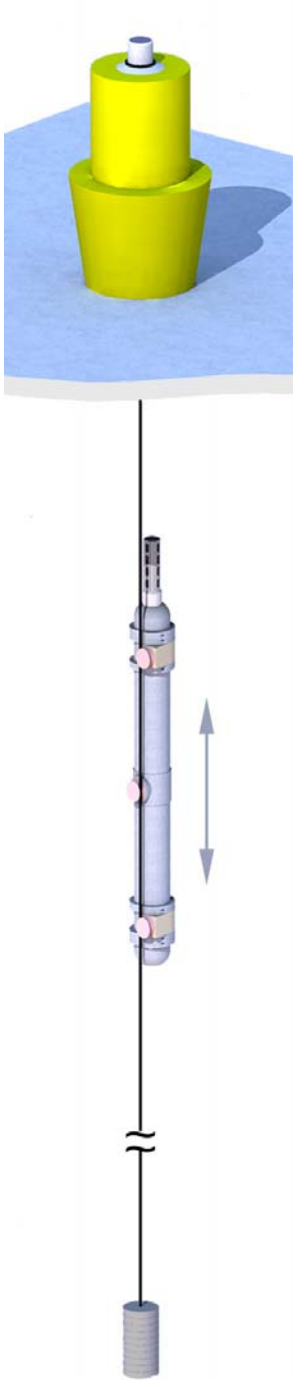
Report on
THE JAMES M. AND RUTH P. CLARK ARCTIC RESEARCH INITIATIVE



Schematic drawing (not to scale) of the WHOI Ice-Tethered Profiler system.

Project No. 25070102, ARI: WHOI Leadership Arctic

Project No. 25070123, ARI: Ice Tethered Profiler

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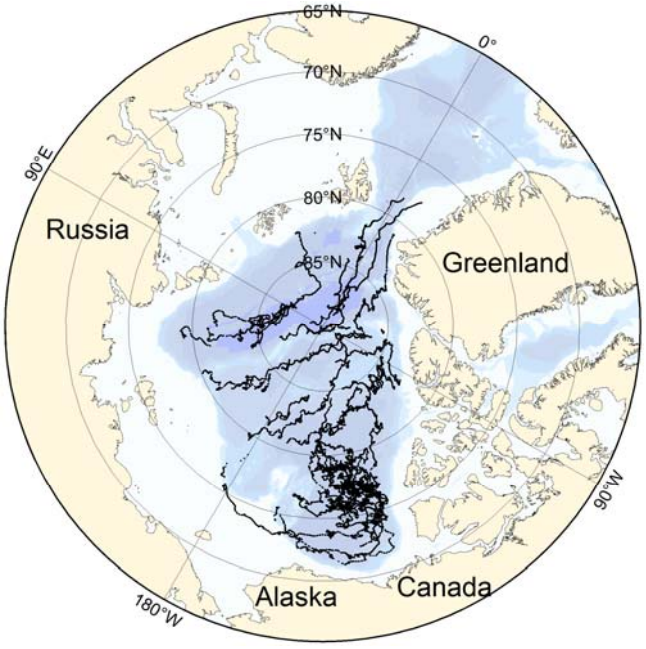
These interrelated ARI awards provided vital support to the sub-element of the International Polar Year (IPY) field program involving WHOI Ice-Tethered Profiler (ITP) operations. Support went both towards facilitating operational deployments of ITP instruments in the Arctic and evolving/enhancing the ITP system design.

The Arctic is undergoing significant climate changes that include warming atmospheric and ocean temperatures, freshening of sea water, rising sea levels, melting permafrost and the decline of sea ice. The rapid loss of permanent sea ice underscores the need for sustained, uninterrupted Arctic observations and analyses to understand and predict future Arctic changes. Some research suggests that atmospheric circulation, rising global temperatures and complex feedbacks between the sea ice and the ocean will lead to ice-free summers in the Arctic Ocean in as few as 10 years from now, while other studies indicate that the strong natural variability of the Arctic system will inhibit further loss of summer sea ice, at least in the near term. The coming years will be of great significance in Arctic research.

