

QARTOD

QUALITY ASSURANCE/QUALITY CONTROL OF REAL-TIME OCEANOGRAPHIC DATA

U.S. IOOS Quality Assurance / Quality Control of Real-time Oceanographic Data (QARTOD) Project

Mark Bushnell
National Coordinator, US IOOS/QARTOD



NSF Ocean Observatories Initiative Facility Board
October 30, 2018

QARTOD Manuals, Manual Maintenance



Who else is using QARTOD?

NSF Ocean Observatories Initiative

“**Data Quality Control Processes** - Oceanographic and engineering data throughout the OOI system are reviewed through manual (human in the loop) and automated quality control procedures. The overall goal is to ensure that the data and metadata delivered by the OOI meet community data quality standards. These standards were designed with the goal of meeting the Integrated Ocean Observing System (IOOS) Quality Assurance of Real Time Ocean Data (QARTOD) standards.”

Smith, L.M., J.A. Barth, D.S. Kelley, A. Plueddemann, I. Rodero, G.A. Ulses, M.F. Vardaro, and R. Weller. 2018. *The Ocean Observatories Initiative*. *Oceanography* 31(1):16–35, <https://doi.org/10.5670/oceanog.2018.105>.

After nearly **10 years** and **expenses of US\$386 million**, in June 2016, NSF announced that most OOI data were flowing in real time from more than **900 sensors at the 7 sites**. The **annual budget is approximately \$55 million**. Witze, Alexandra (2016-06-09). "US ocean-observing project launches at last". *Nature*. 534 (7606): 159–160. Bibcode:2016Natur.534..159W. doi:10.1038/534159a



Who else is using QARTOD?

U.S. Private Sector & University Classroom

- **Rutgers University** - Masters of Integrated Ocean Observing, a software/QA/QC boot camp informed by QARTOD.
- Jay Titlow / **Weatherflow** – Using wind tests for QC for their Caribbean installations
- Jeff Hansen / **WaveForce Technologies** - “We’ve applied QARTOD rules when rebuilding the USACE/FRF database.”
- Bruce Magnell / **Woods Hole Group** – “The QA/QC procedure implemented by WHG, in part follows QARTOD recommendations.”

Who else is using QARTOD?

International Use, Government & Private Sector

- British Oceanographic Data Centre - Global Sea Level Observing System (**GLOSS**) Quality Control Manual
- The **Southern Ocean Time Series** (SOTS) - Quality Assessment and Control Report
- **OMC International**, Australia - QC optimised for operational under keel clearance management purposes
- Mark Calverley / **Fugro UK** – “We've been advocating QARTOD in the oil and gas sector for quite a few years...”
- Carlos Garcia /SIMCosta – Implementing QARTOD in SiMCosta, the **Brazilian Coastal Monitoring System**.
- Christian Senet / **Bundesamt fuer Seeschifffahrt und Hydrographie** - “Have started to implement QARTOD wave QC testing.”

What's next for QARTOD?

FY 2019 QARTOD Plans

- One new manual, pH, ASLO kick-off
- Update waves & currents manuals
- Shift a bit toward QA, measurement uncertainty examples
- Continued international interaction
- Support for implementation, i.e. OMAO use aboard NOAA vessels, data flagging standards, others?

Dissolved Oxygen Tests & Grouping

Group 1 <i>Required</i>	Test 1 Test 2 Test 3 Test 4 Test 5	Gap Test Syntax Test Location Test Gross Range Test Climatological Test
Group 2 <i>Strongly Recommended</i>	Test 6 Test 7 Test 8	Spike Test Rate of Change Test Flat Line Test
Group 3 <i>Suggested</i>	Test 9 Test 10 Test 11	Multi-Variate Test Attenuated Signal Test Neighbor Test

IOC & QARTOD Data Flagging Scheme

Level 1

Flag	Description
Pass=1	Data have passed critical real-time quality control tests and are deemed adequate for use as preliminary data.
Not Evaluated=2	Data have not been QC-tested, or the information on quality is not available.
Suspect or Of High Interest=3	Data are considered to be either suspect or of high interest to data providers and users. They are flagged suspect to draw further attention to them by operators.
Fail=4	Data are considered to have failed one or more critical real-time QC checks. If they are disseminated at all, it should be readily apparent that they are not of acceptable quality.
Missing Data=9	Data are missing; used as a placeholder.

UNCW Implementation – Quality Report

Dorton, Jennifer

CORMP buoy quality report

To: LaClairc@uncw.edu, Bolton, Brett D., Charlton Galvarino, Jennifer Dorton, Leonard, Lynn A.

