An eerie creature scuttles along the sea floor intent on reaching a pink dead shrimp. It’s a brittle star equipped with five skeletal legs—or arms?—attached to a body resembling a flat metal disc. Soon, other brittle stars dash in for a bite and they pile up like a bunch of linebackers during a Sunday afternoon football game.

All this happens at depths of more than two kilometres.

Closer to the surface, a webcam light illuminates other ocean organisms whose large white beaks extend a leaflike fan into the water, move it for a second or two to catch nutrients and then suck it back in. It turns out to be a family of barnacles, just like those sharp protuberances on rocks that tear our inflatable dinghy’s tubes—only these are huge and have found a home far from shore.

ROPOS, a remotely operated vehicle, took the video of the brittle stars. We can observe the barnacles through the images captured by a live, streaming camera. Both images reflect but a tiny part of the research performed by VENUS and NEPTUNE, (operated by Ocean Networks Canada [ONC]), a unique and wide-ranging marine project with its scientific home at the University of Victoria.

Boaters who float on the water’s surface and enjoy the exuberance of Dall porpoises, dolphins and whales that emerge briefly from the deep, may speculate about what lies beneath our keels. VENUS and NEPTUNE reveal some of what takes place in the ocean’s unseen reaches.

The research is unique—presently it’s the world’s first and only underwater program that collects data continuously and in real time by streaming information into huge computer banks. The fibre-optic cables and hundreds of ocean sensors gather data and make it instantly available—globally and free of charge—through the internet. As the data gathering is unceasing, it establishes baseline thresholds and can document later changes in ecosystems, temperature, salinity, oxygenation, carbon dioxide concentrations, acidification, and zooplankton and fish behaviour.

Stationary and floating sensors attached to powered cables monitor four highly diverse sites: A 40-kilometre cable in...
the Strait of Georgia outside the Fraser River delta; a four-km cable in Saanich Inlet; an 812-km loop extending over the Pacific Ocean’s Juan de Fuca Plate; and a small observatory in the Arctic at Nunavut’s Cambridge Bay. All sites require highly technical and robust equipment to survive the deep, cold, saltwater environments.

We have all seen terrific underwater photography that highlights marine habitats. They catch the colourful, the exotic, sometimes the violent aspects of the food chain, but these entertainments don’t show how the food web works, can’t warn us of earthquakes and tsunamis, nor demonstrate how climate change affects our oceans.

How it Started  More than 20 years ago, University of Victoria marine biologist Verena Tunnicliffe began exploring hydrothermal (hot) vents. At the juncture where tectonic plates are moving apart, new crust is forming and black smokers emerge from the earth’s hot magma. The Juan de Fuca plate, which runs along Vancouver Island, Washington and Oregon and is sliding under the North American plate is one such site.

Tunnicliffe became a renowned expert on the species that live there in water with temperatures exceeding 400°C. To survive, the tubeworms and other species that abound rely on primitive bacteria that transform energy-rich hydrogen sulphide into nutrients. It’s called chemosynthesis; a process that shows life can exist without photosynthesis or oxygen.

Tunnicliffe pinpointed a group of vents to study but when a submersible dove down two years later, the ocean-floor rifts and its vents had moved. This form of “geology in action” spawned the idea for permanent observation posts that could track changes several kilometres down. Fortunately, in 2000, the Canadian Foundation for Innovation (CFI) chose to
fund infrastructure for scientific research. Richard Dewey, ONC’s Associate Director of Science, explained that CFI money allowed for a “pie in the sky” idea to become reality. The result? VENUS—an acronym for Victoria Experimental Network Under the Sea—and the creation of the Saanich Inlet and Strait of Georgia observatories. Both became operational in 2006.

More funding allowed for the 2008 launch of the NorthEast Pacific Time-Series Undersea Networked Experiments—NEPTUNE—which runs in a loop from Port Alberni through Barkley Sound, and over the continental shelf to the Juan de Fuca plate.

Different Results Each observatory gathers diverse kinds of information. Take the Saanich Inlet station. “We measure the flows in and out of that fascinating fjord,” said Dewey, who spoke with enthusiastic fervour in his office at the Technology Enterprise Facility. “It’s a nursery and a dynamic biological and chemical system, with slow-moving currents. Below 100 metres, the water is hypoxic [low oxygen] where a unique benthic [bottom dwelling] animal population lives. We have a mooring there that monitors oxygen, temperature, pressure and salinity. Saanich Inlet resembles many fjords. What happens there helps us to understand how parts of the ecosystem work. We look for sensitivities, small changes, and how these affect the system. And to determine what is sensitive, what is robust.”

