Since 1981, Robert Ballard has envisioned a concept of ocean exploration with multiple ships collecting video and data from the depths of the world ocean and broadcasting discoveries in real time through ship-to-shore satellite technology. In 1989, the telepresence vision was realized when the first Jason Project broadcasts employed ROV technology developed by the Deep Submergence Laboratory at Woods Hole Oceanographic Institution (WHOI). Those early telepresence-enabled broadcasts delivered live educational programming to vast audiences who could participate in the exploration as it was happening.

The vision expanded in 2003 when the Institute for Exploration developed a new suite of ROV and telepresence technologies as part of a portable system that was installed on ships of opportunity. In 2007, those expeditions began to feature live broadcasts 24 hours a day to audiences on the Internet and at venues such as Mystic Aquarium, all made possible through a prototype version of the Inner Space Center (ISC) at URI GSO. Since 2009, the telepresence paradigm has grown substantially with the development of E/V Nautilus, introduction of the NOAA Ship Okeanos Explorer, and construction of the permanent ISC. Live broadcasting can now originate from two ships of exploration that have dedicated ROV and telepresence systems installed on board and that conduct field work up to six months each year.

Beginning in 2013, the telepresence-enabled exploration paradigm expanded yet again to involve more ships, including the Schmidt Ocean Institute’s R/V Falkor, the University of Washington operated R/V Thomas G. Thompson, and the WHOI operated R/V Atlantis (the latter two ships are part of the University-National Oceanographic Laboratory System [UNOLS]). Many more live feeds could now be received and distributed through the ISC and used for live video production associated with the Exploration Now program (see page 22). We report here on two specific telepresence-enabled projects conducted during the summer of 2013 on board R/V Atlantis that used the Jason ROV system (Figure 1). This project represents a milestone in the development and use of telepresence technology for UNOLS platforms, leading to even greater expansion of the telepresence vision for the academic research fleet, with several new ships slated to come on line in the near future.
Implementing Telepresence on UNOLS Cruises

The *Atlantis/Jason* telepresence project was conceived in late 2012 and early 2013 after OET and ISC staff presented the telepresence vision to the UNOLS Council. Subsequently, the OET and ISC worked with UNOLS to identify projects that were scheduled to utilize the *Jason* ROV system in 2013, and found two projects that had *R/V Atlantis* work planned off the Washington and Oregon coasts. To support the telepresence aspects of these cruises, the Office of Naval Research provided funding to purchase satellite time and to support onboard fly-away satellite system technicians and ISC technical and operational services. In addition, the National Science Foundation provided funding to WHOI to develop a mobile telepresence unit (MTU) to be integrated with the *Jason* topside system to provide video streaming and voice communications capabilities through the satellite link.

In May, following several weeks of preparation, we installed the fly-away satellite system on *R/V Atlantis* as a temporary solution to provide the high-bandwidth telepresence required for the project (Figure 2). During this time, OET held its annual Science Communication Workshop, which included participants from both *Atlantis* cruises. This experience enabled selected shipboard participants to learn about the broader educational outreach programs primarily designed and employed by the Nautilus Exploration Program and to see how the shore-side operation works. This workshop allowed for team building, technical orientation, and scientific discussion, all valuable for any telepresence project. At the same time, the Exploration Now production team coordinated the live outreach program, focusing on the *Nautilus* and *Atlantis* missions. The ISC facility was modified and improved to meet the demands of supporting multiple ships while the *Oceano Explorer* team was also preparing for its field season.

ISC staff designed, built, and configured the MTU for compatible integration into the *Jason* ROV van and remote viewing station. The system enabled different video feeds and audio sources to be mixed and switched through a simple interface and routed to a high definition video encoder for streaming through the satellite connection. Up to four video feeds and four audio sources can be controlled through the MTU at one time to permit multiple users and multiple cameras to contribute to the broadcast. Along with a lighting kit, a portable high definition camcorder was procured as part of the integrated system. This camera could be used to originate recorded video for later playback or as a “host” camera for interactive communications with live audiences on shore. The MTU and *Jason* control vans were each equipped with IP-enabled voice intercom keypanel systems for real-time ship-to-shore communications with the ISC. A headset and microphone could integrate with the intercom and audio mixer in the MTU to provide multiple audio inputs into the live stream. The MTU could also be used for interactive communications with shore and/or used independently for simple audio commentary during ROV dives. All devices in the MTU were configured to work with the high-bandwidth satellite system as an expansion of the ISC IP network for seamless connectivity to shore.

The two *Atlantis/Jason* legs were mobilized in Astoria, Oregon, in late June 2013. A team of satellite and video broadcast engineers worked on board to complete the final integration and testing of the telepresence systems. The satellite tracking antenna was fully assembled, configured, and tested, and the MTU was integrated into the *Atlantis* main lab as part of the remote viewing station, providing the telepresence link between the *Jason* ROV van and the satellite van through which the feeds were broadcast. One OET/ISC engineer sailed on the first leg to provide technical support for the satellite telecommunications and MTU systems. He trained the shipboard scientific support group (SSSG), an SSSG UNOLS/MATE (Marine Advanced Technology Education) intern, and the *Jason* technical team members to operate the telepresence gear and to run the systems themselves during subsequent missions.
Cascadia Initiative Expedition
The first of the two expeditions aboard R/V Atlantis was in support of the Cascadia Initiative, a four-year experiment to deploy arrays of ocean-bottom seismometers and pressure gauges off the Pacific Northwest coast to better understand earthquake generation in this region, volcanic arc structure, and the formation and deformation of the Juan de Fuca Plate. The goal of this cruise was to recover a large number of the ocean bottom seismometers from various water depths (Figure 3).

