QARTOD VI Summary of Discussion
31 July – 1 August 2012
National Data Buoy Center

Tuesday, 31 July……………………………………………………………………………………

Partner Overviews

USGS – Dennis Demcheck

Real-time definition - have a site with RT DO. Stamp it preliminary – must be approved within 150 days from last visit (Try to keep it less than that-and am moving toward shortening that time) . Require humans to look at the data. Run through a system called Hydra (preliminary and RT). In an estuarine system – probe going out of water can appear to be a real change because it is gradual. Have no data that is RT and approved. Not automated.

Ratings – Excellent, Good, Fair, Poor - off by .8 mg/l – don't have an internal QA method—by internal I refer to within the deployed instrumentation, not internal to the USGS

From membrane to optical (fluorescent) sensor technology – no probe drift. Works or it doesn't. Saves money –use YSI ROX. Try to have as few different kinds of equipment as possible.

Love nationally consistent protocols – don't work well in Louisiana coastal zones. Methods for monitoring are on the Web. Had a report written in 2000 (USGS WRIR 00-4452) emphasizing membrane-based technology. The report was updated on the web in 2006 accessible at http://pubs.usgs.gov/tm/2006/tm1D3/. Technology has increased time between site visits.

Get a field reading against standards.. Don't calibrate against another meter. Stay deployed – maintained (cleaned) reading after cleaning but before calibration. This determines the t percentage of problem that is due to bio-fouling, drift, etc. Little wiper sponges last 2 months – replace in the field. Praises of fluorescent to membranes. Coppersheathing is a good weapon but not the ultimate solution. Different kinds of bio-fouling at different times of the year.

Uses saturated water for calibration check.

Have one DO site that's real-time., the Mississippi River at Baton Rouge. We maintain about 70 real-time sites in Louisiana for water temperature specific conductance, and salinity. Data are immediately available for public view (RT), but are flagged "Preliminary Data-Subject to Review and Revision" . Data are marked Approved within 150-day delay. Still will be human-based for monitoring data. Mark asked for a couple references.

EPA/Rutgers (EPA Region 2) – Darvene Adams and Josh Kohut

AUVs (Glider) in coastal NJ – evaluate use of AUVs/real-time sensors to monitor DO in broad spatial area. – pre- and post-deployment checklists. Provisional RT and post-processed (submitted within 30 days).

Glider surfaces every 2-hours. Sampling every 2 seconds. 100-meter resolution for each profile. Need consecutive up and down for QC.

5 mg/l is the state cutoff value. Quantifying the data.

How do we classify an environment when it changes so rapidly? Titration is to verify calibration – pre- and post-deployments. Below keel depth of most commercial vessels – deeper than the surface. Impact of ambient light on the sensor is minimized, most profiles do not go to the surface. Try to keep the gilder about (30-meter pump) within a half-meter from the bottom. MARACOOS page – data available. Seabird 19 sensor. Focuses on QA right now. There is real-time offset correction. (Aanderaa Optode 3835) Slower foil (25 sec time lag) – shallower water depth.

GLOS – Fresh Water – Scott Kendall

Great Lakes Observing System RA – send data to GLOS, but GLOS not yet accepting DO data. (Lake Michigan) All data generators are doing something different. YSI ROX equipment – also Wetlabs WQM (new to them, not in real time). YSI membranes go bad. Wiper motors go out. Electronics in sensor go out. Biofouling issues – algae, zebra/quagga mussels. Long deployments, ~ 1 year. Steep rates changes due to upwellings 1.5 mg/l per hour. Overlap temperature – baseline noise level based on time of year. Things are quieter in the winter – no stratification. 15 minute sample interval.

QC program – computer based – gross range limits set to 0-20 mg/l. Manually – variance check and depth check. Issue with how many data points. 2X standard deviation - adding in a factor of 1.

Lab-based – dirty sensor checks 4X/yr, re-calibrations – tank test comparisons plus saturated air cal check.

Field based – depth adjustment

Gross range check does a good job of cutting out bad data. Not the same scale for every day.

Dirty sensor check – putting them in a known standard – saturated air. Threshold was data quality objective for each parameter (25%). Accuracy and precision

Tank test comparison – replace membranes at least annually. Easy for user to replace, just two screws. Replacement cost is $120.

CalCOFI – David Wolgast

California Cooperative Fisheries Investigations – Started in 1949 crash of the sardine industry. Same variables. Map of stations they do – 9-near-shore stations are SCCOOS (Southern CA Coastal OOS.

