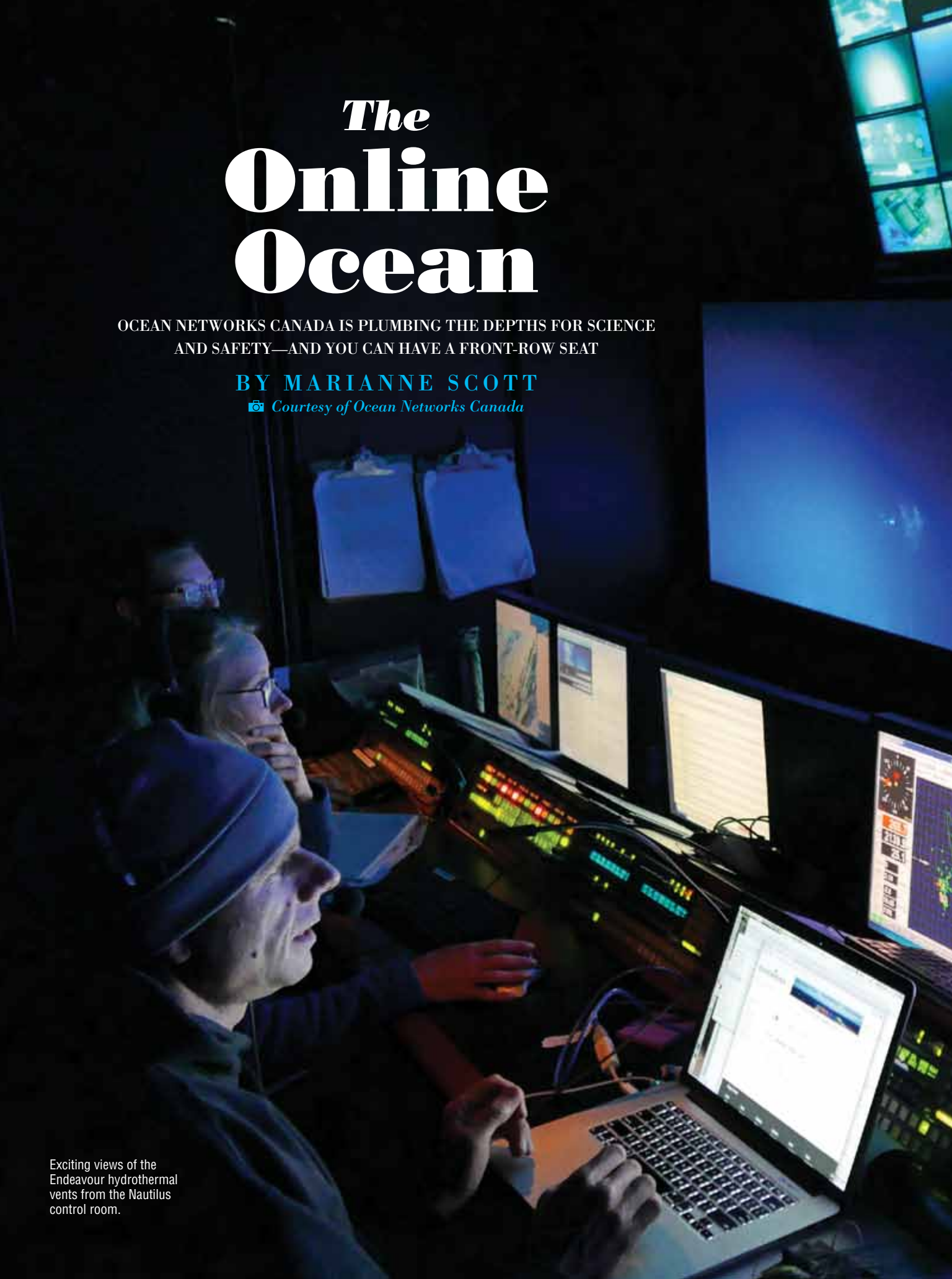
The Online Ocean

OCEAN NETWORKS CANADA IS PLUMBING THE DEPTHS FOR SCIENCE AND SAFETY—AND YOU CAN HAVE A FRONT-ROW SEAT

BY MARIANNE SCOTT

Courtesy of Ocean Networks Canada



Exciting views of the Endeavour hydrothermal vents from the Nautilus control room.

The live camera shows throngs of light-green sea anemones undulating in the ocean currents. In between, seaweeds are glommed onto rocks and rooted in sediment. Small schools of fish dart by, as do numerous individual fish of all sizes. They move jaggedly, whizzing in all directions. Something black sinks slowly into the bottom vegetation. Is it seaweed debris that bottom dwellers feed on? Maybe a dead creature?

