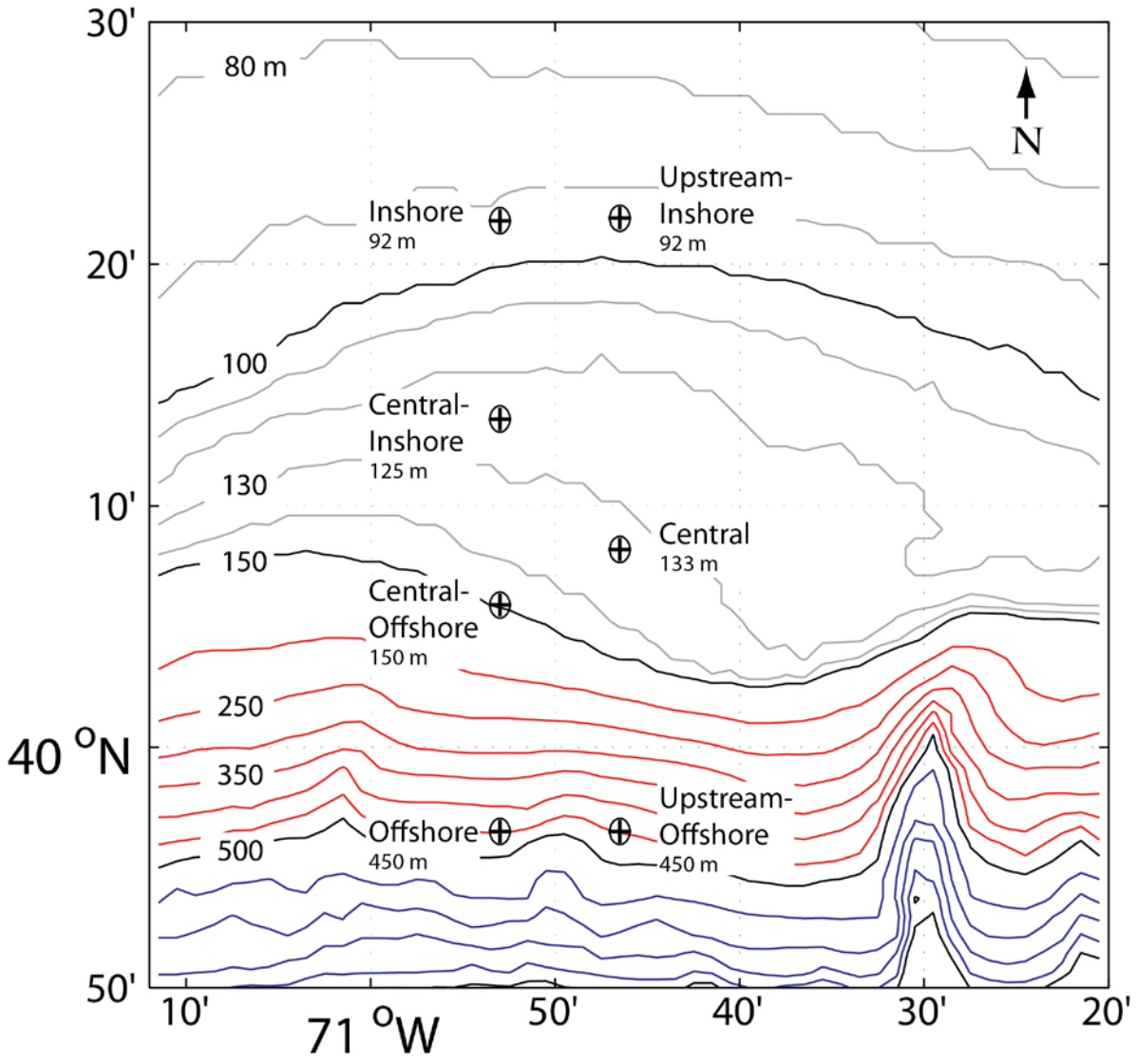

Figure 2-2 – Pioneer Array mooring site locations.
Site centers are marked by black "+" and encircled by approximate 0.5 nm radius buffer zones. Bathymetry is shown at 10 m (gray), 50 m (red) and 100 m (blue) intervals, respectively. Black contours are at 100 m, 150 m, 500 m and 1000 m.

2.2. Staging and De-Staging

Staging and loading will be done at the Woods Hole Oceanographic Institution (WHOI) in two periods. Staging for Leg 1 will begin on 23 Sep with the transport of CPM equipment to the WHOI dock and initial loading. The primary loading day for Leg 1 will be 26 Sep. Staging for Leg 2 will begin on 29 Sep with the transport of CSMs to the dock. The primary loading day for Leg 2 will be 5 Oct. The ship's crane will be suitable for loading most science gear. If necessary, this will be supplemented by the large WHOI crane for loading 20' containers/vans and other heavy items. At the discretion of the R/V *Armstrong*, partial loading and access to the ship may be possible prior to the primary loading days.

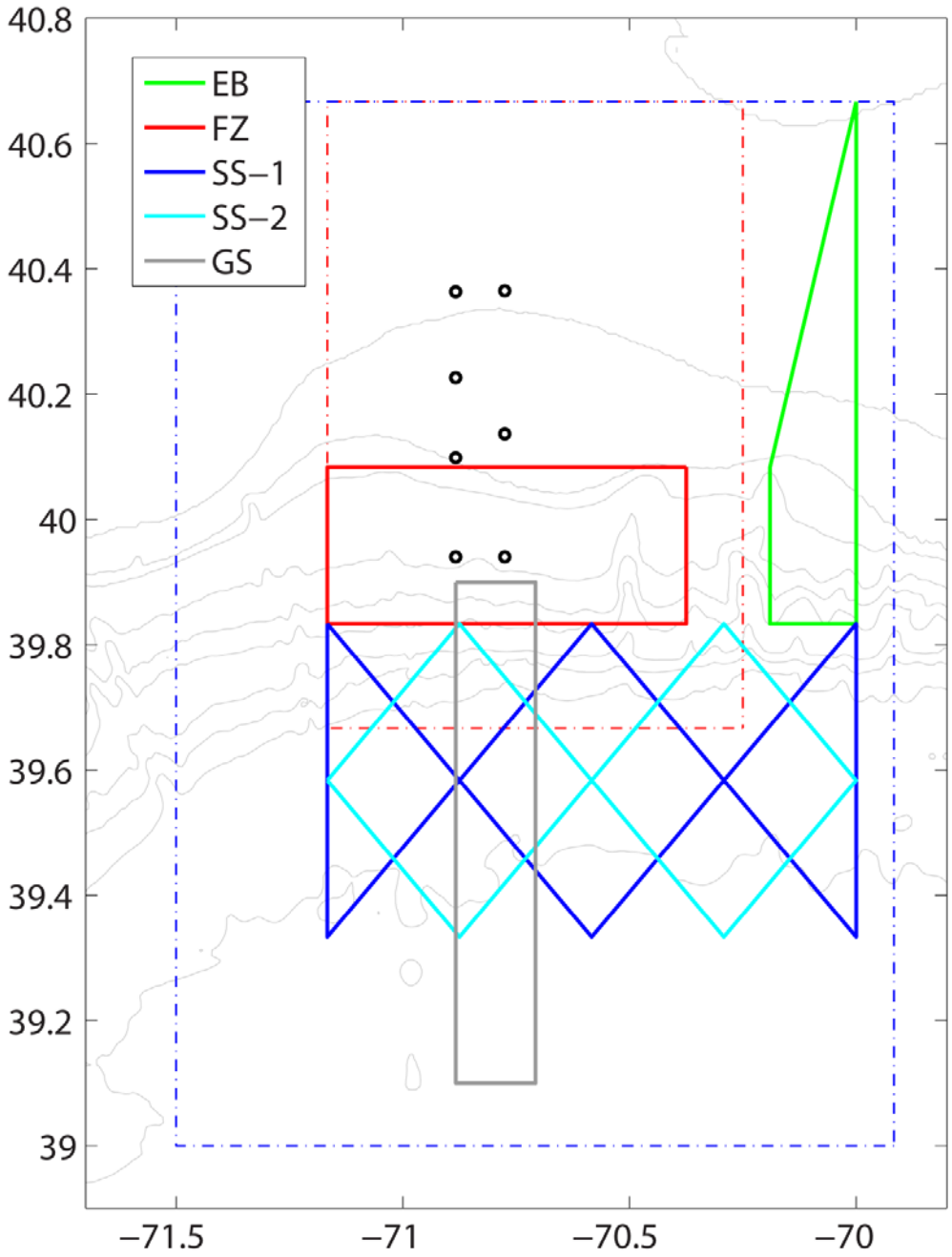

Figure 2-3 – Pioneer Array glider lines.
The Eastern Boundary (EB, green), Frontal Zone (FZ, red), Slope Sea (SS-1, blue; SS-2, cyan) and Gulf Stream (GS, gray) tracks are shown along with the Pioneer Array moorings (circles) and the glider and AUV operating areas (blue and red dashed lines, respectively).

