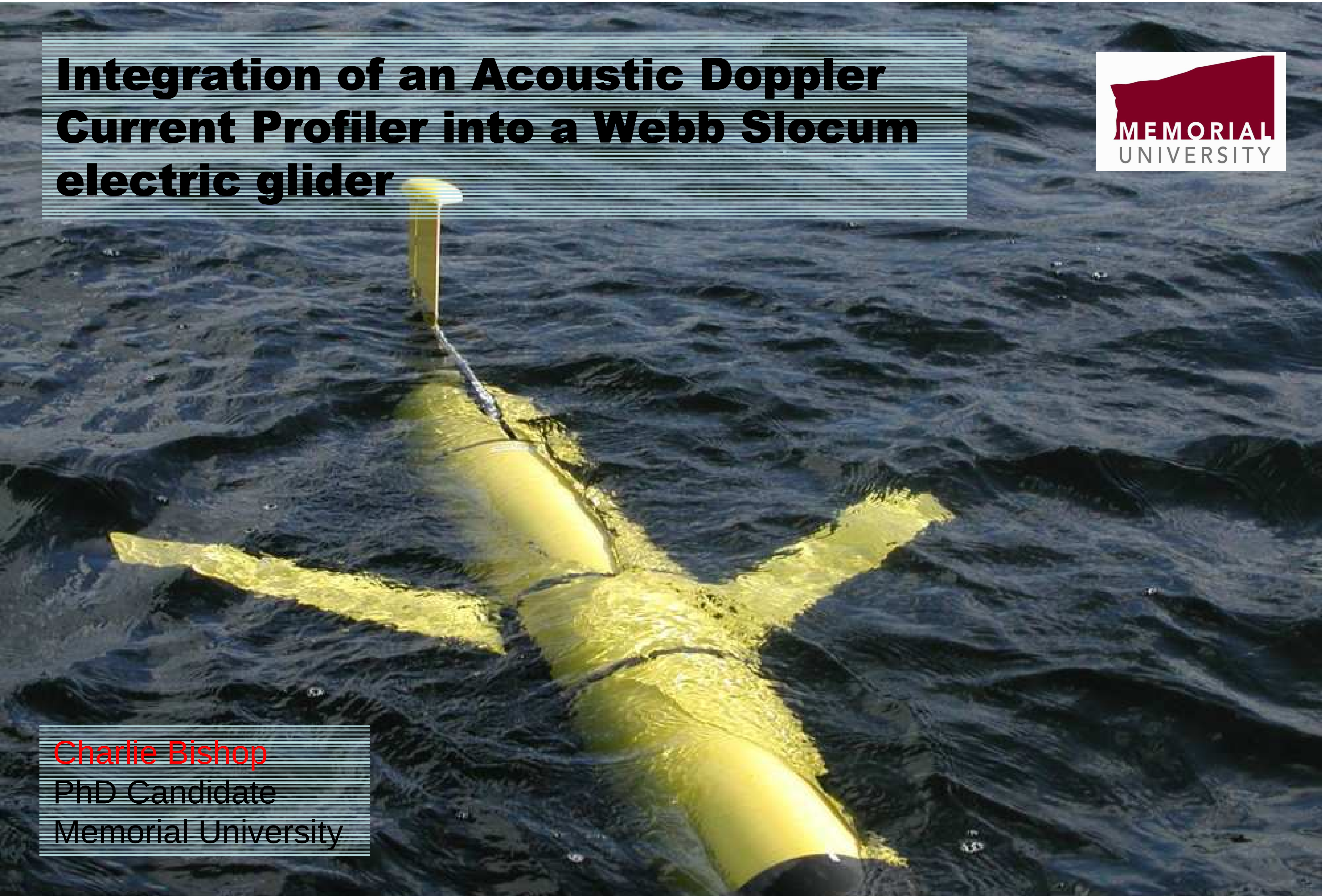
Integration of an Acoustic Doppler Current Profiler into a Webb Slocum electric glider



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The Goal

- The goal of this project is the integration of a 400 kHz 3-beam Nortek Aquadopp Current Profiler into a Webb Slocum ocean glider.

- We aim to obtain profiles of absolute current velocity, along with calculations of shear, over the full profile range of the Slocum glider, roughly 200 m plus the Current Profiler's sampling range of 60 - 90 m.

- Such profiling capability means that we can sample to the bottom over most of the continental shelf.

WHY?

