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The Past, Present, and Future of Nortek and Glider Measurements

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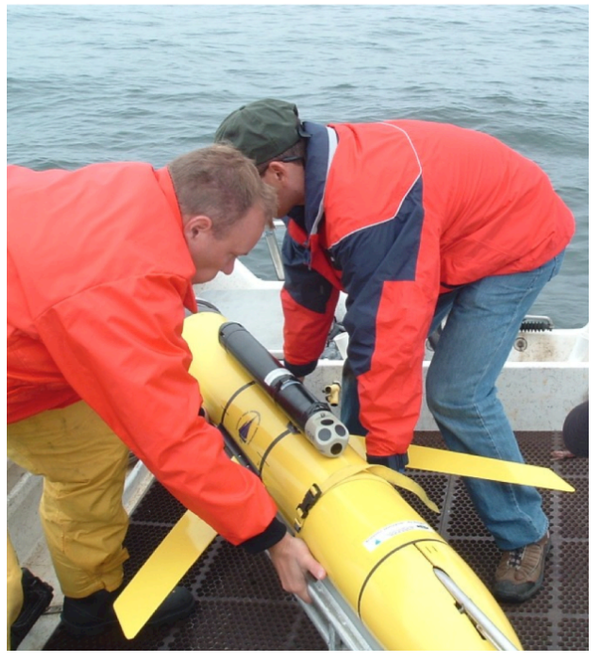
Our History with Gliders

- We've worked with customers for the past several years to make glider based measurements.

- We are more sophisticated than duct tape and hose clamps these days.



Early glider test using an Aquadopp profiler

please see http://www.nortek-as.com/en/knowledge-center/bibliography for example applications

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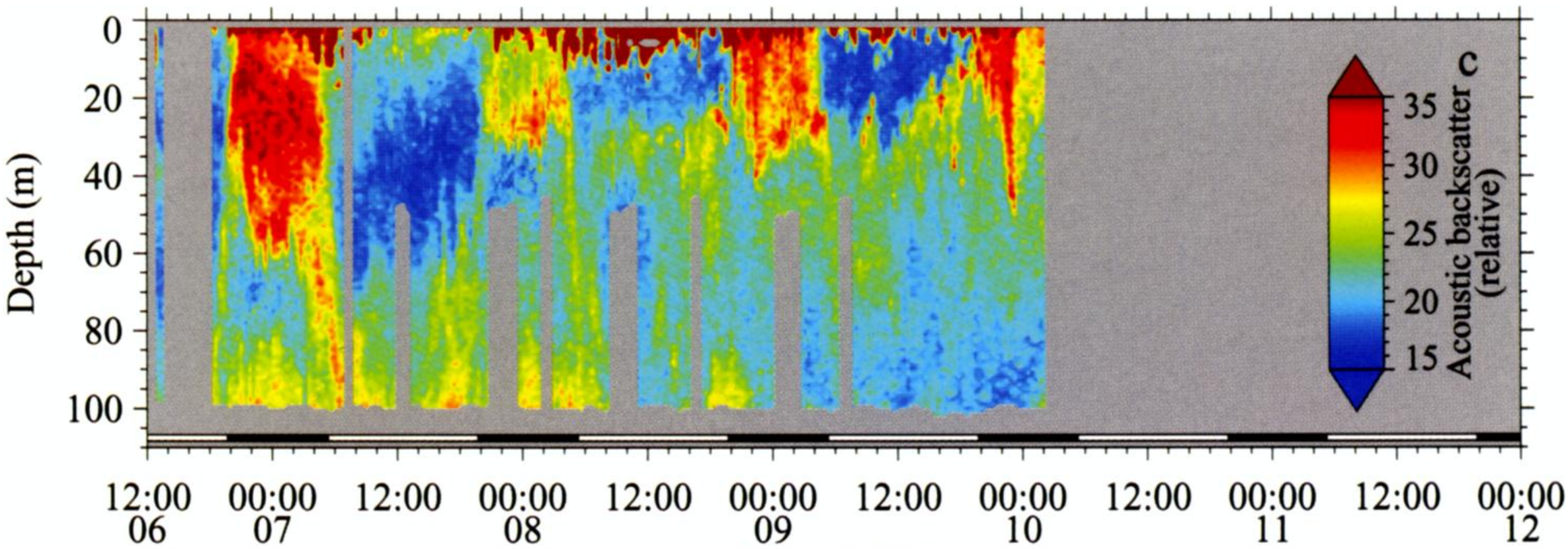
Use as an Echosounder

- Early measurements used acoustic backscatter to track biomass in the oceans.

Baumgartner, Mark F. and Fratantoni, David M. (2008)Diel Periodicity in Both Sei Whale Vocalization Rates and the Vertical Migration of Their Copepod Prey Observed from Ocean Gliders. Limnology and Oceanography, 53(5), pp. 2197-2209.



The goal of putting an AD2CP on a glider is obtaining both water current profiles and improving navigation.

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Our Motivations

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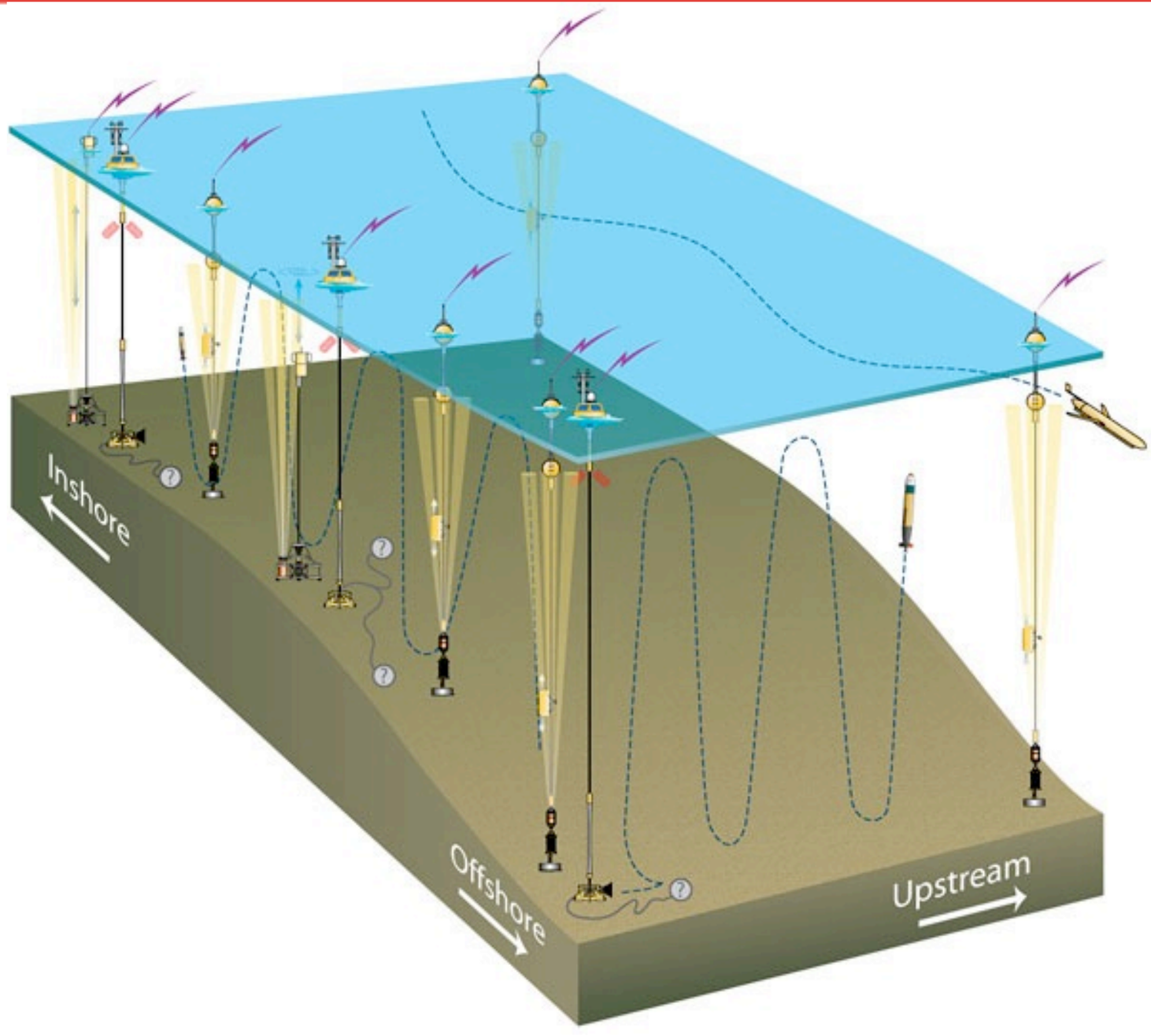
This is a developing area, like waves processing 10-15 years ago.