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.

Offloading and destaging of scientific equipment will be conducted between the two cruise legs and upon termination of Leg 2 on 14 Oct. Destaging may continue during 17-19 Oct. The ship's crane will be suitable for offloading most science gear, supplemented by a shore crane for containers/vans if necessary.

2.3. Cruise Operations and Objectives

The R/V *Armstrong* 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 CPM operations during Leg 1 and CSM, glider and AUV operations during Leg 2. CTDs with bottle samples will be done in conjunction with deployment and recovery operations on both legs. Glider operations will be interspersed with mooring operations at times and locations chosen for efficiency. Additional Objectives will typically be conducted overnight or in late evening after Primary Objectives for the day are completed.

The Primary Objectives (*O1-O24*) are listed below. Nominal dates 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-00004).

O2. Recover the Central Coastal Surface Mooring anchor (CP001CNSM-00005).

O3. Recover the Inshore Coastal Surface Mooring (CP03ISSM-00004).

O4. Recover the Upstream-Offshore Profiler Mooring (CP02PMUO-00007).

O5. Recover the Offshore Profiler Mooring (CP04OSPM-00005).

O6. Recover the Central Offshore Profiler Mooring (CP02PMCO-00006).

O7. Recover the Central Inshore Profiler Mooring (CP02PMCI-00006).

O8. Recover the Upstream Inshore Profiler Mooring (CP02PMUI-00007).

O9. Recover one deep (1000 m engine) coastal glider (SS-1).

O10. Deploy the Offshore Coastal Surface Mooring (CP04OSSM-00005).

O11. Deploy the Central Coastal Surface Mooring (CP01CNSM-00006).

O12. Deploy the Inshore Coastal Surface Mooring (CP03ISSM-00005).

O13. Deploy the Upstream-Offshore Profiler Mooring (CP02PMUO-00008).

O14. Deploy the Offshore Profiler Mooring (CP04OSPM-00006).

O15. Deploy the Central Offshore Profiler Mooring (CP02PMCO-00007).

O16. Deploy the Central Inshore Profiler Mooring (CP02PMCI-00007).

O17. Deploy the Upstream-Inshore Profiler Mooring (CP02PMUI-00008).

O18. Deploy a shallow (200 m engine) coastal glider on the EB line.

O19. Deploy a deep (1000 m engine) coastal glider on the FZ line (FZ-1).

O20. Deploy a deep (1000 m engine) coastal glider on the SS line (SS-1).

O21. Deploy a deep (1000 m engine) coastal glider on the SS line (SS-2).

O22. Deploy a shallow (200 m engine) coastal glider on the FZ line (FZ-2).

O23. Conduct multiple AUV missions in the vicinity of the moored array

O24. Conduct CTD casts with water sampling at the deployment/recovery sites.

The Additional Objectives (*A1-A5*) are listed in rough priority order below, and will be completed as time and conditions permit. 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. Bathymetric and oceanographic surveys may be conducted at various times based on weather conditions and other factors.

A1. Conduct ship vs. buoy meteorological comparisons at each CSM site.

A2. Conduct CTD surveys (no bottle samples) in the vicinity of the moored array.

A3. Conduct multibeam bathymetry surveys in the Pioneer region.

A4. Conduct shipboard surveys (ADCP, EK-80) in the vicinity of the moored array.

A5. Deploy a deep (1000 m engine) coastal glider on the GS line.

The cruise also has ancillary activities, requested by outside users and scheduled in consultation with the Chief Scientist and Program Manager. On Leg 1, Dr. Mark Baumgartner (Associate Scientist, WHOI, Biology Department) requested deployment of a passive acoustic surface mooring at a nominal location of 41° 08.49' N, 70° 56.41' W. This is along the outbound path to the Pioneer Array and should take about 2 hours on the evening of departure. It will not interfere with any other objectives. On Leg 2, Dr. Brian Claus (Postdoctoral Scholar, WHOI Applied Ocean Physics and Engineering Department) has requested deployment of a glider. The glider is similar to those used in the Pioneer Array and can be deployed at the same location as the Pioneer slope-sea gliders. This activity is anticipated to take 1-2 hours on the evening of departure and will not interfere with any other objectives.

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 (in priority order).

Table 2-1 – Pioneer-7 glider deployment plan.

Name	Region	Priority	Buoyancy Engine	Pioneer-6
EB	Eastern Boundary	As-deployed	200 m	Planned deployment
FZ-1	Frontal Zone	As-deployed	1000 m	Planned deployment
SS-1	Slope Sea	As-deployed	1000 m	Planned deployment
SS-2	Slope Sea	As-deployed	1000 m	Planned deployment
FZ-2	Frontal Zone	Baseline	200 m	Planned deployment
GS	Gulf Stream	Baseline	1000 m	Additional objective

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 holding them there while conducting acoustic interrogation. The science party will bring an acoustic transceiver (deck box) than can be lowered over the rail with a cable run to the main lab and connected to a transceiver controller. Alternatively, the deck box 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 A-frame, plus winches and air tuggers 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, starboard arm, 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 and recoveries are expected to be done using either the ship’s crane or the starboard arm located aft of the CTD. In both cases the ship's equipment will be supplemented by a handling gear supplied by the science party. AUV recoveries may require a small boat operation prior to lifting the vehicle aboard, but this is not expected to be a normal part of the operation. 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, 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. Efficiency of the surveys is increased if the release deck gear can be connected to the ship's 12 kHz hull transducer.

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 may be conducted with at surface mooring sites. For evaluation 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 underway. The EK-80 system will be used for selected transects or time-series stations. Sea surface temperature and salinity will be recorded continuously, using the ship's thermosalinograph.

2.3.9. 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.

2.3.10. Small Boat Operations

The use of a work boat may be requested for AUV recovery operations and 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) may 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

23 Sep – 26 Sep, Mobilization, LOSOS and WHOI pier

27 Sep – 14 Oct, Cruise dates, Leg-1 (8 days), 1 mob day, Leg-2 (9 days)

14 Oct – 15 Oct, Demob, WHOI pier and LOSOS

Timeline

27 Sep	Complete loading, depart WHOI, deploy Baumgartner mooring
28 Sep	Recover OSPM, deploy OSPM, CTD casts,
29 Sep	Recover PMUO, deploy PMUO, CTD casts
30 Sep	Recover PMCO, deploy PMCO, CTD casts
01 Oct	Recover PMCI, deploy PMCI, CTD casts
02 Oct	Recover PMUI, deploy PMUI, CTD casts
03 Oct	Cross-shelf CTD survey and/or complete primary objectives
04 Oct	Arrive WHOI, offload
05 Oct	In-port WHOI, staging and loading for Leg 2
06 Oct	Complete loading, depart WHOI, recover glider, deploy Claus glider
07 Oct	Deploy OSSM, CTD cast, deploy slope gliders, CTD cast
08 Oct	Deploy CNSM, CTD cast, deploy shelf gliders, CTD cast
09 Oct	Deploy ISSM, CTD casts, recover ISSM
10 Oct	Recover OSSM, recover CNSM
11 Oct	Cross-shelf AUV/CTD survey and/or complete mooring work
12 Oct	Start dual AUV survey
13 Oct	Complete dual AUV survey, complete primary and/or additional objectives
14 Oct	Arrive WHOI, begin offload

