RBR

Welcome, the RBR Webinar will begin shortly…

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rbr-global.com

RBR*legato*³ CTD for Ocean Gliders

Eric Siegel

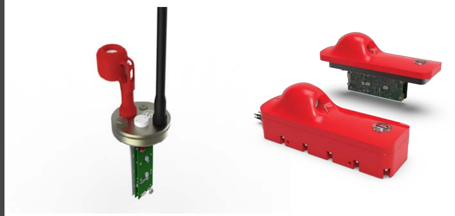
RBR Products

Loggers

OEM

Sensors

Systems



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OEM

- Low power electronics
- High accuracy (WOCE)
- Sensor hub
- Integrated solutions

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RBR CTD

Accuracy	RBR	Pumped CTD
Conductivity	±0.003 mS/cm	±0.003 mS/cm
Temperature	±0.002°C	±0.002°C
Depth	±0.05% FS	±0.1% FS
Power Req	18mJ	175mJ

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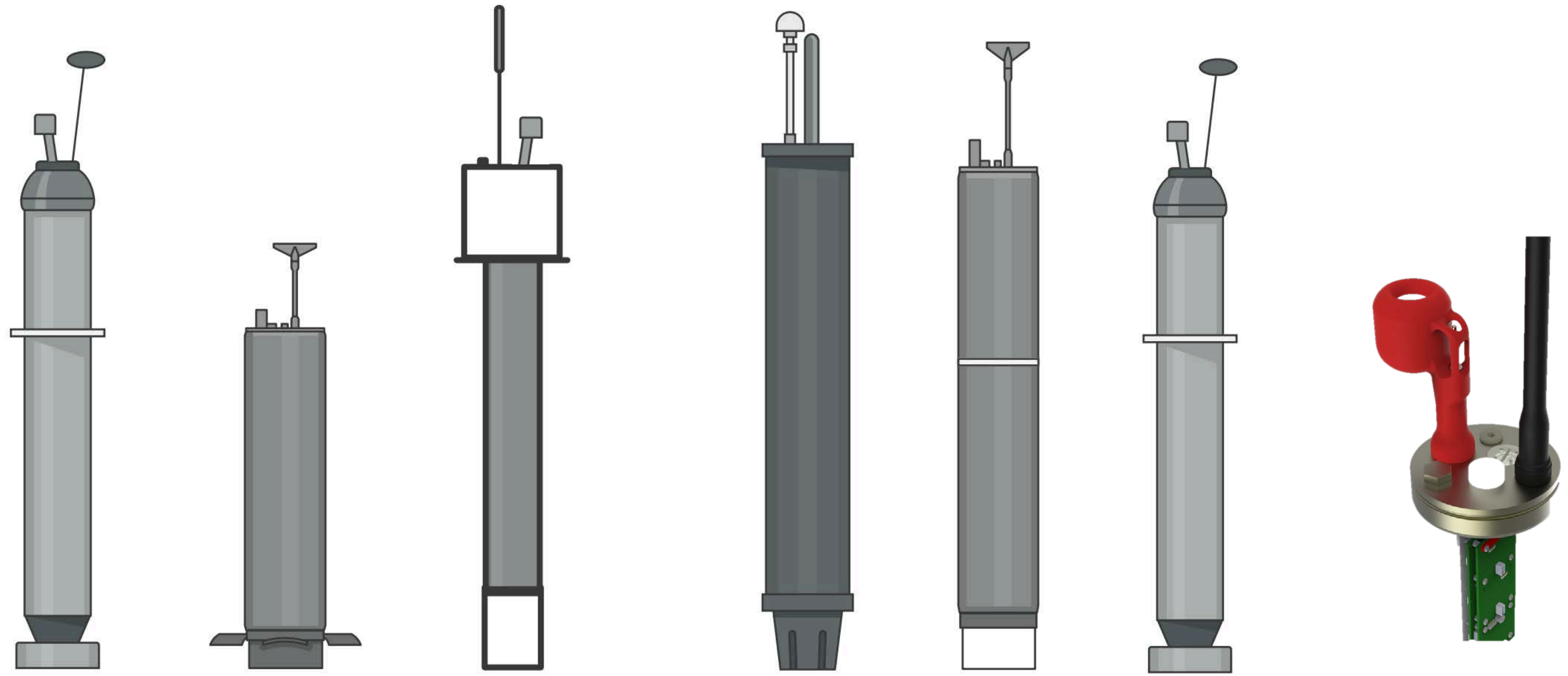
RBR on Argo floats



Teledyne APEX | MRV ALAMO | NKE ARVOR | MetOcean PABLO | MRV S2-A | NOTC COPEX

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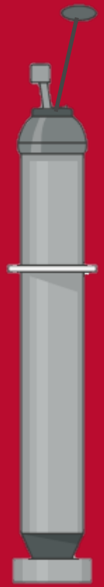
Value to Argo Program



- Low power electronics
- No pump needed
- High sensor stability
- Sensor hub

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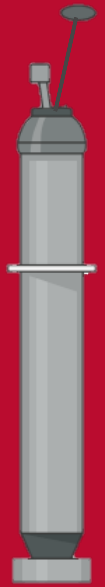
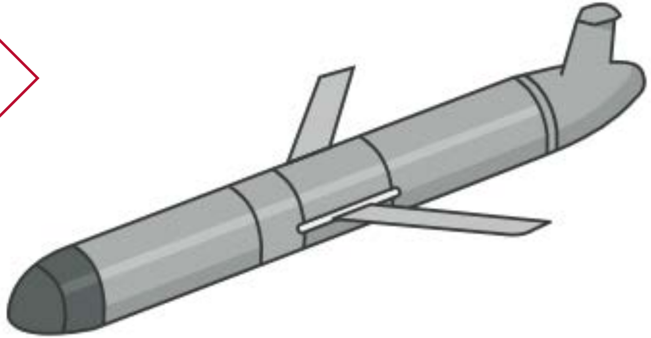
Value to Argo Program



Value to Glider Program



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Evolution of RBR CTD

RBR*legato*³ CTD

- Smooth
- Connected
- Carefully integrated

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RBR*legato*³ CTD

RBR*legato*³ CTD

Specifications

- Standard GPCTD bay
- 1000m depth rating
- 2Hz sample rate
  - 16Hz optional
  - 100ms response thermistor
- Natural flushing (no pump)
- 18mJ power at 1Hz (GPCTD 175mJ)
- Same CTD accuracy as SBE
- Custom design to fit each glider

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RBR*legato*³ CTD

New Opportunities

- Low power
  - Greatly extend missions
  - Sample on descent & ascent
- Reduce salinity spiking
  - Co-located thermistor
  - RSKtools to align C and T
- User removable (Wet Bay)
  - Wet-pluggable connector
  - Quick calibration (4 weeks)

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RBR*legato*³ CTD

New Opportunities

- Silent operation
    - No pump
    - Improves passive acoustics
    - Improves turbulence studies
- Sensor hub
    - Easily integrate new sensors
    - Manages sampling and power
    - One data stream

