Development and implementation of best practices for the Ocean Networks Canada ocean observatories

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Ocean Networks Canada
Quality Assurance Process - Instruments

1) Procurement
   DS, MO
2) Development
   DS, MO, SE, DT, SC
3) Testing
   DS, MO, SE, DT, SC
4) Deployment
   DS, MO, SYS
5) Commissioning
   DS, MO, SE, DT, SC, COMMS
6) Recovery
   DS, MO, SYS
7) Servicing
   DS, MO
8) Decommissioning
   DS

DS - Data Stewardship
MO - Marine Operations
SYS - Systems
SE - Software Engineering
DT - Data Team
SC - Science Team
COMMS - Communications
Pre-Deployment Testing - Instruments
Instrument deployments

Barkley benthic pod 3 in position on the seafloor, with rotary sonar lifted into deployment position, 11 September 2009.
Instrument Deployment and Maintenance Expeditions – Workflows

### Autonomous Cruise Device On-Shore Development

<table>
<thead>
<tr>
<th>Task</th>
<th>Area of Responsibility</th>
<th>Status</th>
<th>Comment</th>
<th>JIRA</th>
<th>Last Modified (UTC)</th>
<th>Modified By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device - create</td>
<td>Data Stewardship</td>
<td>Complete</td>
<td></td>
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<tr>
<td>Sensors - create</td>
<td>Data Stewardship</td>
<td>Complete</td>
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<td>Ports - create</td>
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<tr>
<td>Calibrations - update</td>
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<td>Complete</td>
<td>calibration sheets received</td>
<td>NEPDATA-1876</td>
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<td>Conversion routine - prepare</td>
<td>Data Stewardship</td>
<td>Complete</td>
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<tr>
<td>Parser - develop</td>
<td>Software Development/Testing</td>
<td>Complete</td>
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<tr>
<td>Data Products - develop</td>
<td>Data Team</td>
<td>Complete</td>
<td>log files are sufficient for now</td>
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</table>

### Autonomous Cruise Device Field Procedure

<table>
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<tr>
<th>Task</th>
<th>Area of Responsibility</th>
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<th>Comment</th>
<th>JIRA</th>
<th>Last Modified (UTC)</th>
<th>Modified By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument Documentation - collect</td>
<td>Data Stewardship</td>
<td>Complete</td>
<td>scanned calibration sheets obtained by Karen</td>
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<tr>
<td>Power supply - verify</td>
<td>Engineering</td>
<td>Complete</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Autonomous Data Storage - verify</td>
<td>Data Stewardship</td>
<td>Complete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrument - prepare</td>
<td>Engineering</td>
<td>Complete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrument Clock - synchronize</td>
<td>Engineering</td>
<td>Incomplete</td>
<td></td>
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<tr>
<td>Autonomous data - download</td>
<td>Engineering</td>
<td>Complete</td>
<td></td>
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<tr>
<td>Data Stream - verify</td>
<td>Systems</td>
<td>Complete</td>
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<td></td>
</tr>
<tr>
<td>Instrument - configure</td>
<td>Engineering</td>
<td>Complete</td>
<td>via ROV dive logs, topology, sideneeds and device actions</td>
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</table>
Logging during ROV maintenance operations
Logging during ROV maintenance operations

- SeaScribe logging system annotates maintenance, survey, and sampling activities on ROV video
- Annotations also record scientific observations of seafloor substratum and biology
- Increases searchability and usability of dive video
- Supports derivative applications, such as automated classifiers and generation of geodatabase layers
Integrating Physical Sample Info and Video Annotations into Digital Infrastructure
ONC Quality Assurance and Quality Control (QA/QC) Best Practices

Quality Assurance

• Entire organization follows process to ensure best possible data quality
• Instruments collecting data must be tested, validated and commissioned to ensure data quality throughout deployments

Quality Control

• Maximizing scientific value of data received from instruments by
  o Identifying and flagging outliers in the data
  o Returning information about the quality to the user
  o Adhering to international standards for quality control
ONC Quality Control

Automated tests and Manual review

• Automated QC tests:
  o Provide QC flags in real-time
  o Gross range values tests to ensure instruments are working within specifications
  o Other range values tests to ensure data are similar to other data from the site

• Manual QA/QC
  o All data are reviewed by a Data Specialist
  o QC flags are adjusted as needed
Automated QC

• Tests applied to most scalar data as they are parsed from received data string
• Flagged data available in real-time
• Two types of Automated tests: Real-time and Delayed mode QA/QC
  o Real-time tests
    • Single sensor tests – range value test
      – Instrument manufacturer levels for sensors
      – Regionally applicable levels (climatological)
      – Site specific levels – 3-σ values based on statistics of previously recorded data
    • Dual Sensor tests – use of 2 sensors to qualify data
      – Temperature/Conductivity tests to validate conductivity data based on previous site data
  o Delayed mode tests are not ‘real-time’
    • Spike and gradient tests - both need data surrounding in time to validate the data being tested
    • Delayed by sample time but can also be batch processed on a schedule
ONC QA/QC Model

