Ocean Observatories Initiative

OOI Coastal & Global Scale Nodes

July 7, 2016

Woods Hole Oceanographic Institution
Oregon State University

CGSN (WHOI), EA (OSU) Introductions

- Project Managers
  - Paul Matthias (CGSN)
  - Ed Dever (EA)
- Project Scientists
  - Al Plueddemann
    - Pioneer Array
  - Jack Barth
    - Endurance Array
  - Bob Weller
    - Global Arrays
- Engineering/Operations Leads
  - Sheri N. White
    - Instruments
  - Matt Palanza
    - Electrical
  - Kris Newhall
    - Mechanical
  - Peter Brickley
    - Ops, Gliders, AUVs
  - Jon Fram
    - EA

http://oceanobservatories.org/observatories/

Agenda

- Overview of Arrays (configuration, platforms, etc.)
  - Global Arrays (4)
  - Coastal Arrays (2)
- Core OOI Science instrument details
  - Makes/models, etc.
- Mooring details (power, communications, etc.)
  - Coastal Profiler Moorings
  - Coastal Surface Moorings
  - Global Surface Moorings
  - Global Profiler Moorings
  - Global Flanking Moorings

Agenda, cont.

- Vehicle details
  - Coastal Surface Piercing Profilers
  - Gliders (Coastal, Open Ocean, and Global Profiling)
  - AUVs
- Opportunities related to CGSN/EA Arrays
  - Adding instruments connected to CGSN infrastructure
  - Altering sampling strategies of existing platforms
  - Cruise participation
- Proposal/Integration process

- Questions

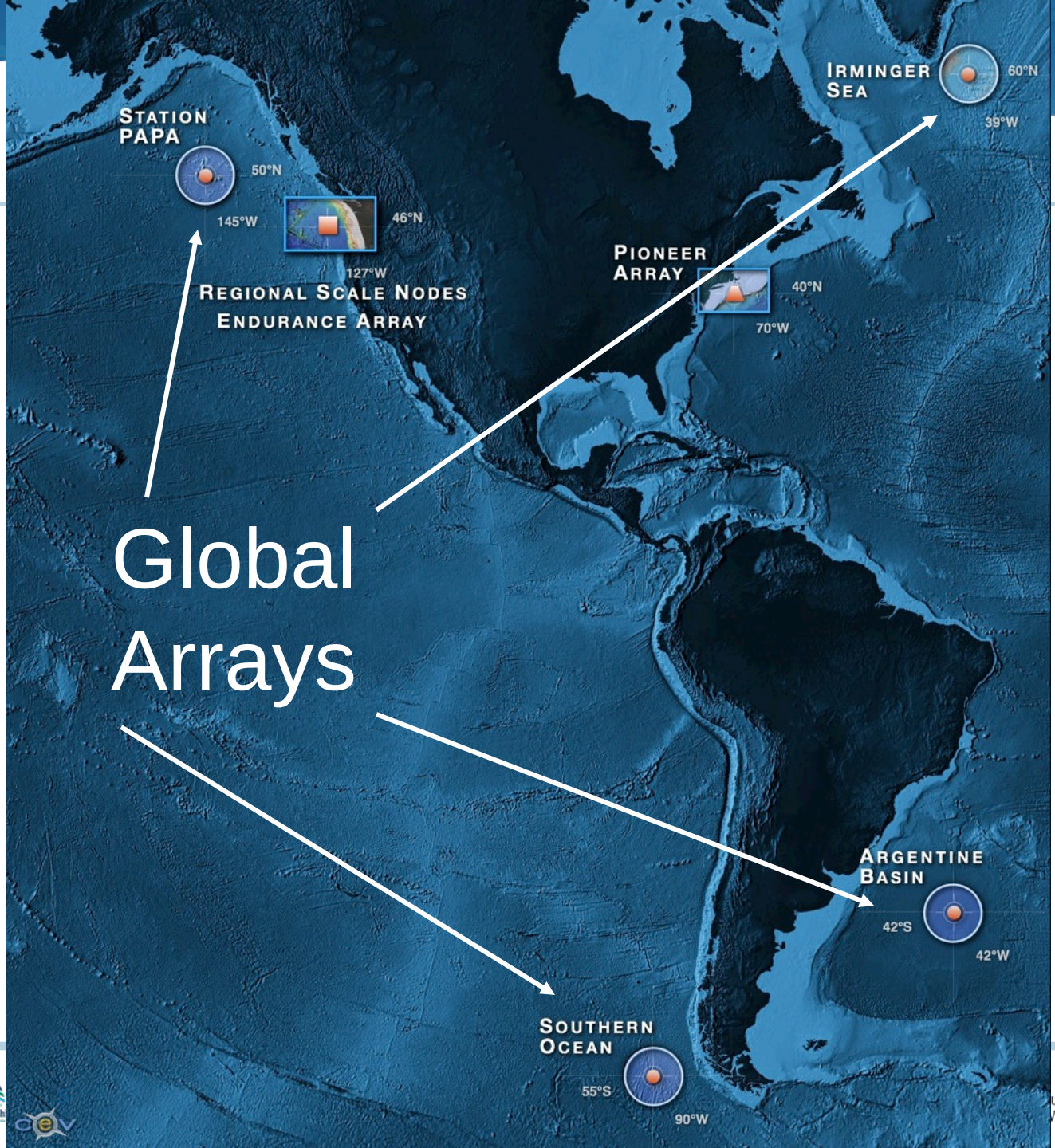
OOI Science Themes

OOI Science Themes		Pioneer	EA	Global
A1	Global Biogeochemistry and Carbon Cycling	X	X	X
A2	Ocean-Atmosphere Exchange	X	X	X
A3	Ocean Circulation, Mixing and Ecosystems	X	X	X
A7	Climate Variability and Ecosystems	X	X	X
A9	Coastal Ocean Dynamics and Ecosystems – Hypoxia on Continental Shelves	X	X	
A10	Coastal Ocean Dynamics and Ecosystems – Shelf/Slope Exchange Processes	X	X	

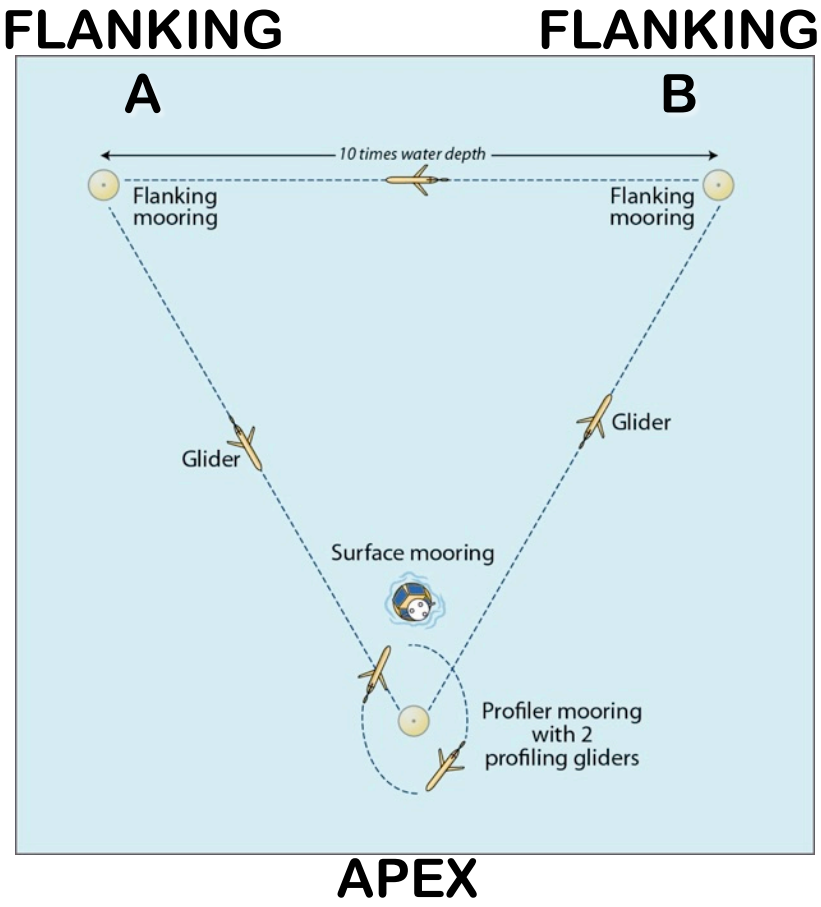
http://oceanobservatories.org/major-science-themes/

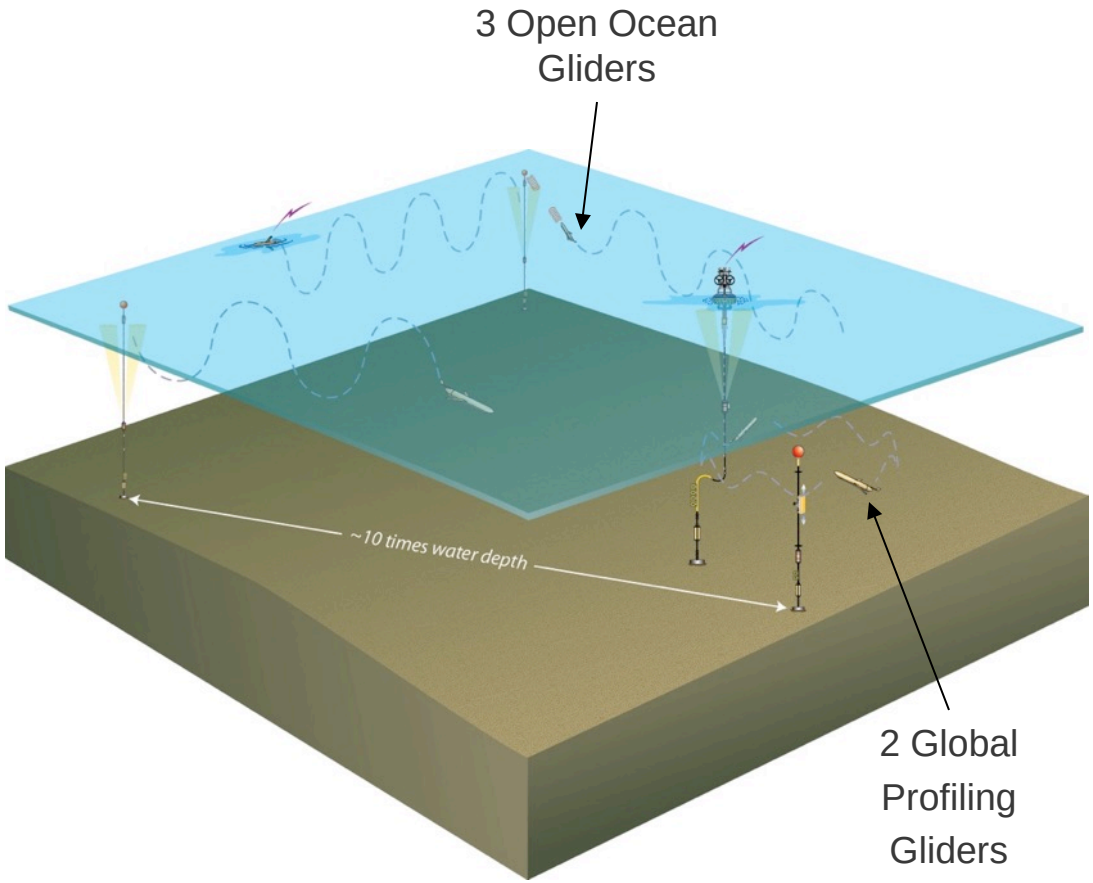
OOI Science Prospectus Oct 10, 2007

CGSN Overview



Global Array Configuration

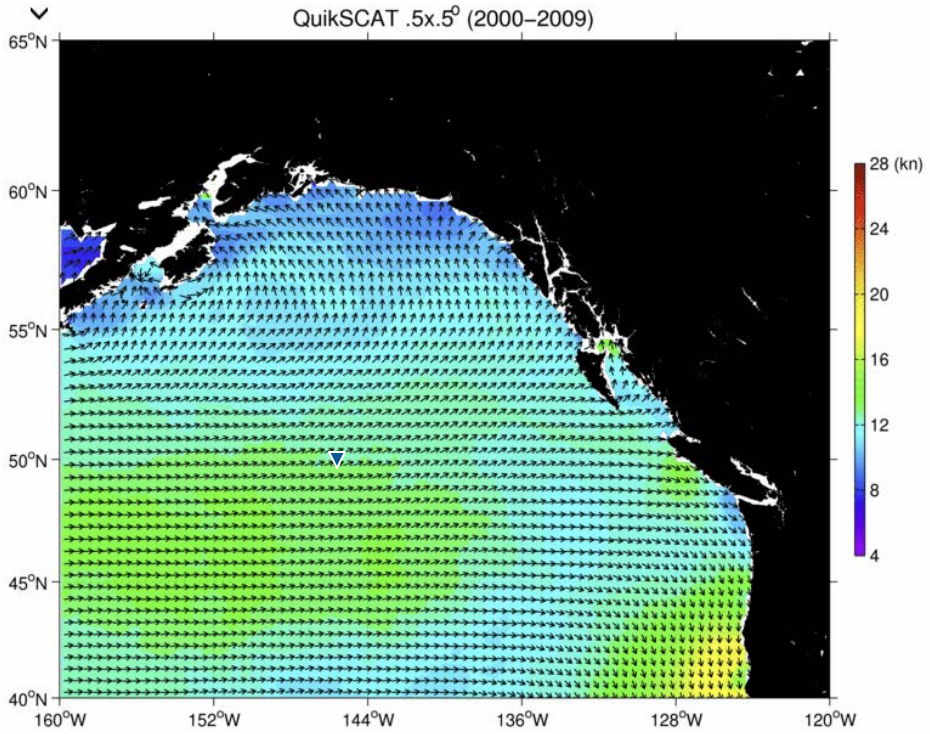




http://oceanobservatories.org/array/global-argentine-basin/

Global Station Papa Array

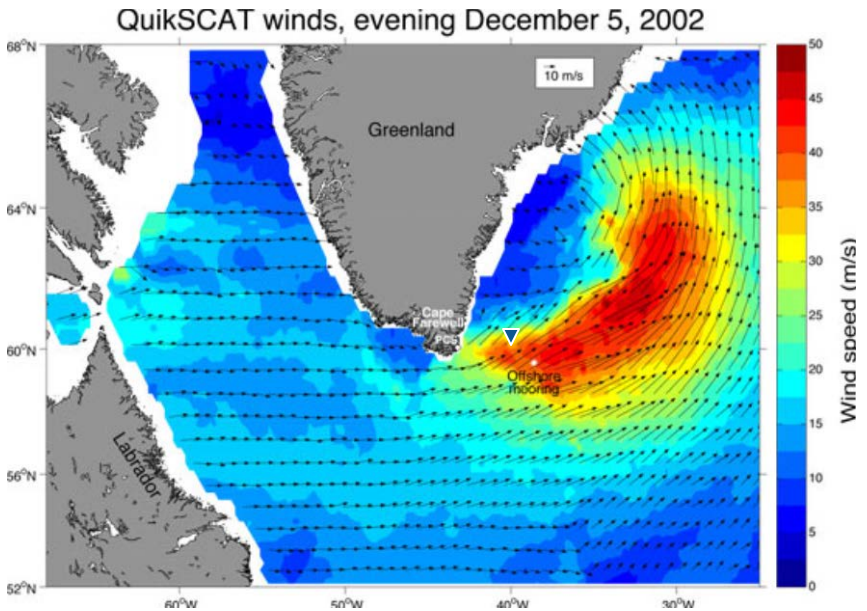
- 50° N, 145° W
  - Nominally 4250 m
  - Apex to the WSW
  - No OOI Surface Mooring
- Strong wind and waves
- Moderate to low eddy activity
- Long history of observation here (since 1949)



Station Papa Site Characterization Paper

Global Irminger Sea Array

- 60° N, 40° W
  - Nominally 2800 m
  - Apex to the NNE
  - Flanking Moorings inline with OSNAP moorings
- Strong wind and waves associated with tip jet
- High eddy activity
- North Atlantic Deep Water formed here

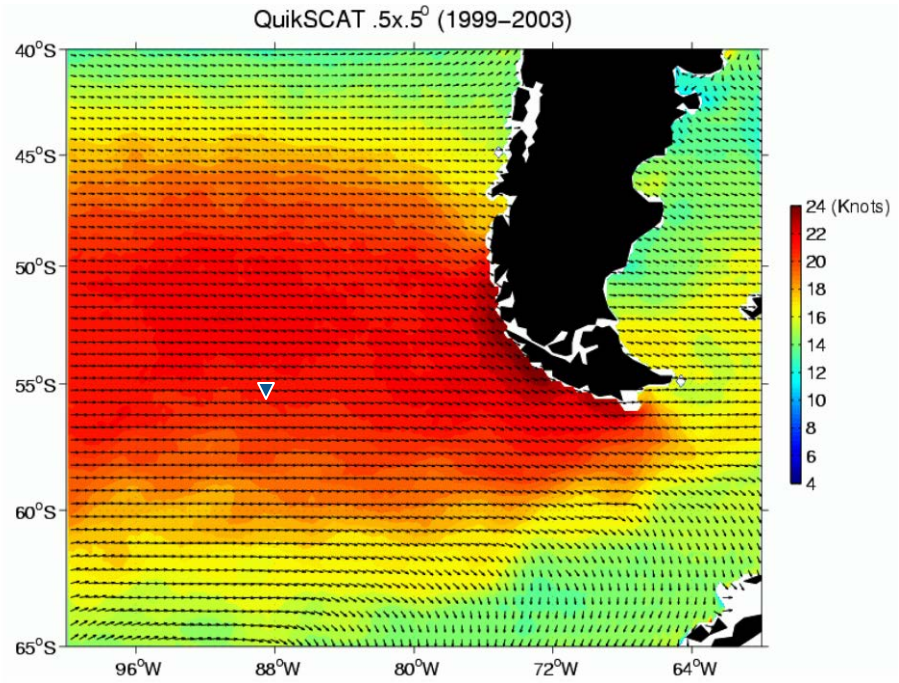


3202-00007 Irminger Sea Site Characterization Paper

Global Southern Ocean Array

- 55° S, 90° W
  - Nominally 4800 m
  - Apex to the South

- Strong wind and waves, strong atmospheric forcing
- Antarctic Intermediate Water formed here