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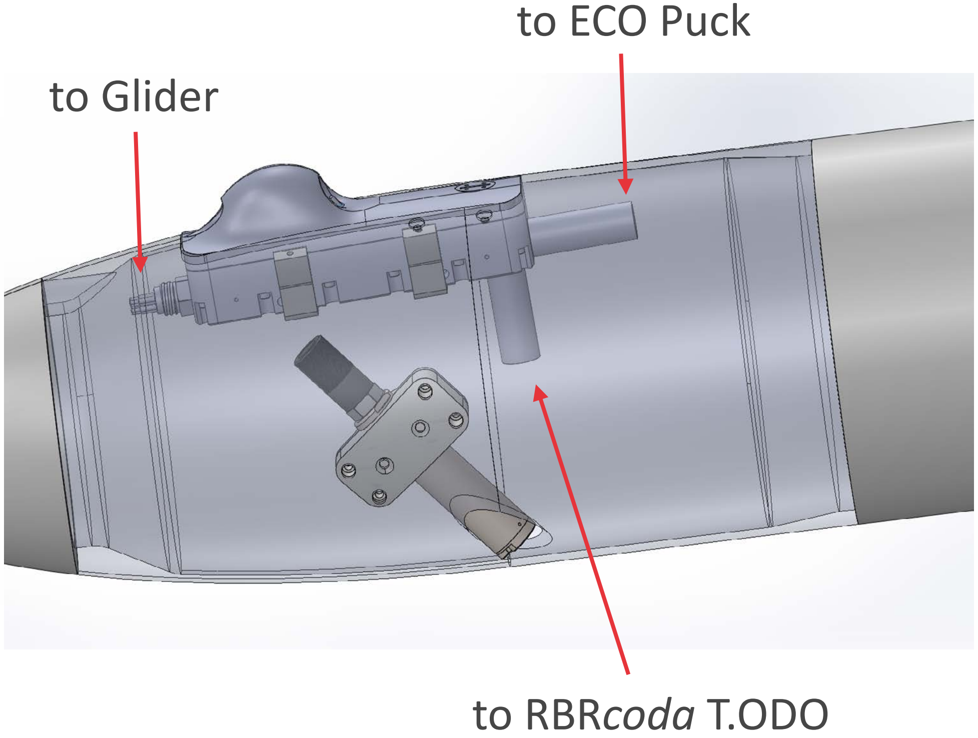
RBR*legato*³ CTD



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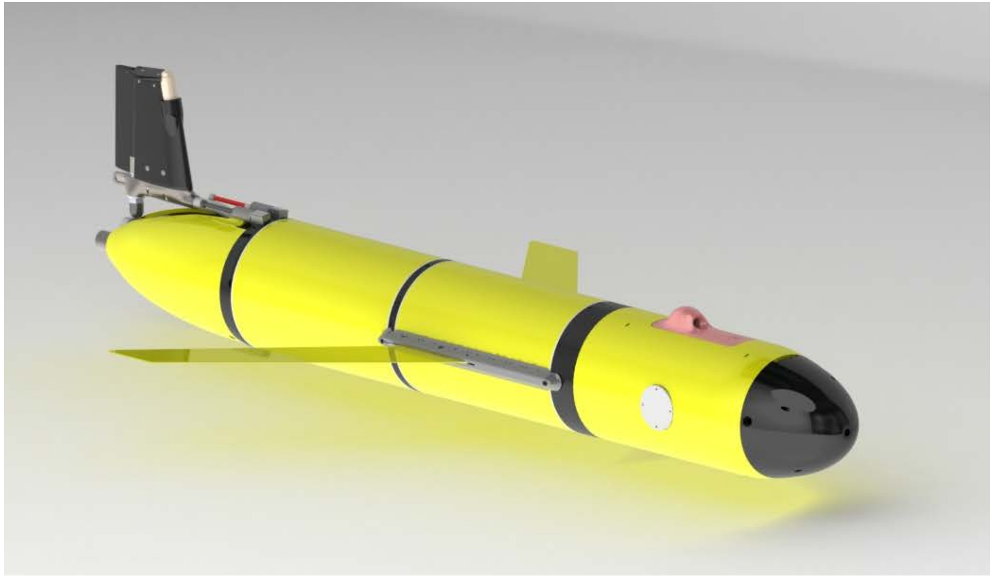
RBR*legato*³ CTD Teledyne Slocum



G3 – wet bay

RBR*coda* T.ODO optode

ECO Puck

G3 – wet bay

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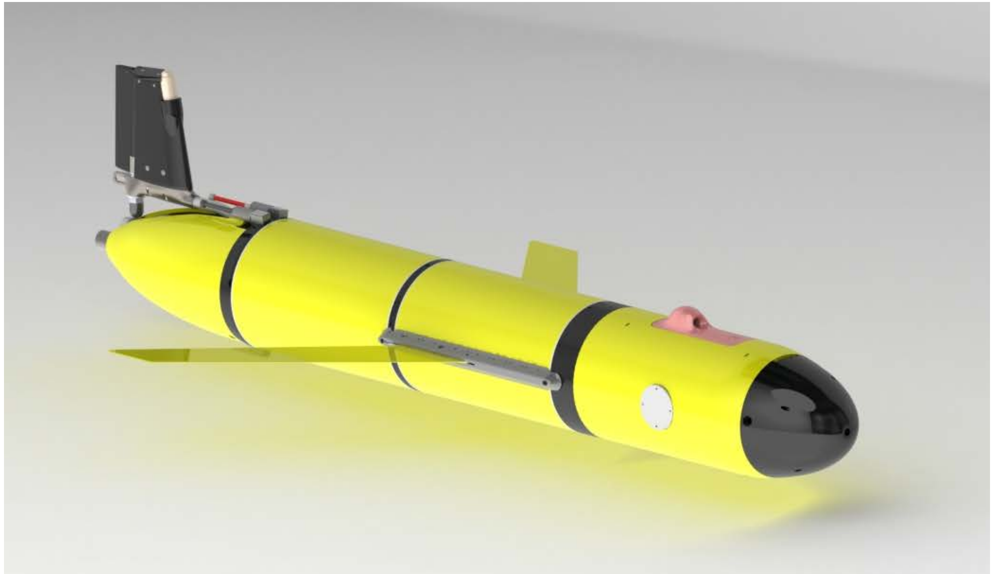
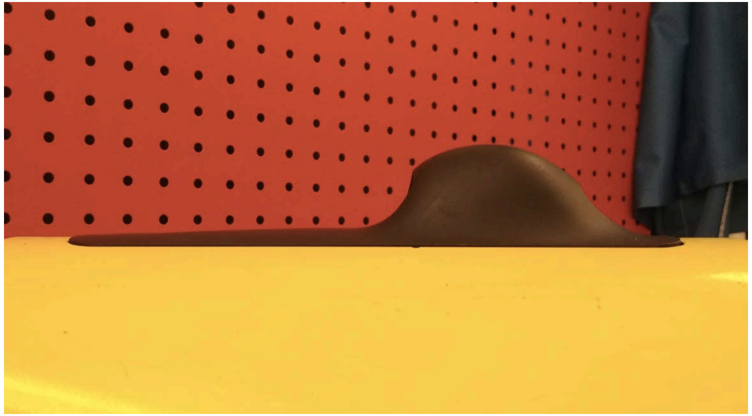
RBR*legato*³ CTD Teledyne Slocum