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- Oceanography is observationally limited
- Characterizing the ocean requires introducing sensors to its interior depths at great expense. Consequently, the ocean is poorly sampled, limiting our scientific understanding of the earth's environment.
- This defines a critical scientific need, which AUVs are well suited to address. (Bellingham 97)

The Slocum Glider

Typical glider features:

- Buoyancy driven
- Fixed wing and tail
- Attitude controlled by sliding and rolling internal mass, control surfaces

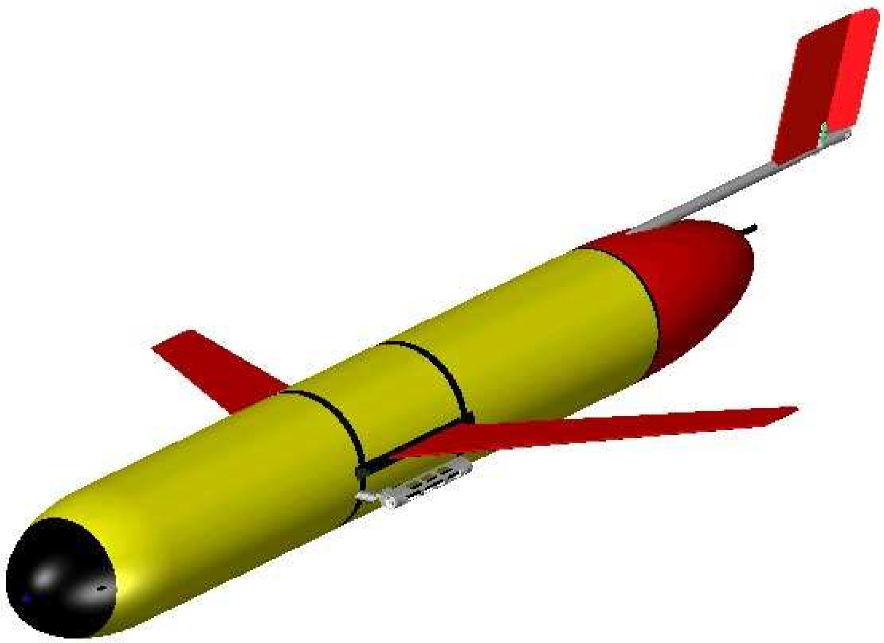
Examples of operational gliders:

Slocum, D. Webb *et al.*

Spray, R. Davis *et al.*

Seaglider, C. Eriksen *et al.*

SeaExplorer



WRC Slocum

Webb Research Corporation Electric Slocum Glider

+/- 250ccm ballast

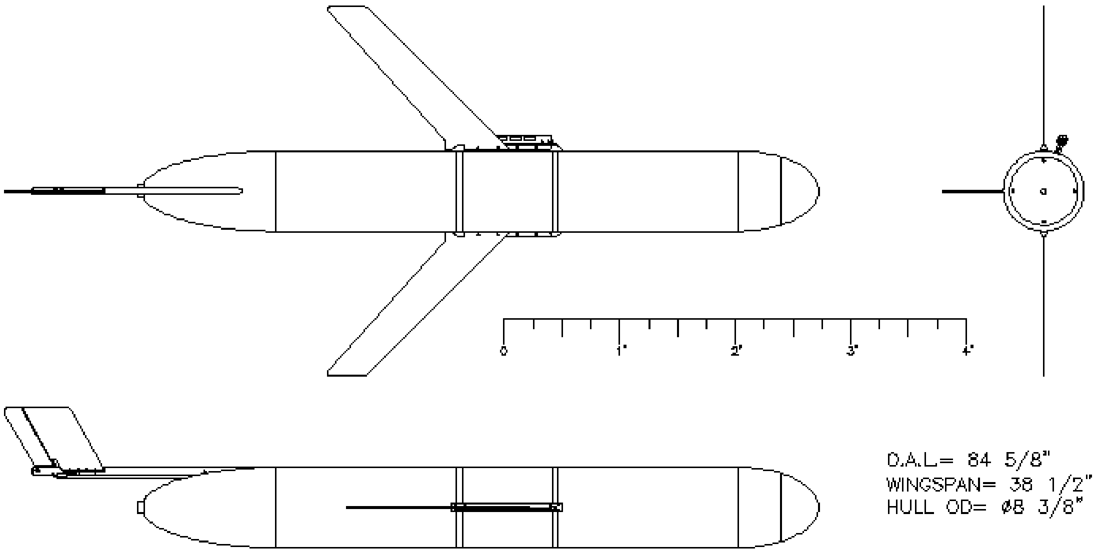
~2kWh battery (70W/day for a 30 day mission)

1.5 m length, 50 kg (in air)

200 m depth

0.35 m/s horiz. Speed

0.2 m/s vertical



What is an ADCP?

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The Nortek Current Profiler measures water currents with sound using the Doppler effect.

