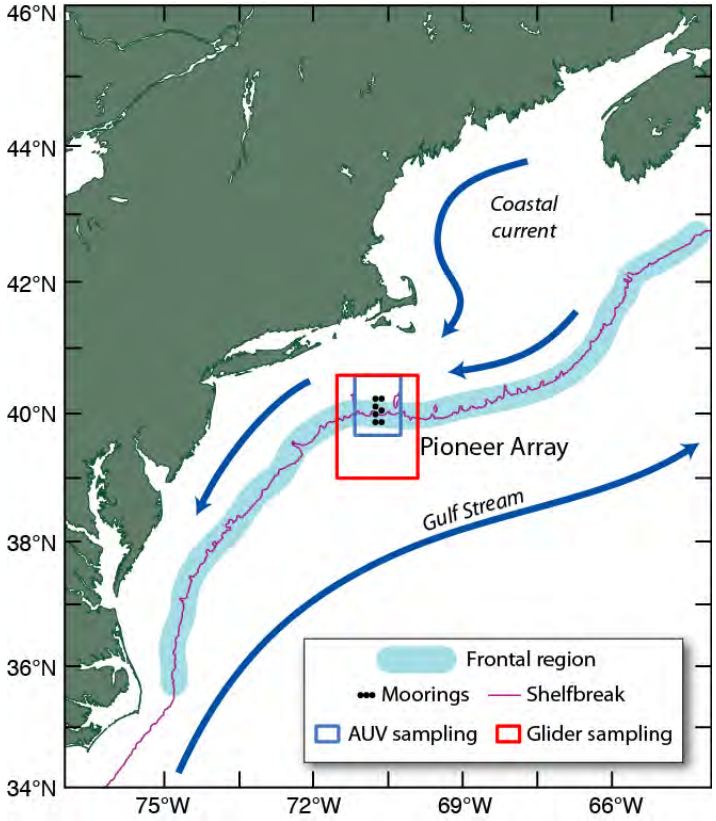
Pioneer Array

- MAB continental shelf and slope
- Context:
  - Fresh water to the north drives along-shelf flow
  - Persistent front at ~150 m isobath
  - Complex slope sea influenced by Gulf Stream eddies and meanders
  - A vibrant shelfbreak ecosystem
- Array design:
  - Captures relevant dynamical processes on multiple scales



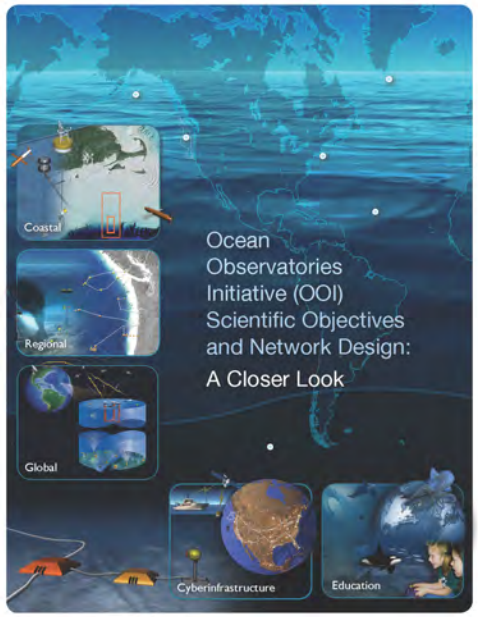
Plueddemann 2014, Illustration by Jack Cook

Pioneer Array Milestones

- Science Plan (2005)
  - Overarching theme: Coastal Ocean Dynamics and Ecosystems
  - Approach: Sustained, multi-scale observatory, power, fixed & mobile platforms
- Shelfbreak RFA (2005)
  - Concept: Multi-scale shelfbreak observatory in the MAB
  - Consortium: WHOI, URI, UMass, Lamont, Stony Brook
- Pioneer Science Workshop (2011)
  - Confirmed the key science question, added of four interdisciplinary focus areas
  - Suggested refinements to Pioneer infrastructure; 5 of 6 were implemented
- Micrositing (2011)
  - Interaction with commercial fishing industry, fine-tuning of mooring locations
  - Changes vetted with Science Workshop leads.
- Pioneer Sampling Focus Group (2012)
  - Reviewed the details of sampling strategy for each platform
  - Recommended strategies for “default” and “pivotal” sampling

