Figure 6. ONC senior scientist Fabio De Leo co-hosting a ship-to-shore interaction with OET lead science communication fellow Malanai N. Kāne Kuahiwinui in the studio aboard E/V *Nautilus*.

A MATTER OF PUBLIC SAFETY

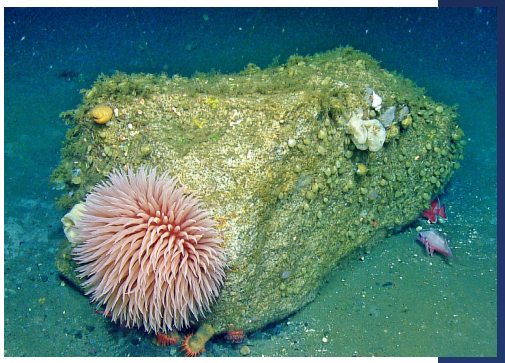
ONC's Earthquake Early Warning system includes subsea sensors located at the Clayoquot Slope, Cascadia Basin, Barkley Canyon, and Endeavour observatory sites, which were serviced and maintained during the expedition. The accelerometers are the foundational sensors of the system, as they measure an earthquake's primary (faster moving) energy wave that precedes the (slower) ground-shaking secondary wave. ONC's Earthquake Early Warning system is capable of detecting earthquakes and issuing automatic messages before major shaking arrives. This data will be shared with government organizations who issue public alerts, with messages also being sent to operators of infrastructure.

EDUCATION AND OUTREACH

ONC and OET invited ocean enthusiasts from all over the world to join this deep-sea exploration through a live streaming interactive portal that showcased expedition footage from topside cameras on deck and underwater cameras on ROV *Hercules* and *Atalanta*. During ROV dives, the audience submitted their questions through the *Nautilus*Live website, with answers provided by ONC staff or OET's science communication fellows (Figure 6). These live interactive events allowed real-time descriptions of the expedition's immediate scientific goals and its processes and technology, thus removing barriers between the public and scientists. While at sea, the expedition team created 11 new education and outreach products and hosted 32 ship-to-shore interactions with schools and community events, reaching over 1,200 people across North and South America. Early expedition results were featured in 58 media stories published in 14 countries and 12 different languages.

OPEN OCEAN DATA AND LOOKING AHEAD

In addition to data from the newly installed instruments, ROV video, and annotation data collected during this expedition were delivered to ONC for archiving and public distribution via Oceans 3.0. This advanced data management system provides high-resolution sensor measurements, video, underwater sound recordings, and data products that are used by researchers, communities, and decision-makers around the world. The 2023 expedition was funded by the Canada Foundation for Innovation and the Government of Canada. ONC and OET will partner again in 2024 to conduct an expedition aboard E/V *Nautilus* in service of ONC's cabled observatory.



EXPLORATION OF DEEP SEAMOUNT GEOLOGY AND BIOLOGY WITHIN THE JOHNSTON UNIT

OF THE PACIFIC REMOTE ISLANDS MARINE NATIONAL MONUMENT

Steven Auscavitch, Robert Pockalny, Paula Rodríguez-Flores, Raissa Hogan, Nick Foresta, Jane Carrick, Bronwyn Kay, Moronke Harris, Lila Ardor Belucci, Renato Kane, and Dwight Coleman

In 2023, E/V *Nautilus* returned to the waters of the Johnston Unit of the Pacific Remote Islands Marine National Monument (PRIMNM) thanks to support provided by NOAA Ocean Exploration via the Ocean Exploration Cooperative Institute. Expedition goals focused on understanding the geological origins and biodiversity inhabiting seamounts in the region, as well as acquiring data to support decision making relating to the Monument Management Plan that is currently being developed, and the proposed designation of the area as a new National Marine Sanctuary. ROV dive targets were concentrated on seamount features of the less explored western portion of the Johnston Unit of PRIMNM (Figure 1). A total of 11 ROV dives were conducted, each on a different seamount, which yielded 170 hours of dive time, as well as a total of 284 biological, geological, and water samples. A total linear distance of over 32 kilometers was surveyed during the ROV dives, which explored seafloor at depths between the 975–3,163 meters. Seafloor mapping efforts, critical to ROV dive planning, yielded high-resolution maps for 32,259 square kilometers of seafloor, including 19,488 square kilometers within the US Exclusive Economic Zone.

