Shear madness: a new method to measure ocean currents from a glider

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Project rationale

This project will expand on the work of recent studies that have used ocean gliders to measure velocity shear using acoustic doppler current profilers (ADCPs) mounted on gliders[2,3,4]. This will be the first full scientific deployment of an ADCP glider in the UK and one of few studies using the Konsberg Seaglider platform.

The environment of interest is the shelf break, the top of the slope between the coastal and deep ocean. These are localized areas of rapid slope change where strong along slope jets and important cross shelf processes occur, affecting mixing and primary production.

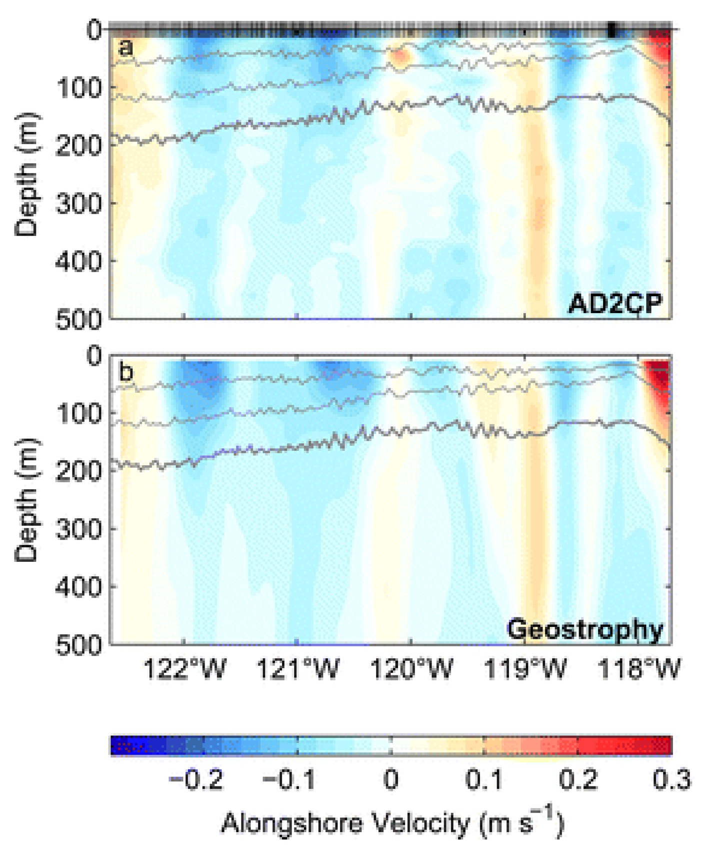
This project will measure ocean current shear at shelf breaks by sampling the region with a Nortek 1 MHz acoustic doppler dual current profiler (AD2CP) integrated in the aft bay of a Kongsberg Seaglider (right). Previously this data could only be collected by spatially limited moorings or expensive research ship surveys. The central aim o this project is to determine whether an ADCP glider can collect this data at sufficiently high accuracy.