Pioneer Array Science Drivers

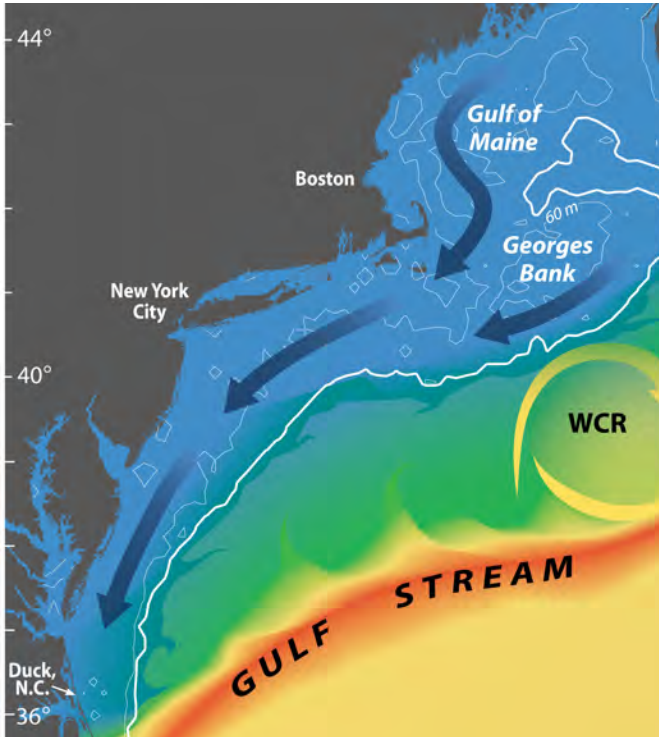
- Key Question (RFA 2005 and Science Prospectus, 2007)
  - How do shelf/slope exchange processes structure the physics, chemistry, and biology of continental shelves?
- Additional Focus areas (Science Workshop, 2011)
  - Nutrient and carbon cycling over the outer continental shelf and upper continental slope;
  - Abundance, distribution, and biodiversity of phytoplankton near the shelfbreak;
  - Controls on the abundance and distribution of marine organisms at higher trophic levels;
  - Extreme events; winter storms and hurricanes
- Infrastructure modifications
  - Shift mooring locations
  - Revise carbon system and nutrient meas.
  - Refine goals for glider sampling



Science Prospectus, 2007

Regional Context

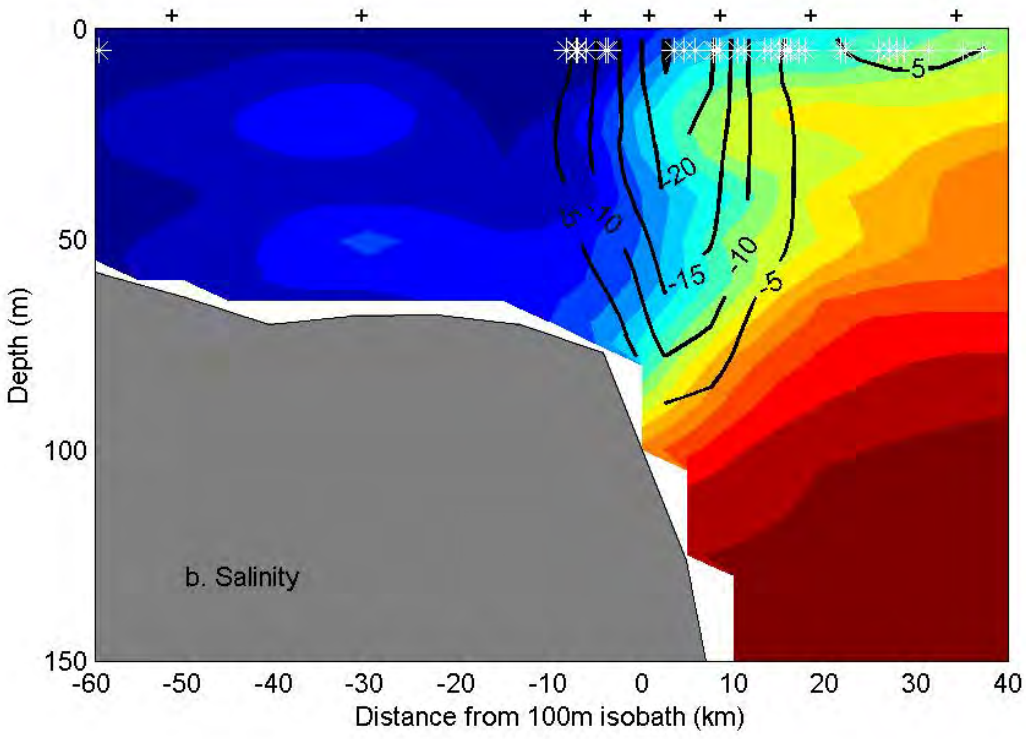
- MAB Continental Shelf & Slope
  - Prototypical broad western boundary shelf remote from the WBC (Loder, et al., 1998)
  - Advective to first order, fresh water to the north drives along-shelf flow
  - Persistent front at ~150 m isobath, from Georges Bank to Cape Hatteras
  - Complex slope sea influenced by Gulf Stream eddies and meanders
  - A vibrant shelfbreak ecosystem; slope water is the presumed nutrient source