Appendix B – Selected Waypoints and Maps

Table 3-1 – Pioneer-7 station list

Station List: Pioneer 7, R/VArmstrong, Sep-Oct 2016					
See timeline for order of occupation; some sites are occupied more than once					
"Mooring Turn" implies recovery of one mooring and deployment of another					
Name	**Code**	**Lat**	**Lon**	**water depth**	**comments**
Upstream-Inshore	UI	40 21.9	70 46.5	95 m	profiler mooring turn, CTD
Inshore	IS	40 21.8	70 53.0	95 m	surface mooring turn, CTD
Central-Inshore	CI	40 13.6	70 53.0	127 m	profiler mooring turn, CTD
Central	CN	40 08.2	70 46.5	135 m	surface mooring turn, CTD
Central-Offshore	CO	40 05.9	70 53.0	147 m	profiler mooring turn, CTD
Offshore	OS	39 56.4	70 53.0	450 m	surface mooring turn, profiler mooring turn, CTD
Upstream-Offshore	UO	39 56.4	70 46.5	450 m	profiler mooring turn, CTD
Cross-shelf 1	CS-1	40 17.6	70 46.5	115 m	part of cross-shelf CTD line
Cross-shelf 2	CS-2	40 13.2	70 46.5	125 m	part of cross-shelf CTD line
Cross-shelf 3	CS-3	40 04.3	70 46.5	140 m	part of cross-shelf CTD line
Cross-shelf 3	CS-4	40 00.4	70 46.5	270 m	part of cross-shelf CTD line
AUV cross 1	AC-1	40 20.6	70 45.0	TBD	AUV cross-shelf mission box
AUV cross 2	AC-2	39 55.3	70 45.0	TBD	AUV cross-shelf mission box
AUV cross 3	AC-3	39 55.3	70 54.5	TBD	AUV cross-shelf mission box
AUV cross 4	AC-4	40 20.6	70 54.5	TBD	AUV cross-shelf mission box
AUV along 1	AL-1	40 20.6	71 05.7	TBD	AUV along-shelf mission box
AUV along 2	AL-2	40 20.6	70 33.3	TBD	AUV along-shelf mission box
AUV along 3	AL-3	40 12.3	70 33.3	TBD	AUV along-shelf mission box
AUV along 4	AL-4	40 12.3	71 05.7	TBD	AUV along-shelf mission box
Baumgartner		40 08.49	70 56.41	TBD	passive acoustic mooring deployment
Gliders		various	various	various	recoveries and deployments, CTDs

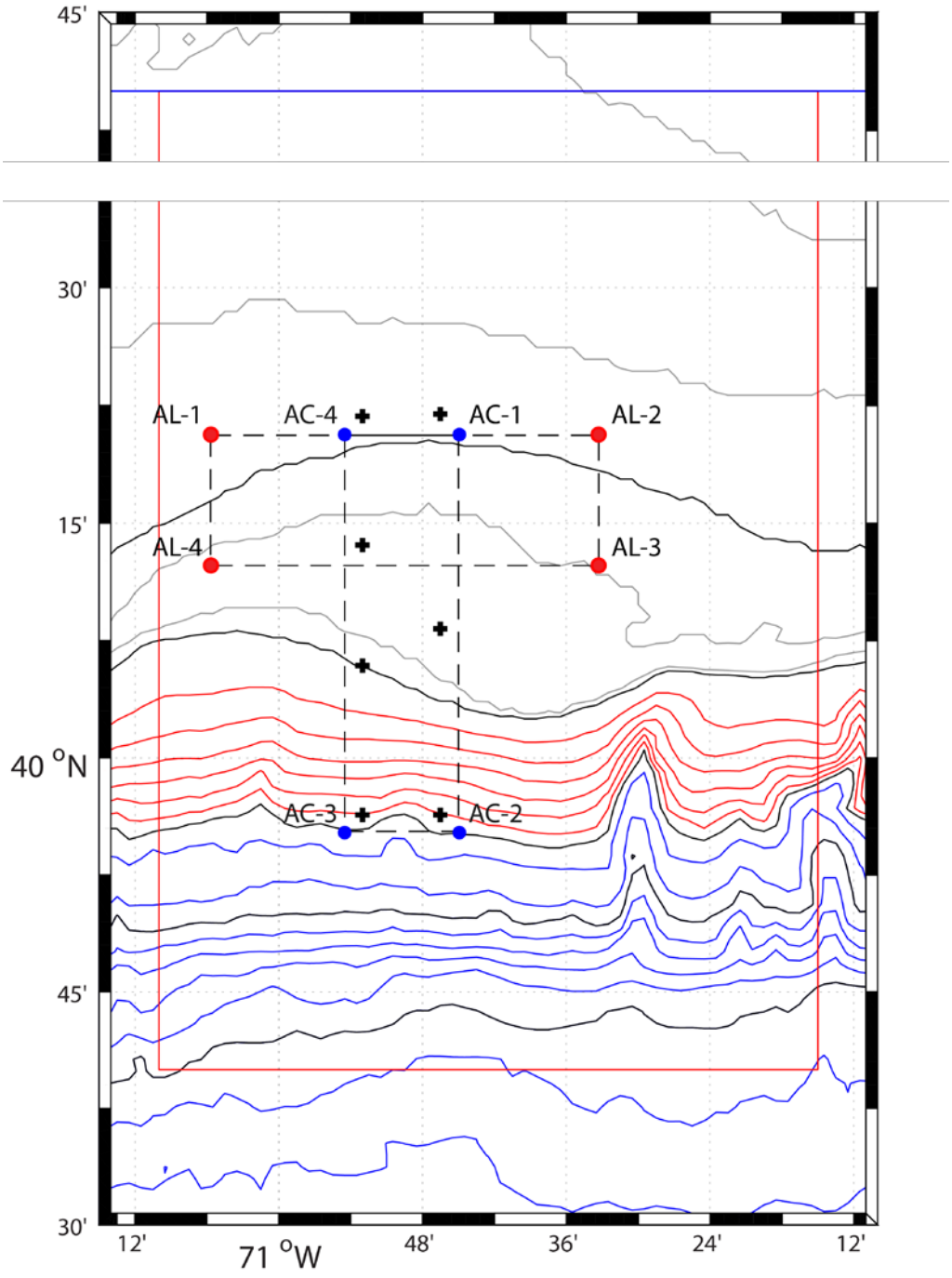

Figure 3-1 – AUV mission track lines.
The Along-Shelf (AL, red) and Across-Shelf (AC, blue) track lines are shown (dashed lines) along with the Pioneer Array moorings (crosses) and the AUV operating area (red rectangle).

