Final Cruise Report: RV Falkor cruise FK150324

Cruise Science Party

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Cruise Purpose
Engineering trials and experimental data gathering around robotics techniques for seafloor mapping and water column characterisation with multiple, heterogeneous vehicles.

Cruise Outcomes

The cruise was focused on engineering development around robotic systems for autonomous benthic and water column observations. Initial activities related to calibration and testing of individual robotic platforms, followed by progressively more complex deployments involving multiple platforms.
The initial deployments of the AUV Sirius were guided by existing sites established in 2009 and revisited in 2011 with AIMS as part of the IMOS benthic monitoring program. We performed 11 dives that revisited dives from 2009 and 2011 while the Lagrangian imaging float was deployed nearby. The modified WHOI Slocum glider was put through its paces to test the onboard scanning sonar and automated mission scheduling and planning. In parallel, the UH waveglider served as a secondary acoustic tracking and comms station (in addition to the Falkor), with members of the ACFR, Evologics and UH working together to get acoustic messaging working reliably.

Given the extensive use of small boats to deploy and recover the glider, float and smaller AUVs, we settled on a schedule of daylight ops. Typically beginning with the larger AUV deployed from Sirius and then a series of deployments throughout the morning of the smaller vehicles. At night Falkor multibeam mapped the lagoon for around 10-12 hrs covering most of the areas of AUV operations and around 50% of the lagoon. This dataset is being used to demonstrate predictive habitat mapping techniques given the imagery collected by the robotic platforms.

From a platform-centered view the cruise allowed individual and joint testing and development of systems.
Sirius: calibration, IMOS monitoring dives, joint float-AUV ops, coordinated ops with glider and float, tracking with waveglider.
Float: System testing, visual odometry, integration of modem for USBL tracking, joint float-AUV ops, tracking with waveglider.
Glider: Satellite comms testing, Sonar scanning for localization, Rescheduling and adaptive planning, coordinated deployments with AUV and float.
Waveglider: RF comms testing, testing of tracking of AUV and float

Lessons and future work
Coordination becomes critical. Realistically, different assets may have varying degrees of autonomy. Our last experiments demonstrated a promising approach,

Project outcomes

Engineering trials, Vehicle testing, Scheduling glider, Float and AUV ops, tracked by Falkor and/or waveglider.

Photo float surveys

21 dives
59,450 image pairs, 260GB
~33 hrs of bottom time @0.25 Hz

Sirius surveys

20 dives
358,340 image pairs, 950GB
~100 hrs of bottom time @1-1.5 Hz
12 Sirius dives also covered by float
Revisited some of the IMOS monitoring sites, with 11 AUV dives that covered the same ground as dives done in 2009 and 2011.

Glider missions

Total number of missions: 36
Max depth reached: 50.6 m
Mean mission max depth: 31.9 m
Total horizontal distance travelled: 32.33 km
Mean horizontal distance travelled per mission: 0.9 km
Total missions time: 21.9 hours
Mean mission time: 36.5 min
Glider database size: 275 MB
Sonar ROS bagfiles size: 1722 MB

Collected large amounts of imagery (Sirius, float), bathymetry (Falkor and glider) and water column data (all platforms). In addition to tracking information from Falkor and the waveglider.

Outputs

Presentations/Posters

O. Pizarro, D. Steinberg, S. O'Callaghan, A. Bender, D. Rao, and S. Williams. Predictive habitat mapping and iterative planning of image surveys given existing bathymetry and imagery - a machine learning perspective. Ocean Sciences 2016 abstract ID: 92125
A.Friedman, O. Pizarro, S.B. Williams. Online Framework For Collaborative Annotation Of Underwater Imagery & Video. ICRS 2016 Abstract ID: 29134
S.B.Williams, O. Pizarro, M. Bryson. Multi-year Surveying Of Coral Reefs Using Autonomous Underwater Vehicles. ICRS 2016 Abstract ID: 29139
L. Zapata, A. Mallios, P. Ridao, R. Camilli, O. Pizarro. Preliminary results on terrain-aided localization algorithm for glider AUV. ICRA 2016 Workshop on Marine Robot Localization and Navigation.

Planned Publications

subject	journal /conf	ACFR	WHOI	URI	MIT	UH	Evo	AME
1. Overview of cruise	JFR							
2. AUV+float reconstructions/monitoring (centralised)	JFR							

3. distributed SLAM								
4. Adaptive, coordinated missions								
5. Glider terrain-aided nav	JFR							
6. float trials/system enhancements								
7. float terrain-aided nav	JFR							
8. predictive habitat mapping MB+images								
9. change on AUV sites since 2009								

Lead, collaborator

Media Releases and Outreach

http://schmidtocean.org/new-seafloorexplore-app-features-coordinated-robotics-cruise/

For this cruise we adapted the Squidle annotation interface into a citizen science tool for exploration and labelling marine imagery. Over 22,000 labels were applied by the general public from around the world.
https://squidle.acfr.usyd.edu.au/citizenscience/citizenSOI201503/

Dr. Friedman also developed a web-based tracker that allowed the large science party and ship's crew to keep tabs of the progress of operations involving multiple robots. It also allowed the general public to observe the deployments online.

Datasets

AODN portal
https://portal.aodn.org.au/

AUV viewer
https://auv.aodn.org.au/auv/

Data Set Citation	Data DOI	# Data File Downloads

Pizarro, O., (2016). Processed ship-based Swath Bathymetry Sonar Data (EM710) acquired during the Falkor expedition FK150324 (2015). Integrated Earth Data Applications (IEDA). doi: http://dx.doi.org/10.1594/IEDA/322034.	10.1594/IEDA/322034 Edit Metadata	283
Pizarro, O., (2016). Processed Shapefiles derived from AUV Navigation Data from the Timor Sea acquired during the Falkor expedition FK150324 (2015). Integrated Earth Data Applications (IEDA). doi: http://dx.doi.org/10.1594/IEDA/322286.	10.1594/IEDA/322286 Edit Metadata	
Pizarro, O., (2016). Processed AUV Sirius Navigation Data from the Timor Sea acquired during the Falkor expedition FK150324 (2015). Integrated Earth Data Applications (IEDA). doi: http://dx.doi.org/10.1594/IEDA/322287.	10.1594/IEDA/322287 Edit Metadata	
Pizarro, O., (2016). Processed GeoTiff Images derived from ship-based Acoustic Backscatter and Bathymetric Sonar Data (EM710) from the Timor Sea acquired during the Falkor expedition FK150324 (2015). Integrated Earth Data Applications (IEDA). doi: http://dx.doi.org/10.1594/IEDA/322289.	10.1594/IEDA/322289 Edit Metadata	

Float data: Pending. The logs contain imagery from the surface and through the water column that is not useful. MGDS has asked to provide start-stop times for when the float was acquiring images near the seafloor. Chris Roman to provide time intervals.