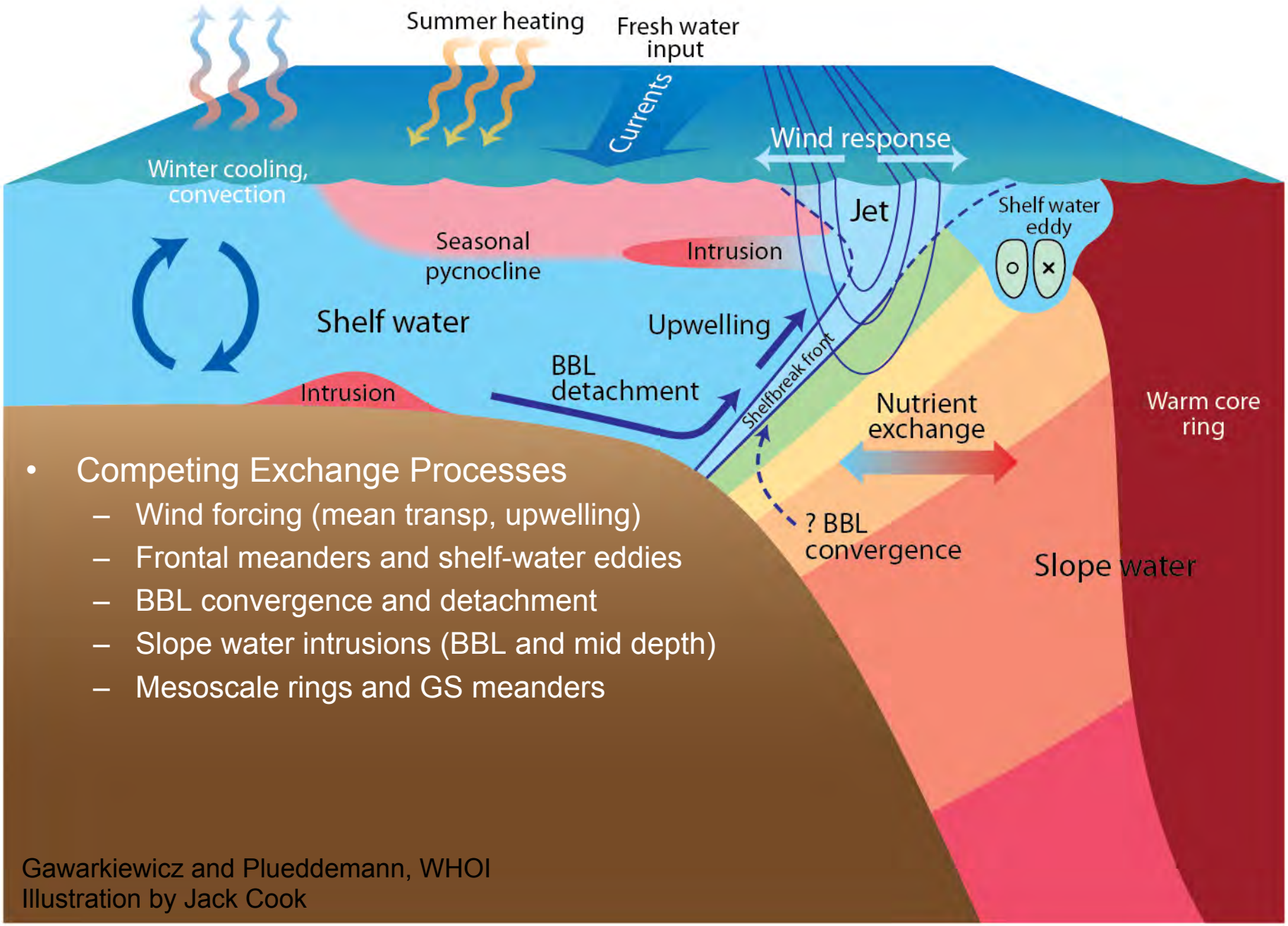
Plueddemann, Trowbridge, and Sosik, 2006

Fontal Characteristics

- Persistent salinity gradient, Surface-intensified jet, Bathymetric “trapping” at roughly the 150 m isobath
- Competing theories for frontal dynamics
- Dominant mechanism(s) of shelf-slope exchange not known



Linder and Gawarkiewicz (1998)