Appendix C – Deck Plan

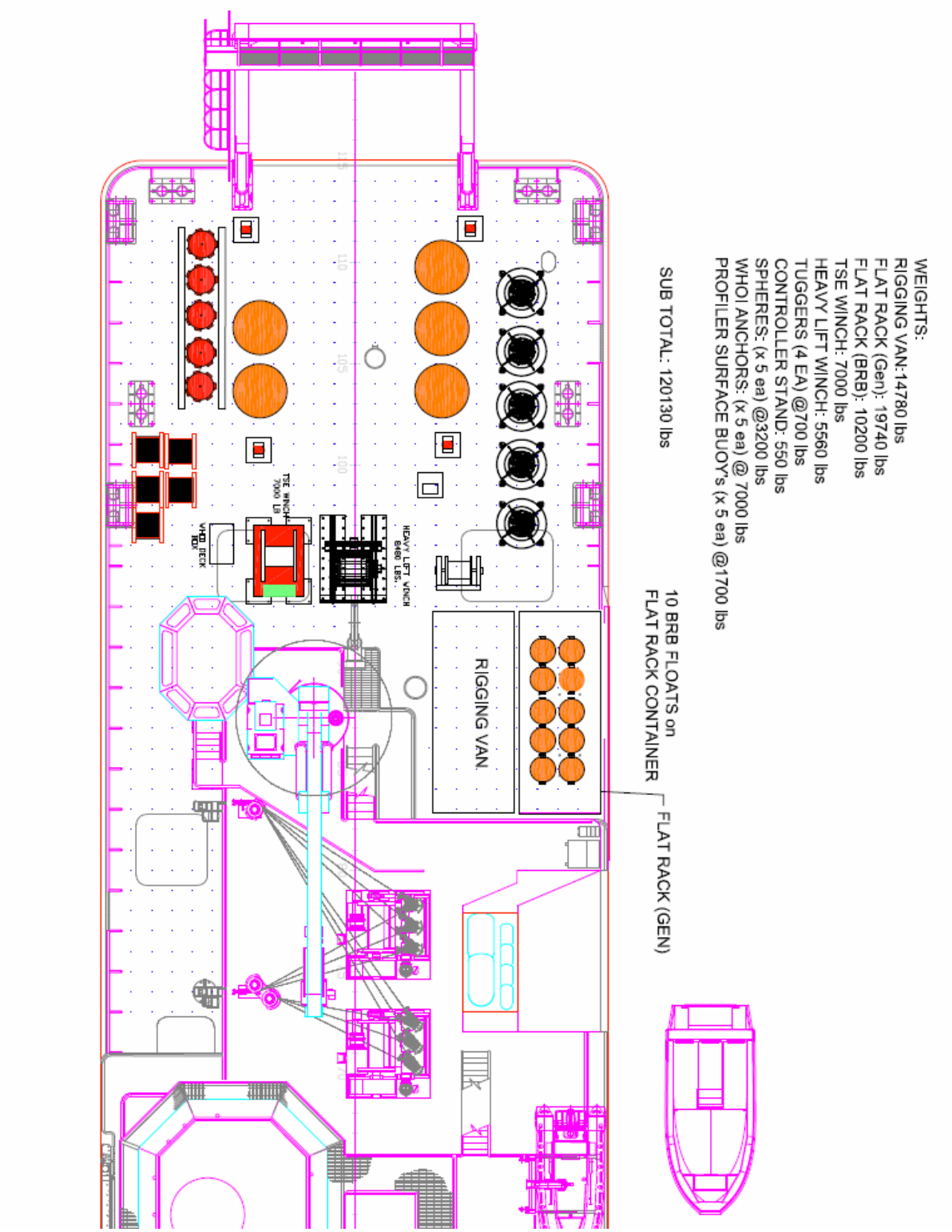

Figure 3-2 – Deck plan for Pioneer-7, Leg 1.
Nominal deck layout for the major components associated with Pioneer-7 Leg 1 operations.

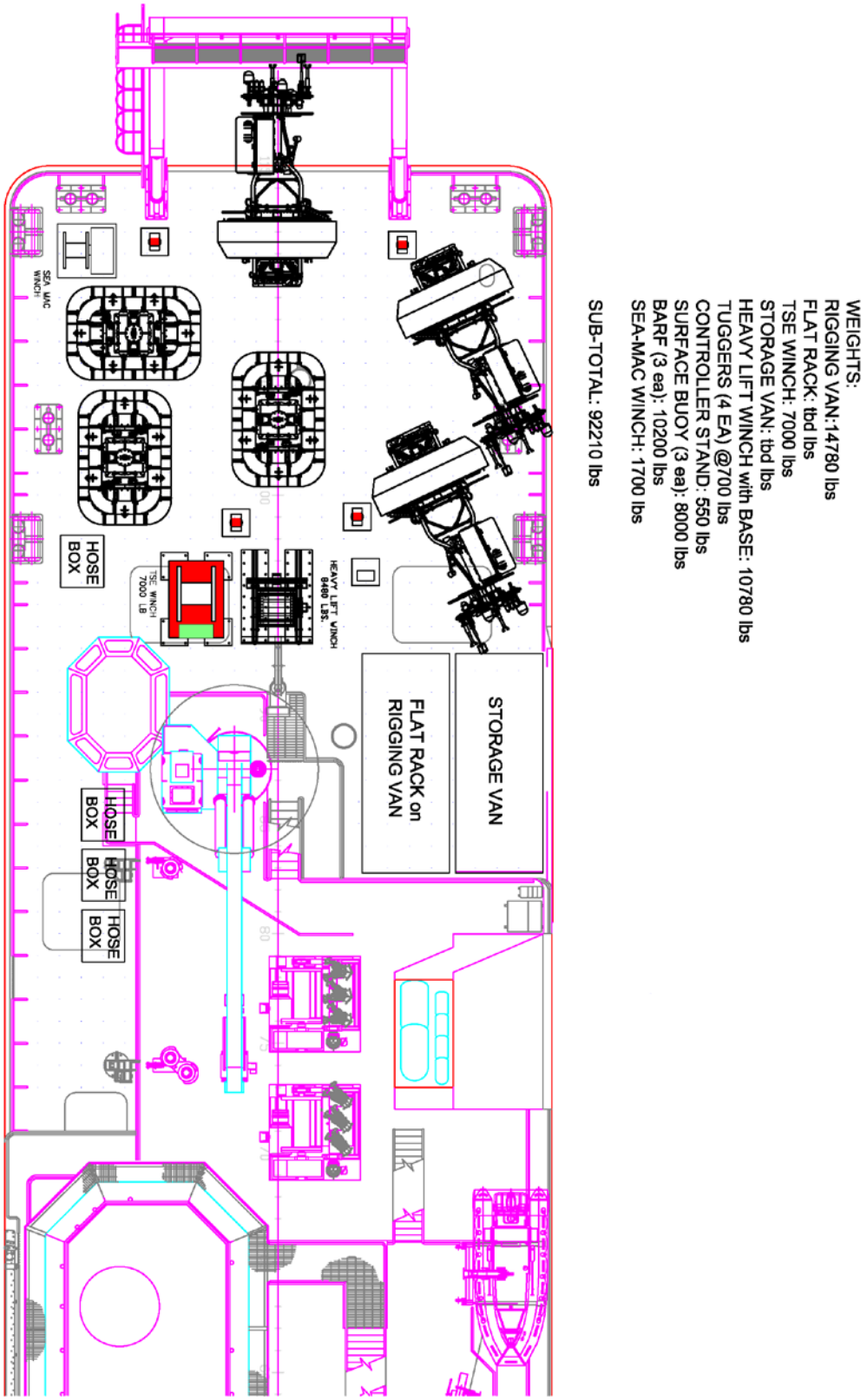

Figure 3-3 – Deck plan for Pioneer-7, Leg 2.
Nominal deck layout for the major components associated with Pioneer-7 Leg 2 operations.

Appendix D – Science Party

Leg 1: There will be 10 participants in the science party for Leg 1. The Chief Scientist is Dr. Albert J. Plueddemann (WHOI). An alphabetical list is given in the table below.

Participating Scientists

Name	Gender	Nationality	Affiliation
1. Alai, Aidan	M	USA	WHOI
2. Kemp, John	M	USA	WHOI
3. Lumping, Chris	M	USA	WHOI
4. Petillo, Stephanie	F	USA	WHOI
5. Plueddemann, Al	M	USA	WHOI/Chief Sci
6. Perry, Charles	M	USA	McLane
7. Sealey, Andrew	M	USA	McLane
8. Thomas, Tina	F	USA	Texas A&M
9. Wellwood, Dave	M	USA	WHOI
10. Williams, Mike	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
  - Al Plueddemann, Aidan Alai (CPMs), Tina Thomas
- Logistics, deck operations, mooring hardware, mooring operations
  - John Kemp, Chris Lumping, Mike Williams
- Mooring control and power, telemetry systems
  - Aidan Alai, Stephanie Petillo (CPMs)
- Instrument configuration, preparation and pre-deployment checks
  - Aidan Alai (CPMs)
- Platform configuration and mission plan
  - Aidan Alai, Stephanie Petillo (CPMs)
- Hydrographic sampling, including physical sample preparation
  - Dave Wellwood, Tina Thomas

Leg 2: There will be 14 participants in the science party for Leg 2. The Chief Scientist is Dr. Albert J. Plueddemann (WHOI). An alphabetical list is given in the table below.