G3 – wet bay



G2 – dry bay

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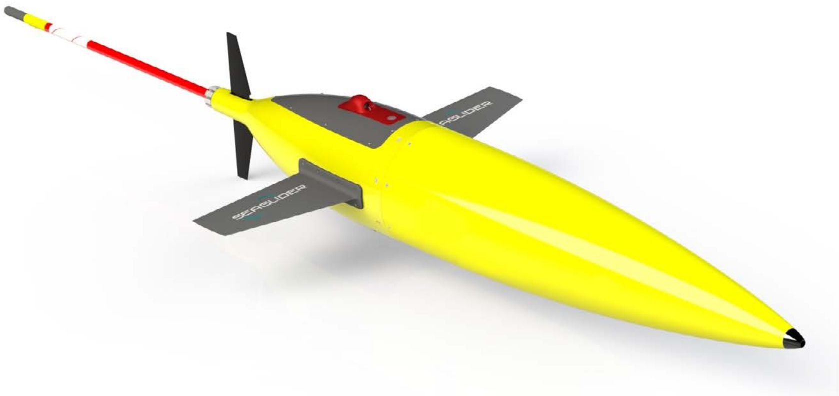
RBR*legato*³ CTD

Hydroid HHI Seaglider & AUVs



BAE Riptide µUUV

Teledyne Gavia AUV

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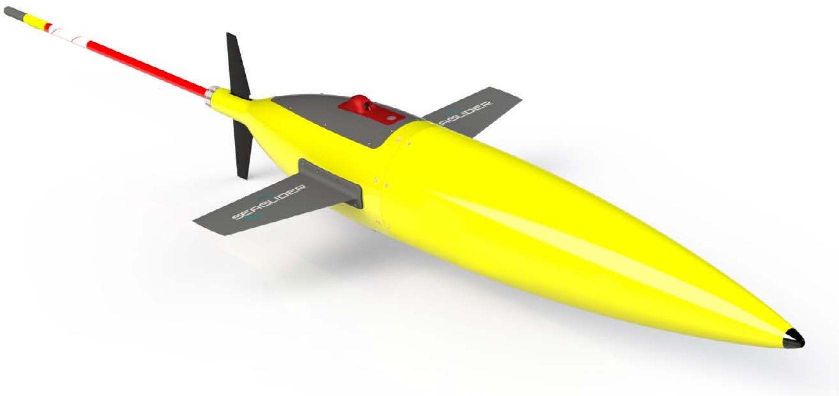
RBR*legato*³ CTD



APL-UW Seaglider

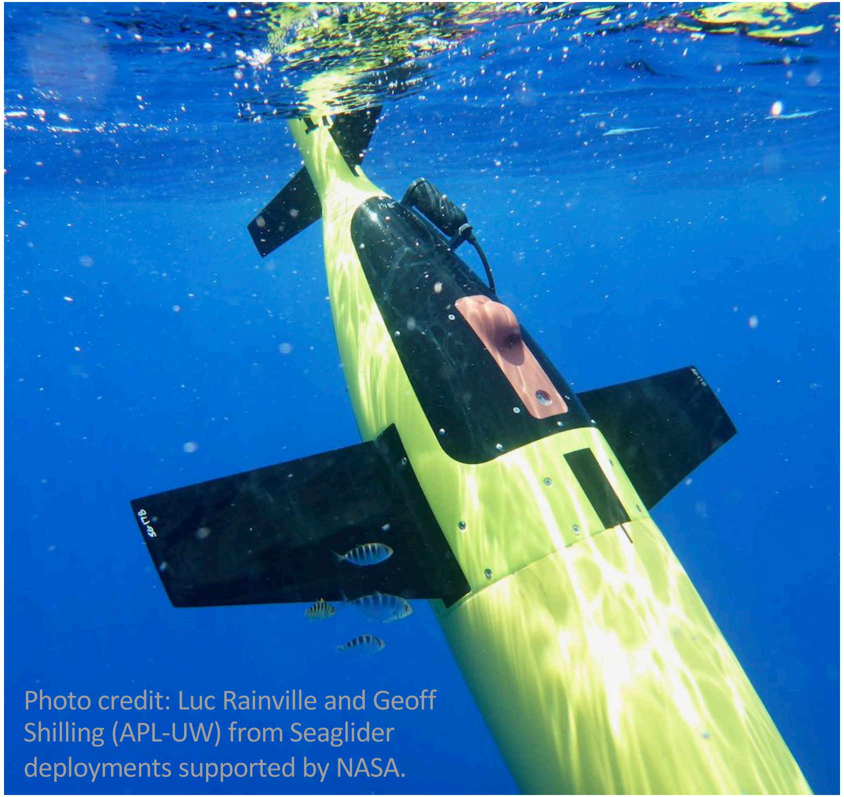
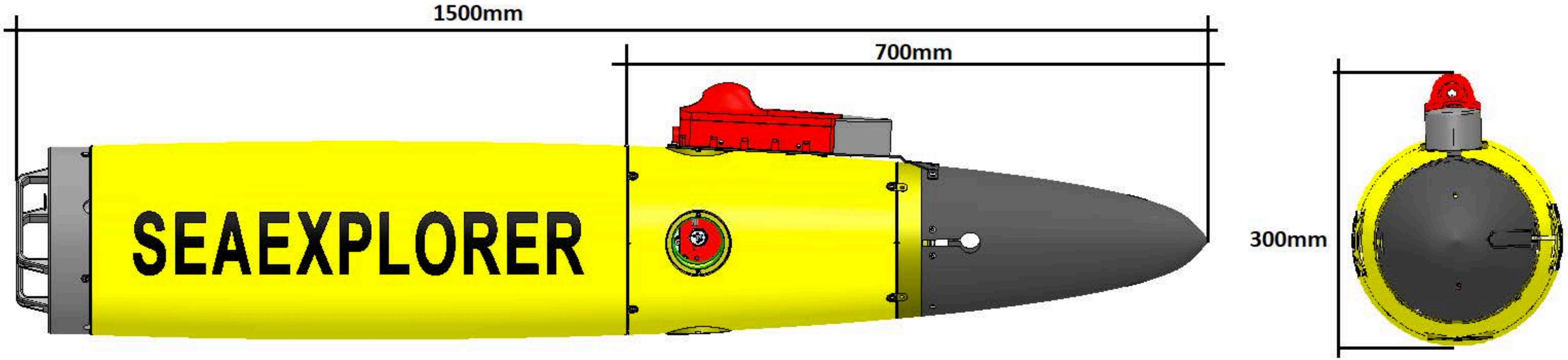


