Instrumentation for Observing and Sampling Drifting Icebergs in the Southern Ocean

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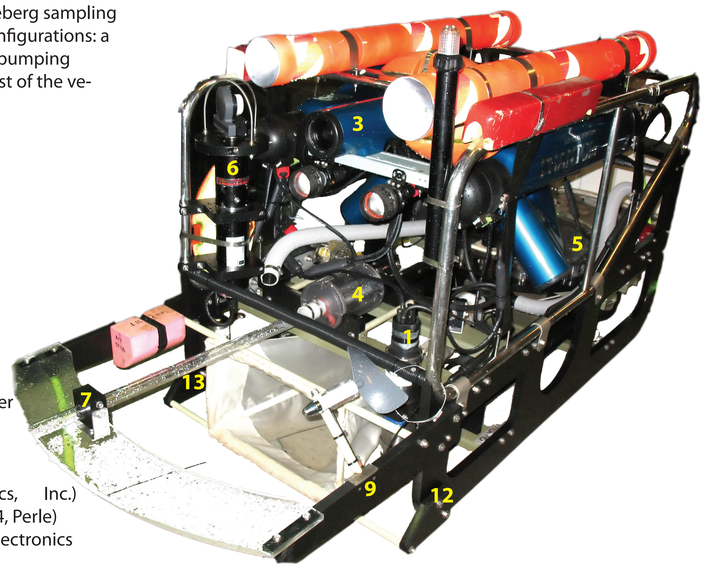
Abstract

Drifting icebergs in the Southern Ocean are surrounded by unique ecosystems. The recent proliferation of icebergs from the Antarctic continent into the Southern Ocean makes understanding the impact of these moving ecosystems even more important and timely. Studying drifting icebergs is highly challenging due to their irregular structure, their unpredictable trajectories, and their inherent instability. During two research cruises in 2008 and 2009, a specially modified remotely operated vehicle (ROV) and autonomous drifters were deployed to sample and observe the ecosystems surrounding drifting icebergs in the Southern Ocean. The ROV consists of a commercially available Phantom S2 (Deep Ocean Engineering) modified for this mission to include both chemical and biological sampling payloads. Autonomous drifters, known as Lagrangian Sediment Traps (LSTs), were developed to sample the sinking particulate matter associated with the drifting icebergs. The core of each LST is a Sounding Oceanographic Lagrangian Observer (SOLO) float (Scripps Institution of Oceanography), on which four sediment traps have been mounted. The floats were deployed in the path of a drifting iceberg. Once deployed, the floats were designed to sink quickly to a target depth, usually between 500-600m. When the floats reach their target depth they become neutrally buoyant and drift with the current, collecting particulate matter in the attached sediment collectors. An acoustic echosounder is used to detect the presence of the iceberg above the float. After a fixed time period, estimated from the speed and trajectory of the iceberg, the LST is programmed to return to the surface and is located using satellite and line-of-sight RF beacons. During one 40-day research expedition in the northwest Weddell Sea, these drifters were deployed five times in proximity to icebergs and at control sites. Additionally, eighteen ROV dives were conducted on a series of icebergs. The two platforms provided samples that were previously unattainable, and our experiences provided us with better insight into how to observe these moving targets. The proliferation of free-drifting icebergs in the Southern Ocean and their influence on the surrounding pelagic ecosystem suggests their possible importance in the marine carbon cycle.

ROV for Iceberg Exploration

A Phantom ROV (S-2) was modified for iceberg sampling missions. The vehicle had two primary configurations: a biological sampling payload and a water pumping (chemical sampling) payload. Below is a list of the vehicle attributes:

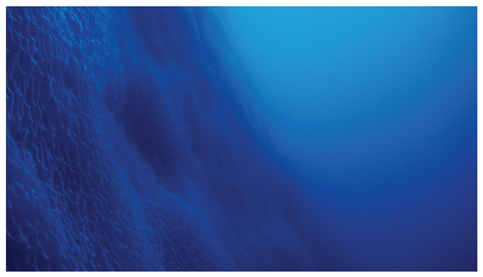
- Depth rated to 300m
- Tether length 600m
- Two additional horizontal thrusters



Instruments
1. CTD (uCTD, FSI)
2. Fluorometer (FLNTU, Wetlabs)
3. HD Camcorder (HD-SR12, Sony)
4. 2-L discrete water sampler
5. 20-position indexing suction sampler
6. Forward-looking sonar
7. Continuous water pumping system
8. Ice scraper
9. Flow meter (2031H, General Oceanics, Inc.)
10. 4-port serial port multiplexer (STS4, Perle)
11. High-speed router (3241, Patton Electronics Company)
12. Custom tool sled
13. Sample Net

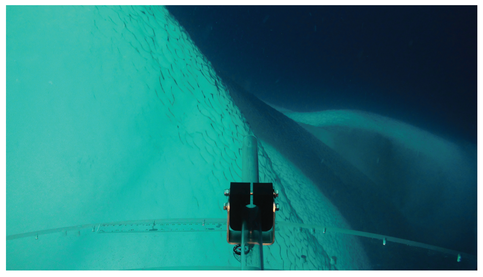
The Phantom ROV completed 18 dives during our 40-day expedition in the Weddell Sea. During some missions the vehicle was positioned next to the iceberg where large volumes of water were pumped for chemists, who measured the radio isotopes and iron content of the surrounding sea water. Other missions were used to conduct video transects near the icebergs and collect biological specimens. Below are some still images captured with the HD camcorder.