Participating Scientists

	Name	Gender	Nationality	Affiliation
1.	Alai, Aidan	M	USA	WHOI
2.	Botello, Roberto	M	USA	Raytheon
3.	Houghton, Leah	F	USA	WHOI
4.	Jeans, Grace	F	USA	Raytheon
5.	Kemp, John	M	USA	WHOI
6.	Lumping, Chris	M	USA	WHOI
7.	Ngo, Han	M	USA	Raytheon
8.	Palanza, Matt	M	USA	WHOI
9.	Plueddemann, Al	M	USA	WHOI/Chief Sci
10.	Thomas, Tina	F	USA	Texas A&M
11.	Travis, Rebecca	F	USA	WHOI
12.	Wickman, Diana	F	USA	WHOI
13.	Williams, Mike	M	USA	WHOI
14.	*TBD*, AUV lead	?	?	?

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
  - Tina Thomas, Matt Palanza (CSMs), Diana Wickman (gliders, AUVs)
- Logistics, deck operations, mooring hardware, mooring operations
  - John Kemp, Chris Lumping, Mike Williams
- Mooring control and power, telemetry systems
  - Matt Palanza (CSMs), Diana Wickman (gliders)
- Instrument configuration, preparation and pre-deployment checks
  - Aidan Alai (CSMs), Diana Wickman (gliders)
- Platform configuration and mission plan
  - Matt Palanza (surface moorings), Diana Wickman (gliders), AUV lead (AUVs)
- Hydrographic sampling, including physical sample preparation
  - Leah Houghton, Tina Thomas
- AUV mission planning and execution
  - AUV lead, Diana Wickman

Appendix E – Mooring Drawings

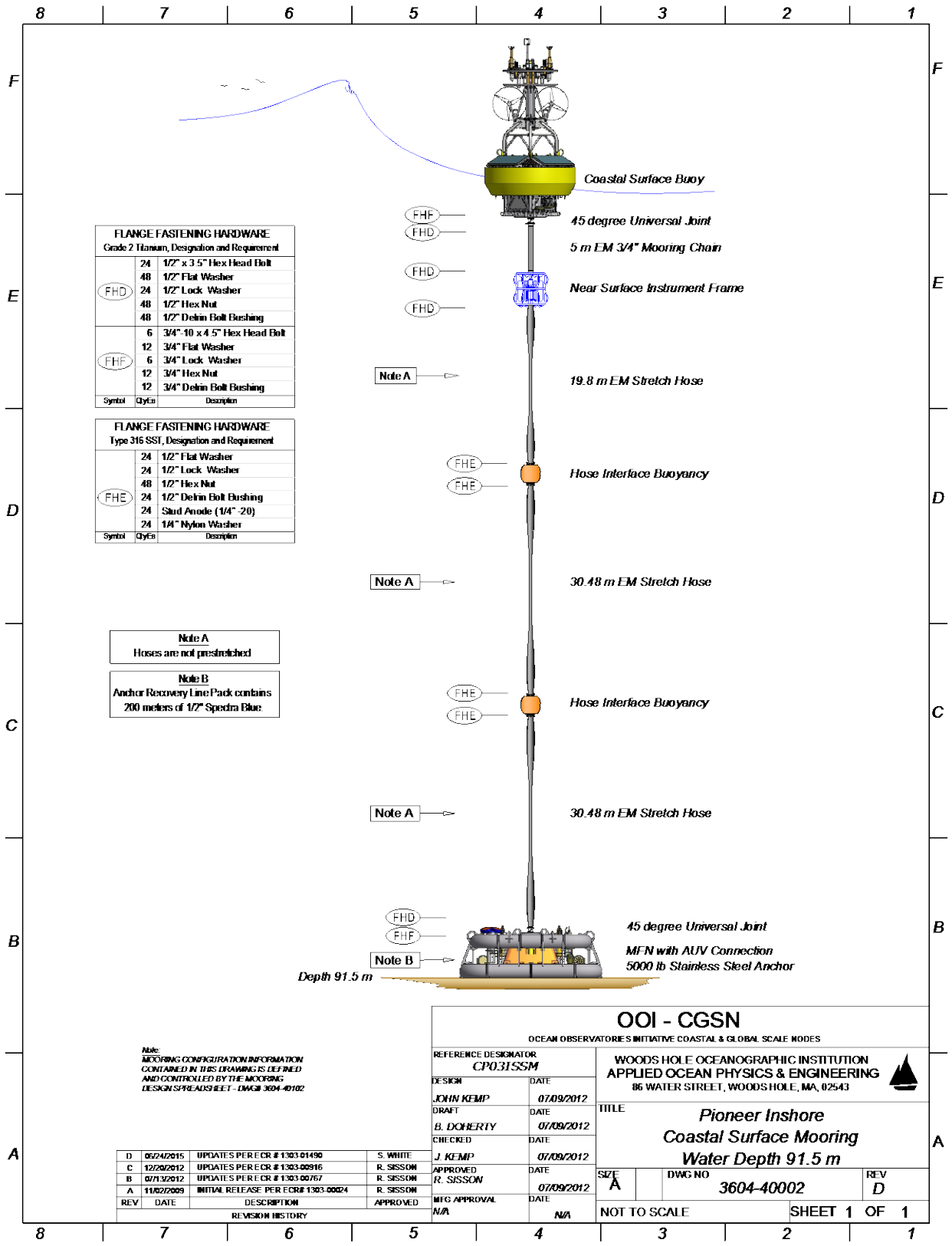

Figure 3-4 – Pioneer Inshore Surface Mooring (ISSM).

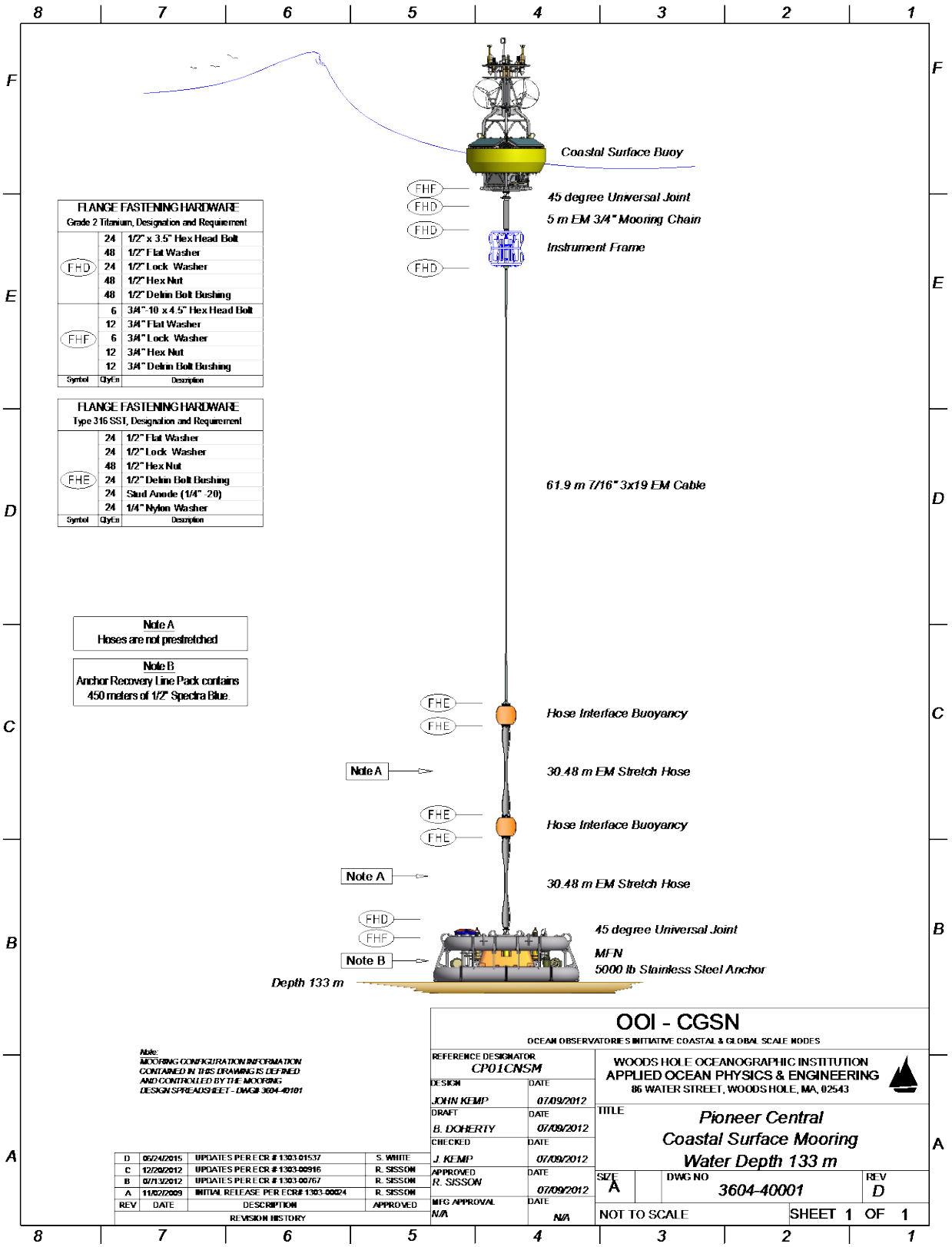

Figure 3-5 – Pioneer Central Surface Mooring (CNSM).