DO QA of all data using the Winkler method – lots of samples. Automated Winkler titration. Automation has eliminated transcription errors and human error. Data go to many agencies and available on Web. Work with others' data (Uwe Send, for example) - relaxation from upwelling.

Calibrations of their data – slope what the Winkler gives and the sensor gives them. SBE 43 sensor. Slope – just a few outliers. Could be outliers from the sensor as well. Difference in calibration method – one by station and over the whole cruise. Using cruise average data correction get better agreement so that we can use sensor data. If doesn't agree perfectly, figure out how to get the best sensor data – figure out which method to use. Tending toward the station average.

New Horizon research ship – also working on NOAA vessel.

CTD casts. – saw downwelling - looks like the data should have been thrown out, but when they went back through and fished out data to show how prevalent features were. Tempted to throw out data because you wouldn't have understood what was happening. (One slide showed a leaker bottle – saw and eliminated bad point- comparison of one good and one bad data point.

Want good agreement between discreet oxygen and sensors. Did have a failure – hit the bottom. Semi-real-time. 100 meter oxygen anomaly – (low) interesting to fisheries = changes in biomasses.

Agreement with more sensors, better sensors, fewer samples = more and better data = codeable data archiving and less sampling. Crazy saturation numbers (200%+) results of blooms (red tide) – a mile offshore. High numbers for the ocean Santa Barbara basin – Hydrogen sulfide was a problem with membrane (low oxygen levels) but not with fluorescent sensors. No experience with hydrogen sulfide environment.

Data presented as numbers in a book. Have since gone to an Access database to send out numbers. With so much archived data – still stuff to clean up (63 years of data).

UCONN – Kay Howard-Strobel

Marine Sciences Department = several buoys in Long Island Sound, outfitted for bottom DO observations in real time –hypoxia problem there. Before buoys go out, do pre-and post-calibration. Seabird 19 and do casts. All saved for post-processing. In RT – data (CDMA modems grabbing data) Provisional and archival data. 2 routines – (1) Is data within the realms routine and (2) does it fall within historical values for that time of year?

Jagged data – go back later for archival data to decide if something is thrown out.

Services moorings every 3 weeks, diver swap out of YSI 6600 optical sondes. Cuts down on calibration time. Don't want to cut off too much because that tells you when you need to do maintenance. The way she knew SB had failed was because of RT data. See disclaimers – bad connection on a cable? Time series that is intermittent – seat connection – depends on where the connection failed whether sensor is still okay. Maybe check the connection to the CTD. Can plug in a YSI to get RT data. Some lines aren't quite getting to zero. Perhaps standard deviation check. CDMA drops out – get flat lines. YSI are SDI-12.

For archive database called Streamline – uses USGS database - trend corrections. Put a yellow flag on it. Doesn't take away data = just allows you to take it off manually. Hypoxic = below 3 mg/l. (Ray requested any procedures they have in place now).

Barauch Institute NERRS – Melissa Ide

28 reserves w/ an avg of 4 stations, monthly water quality checks. Collect data at 15-min intervals and xmit hourly. Uses YSI ROX products. Want everyone using the same equipment. RT actually near RT – 1-hr. Charged with maintaining QC protocols. Using SWMP software. In 2007 initiated automated QC missing data, out of range data. Have sent manual to Ray. Flag and codes. Automated processes limited 2-3 std historical seasonal historical mean. Other check = abnormal spring check. Both failures. Too many false positives. Causing too much extra work. Concrete check – sensor range – optional tests and check okay. Document failures? Not really. Deployments and checking between deployments.

Push out data through Web services – get data directly from HADs. Collect a lot of parameters. Try to do everything system-wide. Range, formatting, missing data checks -how often they are serviced depends. Each NERRS does the maintenance. .Support GOES.

Wouldn't see flat line (because cell tower dropped out) data no longer removed – just flagged. At one point deleting rejected values. Have choice of complete data set or flagged.

VIMS – Grace Cartwright

Researcher – started at the beginning. Have used CB NERRS data a lot. Like going back to archive.

Doug Wilson/CBIBS

CBIBS – 10 buoys in CB. Collect met, wind, wave, water quality and current data. Focused on delivering high data rate and delivering RT data at expense of documenting data quality.

For DO – Wetlabs WQM – optical puck grafted onto SeaBird SBE 43 sensor. All except one are Wetlabs – there's one YSI in MD – data every 15 minutes. Other reports hourly. Cellular comms. Preliminary DB – pushed into larger one. Went through calibration procedures. Crude QA/QC tests = wide range (<0, <20), Exists/Doesn't exist.