We see glider based measurements playing a part in the future of oceanographic research and exploration.

Our goal is to provide a complete solution: self contained hardware, post processing algorithms, and display and analysis software.



The Pioneer Array, WHOI-OOI

Ongoing iRobot Collaboration

- Development of new hardware began two years ago with initial meetings between iRobot and Nortek.
- First prototype system in the water within 10 months.
- Five tests with Seaglider mounted systems: coastal North Carolina, Antarctica, Puget Sound, Cayuga Lake (Finger Lakes, NY), and Port Susan (Puget Sound, WA).

Goals of Testing

- Operational test of AD2CP-Glider integration on Seaglider.
- Operational test of the AD2CP-Glider in various environmental conditions.
  - Data quality assessment.
- Implement post processing methods to obtain water and glider velocities.
- Assess the accuracy of the post processed data.

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Antarctica, Jan/Feb. 2012

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- First deep water test of the integrated system.
  - Challenging environment with low scatterers resulted in a limited profile range.
- Enough data for dead reckoning navigation.

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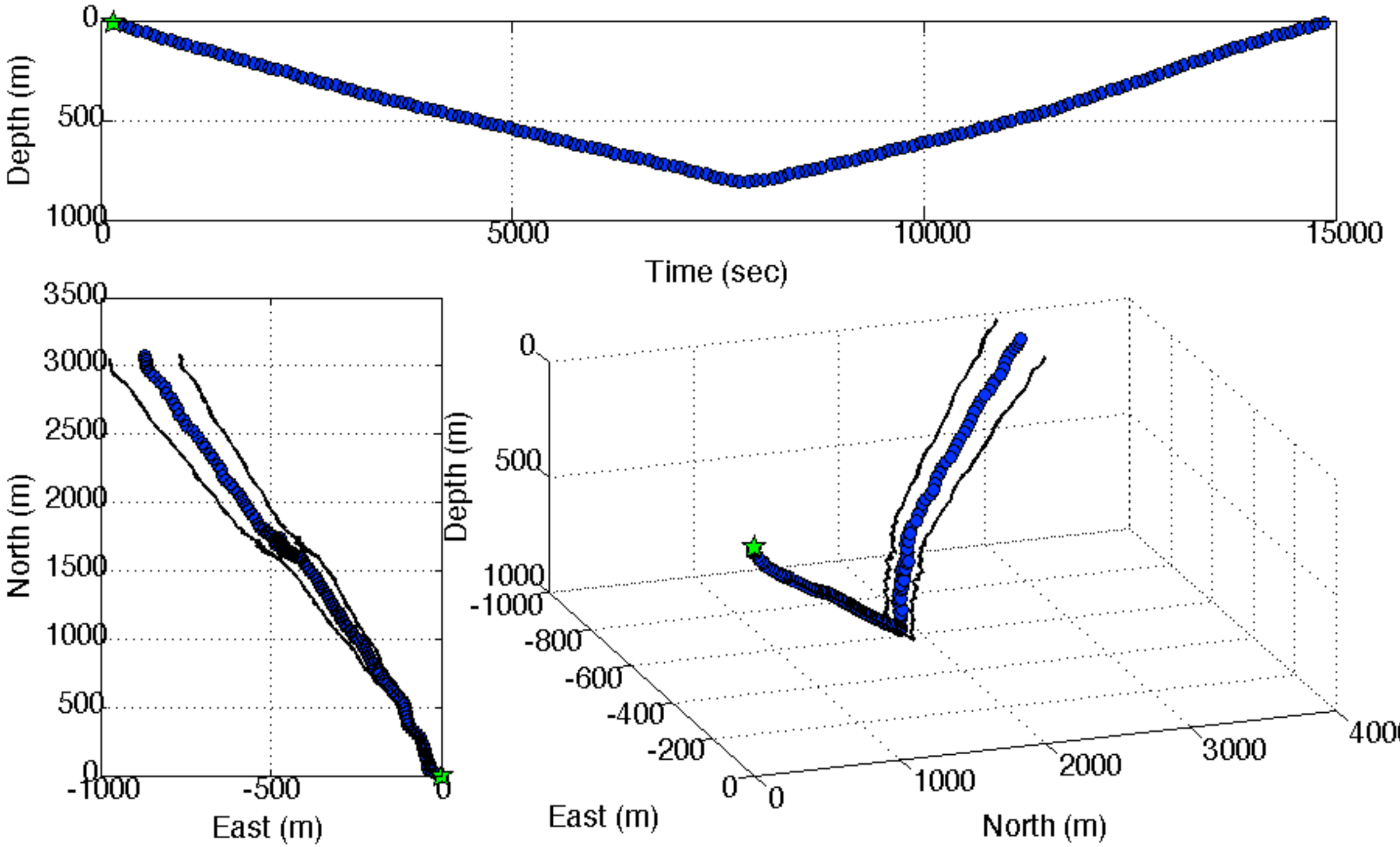
Dead Reckoning, Antarctica



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Puget Sound, March 2012

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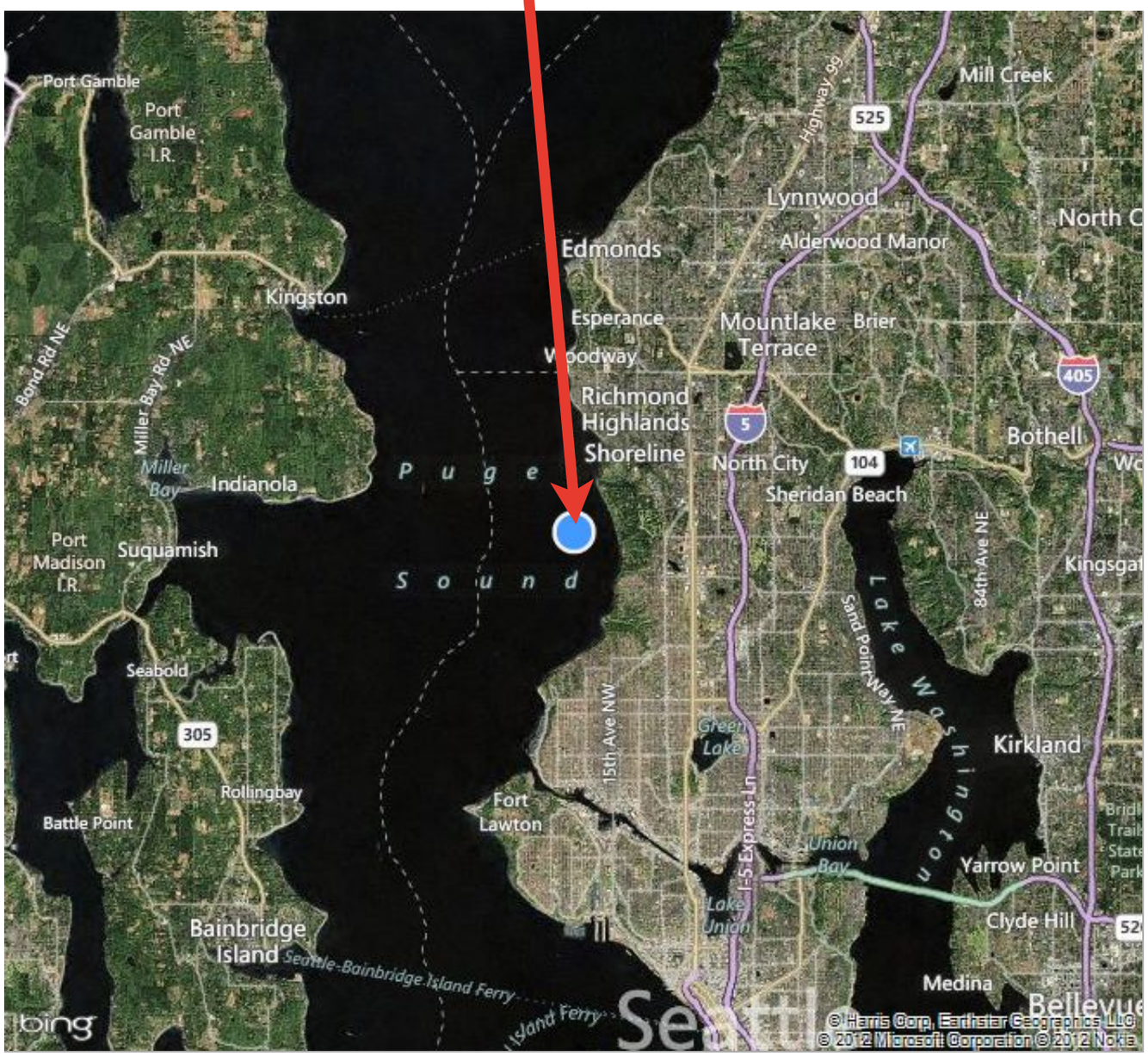
Glider Operation Area



- Testing performed in conjunction with Ogive fairing testing.
- Shallow, challenging environment with shipping lanes and unknown bathymetry.
- Potentially strong tidal currents at the surface.

