OOI Data Flow and Data Access

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1. OOI & Data Team Intro
2. OOI Data Flow
3. OOI Data Access

OOI By the Numbers

7 Arrays

57 Stable Platforms
Moorings, Profilers, Nodes

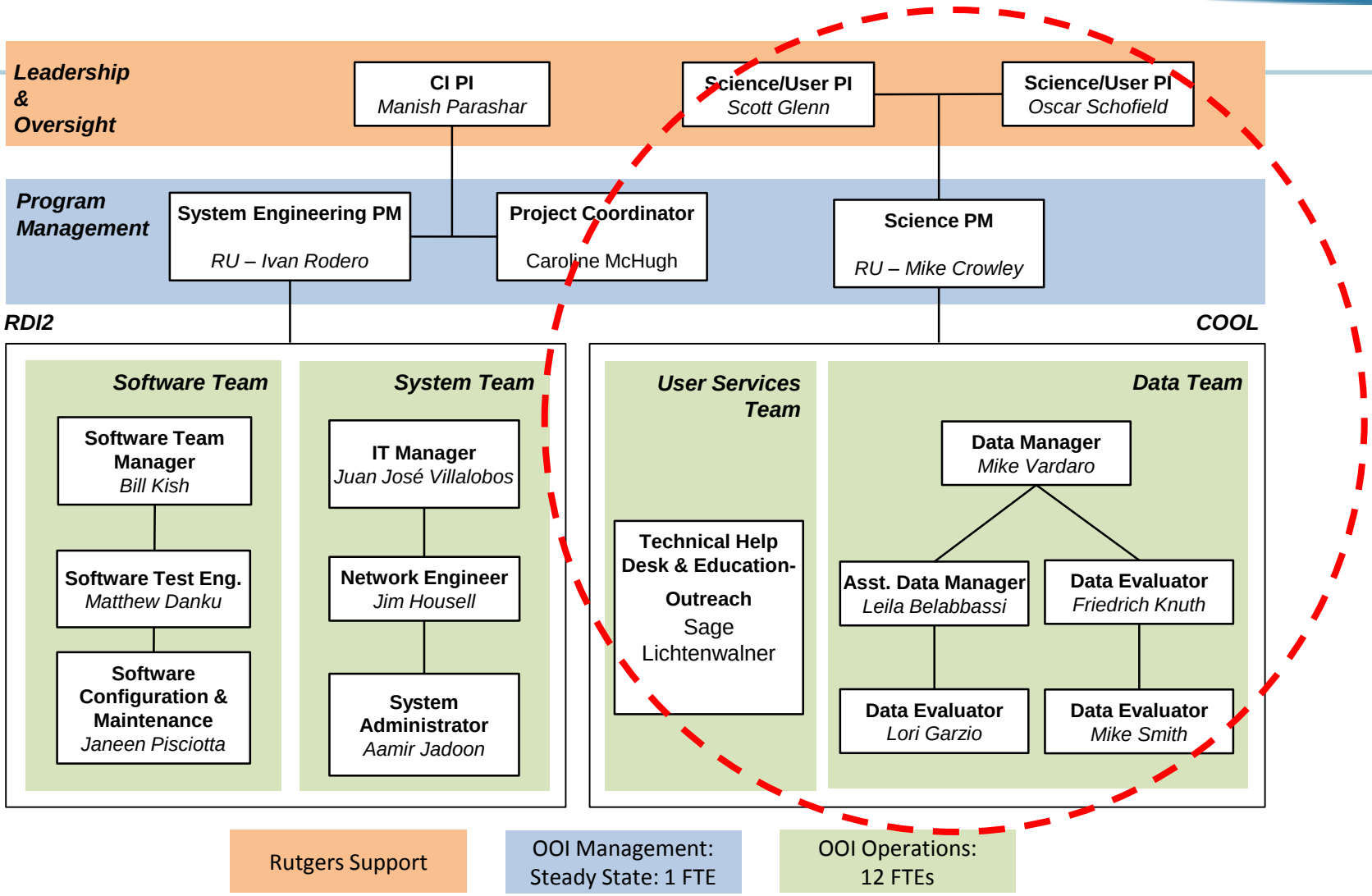
32 Mobile Assets
Gliders, AUVs

>850 Instruments

>2500 Science Data Products

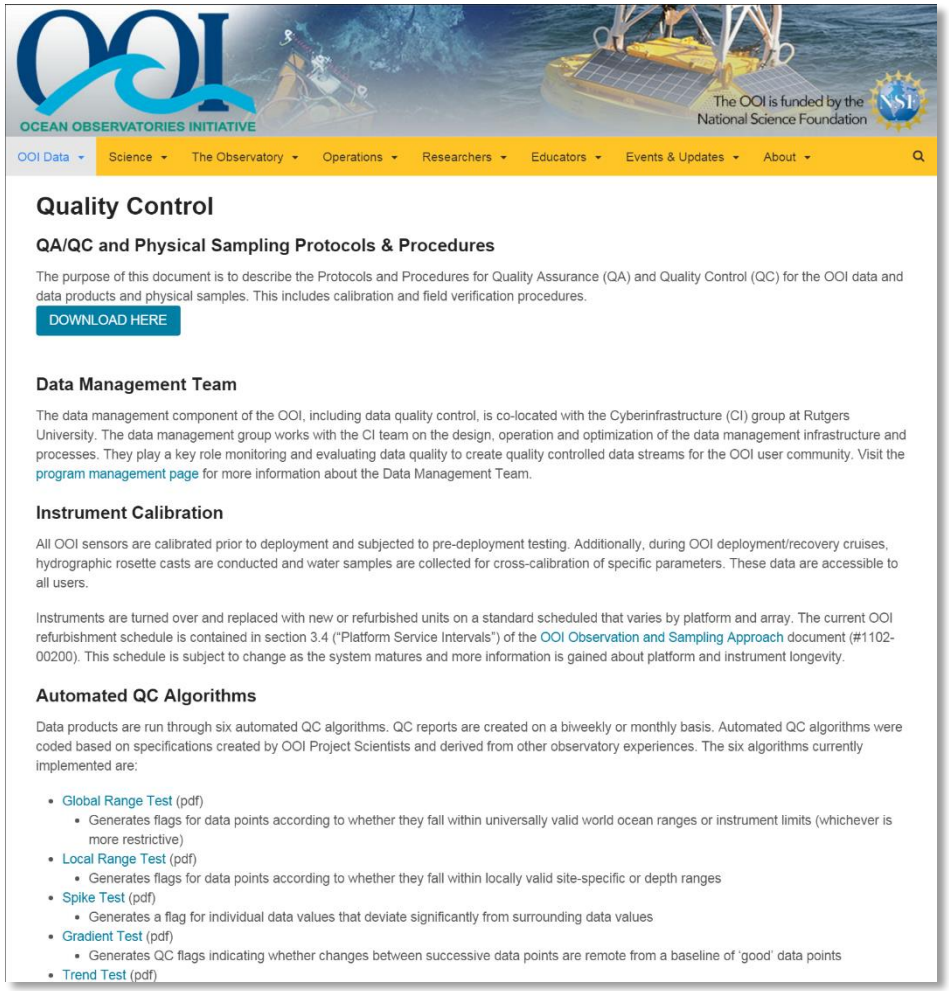
>100K Science/Engineering Data Products

Data Team


Leadership & Oversight
CI PI
Manish Parashar
Science/User PI
Scott Glenn
Science/User PI
Oscar Schofield
Program Management
System Engineering PM
RU – Ivan Rodero
Project Coordinator
Caroline McHugh
Science PM
RU – Mike Crowley
RDI2
COOL
Software Team
Software Team Manager
Bill Kish
Software Test Eng.
Matthew Danku
Software Configuration & Maintenance
Janeen Pisciotta
System Team
IT Manager
Juan José Villalobos
Network Engineer
Jim Housell
System Administrator
Aamir Jadoon
User Services Team
Technical Help Desk & Education-Outreach
Sage Lichtenwalner
Data Team
Data Manager
Mike Vardaro
Asst. Data Manager
Leila Belabbassi
Data Evaluator
Friedrich Knuth
Data Evaluator
Lori Garzio
Data Evaluator
Mike Smith
Rutgers Support
OOI Management: Steady State: 1 FTE
OOI Operations: 12 FTEs