Team members established Skype communications between a laptop connected to the large monitor at the remote viewing station via the ship's wireless video camera monitoring network. This configuration enabled the team to host Skype broadcasts from the deck of Atlantis using a mobile tablet to originate and send imagery to the laptop for projection onto the large monitor, and to use that connection to stream shipboard activities to the ISC. The science and education team quickly became familiar with the telepresence setup and the ways to interact with shore. Team members Greg Mulder, Jonas Cervantes, and Dean Livelybrooks organized ways to communicate to shore during the Jason ROV dives to provide real-time commentary and to organize the hosting of live interactions with the Exploration Now partner museums and aquariums. Those team members, along with other members of the science party—students, co-chief scientist Anne Tréhu, Jason team member Jefferson Grau, Lamont-Doherty Earth Observatory engineers David Gassier (a French speaker) and Carlos Becerril (a Spanish speaker)—all took turns hosting these programs and answering questions live from audiences at the partner sites. The underwater camera feeds from Jason and the main lab were live 24/7 to the Atlantis Live website, and the team provided commentary, in several languages, for Internet audiences during events such as Jason dives and instrument recoveries.

Photos and videos were used to explain the particular mission, describe the geology of the Cascadia margin, and communicate the scientific goals of the project. Community college (CC@Sea) participants Haley Domer, Jonas Cervantes, and Greg Mulder also made informative videos from contributed clips, including a presentation about the Linn-Benton ROV club and the MATE ROV competition. Mulder and Cervantes also initiated an outreach activity that involved sending Styrofoam cups to the ocean bottom during one dive. Compression of the cups during the dive facilitated discussion of the effects of pressure in the ocean.

We also employed the broadband connection to test upload to a land-based repository of some of the recovered seismic data files, as a proof of concept. A later Cascadia Initiative deployment cruise aboard R/V Oceanus encountered issues with losing communications with two instruments immediately after they reached the seafloor. Access to WHOI engineers via telepresence likely would have aided attempts to diagnose the equipment problems.

Juan de Fuca Ridge Expedition
During the second expedition aboard R/V Atlantis, the team conducted operations along the eastern flank of the Juan de Fuca Ridge as part of a National Science Foundation-supported project to study the movement of water in the oceanic crust, the properties of that water, and the microbial communities that call these dark, wet depths home. This work follows Integrated Ocean Drilling Program Expedition 327, which took place in summer 2010; Atlantis/Jason Expedition AT18-07 in summer 2011; and numerous earlier drilling and submersible/ROV expeditions (e.g., Fisher et al., 2011a,b, 2012). As part of this ongoing research, Jason operations in 2013 included returning to six subseafloor borehole observatories to download pressure and temperature data, collect water samples for geochemical and microbial analysis, and retrieve and install
instruments from at and below the seafloor.

Telepresence-enabled educational programming during this leg included: (1) short-format interactions with informal science education partners, (2) longer-format programs broadcast to expedition members’ organizations (e.g., Figure 4), and (3) informal “shows” directed at fairly regular times to Internet audiences. During these shows, the education team interviewed scientists and answered questions submitted through the website. The question of the significance and importance of this research came up many times—it was a major goal of the team to be able to clearly articulate why it makes sense to devote time and resources to basic research. In addition, team members used this web portal daily to update the expedition’s activities, post blogs, and add photos and video highlight clips.

In addition to the four people on the education team, numerous scientists answered questions, described their research, and narrated the live stream from underwater cameras. Scientists made regular use of the high bandwidth connection for the educational broadcasts, and also used it to upload data to shore to aid their ongoing scientific work.

Throughout the expedition, there were successes and challenges—equipment was successfully brought back on deck, and data and samples were retrieved, but some instruments were lost or malfunctioned, and one flotation package was found to have had a spectacular implosion. During all of these events, the public was invited to follow along and ask questions.

While it was difficult to gauge the impact on individual museum visitors who took part in the public programming, the numerous questions and comments indicated broad interest and engagement. Even more encouraging was a thank you letter, excerpted below, that the team received after an hour-long program directed to the Seymour Center in Santa Cruz:

*So many, many kudos to you, your team, and the NSF. This was a model for what all of us should be doing to educate the public on the value of basic research. At the conclusion of your presentation, one of my anti-government acquaintances came up to me to say that this was indeed research worthy of public support!*  

**Concluding Remarks**

The R/V *Atlantis* cruise teams were invigorated and encouraged by the addition of telepresence as a part of their work. While at times it was technically challenging, they acknowledged that it has tremendous potential to change the way scientists interact with the public. It also helped the teams better understand how the public perceives their work. Importantly, telepresence expands the number of lay people who know about this kind of basic research and teaches them about the scientific process. We hope to continue this collaboration with scientists sailing on UNOLS ships in the future.