Uses a shadow data set (the "development" page) - can mess with one and it doesn't affect the other. Look at test instruments. Allows you to look at everything to check data quality. If measuring other parameters important to build a test based on correlation with other parameters.

**What do you do with the record (at First Landing -= almost the mouth of the CB) – at what point would you pick it up and what would you do about it? When we cleaned it up, still the same result. Deteriorates over a week or so. Pre- and post-deployment - a good QA lesson – gives definitive reason. Instruments in PVC wells. Hurricane Irene – DO is solid – significant wave height in 30 ft of water. In spite, maintained a solid DO reading. Significant test. Production DB – public does not see.

On correcting for drift – don't know when it happened and how - match it to the physics – Danger of skewing data. Individual programs and people who know their instrument. You know where it went bad

– only correct that chunk = not the whole data set. But the risk is that a fouled sensor also attenuates (dampens) the signal. End user decision. Flag data = algorithm used to correct – as a user, which do you want? How to handle this in RT? As a scientist, I want to know it's bad. Should be a flag. (Again, what's the definition of RT). If you're putting a sensor near surface, should be near saturation (100, 102). (Carol). When do you flag?

Alternate technology.

WQM nested CE to variance. Slope of covariance of each of the parameters – increases with each. When one crosses this other, need a sense of the variability of all sensors – (Ian Walsh). Bayesian logic problem. Could build into the RT data. Want to flag from delta between mid-June and July – looks real, just offset. Decision by the end users – Future development but not part of this report.

Carol Janzen – SeaBird SBE 43 (also some Ian Walsh via phone)

Collaborated with Wetlabs to develop WQM – inside copper CT – bleach injection system. Multi-parameter instrument designed to combat fouling. Has a membrane =not user replaceable. Reduced drift using slope correction. Add another sensor Optical sensor to our list. SB 63 – plumbed and pumped like the SBE 43. Was designed with ARGO program in mind.

Challenging parameter = stratification, complex system.

Desalinization plant from Coburn Sound. Adding brine into deep water.

How you compare the sensors when you're changing them out?

Make sure you're not overcorrecting your data. If sensor accuracy is spec'd - don't correct more than needed.

Validity checking. Corrosion on bulkhead connecting cable. Do red, green, yellow AC analysis. (Canadian group)

WQM – still SBE 43 = future models will incorporate new technology. Copper has reduced maintenance and kept it clear of fouling. Bleach has a quicker effect. Advantage in long-term deployments.

Variability in surface layer.

Have to be careful about what we put out. Too much automation might be handed to someone without the skill to deal with it. = flag data but don't throw it out. Don't think you can completely remove the scientist from the effort.

Hard to get post-calibration in-situ before you recover the mooring. When cleaned, it recovered the calibration.

Two different kinds of drift – now instruments are good – flag all suspect data – why do they drift. Can't address drift in RT = Divide it - instrument drift and fouling drift. Biofouling tends to be the biggest problem. 5% accuracy widely used – 3-4% Winkler typical for mariculture – 1-2 % high accuracy requirement for desalinization plant studies = tolerances of accuracy depends on user requirements.

Expectations of accuracy – tolerances. Comparable sensors – challenge to code. RA – select two sensors to compare = spatial, temporal variability – also need to know biological impacts.

The order in which you do tests: check other parameters and see if there's a similar result (Mark gave example). Range tests.

If instruments have different response times – will be vastly different. Platform is the determiner. QC test bigger differentiation is how it's deployed.

Rely on partners (Josh) who submit data – glider deployment example of how – SOP developed and posted on MARACOOS web site. Want data access across all of IOOS. Output of this meeting = have more comfort in data. Range for each station – seasonally dependent and region dependent. How much you want to constrain that – upper limit – Delaware Bay, Oregon, wind and bloom event concentrates chlorophyll – Is there anything wrong with flagging it? Flags don't mean bad data - just anomalous data. Sensor failure would be useful - flag outside of expected parameters – another consideration. Rate of going to zero = something drops in DO and other parameter are still there.

Potential Document re-organization

- Rationale/Justification
- Background
- Universal across All Sensors
- Mobile Platform
- Fixed Platform
- Technology-Specific Considerations

Device independent. Match data acquisition rate with platform motion.

Stuck Value Test – Mark – is there a need for it? PHP script – should leave a blank – a false line connecting two data points? Exclude stuck value of zero. If truly anoxic, will be zero. How long do you count it as stuck? Two values, 1 hour of 15-minute data - these have to be set by the operator.