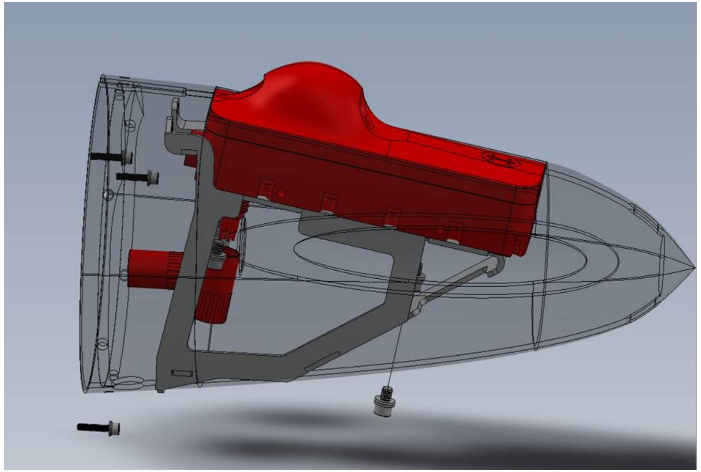
Photo credit: Luc Rainville and Geoff Shilling (APL-UW) from Seaglider deployments supported by NASA.

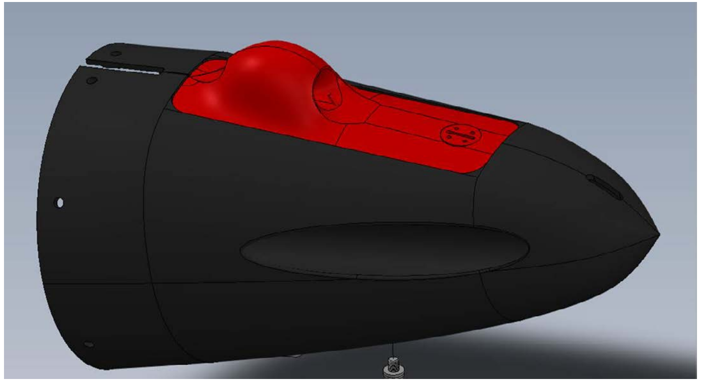
RBR*legato*³ CTD Alseamar SEAEXPLORER



Used when hydrophone is mounted in bow section

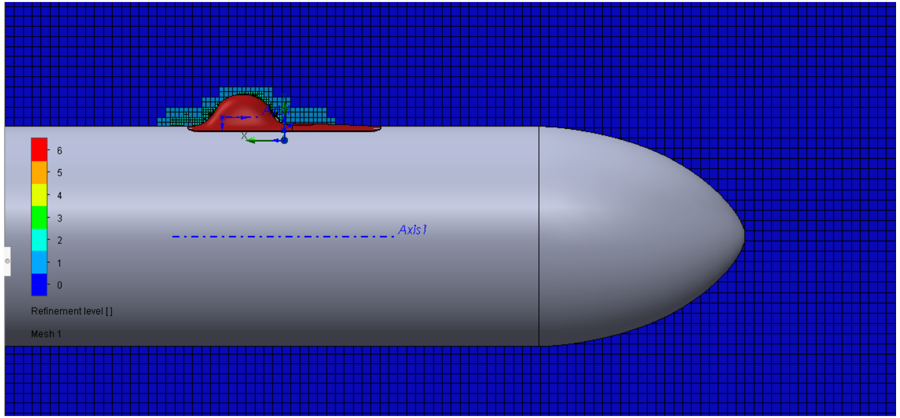
RBR*legato*³ CTD Alseamar SEAEXPLORER

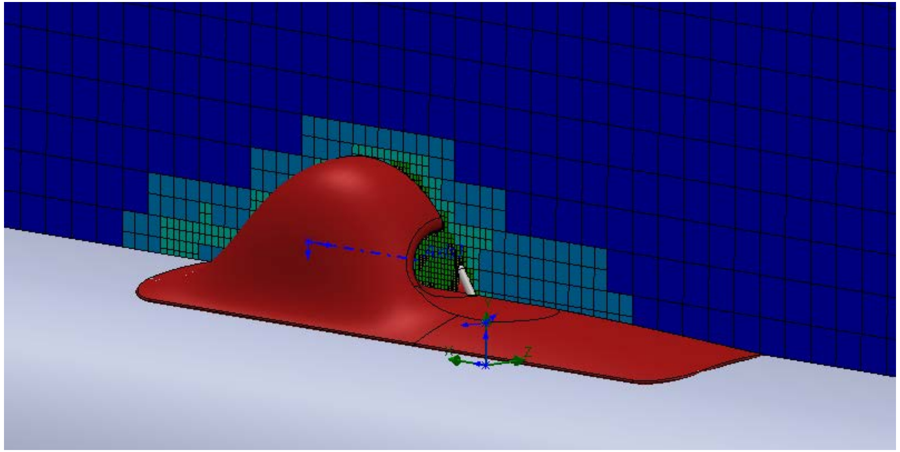




CFD Flow Analysis

- No pump required
- Ensure natural flushing
- Reduce salinity spiking
- Reduce drag





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CFD Flow Analysis

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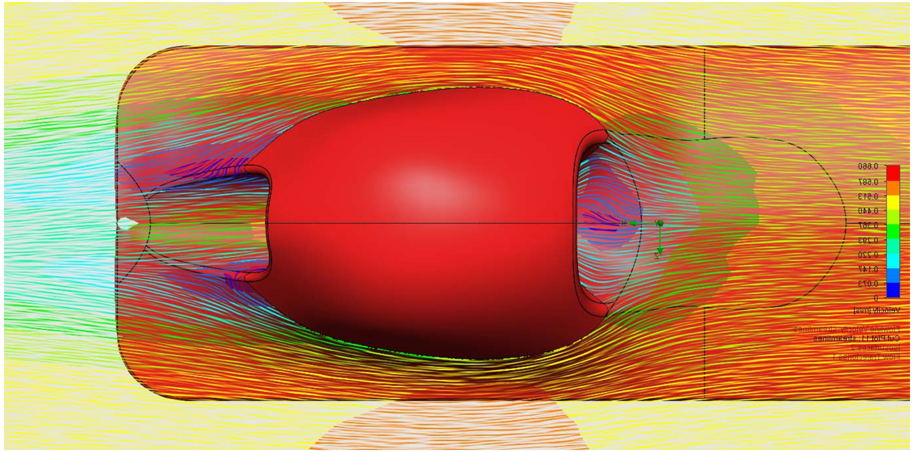