Salp chains were some of the most common organisms seen near the icebergs.



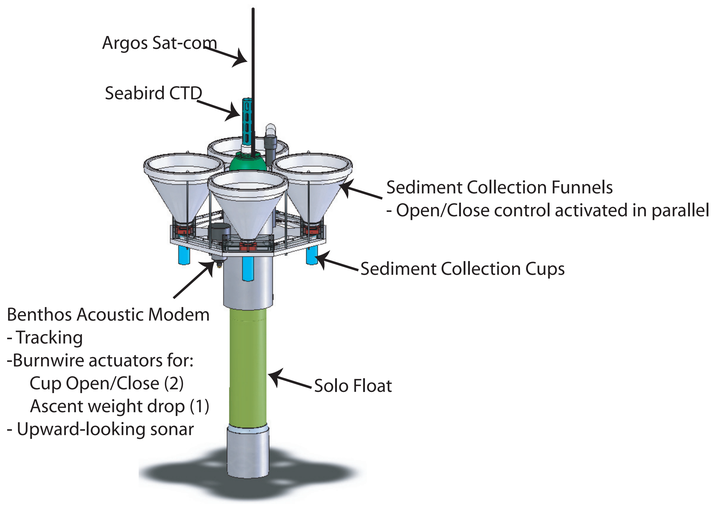
The face of the iceberg below the water is covered with "sun cups", and looks similar to the surface of a golf ball.

This image shows "dirty ice", which is ice that appears dark in color because of trapped sediment and rock.

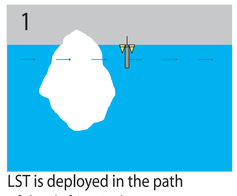


Both above and below the water line, icebergs can have irregular shapes, such as seen in the image above.

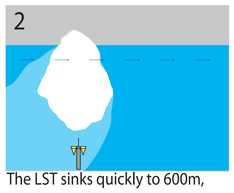
Lagrangian Sediment Traps



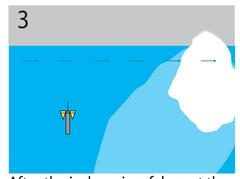
Iceberg Sampling Deployment Scenario



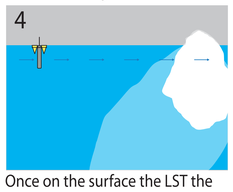
1 LST is deployed in the path of the drifting iceberg.



2 The LST sinks quickly to 600m, and then drifts while the iceberg passes overhead. The sampling cups are moved into the open position during the descent.



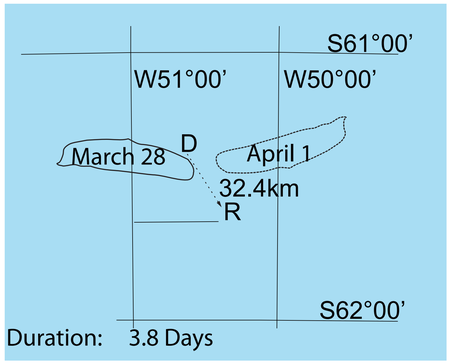
3 After the iceberg is safely past the LST, the cups are closed and the unit comes to the surface.



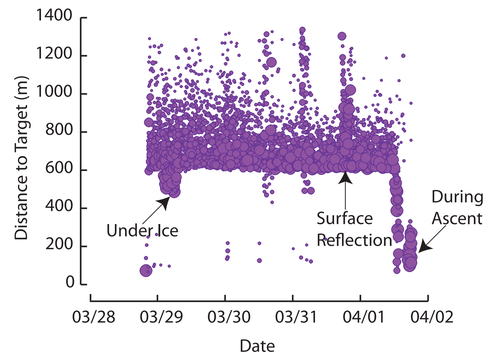
4 Once on the surface the LST the Argos system transmits the position of the vehicle, and it is recovered by the ship.

Deployments of Lagrangian Sediment Traps in Weddell Sea March-April 2009

During our 40-day expedition in March/April 2009, three LSTs were deployed for a total of 5 missions. The first was a short test mission under a small iceberg, followed by three missions near or under C18A. Finally, the last mission was at a control site 40 nautical miles from C18A.



This figure illustrates how much the icebergs and the LST drifts during a ~3 day deployment. The deployment (D) and recovery (R) positions of the LST are plotted along with the estimated positions of the iceberg based on satellite imagery. The quality and clarity of these images varied greatly, so although the latitude and longitude of the iceberg is accurate the orientation may not be accurate.



Sonar returns from the LST acoustic transducer are plotted over time. Each circle represents a discrete return at 9 kHz (the frequency of the excitation chirp). The diameter of the circle is proportionate to the strength of the return. This plot shows that the LST was under the iceberg for 5 hours on March 29. The returns suggest the depth of the iceberg was about 200m which was consistent with observations from the ROV.

Deployment 2: (Underneath C18A) Fecal pellets and exuviae collected under the influence of the iceberg.

Deployment 5: (Control) Senescent diatoms collected during open water deployment 40nm away from C18A.

Results: Samples collected near and underneath the iceberg contained larger amounts of particulate matter than those collected at the control site 40nm away.