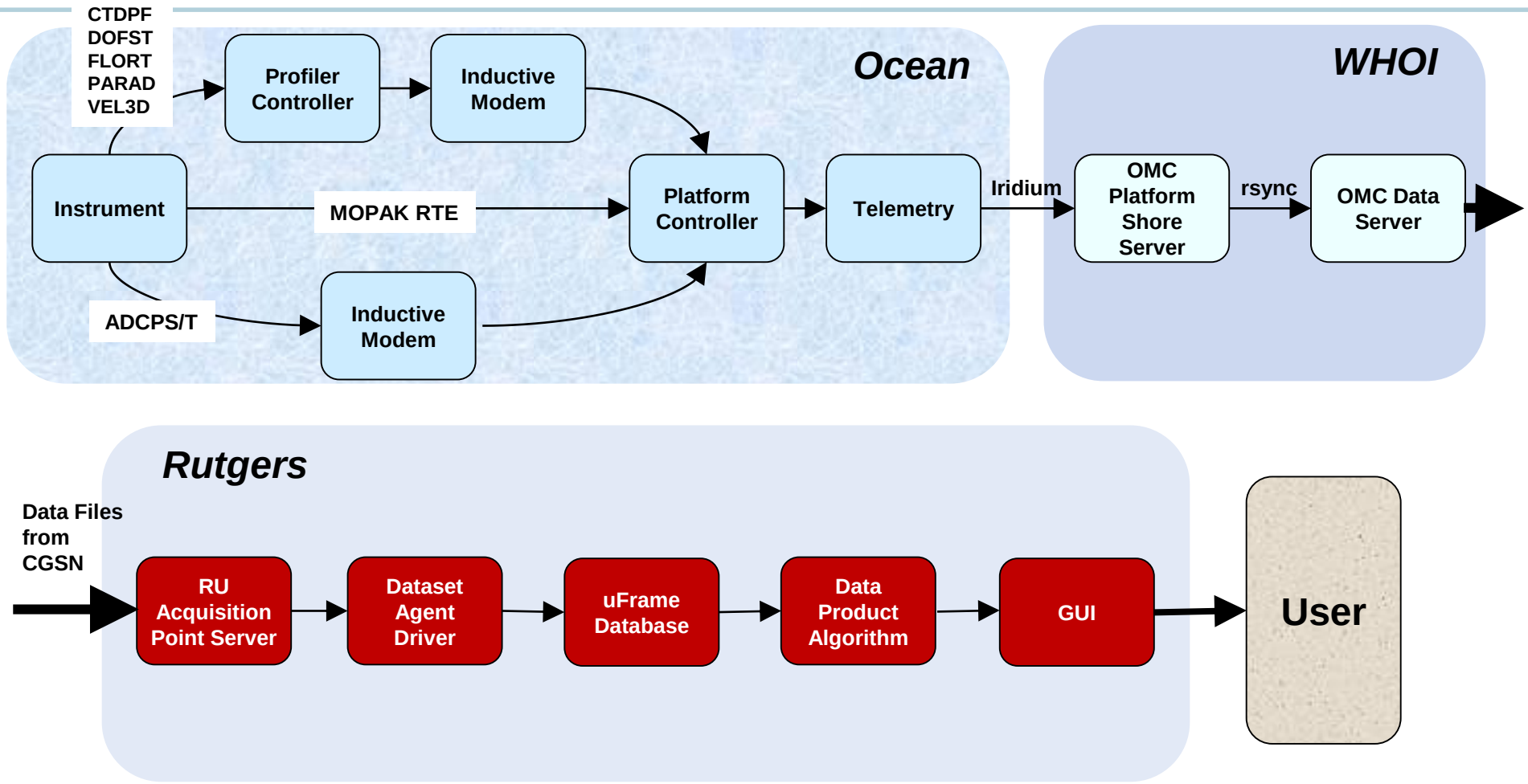
Data Evaluation Procedures & Tools

- Data QA/QC and Sampling Plan:
  - 1102-00300_QAQC_Cal_Physical_Samples_OOI
- Sampling Strategy Document:
  - 1102-00200_Observation_and_Sampling_Approach_OOI
- Data Product Specifications:
  - 1341-000xx (DPS) and 1342-000xx (Data Flow)
- Calibration Information
  - github.com/ooi-integration/asset-management
- Data Product and QC Algorithms:
  - github.com/ooici/ion-functions/tree/master/ion_functions
- Quality Control Lookup tables:
  - github.com/ooi-integration/qc-lookup
- Data Team download and plotting tools:
  - github.com/ooi-data-review

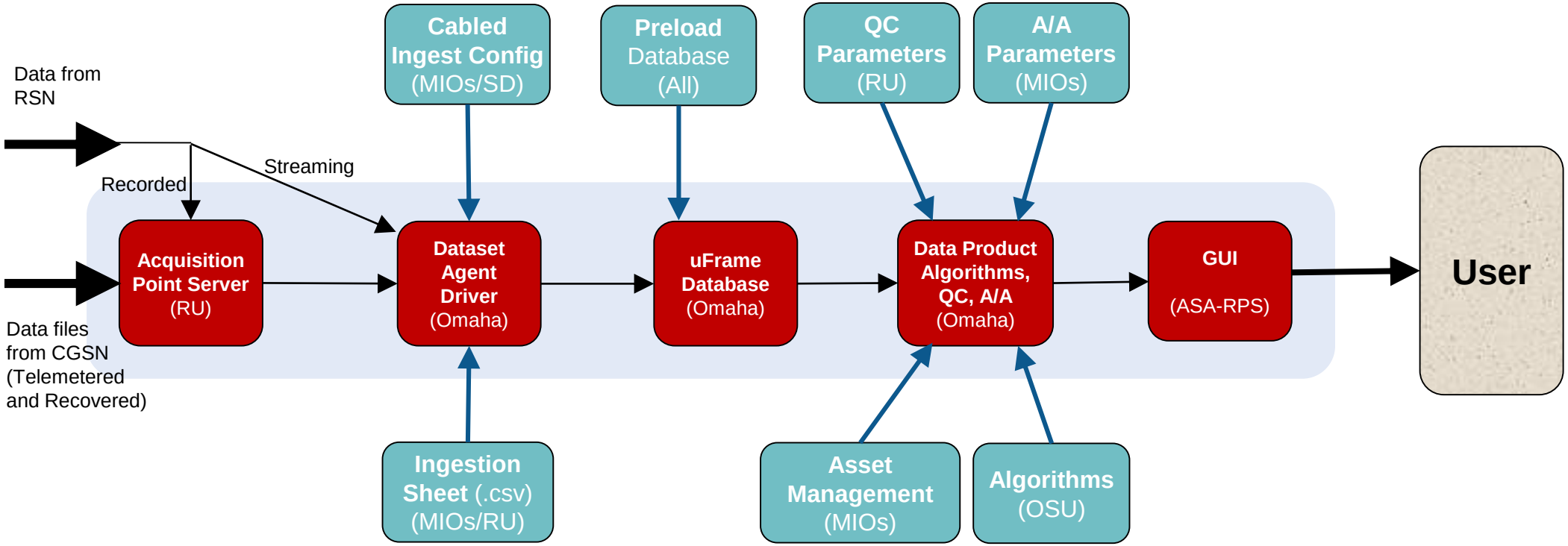


OOI Data Flow

Data Flow Example: Pioneer Profiler



Data Processing Flow



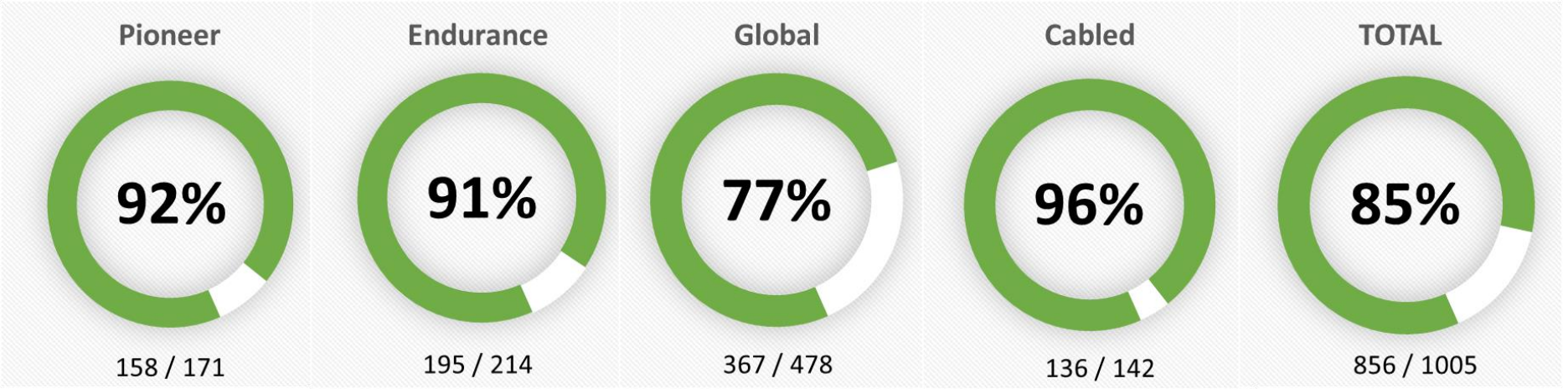
OOI Data Product Levels

- **Raw data**: The datasets as they are received from the instrument
  - May contain multiple L0, L1, or L2 parameters, data for multiple sensors, and be in native sensor units
  - Always persisted and archived by the OOI
  - Example: format 0 binary file from an SBE-37IM on a Global Flanking Mooring.
- **Level 0 (L0)**: Unprocessed, parsed data parameter that is in instrument/sensor units and resolution
  - Sensor by sensor (unpacked and/or de-interleaved) and available in OOI supported formats (e.g., NetCDF)
  - Always persisted and archived by the OOI
  - Example: SBE-37IM Temperature portion of the hex string
- **Level 1 (L1)**: Data parameter that has been calibrated and is in scientific units
  - QC may be applied at this level, utilizing simple automated techniques or human inspection
  - Actions to transform Level 0 to Level 1 data are captured and presented in the metadata of the Level 1 data
  - Example: SBE-37IM Temperature converted from hex to binary and scaled to produce degrees C
- **Level 2 (L2):** Derived data parameter created via an algorithm that draws on multiple L1 data products
  - Products may come from the same or from separate instruments
  - Example: SBE-37IM Density and Salinity

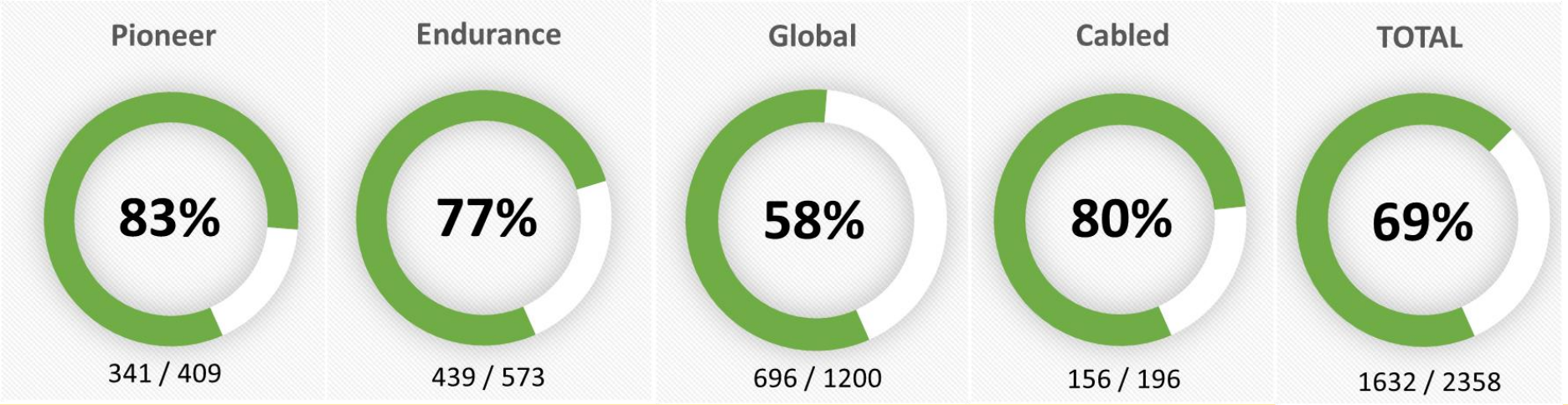
Streams vs. Parameters

- Raw data are parsed by system code into data streams (science, engineering, metadata, etc.)
- Each stream is a “package” containing multiple parameters
- A single instrument can produce multiple data streams with many different parameter types within them
- Science parameters are processed (and combined) via additional algorithm code to produce L1 and L2 data products
- If an algorithm uses data streams from multiple instruments to produce L2 products, data from all relevant instruments will be provided during download