Data is given as profiles of X,Y,Z components of water velocity in depth bins away from the instrument.

Additional profile parameters are measured such as signal strength which is required for data processing and quality control.

Nortek Current Profiler

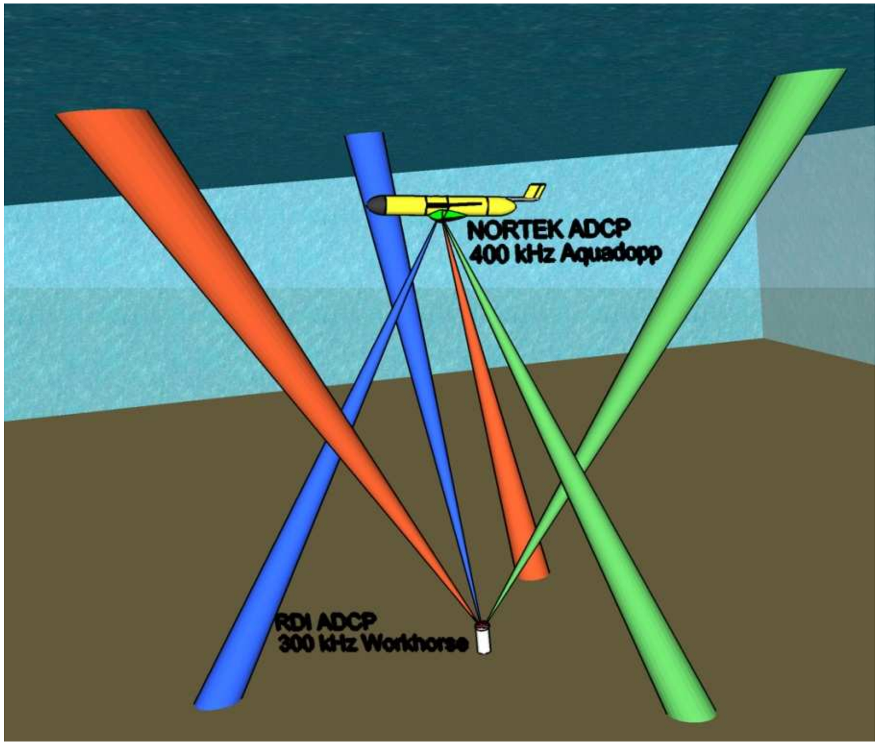
- Frequency: 400 kHz
- Max. range: ~90 m
- Cell size: 2-8 m
- Max. sampling: 1 Hz
- Number of beams: 3
- Beam width: 3.7°
- Compass: flux gate with liquid tilt. Accuracy of 2°
- Weight: 3.7 Kg

ADCP used to observe many different processess

- Zooplankton abundance
- Diel vertical migration of zooplankton
- Suspended sediment concentration
- Bottom boundary layer
- Geostrophic currents on basin-wide scales
- Mean flow and shear and making turbulence measurements.
- Mixing on scales ranging from rivers to deep ocean basins

Field Deployments

- 3 Field tests in Conception Bay
- Comparisons with an independent mooring (RDI ADCP) revealed various sensor issues.