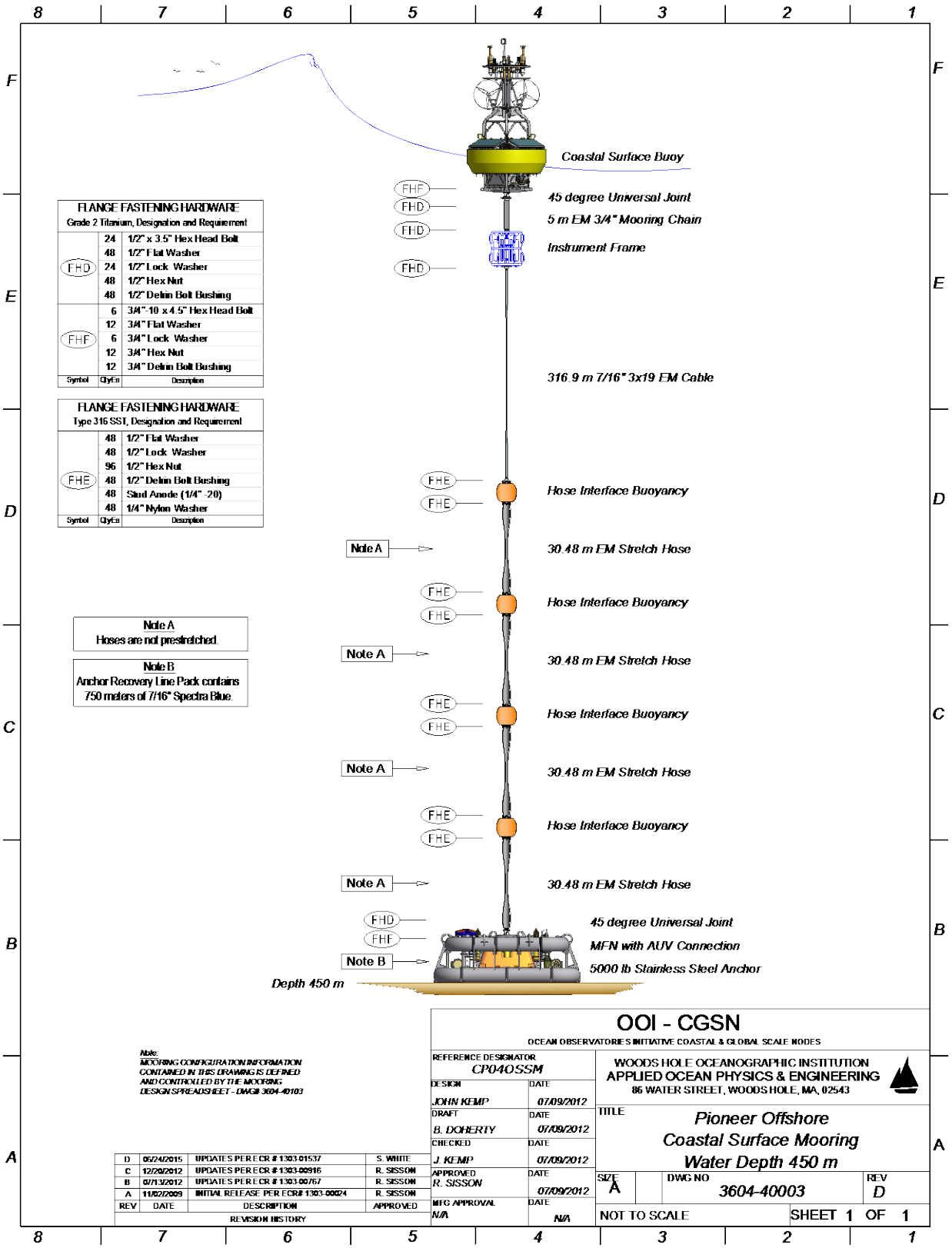

Figure 3-6 – Pioneer Offshore Surface Mooring (OSSM).

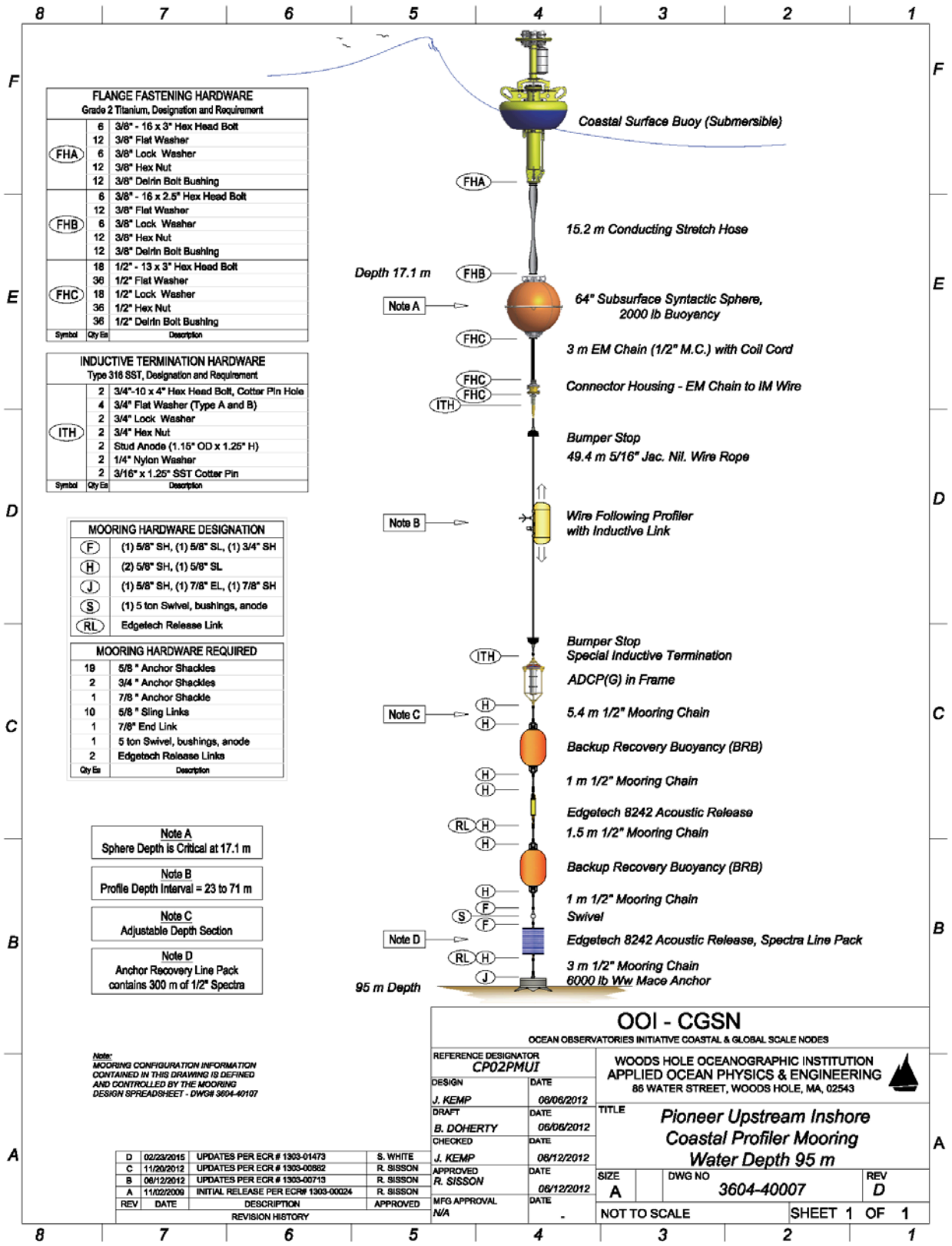

Figure 3-7 – Pioneer Upstream Inshore Mooring (PMUI).