Online, I'm peering at the screen, watching life flourishing at the Folger Pinnacle Reef some 23 metres below the ocean surface. It's located at the mouth of Barkley Sound, on Vancouver Island's west coast, near Bamfield, and monitors a rockfish conservation zone. I'm observing this scene through a real-time portal into the ocean. It's unlike the beautifully photographed, groomed underwater films we see on nature channels. Nor can we grasp the elements of this abundant life from any vessel floating on the surface. But through the pioneering systems of underwater cables and advanced instrumentation, it's one of the sites where Ocean Networks Canada (ONC) is researching and documenting the health of our oceans. Through its high-tech systems, ONC promotes evidence-based decision-making, not guesswork, about the state of the oceans. As CEO Kate Moran has stated: "We cannot manage what we don't observe."

ONC is the leading cabled ocean observatory in the world and has gained more than a decade's worth of experience deploying armoured submarine cables with sensors that track a multiplicity of ocean conditions at depths down to 2.7 kilometres. With an ever-expanding system, the numbers are stunning: it now includes more than 850 kilometres of cables, 400-plus instruments with 5,000 sensors, 11 instrument sites, 32 instrument platforms, six mobile instrument platforms and three observatories with five shore stations. To manage and maintain these data collection sites, ONC employs about 100 people. Marine scientists around the world and "citizen scientists" who study the data and provide annotations complement the staff. All the data collected from all of these sites—at present 500-plus terabytes—are streamed online 24/7/365. And they are open source—anyone anywhere can access them.

HEADQUARTERED AT THE UNIVERSITY of Victoria, the project got its feet wet with the 50-kilometre Victoria Experimental Network Under the Sea, or VENUS, with underwater observatories in Saanich Inlet and the Strait of Georgia. The initiative's second system consisted of the North East Pacific Time-series Underwater Networked Experiments, or NEPTUNE, which deploys an 812-kilometre loop from Port Alberni into the Pacific over the Juan the Fuca Ridge. This loop, with its nodes and sensors, monitors many aspects of the state of the ocean and also transmits data on the deep-sea volcanic rift where the Juan de Fuca and North American tectonic plates meet, called the Cascadia Subduction Zone.

In 2016, three community stations, located near Prince Rupert, Campbell River and Kitamaat Village in Douglas Channel, were equipped with an underwater, cabled seafloor platform with a live-streaming video camera. These stations are part of the Smart Oceans BC initiative, through which communities can assess the impact of marine traffic, environmental changes, water quality, storm surges and underwater landslides.

In addition, Arctic stations in Cambridge Bay and Peel Sound are recording data about ice and temperature changes, and a platform in the Bay of Fundy, home to the highest tides in the world, also operates under the ONC umbrella. Thus, with observatories spanning our three coastlines, ONC reflects Canada's national motto, *a Mari usque ad Mare*, or, "From sea to sea to sea."

ALL INFORMATION GATHERED from ONC's stations is handled through Oceans 2.0, an advanced data management and archiving system. As the data stream is unceasing, it establishes baseline thresholds and documents changes as they occur in ocean ecosystems, temperature, salinity, oxygenation, carbon dioxide concentrations, acidification and zooplankton and fish behaviour. As one example, it thoroughly documented the 2014/15 heated north Pacific zones called the "blob," one the greatest sea surface temperature anomalies. As much as 280 gigabytes of data are added each day. Servers near observatories in Port Alberni, Saanich Inlet and Vancouver coordinate data acquisition, while servers at UVic store the information, with backups at the University of Saskatchewan.

Each part of the system tracks different phenomena. "Take the Strait of Georgia at the Fraser River Delta," said associate director of science services Richard Dewey. "We learn about underwater avalanches caused by deposits from the silt-laden Fraser. The area also experiences continual, heavy marine traffic. It's home to big salmon and orcas—animals at the top of the food chain. We've installed hydrophones that measure noise from ships, ferries and sonars. We're evaluating how noise affects these animals." (The public can listen to the hydrophones on ONC's website in real time.)

So how do the huge swathes of raw data turn into useful knowledge? Senior scientific programmer Ben Biffard explained how he plots the data. "Let's say I want to know the results of a year's worth of acoustics through the hydrophones stationed in the Strait of Georgia. With the software we've developed I can create one plot from many terabytes of data and provide an overview of what actually happens below the surface. We can separate ocean background noise from the spikes created by ships' engines and sonars, and identify the volume of noise and the tone or pitch of different whale sounds. And by seeing how whales behave, we can analyze how they react to the noises rumbling through the water. The plot can also reveal earthquakes, wave action and rain. We are also making continual software improvements. It's to ensure the 'fire hose of data' is easily accessed and integrated by scientists around the world."