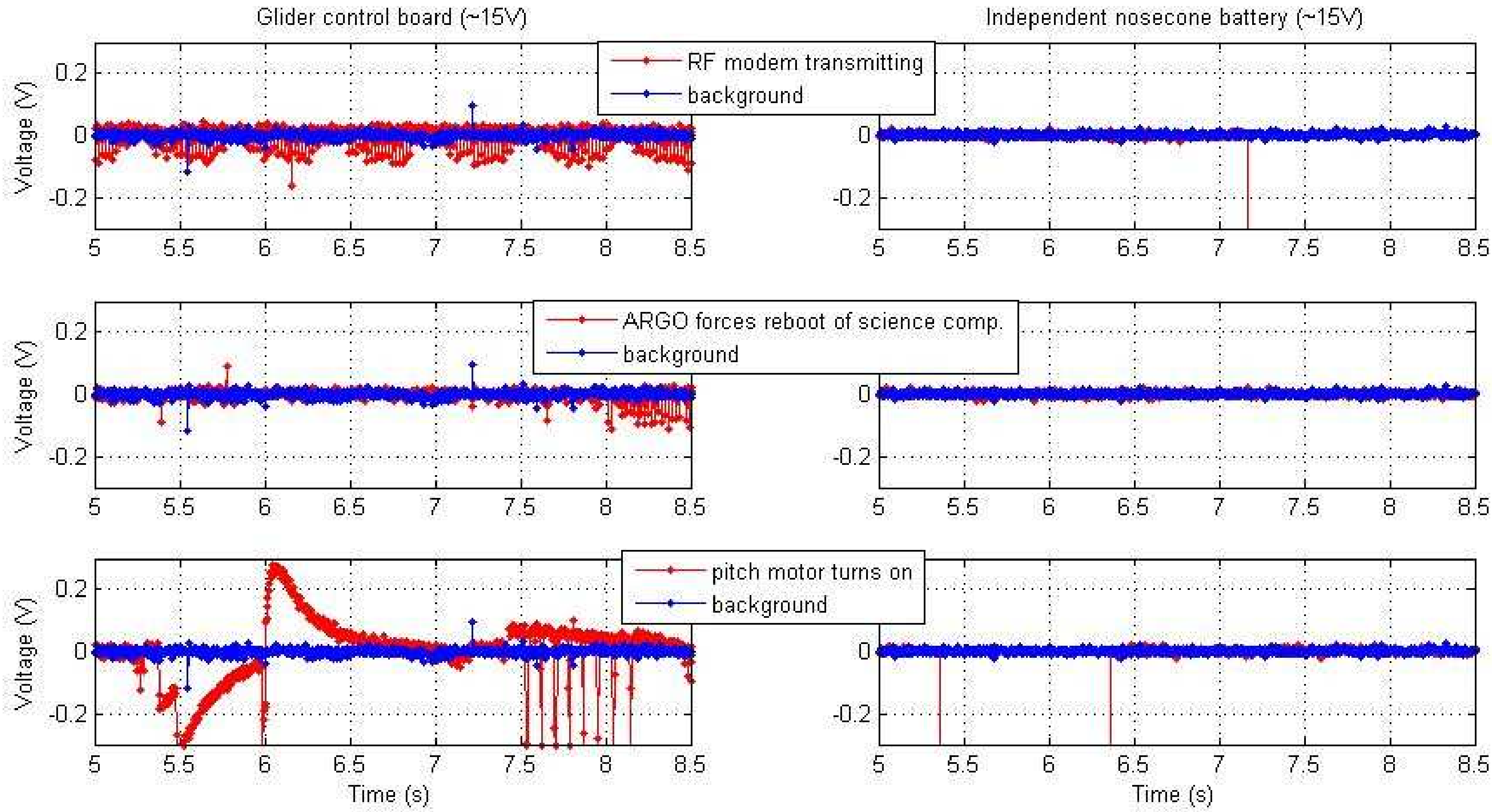


Phase 1: Electrical and Software Integration

- Initial electrical integration had the ADCP hooked directly to main glider power and was not ideal.
- ADCP compass would not calibrate correctly.
- Glider software would not allow ADCP to turn on while at the surface

Problem Solving

Initially, the ADCP was wired directly into the main power source of the glider. However, the various motors and antennae created a lot of noise in the instrument.



Problem Solving (cont)

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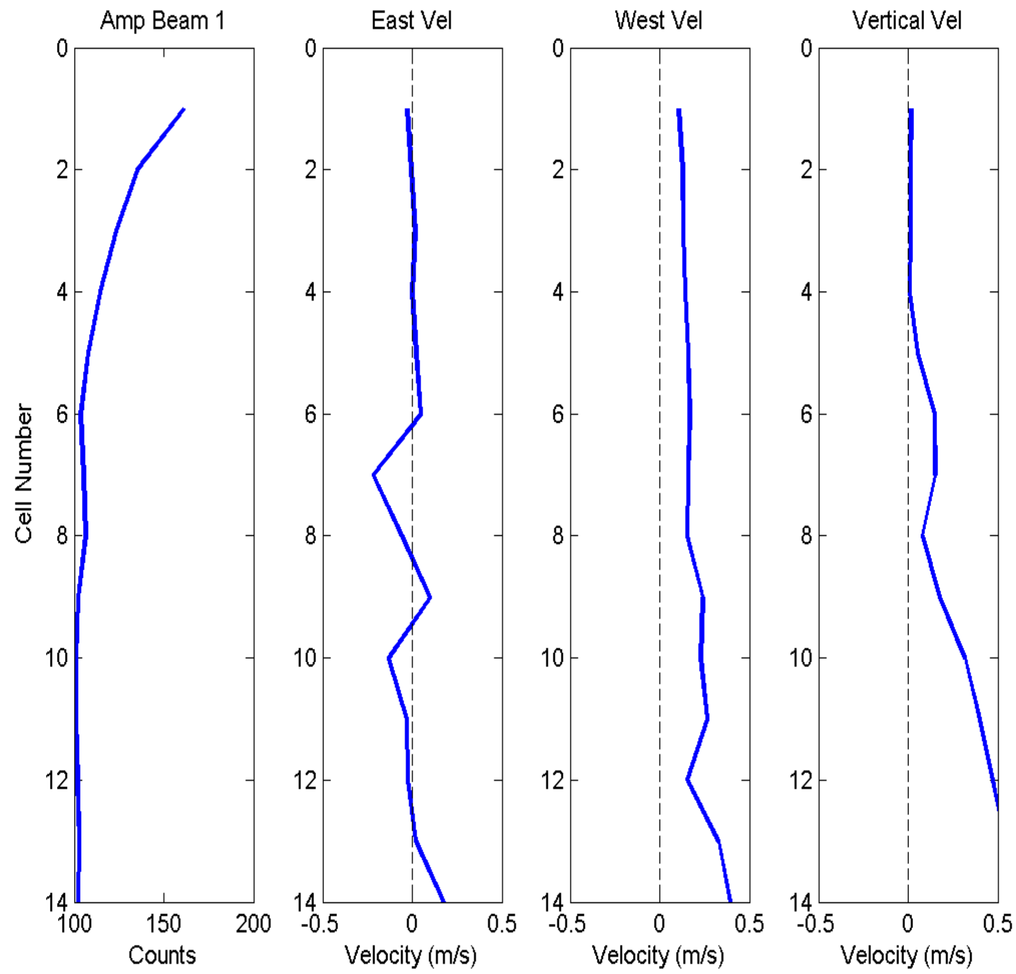
- The new configuration is not without its problems. The ADCP's RS232 connection creates a source of noise in the backscatter measurements. The connection to the science board of the glider acts as a ground loop while the external RS232 connector acts as an antennae and creates noise when the GPS is turned on.