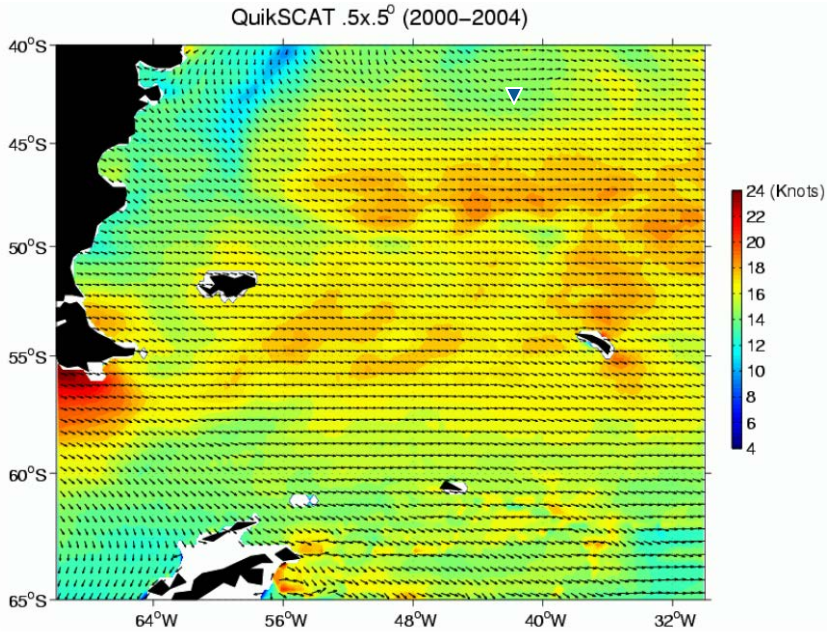


3201-00007 Southern Ocean Site Characterization Paper

Global Argentine Basin Array

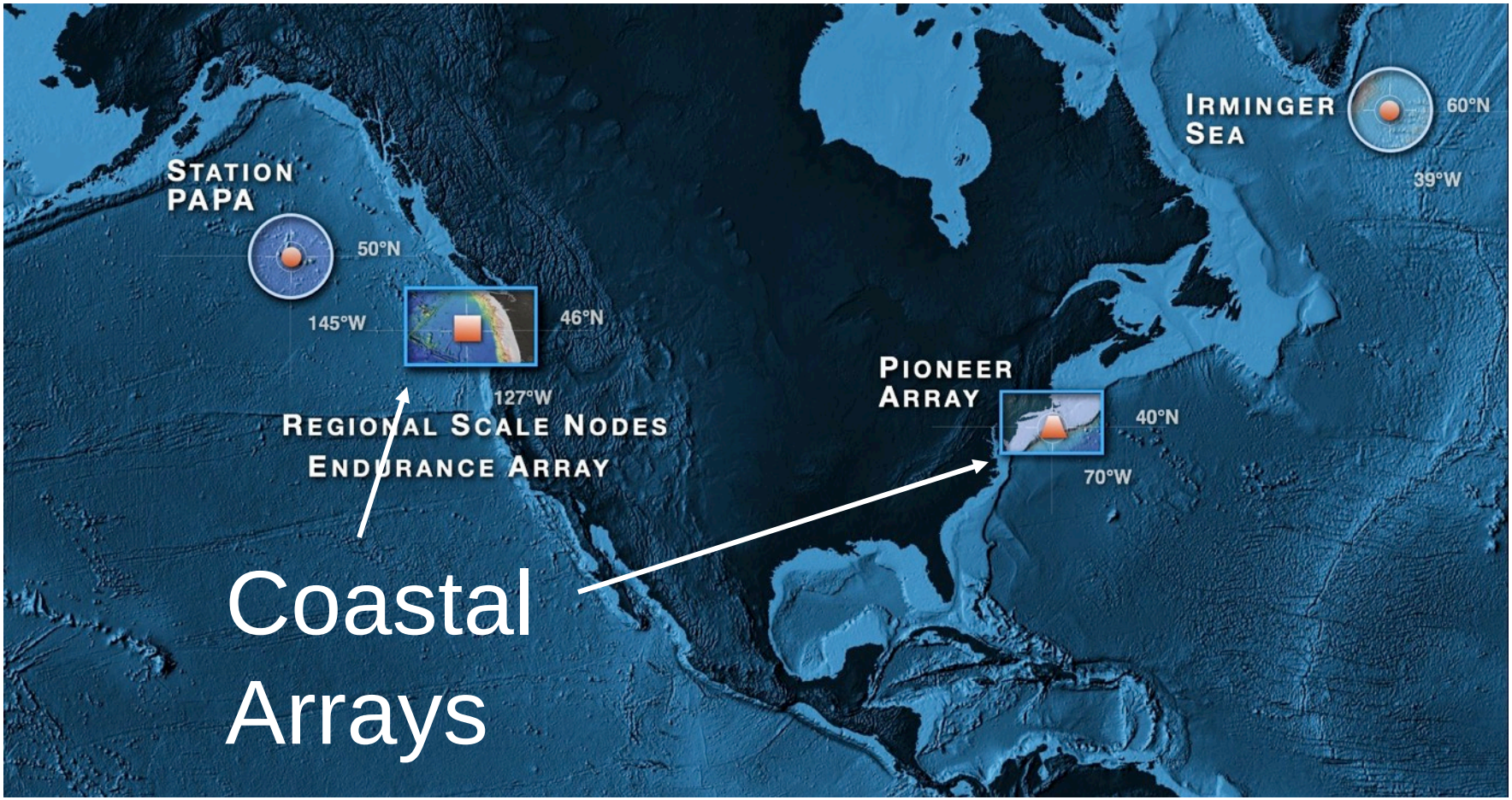
- 42° S, 42° W
  - Nominally 5200 m
  - Apex to the South

- Strong wind and waves, atmospheric forcing
- High eddy activity
- Bathymetric “mud waves” found here



3206-00007 Argentine Basin Site Characterization Paper

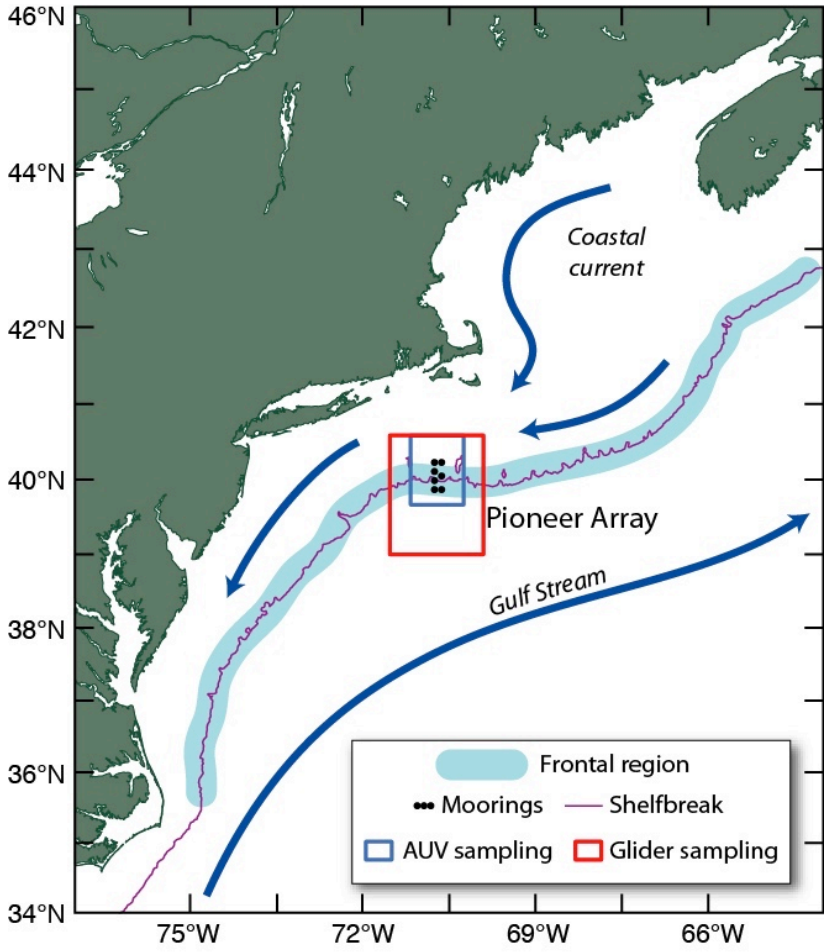
CGSN, EA Overview



Coastal Pioneer Array

- 40° N, 71’ W
- 91.5 m to 450 m

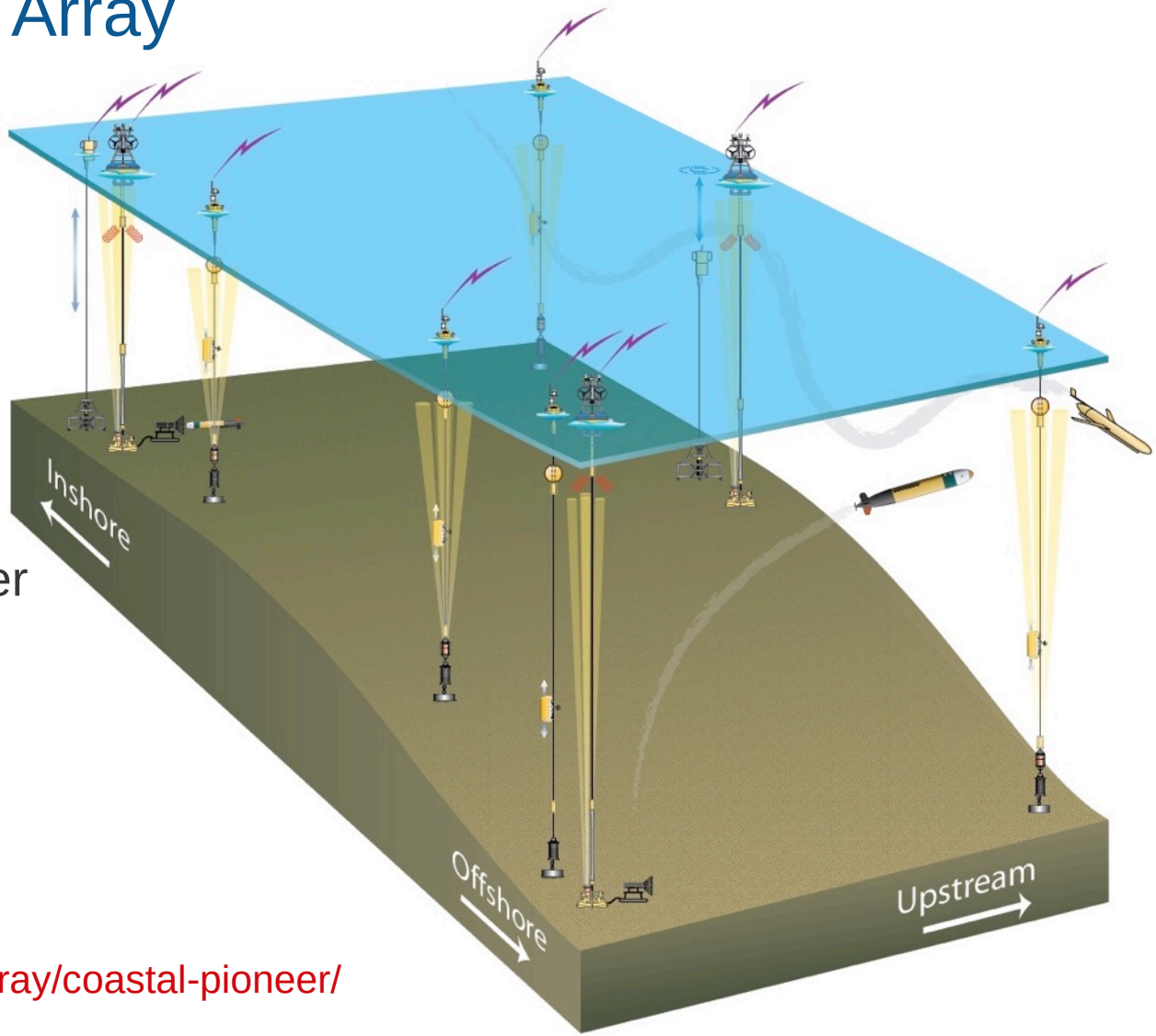
- Spans the shelfbreak front on the northwest Atlantic continental shelf



3204-00007 Pioneer Site Characterization Paper

Coastal Pioneer Array

- 3 Surface Mooring-Profiler pairs
  - 2 Coastal Surface Piercing Profilers
  - 1 Coastal Profiler Mooring
- 4 single Coastal Profiler Moorings
- 6 Coastal Gliders
- 2 AUVs