Summer heating
Fresh water input
Currents
Wind response
Winter cooling, convection
Jet
Shelf water eddy
Seasonal pycnocline
Intrusion
Shelf water
Upwelling
BBL detachment
Shelfbreak front
Intrusion
Nutrient exchange
Warm core ring
? BBL convergence
Slope water
• Competing Exchange Processes
– Wind forcing (mean transp, upwelling)
– Frontal meanders and shelf-water eddies
– BBL convergence and detachment
– Slope water intrusions (BBL and mid depth)
– Mesoscale rings and GS meanders
Gawarkiewicz and Plueddemann, WHOI
Illustration by Jack Cook

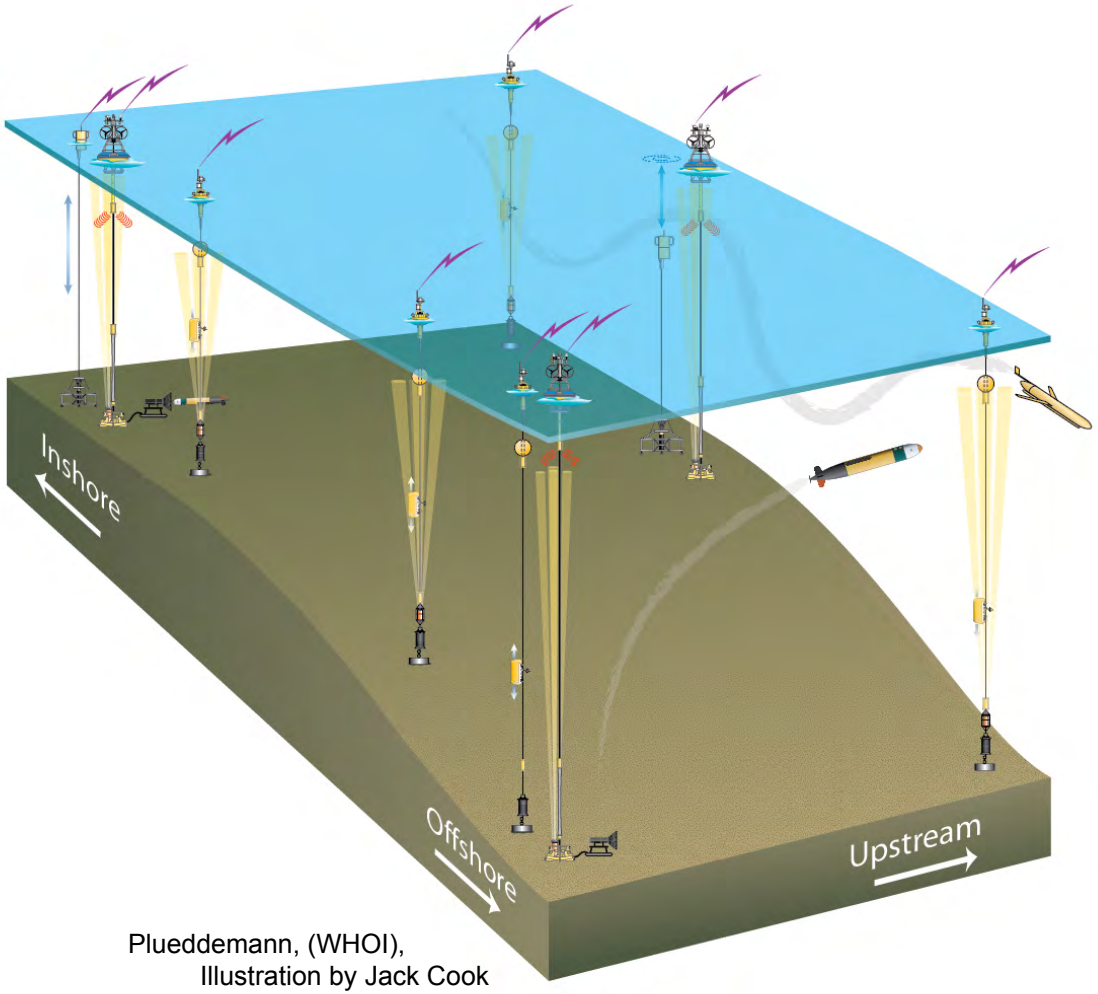
Pioneer Array Infrastructure

Features

- Full water column
- 3D volume sampling
- Two-way satellite links
- Power- generating buoys
- Multi-function seafloor nodes
- AUV docks