To investigate variations in the Arctic Ocean water properties below the permanent sea ice cover and begin to explore changes in the biological ecosystem, we developed the Ice-Tethered Profiler system here at WHOI. The ITP system consists of a small surface capsule that sits atop an ice floe and supports a plastic-jacketed wire rope tether that extends through the ice and down into the ocean, ending with a weight (intended to keep the wire vertical). A cylindrical underwater instrument (approximately 6' in length) mounts on this tether and cycles vertically along it, carrying oceanographic sensors through the water column. Water property data are telemetered from the ITP to shore in near-real time. The system design

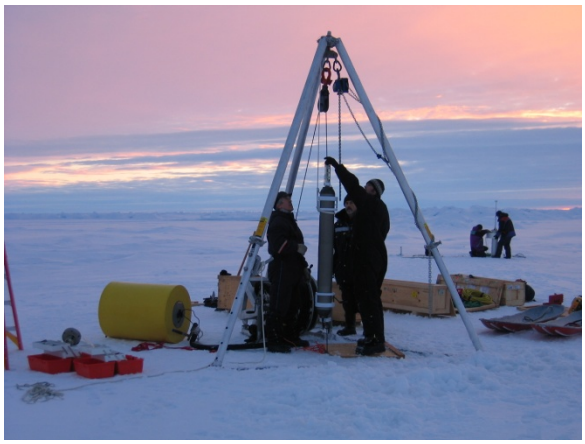
lifetime is up to 3 years but commonly ITPs are lost in ice ridging events on shorter time. Because all data are sent to shore as soon as they are collected, instrument loss does not mean loss of data (as is the case with internally-recording sensors). To date, a total of 37 ITP systems have been deployed in the Arctic since the first prototype was launched in fall 2004. This effort represents the collaborative effort by investigators from France, Russia, Germany, England and WHOI, funded by U.S. National Science Foundation and European Union grants with key contributions from the WHOI Arctic Research Initiative program. Collectively, these systems have now returned more than 25,000 temperature and salinity profiles of the upper ~750 m of the water column throughout much of the permanently-ice-covered central Arctic. The so-called Level 1 ITP data (basic processing but no human quality control) are available within hours of collection from the web site www.whoi.edu/itp. On irregular basis, data sets are subjected to a more intensive processing and quality control procedure; this version of the data are submitted to national archives for long-term storage and general distribution.



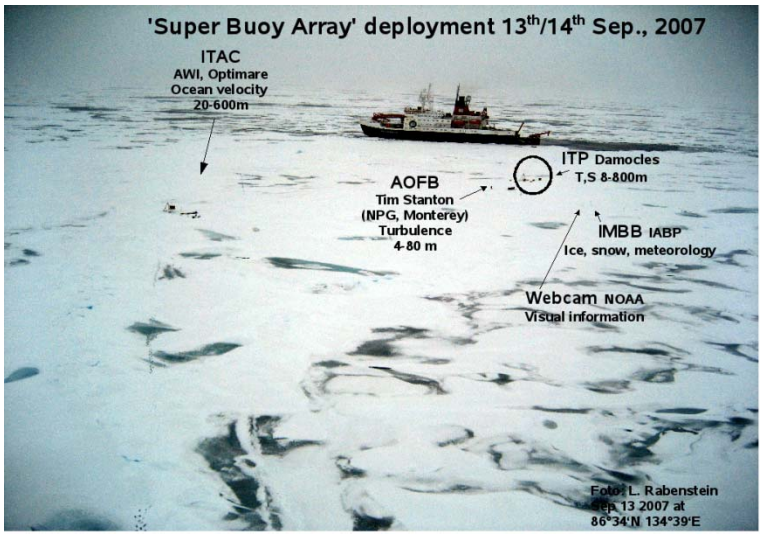
Locations of profiles obtained by ITPs since 2004. As the ITPs typically return two profiles per day, the profile positions appear as solid lines at this scale.

