Barents Sea Monitoring with a SeaExplorer Glider

Michael Field[1], Laurent Beguery[2], Laurent Oziel[1], Jean Claude Gascard[1]
[1]LOCEAN, UMR 7159, CNRS/UPMC/MNHN/IRD, Université Pierre et Marie Curie, Paris, France
[2]ACSA, Meyreuil, France
Email: michael.field@locean-ipsl.upmc.fr, lbeguery@acsa-alcen.com,
laurent.oziel@locean-ipsl.upmc.fr, jga@locean-ipsl.upmc.fr

***Abstract* — The use of gliders in the Polar Regions offers clever and inexpensive methods for large scale monitoring and exploration. In August and September of 2014, a SeaExplorer glider successfully completed a 388 km mission in the central Barents Sea to monitor the physical and biological features over a transect between 72°30’ N and 74°30’ N latitude and between 32° E and 33° E longitude, as part of the European FP7 ACCESS project and in cooperation with the Institute of Marine Research, Norway.**

The paper discusses the performance of the SeaExplorer vehicle during the mission in Arctic waters. The behavior of the magnetic compass in close proximity to the magnetic north pole is described and its resulting impact on the flight of the glider. The reliability and robustness of the vehicle is evaluated for operations in these difficult conditions. This successful and cost-effective mission now opens the door to future opportunities to conduct repeat autonomous monitoring in the Barents Sea.

I. Introduction

A. *The Barents Sea*

During the last decade, which has been the warmest ever observed in the Arctic [1], climate change in the Barents Sea has been illustrated by an unprecedented decline in sea ice [2]. The Barents Sea is one of the most productive areas in the world for fisheries and extraction of mineral resources. This is also a key area for observing exchanges between the North Atlantic Ocean and the Arctic Ocean.

The Barents Sea is a challenging operating area for a glider, with a shallow average depth of 230 m and banks and sea mounts rising to less than 50 m depth [3], in addition to strong ocean currents, in some cases with an average velocity of more than 25 cm/s [3].

Approaching the magnetic north pole, the declination varies greatly over short distances and the inclination of the magnetic field approaches +90°, resulting in an unstable glider-heading component when resolving the glider direction. In the Barents Sea, the magnetic declination ranges between 0° and +35°, while the magnetic inclination ranges between +78° and +84° [4].

C. *The SeaExplorer Glider*

The SeaExplorer is a proven underwater vehicle with a wingless design that can travel at speeds of up to 0.5 m/s. Here we use a standard model of the SeaExplorer glider, equipped with a 3D digital magnetic compass that combines 3-axis accelerometers with 3-axis magnetic sensors, providing a tilt-compensated heading, pitch and roll.

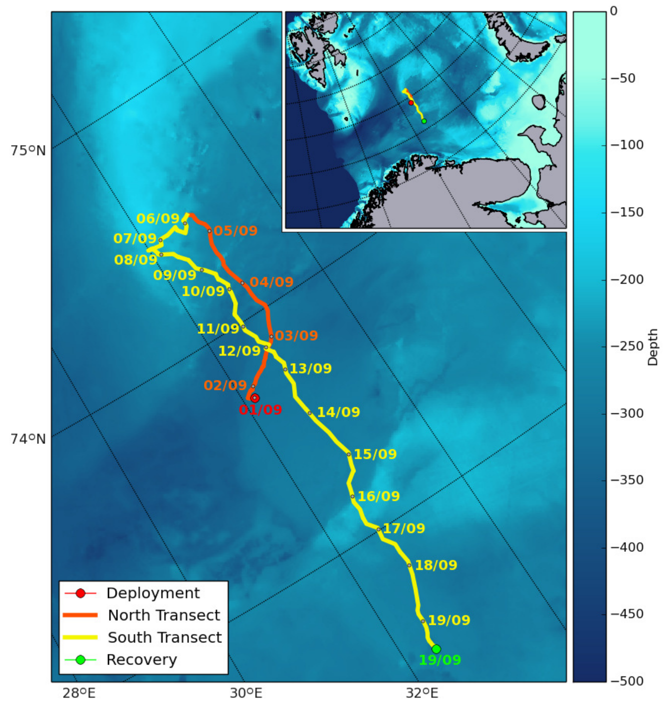

Fig. 1 Track of the SEA004 SeaExplorer during the Barents Sea mission.