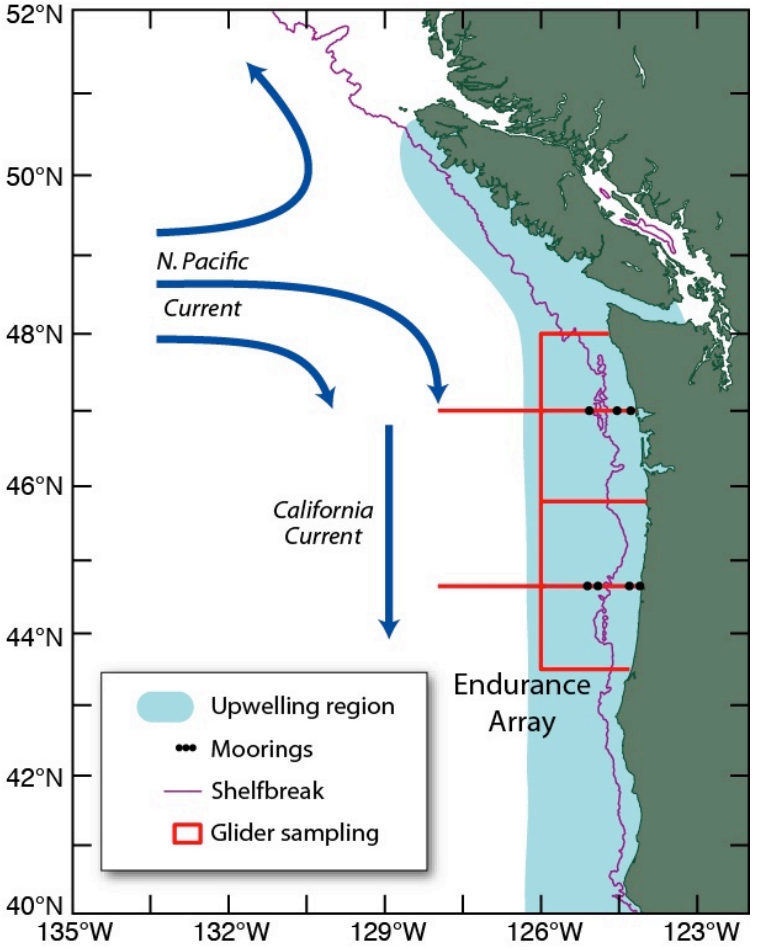


http://oceanobservatories.org/array/coastal-pioneer/

Coastal Endurance Array

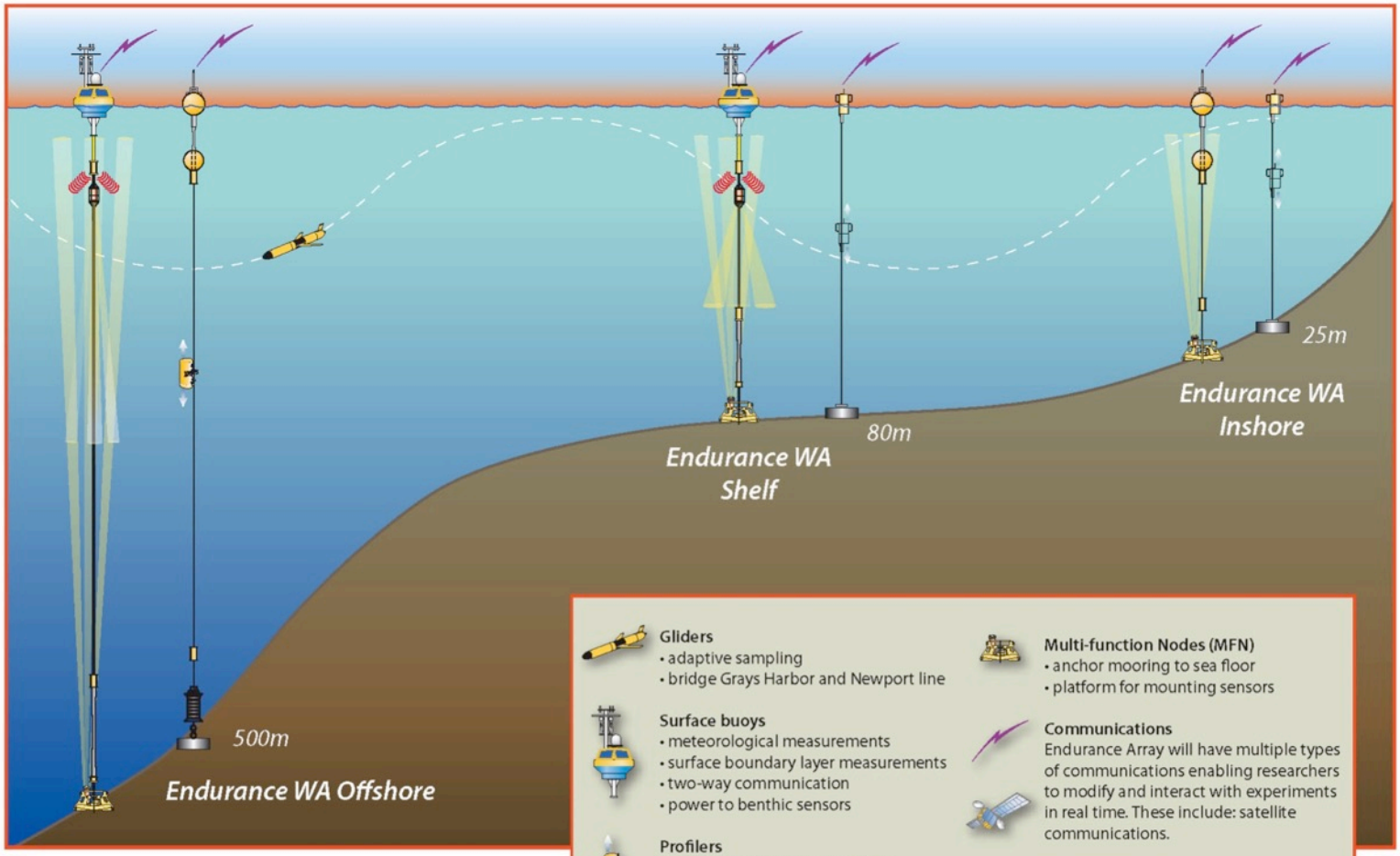
- WA line (~47° N)
  - 3 Surface Mooring-Profiler Mooring pairs
    - 2 Coastal Surface Piercing Profilers
    - 1 Coastal Profiler Mooring
- OR line (~44.5° N)
  - 3 Surface Mooring-Profiler Mooring pairs
    - 2 Coastal Surface Piercing Profilers
    - Cabled Shallow and Deep Profilers
- 6 Coastal Gliders

3205-00022 Endurance Site Characterization Paper



Coastal Endurance Array

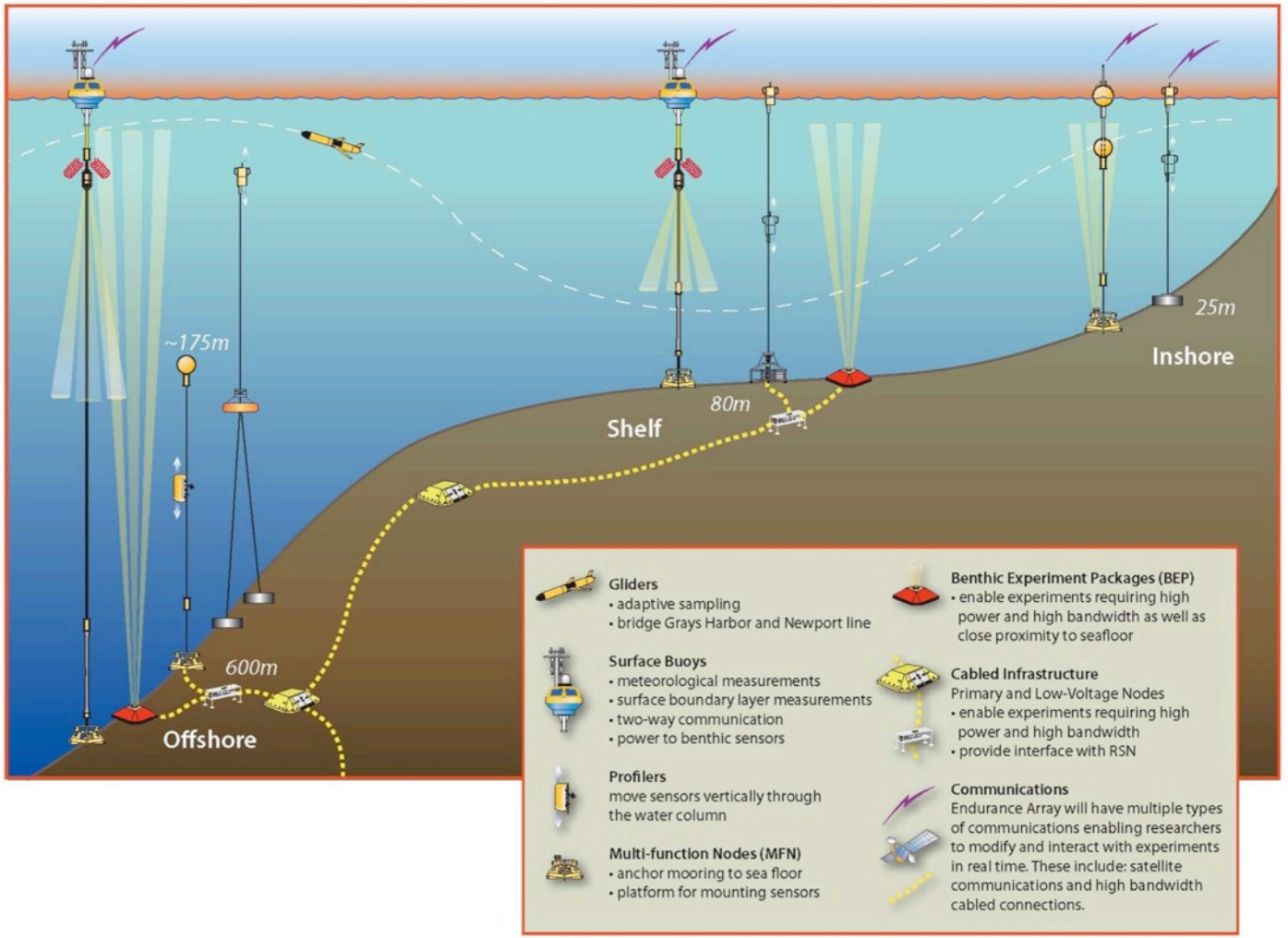
Washington Line



http://oceanobservatories.org/array/coastal-endurance/

Coastal Endurance Array

Oregon Line



CORE INSTRUMENTS DETAILS

http://oceanobservatories.org/instruments/

CGSN & EA Core Science Instruments

Instrument	OOI 5-Letter Code	Vendor	Model
Conductivity, Temperature, Depth (CTD)	CTDBP	SeaBird	SBE 16plusV2
	CTDMO	SeaBird	SBE 37-IM
	CTDPF	SeaBird	SBE 49, SBE 52MP
	CTDGV, CTDAV	SeaBird	SBE GP
Seafloor pressure	PRESF	SeaBird	SBE 26plus
Dissolved Oxygen	DOFST	SeaBird	SBE 43F
	DOSTA	Aanderaa	AADI optode 4831, 4330
Acoustic Doppler Current Velocity (ADCP)	ADCPA	Teledyne RDI	Explorer 600 DVL Navigator 600
	ADCPS, ADCPT	Teledyne RDI	WorkHorse, LongRanger
Single Point Velocity	VELPT	Nortek	Aquadopp
3-D Velocity	VEL3D	Nortek	Vector
Surface Wave Spectra	WAVSS	Axys Technologies	TRIAXYS
Direct Covariance Flux	FDCHP	WHOI	DCFS
Bulk Meteorology	METBK	Star Engineering	ASIMET

CGSN & EA Core Science Instruments, cont.

Instrument	OOI 5-Letter Code	Vendor	Model
Multi-Channel Fluorometer	FLORD	WET Labs	ECO Puck FLBB
	FLORT	WET Labs	ECO Triplet ECO Puck FLBBCD ECO Puck BB3
Optical Attenuation and Absorption	OPTAA	WET Labs	AC-S
Photosynthetically Available Radiation (PAR)	PARAD	WET Labs	ECO PAR
	PARAD	Biospherical	QSP
Spectral Irradiance	SPKIR	Satlantic	OCR507
Nitrate	NUTNR	Satlantic	ISUS SUNA
Partial Pressure of CO2 in Air & Water	PCO2A	Pro-Oceanus	pCO2-PRO with ATM
Partial Pressure of CO2 in Water	PCO2W	Sunburst Sensors	SAMI-CO2
pH	PHSEN	Sunburst Sensors	SAMI-pH
Bio-Acoustic Sonar	ZPLSC	ASL Environmental	AZFP
	ZPLSG	ASL Environmental	AZFP
Camera	CAMDS	Kongsberg	

CGSN & Uncabled-EA Instrument Interfaces

- Power
  - Self-Powered (alkaline or Li batteries)
  - Powered by infrastructure (on Moorings, 12 or 24 VDC)*
- Communications
  - Self-Recording
  - Inductive comms
  - Serial or Ethernet direct connection
- Mounting
  - Custom clamps for mounting to infrastructure (tower, buoy, frames, etc.)
  - Clamping to inductive wire rope
- Sampling strategies
  - 1102-00200 OOI Observation and Sampling Approach

***Data Concentrator/Logger (DCL)** – Surface Mooring controller electronics package that provides power (12 or 24 VDC) and data logging capabilities; data transmitted to shore via satellite

MOORING DETAILS

Mooring Details

- Mooring Types
  - With Surface Expression
    - Coastal Profiler Moorings
    - Coastal Surface Moorings
    - Global Surface Moorings

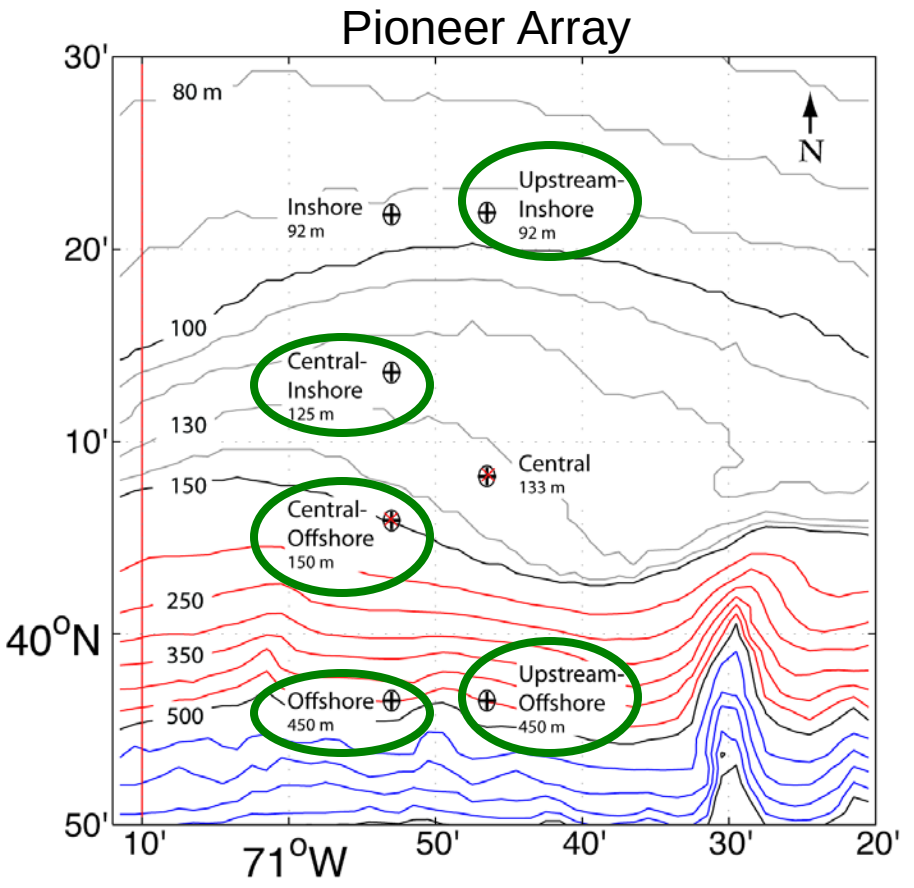
Common design:
- Power generation on Surface mooring
- Platform control/data logging
- Satellite and line-of-sight communications

  - Subsurface Moorings
    - Global Profiler Moorings
    - Global Flanking Moorings

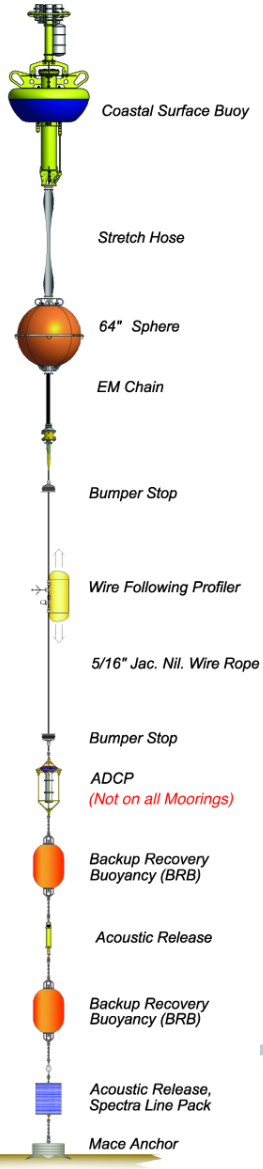
Common design:
- Battery powered
- Low-power platform control/data logging
- Acoustic communications

Coastal Profiler Moorings

- Moorings with Wire Following Profilers (WFP; McLane MMP)
- 5 moorings at Pioneer
  - Central Inshore (125 m)
  - Central Offshore (150 m)
  - Upstream Inshore (91.5 m)
  - Upstream Offshore (450 m)
  - Offshore (450 m)
- 1 mooring at Endurance
  - WA line Offshore site (542 m)

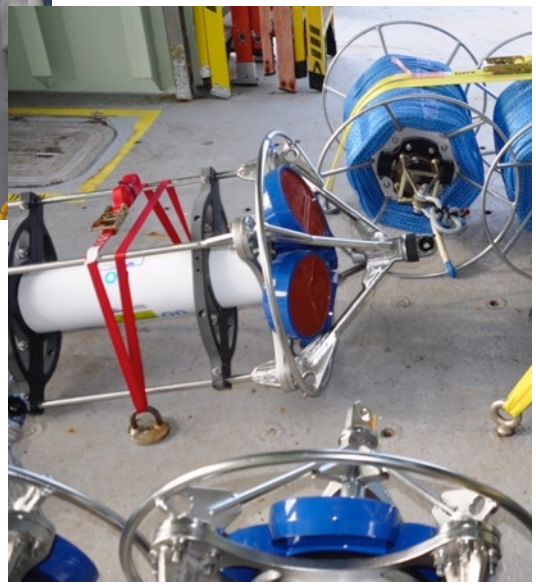


Coastal Profiler Mooring

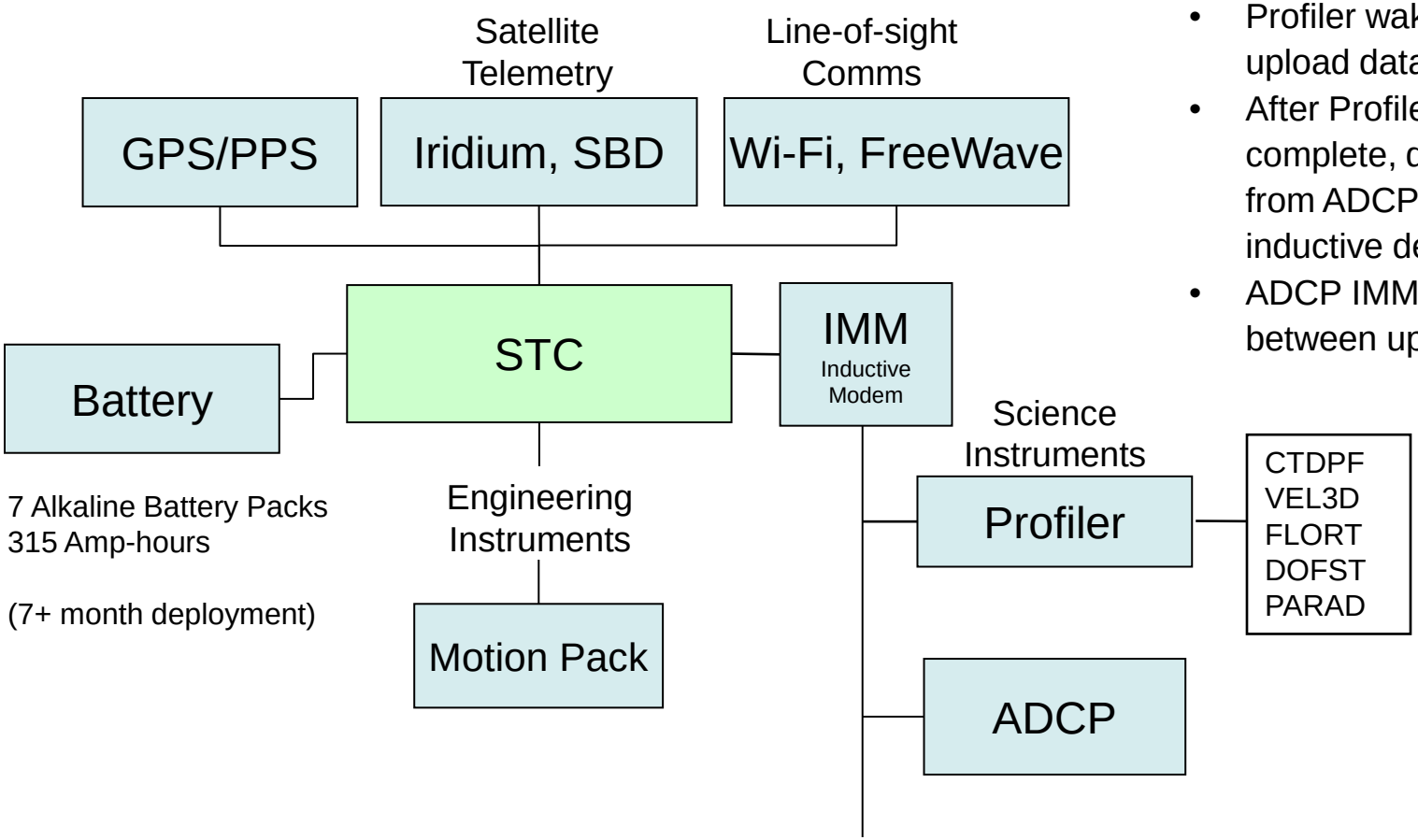


Sub-System	Coastal Profiler Mooring Configuration
Surface Buoy	Submersible Surface Buoy
Platform Control	Sensor & Telemetry Controller (STC)
Telemetry	Iridium 9522, Iridium SBD, Freewave, Wi-Fi, inductive modem
Power System	Primary Batteries
Mooring Riser	EM stretch hose, Sub-surface float, Inductive Wire, Anchor with Release Line Pack
Profiler	McLane Moored Profiler
Instruments *(5-6 total)*	CTDPF, DOFST, FLORT, PARAD, VEL3D on profiler ADCP mounted in in-line frame *(not on all)*