One important ARI contribution to the ITP program during the International Polar Year involved WHOI partition on icebreaker expeditions of the Russian Arctic and Antarctic Research Institute (AARI) and German Alfred Wegener Institute (AWI) in 2007 and 2008 in order to deploy ITPs in the Eurasian sector of the Arctic. AARI and AWI expeditions offer significant capability in terms of ships and helicopters and access to sectors of the Arctic otherwise difficult for us to reach. Costs for travel, living expenses and logistical support (particularly AARI helicopter time) were drawn from our ARI award to supplement our NSF grant (that didn't include such costs in its budget that had assumed working from U.S. vessels). Ability for us to take advantage of the AARI and AWI cruise opportunities using ARI support proved key to collection of data over broad sectors of the Arctic otherwise inaccessible to us. Moreover, relationships developed with AARI scientists during the Polar Year expeditions has laid the groundwork for future collaborations and continuing deployments of ITP systems in the Eurasian sector of the Arctic.

An AARI helicopter was used to transport ITP instrumentation from an icebreaker vessel to appropriate ice floes for deployment

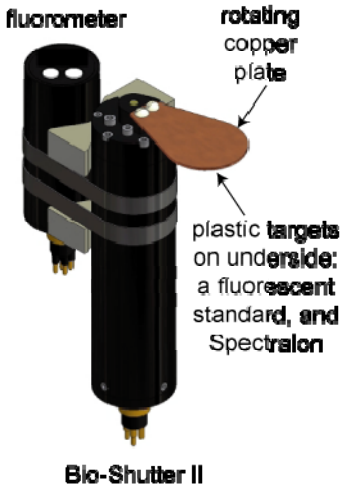


An Ice-Tethered Profiler being deployed during one of the AARI expeditions during the IPY.



Photograph of a buoy cluster deployed from the German icebreaker Polarstern during the IPY. ITP deployments during this expedition were a collaborative effort between WHOI investigators and scientists involved in the EU Damocles project.

The other major ARI contribution to the WHOI ITP effort involved adding sensors to the basic ITP instrument to measure water properties that shed light on biological ecosystem dynamics in the Arctic Ocean. Our NSF IPY proposal originally requested support for Carin Ashjian to work on developing a suite of bio-optical sensors for the ITP system. NSF program managers cut this element of our proposal from the final grant award. Believing that interdisciplinary research was critical to building understanding of Arctic change, we tapped ARI funds to restore Carin's involvement in the program. A prototype ITP system with several bio-optical sensors was constructed and deployed in the Canada Basin north of Alaska in August 2008. Unfortunately, a programming error had the effect of instructing the vehicle to sleep until spring 2009. But before that date, the system was lost, we presume to an ice ridging event. While disappointing, this experience buttressed our subsequent NSF proposal that again requested funding for interdisciplinary research. This time we were successful. Sam Laney has taken the lead developing a second-generation bio-optical sensor package for the ITP that includes a shutter system designed to both



Schematic drawing of the bio-optical sensor subsystem being developed for the ITP

Photograph of the prototype bio-optical sensor system mounted on an ITP end cap .

minimize biofouling of the optical sensors and return reference information that should prove useful to track sensor drift. The bio-optical subsystem is now being tested here at WHOI with first deployment slated for summer 2011.

Photograph of an ITP system deployed in open water from a Russian vessel in late summer 2009.