TWO TECTONIC PLATES collide at the continent's edge—offshore where the Juan de Fuca plate pushes into the North American plate. The rift stretches about 1,000 kilometres from Vancouver Island to northern California. The ocean's floor spreads at depths of five kilometres, with vents spouting mineral-laden 400ºC water superheated by the Earth's magma. The minerals build up in oddly shaped chimneys, somewhat resembling the helter-skelter construction of coral reefs. Vents can shut down and new ones start up as the plates' edges contort, a process that is tracked by ONC's instruments.

Amazingly, animals thrive in the vents' total darkness without the benefit of photosynthesis. Instead, in these sunless reaches, it's chemosynthesis that sustains life. Primitive bacteria living inside such species as tubeworms supply energy directly to their hosts by transforming poisonous-to-us hydrogen sulphide into nutrients. Through ONC's research, about 75 species of these primitive animals have been classified.

Recovering a Vertical Profiler System platform from the Clayoquot Slope.

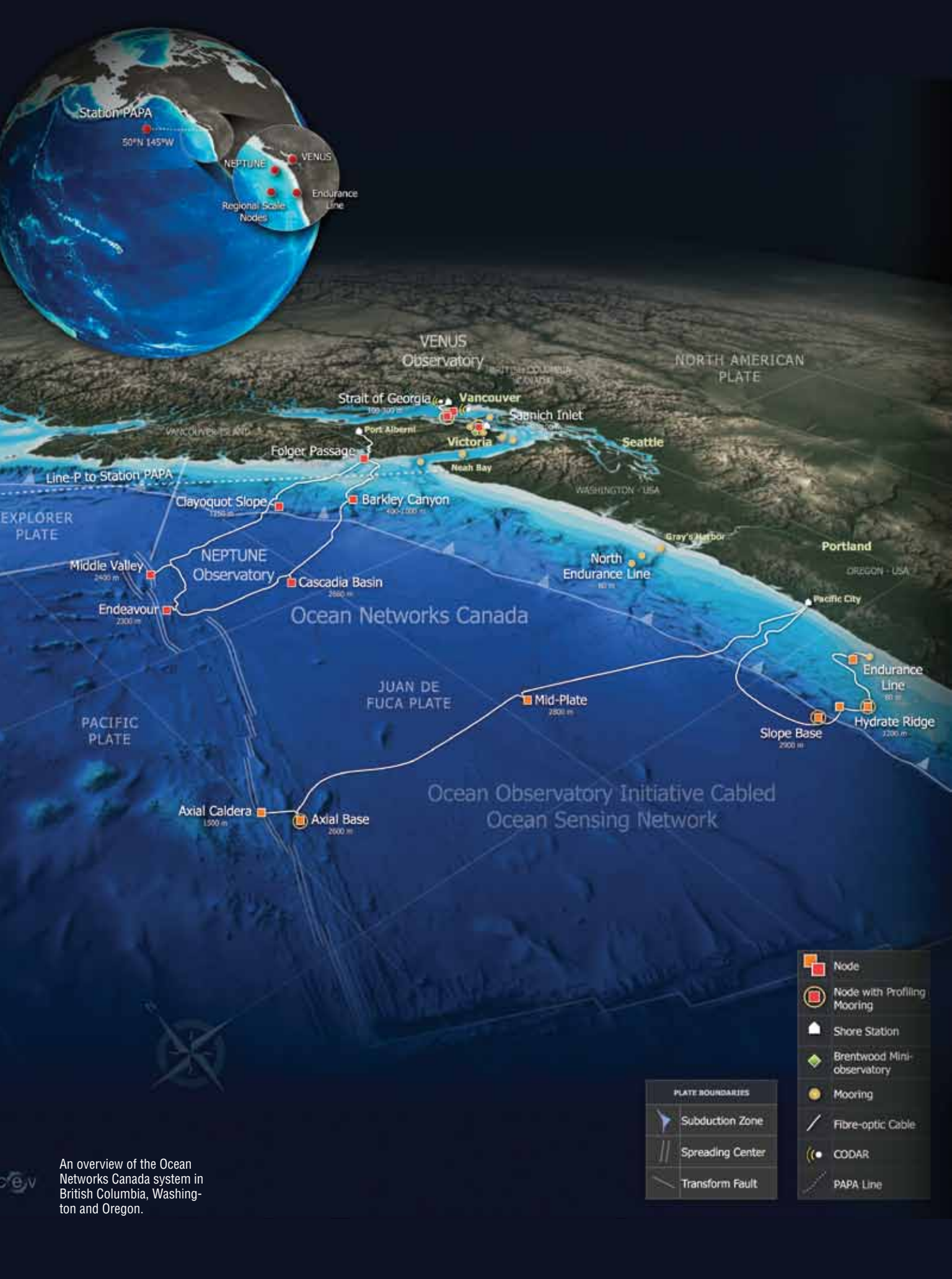
The tectonic collision is where earthquakes and potential tsunamis are likely to be triggered. As earthquakes have been unpredictable and the slippage along the Cascadia Subduction Zone may cause "The Big One," ONC is working with Emergency Management BC to build an early warning system. In June 2016, as part of its 40-day "Wiring the Abyss" expedition, ONC lowered the first seismic sensor—a Titan accelerometer, a vibration detector encased in a glass ball to withstand pressure at 850 metres—at the rift. Other seismic sensors will form a network on both land and sea that may mitigate damage and fatalities when the Earth starts to shake.