Coastal Profiler Moorings



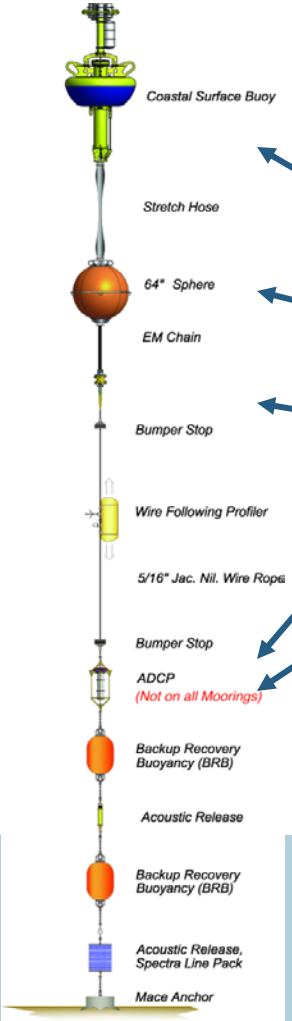
Coastal Profiler Mooring Controller & Telemetry



Concept of operations

- Profiler wakes up STC to upload data
- After Profiler upload is complete, data is retrieved from ADCP and other future inductive devices
- ADCP IMM buffers data between uploads

Coastal Profiler Mooring Instrument Locations

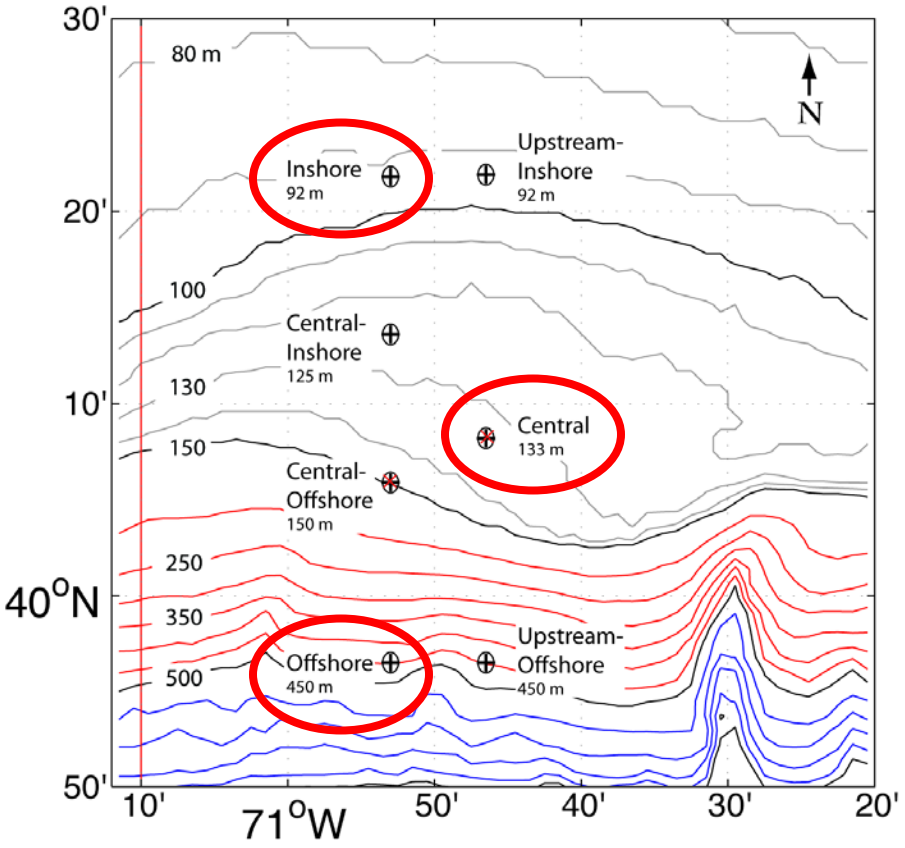


- Instruments can be mounted in the following locations
  - On the submersible surface buoy
  - On the 64” sphere (~20 m depth)
  - On the inductive line above the top profiler stop or below the bottom profiler stop
  - In the ADCP frame
- Adding instrumentation to the profiler would require a design change of the profiler by McLane

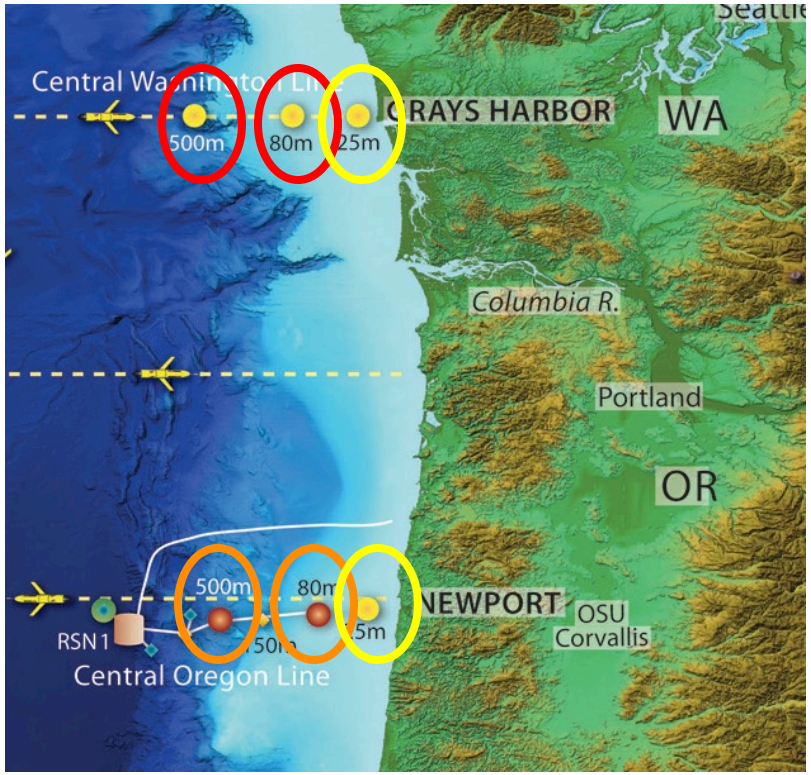
NOTE: Addition of instruments in any location requires reanalysis of mooring design due to added weight/drag

Coastal Surface Moorings

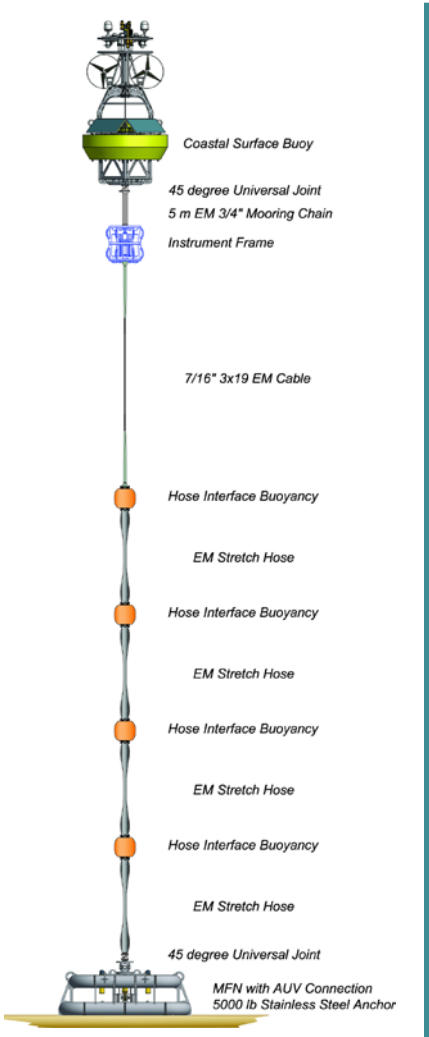
Three at Pioneer Array



Six at Endurance Array

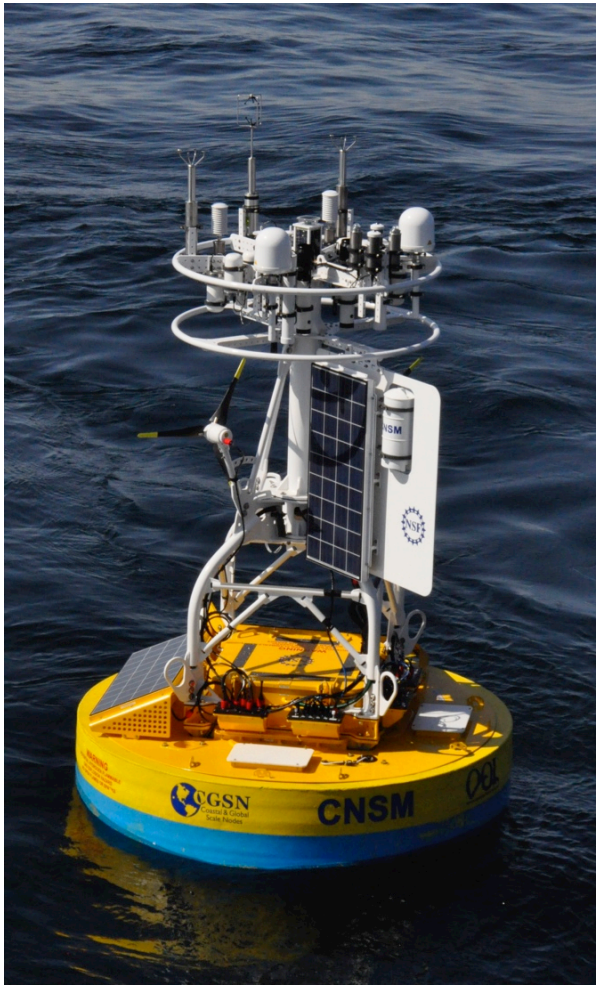


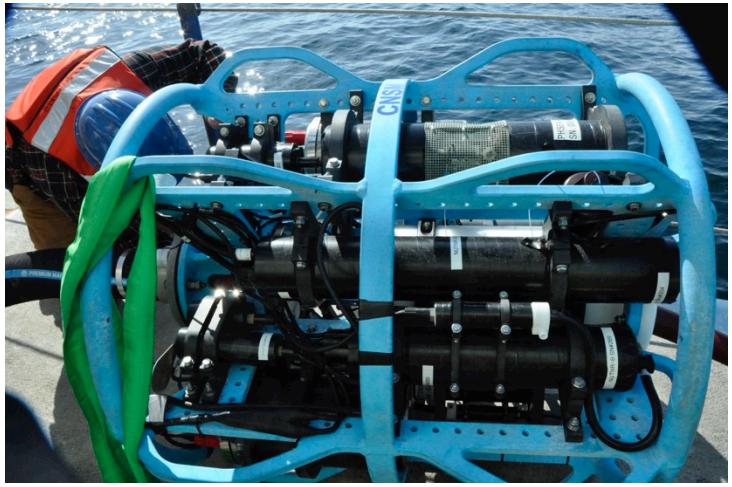
Coastal Surface Moorings



Sub-System	Coastal Surface Mooring Configuration	
Surface Buoy	Submersible Buoy	Coastal Surface Buoy
Platform Control	CPM/DCL Controller	
Telemetry	**Satellite:** Fleet BroadBand, Iridium 9522, Iridium SBD **Line-of-Sight:** Freewave, Wi-Fi **Subsurface:** acoustic modem	
Power System	Batteries in Buoy & MFN	Wind Turbines, Solar Panels, Rechargeable Batteries
Mooring Riser	EM Chain, Near Surface Instrument Frame, EM Cable, EM Stretch Hose	
Multi-Function Node	Benthic Anchor Recovery Frame w/ Power, PlatCon and Instruments	Benthic Anchor Recovery Frame
Instruments *(13-23 total)*		**Buoy:** METBK, PCO2A, WAVSS, VELPT, FDCHP
	NSIF: CTDBP, DOSTA, PHSEN, NUTNR, VELPT, ADCPT, FLORT, OPTAA, SPKIR	
	MFN: CTDBP, DOSTA, PHSEN, PCO2W, PRESF, VEL3D, ADCPT, OPTAA, CAMDS, ZPLSC	*(None at Oregon Shelf and Offshore sites)*