Use of ADCP gliders

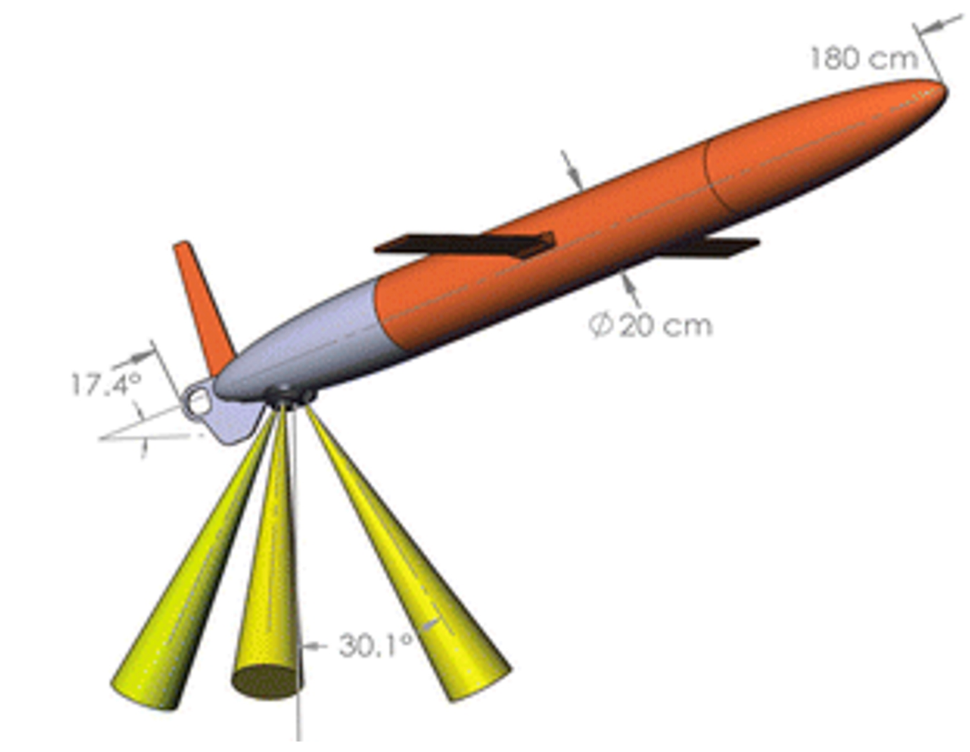
Marine gliders have been profiling the ocean for over 15 years, greatly enhancing the coverage and resolution of ocean data. Advantages offered by gliders compared to ship based surveys:

- Range 6 month+ deployments over 1000s km
- Ease of deployment from small vessels
- Buoyancy engine provides an energy efficient quiet ride
- Sensors to measure temperature, salinity, passive acoustics, microstructure, velocity shear, acoustic and optical backscatter, chlorophyll florescence and an increasing number of dissolved chemical compounds[1].

ADCPs have been mounted on gliders since the beginning of the decade, being successfully used to measure ocean shear in several technical and scientific deployments. The results agree very well with velocity fields estimated from CTD data (below). However, data processing is onerous and there is still considerable uncertainty on glider path during dives, when location by GPS is impossible. This problem needs to be solved as gliders achieve their maximum utility in areas not covered by ship surveys or moorings.