The goal is to provide a warning of up to 90 seconds before the quake strikes. That may not seem like much time, but it may give B.C. residents the chance to hide under a desk or in a doorway, open doors for emergency response vehicles, stop or slow SkyTrain or other mass-transit lines, close gas mains and pause surgeries.

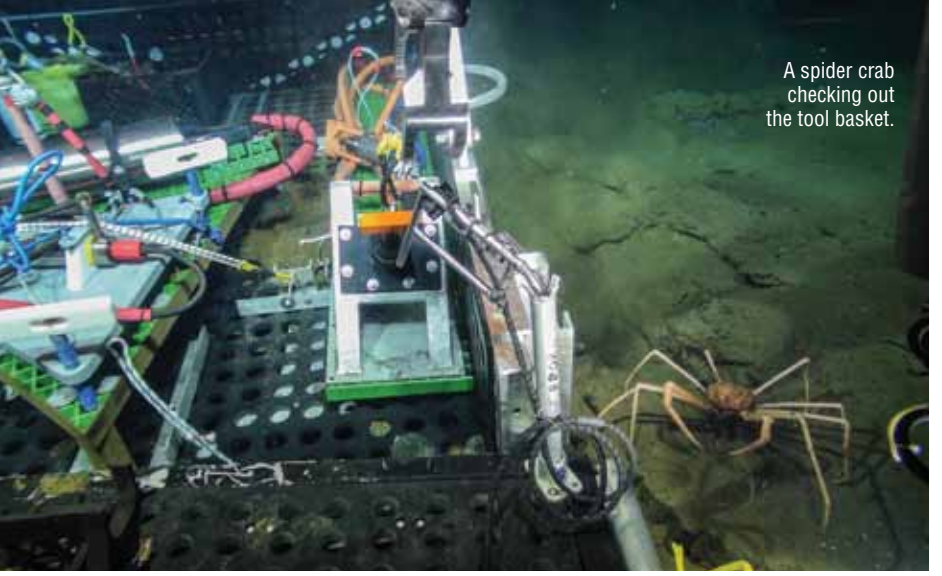
ONC'S EXTENSIVE NETWORK has provided opportunities for scientists and industries to capitalize on its capabilities. In October 2016, for example, Fisheries and Oceans Canada (DFO) asked ONC to use its powerful Oceans 2.0 software to systematize and organize all the data collected on the Pacific fisheries, marine mammals and other ocean data. It's a pilot project designed to make DFO's information more transparent and digestible.

A somewhat offbeat study was conducted by Simon Fraser's criminologist Gail Anderson, who used ONC's network to clarify how pig carcasses decomposed in different underwater locations/conditions. As pigs are a good proxy for humans, their disintegration can help pathologists determine the time of death when homicide victims are found in the water—something quite unknown until now. In this research, dubbed "CSI: Salish Sea," Anderson used cameras and lights to monitor the effects of water immersion and scavenger attacks. Pigs were submerged in Saanich Inlet and in the Strait of Georgia. Some pigs were caged to prevent sharks from instantly devouring the body (several videos on the ONC website show sharks scavenging). In a feeding frenzy, sea lice (arthropods) invaded by the millions and reduced the carcass to bones in four days. "I've consulted with pathologists who want to use our research to assess when a murder took place," said Anderson. "No one else has studied this and I'm hoping to conduct more investigations."