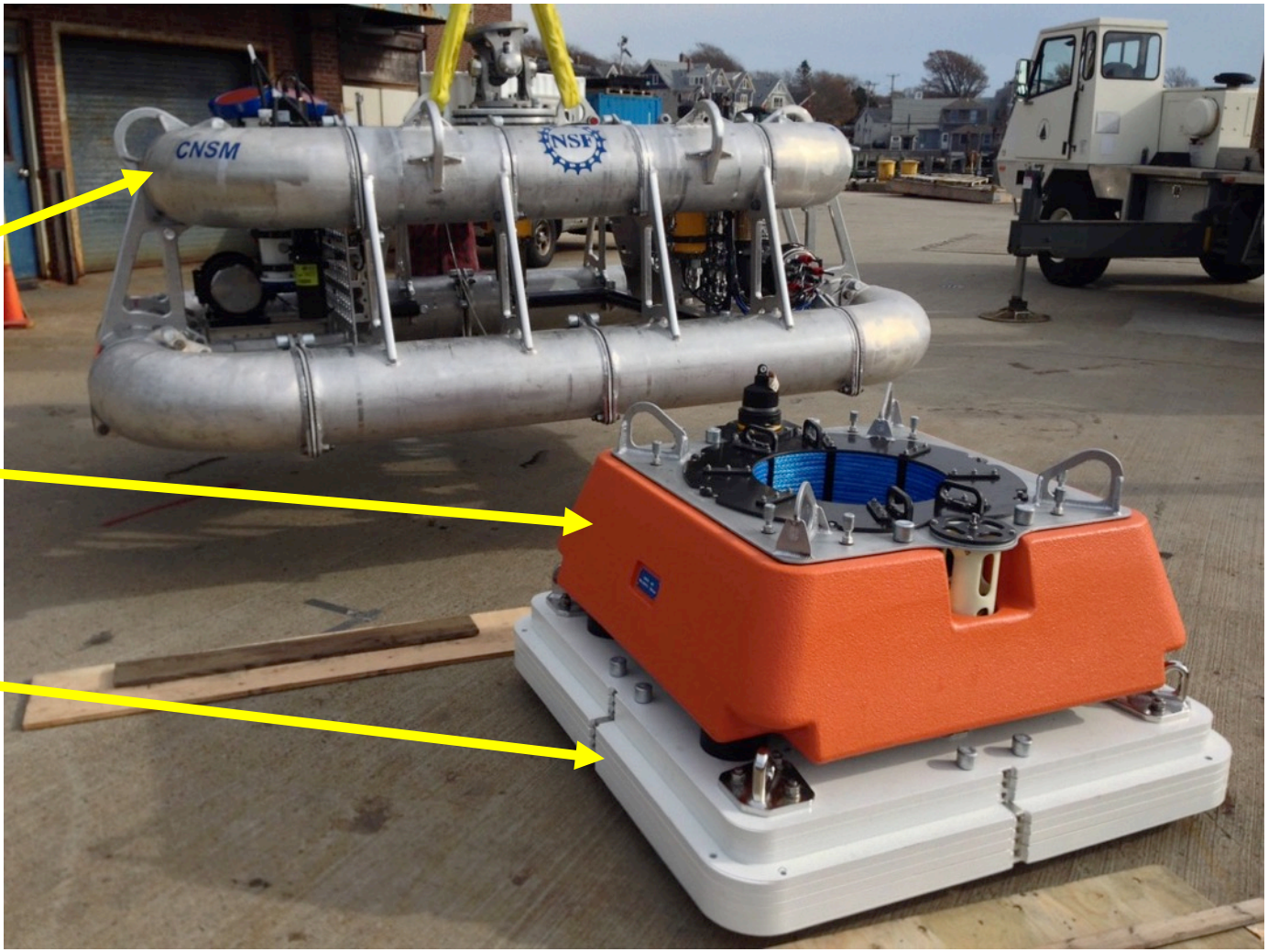
Coastal Surface Moorings





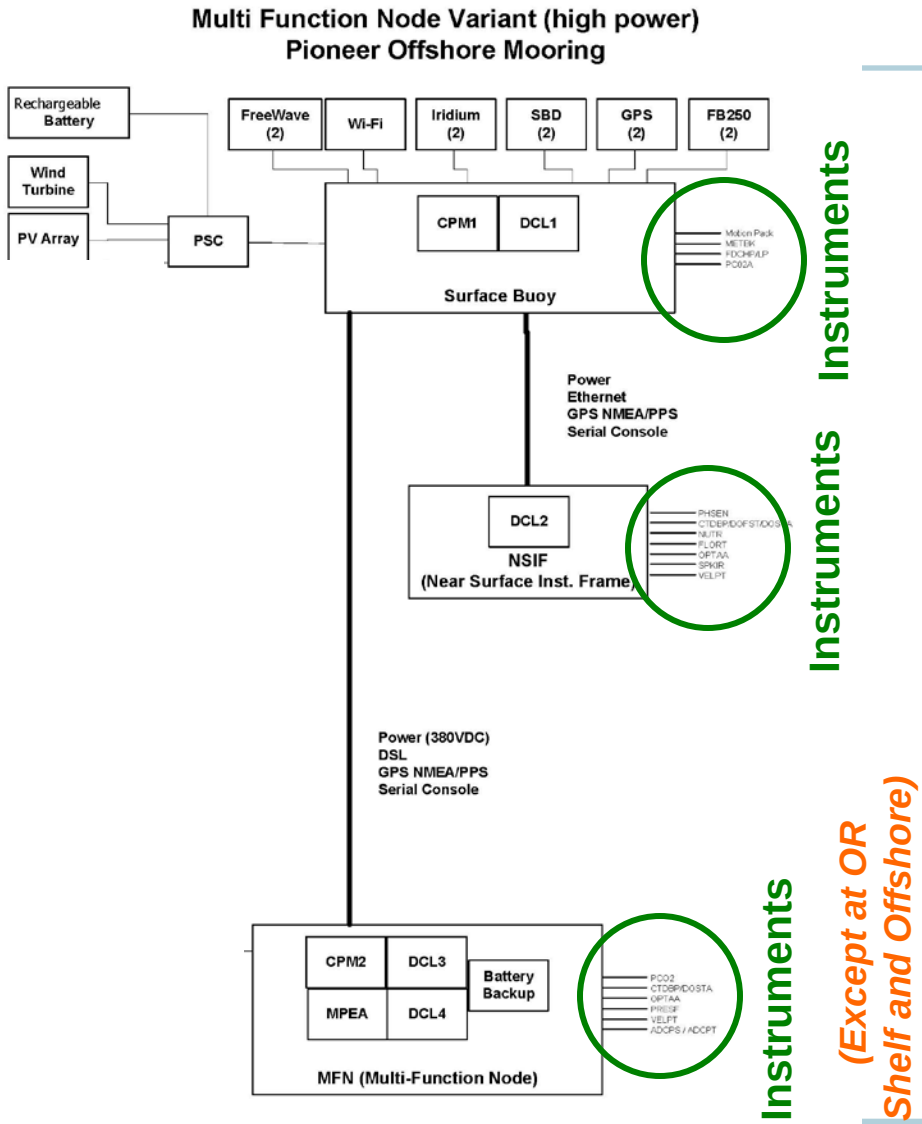
Multi-Function Node (MFN)

- Modular frame provides buoyancy
- Anchor Recovery Module (ARM)
- 3000 kg deadweight anchor



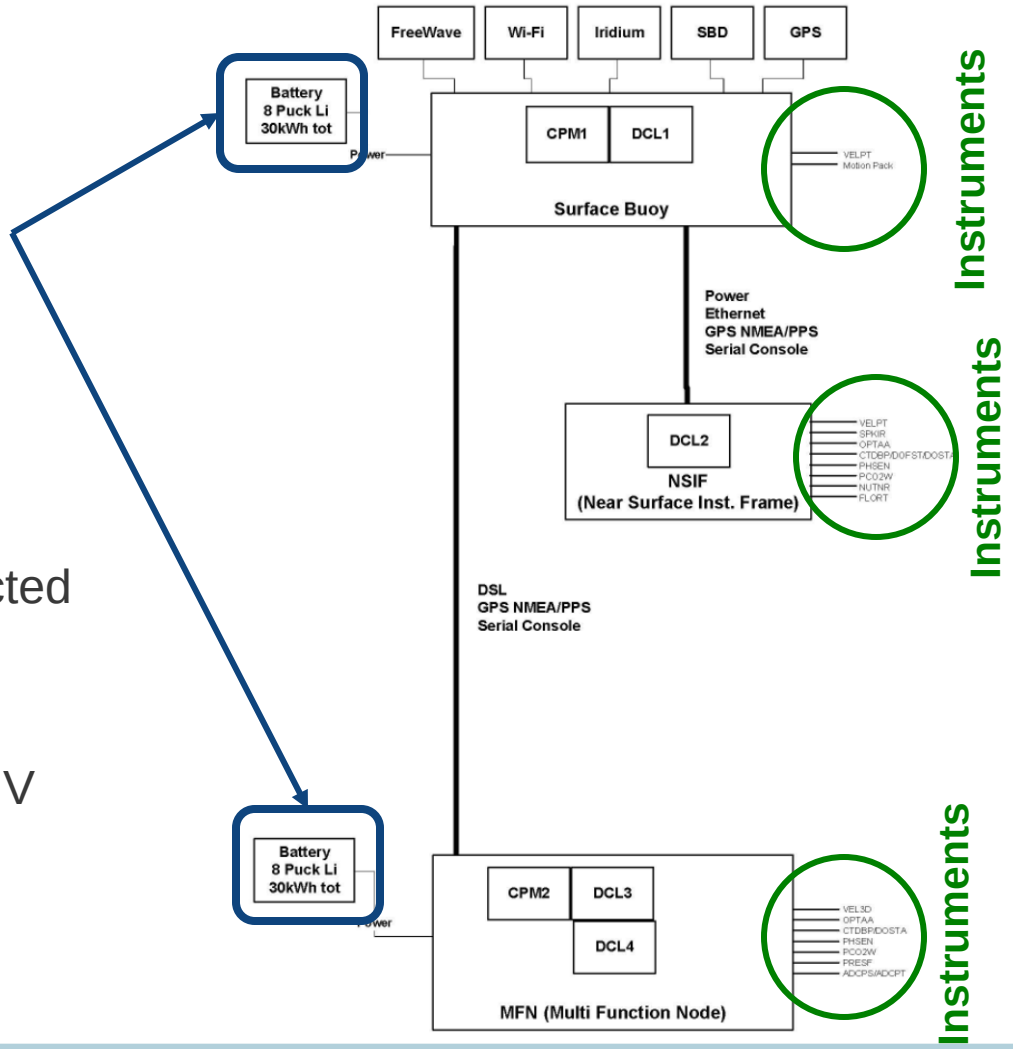
Coastal Surface Mooring

- Power
  - Wind Turbines (2)
  - Solar Panels (4)
  - Rechargeable Batteries
- Communications
  - Duplicate telemetry
- Instruments
  - Instruments mounted/connected to buoy, NSIF (5 m) or MFN (seafloor)
  - DCLs can provide 12V or 24 V to instruments
  - Serial or Ethernet communications

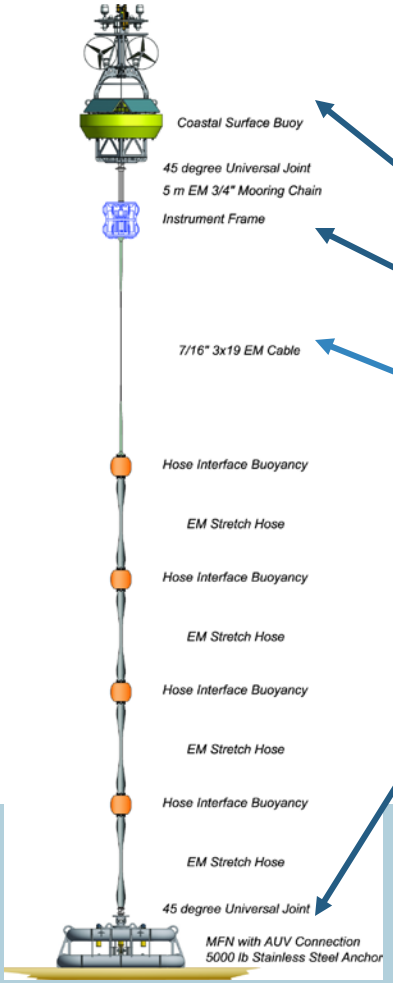


Coastal Surface Mooring

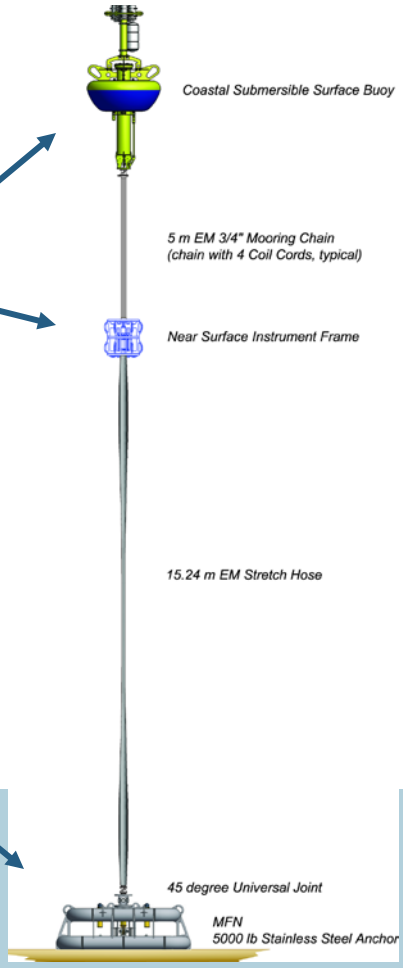
- Power
  - Lithium batteries in buoy and MFN
- Communications
  - Single telemetry
  - No FleetBroadband
- Instruments
  - Instruments mounted/connected to buoy, NSIF (5 m) or MFN (seafloor)
  - DCLs can provide 12V or 24 V to instruments
  - Serial or Ethernet communications



Coastal Surface Mooring Instrument Locations

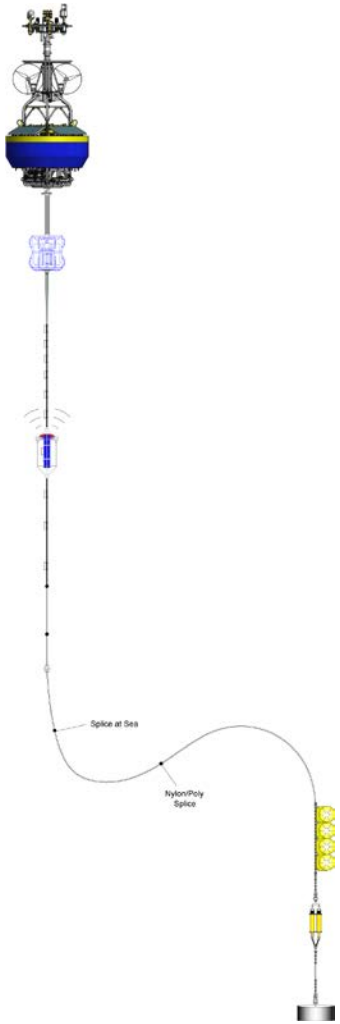


- Instruments can be mounted in the following locations
  - On the surface or submersible buoy
  - On the Near Surface Instrument Frame
  - On deeper moorings (>100 m) instruments could be clamped to EM Cable (no power/comms available)
  - On the Multi-Function Nodes



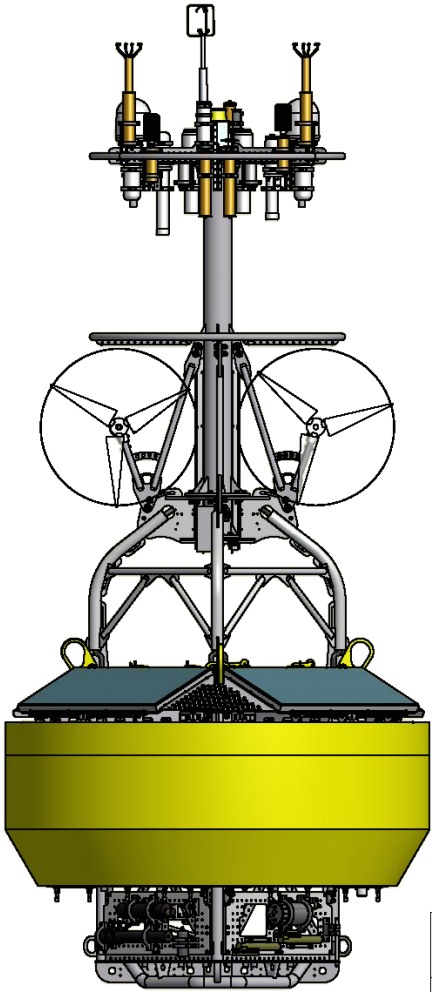
NOTE: Addition of instruments in any location requires reanalysis of mooring design due to added weight/drag

Global Surface Mooring

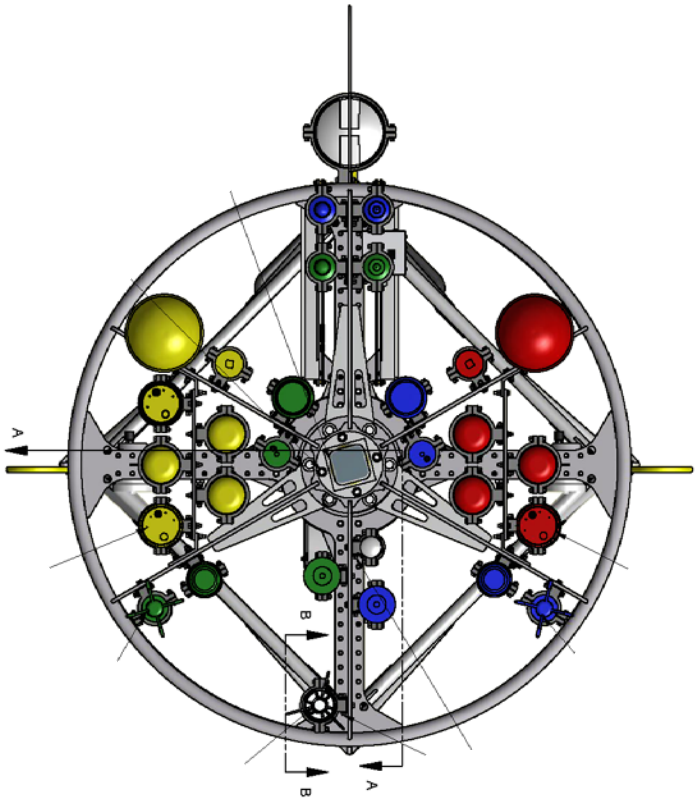


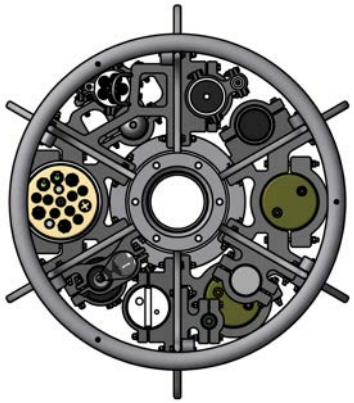
Sub-System	Global Surafce Mooring Configuration
Surface Buoy	Global Surface Buoy
Platform Control	CPM/DCL Controller
Telemetry	Fleet BroadBand (2), Iridium 9522 (2), Iridium SBD (2), Freewave (2), Wi-Fi, inductive modem, acoustic modem
Power System	Wind Turbines (2), Solar Panels (4), Rechargeable Batteries
Mooring Riser	EM Chain, NSIF, Inductive Wire, Acoustic Release
Instruments *(43 total)*	**Buoy:** METBK (2), FDCHP, SPKIR, PCO2A, WAVSS, OPTAA, FLORT, NUTNR, DOSTA **NISF:** CTDBP, VELPT, FLORT, DOSTA, OPTAA, NUTNR, PCO2W, SPKIR **Inductive Wire:** CTDMO (10), CTDBP (3), DOSTA (3), FLORD (3), PCO2W (3), PHSEN (2), ADCPS