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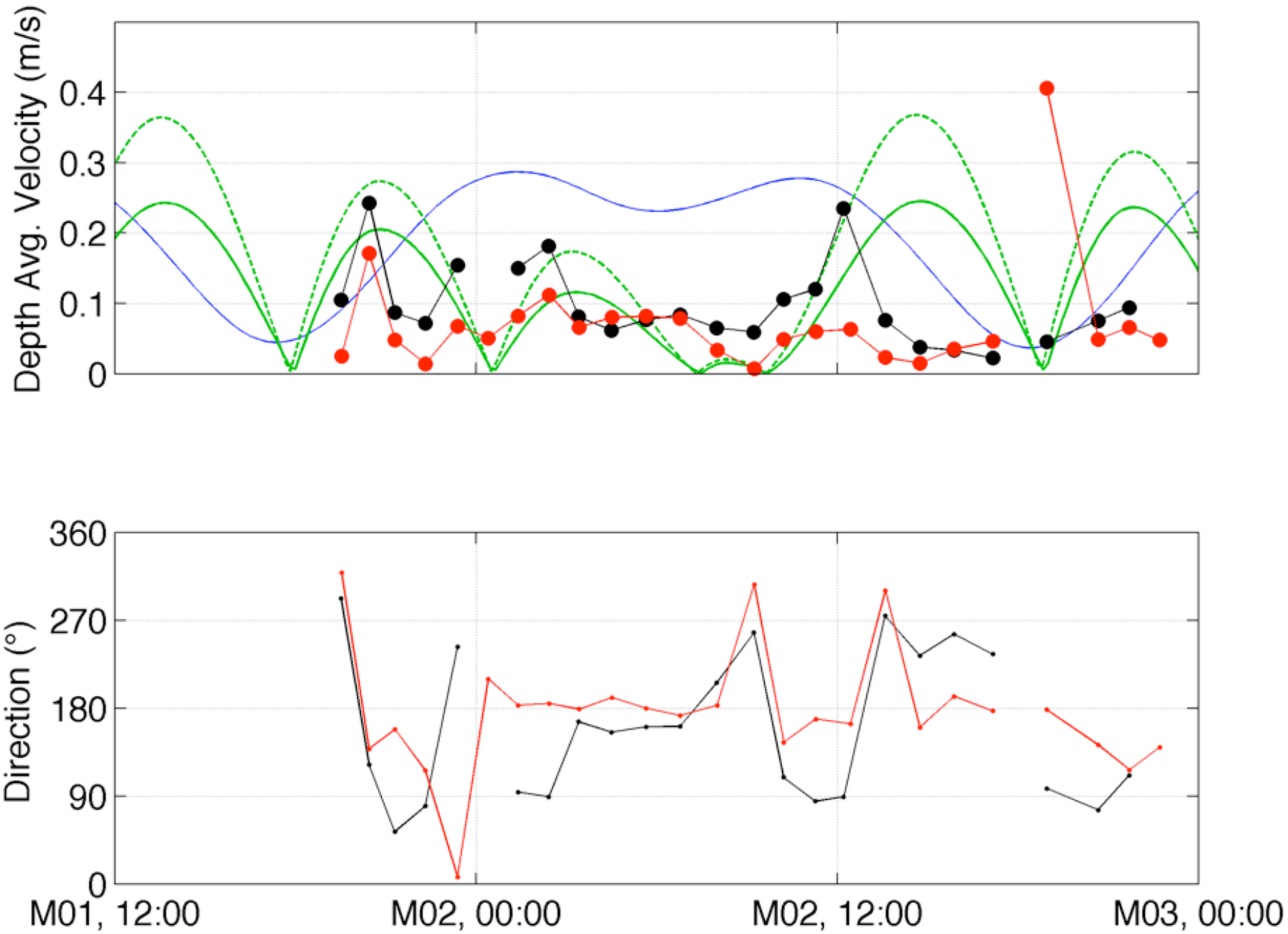
Depth Averaged Currents

AD2CP

Seaglider

Tidal Current

Estimates



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Dead Reckoning and Depth Averaged Currents

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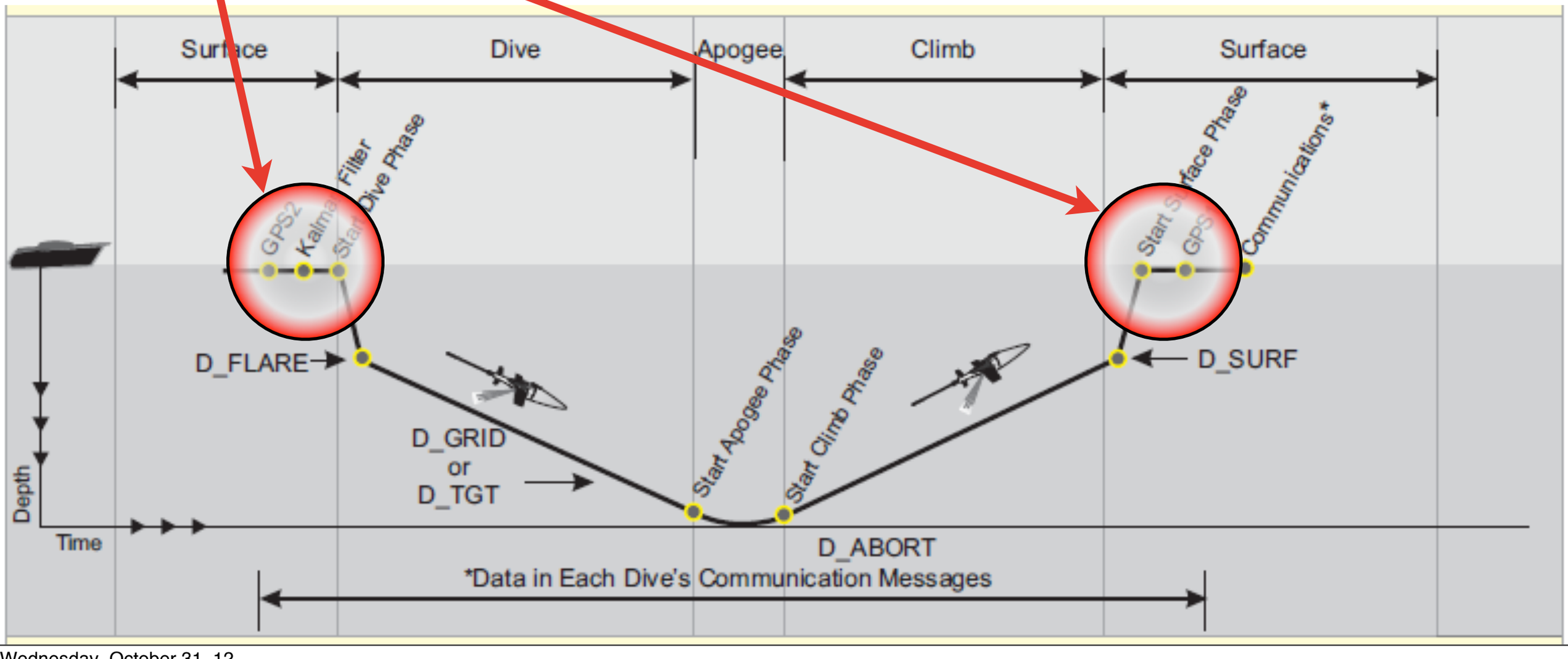
- Dead reckoning is working well. Comparisons against other datasets are needed to validate the Depth Averaged Current estimates.
- One constraint on accuracy is the gaps between GPS positions, the glider diving and surfacing, and the AD2CP-Glider data record.



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Cayuga Lake, June 2012

- Three gliders were flown for 5 days.
- About 100m depth in operating area.
- Large wind event on the last two days created strong surface currents/drift.
- Implemented a global least squares solution to obtain water and glider velocity profiles.