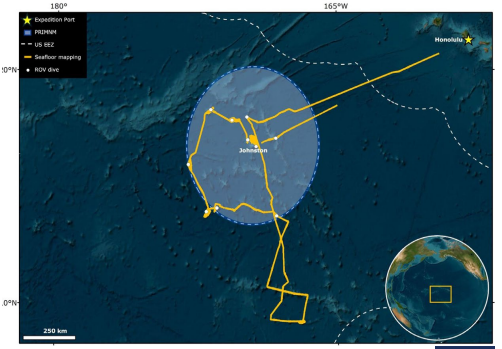


Figure 1. Map showing the locations of seafloor mapping operations and ROV dives conducted during the NA153 expedition to Johnston Atoll.

The geologic ROV dive surveys had two general approaches, including exploring potential regions where polymetallic nodules may be found on the flanks of seamounts (e.g., along the more gently sloping saddles and flat-topped summits), or targeting the edges of possible slope failures to observe geologic cross-sections. Two general patterns of nodule occurrence included extensive

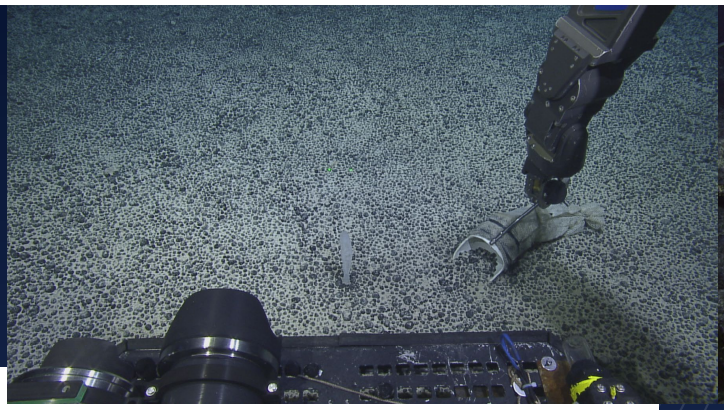


Figure 2. ROV *Hercules* scooping polymetallic "nuggets" from an expansive flat-lying region south of an unnamed seamount (H1998). Green laser dots mid-frame indicate 10 cm scale.

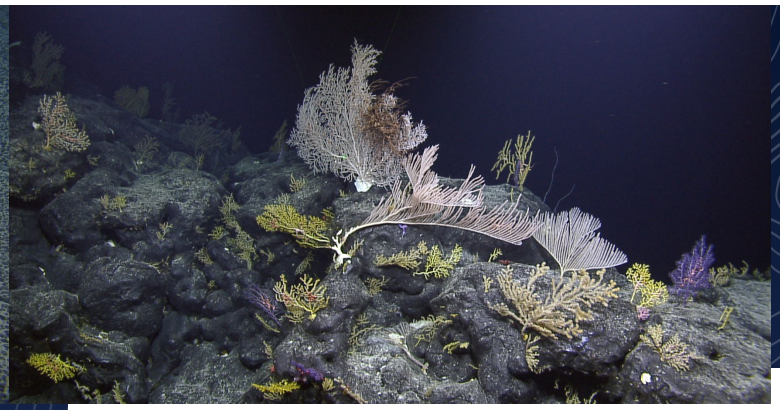


Figure 4. A dense and diverse deep-sea coral community encountered on the summit of a seamount during dive H1993.

fields of nodules on flat sedimented regions (Figure 2), and nodules distributed along channels resembling stream beds on slightly steeper regions. Transects along the exposed scarps frequently revealed successions of lava flows with rock samples often characterized by flow breccias and hyaloclastites (Figure 3).