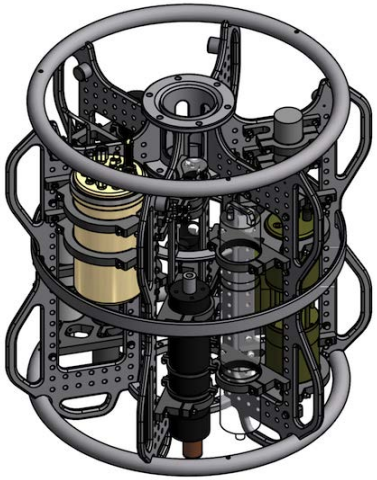
Global Surface Moorings



*	INSTRUMENT PAC	CONFIGURATION DR
	TELEMETRY 1	3701-00516
	TELEMETRY 2	3701-00517
	DUAL METBK 1	3701-00518
	DUAL METBK 2	3701-00519

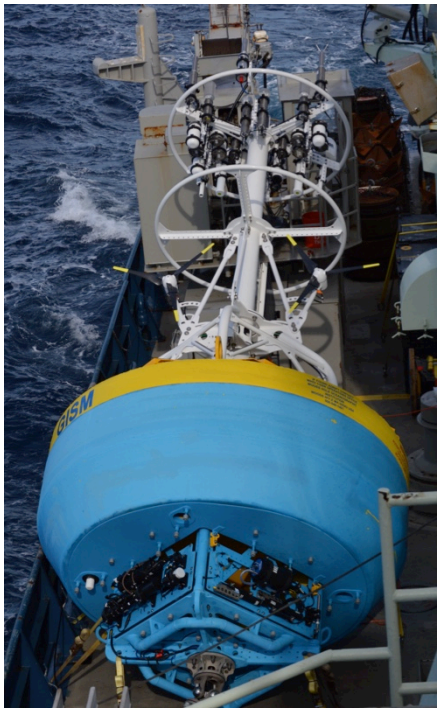






Global Surface Mooring

- Standard Power Surface Moorings
  - Power and Communications the same as the Coastal Standard Power Surface Moorings
  - No power transmitted below the NSIF
  - Only inductive communications below the NSIF

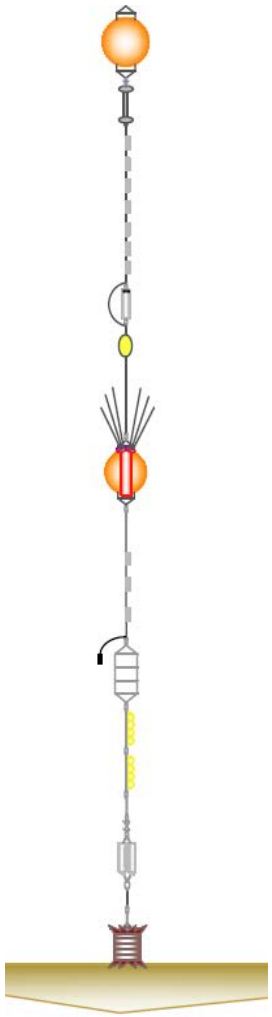


Global Surface Mooring Instrument Locations

- Instruments can be mounted in the following locations
  - On the surface buoy (Tower or bottom frame)
  - On the Near Surface Instrument Frame (~15 m depth)
  - Clamped on the inductive line (down to 1500 m depth)
  - In the ADCP frame at 500 m
    - ✦ Anything mounted below 1500 m will not have inductive comms

NOTE: Addition of instruments in any location requires reanalysis of mooring design due to added weight/drag

Global Flanking Mooring



Sub-System	Flanking Mooring Configuration
Platform Control	Main Controller in lower load cage Secondary Controller in upper 64” sphere
Telemetry	Inductive modem Acoustic modem (data to shore via glider)
Power System	Primary Batteries
Mooring Riser	64” Sphere, Inductive Wire Rope to 1500 m, In-line release, ADCP Flotation Sphere, Load Cage, Glass Spheres, Anchor with Release Line Pack
Instruments *(16-24 total)*	CTDMO, DOSTA, FLORT, PHSEN in 64” Sphere CTDMO (10) on inductive line ADCP, CTDMO in Flotation Sphere at 500 m *4 CTDMO/VELPT pairs on Irminger Flanking Moorings*

Global Flanking Mooring

Global Flanking Mooring Block Diagram

- Secondary Controller
- FLORD
- PHSEN
- DOSTA
- CTDMO

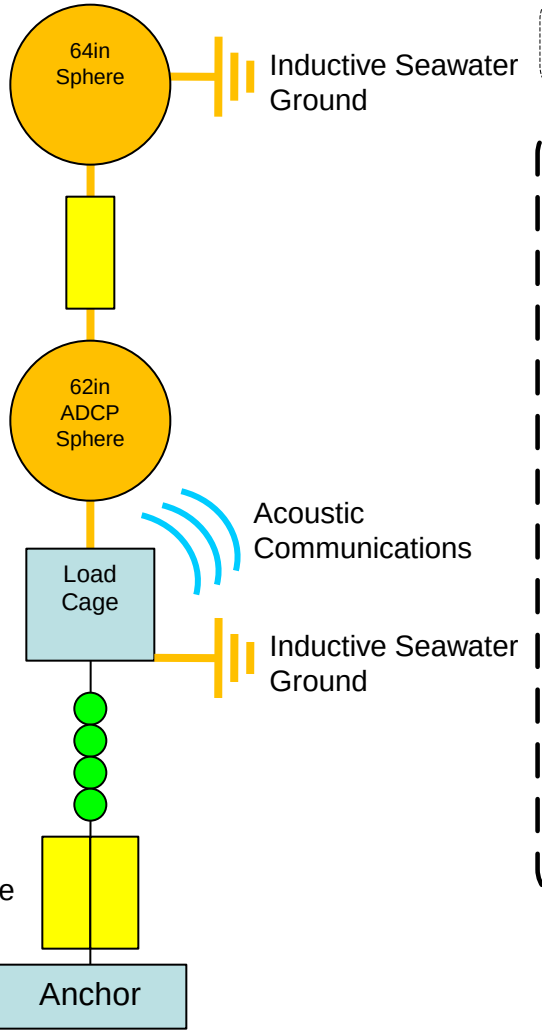
- Acoustic Release

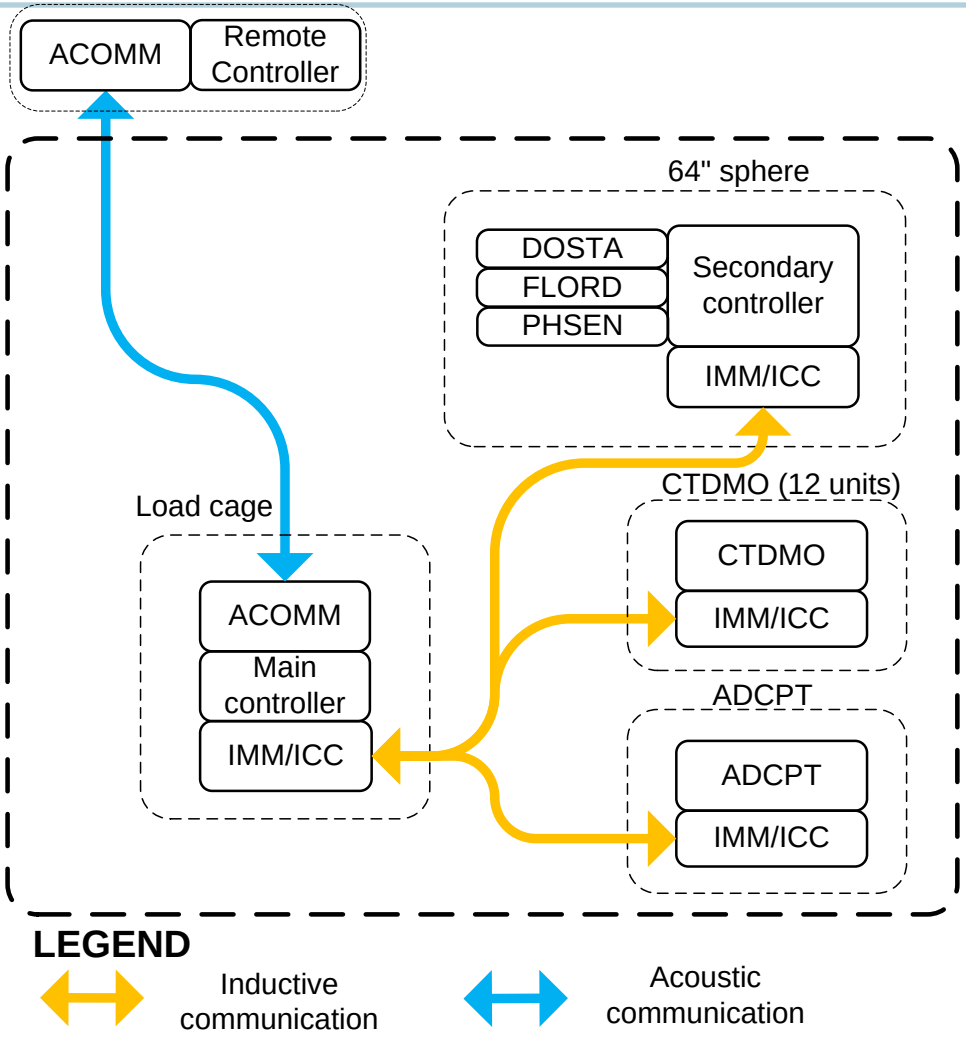
- ADCPS

- Main Controller
- ACOMM
- Inductive Modem

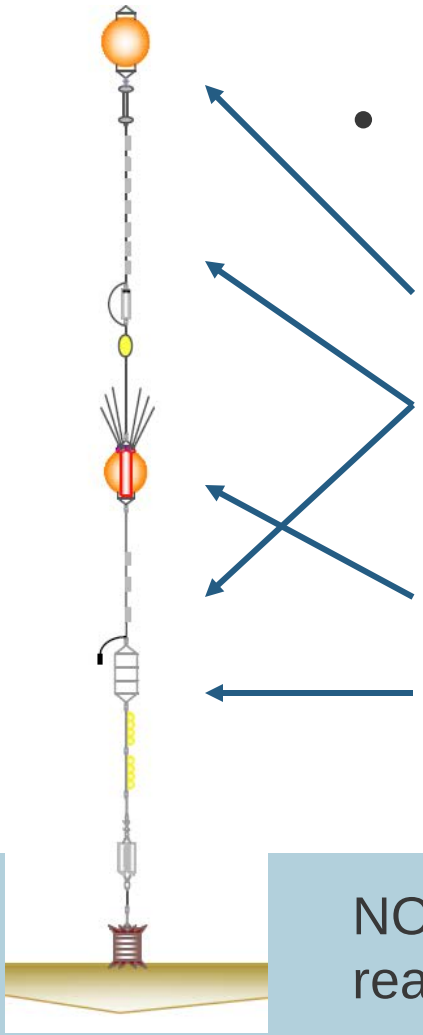
- Glass Balls (17in)

- Dual Acoustic Release





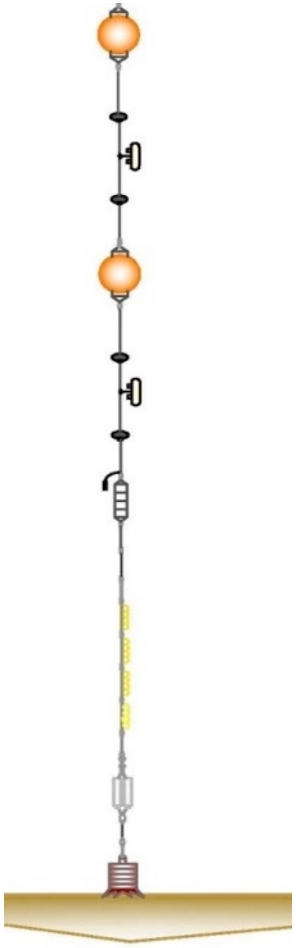
Global Flanking Mooring Instrument Locations



- Instruments can be mounted in the following locations
  - On/in the 64” sphere (~30 m)
  - Clamped on the inductive line (down to 1500 m depth)
  - In the ADCP sphere at 500 m
  - In the Load Cage

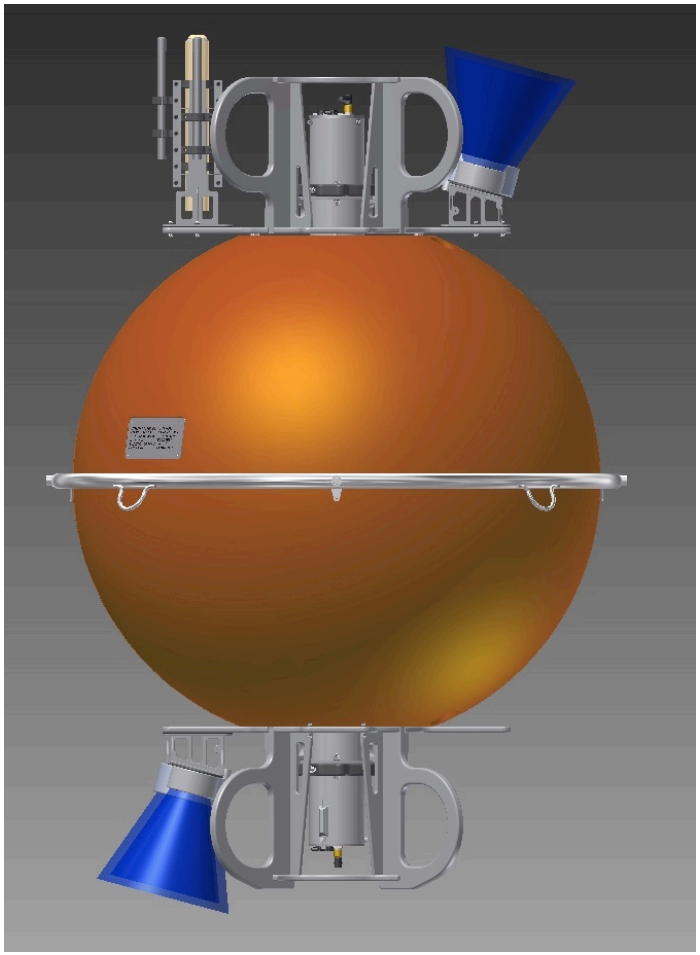
NOTE: Addition of instruments in any location requires reanalysis of mooring design due to added weight/drag

Global Profiler Mooring



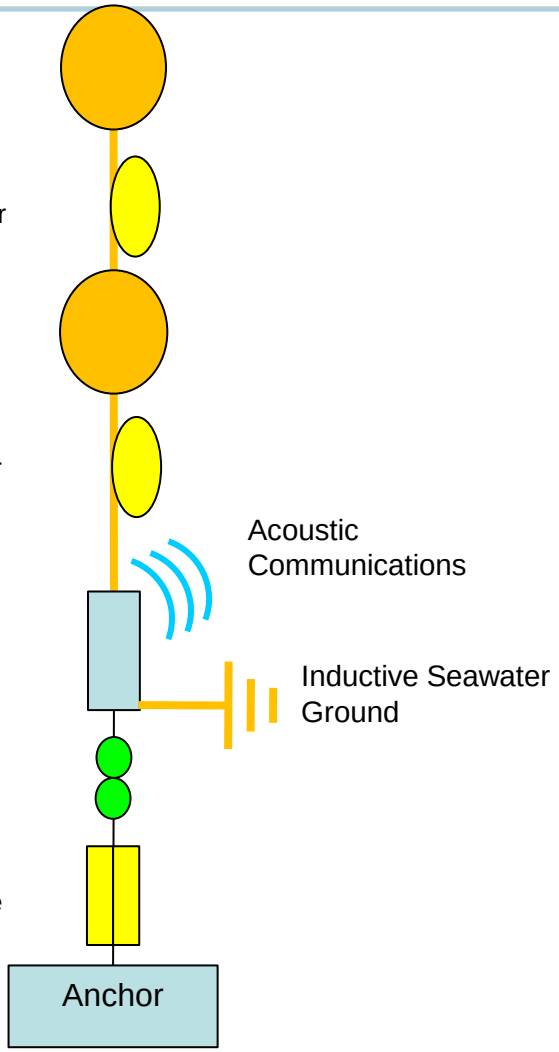
Sub-System	Global Profiler Mooring Configuration
Platform Control	Main Controller in lower load cage
Telemetry	Inductive modem Acoustic modem (data to shore via glider)
Power System	Primary Batteries
Mooring Riser	64” Sphere, Inductive Wire Rope, In-line Release, Mid-water Flotation Sphere, Inductive Wire Rope, Load Cage, Glass Spheres, Anchor with Release Line Pack
Profiler	McLane Moored Profiler 2 (upper and lower) – *except at Irminger*
Instruments *(7-11 total)*	CTDPF, DOSTA, FLORD, VEL3D on profiler(s) ZPLSG (2) mounted in 64” Sphere CTDMO mounted on inductive rope above WFP