Data on Production System



Instruments

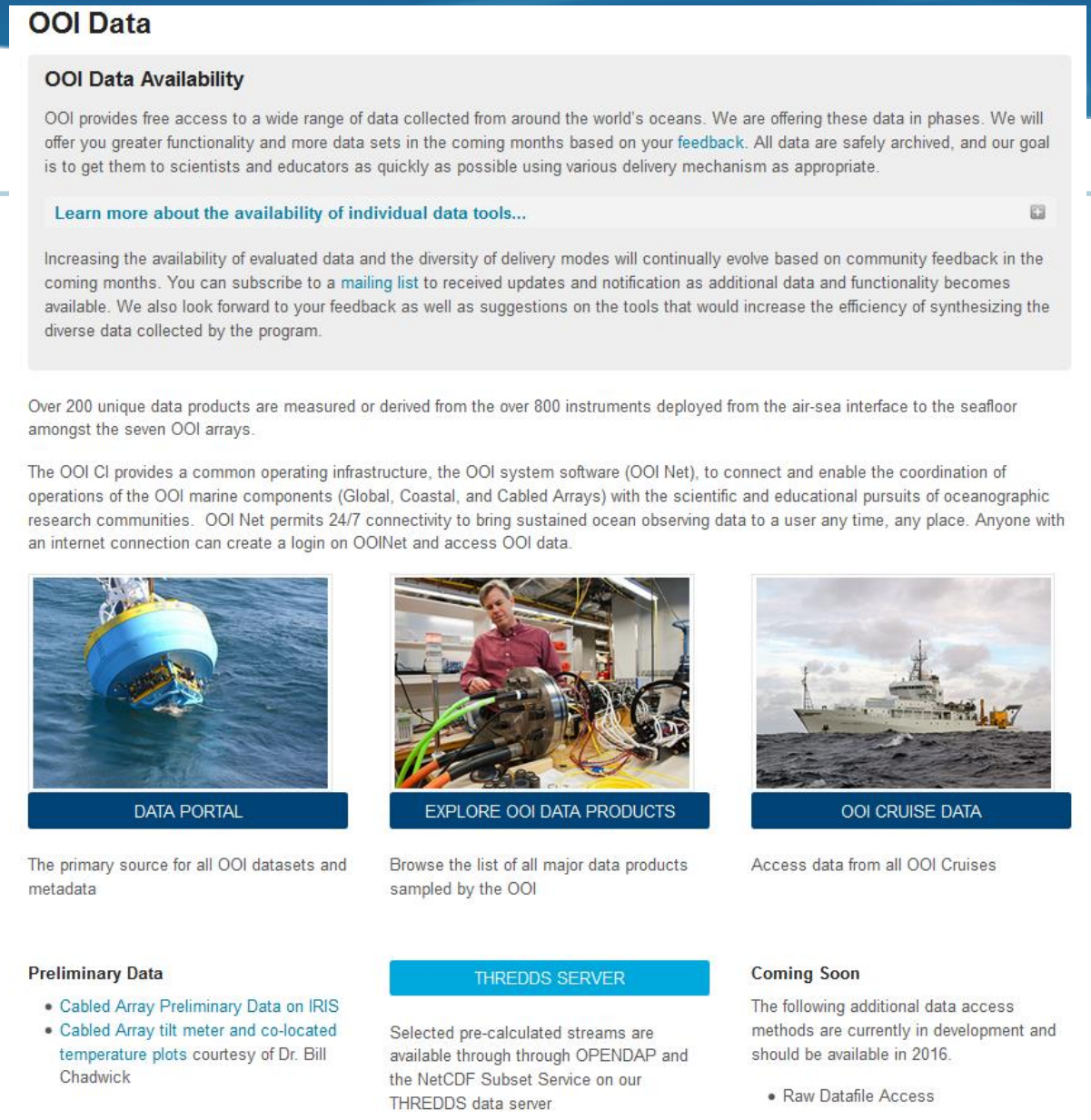


Data Streams

OOI Data Access

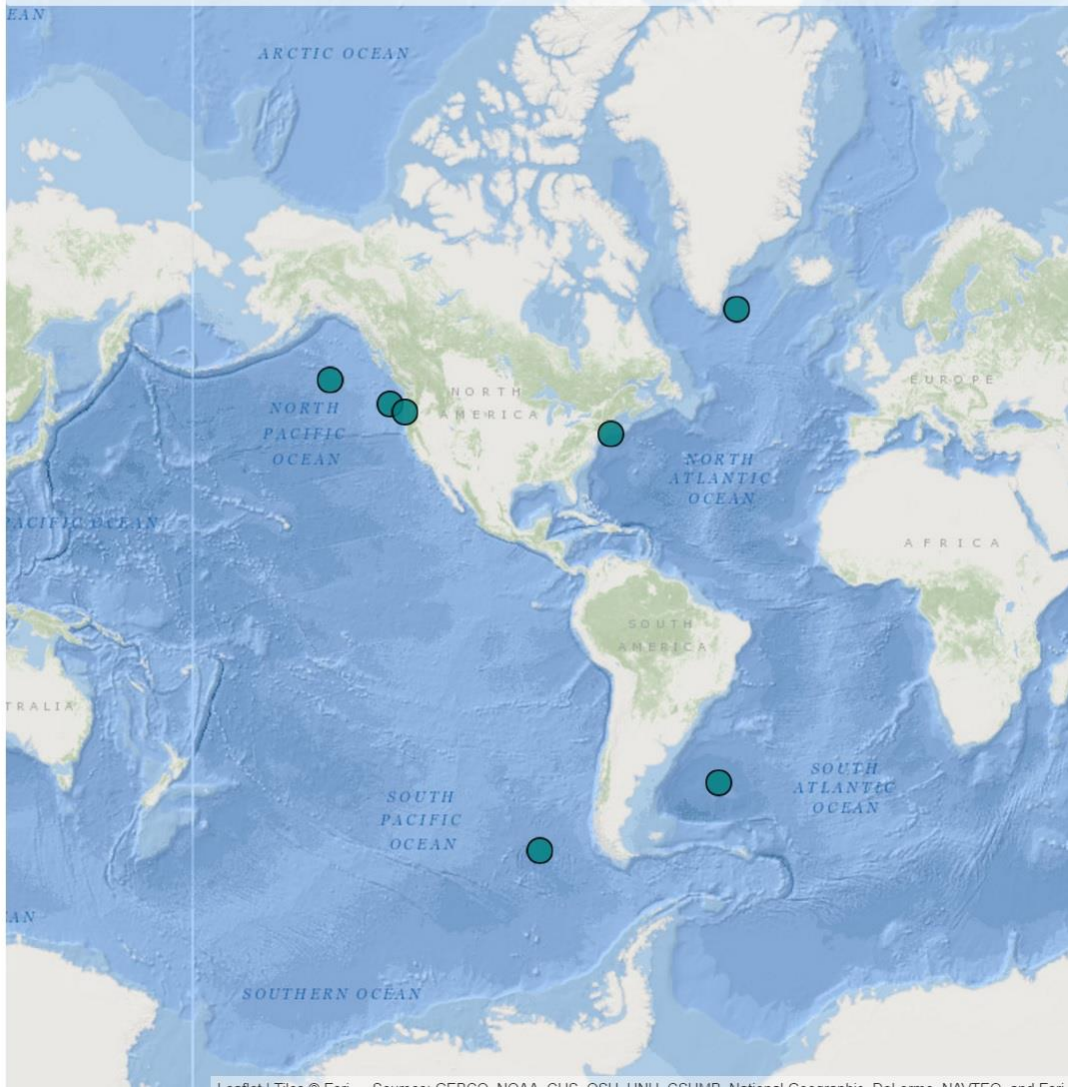
Data Access Points

- Data Portal (GUI)
  - Updated with new landing page, navigation, and plotting functionality (including streaming plots)
- ERDDAP (in beta form; Winter 2016)
- M2M Interface (Fall 2016)
- Shipboard Data
  - Available via Alfresco; currently being updated
- Raw data files
  - Mirror of OOI data repository; data files as they are delivered from instruments
- Direct Pass to community organizations
  - IRIS
  - IOOS portals; NANOOS, MARACOOS (soon)
  - OceanSITES (soon)



Research Arrays Select an array on the map or choose from the list.

- Endurance
- Station Papa
- Pioneer
- Argentine Basin
- Irminger Sea
- Southern Ocean
- Cabled Array

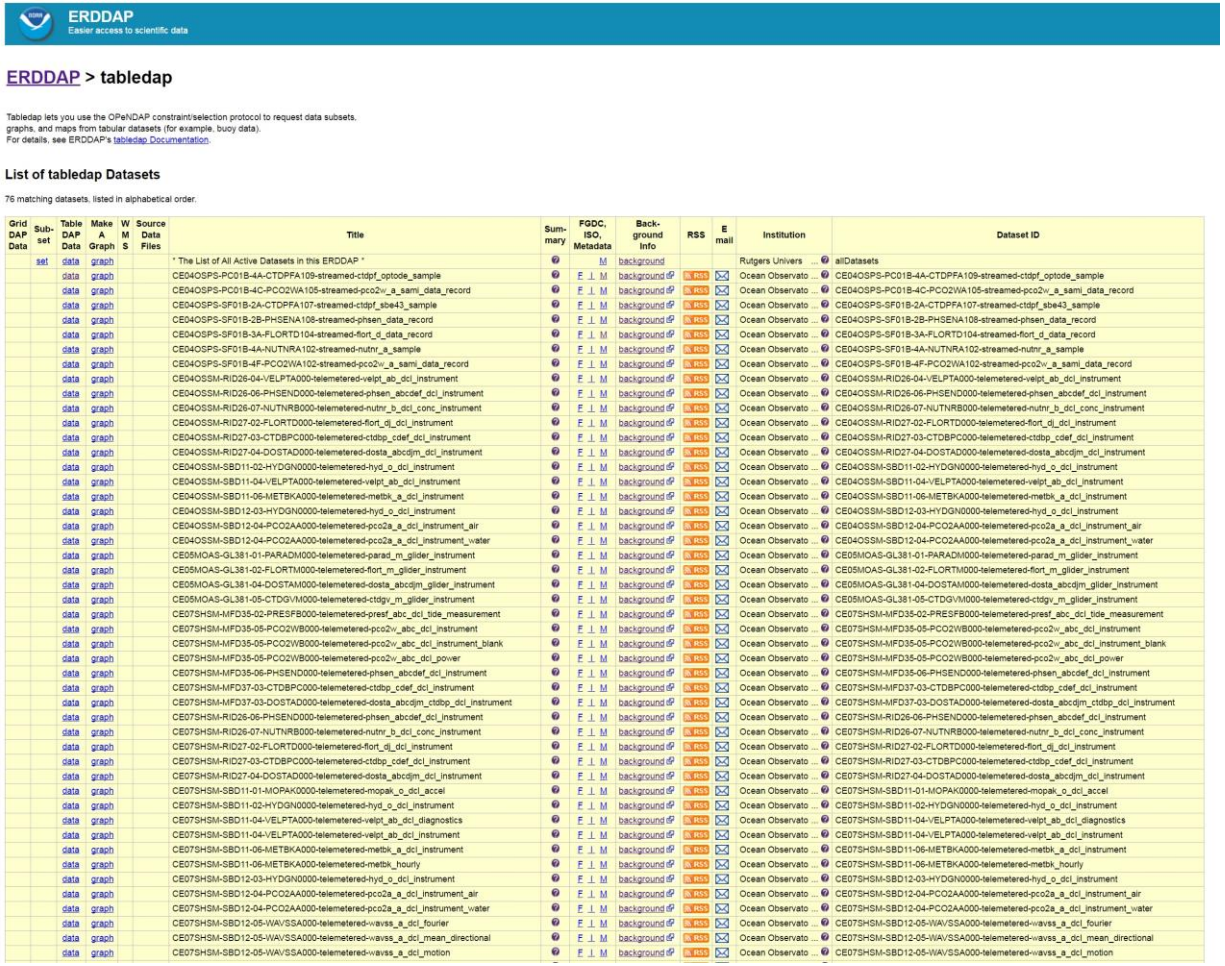


OOI Prioritized Datasets

1. <u>All Arrays, all platforms:</u>
   a. CTD data products (Temperature, Conductivity, Pressure, Density, Salinity)
   b. Dissolved Oxygen
   c. ADCP (all series)
   d. Bulk Meteorology (all products)
   e. Surface Wave Spectra – significant wave height
   f. Fluorometric Products (CDOM/Chlorophyll/Backscatter)
   g. Nitrate
   h. Seawater pH
   i. In-Water and Air/Sea pCO_2
2. <u>Cabled Array EOVs</u> (these instruments are only on the Cabled Array):
   a. HD Camera Products
   b. Bottom Pressure/Tilt Products
   c. Seafloor Pressure
   d. Low-Frequency Hydrophone Products
   e. Vent Fluid and Particulate DNA Sampler – D1000 Temperature Products