REPORT PERIOD Thu Jul 05

station	parameter_table	parameter_column	number_suspect	percent_suspect
CAP2	air_humidity	humidity	(1 / 29)	3%
CAP2	air_pressure	pressure	(0 / 29)	0%
CAP2	air_temp	temp	(0 / 29)	0%
CAP2	battery	battery	(0 / 29)	0%
CAP2	conductivity	conductivity	(0 / 29)	0%
CAP2	salinity	salinity	(0 / 29)	0%
CAP2	temperature	temperature	(0 / 29)	0%
CAP2	wind	direction	(0 / 29)	0%
CAP2	wind	gust	(0 / 29)	0%
CAP2	wind	velocity	(0 / 29)	0%
FRP2	air_humidity	humidity	(0 / 29)	0%
FRP2	air_pressure	pressure	(0 / 29)	0%
FRP2	air_temp	temp	(0 / 29)	0%
FRP2	battery	battery	(0 / 29)	0%
FRP2	conductivity	conductivity	(0 / 29)	0%
FRP2	salinity	salinity	(0 / 29)	0%
FRP2	temperature	temperature	(0 / 29)	0%

UNC Implementation – Quality Dashboard 1

CORMP Data Quality Dashboard

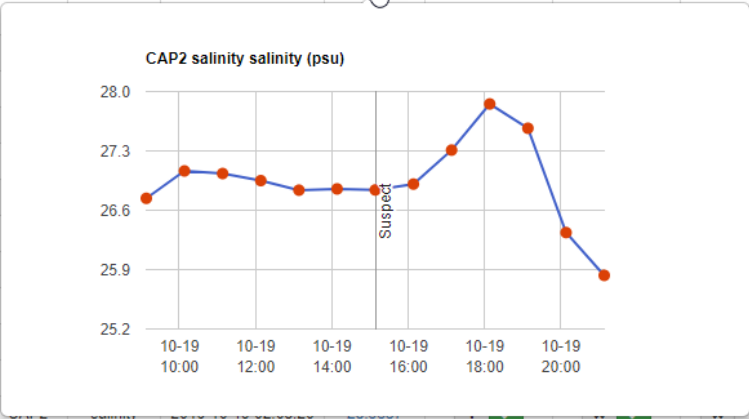
Date Range

2016-10-19 - 2016-10-19

Sensor

CAP2 surface water salinity

Platform	Parameter	Time (EDT)	Value (psu)	Test 1 (Timing)	Test 2 (Syntax)	Test 3 (Location)	Test 4 (Range)	Test 5 (Climatology)	Test 6 (Spike)	Test 7 (Change Rate)	Test 8 (Flat Line)	CORMP Rollup
CAP2	salinity	2016-10-19 19:08:20	27.5672	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 18:08:20	27.8537	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 17:08:20	27.3095	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 16:08:20	26.9087	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 15:08:20	26.9395	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 14:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 13:08:20	26.7095	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 12:08:20	26.7095	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 11:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 10:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 09:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 08:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 07:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 06:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 05:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 04:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 03:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 02:08:20	26.6547	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 01:08:20	28.5647	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-19 00:08:20	28.4294	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-18 23:08:20	28.421	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-18 22:08:20	28.2675	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-18 21:08:20	28.0119	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>
CAP2	salinity	2016-10-18 20:08:20	28.0032	? <input checked="" type="checkbox"/>	x <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	x ! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	! <input checked="" type="checkbox"/>	? x ! <input checked="" type="checkbox"/>



Climatology Ranges

Platform	Parameter	From (± 1 day)	To (± 1 day)	Min (psu)	Max (psu)
CAP2	surface_water_salinity	Jan 01	Dec 31	30	36.5

UNC Implementation – Quality Dashboard 2

CORMP Data Quality Dashboard

Date Range

2016-10-19 - 2016-10-19

Sensor

CAP2 surface water salinity

Platform	Parameter	Time (EDT)	Value (psu)	Test 1 (Timing)	Test 2 (Syntax)	Test 3 (Location)	Test 4 (Range)	Test 5 (Climatology)	Test 6 (Spike)	Test 7 (Change Rate)	Test 8 (Flat Line)	CORMP Rollup
CAP2	salinity	2016-10-19 19:08:20	27.5672	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 18:08:20	27.8537	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 17:08:20	27.3095	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 16:08:20	26.9087	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 15:08:20	26.8395	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 14:08:20	26.8516	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 13:08:20	26.837	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 12:08:20	26.9496	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 11:08:20	27.033	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 10:08:20	27.0636	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 09:08:20	26.7407	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 08:08:20	26.8851	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 06:08:20	27.5844	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 05:08:20	27.9665	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 04:08:20	28.2116	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 03:08:20	28.4259	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 02:08:20	28.5337	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 01:08:20	28.5647	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-19 00:08:20	28.4294	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-18 23:08:20	28.421	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-18 22:08:20	28.2675	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-18 21:08:20	28.0119	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓
CAP2	salinity	2016-10-18 20:08:20	28.0032	? ✓	x ✓	x ! ✓	x ! ✓	! ✓	! ✓	! ✓	! ✓	? x ! ✓

Climatology Ranges

Platform	Parameter	From (± 1 day)	To (± 1 day)	Min (psu)	Max (psu)
CAP2	surface_water_salinity	Jan 01	Dec 31	30	36.5



Closing Thoughts

QARTOD

- Provides mature, broadly accepted standards for QC tests
- Updates manuals ~3 years
- Adheres to an IOC data flagging standard
- Doesn't provide standards for the use of QC flags

Thanks!