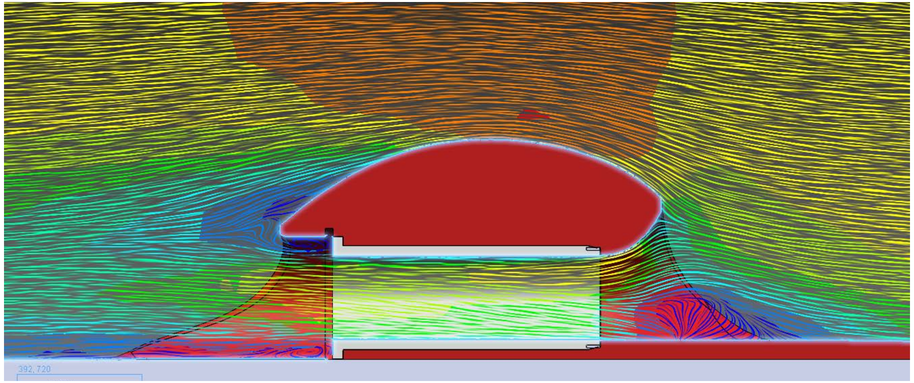

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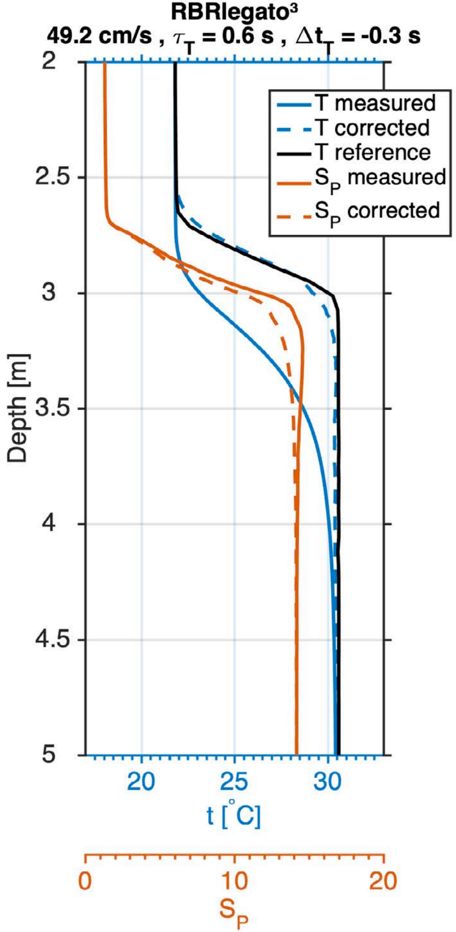
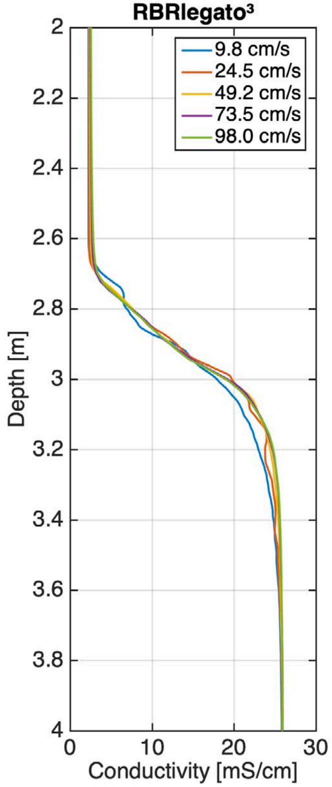
Data



RBRlegato³
49.2 cm/s , τ_T = 0.6 s , Δt_T = -0.3 s
T measured
T corrected
T reference
S_P measured
S_P corrected
Depth [m]
2
2.5
3
3.5
4
4.5
5
20
25
30
t [°C]
0
10
20
S_P



RBRlegato³
9.8 cm/s
24.5 cm/s
49.2 cm/s
73.5 cm/s
98.0 cm/s
Depth [m]
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
0
10
20
30
Conductivity [mS/cm]

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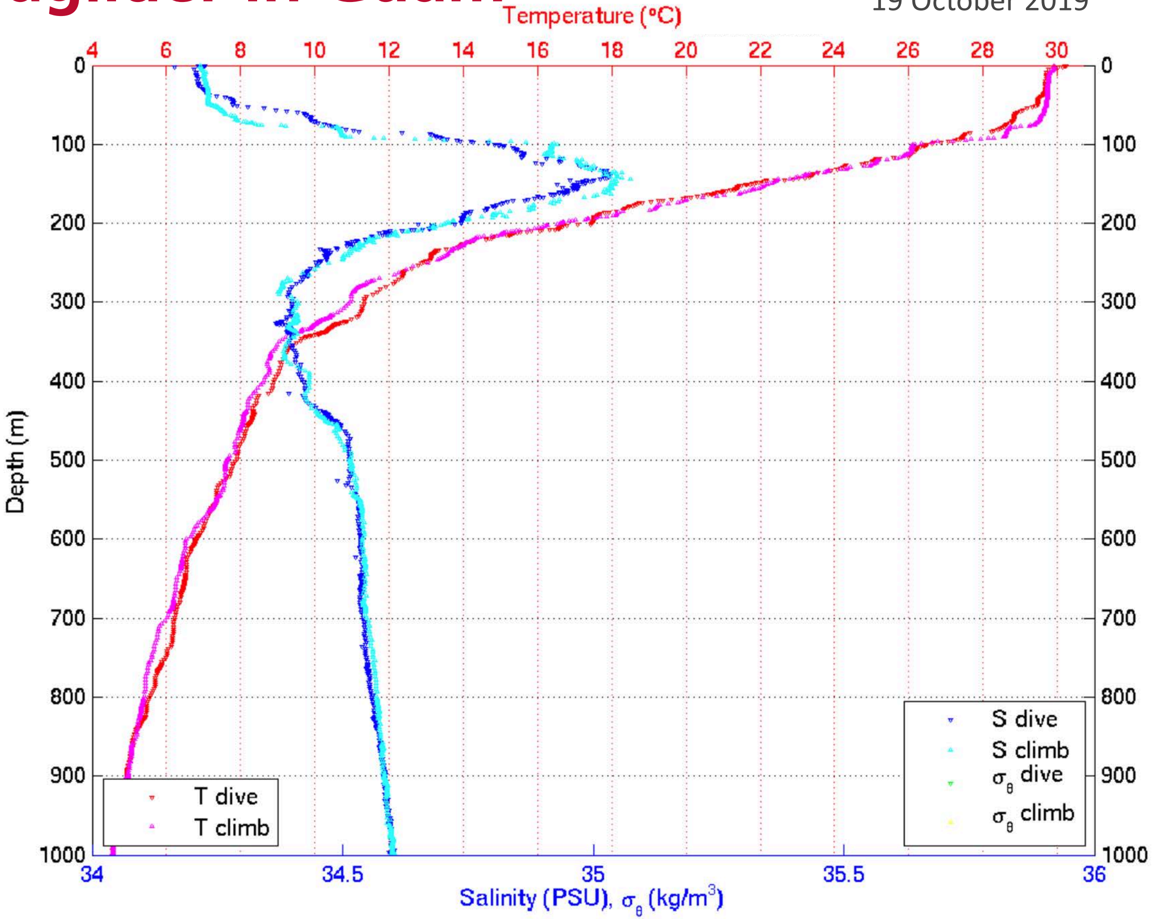
UW-APL Seaglider in Guam