ERDDAP Data

- http://ooi-data.marine.rutgers.edu/erddap/tabledap/
- Draft form – data are still being loaded to test the system
- Latest 6 months of data available for download, from the available platforms (Endurance, Station Papa, and Cabled)
- Production-level public-facing server hosted at Rutgers CI (Winter 2016)
  - Designed to serve (at least) the latest 6 months of data from all platforms



ERDDAP
Easier access to scientific data

ERDDAP > tabledap

Tabledap lets you use the OPeNDAP constraint/selection protocol to request data subsets, graphs, and maps from tabular datasets (for example, buoy data).
For details, see ERDDAP's tabledap Documentation.

List of tabledap Datasets

76 matching datasets, listed in alphabetical order.

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	WMS	Source Data Files	Title	Sum-mary	FGDC, ISO, Metadata	Back-ground Info	RSS	E mail	Institution	Dataset ID
	set	data	graph			* The List of All Active Datasets in this ERDDAP *		M	background			Rutgers Univers ...	allDatasets
		data	graph			CE04OSPS-PC01B-4A-CTDPFA109-streamed-ctdpf_optode_sample		F I M	background	RSS		Ocean Observato ...	CE04OSPS-PC01B-4A-CTDPFA109-streamed-ctdpf_optode_sample
		data	graph			CE04OSPS-PC01B-4C-PCO2WA105-streamed-pco2w_a_sami_data_record		F I M	background	RSS		Ocean Observato ...	CE04OSPS-PC01B-4C-PCO2WA105-streamed-pco2w_a_sami_data_record
		data	graph			CE04OSPS-SF01B-2A-CTDPFA107-streamed-ctdpf_sbe43_sample		F I M	background	RSS		Ocean Observato ...	CE04OSPS-SF01B-2A-CTDPFA107-streamed-ctdpf_sbe43_sample
		data	graph			CE04OSPS-SF01B-2B-PHSENA108-streamed-phsen_data_record		F I M	background	RSS		Ocean Observato ...	CE04OSPS-SF01B-2B-PHSENA108-streamed-phsen_data_record
		data	graph			CE04OSPS-SF01B-3A-FLORTD104-streamed-flort_d_data_record		F I M	background	RSS		Ocean Observato ...	CE04OSPS-SF01B-3A-FLORTD104-streamed-flort_d_data_record
		data	graph			CE04OSPS-SF01B-4A-NUTNRA102-streamed-nutnr_a_sample		F I M	background	RSS		Ocean Observato ...	CE04OSPS-SF01B-4A-NUTNRA102-streamed-nutnr_a_sample
		data	graph			CE04OSPS-SF01B-4F-PCO2WA102-streamed-pco2w_a_sami_data_record		F I M	background	RSS		Ocean Observato ...	CE04OSPS-SF01B-4F-PCO2WA102-streamed-pco2w_a_sami_data_record
		data	graph			CE04OSSM-RID26-04-VELPTA000-telemetered-velpt_ab_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-RID26-04-VELPTA000-telemetered-velpt_ab_dcl_instrument
		data	graph			CE04OSSM-RID26-06-PHSEND000-telemetered-phsen_abcdef_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-RID26-06-PHSEND000-telemetered-phsen_abcdef_dcl_instrument
		data	graph			CE04OSSM-RID26-07-NUTNRB000-telemetered-nutnr_b_dcl_conc_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-RID26-07-NUTNRB000-telemetered-nutnr_b_dcl_conc_instrument
		data	graph			CE04OSSM-RID27-02-FLORTD000-telemetered-flort_dj_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-RID27-02-FLORTD000-telemetered-flort_dj_dcl_instrument
		data	graph			CE04OSSM-RID27-03-CTDBPC000-telemetered-ctdbp_cdef_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-RID27-03-CTDBPC000-telemetered-ctdbp_cdef_dcl_instrument
		data	graph			CE04OSSM-RID27-04-DOSTAD000-telemetered-dosta_abcdjm_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-RID27-04-DOSTAD000-telemetered-dosta_abcdjm_dcl_instrument
		data	graph			CE04OSSM-SBD11-02-HYDGN0000-telemetered-hyd_o_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-SBD11-02-HYDGN0000-telemetered-hyd_o_dcl_instrument
		data	graph			CE04OSSM-SBD11-04-VELPTA000-telemetered-velpt_ab_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-SBD11-04-VELPTA000-telemetered-velpt_ab_dcl_instrument
		data	graph			CE04OSSM-SBD11-06-METBKA000-telemetered-metbk_a_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-SBD11-06-METBKA000-telemetered-metbk_a_dcl_instrument
		data	graph			CE04OSSM-SBD12-03-HYDGN0000-telemetered-hyd_o_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE04OSSM-SBD12-03-HYDGN0000-telemetered-hyd_o_dcl_instrument
		data	graph			CE04OSSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_air		F I M	background	RSS		Ocean Observato ...	CE04OSSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_air
		data	graph			CE04OSSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_water		F I M	background	RSS		Ocean Observato ...	CE04OSSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_water
		data	graph			CE05MOAS-GL381-01-PARADM000-telemetered-parad_m_glider_instrument		F I M	background	RSS		Ocean Observato ...	CE05MOAS-GL381-01-PARADM000-telemetered-parad_m_glider_instrument
		data	graph			CE05MOAS-GL381-02-FLORTM000-telemetered-flort_m_glider_instrument		F I M	background	RSS		Ocean Observato ...	CE05MOAS-GL381-02-FLORTM000-telemetered-flort_m_glider_instrument
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		data	graph			CE05MOAS-GL381-05-CTDGVM000-telemetered-ctdgv_m_glider_instrument		F I M	background	RSS		Ocean Observato ...	CE05MOAS-GL381-05-CTDGVM000-telemetered-ctdgv_m_glider_instrument
		data	graph			CE07SHSM-MFD35-02-PRESFB000-telemetered-presf_abc_dcl_tide_measurement		F I M	background	RSS		Ocean Observato ...	CE07SHSM-MFD35-02-PRESFB000-telemetered-presf_abc_dcl_tide_measurement
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		data	graph			CE07SHSM-MFD35-06-PHSEND000-telemetered-phsen_abcdef_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE07SHSM-MFD35-06-PHSEND000-telemetered-phsen_abcdef_dcl_instrument
		data	graph			CE07SHSM-MFD37-03-CTDBPC000-telemetered-ctdbp_cdef_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE07SHSM-MFD37-03-CTDBPC000-telemetered-ctdbp_cdef_dcl_instrument
		data	graph			CE07SHSM-MFD37-03-DOSTAD000-telemetered-dosta_abcdjm_ctdbp_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE07SHSM-MFD37-03-DOSTAD000-telemetered-dosta_abcdjm_ctdbp_dcl_instrument
		data	graph			CE07SHSM-RID26-06-PHSEND000-telemetered-phsen_abcdef_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE07SHSM-RID26-06-PHSEND000-telemetered-phsen_abcdef_dcl_instrument
		data	graph			CE07SHSM-RID26-07-NUTNRB000-telemetered-nutnr_b_dcl_conc_instrument		F I M	background	RSS		Ocean Observato ...	CE07SHSM-RID26-07-NUTNRB000-telemetered-nutnr_b_dcl_conc_instrument
		data	graph			CE07SHSM-RID27-02-FLORTD000-telemetered-flort_dj_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE07SHSM-RID27-02-FLORTD000-telemetered-flort_dj_dcl_instrument
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		data	graph			CE07SHSM-SBD11-04-VELPTA000-telemetered-velpt_ab_dcl_diagnostics		F I M	background	RSS		Ocean Observato ...	CE07SHSM-SBD11-04-VELPTA000-telemetered-velpt_ab_dcl_diagnostics
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		data	graph			CE07SHSM-SBD12-03-HYDGN0000-telemetered-hyd_o_dcl_instrument		F I M	background	RSS		Ocean Observato ...	CE07SHSM-SBD12-03-HYDGN0000-telemetered-hyd_o_dcl_instrument
		data	graph			CE07SHSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_air		F I M	background	RSS		Ocean Observato ...	CE07SHSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_air
		data	graph			CE07SHSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_water		F I M	background	RSS		Ocean Observato ...	CE07SHSM-SBD12-04-PCO2AA000-telemetered-pco2a_a_dcl_instrument_water
		data	graph			CE07SHSM-SBD12-05-WAVSSA000-telemetered-wavss_a_dcl_fourier		F I M	background	RSS		Ocean Observato ...	CE07SHSM-SBD12-05-WAVSSA000-telemetered-wavss_a_dcl_fourier
		data	graph			CE07SHSM-SBD12-05-WAVSSA000-telemetered-wavss_a_dcl_mean_directional		F I M	background	RSS		Ocean Observato ...	CE07SHSM-SBD12-05-WAVSSA000-telemetered-wavss_a_dcl_mean_directional
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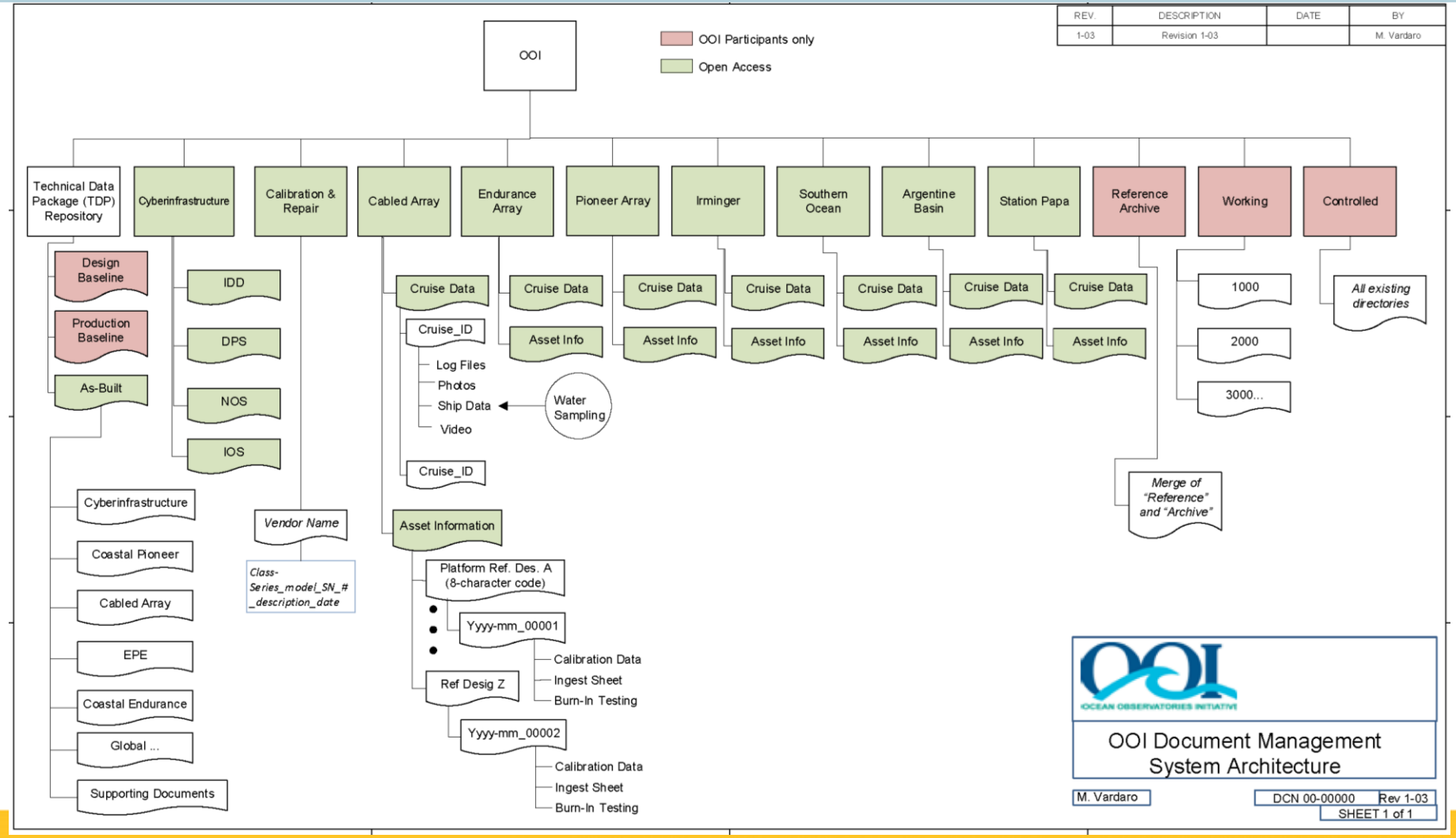
M2M Interface