Process-Oriented Quality Assurance (QA)
- Manual Data Assessment Annotations
- Workflow processes QA
  - Ensure high quality data delivery (On Instruments)

Product-Oriented Data Quality Control (QC)
- Automated Real-time QC
- Automated Near-Real time (Delayed) QC
- Manual QC

Post deployment Commissioning

Pre deployment Testing

Note: The tasks listed under workflow processes are limited to those actions that have a direct impact on data quality.
Data Curation and Access

- all sensor data and imagery archived
- records of data processing and derivations
- free and open access to all data and imagery
- online graphical previews of scalar data
- online viewing of annotated, archived video
- web services delivery of data & downloads of all data

Seatube

Plotting utility
Data Stewardship Best Practices & Standards

- Member of the World Data System since July 2014
  - Committed to high quality data, data stewardship and participation in interoperability efforts.

- Data acquisition and hosting services for third party organizations
  - Partners include Pacific Salmon Foundation, FORCE, DFO’s Arctic drifter program, and more.

- Actively participation in relevant working group activities
  - CODATA, RDA, ESIP, WDS, Earth Cube and others.
Data Stewardship Best Practices & Standards

Future Plans
• ISO 19115 metadata records
• IGSN registration of geological samples,
• OBIS support for biological samples,
• Glider data contributions to the IOOS Glider Data Assembly Center,
• Citations and unique identifiers for datasets
• OPeNDAP dataset expansion
### Interoperability Protocols, Formats & Conventions

| Data Access Protocol          | - OPeNDAP (Open source Project for a Network Data Access Protocol)  
|                              |   • Initially designed by oceanographers and computer scientists  
|                              |   • Existing web services for metadata and data delivery          |
| Data Format                   | - NetCDF (Network Common Data Form)                             
|                              |   • Multi-dimensional data and embedded metadata                 
|                              |   • Widely adopted by oceanographic and climate communities       |
| Metadata Convention           | - CF (Climate & Forecast)                                       
|                              |   • Specifically designed for use with NetCDF                    
|                              |   • Defines metadata field-value options, and standard variable names |
Case Study - BC Ferries sea-surface monitoring program
Daily patterns: Salinity

- Measurements every 10 seconds; Trip duration = ~1.5 - 2.5 hours
- 4 - 8 cross-Strait trips / day
- Central route typically transits through the Fraser River plume
- Northern and Southern ferries often transit through the plume
- Strong cross-strait salinity gradient
Instrumentation

Meteorological

Oceanographic

Chl. / CDOM Turbidity

Oxygen Optode

Thermosalinograph
Impact of fouling and cleaning on CDOM fluorescence

1. Significant bio-fouling of optical instruments

2. Fouling:
   a) Elevated baseline
   b) Diminished signal range

• Instruments cleaned every 2-3 weeks
Impact of fouling and cleaning on CDOM fluorescence

1. Significant bio-fouling of optical instruments

2. Fouling:
   a) Elevated baseline
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- Instruments cleaned every 2-3 weeks
- Cleaning yields significant improvement of signal quality
Inter-variable comparisons: Salinity and CDOM

1. Fraser River = major source of freshwater and CDOM in the Strait of Georgia
2. Salinity-CDOM relationship is strong
3. Thermosalinograph not as susceptible to fouling
4. Salinity-CDOM = potential index of fouling
Salinity vs. CDOM (pre/post cleaning)

1. $R^2_{adj} > 0.93$ : Spatio-temporal pattern of CDOM/Salinity relatively immune to fouling

2. Compared slope of Salinity-CDOM relationships on the trip before and after cleaning

3. Slope of the relationship significantly reduced due to fouling

4. Good index of fouling *specific to this environment*
Methods: Routine Maintenance Program

1. CDOM fluorescence measurements are very sensitive to bio-fouling

2. Fluorescence is clearly improved with cleaning every 2-3 weeks

3. Pre/Post cleaning fluorescent measurements using a CDOM “standard” = Tonic Water

4. Applied a linear retrospective correction based on % change in fluorescence Pre/Post cleaning
Salinity vs. CDOM: Calibration corrections

Slope (pre) = -0.94  Pre = -0.36  Pre = -0.25  Pre = -0.14
Slope (post) = -1.02 Post = -0.39  Post = -0.26  Post = -0.15

In all cases, application of standards-based correction factors improved pre/post Salinity-CDOM slopes
Summary

1. Optical sensors are susceptible to fouling

2. Especially problematic in surface waters (shallow coastal, gliders, ferries)

3. Regular cleaning routines are necessary

4. Inter-variable relationships are negatively impacted by fouling in short time-scales

5. “Correction-factors” can be derived using pre/post cleaning approaches

6. Useful approach to improve data quality

7. Applicable at a variety of time-scales?