- This is currently being resolved by the addition of an optical-isolator on the rs232 line and the addition of shielding around the cable.



Problem Solving (continued)

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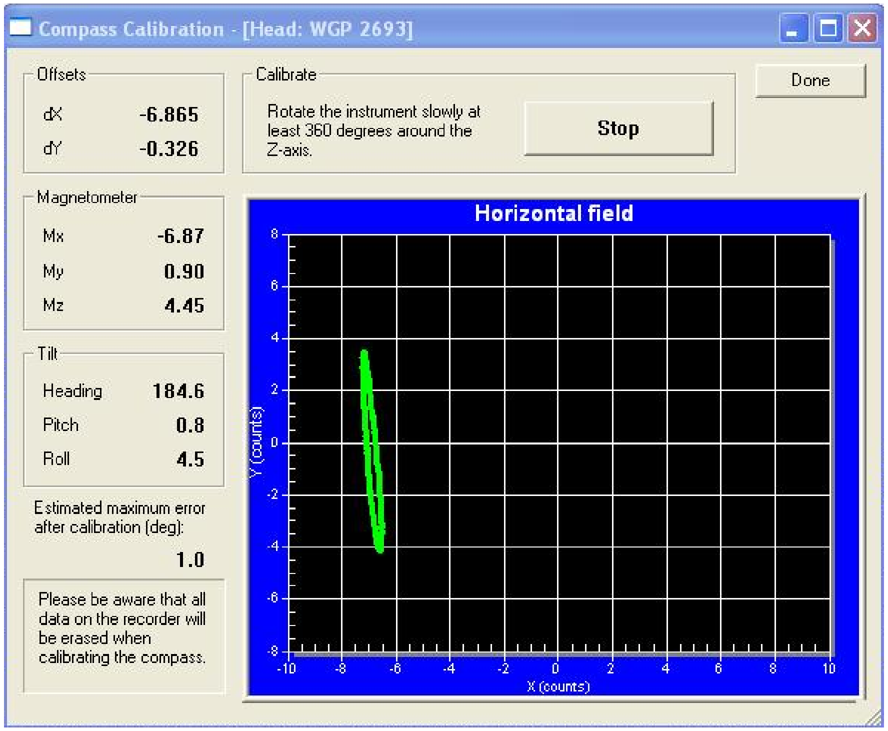
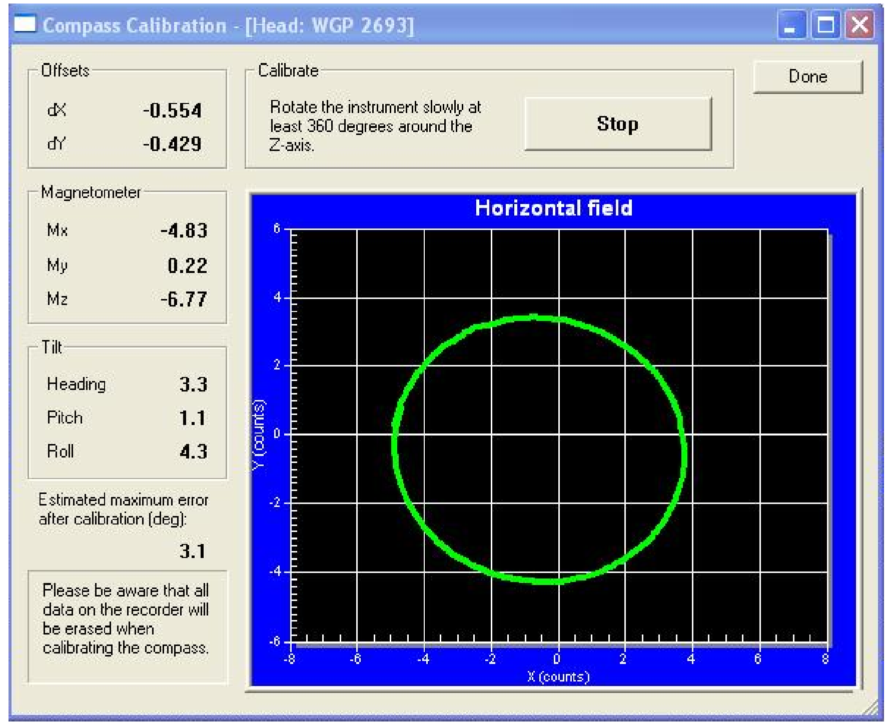