- Machine to Machine, script-based data download
- Use Python script to send properly formatted request to the system (using API username and token), data file is returned
- User requests consist of the rest of the URL and parameters that normally form a uFrame data request
- Data returns are not aggregated, so small, recurring requests are better (this may change)
- Still in testing/feedback phase

Alfresco Document Management



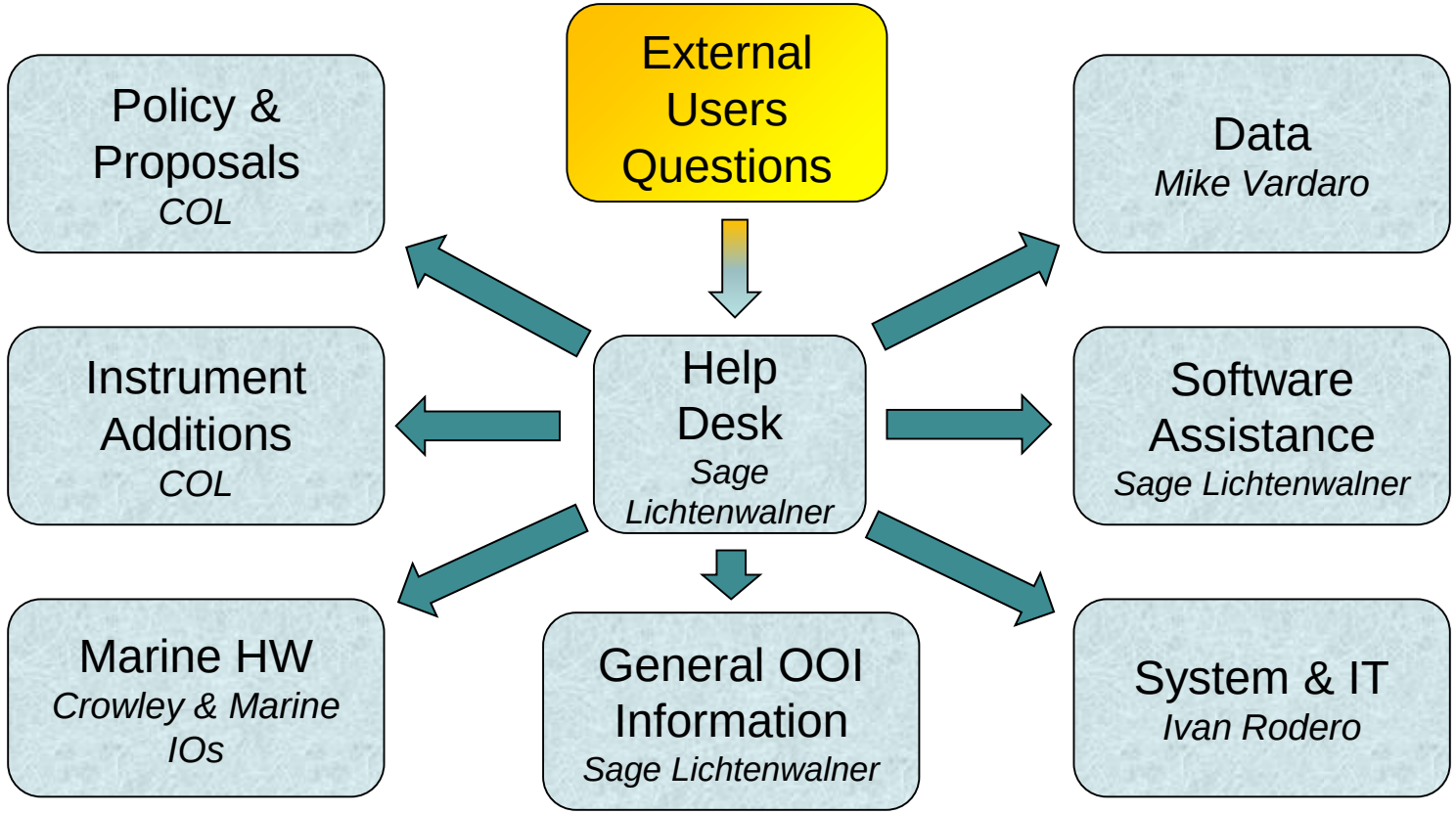
Shipboard Data Types

Data Type	Examples	Source/Format	Purpose	User-Needed Functions
UNOLS Shipboard Instrumentation	Navigation Track Multibeam Data Underway Meteorologic Data (e.g. SST, air temp, humidity, wind speed) ADCP CTD Cast Data (Raw Files) CTD Cast Data (Processed Files) Sailing Orders, Staffing Logs In-line (underway) Cytometer	R2R – or – .pdf, csv file, spreadsheet, native file format (ship tech and scientist upload) ~100 Gb/cruise	Field Verification Support/enable Science Users	Access/Download Plotting in OOINet (?)
Cruise Report	Text Figures Maps E-log ROV dive tracks, ROV Log Instrument Layouts	.pdf for report - and - raw spreadsheets, csv files, high-res figures (scientist upload) ~100 Mb/cruise max	Support/Enable Science Users	Access/Download
Water Samples from CTD Rosette	Salinity (shore-based) Dissolved oxygen (ship- or shore-based) Chl-a fluorescence (ship- or shore-based) Pigment distribution (shore-based) Nitrate + nitrite (shore-based analyses) Full nutrient suite: PO4, NO3, NO2, SIOH4, NH4 (shore-based analyses) Total DIC, total alkalinity (shore-based) pH, spectrophotometric (shore-based)	spreadsheets, csv files, native file format (scientist upload) <100 Mb/cruise max	Calibration Field Verification Support/Enable Science Users	Access/Download Plotting in OOINet (?)
Physical Samples from Seafloor (Water, Gas, Other)	Methane Ethane Hydrogen sulfide Carbon dioxide pH Sediment Cores	spreadsheets, csv files, high-res figures, native file format (scientist upload)	Calibration Field Verification Support/Enable Science Users	Access/Download Plotting in OOINet (?)

Raw Data Access

- Apache server mirroring Rutgers data archive
- HD Video
- Still images
- Seismic Data
- Low-Frequency Hydrophones
- Broadband Hydrophones
- Bioacoustic Sonar

Help Desk Process



- help@oceanobservatories.org
- Redmine used to track trouble tickets.
- Help desk will be covered by DM and PM in Help Desk absence.

Questions?

