NEW FRONTIERS IN OCEAN EXPLORATION

The E/V *Nautilus*, NOAA Ship *Okeanos Explorer*, and R/V *Falkor* 2020 Field Season

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Ocean Networks Canada

Advancing Ocean Observing Technology and Science

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Marking the fifth anniversary of working in partnership with Ocean Exploration Trust, the E/V *Nautilus* team supported the maintenance of the University of Victoria's Ocean Networks Canada (ONC) offshore cabled ocean observing infrastructure (Figure 1). Despite the global pandemic—which limited the number of onboard crew and required strict adherence to COVID-19 safety protocols—the team was able to successfully maintain, upgrade, and expand over two dozen instruments in 2020.

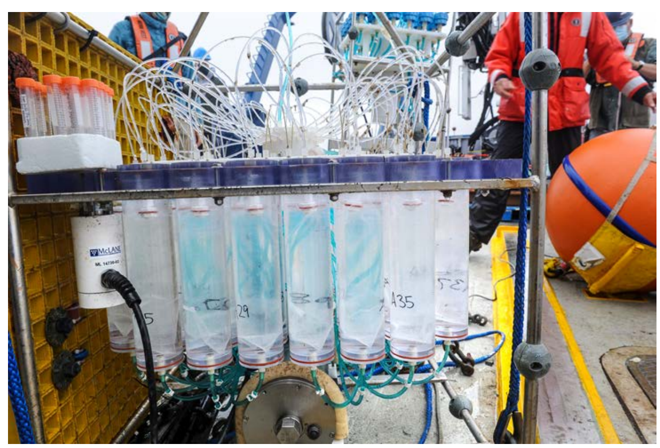
During the 14-day expedition from September 4 to September 18, 2020, and in coordination with researchers from around the world, *Nautilus* visited 11 sites to deploy, recover, and maintain sensors and instruments, more experiments than ever before in a single expedition. The team completed a significant amount of scientific work using the ship's ROV *Hercules,* performing numerous vertical and horizontal video surveys, mapping the seafloor, and collecting biological and geological samples.

ROV *Hercules* placed a total of 18 new passive larval tube traps on the ocean floor at all of ONC's deepwater sites (Figure 2). Once in place, these tubes will collect larvae of benthic organisms over one full year to better understand patterns of connectivity, dispersal, and biodiversity of deep-sea animals. This new research is a collaboration between researchers from the United States, Spain, France, Portugal, United Kingdom, Japan, and Canada, including ONC.

Using the ROV *Hercules* "slurp" suction sampler at the Endeavour Hydrothermal Vent Field Marine Protected Area, the science team gathered samples of a new-to-science sponge species. These specimens are being studied by researchers at the Natural History Museum of London to further examine microbial symbionts living within the sponges as a way to understand what they eat. Additionally, a sample of this new species will be deposited in the zoological collection of the Royal BC Museum, Victoria.

The growing field of environmental DNA, or eDNA, research is a paradigm shift in ocean science, making it possible to monitor ecosystem biodiversity with only a few liters of seawater. Deployed at Endeavour in 2019 and recovered by *Nautilus* in 2020, paired McLane instruments collected samples for eDNA and associated water chemistry to enable time-series analysis of temporal changes in the microbial biodiversity in hydrothermal vent fluids (Figure 3). Microbial colonization modules attached to the McLane sampling apparatus deployed in the vents' hydrothermal fluids will be used specifically to study protists—slightly more complex microbes with unknown roles

FIGURE 3 (below). The eDNA sampling device with phytoplankton sampler. *Image credit: ONC*



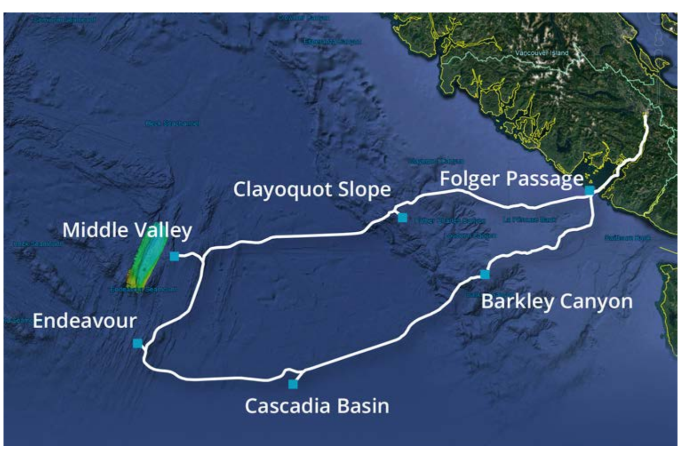


FIGURE 1 (above). Ocean Networks Canada cabled infrastructure and new multibeam map near Middle Valley.