The SeaExplorer “SEA004” used for this mission was equipped with a SeaBird pumped CTD with a SBE43 dissolved oxygen sensor, a WETLabs ECO puck fluorometer and backscattering meter, and an altimeter for sea floor detection.

II. Operations and Performance

A. *Tromsø Fjords*

The SeaExplorer glider was comprehensively tested in Tromsø, Norway, prior to the Barents Sea mission. The digital compass was calibrated to the magnetic conditions of Tromsø (+7.91° declination, +78.35° inclination [4]), instead of those expected along the Barents Sea monitoring track (+17° declination, +81° inclination [4]), as the compass could not be re-calibrated while at sea.

Performance data was gathered on land using different calibrations, some examples shown in Fig #2. A 24-hour fjord mission was successfully completed using the less accurate calibration of Fig #2, proving that the SeaExplorer could be safely piloted with challenging magnetic compass conditions, based on the information gathered from the testing on land.

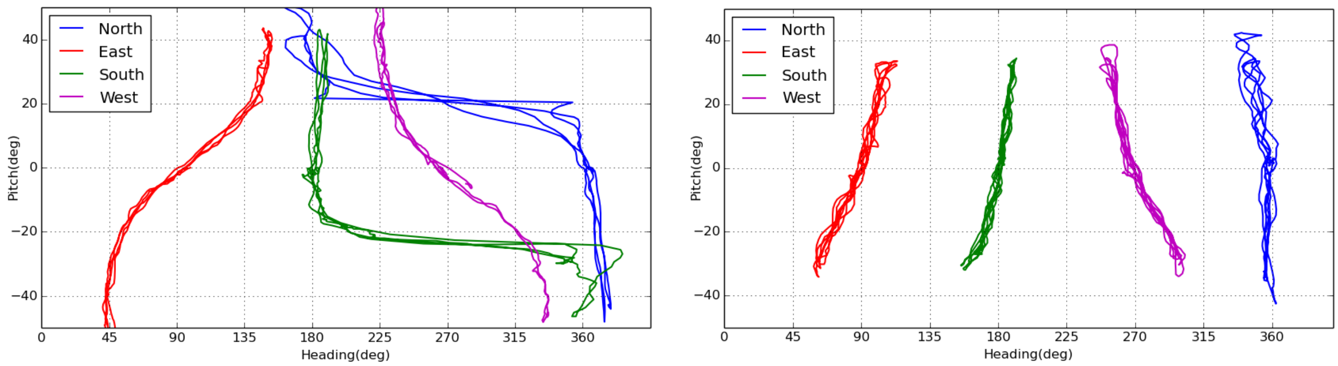

Fig. 2 Compass readings for varying pitch angles for fixed headings, (left) using a less accurate magnetic calibration, (right) calibrated for Tromsø.

B. *Barents Sea Monitoring*

The SEA004 glider was deployed for mission M120 in the Barents Sea on 1 September 2014 from the rescue boat of the R/V GO SARS. The glider first travelled north over five days, having to gradually compensate for a strong current pushing the glider to the east. The glider then travelled west for two days before travelling south for the remaining eleven days, again needing to gradually compensate for a current pushing the glider to the east. The SEA004 glider was recovered on 19 September 2014, with 40% available battery power remaining, in challenging conditions (Sea State 6) by the R/V Johan Hjort, successfully completing a track of 388 km.

The magnetic compass performed well throughout the mission, improving as the glider moved further south. When heading north and pitching up, the compass occasionally (~20% of cycles) performed badly with 180° shifts in value, as the glider was placed perpendicular to the magnetic field. When heading south, the digital compass performance quickly improved and performed well for the remainder of the mission.