Improving Depth Averaged Velocity Measurements from Seaglider with an Advanced Acoustic Current Profiler, the Nortek AD2CP-Glider
Session: Oceanographic instrumentation and sensors Tuesday, October 16, 2012, 1:30 PM - 2:50 PM, Room MR 4A

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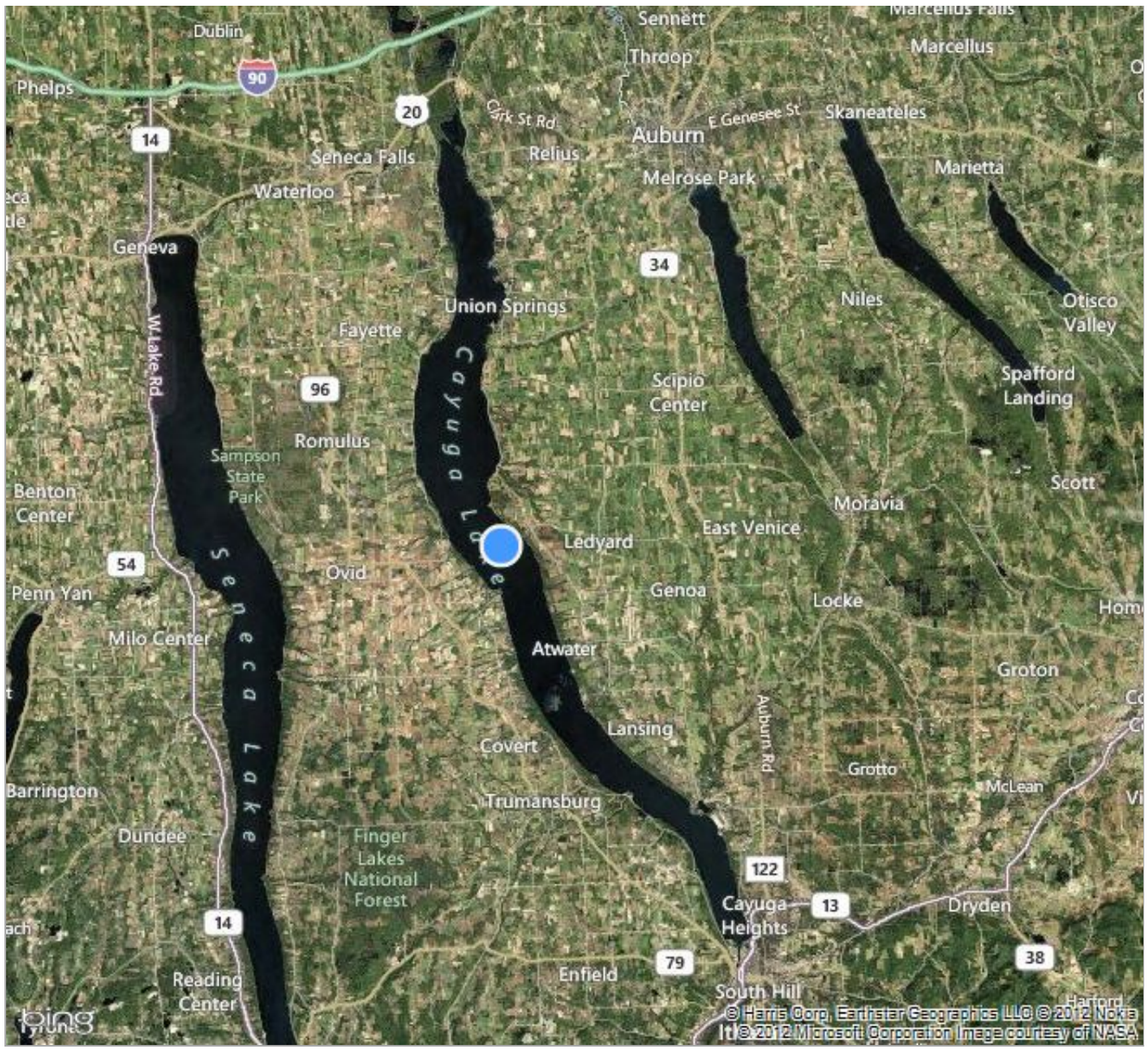
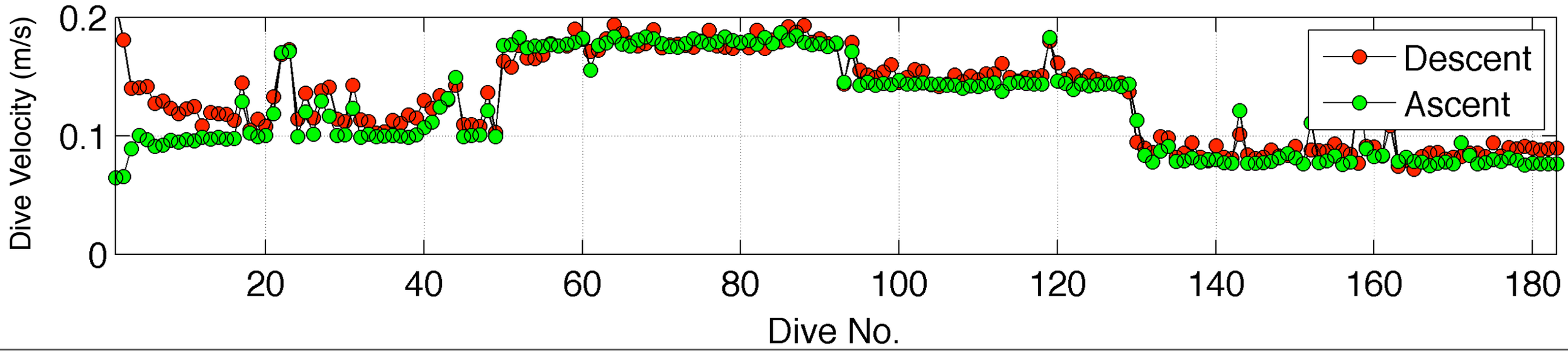
Cayuga Lake



- Second Largest Finger Lake in NY State
- Mean depth of 60 m
  - Maximum depth of 130 m
- Steep sided and dominated by thermal stratification during the test period.

Global Least Squares Solution

- This was a basic implementation which used only a total displacement constraint.
- Minimal pre-processing, only low correlation (<40%) data removed.
- Variety of cell sizes used from 0.5 to 2.0 m.
- Various dive speeds resulted in profile overlap from 90–95%.