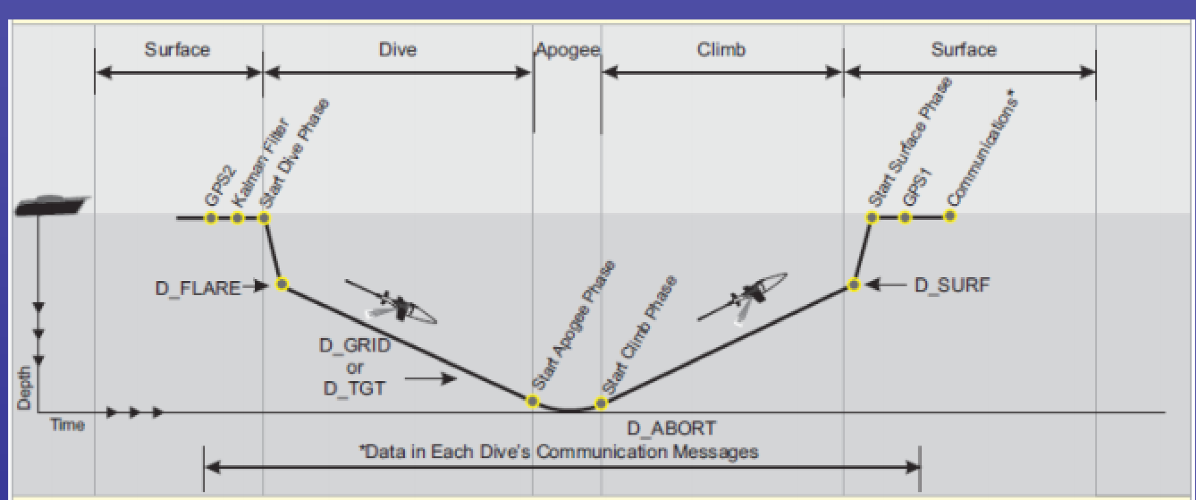


Comparison of velocity fields estimated form AD2CP data (top) and from the geostrophic calculation that uses CTD data recorded by the glider (bottom) in the California Current System from a study published this year[2].



Top: The Nortek 1 MHz AD2CP mounted on the aft hull section of a Seaglider[3]

Bottom: An example of the sensor on a spray glider[2]. The Janus configuration of the Nortek 1 MHz results in 3 of the 4 transducers near evenly spaced around the vertical when the glider ascends or descends at 17.4^{0}



Completed trials of the AD2CP Seaglider

The iRobot Seaglider with integrated AD2CP underwent four short tests in North American lakes and coastal waters and one field test in the Antarctic Ocean in 2012. Results were positive, with the AD2CP performing well except in the very low scattering environment of the Antarctic.

- All coastal/inland tests shallow water only
- Good dive average current
- Vertical velocities agree with measurements by pressure sensor to rms 0.015 m s^{-1}
- Large profile overlap of 90-95% ensured a near gapless record
- Navigation strategy under review. To minimise beam misalignment of the AD2CP, course corrections should be minimised.

Sensor and sampling

The Seaglider profiles to a maximum depth of 1000 m before surfacing, each profile typically takes 6 hours and covers approximately 6 km horizontally (left). The Seaglider's near neutral buoyancy from the aluminium pressure hull reduces energy consumption compared to other gliders, increasing the range and the amount of energy available for the AD2CP.

The Nortek sensor has an operating frequency of 1 MHz. This picks up scatters from suspended matter the size of zooplankton and gives an effective range of 15–30 m in adequately high scattering waters.

The downward facing sensor is capable of tracking the seafloor when in range, providing an absolute reference for velocity shear.

Kalman filter aids navigation

Unlike preceding 3 sensor units, the Nortek AD2CP can profile during ascent and descent.

*adapted Rudnick figure here

With the large overlap of data (figure from todd 11 here?) and high number of repeats strict data quality control measures can be applied without reducing data coverage. Laving an overdetermined linear system to be solved by least squares

Nortek provide a comprehensive system from sensor integration on the Seaglider to data processing algorithms and display software

Project Aims

Primary:

- Adapt the velocity analysis method used for spray glider data to Seaglider gathered velocity data
- Measure shelf break jets in the Faroe Shetland Channel
- Improve flight model of Seaglider with input from the AD2CP to better determine flight path

Secondary:

- More accurately measure vertical velocities to detect internal waves
- Estimate primary production from AD2CP backscatter

[1]Rudnick, Daniel L. (2016). "Ocean Research Enabled by Underwater Gliders". In: Annual Review of Marine Science 8.1, pp. 519–541
[2]Todd, Robert E., Daniel L. Rudnick, Jeffrey T. Sherman, et al. (2017). "Absolute Velocity Estimates from Autonomous Underwater Gliders Equipped with Doppler Current Profilers". In: Journal of Atmospheric and Oceanic Technology 34.2, pp. 309–333.
[3]Rusello, P. J., C. Yahnker, and M. Morris (2012). "Improving depth averaged velocity measurements from Seaglider with an advanced acoustic current profiler the Nortek AD2CP-Glider". In: Oceans 2012. IEEE..
[4]Todd, Robert E., Daniel L. Rudnick, Matthew R. Mazloff, et al. (2011). "Poleward flows in the southern California Current System: Glider observations and numerical simulation". In: Journal of Geophysical Research 116.C2, p. 26.