Ben Biffard pointed out that a variety



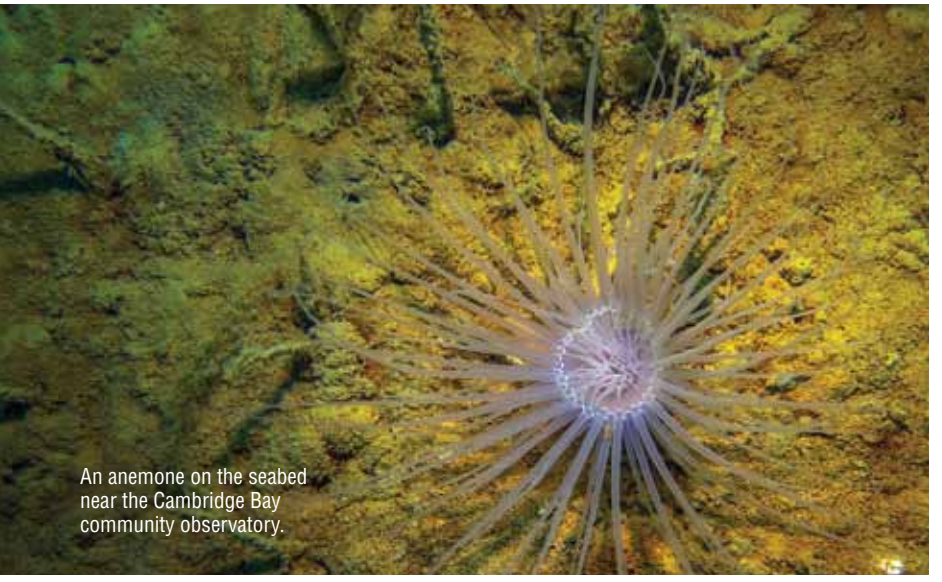
An overview of the Ocean Networks Canada system in British Columbia, Washington and Oregon.



A spider crab checking out the tool basket.

Opportunities to see interesting sea life through the ONC website are endless.

The cable repair ship *Wave Venture.*



An anemone on the seabed near the Cambridge Bay community observatory.

of Canadian companies are using ONC's capacity to test and bring new products to market. "We have become partners in the Victoria area tech industry," he said. "But many others around Canada and the world are collaborating with us and using our resources."

Sidney-based AML Oceanographic Ltd. created a novel anti-biofouling technology that prevents plants and animals from colonizing ONC's underwater equipment. Housed in a glass pressure case, the product uses stackable LED modules that emit UV radiation and kill invading algae and barnacles. "It's one of the biggest challenges to keep camera lenses, sensors and lights from being encrusted by sealife," wrote Scott McLean, ONC's innovation centre director. "Biofouling, particularly in the coastal zone, can stop operations, and at the same time cause maintenance costs to skyrocket."

In Burnaby, Oceanworks International has built and provided its subsea instrument interface modules, or "junction boxes," to connect much of the NEPTUNE and VENUS cabling. Jan Buermans of ASL Environmental Sciences in Victoria spoke about the company's Acoustic Zooplankton Fish Profiler for scientists. "It started as a demo project in Saanich Inlet on the VENUS cabling system," he said. "It can stay in one place for long periods. The backscatter showed the number of fish and the amount of zooplankton in the water column in real time. [Zooplankton presence is crucial as it forms the base of the oceans' food chain.] The demo helped put the product on the map. ONC has since installed six of these instruments, but the real payoff came when we sold 34 fish profilers in the U.S. for $1.8 million. We've installed 135 of them around the world."

IN KEEPING WITH its policy to make ocean research available without restrictions, ONC maintains a continually updated, extensive—almost exhaustive—website (oceannetworks.ca). Staff abstracts of publications in scientific journals as well as book chapters and dissertations based on ONC's data and infrastructure are itemized. That's for the academic side.

ONC also offers such apps as "Community Fishers" and has published its own e-books for non-specialists. I particularly like the *Marine Life Field Guide*, which shows the many species of marine life documented by ONC's cameras in our own backyard. As new images are captured, the book is updated. You can download it as a PDF, or view it online with video. Besides publications, live and many archived video and audio presentations are available. It's how I watched the bustle of life on the Folger Pinnacle Reef and listened to underwater noise in the Strait of Georgia. Materials for teachers and students are also downloadable. If you want discover how humans are affecting the northeast Pacific Ocean's ecology, how life is faring in the Salish Sea, and how the seafloor, ocean and atmosphere interconnect, all this fascinating information is accessible with the click of a mouse.

Should we care about this research, the probing, the streams of data, the education, the advocacy and the spending? As ONC states: "The ocean is the lifeblood of this planet. No healthy ocean, no healthy us."