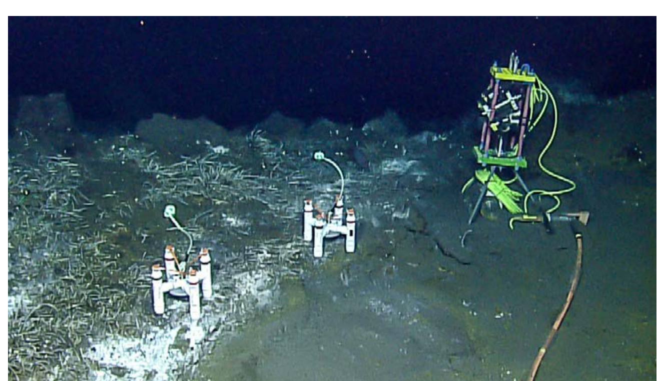
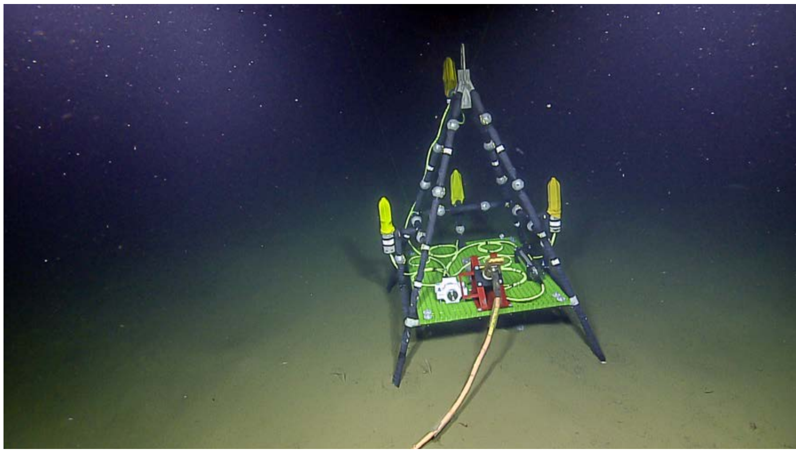


FIGURE 2 (right). Larval traps deployed at Endeavour Hydrothermal Vent Field Marine Protected Area. *Image credit: OET/ONC*

FIGURE 4 (left). Deploying cable to connect tsunami array at Cascadia Basin. *Image credit: ONC*

FIGURE 5 (below). New hydrophone at Cascadia Basin. *Image credit: OET/ONC*



in hydrothermal vent ecosystems. Scientist Sheryl Murdock will use eDNA from the sampler to compare organisms grown in culture from the colonizers to the time series of eDNA samples. Study of individual genomes and abundance shifts over time will increase understanding of the mechanisms of protist survival in these harsh vent environments.

ONC completed the highly anticipated tsunami detection array—first conceived and partially deployed in 2012—on the vast abyssal plain at Cascadia Basin, ONC's deepest site (Figure 4). The array was to have one instrument at the Cascade instrument platform and three others 120° apart and 25 km away from the instrument platform, but two of the three experimental 25 km fiber-optic cables were damaged during cable laying in 2012. Since then, ONC developed an innovative solution using the cables' copper conductors to transmit both power and communications, eliminating the need for fiber optics. This innovative "comms over copper" solution—deployed in 2016—allowed real-time data to flow from the bottom pressure recorders located at the ends of two of the long cables.

In September 2020, the third fiber-optic cable was laid using a custom cable-spooling frame lashed to the deck of *Nautilus*. The entire operation was conducted using the weight of the falling cable (instead of power) while the vessel moved slowly forward, a band brake on the spool to control its speed, and pre-calculated tables to ensure the cable lay speed matched the vessel speed.

Once the cable was laid on the seafloor, the final bottom pressure recorder package was dropped overboard with two floats for a freefall deployment. ROV *Hercules* then plugged the instrument into the Cascadia Basin junction box, connecting the bottom pressure recorder to the Internet-connected network. This third and final cable allowed the fourth instrument to switch from operating autonomously to providing real-time data.

Completing the tsunami array, which now consists of three triangulated bottom pressure recorders surrounding a fourth at their center, was a significant accomplishment. This array allows precise real-time determination of tsunami wave speed, direction, and amplitude. The ability to assimilate open-ocean data from ONC's cabled observatory into an operational tsunami forecast model makes it possible to mitigate the impact of future tsunamis approaching the west coast of British Columbia.

At Cascadia Basin, the team also installed a new hydrophone array (Figure 5) and made preparations for a second pathfinder neutrino experiment (installed later in 2020) and additional cable extension installations (to be installed in 2021).

During inclement weather that prevented ROV operations, the team undertook mapping operations using *Nautilus's* multibeam echosounder to create a high-resolution bathymetric map at West Valley, an unexplored vent field near the undeveloped Middle Valley branch of ONC's offshore network.

While at Barkley Canyon, preparations were made to reconnect this important site to the network. With depths ranging from 200 m to 2,000 m, this deep-sea study site provides a significant location for the study of gas hydrates, sediment dynamics, upwelling, plankton, and productivity. The team also recovered a corrosion experiment deployed in 2019 that was testing various metals and their ability to hold up under 100–200 atm of pressure—equivalent to ocean depths of 1,000–2,000 m.

Other expeditions in 2020—aboard the Canadian Coast Guard Ship *John P. Tully* using the Pelagic Research Services ROV *Odysseus*—resulted in retrieval of the Delta Dynamics Lab from the mouth of the Fraser River and installation of a new hydrophone at Folger Passage and a new hydrophone array in the Strait of Georgia, home to the resident endangered southern killer whales near Canada's busiest port, Vancouver. New community observatories were installed in Douglas Channel near Hartley Bay in partnership with the Gitga'at First Nation and in Alberni Inlet at China Creek with the Nuu-chah-nulth people.