Components

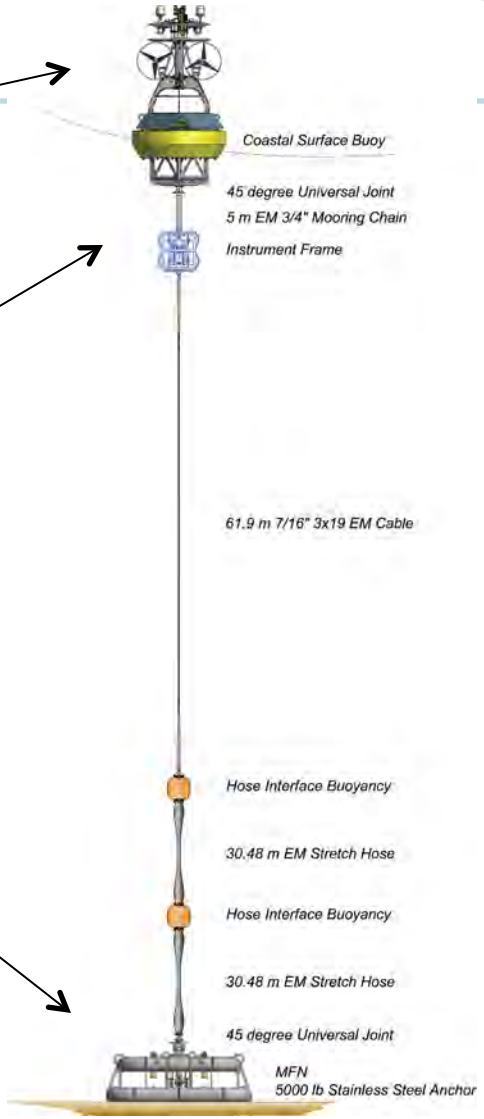
- Surface moorings (3)
- Wire-following profilers (5)
- Surface-piercing profilers (2)
- Gliders (6)
- AUVs (2)



Plueddemann, (WHOI),
Illustration by Jack Cook

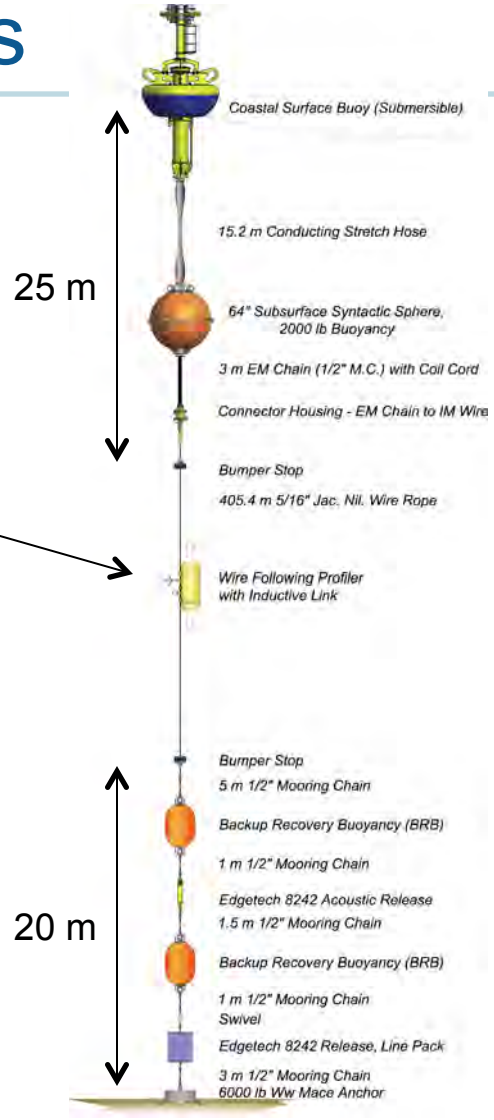
Pioneer Surface Moorings

- Air-Sea Interface
  - Power generation
  - Bulk met, DC flux, pCO2, SST, SSS, waves
- Near Surface Instrument Frame
  - CTD, DO, velocity, optics, pH, 3-channel fluoro, nitrate
- Near Bottom (MFN)
  - CTD, DO, velocity, optics, pH, 3-channel fluoro, pCO2, bio-acoustics
- AUV Dock
  - Cabled to MFN