On those dives where the ROVs reached the seamount summit, lava morphologies were observed at or near the peak of seamounts. However, carbonate reef material may have been present just below the summit on dives H1997 and possibly H1993. Preliminary observations indicate the majority of rocks collected during the expedition represent a mixture of alkalic and highly silica undersaturated lithologies, consistent with previous reports from the region. The presence of basalt atop all of the seamount summits, and the occurrence of lava morphologies overlying carbonate reef material (e.g., H1997), suggests the possibility that some flat-topped seamounts in the region may have experienced multiple discrete phases of volcanism.

Follow-up work on collected rock samples will consist of petrographic analyses followed by age determinations via the $^{40}Ar/^{39}Ar$ incremental heating method and whole rock geochemical analyses in order to determine the geodynamic origin of these seamounts. The long ROV dive transects, coupled with relatively dense sampling (i.e., 6-10 rocks per dive), will allow for novel insights into how these ancient volcanoes were constructed, particularly whether they formed via a continuous event or multiple discrete pulses of volcanism.

Figure 3. Meter-thick basalt flows at the top of slump scarp on western side of Johnston North Ridge (H1999).

This expedition also yielded substantial new insights into the marine biodiversity surrounding Johnston Atoll. Deep-sea corals and sponges were present at all sites, and included both high-density and high-diversity assemblages within 9 of the 11 dives. The densest observed coral communities were associated with near-summit depths at dive H1993, which was dominated by sea fans (including *Victorgorgia* sp.), bamboo corals, as well as an unknown *Acanthogorgia* species (Figure 4). Other noteworthy observations included a substantial woodfall (Figure 5), which included several previously unknown species records for this region. We also observed novel occurrences of seafloor gelatinous organisms, including tunicate species, which are poorly known from this region. These organisms were most commonly associated with soft sediments and small ferromanganese gravel fields, whose biological communities are not as well studied compared to high-relief ferromanganese crust communities.

This expedition also marked the beginning of a new partnership between the Ocean Exploration Trust and the Ocean Census, a global alliance that aims to accelerate the rate of new species discoveries (see Fundis and Wagner in this report). Specifically, Ocean Census affiliated scientist Raissa Hogan joined the expedition, and provided important contributions to the biodiversity expertise onboard the mission.

Johnston is the most remote atoll on Earth, and its deep-sea biodiversity is still poorly known. Biological sample collections on this mission documented several range expansions, as well as new species to science. For example, of the 24 squat lobsters (*Galatheoidea* and *Chirostyloidea*) collected on the expedition, at least nine represent new species and five include new geographic records for the Johnston Atoll region. Additionally, the six invertebrate species collected from the woodfall community were not previously known from PRIMNM (Figure 5). Among the dominant structure-forming, deep-sea corals collected throughout this expedition, at least 12 were found to be potentially undescribed species or new records for the region. This high rate of new discoveries indicates that we are only scratching the surface of understanding the true biodiversity of this remote area in the Pacific.

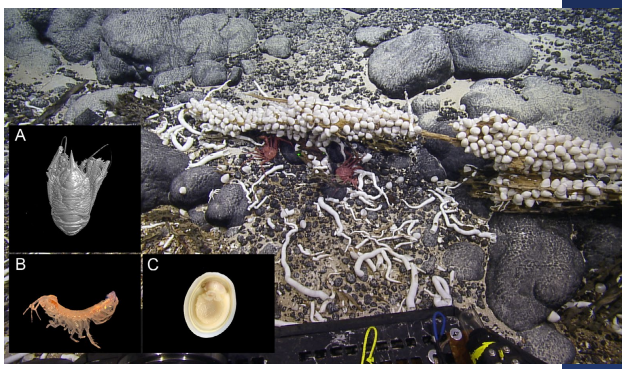


Figure 5. A woodfall community observed at 2379 meters along the northern ridge of Johnston Atoll during dive H1999. Inset images show characteristic species of the woodfall site including A) *Munidopsis* sp. squat lobsters, B) amphipod crustaceans, and C) limpet molluscs (photo credits: Paula Rodríguez-Flores).