- OOI Main Web site: http://oceanobservatories.org
- Data Portal: http://ooinet.oceanobservatories.org

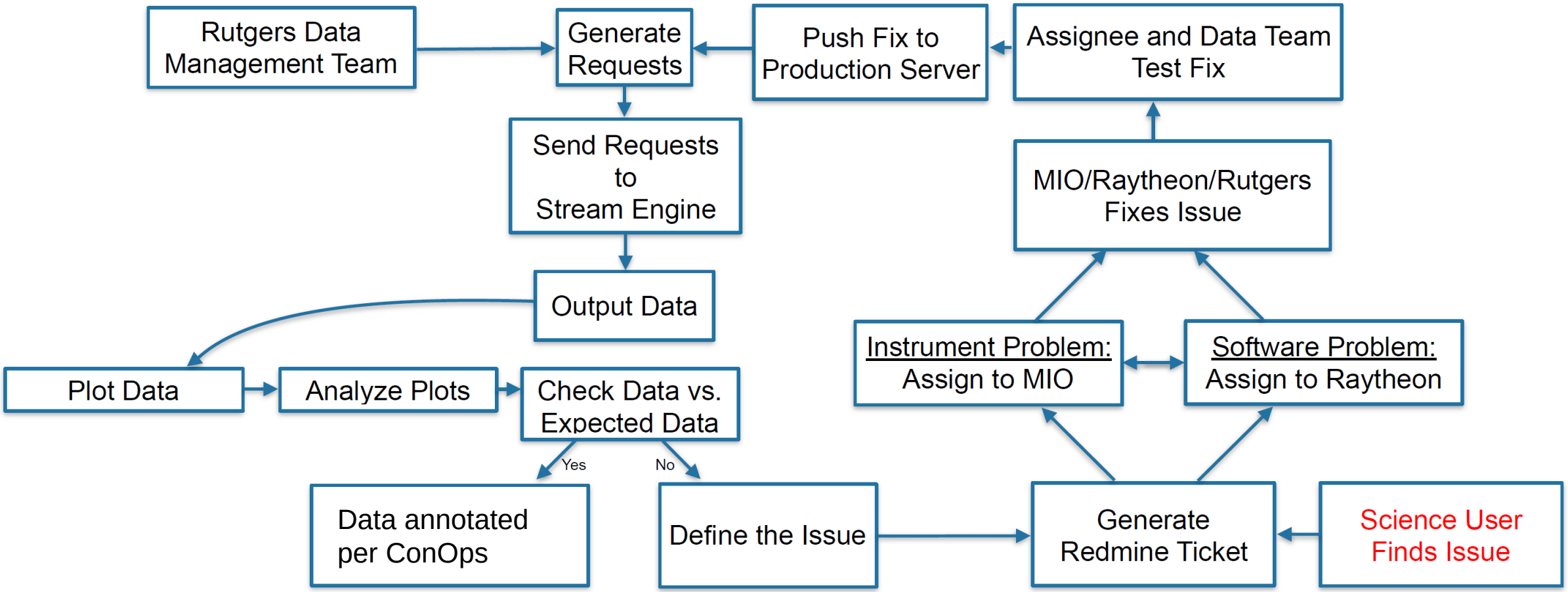
Mike Vardaro, Data Manager, OOI CI Data Team
vardaro@marine.rutgers.edu

Acknowledgements: NSF, COL, Rutgers University, University of Washington, WHOI, Oregon State University, RPS-ASA, Raytheon, UCSD/SIO

Additional Material

QC Procedures and Tools

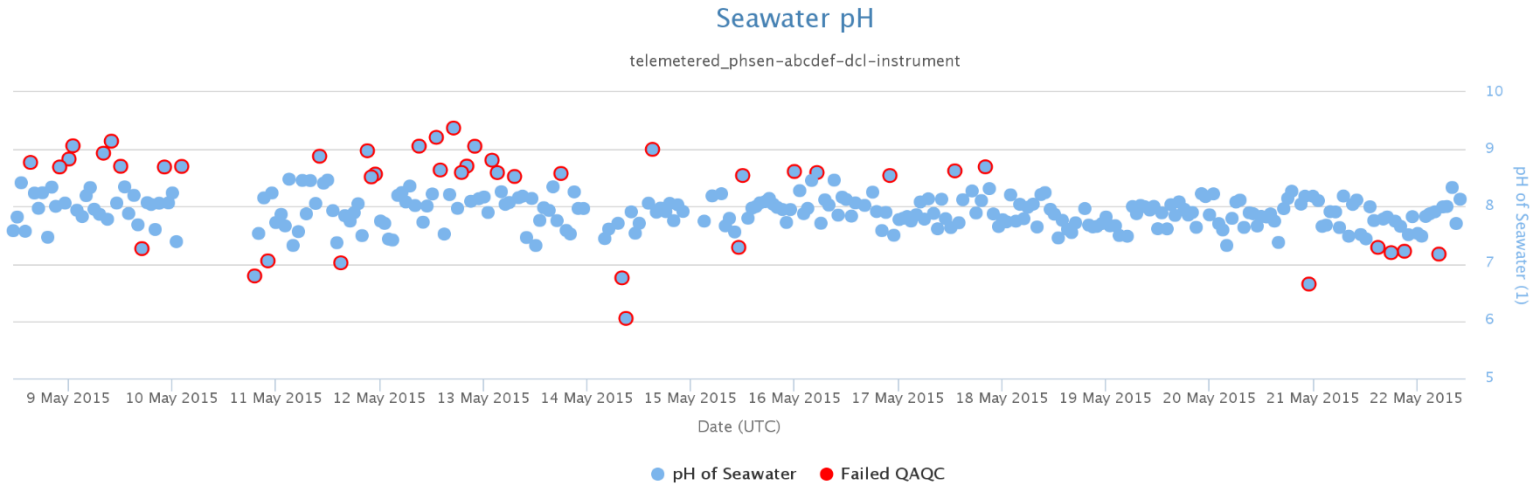
Data Evaluation Team QA/QC Testing



OOI Automated QC Procedures

- 7 automated QC algorithms can produce 8 flags (including logical “or” which combines flags) which are plottable and are included in downloaded files
- Coded based on specifications written by OOI Project Scientists, derived from QARTOD manuals and other observatory experiences
- Algorithms refer to “lookup tables” assembled by OOI Project Scientists with input from subject matter experts: https://github.com/ooi-integration/qc-lookup

1. Global Range Test
2. Local Range Test
3. Spike Test
4. Stuck Value Test
5. Trend Test
6. Temporal Gradient Test
7. Spatial Gradient Test (Profile)



QC Challenges

- Local range values will require ongoing gathering of environmental data for each platform
- Spike test is currently very simple, and needs tweaking to avoid false positives/negatives (especially in biological data) and to work with certain data types
- Trend test may not work as designed, because it requires the system to compare data prior to the user request date
- Gradient test is complicated to apply, requires 2D dataset
- Not all QC algorithms apply to all data products – ongoing review with Project Scientists
- The QC algorithms do NOT trigger alerts in the system
  - Alerts/alarms only trigger when new data is telemetered/streamed
  - Can set alerts on L1/L2 data streams based on Global/Local range values

Progress Since January

- New GUI (faster responses, no terms pop up, more array info, better plotting, better data catalog, asset management improvements)
- Majority of data loaded on production system, downloadable
- Streaming data plotting available
- Raw data access since April
- ERDDAP demo
- M2M nearly ready for release (still needs testing)
- Full database of platforms, instruments, data streams, and parameters created by data team

Work to Go

- GUI upgrades needed (better maps, status info, glider page, plotting updates)
- Aggregation of downloaded data files
- Full data ingestion and delivery
- Full Asset Management
- Health and Status information page, Operator Logs, Data Forum
- Implement full QC plan
- Secondary calibration

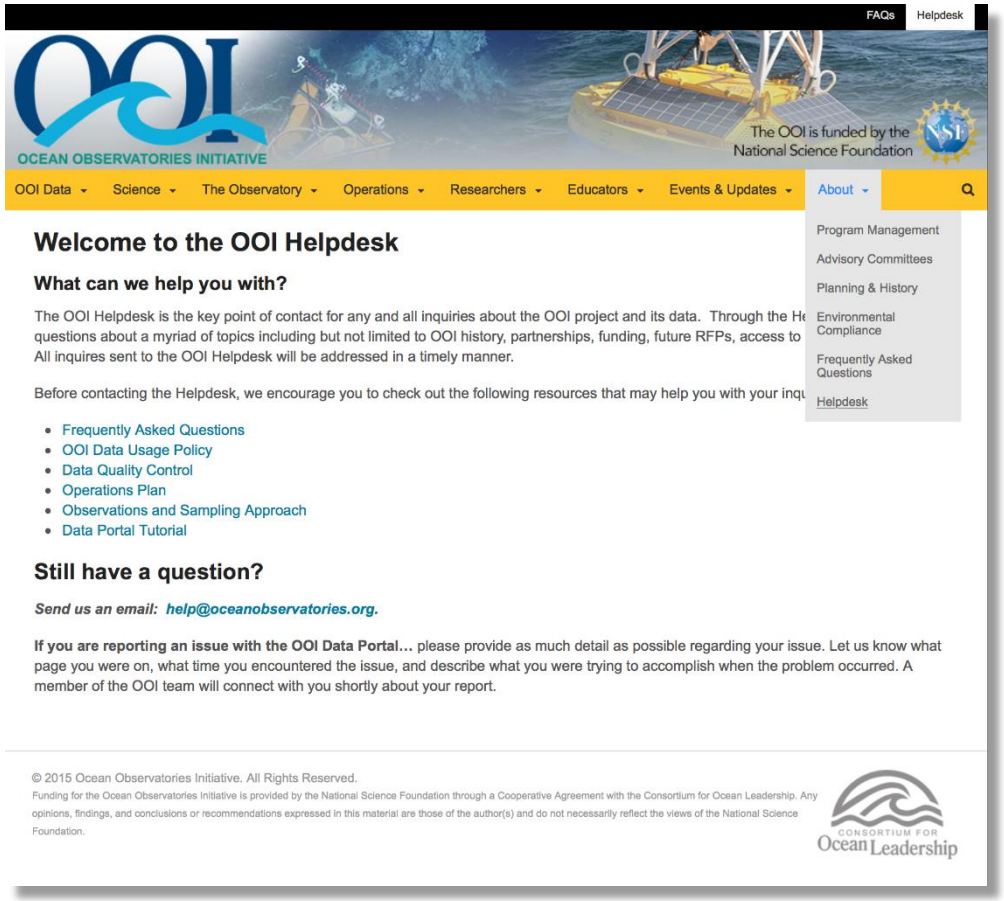
Lessons Learned

Metadata standards

- Process of defining, collecting, and determining presentation of metadata has been ongoing for longer than anticipated
- Software developers interpreted metadata standards differently than intended by the science requirements
- Climate and Forecast (CF-1.6) standards adopted
- Presentation in NetCDF header is incomplete but being improved
- Provenance delivered in a separate .json file
- More formatting work needs to be done

Communication

- The main method of communication from the data team to users is via annotation (requires enhancement)
- Main method of communication from users to data team is through help desk requests (via website)
- Also needed to standardize and improve communication between data team and Marine Implementing Organization personnel



QA vs. QC

- Quality Control is a product check to identify flaws or defects
- Quality Assurance is a defined process used to diagnose why a product is flawed or being produced incorrectly
- The data team has had to become increasingly familiar with the end-to-end production of data products
- Wider teamwork required to track (sometimes mysterious) issues back to a specific cause
  - Software error or missing data vs…
  - Instrument miscalibration by vendor vs…
  - Instrument settings changed during deployment vs…
  - Mooring run over by ship