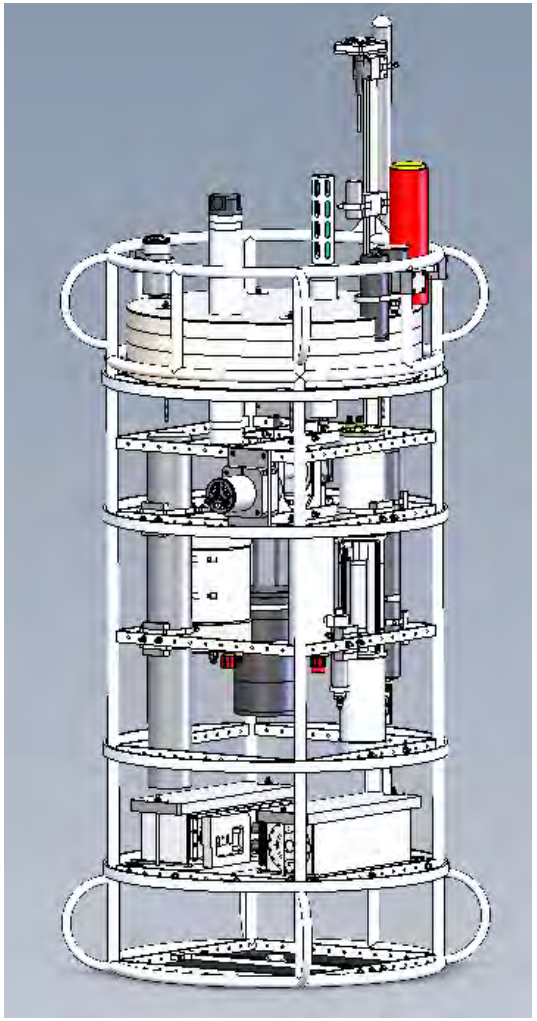
Pioneer Wire-Following Profilers

- Profiles water column away from boundaries
- McLane WFP 600
  - Modified for OOI
- Instruments
  - Seabird SBE-52 MP
  - SBE-43F (Oxygen)
  - Biospherical QSP 2100
  - WET Labs Eco BBFL2
  - Nortek Aquadopp profiler



Pioneer Surface-Piercing Profilers

- Profiles over <=100 m depth, including surface boundary layer
- Based on WET Labs AMP
  - Modified for OOI
- Instruments
  - CTD
  - Dissolved Oxygen
  - PAR
  - 3-channel fluoro
  - 3D velocity
  - Spectral irradiance
  - Nitrate (optical)



Pioneer Mobile Platforms

- Gliders: Teledyne Webb
  - 200 and 1000 m engines
- Instruments
  - Seabird CTD
  - Aanderaa Optode 4330
  - Biospherical QSP 2150
  - WET Labs Eco triplet
  - RDI Explorer 600 DVL

- AUVs: Kongsberg Hydroid
  - REMUS 600
  - Modified for docking
- Instruments
  - Same as Glider, Plus:
  - RDI Navigator 600 (dual)
  - Satlantic SUNA (nitrate)

Pioneer Array Configuration

Moored Array

47 km x 9 km

(90 m to 450 m depth)

AUV Operations

80 km x 110 km

Glider Operations

130 km x 180 km

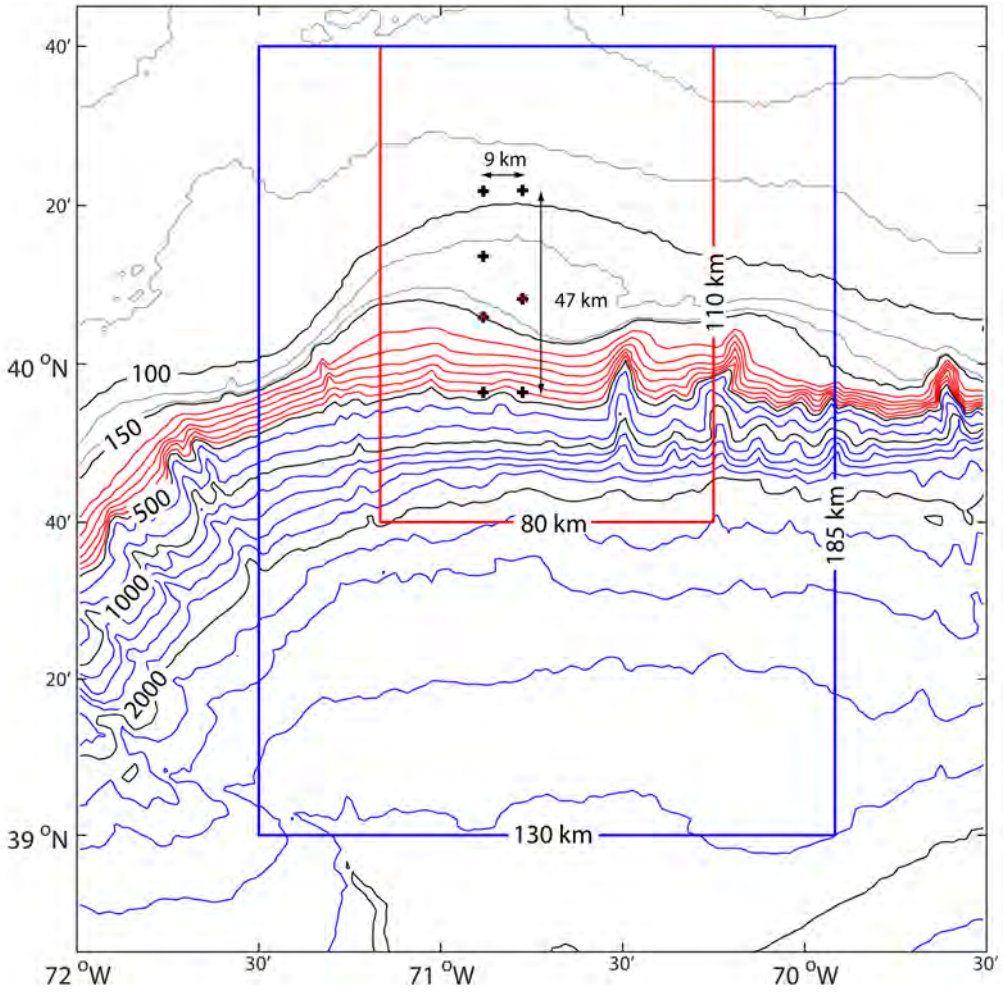
AUV Transect (1.5 m/s)