The Strait of Georgia’s observatory tracks different phenomena. “This area experiences continual, heavy marine traffic,” said Dewey. “It’s also home to many animals at the top of the food chain, big salmon, orcas. Our advanced hydrophones measure noise from ships, ferries, sonars and so on. We want to learn how so much noise affects these animals.”

He added that the Strait of Georgia has strong tides and during the spring freshet, Fraser River water moves into the strait at a rate of 10,000 m$^3$ per second. The fresh and saltwater mix to form a visible plume of buoyant brackish water. Moreover, the Fraser carries hundreds of tons of sediment and the accumulating silt can cause underwater slumps and slides—much like an underwater avalanche. VENUS’s equipment observes...
Dewey, whose research focuses on coastal flows, mixing, turbulence, waves and tides, is a lifelong sailor and still races his Thunderbird. The annual Swiftsure Race calls on his expertise: for every half hour of the race, he predicts tides and currents between Oak Bay to Swiftsure Bank.

His work on how fresh and salt water mix is teaching us just how our regional ecosystem works. And it’s also important for boaters. “Boaters,” said Dewey, “know key things like the rise and fall of tides and current patterns. But fresh water from the Fraser mixes with Pacific, nutrient-rich, salt water. And the constricted tidal flows among the Gulf Islands contribute to turbulence, back eddies and slicks so we have much more complicated water flows. The mixing can cause four- to fivemetre waves below the surface. The good thing is that mixing keeps the Salish Sea very healthy and continues to be a great place for cruising.”

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Dewey has been surprised by how huge the variations in our waters can be. The sensors show that instead of slow seasonal rises in temperature or oxygen content,
they can change rapidly. “From oxygenated to hypoxic in an hour. Temperature changes in minutes. The swings are so big you could compare it to the weather changing from 25°C to a snowstorm in a very short time.”

**Citizen Science** No one group of scientists can analyze the huge amounts of data that stream in daily. So ONC sometimes asks the public to annotate segments of information. It’s “crowd sourcing” science. The current mission is for “digital fishers” to annotate videos of the seabed that are home to stationary crabs—to determine if a new software program identifying these crabs is working properly.

Citizen scientists can provide a single annotation; many participate frequently. The champion to date resides in Germany; Harold Smith holds the record by completing well over 10,000 annotations.

A 14-year-old Ukrainian budding biologist, Kirill Dudko, who’d never seen an ocean, gained fame after he posted an image on YouTube of a “creature with a nose and a moustache snagging a hagfish.” The image came from a Pod 4 camera stationed in Barkley Canyon at a depth of 894 metres. The posting garnered more than 2.5 million hits and Kirill was interviewed multiple times. The “creature” was identified as a female northern elephant seal, capable of diving 1,500 metres and holding its breath for 100 minutes.

**Future Evolutions** ONC’s President and CEO Kate Moran, who’s led the organization for the past two years, asks many questions about our oceans. “We need to think differently,” she said. “We need to visualize what goes on even though it’s dark. We see growth in ocean use. We should be aware of the food web; of ocean sound density; of acidification. From a climate change perspective, so far the ocean has been saving our butt by absorbing excess CO2.”

Moran outlined some of the ONC’s future plans. “We have a proposal called ‘Smart Oceans BC,’” she said. “Our plan puts sensors in the Douglas Channel leading to Kitimat and in the Strait of Georgia’s northern sector. The research will lead to good policy for ocean use, for marine safety and ship traffic. We’ll be able to add to public safety by giving a 60 to 90 second warning for an earthquake at the Juan de Fuca plate. And we’ll have a radar system offering a 30-minute warning for tsunamis.”

Moran is also working on further increasing collaborations with ocean scientists around the world. Joint research agreements are already in place with Japan, Germany and China. “We have years of experience now and novel ways of doing things. Others can piggyback on our research and equipment.”

Working more with industry is on the agenda as well. “We have the best hydrophones in the world,” she said. “Our remote sensors are superb. And we can help commercialize our innovative hardware systems and digital infrastructure.”

In the end, what VENUS and NEPTUNE are all about is the sustainable management of ocean resources. After all, the oceans are our ultimate life support system. ☛