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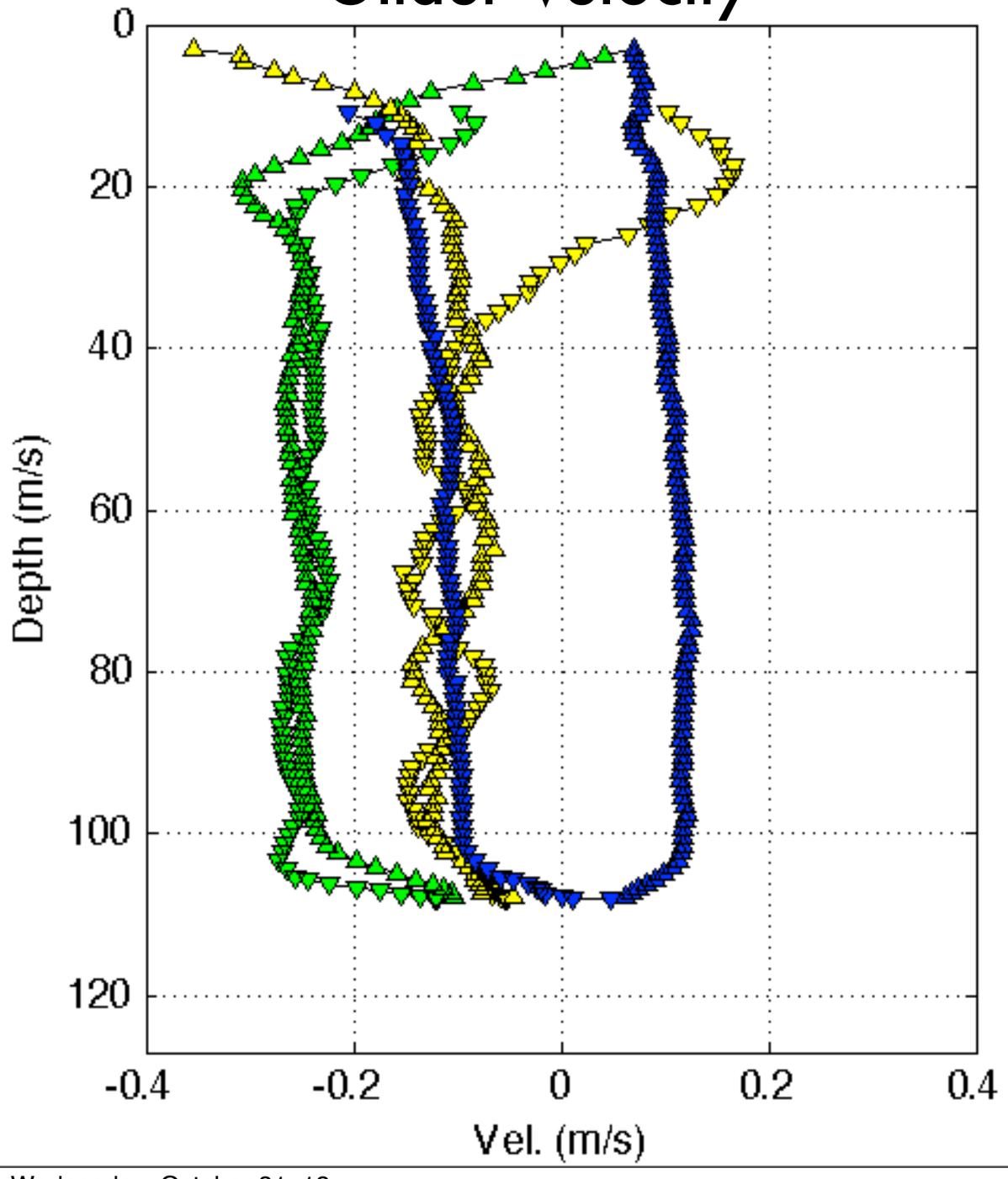
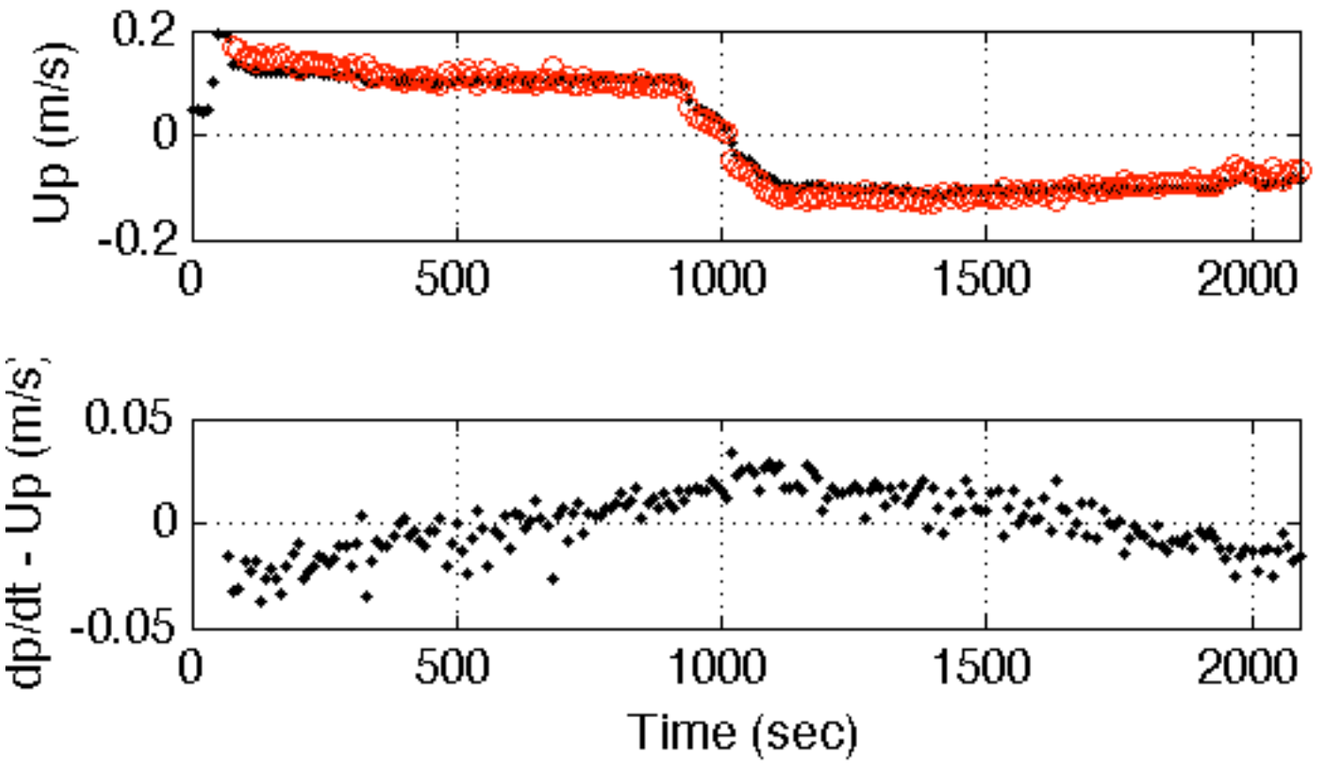
GLS Glider Velocity

Glider Velocity



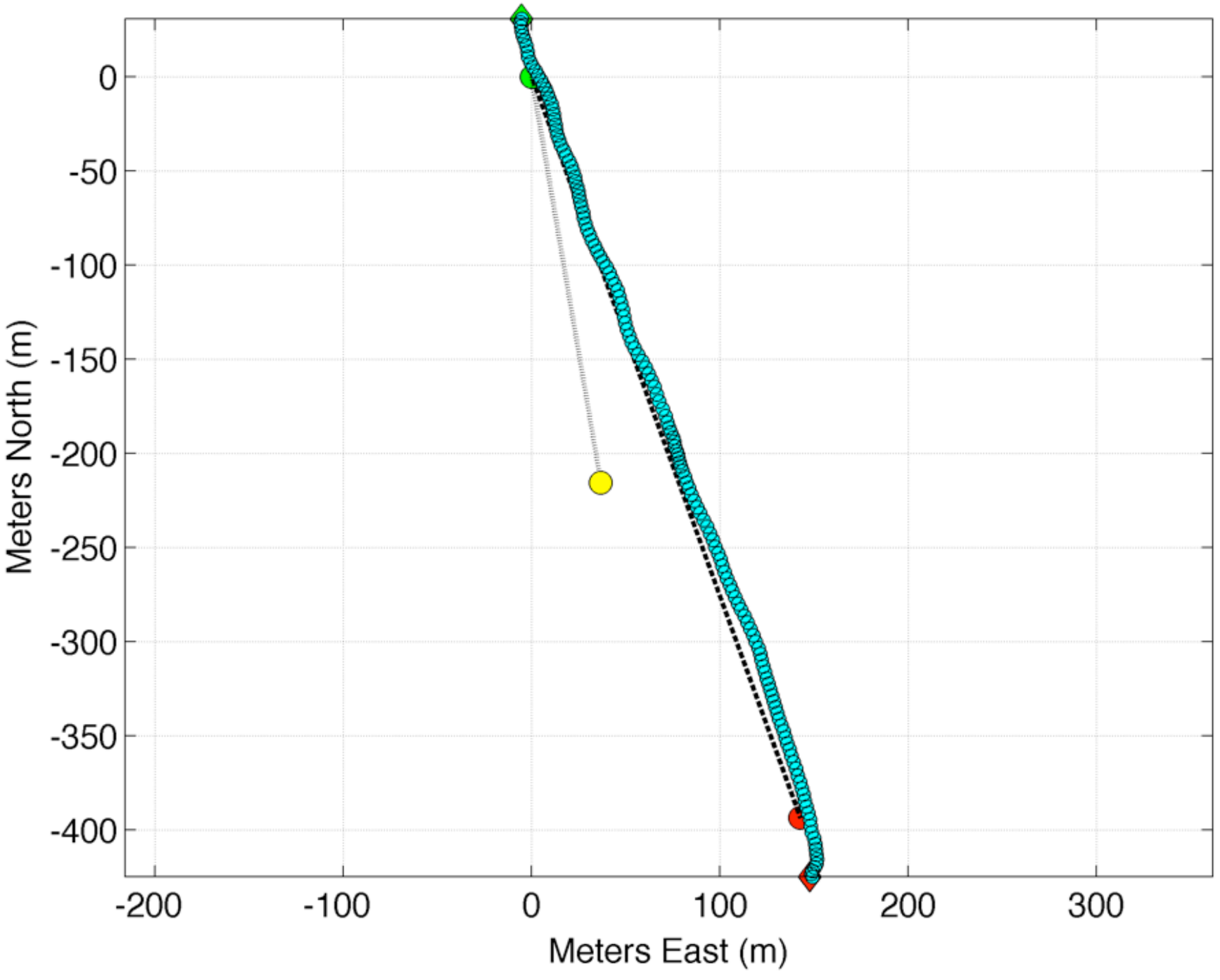


The RMS difference between dp/dt and the measured velocity is about 0.015 m/s

GLS Dead Reckoning

- Because of the displacement constraint, the glider path starts and ends at the GPS positions.