50 km cross-front ~ 10 h

Glider Tracklines (.25 m/s)

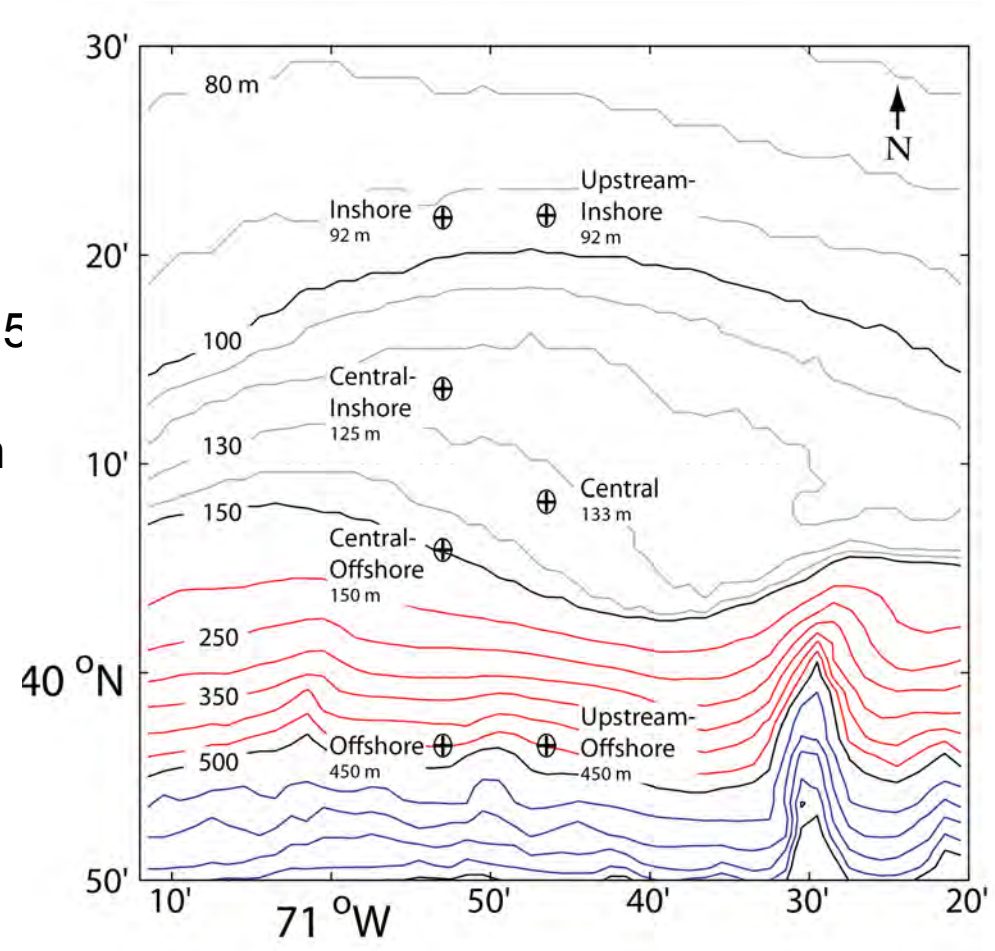
frontal loop ~ 8 days

slope sea ~ 16 days



Moored Array

- Result of Micrositing process
- Spans 90 m depth (shelf) to 450 m depth (slope sea), 47 km cross-shelf
- Focus on frontal region (125-150 m depth), ~10-15 km spacing
- Two cross-shelf lines ~10 km apart



Pioneer Spatial Sampling

Glider Tracklines

Eastern Boundary
(200 km, 8 days)