19 October 2019

400 dives to 1000m



Data collected by Luc Rainville and Geoff Shilling (APL-UW) from Seaglider deployments supported by NASA
http://iop.apl.washington.edu/seaglider/ (Seaglider 178)

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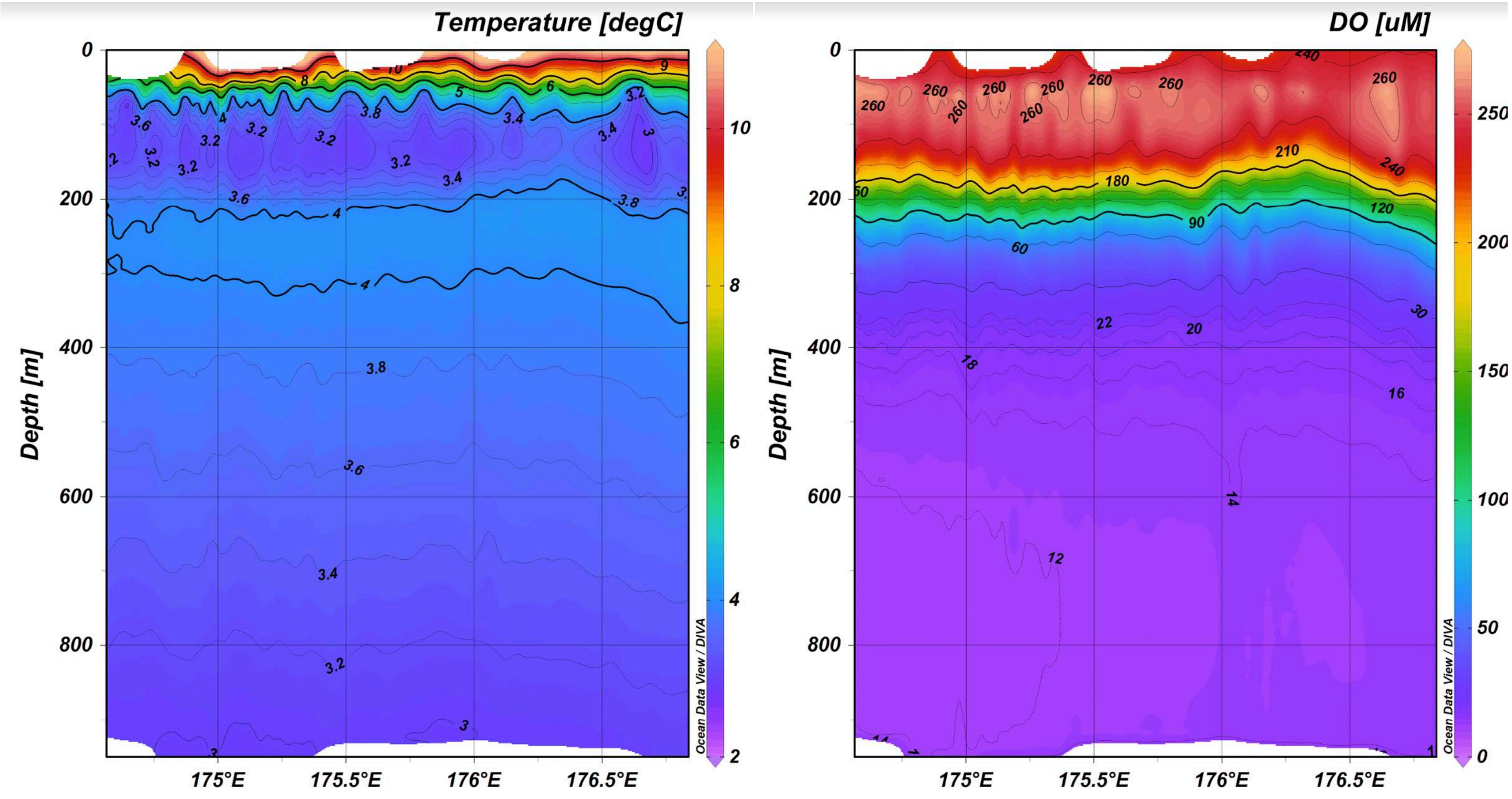
AMT Petrel Glider in polar region



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Dynamic errors and corrections

Profiling through a temperature gradient introduces dynamic errors in temperature and conductivity because it takes time for the sensors to adjust to a changing environment.

1. Finite time for heat transfer
2. Takes time for water to pass through sensors
3. Sensors are not exactly co-located in space

- Dynamic errors affect all CTDs (i.e., electrode and inductive)
- Dynamic errors are magnified in derived variables, such as salinity and density

Webinar: CTD dynamic performance and corrections through gradients
https://rbr-global.com/about-rbr/webinars

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Primary causes of dynamic errors in CTD sensors

Temperature time constant

- Finite time for heat to diffuse through thermistor
- 1s (standard)
- 0.1s (fast)

Conductivity & temperature lag

- Small spatial separation causes sensors to encounter water parcel at different times
- 36mm distance from T to C (centre)

Recommended C-T lag correction

(seconds)

$$lag = -0.92 \times U + 1.22$$

U – flow-rate (not $\partial p/\partial t$) estimated from glide angle

$$lag = 0.94$$

Constant lag is an okay approximation if glide angle is not available

Optimal lag is determined statistically (N = 3,307) by maximizing covariance between conductivity and temperature over short segments (7 s). *Barth et al. (1996), Ullman and Hebert (2014), Dever et al. (2020)*