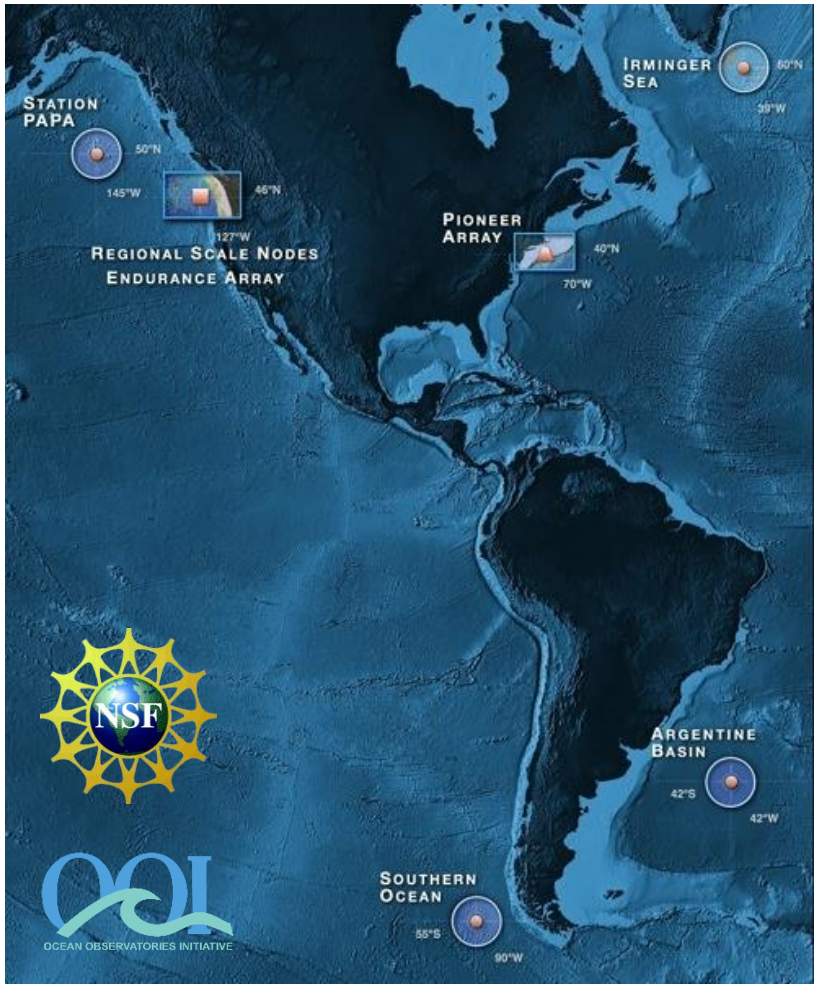
Near-Term Priorities

- Deliver high quality data to the community, enabled and accelerated via feedback and community “eyes” on the products
  - Requires transparency in software releases, QC procedures, and documentation
- Hybrid data delivery approaches to augment asynchronous data delivery via GUI, using THREDDS, ERDDAP, etc.
- Organize a cross-project team to define and develop a method for post-recovery secondary calibration. This group will rely on external community input.
- Several high value and high interest OOI datasets (e.g. bioacoustics, covariance flux measurements, vent fluid chemistry) will require entraining the external community in data quality and delivery discussions
- Addition of a data forum and additional communications to external scientists
  - OOI is more then a collection of sensors: an ongoing distributed community discussion

Education and Public Engagement

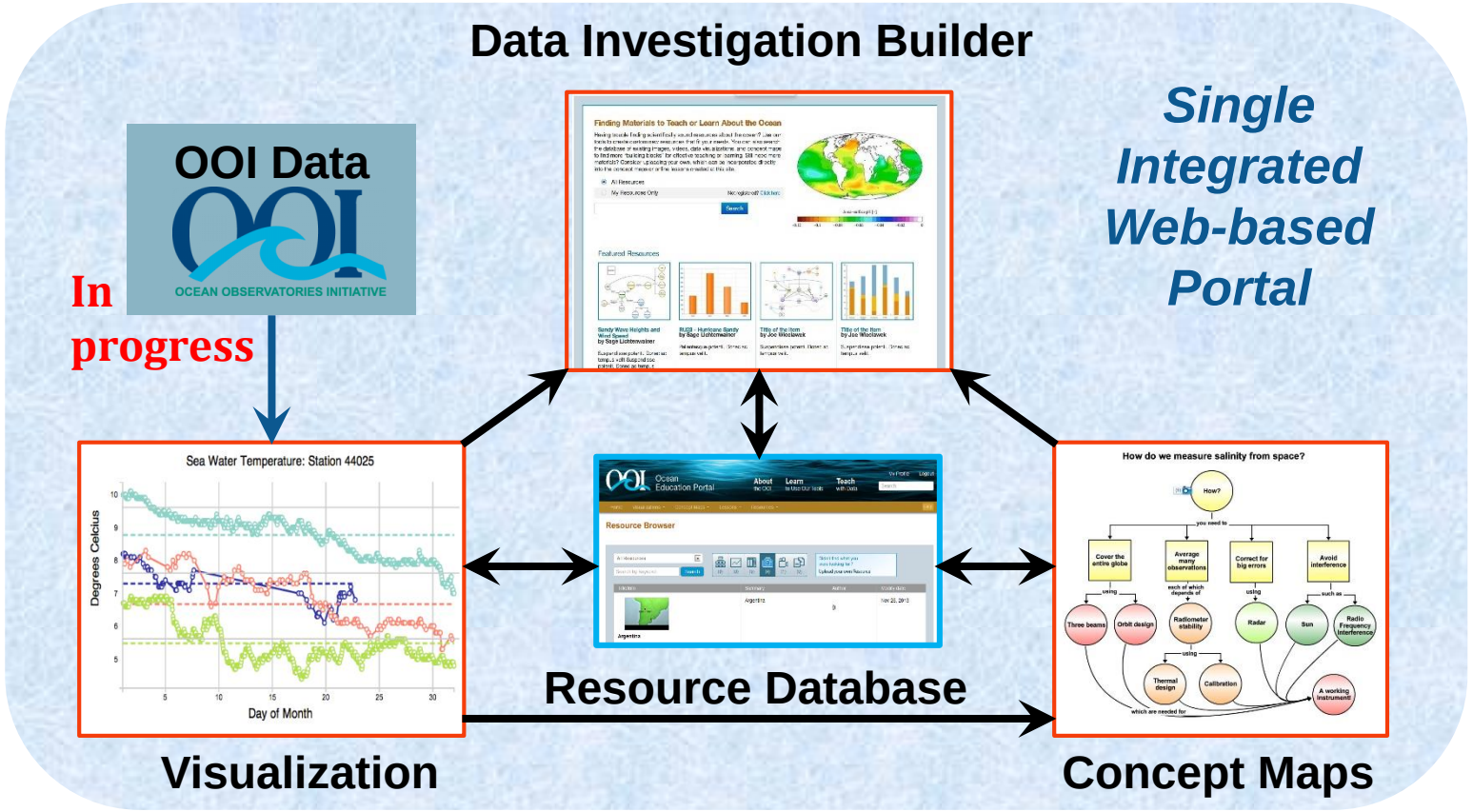
OOI: Education & Public Engagement

Enabling the Use of Real-Time OOI Data in the Undergraduate Classroom



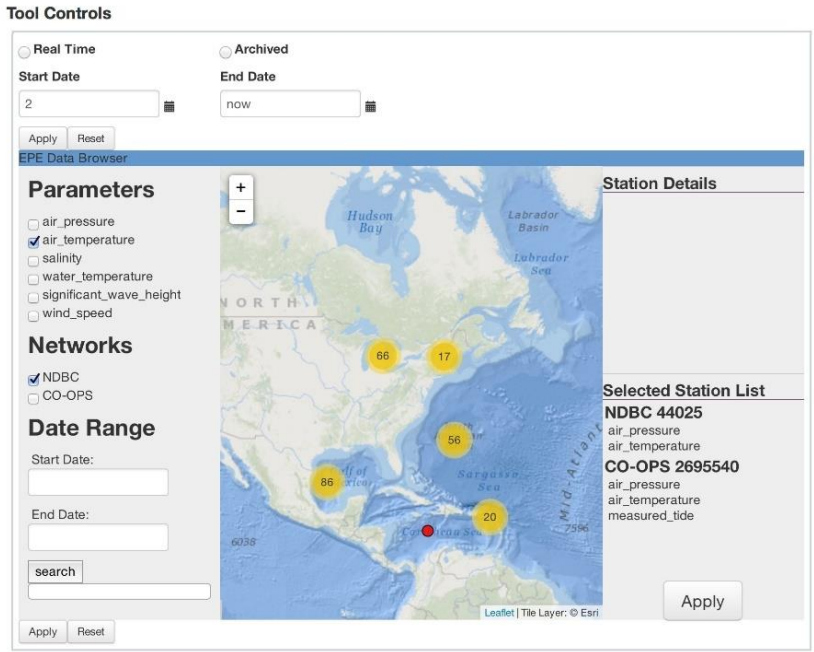
EPE System Architecture

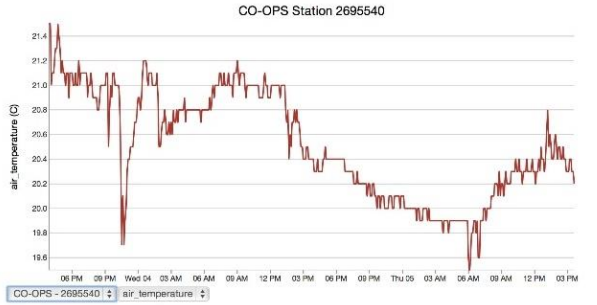
Three primary tools, accessible through a single website, and sharable through a resource database:

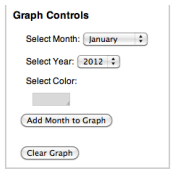


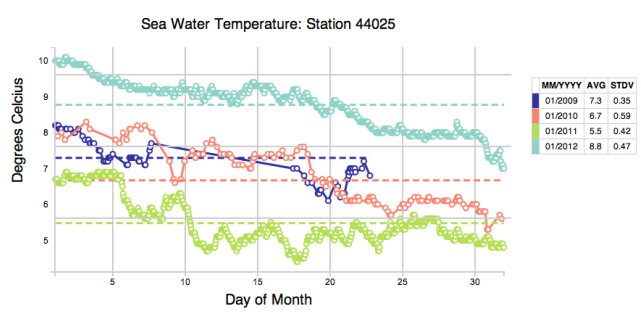
Educational Visualization Service

- Building flexible and customizable visualization tools
- Focused on various time series
- Goal is to balance capability and usefulness
- Multiple entry points (teacher, student, developer)