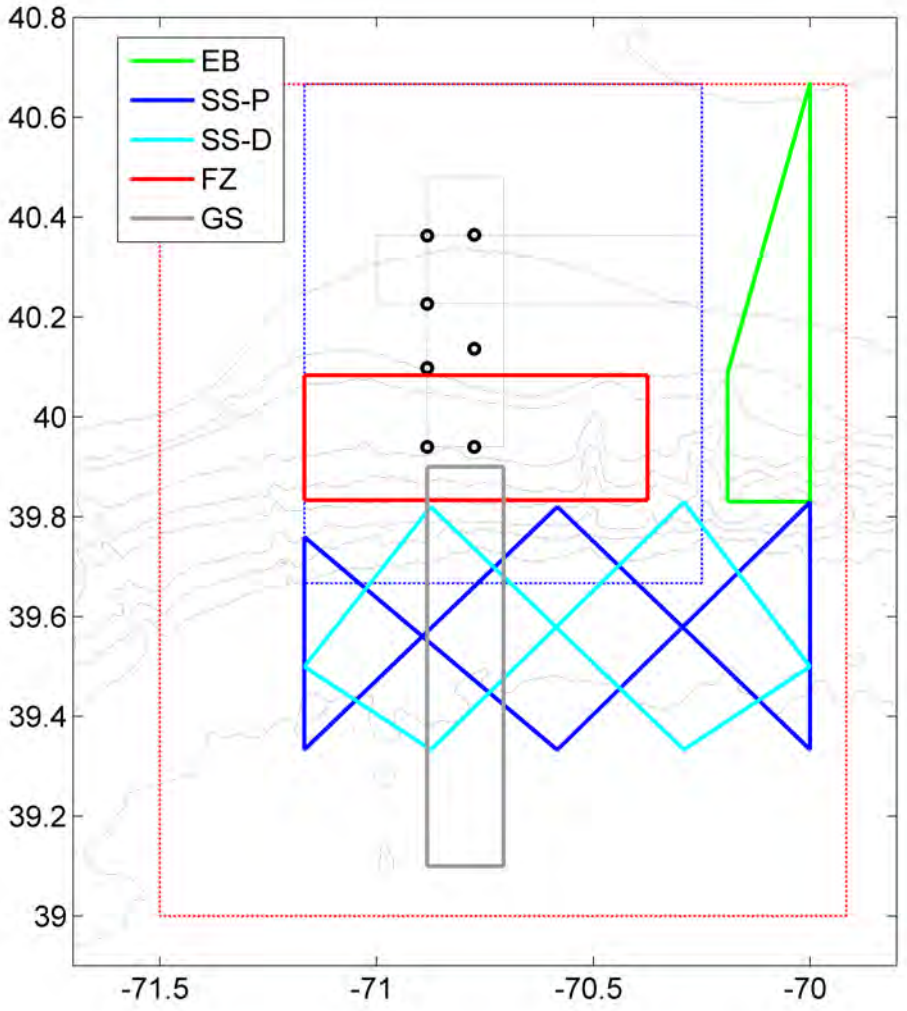
Slope Sea (2)
(350 km, 14 days)

Frontal Zone (2)
(200 km, 4 days)

Gulf Stream
(200 km, 8 days)

AUV Tracklines

Cross & Along Shelf
150 km, 1 day



Pioneer Instruments

- ~150 Instruments, 18 OOI Types, 15 Measurement Classes

Air-sea flux (2)	CO2 flux (2)	Nitrate
Surface waves	Turbulent velocity	pH
Temp/cond/press	Dissolved oxygen	PAR
Seafloor press	Spectral irradiance	Bio-acoustics
Mean currents (2, point and profile)	Optical attenuation and absorption	Chl-a, CDOM, and turbidity

Pre-Deployment Procedures

1. Incoming Inspection
- Completed for all Instruments and Platforms
- Verifies configuration and state as delivered

2. Calibration Records
- Records for each instrument or platform are archived in Vault

3. Quality Conformance Tests (QCT)
- Completed for all Instruments and Platforms
- Confirms basic functionality ("bench test"), detects failures or damage

4. Requirements Verification
- Completed for each instrument type or Class
- Validate first article against requirements and specifications

5. Platform Integration and Test
- Platform operation verified using platform controller
- End-to-End communication verified, instrument to shore station

At-Sea Procedures

Platform monitoring
- Full platform function available when within WiFi range
- Communication with shore station when out of range

Shipboard underway sampling
- Meteorology time series from shipboard systems
- Thermosalinograph time series shipboard system
- Bathymetry from echoshounder and multi-beam

Shipboard CTD profiles
- Casts with water samples at each mooring site
- CTD plus DO, Fluoro, beam x-miss, turb, PAR

Physical Samples
- Multiple samples from four depths at each mooring site
- Salinity and Oxygen analysis completed onboard
- Nitrate/Nitrate, Chlorophyll and Carbon system done in shore labs

* 1102-00300 Protocols and Procedures for OOI Data Products: QA, QC, Calibration and Physical Samples