Levels of Tests - Here's a list of possible tests you might do – not up to this document to define those thresholds. Might vary with the users and platforms. IOOS envisions certifying at different levels. Lowest level test, then do these plus these, then classify them this way. Next level would be something else. Levels of certification.

Document must include QA recommendations. Very important.

Doug – difference between technologies. Maximum that the instrument can read. Not the technology – it's the calibration that drives that. If it's between 160 and 200 – could interpret as stuck, but if it just exceeds the instrument threshold. Data are outside that – useful information – measuring to the ceiling. Being stuck at a max and min is different from stuck elsewhere. Contains actual info about the system. Not a measured value anymore.

Flagging would be different – peaked at the range – outside calibration limit. How would the flag differ.? If instrument has a cap, outside range tells you it's a high value. Green, yellow, red values define.

Stuck value flag = stuck, and stuck at a limit.

Simple green, yellow, red, more complex

Define the test – what is stuck value?

Constrain to now and whatever is coming in the future.

YSI – Mike Lizotte

DO with accessory parameters. New product. Released one month ago. 0.1 mg/l accuracy. Next generation platform. Have made platform changes. Each probe is smart – use a wet pluggable connector. Hot swap sensors while operational. Using cap membrane – designed for field calibration under terrible conditions.

EXO – special website exowater.com

21 mg/l - wet calibrated. Have seen less than precise processes. Water droplets on membranes. Saturated air calibration technique. Temperature equilibration critical = membrane and water temperature are the same = thermistor inside sensor to ensure that. Fast calibration. 6 probes – calibrated with the same sensor. RXO can do that as well, but you can't connect more than one probe. Can even fill an entire sonde?

How ROX might fail through bio-fouling: wiper has been effective. Wearing factor = pads running over rough surfaces can start to fail. Have gone beyond 90 days, but how much pressure can determine failing point – nylon bristles on EXO – chemical contaminants like oil glycol - can interfere but can be quickly removed and would recover nicely.

Using optical DO will make a difference. Effect of fouling will be difference between low sensitivity and high. Monitor wiper position and location - could affect performance - motor value on top of membrane. Can monitor each time where the wiper parks itself. QC output unique to this EXO sensor. Describing antifouling technologies – new data stream coming from sensor.

SDI-12 comms output should capture it – data like a sensor parameter. Have a number assigned to the wiper position.

Does dynamic sampling and making decisions if a certain condition is met, samples faster. Would sensor override what buoy is telling it to do? System can log data autonomously.

Josh Kohut – Aanderaa Optodes

Recommend rep from Aanderaa (US). 3835 Optode.(internal temp. probe) 4000 series with different foils – external temperature probe – integrated into glider platform.

Optode installed at aft end. Quality assurance.

Precision,
Bias
Comparability based on manufacturers
Sensitivity

Sensor output includes amplitude, ?, raw phase, corrected phase – best to receive all in real time.

Do an annual factory calibration, using pre-and post-deployment titration, Use up and downcasts to apply sensor offset, Calculate O2 (corrected phase

Co-efficients based on temperature

Salinity correction assumes a salinity value that the user fixes (they set at 32 psu).

Pressure correction – consider for deeper deployments.

Better be measuring temp and salinity if you're measuring DO. Almost all have CTDs.

Soak for 24 hours before titration.

The way each instrument does timestamps.

Karen Haywood – University of East Anglia UK

Defining accuracy need and sensor spec

Using reported oxygen values

Time correction is post-processing but still RT – just not being done on the platform

Mg/l – unit for coastal environments

Pumping takes care of timing alignment

Mark Bushnell

Including older SBE sensors in manual

When deployed, when last factory calibrated.

Rinko (Rockland/JFE Alec/Advantech) optical sensor missing from this list

Rate of change test – make it available – under-researched – Zero ordered values – tidal environment - daily signal – only flag lack of change? i.e. the stuck test. – look at how Argo program does QC.

Noisy environment – seasonal variability – test more meaningful in some seasons over others.

Things they are implementing now that are working for them. (Carol)

Tiered tests – implementable.

Explanation of tests that Kay, Scott, described.

List of problems – will the tests catch them? Will catch these but won't catch these.

Wednesday, 1 August…………………………………………………………………………

Doug Wilson – Distilled content from yesterday's session

To implement common best practices throughout the IOOS sphere of influence – DO is the first QARTOD variable addressed that the NDBC does not already process.