- ADCP compass was orientated incorrectly inside the glider with respect to the software (left) . This was hardcoded and could not be changed by the user. Nortek provided an updated firmware which resolved this issue (right).

Software Integration

- Proglet written by Wayne Pearson (NRC-IOT) which does the time syncing of ADCP data to Slocum science computer. Proglet creates a log of velocity, backscatter, and heading, pitch and roll on the gliders science computer.

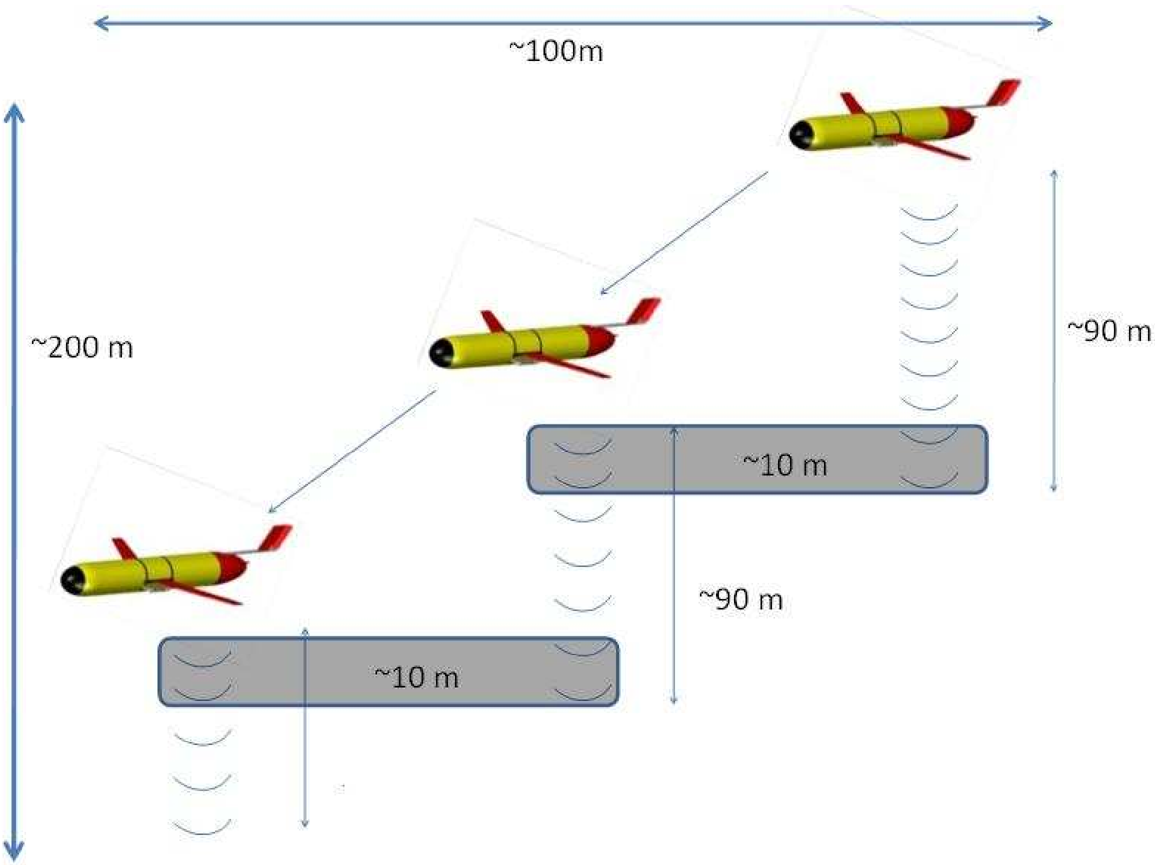
- We wish to leave the glider on the surface to sample for 5-10 mins, while actively receiving LAT/LON position from GPS to correct for surface drift. Problems arose when attempting to sample at the surface as the glider is programmed only to come to surface long enough to communicate over Iridium and then dive again.