- The accuracy of these positions is important in the quality of the solution and the depth averaged current estimate.



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GLS Water Velocity

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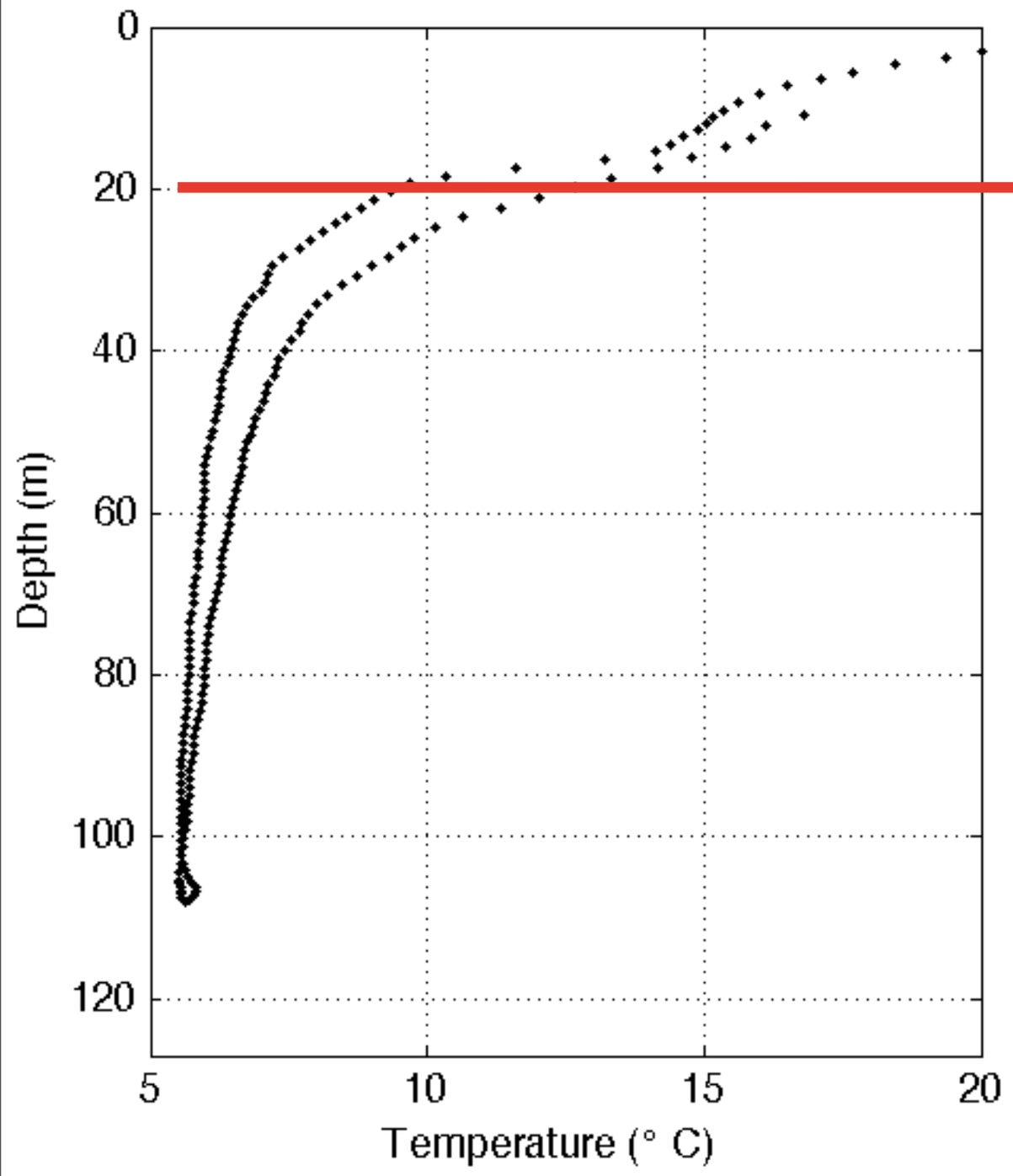

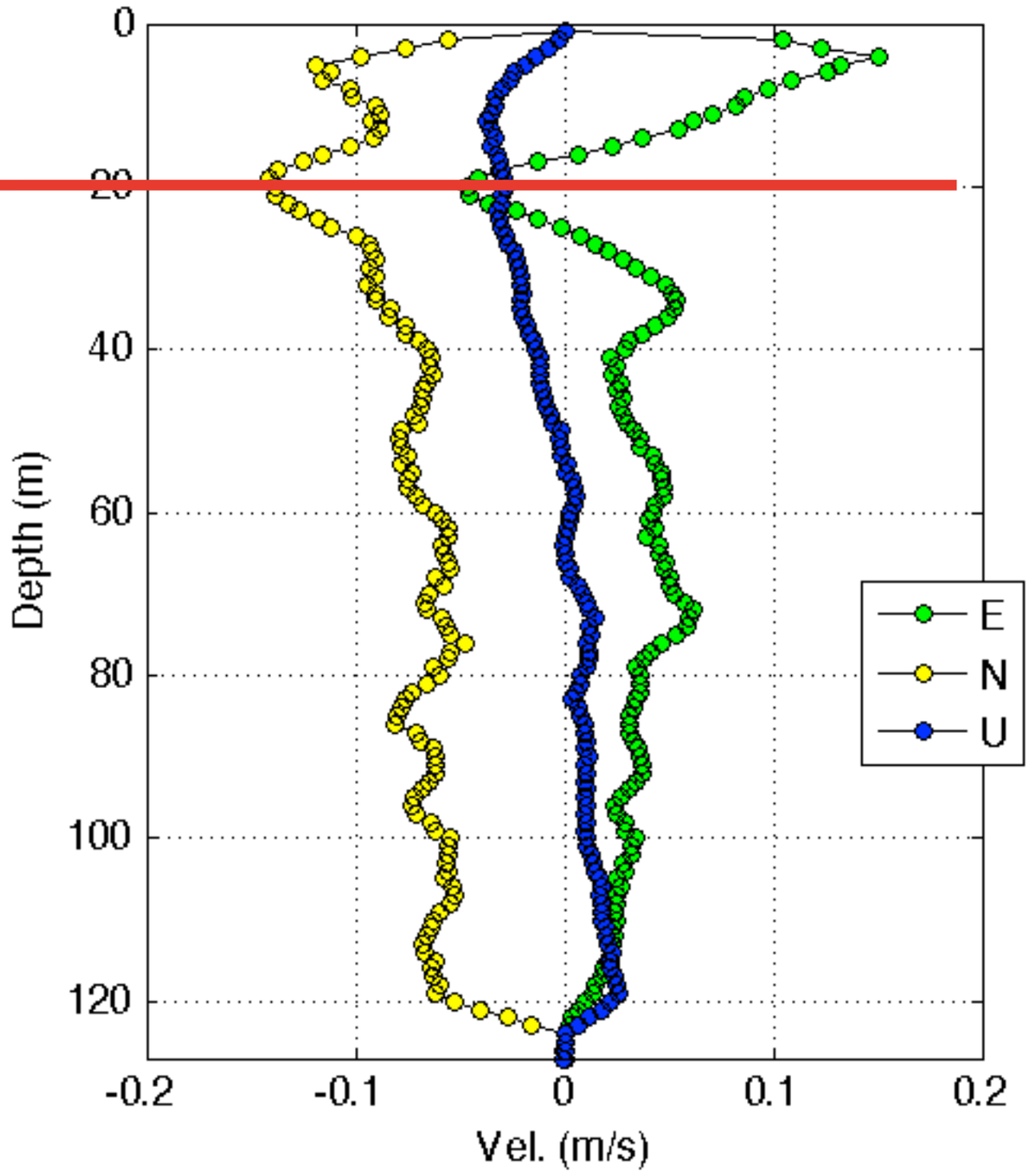

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Comparison to Shear Profiles