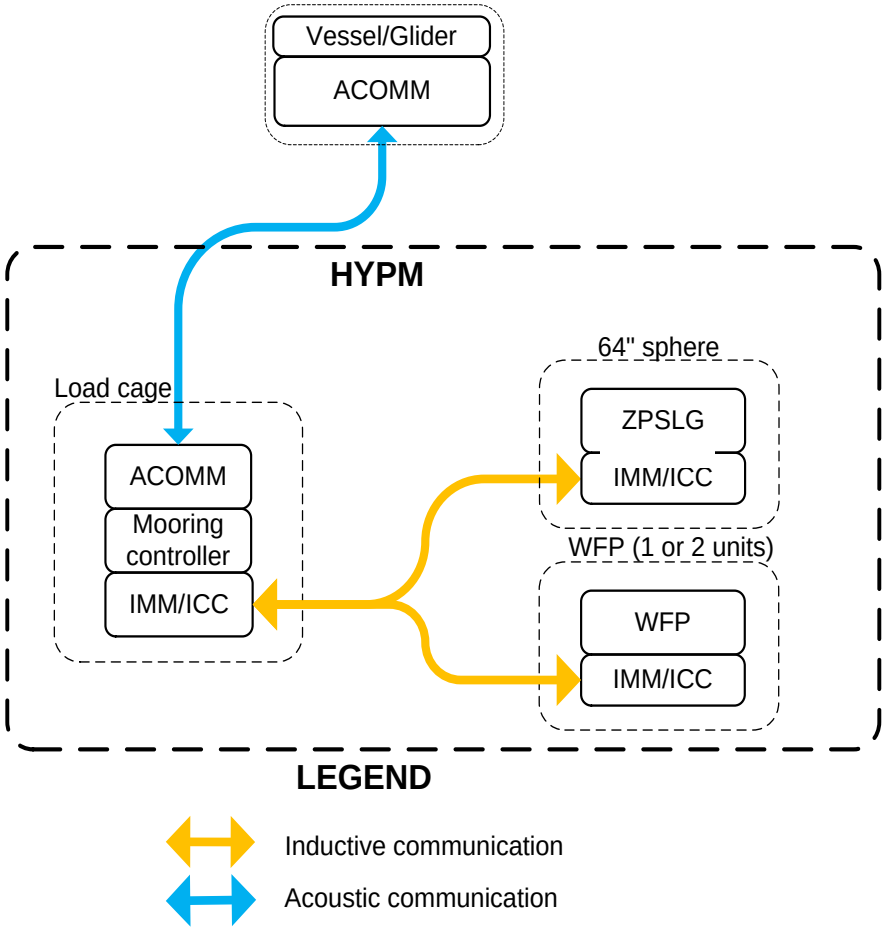
Global Profiler Mooring



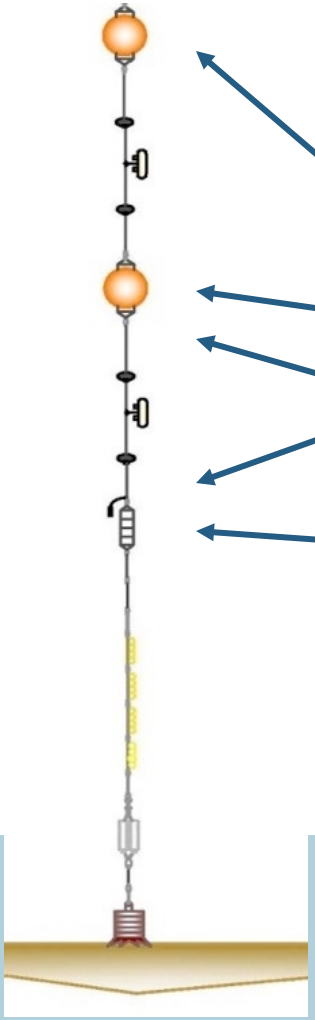
Global Profiler Mooring Block Diagram

- 64” Sphere
- Bio-Acoustic Sonar
- Wire Following Profiler
- 51” or 62” sphere
- Wire Following Profiler
- Load Cage
- Controller
- ACOMM
- Inductive Modem
- Glass Balls (17in)
- Dual Acoustic Release





Global Profiler Mooring Instrument Locations



- Instruments can be mounted in the following locations
  - On the upper 64” sphere (~150 m depth)
  - On the mid-water sphere
  - On the inductive line above the top profiler stop or below the bottom profiler stop
  - In the Load Cage
- Adding instrumentation to the profilers would require a design change by McLane

NOTE: Addition of instruments in any location requires reanalysis of mooring design due to added weight/drag

VEHICLE DETAILS

Coastal Surface Piercing Profiler

- WET Labs AMP
  - Instruments

    CTDPF – SBE 49 CTD

    DOSTA – Aanderaa 4831 optode

    SPKIR – Satlantic OCR 507

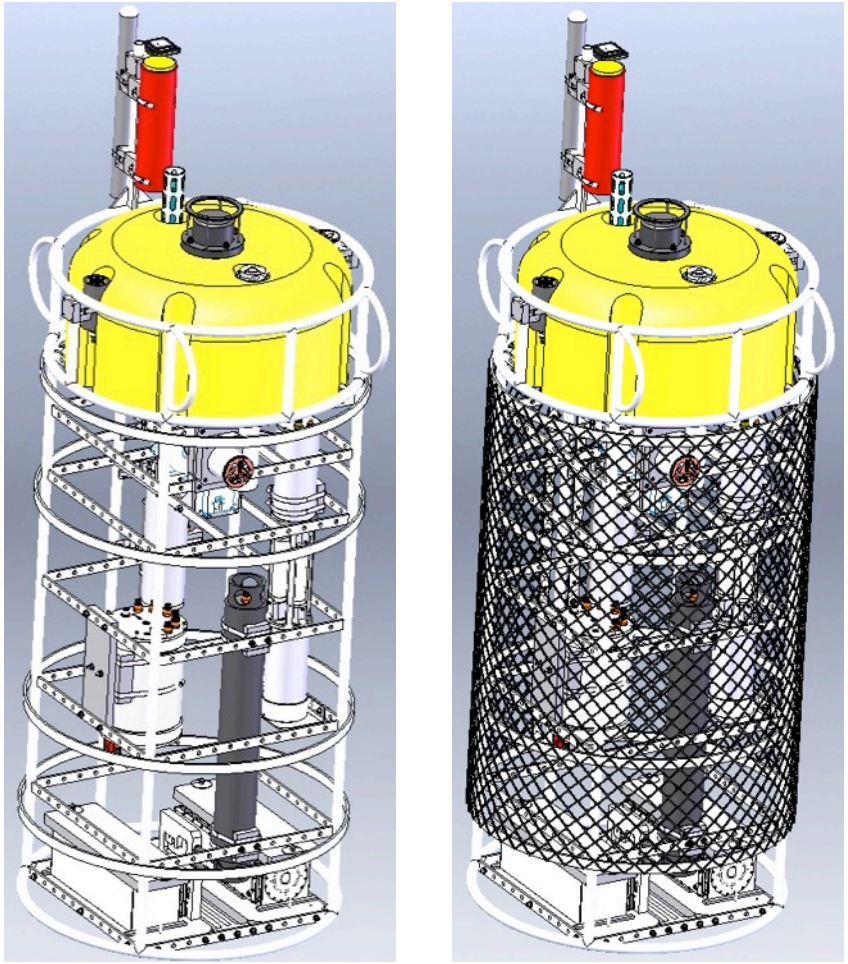
    PARAD – WET Labs ECO PAR

    NUTNR – Satlantic SUNA

    FLORT – WET Labs ECO triplet-w

    VELPT – Nortek Aquadopp

    OPTAA – WET Labs AC-S

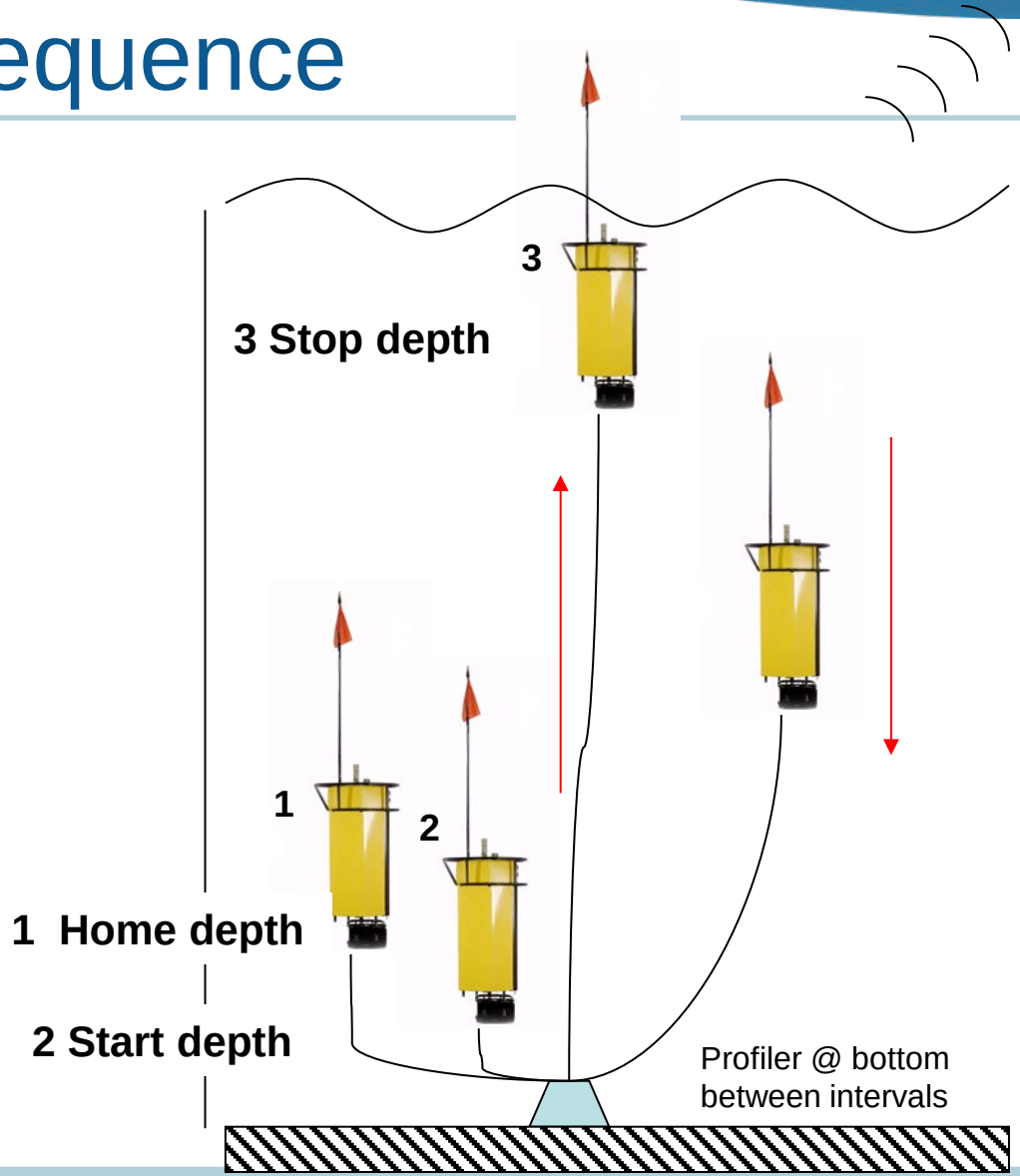


CSPP Profile Sequence

1 Home depth
- Location in between profiling
- Sensors off
- Winch off

2 Start depth
- Sensors on
- Winch on
- Start profiling upwards

3 Stop depth
- Sensors off
- Winch on
- Shallowest depth for profiling
- Radio on – data/communication



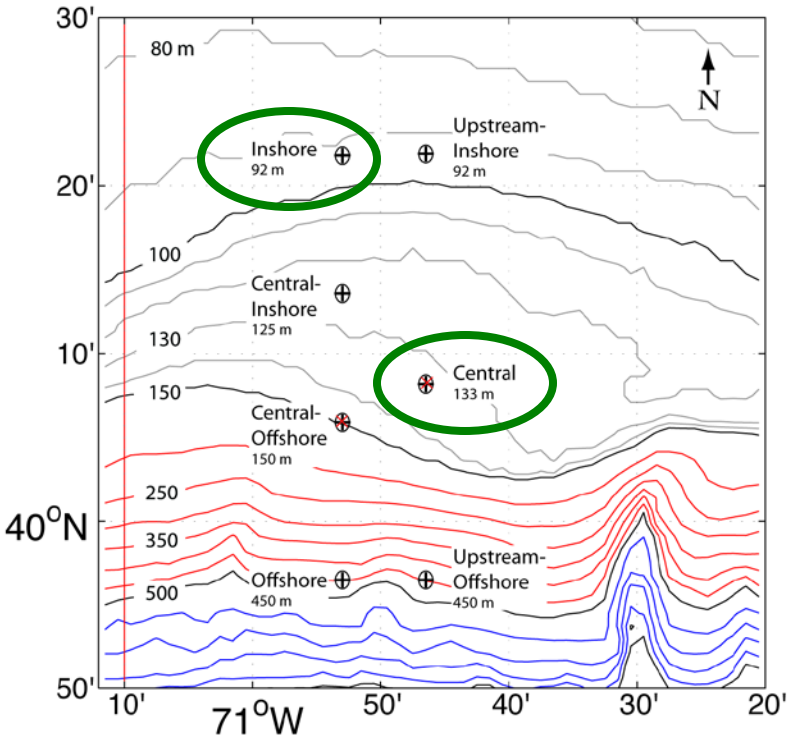
Pioneer CSPP Moorings

- Locations
  - Inshore (91.5 m depth)

    CSPP profiles from 80 m depth to the surface

  - Central (133 m depth)

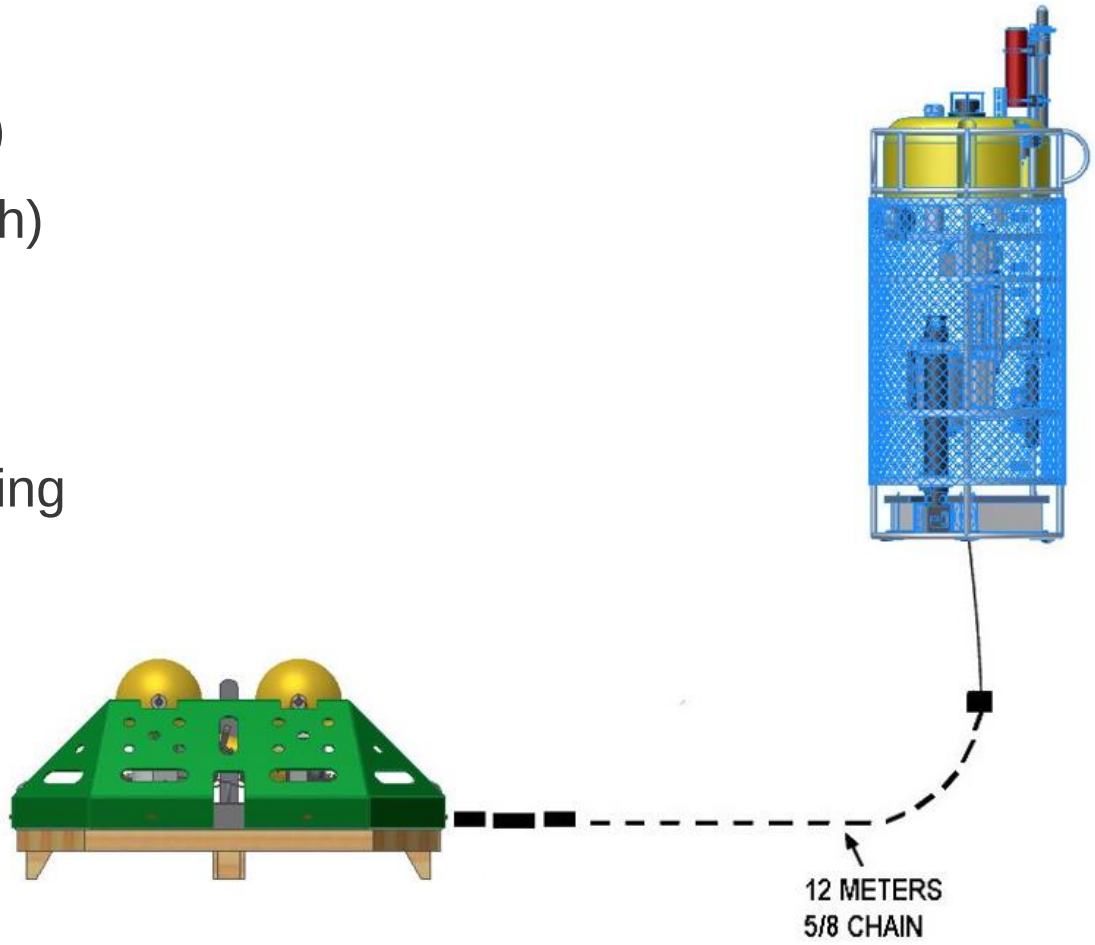
    CSPP profilers from 100 m depth to the surface



Endurance CSPP Moorings

- Locations
  - WA Inshore (29 m depth)
  - OR Inshore (24.3 m depth)
  - WA Shelf (87 m depth)

  - CSPPs not deployed during winter months at Inshore sites
    - Fixed instruments added to Inshore Surface Mooring