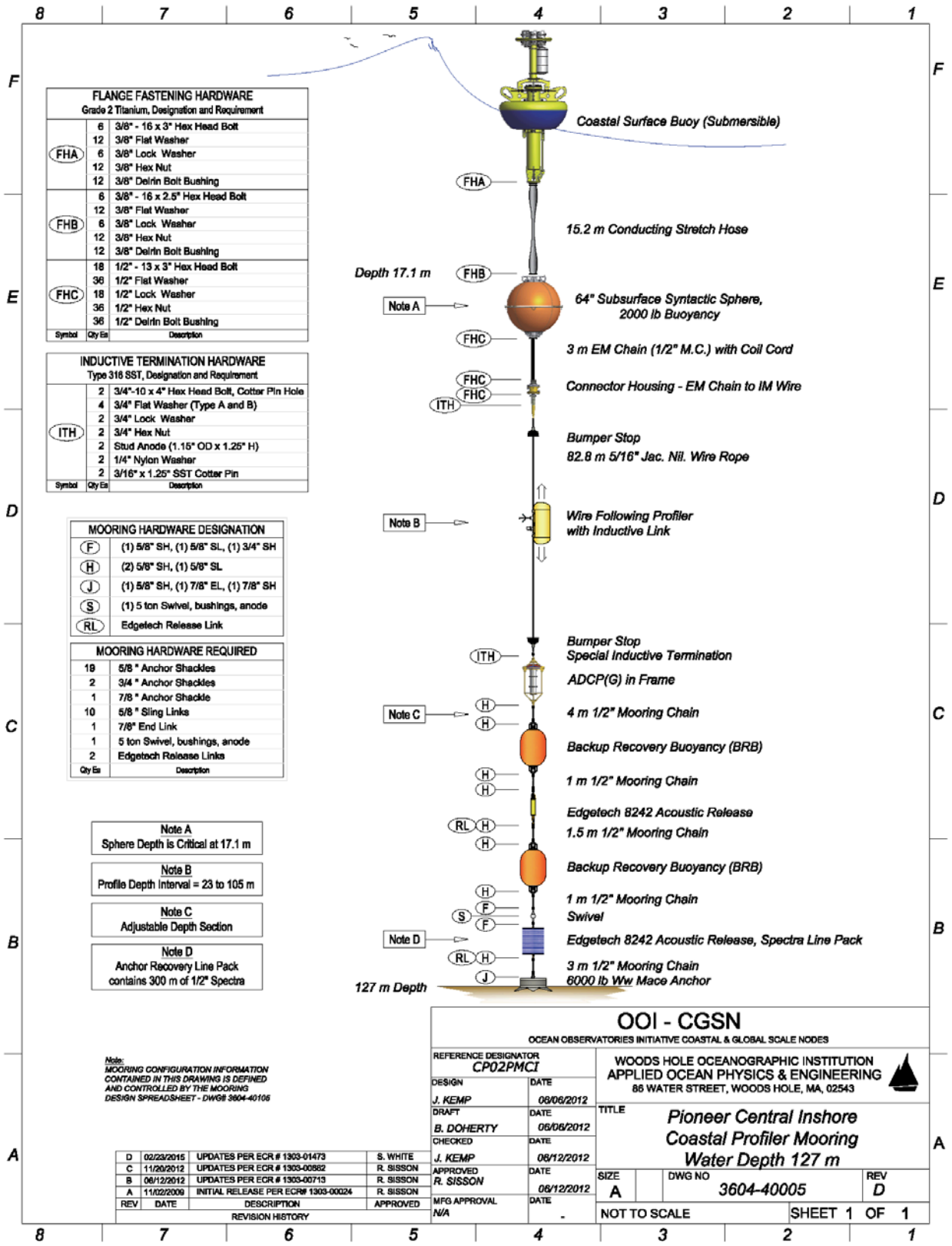

Figure 3-8 – Pioneer Central Inshore Profiler Mooring (PMCI).

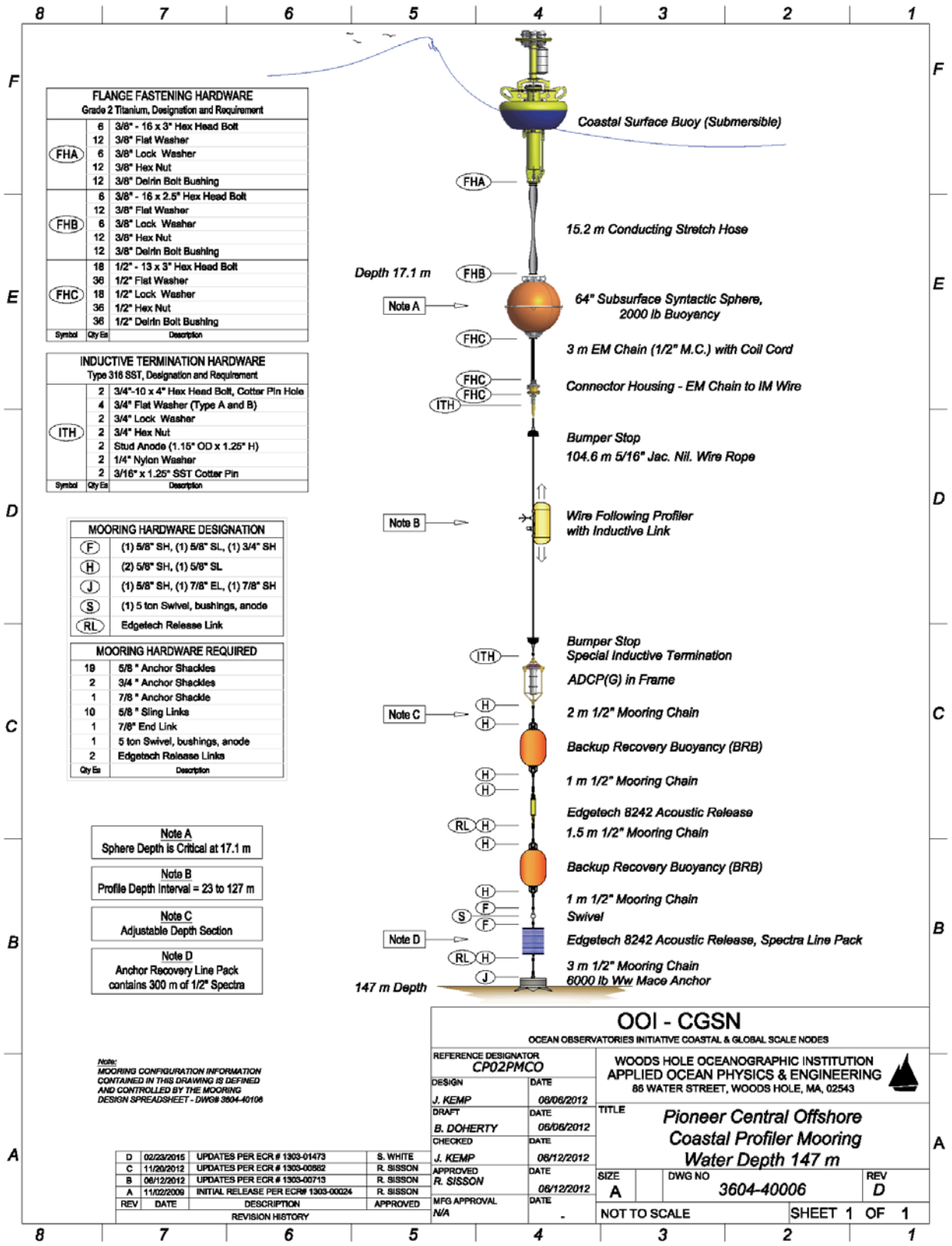

Figure 3-9 – Pioneer Central Offshore Profiler Mooring (PMCO).