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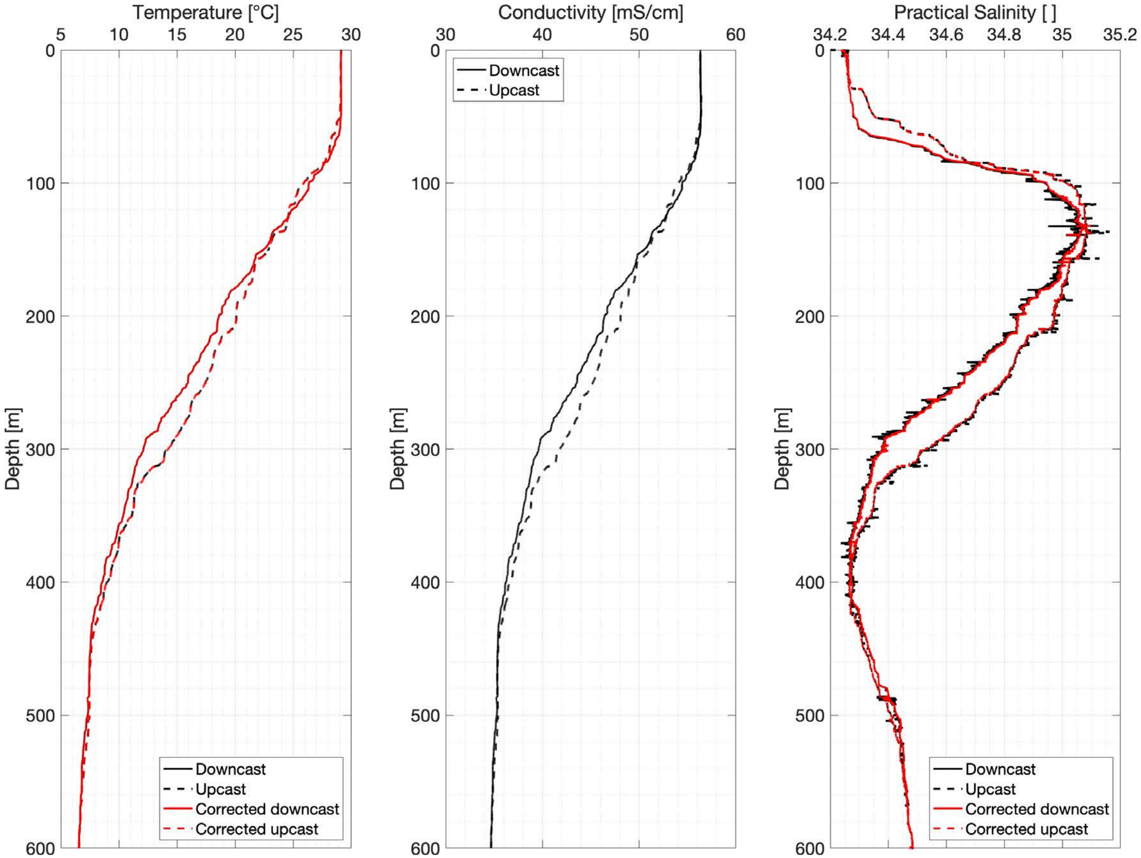
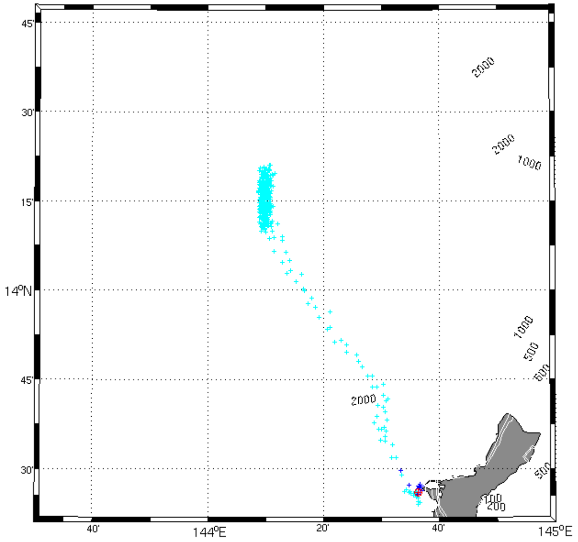
Primary causes of dynamic errors in CTD sensors





Data collected by Luc Rainville and Geoff Shilling (APL-UW) from Seaglider deployments supported by NASA http://iop.apl.washington.edu/seaglider/ (Seaglider 178)

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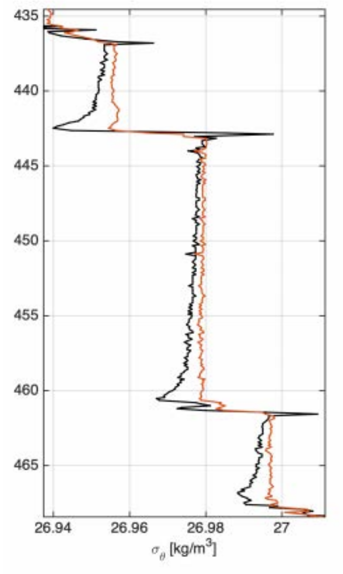
Primary causes of dynamic errors in CTD sensors

Conductivity thermal mass

- Exchange of heat between cell and water changes conductivity
- Thermal mass tends to generate artificial density inversions at sharp gradients



Example of artificial density inversions due to thermal mass errors (black) in a profiling float.

Recommended thermal mass correction

$$\tau = 11\ s$$

$$\alpha = \frac{0.57}{\tau} + 0.03122 = 0.083$$

- Lueck and Picklo (1990)
- Morison (1994)

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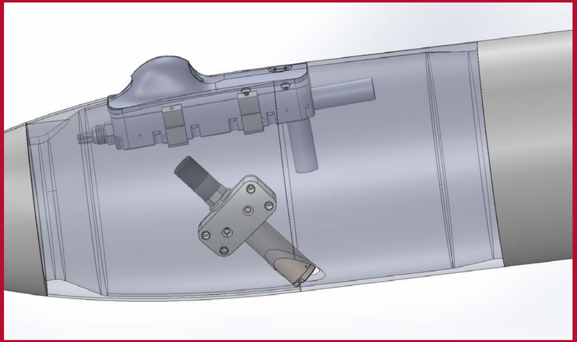
Sensor Hub Integration



Common sensor integrations

- Atmospheric temperature
- Optical DO
  - RBR*coda* T.ODO
  - Aanderaa Optode
- Fluorescence
- Turbidity
- ECO Puck
- PAR

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RBR*coda* T.ODO

Optical accuracy and stability similar to Aanderaa Optode

Standard accuracy of 8 µmol/l

High accuracy marine temperature (0.002°C)