Machine codeable/implementable

Applied in real or near real time and scientifically valid

DO is subject to variability from physical, chemical and biological processes. Changes can be rapid and local – making typical error checking approaches to preventing degradation.

Procedures (tests?)

- **Missing data**
- **Range check**
- **Difference test**
- **Flat line**
- **Recent variance**
- **Compare with coincident WQ data**
- **Existence of required DO calculation inputs**
- **Consider ancillary sensor data**

Partners' Feedback

\Goal to measure variability, not predict and eliminate

Outline known problems

Best practices: consensus of recommendations from QARTOD VI

Dealing with real time checks and not the final product (Carol)

Statement about temperature and salinity dependence

Two issues = oxygen sensor capture temp. – CTD is a better measure of temp than the internal sensor temp measurement. Salinity used to correct oxygen measurement

Phase and temperature along with direct concentration – individual sensor technology is important.

Recommend access to raw data.

Partial pressure (Aanderaa sensor) - how data are arrived at. Must have temperature and salinity.

If temperature or salinity fails, then flag.

Moving – if big fresh water event, don't get anything.

Example of catastrophic temp sensor failure (Melissa)

List of instruments included in this cookbook. (review) – add another sensor Hach HydroLab LDO – -check with the Janice Fulford/HIF. Categories of sensors – then list specific manufacturers/model number. – maybe add others. Rinko (Alec) fast response moving platform. Optical Oxygard (RBR-Global) – maybe another sensor brand. Eureka – still another – Eliminate bad data for managers who are not technical. Most consistent.

How IOOS would use this document to improve data quality.

Describe the technology and give examples of manufacturers who use it – were used to develop these QC processes.

Hach LDO – Aanderaa.

Chris Lowery - Hach

Only 4 have gone through ACT testing – Aanderaa, on 2 different platforms, YSI rapid pulse, Greenspan none did well after two weeks.

User should have access to raw data.

Table listing points of use

Data quality discrepancies -

NDBC Technical Document 09-02 – August 2009 – Handbook of Automated Data Quality Control Checks and Procedures – sample of visual presentation.

Color coding data stream a good thing

Preliminary data – even though RT

DMAC involved with implementing

Set ranges for parameters – look at existing monitoring to help establish QC checks

Concept of getting standards out is important = particularly the IOOS community RAs Document that can be modified, grow, and change as time goes on. Other groups can help improve it. Will be a dynamic document. Technologies improving and advancing.

Ways to improve this process – for future cookbooks. Afternoon of another meeting = or have it regionally – RA meeting – each one pick up a parameter – convene an extra day. November in Baltimore. Solicit people attending. Let them choose parameter. Giving more advance notice. Small core group is more effective. How relevant is DO to other parameters – group the relevant ones.

Federal partners and industry together to get the deliverable = capitalize on the I in IOOS.

Start 3 variables at the time – RA – different workgroups for each one. Do them in parallel. Don't present it in a way so that the RA thinks that this is one more thing that IOOS is telling them to do. Ask for volunteers at a certain meeting on the selected topic. Component of the RA annual meeting.

Prioritize the list of variable according to their 10 year plan. 3 RA reps on the Board of Advisors. RA is about data quality.

Include dialog on QA (Josh) – less vendor specific and more technology specific Refer to vendor recommendations and have a good dialog with the vendor.

Developmental (provisional) and Production (archival) Database – 2 DB –Raw data are retained – can always go back.

From GLOS situation – not doing DO data = good timing as an RA concern that it might be too restrictive – Who's using the data? What would a bad data point mean to them? Connection about who is using whose data = able to communicate with the data user. Tracking form (Melissa) when users export data. Venus does it for funding purposes = write letters to support the program. RT QC is just one of the steps in the process. Post deployment dirty sensor check. Measurement of chlorophyll. Had no idea that Turner sensor is putting out twice the number that YSI even though they are calibrated to the same standard. Develop correlation between two different sensors and the output they are providing. Optical not a consistent technology. Software varies. If not running data through programming source – user would need programming capability. Gross range checks = put in max numbers. There's a cost involved in implementation here. Labview is where you would put in the codes also Aquarius - open source area. Simpler (range checks) would catch many problems.

QA and post processing critical = optional user defined tests after initial one.

Flag is important.

Metadata = needs to be mentioned = needs to accompany the data Where were they captured, was it corrected for salinity, what QA did you do, last serviced, RT data still reflects what's been done previously. Have to be documented – chain of custody.. QA plan for data inputers. Volunteer Observing programs – data user needs to know that.