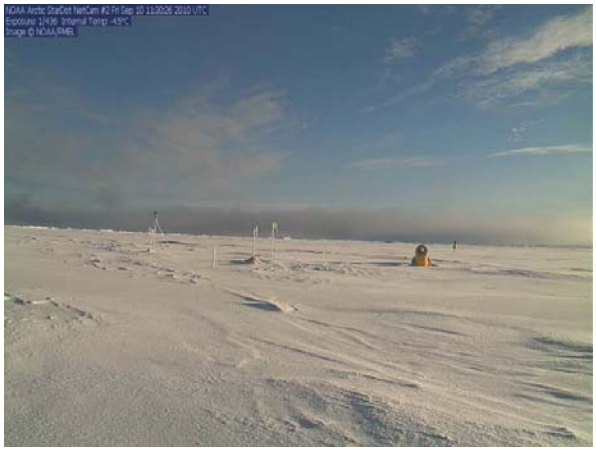
Lastly on the technical development front, ARI funding supported a redesign of the ITP surface buoy package to better survive thin ice and open water. An ironic aspect of the ITP program is that once we had perfected an instrument system for sampling below the perennial sea ice cover, that cover has been shrinking in size. Summer 2007 saw a historical minimum in sea ice extent, with 2009 a close second. In order to sample the ocean in regions of seasonal ice cover, we redesigned the surface buoy to support the system in open water and to better withstand ice ridging events during fall freeze-up. Two prototype versions of the redesigned system were deployed in open water from a Russian vessel in late summer 2009. One of these systems (ITP # 37) is operating as of this writing, sending data back to WHOI daily. The other stopped communicating on October 12, 2009 when we presume it was rafted over by ice. This experience prompted us to undertake another buoy redesign to enhance its ability to function in the marginal ice zone. This new design will be implemented in our new buoy builds in the coming year.

Beyond these technical aspects, the WHOI ITP program is already supporting a host of research activities by scientists around the world. One of our own research foci that is stimulated and supported by ITP data concerns the Arctic Ocean circulation and heat transport from the ocean to the overlying sea-ice: critical components in the delicate balance of sea ice and climate. One of the most significant recent changes to occur in the Arctic Ocean has been a warming of the Atlantic-derived water that lies beneath the surface waters that are in direct contact with the sea ice. This warming can potentially affect the ice cover where Atlantic Water heat can be transported to the surface. With support from the Clark Arctic Research Initiative, we investigated the temperature and salinity of the Atlantic-derived water, based on measurements taken by the ITP. The observations from the central Canada Basin suggest that only a small fraction of the available Atlantic Water heat mixes into the overlying waters; most of the upper-ocean heat appears to derive from solar radiation entering the ocean through leads in the sea ice. Our ongoing analyses are aimed at understanding the fate of the warm waters entering the Arctic from the Pacific and Atlantic Oceans, and the complex relationships between Arctic Ocean heat and fresh water dynamics and atmospheric circulation patterns and thermodynamics.

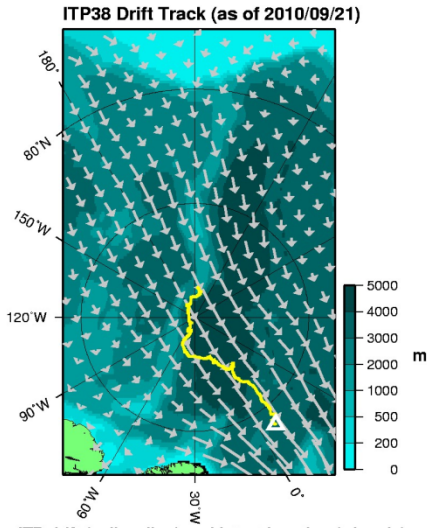
As postscript, we note the recent deployment of a cluster of atmosphere, sea ice and ocean sensor systems near the North Pole in April of this year. Included in the array was ITP #38, as well as a web camera system developed by colleagues at the Pacific Marine Environmental Laboratory. The web camera is trained on the other buoy systems in the cluster and returns multiple images per day. Shown below are select photos of the Ice-Based Observatory and map of the drift record for the system.

April 20, 2010 - installation

July 22 - melt ponds develop



September 10 - winter returns to the Arctic



ITP drift (yellow line) and latest location (triangle), and annual ice drift from IABP (grey vectors) on IBCAO bathymetry (shading).

The ITP research team expresses their great thanks to the Clark family for their generous support of Arctic research at WHOI. The two grants we received from the ARI provided us great flexibility and ability to opportunities to collect novel observations during the International Polar Year and into the future.