Power consumption is 20% of Aanderaa Optode

Depths up to 6000m

- |fast 1s response
- Standard 8s response

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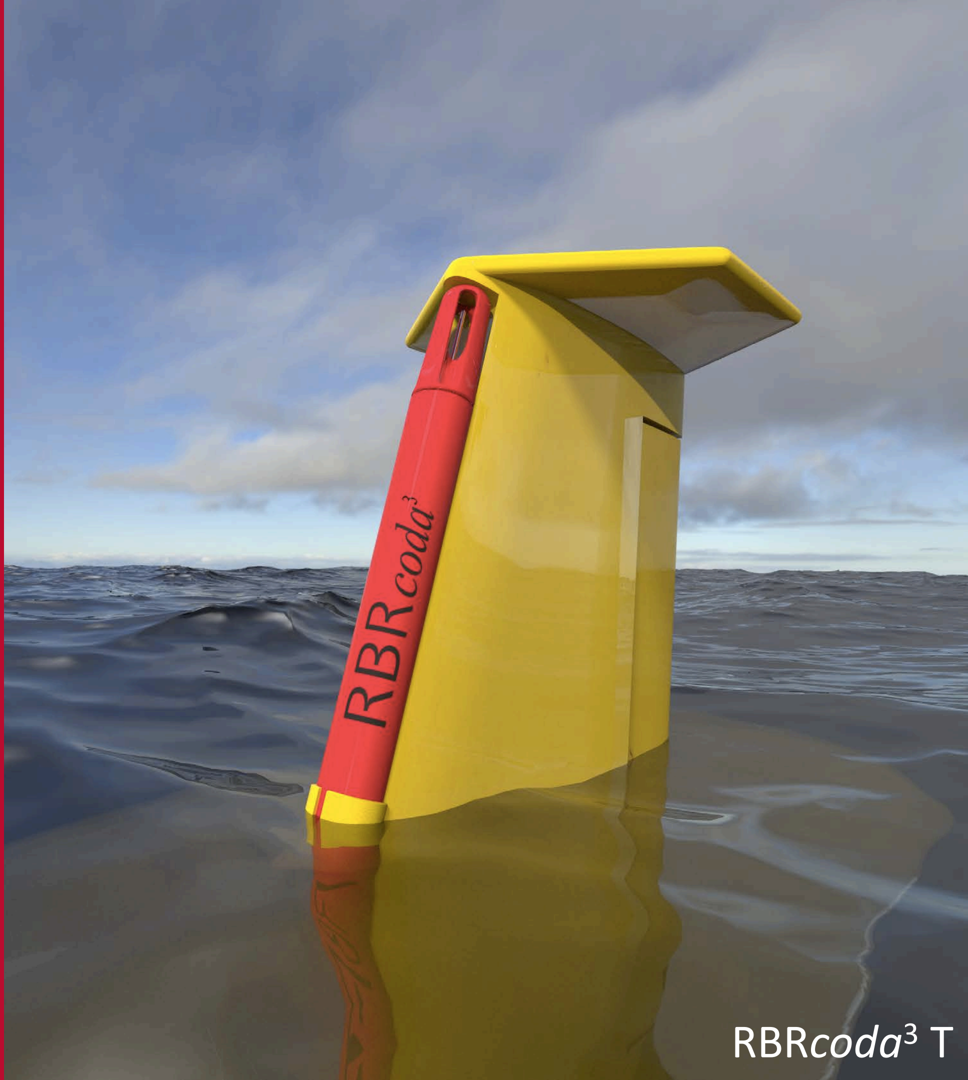
RBR*coda* T
Temperature Sensor



Future

Enable More Innovations

- More autonomous platforms
- Better data
- Longer missions
- More sensors
- More collaborations

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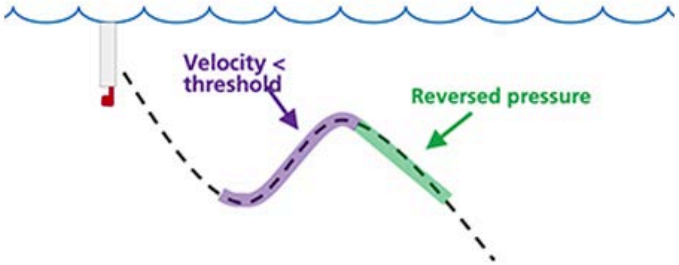
Upcoming Webinars

Future Webinars



RSKtools: a free toolbox for CTD post-processing and data visualization

Greg Johnson

June 3, 2020 at 12PM EDT

Learn more about the many functions in the the free post-processing toolbox and how it can improve your CTD data quality.

Register for the Webinar

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Future Webinars

CTD and sensor calibrations

Greg Johnson

June 10, 2020 at 12PM EDT

Learn about the RBR calibration procedure for conductivity, temperature, pressures, and other sensors, and how you can maintain, verify, and calibrate some sensors in the field.

Register for the Webinar

Wave measurements for ocean, coastal, and transient wave studies

Eric Siegel (RBR) & Curt Storlazzi (USGS)

June 17, 2020 at 12PM EDT

Expand your understanding of wave measurements, learn how to optimize your deployment settings, and review Ruskin wave processing methods

Register for the Webinar

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Thank You

Contact Us

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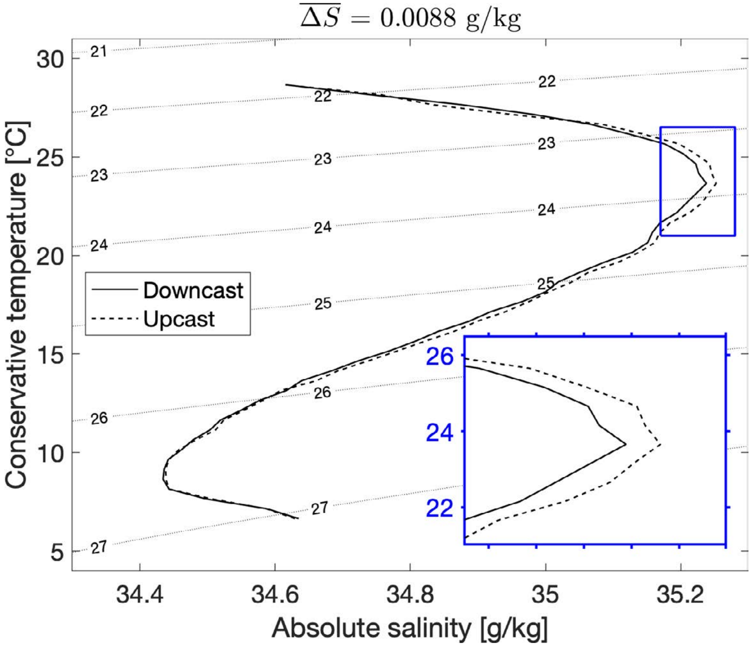
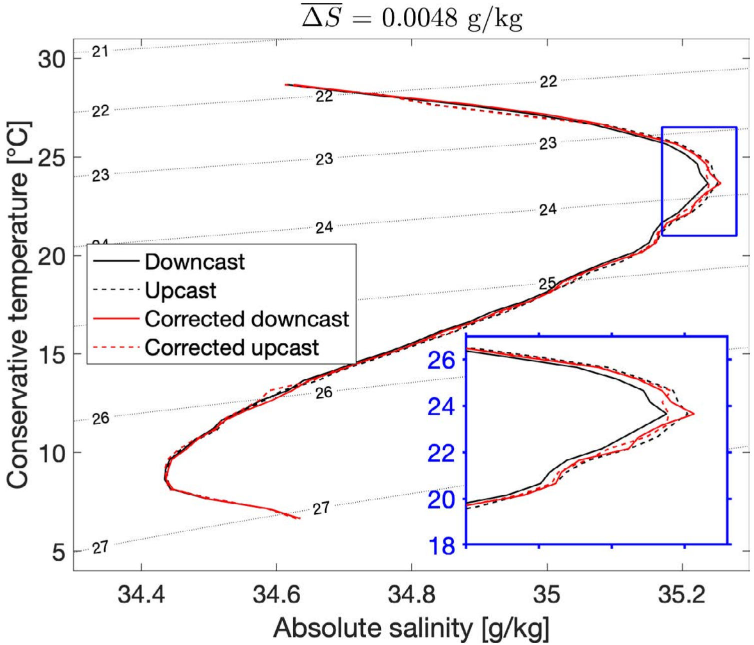
NON-CORRECTED



CORRECTED

C-t lag and thermal mass



Improved match between down- and upcasts along isotherms

Data courtesy of Luc Rainville (UW)

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