Phase 2: Bootstrap Algorithm

- The general approach of the algorithm will be to collect ADCP profiles at 0, 60, 120, and 180 meters depth (3). The ADCP's ideal range is given as 60-90 m depending on water conditions, therefore we hope to obtain error-free profiles of 65 m in length, giving overlapping data segments of 5 m - which can then be aligned into one complete water column profile.

- The four data intervals will be 0-65, 60-125, 120-185, and 180-245 m (or the maximum range of the ADCP, whichever is largest).

- This bootstrap approach will be compared to a traditional moored ADCP to ensure accurate data and to provide error estimates.



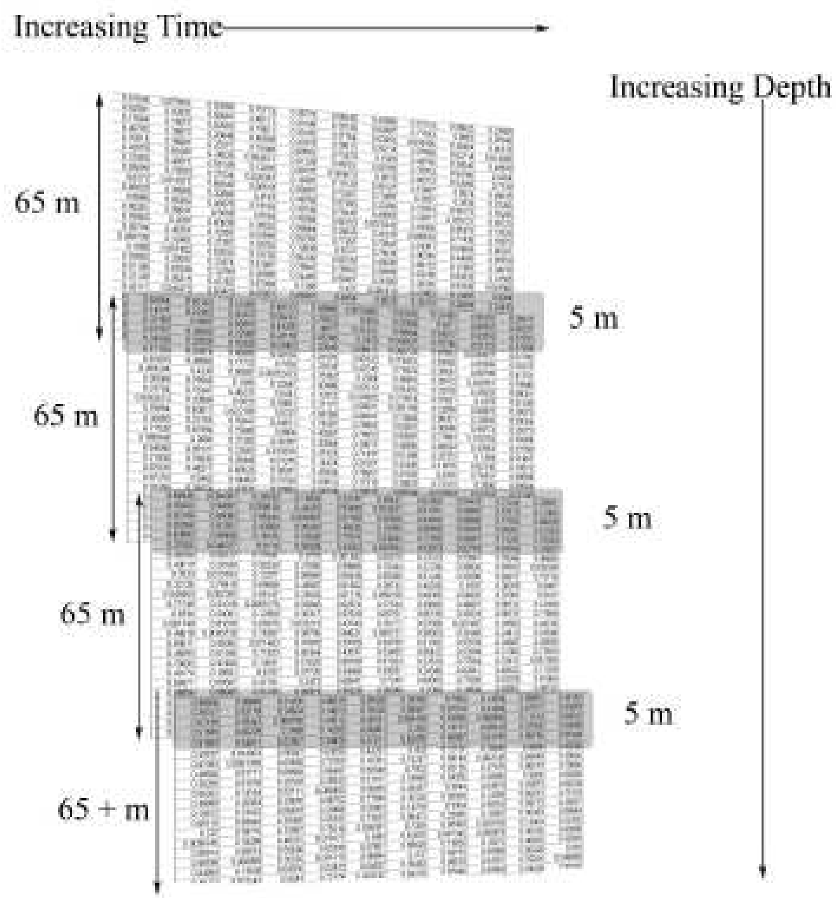
Bootstrap Algorithm (cont)

- Scenario 1 (sea floor < 90m): Glider at surface with sea floor in range of ADCP. This is the ideal situation. The surface measurement is referenced to the GPS to remove surface drift and we have a complete profile to the ocean floor with little uncertainty.

- Scenario 2 (sea floor < 160m): Glider sampling at surface with sea floor out of range. The surface measurement is again referenced to the GPS. Glider dives to ~80m water depth and samples while drifting at depth. Two profiles are bootstrapped together to form continuous profile with little uncertainty.