Coastal Gliders

- Teledyne Webb G2 Slocum Glider
  - 200 and 1000 m engines
- Instruments

  CTDGV – SBE CTD

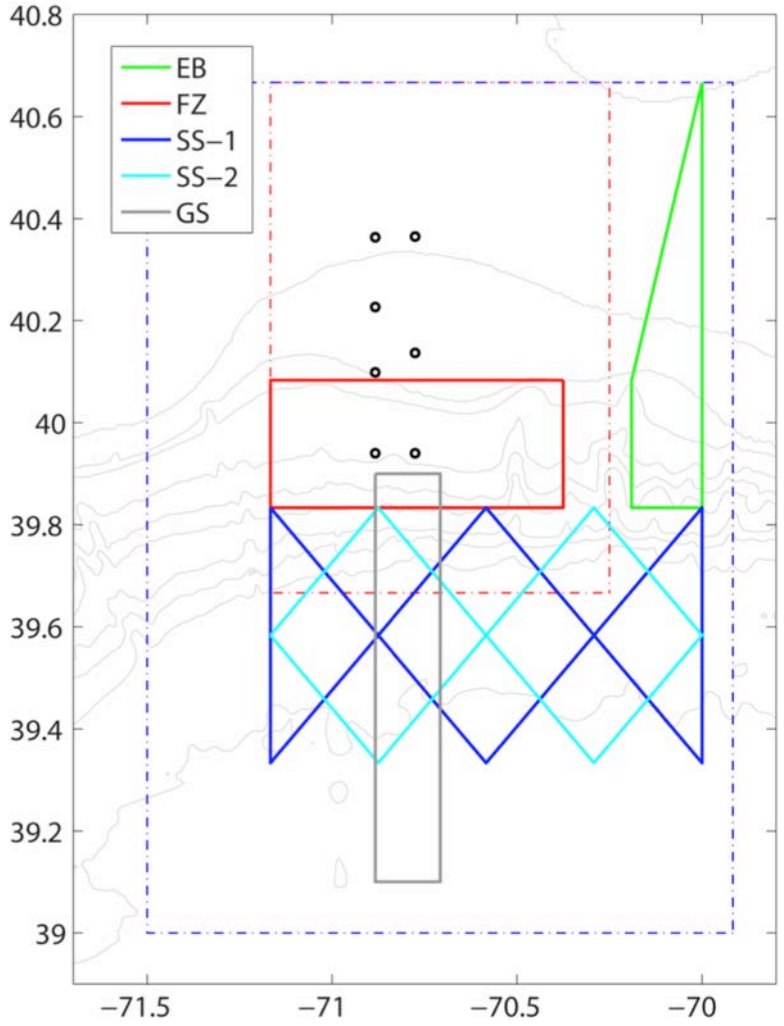
  DOSTA – AADI 4831

  PARAD – Biospherical QSP 2150

  FLORT – WET Labs ECO triplet

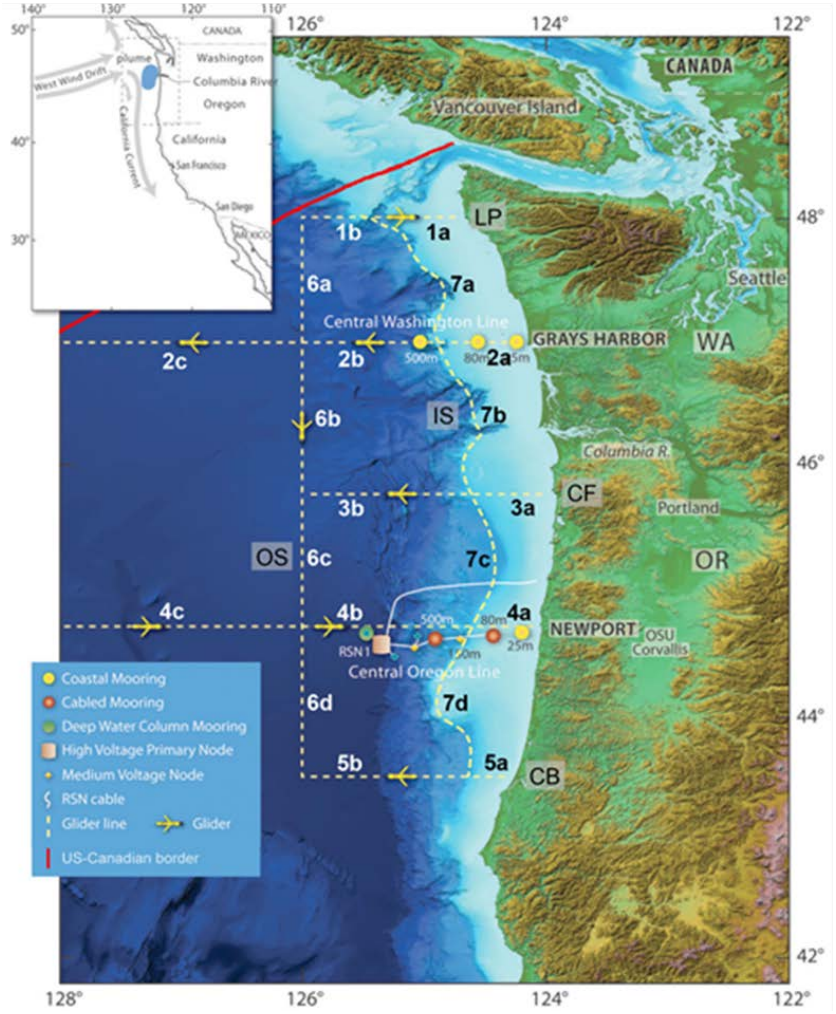
  ADCPA – RDI Explorer 600 DVL

Pioneer Coastal Gliders



Name	Region	Buoyancy Engine
EB	Eastern Boundary	200 m
FZ-1	Frontal Zone	1000 m
SS-1	Slope Sea	1000 m
SS-2	Slope Sea	1000 m
FZ-2	Frontal Zone	200 m
GS	Gulf Stream	1000 m

Endurance Coastal Gliders



Name	Region	Buoyancy Engine
1a 1b	La Push Line	200 m 1000 m
2a 2b/c	Grays Harbor Line	200 m 1000 m
3a 3b	Cape Falcon Line	200 m 1000 m
4a 4b/c	Newport Line	200 m 1000 m
5a 5b	Coos Bay Line	200 m 1000 m
6a/b/c/d	Offshore Line	1000 m
7a/b/c/d	200 m Isobath	200 m

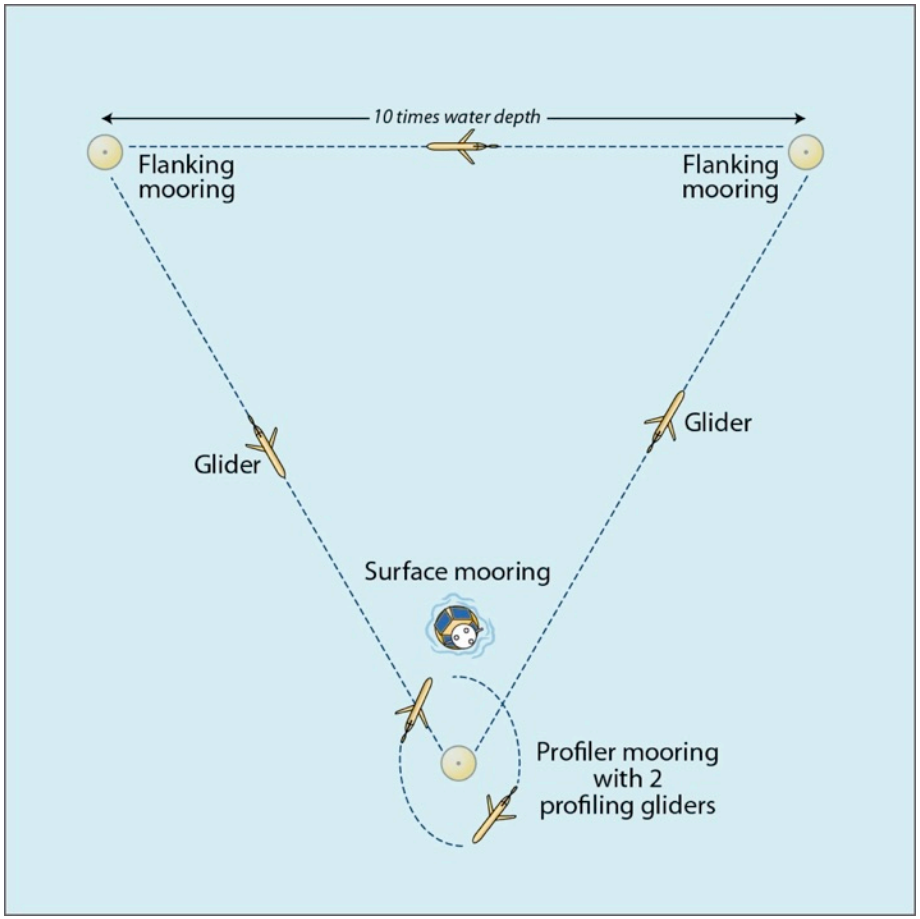
Open Ocean Glider

- Teledyne Webb G2
  - 1000 m engine
- Operations
  - Transit around perimeter of array making measurements
  - Collect data from subsurface moorings and telemeter to shore
- Instruments

  CTDGV – SBE CTD-GP

  DOSTA – AADI 4831

  FLORD – ECO FLBB



Global Profiling Gliders

- Teledyne Webb G2
  - 1000 m engine
- Operations
  - Hold position @ 1000 m
  - Profile 200 m, 2 x 24 hours
- Instruments

  CTDGV – SBE CTD-GP

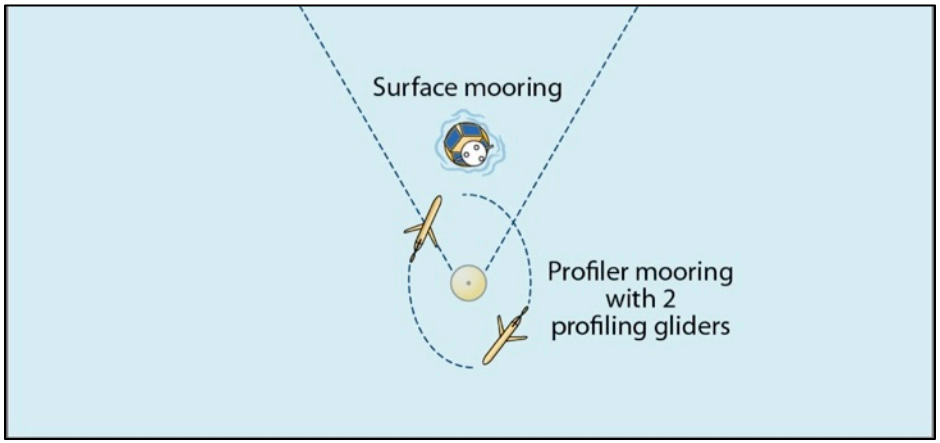
  DOSTA – AADI 4831

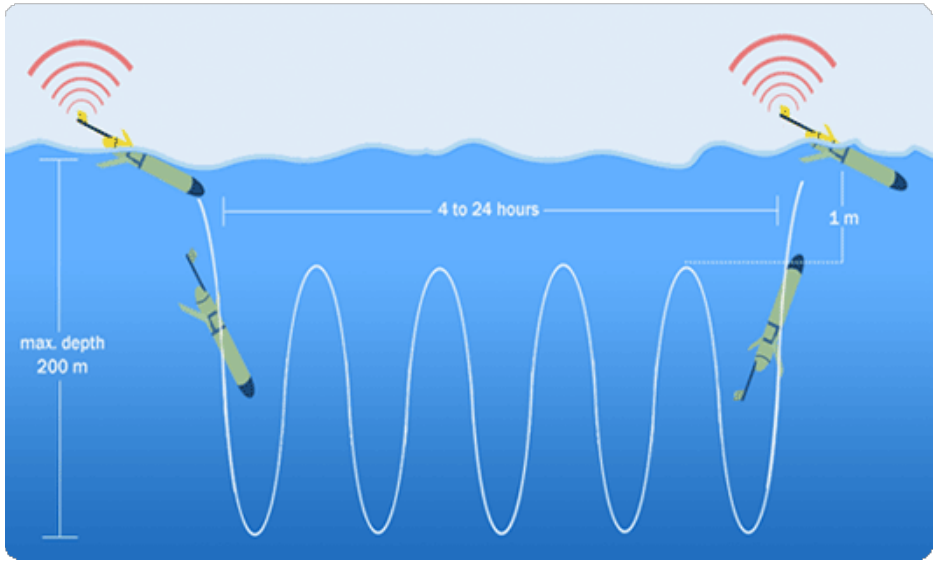
  NUTNR – Satlantic SUNA

  PARAD – QSP-2155 PAR

  FLORT – ECO FLBBCD

  FLORT – ECO BB3





Autonomous Underwater Vehicle (AUV)

- Kongsberg Hydroid
  - REMUS 600
- Instruments

  CTDAV – Seabird CTD

  DOSTA – AADI Optode 4330

  PARAD – Biospherical QSP 2150

  FLORT – WET Labs Eco triplet

  NUTNR – Satlantic SUNA

  ADCPA – RDI Navigator 600

AUV Operations

- 2 AUVs
  - 2 day deployment from ship once per month.
  - Surface to 600 m depth.
- Operations
  - 100 x 80 km box
  - Mission profile: 50 hr at 1.5 m/s, ~250 km
  - Frontal transect: 14 hr at 1.5 m/s ~80 km
  - Horizontal resolution <= 10x water depth (<5km)
- Sampling Metric
  - 1 mission/month per AUV
  - 12 paired missions/yr

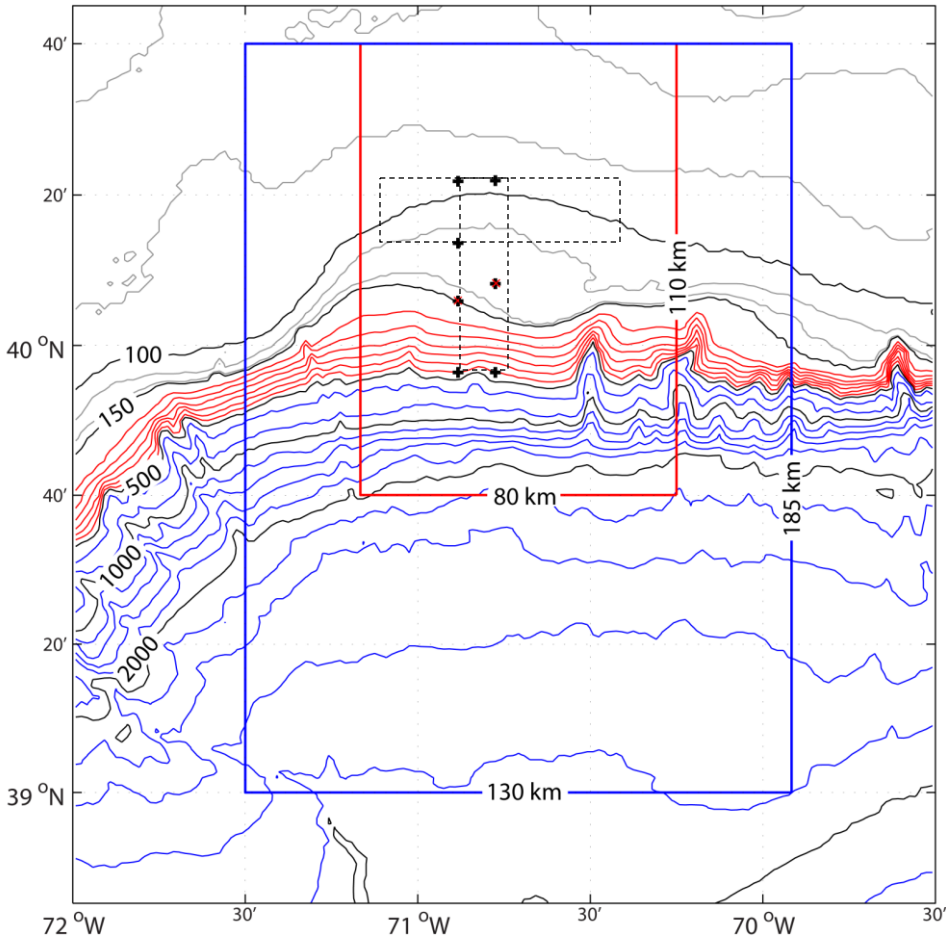


Figure 27 from 3204-00007 Pioneer Array Site Characterization

OPPORTUNITIES

Opportunities

http://oceanobservatories.org/information-for-researchers/

1. Connect new instruments to the observatory network
   a. Connect self-powered, self-logging instruments (Phase 1)
   b. Connect instruments to CGSN infrastructure (Phase 2)
2. Sample rate modification for existing intruments/platforms/vehicles
3. Ancillary work during normally scheduled OOI cruises

1. Other
   a. Add platform (mooring or vehicle) to Array(s)
   b. Add engineering capabilities (power, comms, etc.)
   c. Add calibration techniques for deployed instruments
   d. Etc.

Process for connecting new instruments

- Identification of candidate instruments
- Consultation with CGSN/EA engineers on viability
  - CGSN Staff will provide letter confirming technical feasibility, recommended schedule and costs
- Shiptime request (as needed)
- Funding of proposal
- Researcher development of instrumentation
- Integration and test at CGSN/EA
- Deployment

http://oceanobservatories.org/information-for-researchers/#connecting

Points of Contact

- OOI Help Desk
  - http://oceanobservatories.org/questions/
  - help@oceanobservatories.org
- Paul Matthias (CGSN PM)
  - pmatthias@whoi.edu
- Sheri White (CGSN Engineering)
  - swhite@whoi.edu
- Ed Dever (EA PM)
  - edever@coas.oregonstate.edu
- Jon Fram (EA Engineering)
  - jfram@coas.oregonstate.edu
- Jack Barth
  - Endurance Array
  - jbarth@coas.oregonstate.edu
- Al Plueddemann
  - Pioneer Array
  - aplueddemann@whoi.edu
- Robert Weller
  - Global Arrays
  - rweller@whoi.edu

QUESTIONS