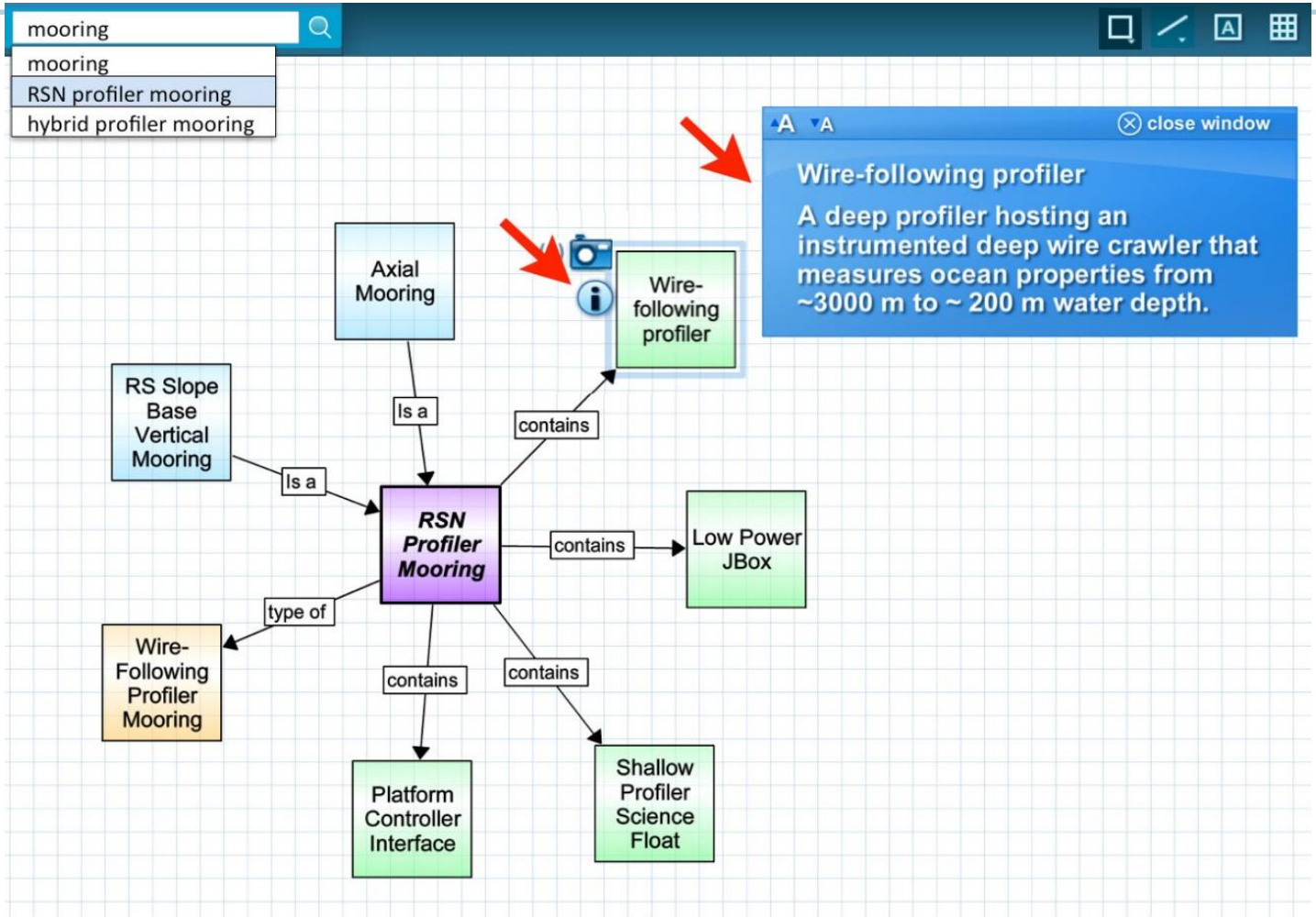






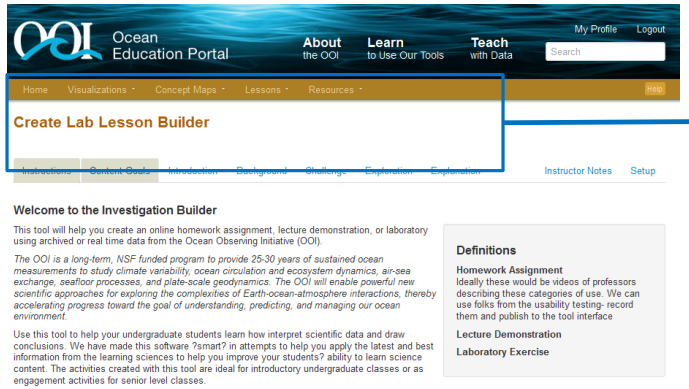
Concept Mapper

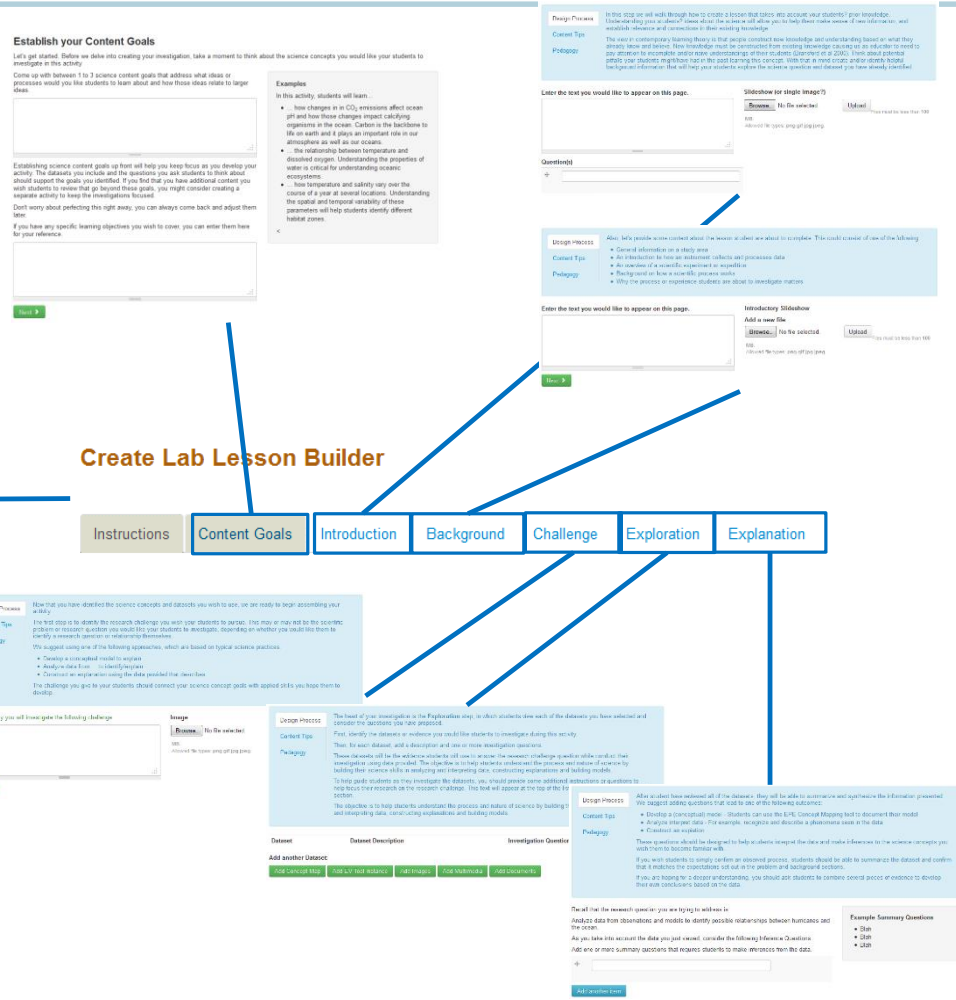
- Concept Map Builder (create & edit) and Viewer
- Concept & linking phrase suggestions (ontologies)
- *Embedded content* resources such as descriptions, data visualizations, photos & videos from OOI & outside resources



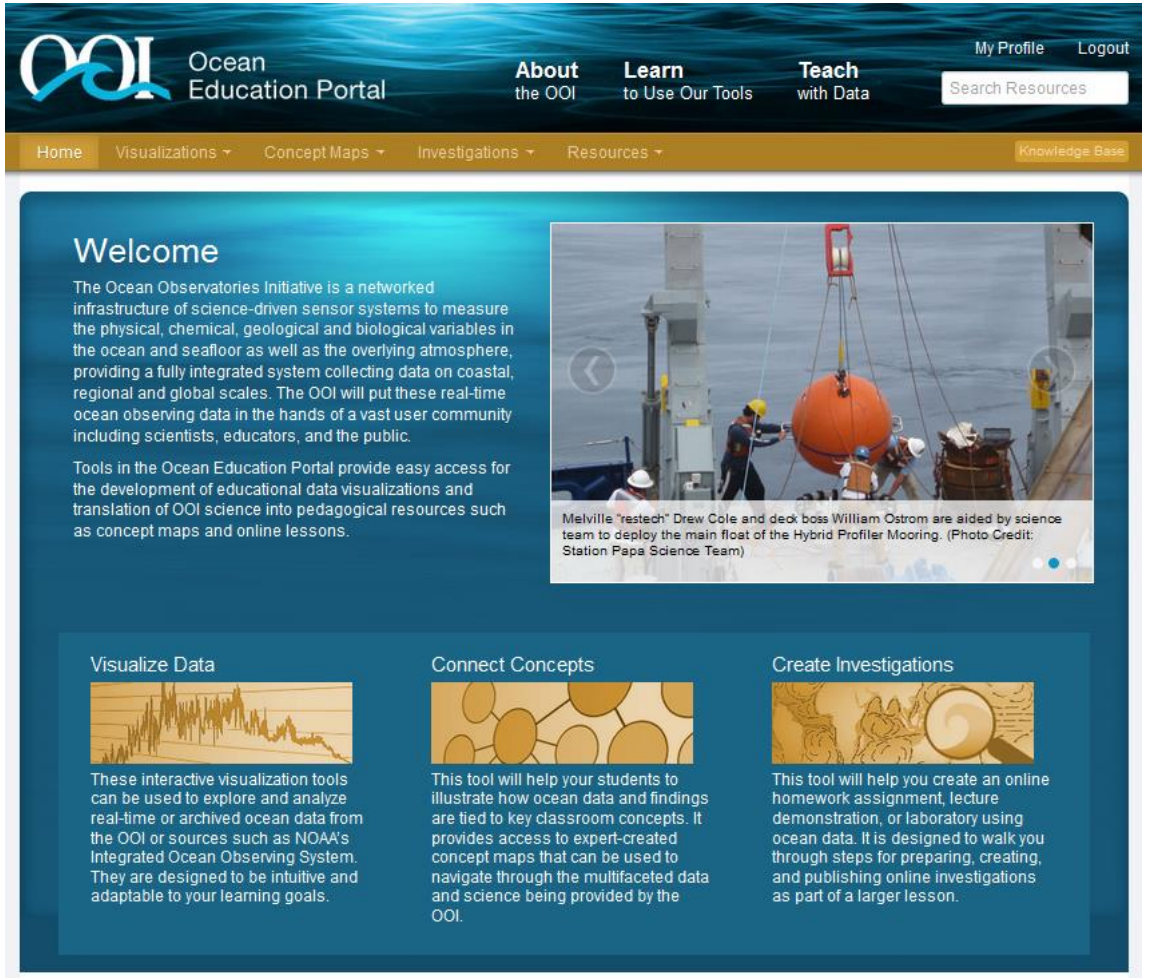
Data Investigation Builder

- Community library of investigations
- Online lesson template
- Investigation Builder Wizard (step by step design process)
- EPE resource integration





EPE Website: http://education.oceanobservatories.org



Ocean Education Portal

Education Tools

- Concept Map Builder
- Investigation Builder
- Visualization Tools
- Vocabulary Navigator
- Resource Database