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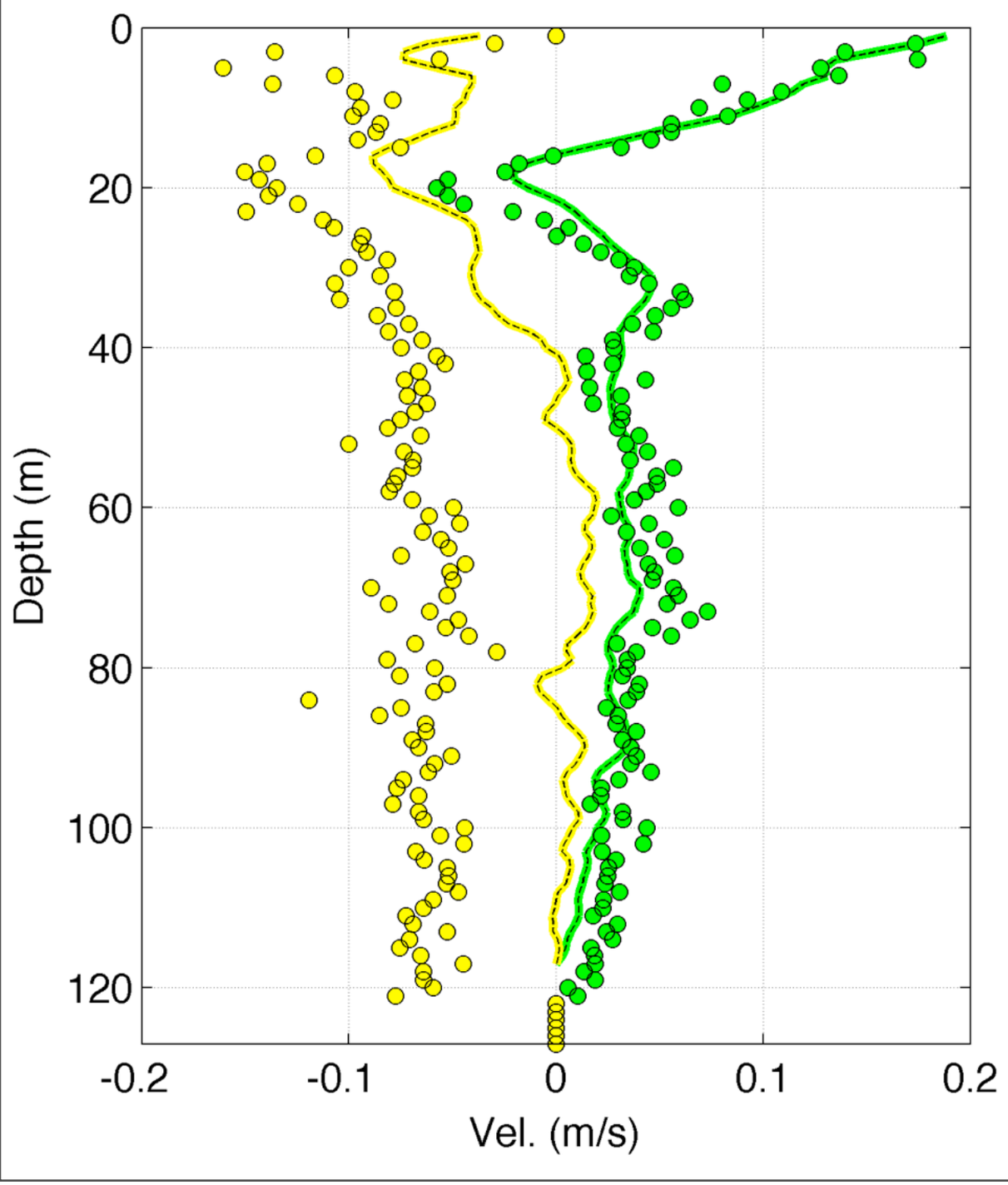