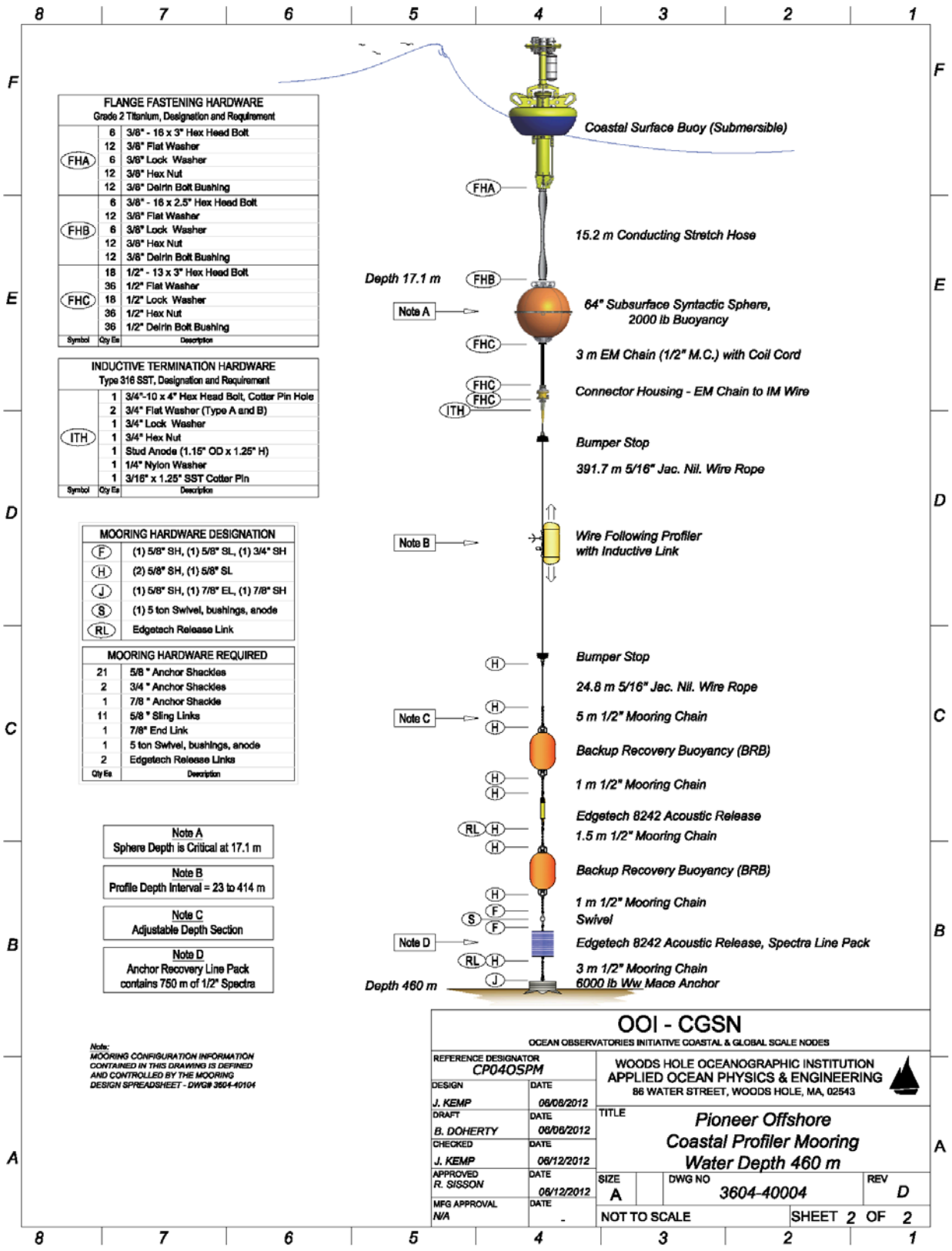

Figure 3-10 – Pioneer Offshore Profiler Mooring (OSPM).

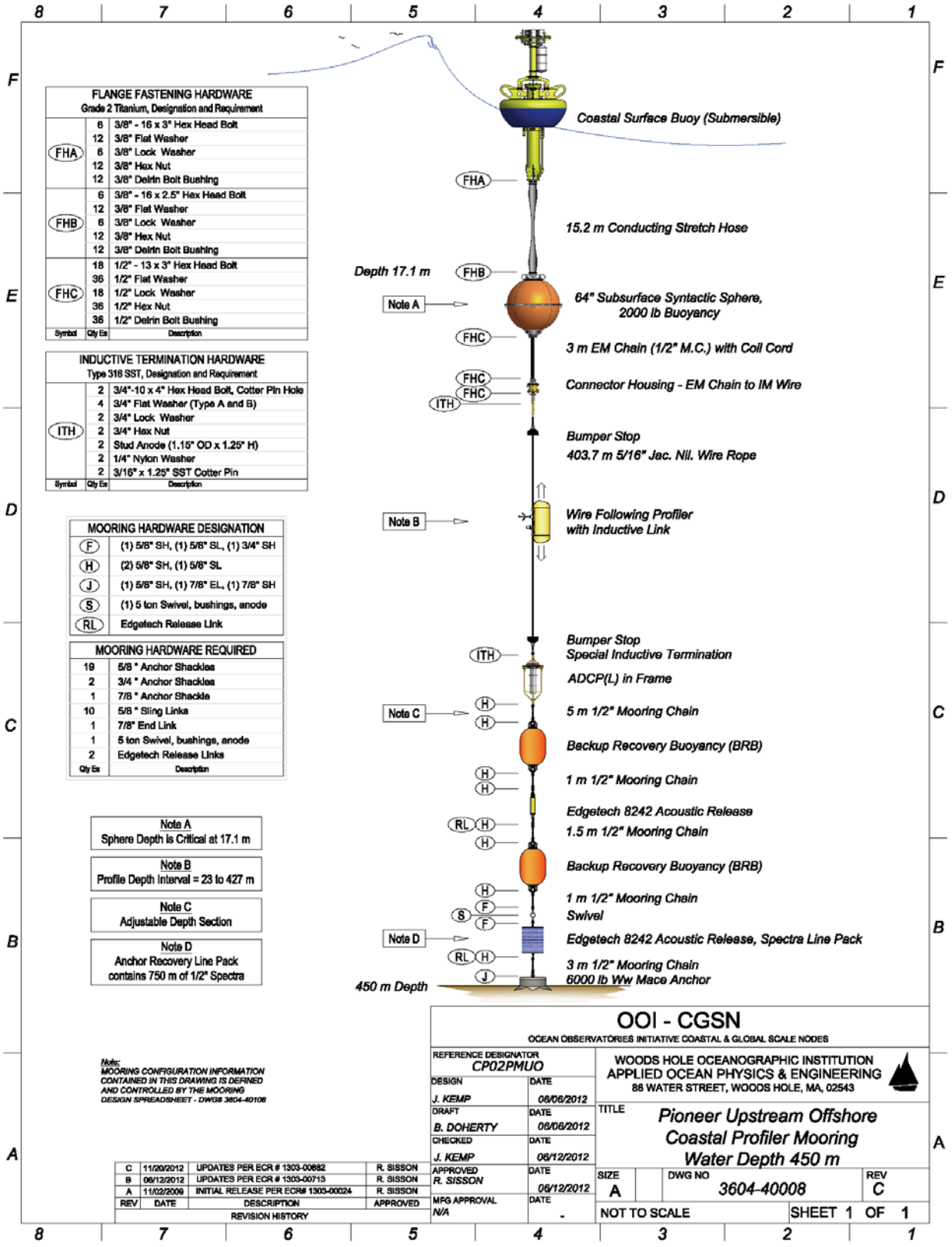

Figure 3-11 – Pioneer Upstream Offshore Profiler Mooring (PMUO).