The altimeter was first disabled to save power. On 4 September, the glider unexpectedly made contact with the sea floor at 143 m depth, 50 m shallower than any recorded bathymetry for this location. The altimeter was then enabled for the remainder of the mission.

The high quality temperature, salinity, oxygen, chlorophyll and depth data was recorded and successfully sent in real-time during surfacing periods. Fig #3 shows the SEA004 temperature profile during the mission.

III. Conclusion

This successful mission in the Barents Sea provided excellent high-resolution data in this remote location with significantly reduced cost and effort. The mission also provided, along with the testing in the Tromsø fjord, detailed information on how to operate the SeaExplorer in these challenging conditions, as well as identifying opportunities for improvement. This mission has proven the robust ability of the SeaExplorer glider in this environment, and opens the door to future opportunities to conduct autonomous monitoring in the Barents Sea and key Arctic shelf seas.

Acknowledgment

The authors would like to thank Dr. Anne Helene and the Institute of Marine Research, Norway, as well as the crews of the R/V GO SARS and R/V Johan Hjort for their assistance and cooperation. The research leading to these results has received funding from the European Union under Grant Agreement n° 265863 within the Ocean of Tomorrow call of the European Commission Seventh Framework Programme.

References

[1] Stocker, Thomas F., et al. "Climate change 2013: The physical science basis." *Intergovernmental Panel on Climate Change, Working Group I Contribution to the IPCC Fifth Assessment Report (AR5)(Cambridge Univ Press, New York)* (2013)..

[2] Comiso, Josefino C., et al. "Accelerated decline in the Arctic sea ice cover." *Geophysical Research Letters 35.1* (2008).

[3] Loeng, Harald. "Features of the physical oceanographic conditions of the Barents Sea." *Polar research* 10.1 (1991): 5-18.

[4] Maus, Stefan, et al. "The US/UK world magnetic model for 2010-2015." (2010).

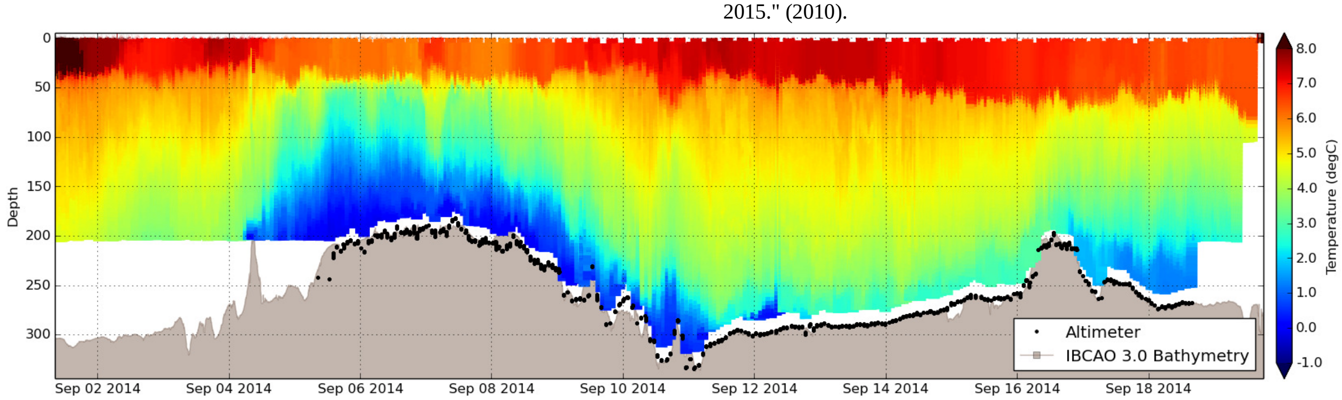

Fig. 3 SEA004 temperature profile during the Barents Sea monitoring mission.