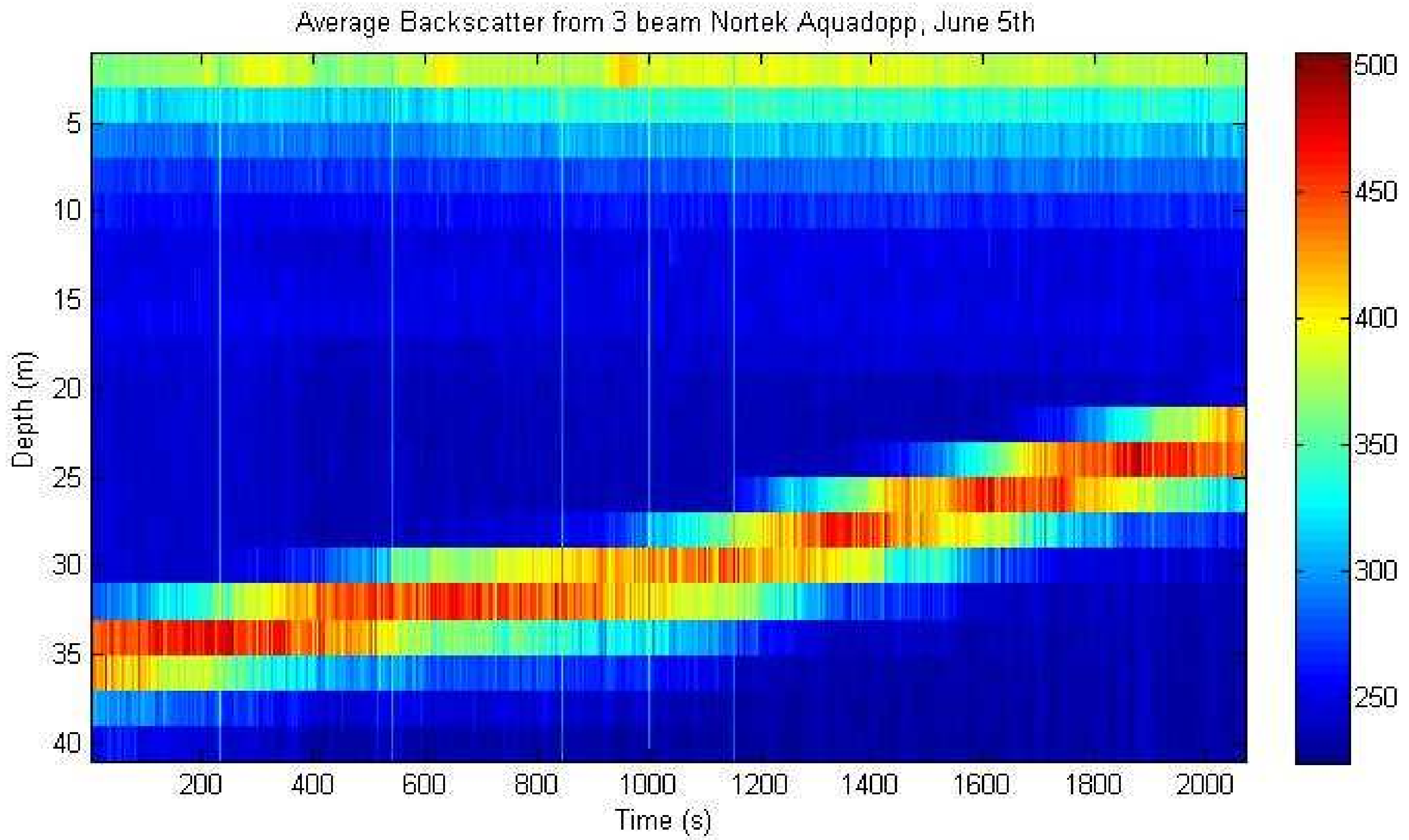
Bootstrap Algorithm (cont)

- Scenario 3 (sea floor < 240m): Glider samples at surface with GPS reference. Diving to 80 to sample and again to a further 160m to sample in range of sea floor. Bottom profile can be post-processed with a bottom tracking algorithm. Middle profile is then aligned to the top and bottom profiles with some uncertainty.
- Scenario 4 (sea floor > 240 m): Worst case scenario. Multiple dives with only reference being while surfaced, this will result in a bootstrapped profile with the largest amount of uncertainty.



Bottom Tracking

- Bottom is clearly visible in backscatter data recorded by the ADCP. It should be possible to create a post-processing algorithm for bottom tracking.



Phase 3: Deployment of glider to study ocean mixing

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- Once integration is completed and bootstrap algorithm has been tested we will deploy for a 1 week mission in Conception Bay.

- Goal here is to prove the vehicles capabilities to monitor ocean currents and to capture data during a storm event to study it’s ability to measure ocean mixing.

Future Work

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- Power-budget study on ADCP with new Li-Ion batteries
- Development of post-processing bottom track algorithms
- Study of storm mixing using Glider w/ ADCP

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