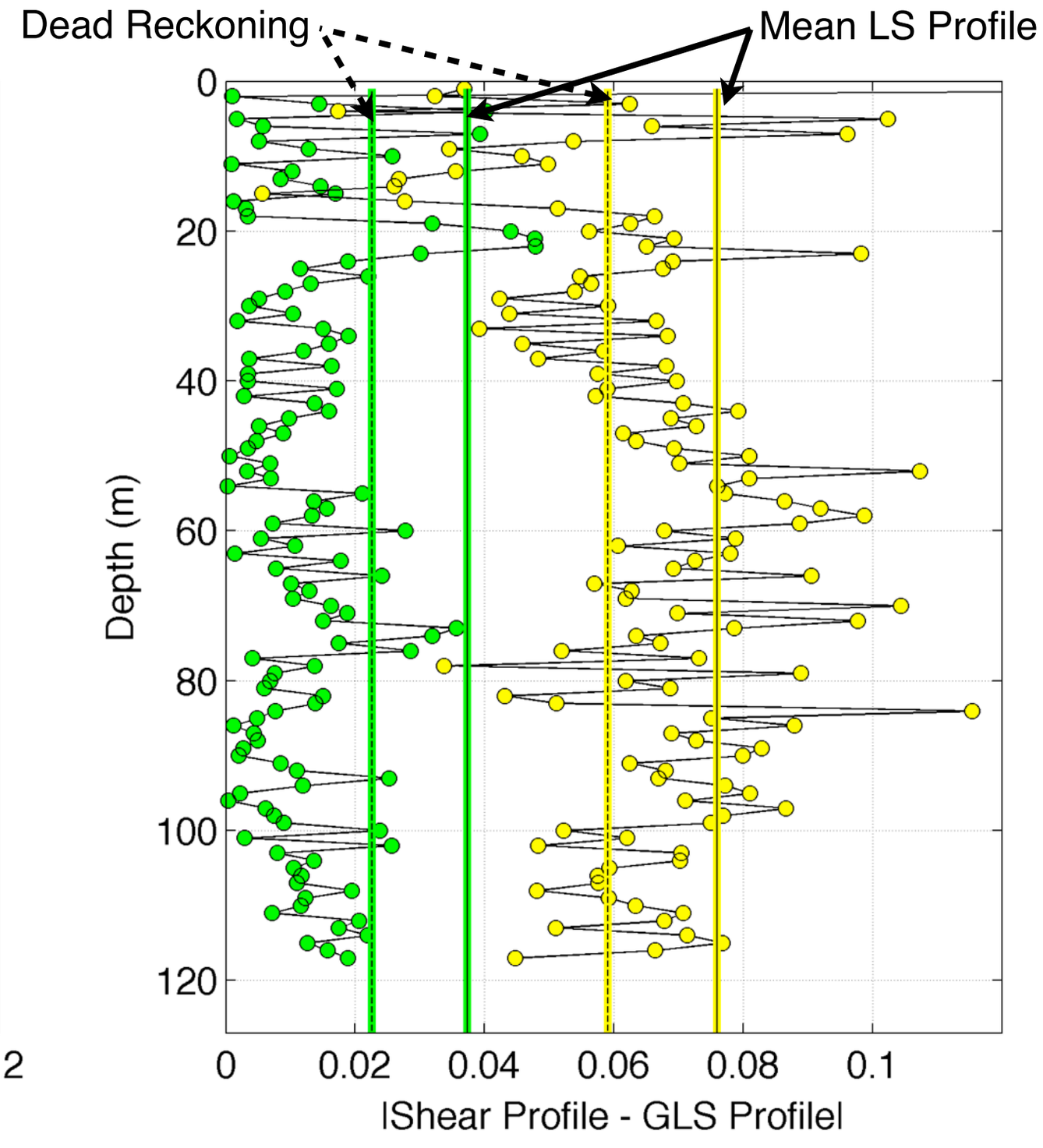

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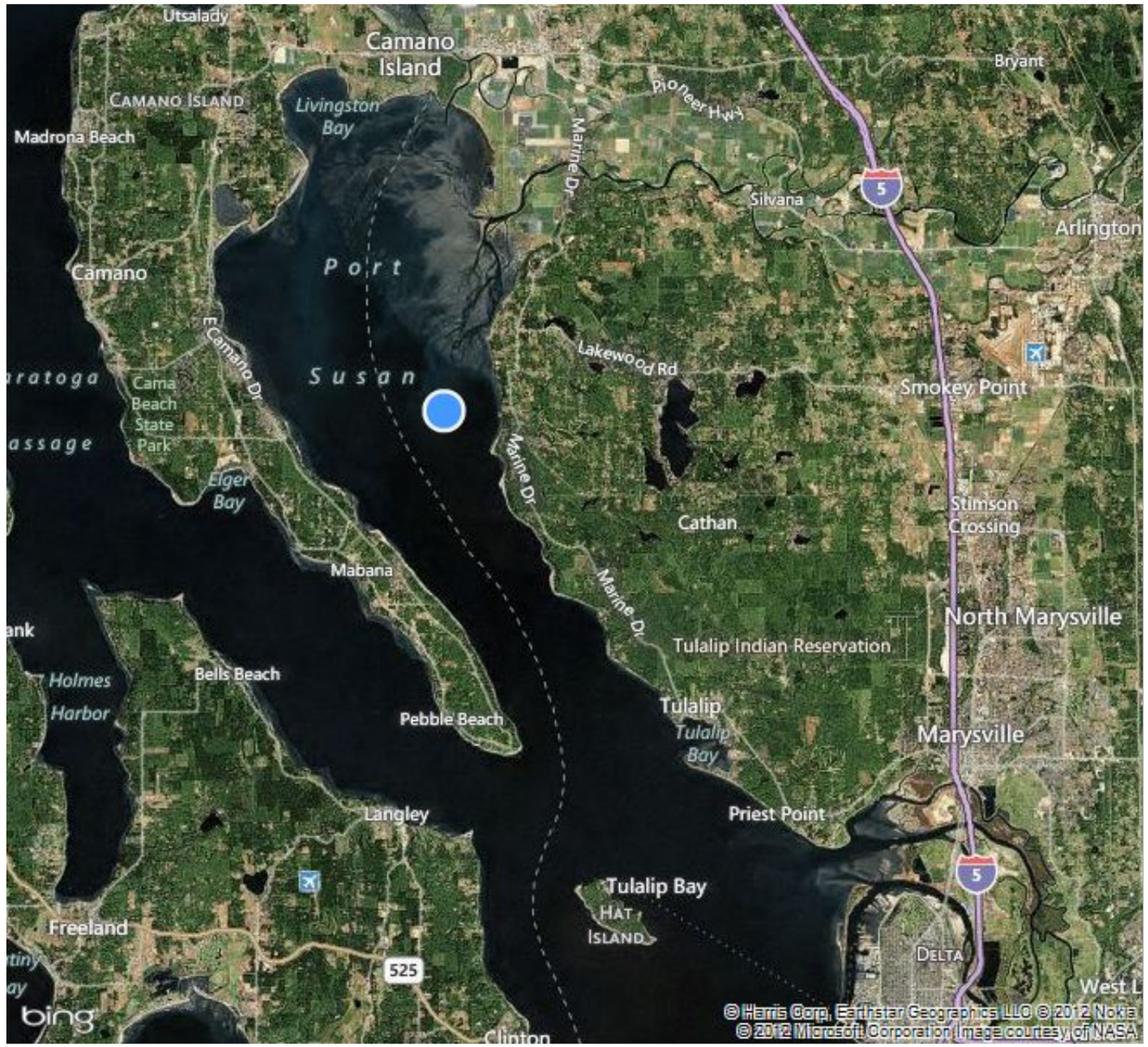
- Located northwest of Seattle, WA.
- Approximately 100 m deep
- Tidally forced with mean currents in the 5-10 cm/s range.



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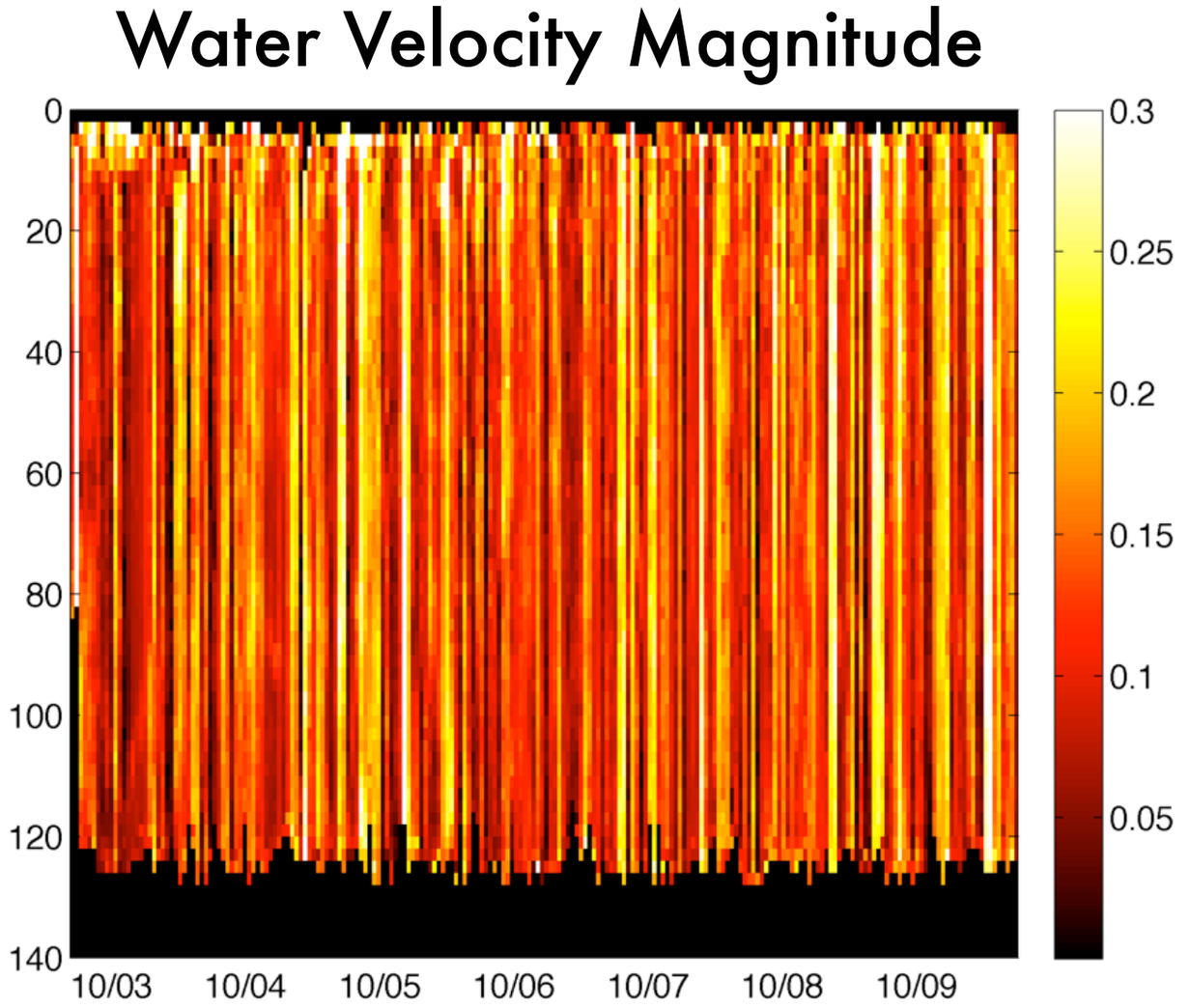
Port Susan

- This test deployment wrapped up last week.
- Three gliders were flown. Multiple moored instruments deployed for comparison.
- Analysis on this starting next week.



Summary of Testing

- Five field tests have provided various amounts and quality of data for analysis.
- Data quality is good except under very low scattering conditions (e.g. Antarctica).
- More work is needed to evaluate when and how best to apply the various algorithms.

Evolving Analysis and Sampling Procedures

- We are using simulated datasets to understand the solution and error behavior of processing algorithms as sampling parameters change.
  - Also comparing to numerical models of the test basins.
- Will using multiple sampling setups to obtain more measurements in critical dive areas improve solution quality?
  - Initial descent, dive apex, near surface on ascent.
- We are also thinking about glider behavior and how to optimize it for velocity measurements.
  - "Navigation mode" already developed by iRobot minimizes roll and minimizes need for beam mapping.

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Evolving Firmware

- Depth based sampling will be added, based on AD2CP high precision pressure sensor.
  - Allows for variation in glider dive speed.
- Store max/min of raw magnetometer data to file.
  - Allows hard iron correction in post processing.
- Additional power management (in process – iRobot firmware is frozen for testing currently).
- NMEA output.
- Special glider features; bottom track and depth sounder/altimeter functions.

Software Solutions

- Global solutions are being incorporated into SeaReport for easy data handling and processing
  - Expect something similar to how we have implemented waves processing.
- We are also looking at what is feasible to implement onboard the AD2CP to meet data telemetry restrictions (about 50kb for AD2CP data).
  - The processor on board is fairly powerful, but memory limited. Really need to optimize for performance and memory use.

Questions?