Deep-Sea Vent and Seep Communities – Tutorial Script

To finish up with benthic ecosystems of the oceans, let's review some of the special seep and vent communities that we first discussed at the beginning of the semester when we studied hydrothermal vents and seafloor spreading. These ecosystems are unique because they exist on deep seafloor where there's no light, and thus photosynthesis cannot be the energy source that serves as the foundation of the food web. These ecosystems are also like oases – only this time in the darkness of the deep – they are found where there is an unusually large concentration of energy gases percolating up from inside the Earth – either methane or hydrogen sulfide or a combination of the two. Chemosynthesis is the major energy transfer mechanism that supports this food chain, as bacteria use the energy stored in these gases to produce sugars. This equation shows one example of chemosynthesis that happens at hot vents atop seafloor spreading centers otherwise known as hydrothermal vents. Notice that in this equation, sulfuric acid is the waste product.

As this map shows, there are a number of different vent or seep communities that have been identified and studied across the world's oceans. They can be separated into two major types – hot vents and cold seeps.

Hot vents are **the hydrothermal vents** that occur at seafloor spreading centers, where hot magmas under the surface heat up seawater that has infiltrated the crust through cracks. This heated water is now less dense, so it rises upwards. Enroute to the surface it leaches out metals from the crust and when it is finally released through a vent on the seafloor, it is carrying many dissolved ions and gases that are released into the cold water. The temperature of the water in the vents can be as high as 400 degrees Celsius. Remember what the temperature of deep water is? Since most of the world's bottom water is from Antarctica, it's likely it's around 0 degrees Celsius. That large drop in temperature that happens to these percolating fluids causes various ions to combine and precipitate as solid minerals, creating progressively taller and taller chimneys around the vents. The black material you see in the liquids that are leaving the vents are very tiny particles of iron sulfide. These chimneys can be made up of many different kinds of metal sulfides, including Zinc, Iron, Copper, and rare metals like gold and silver. A common animal found living near these vents in the Pacific Ocean are tube worms. They are mixotrophs that contain gardens of chemosynthetic bacteria, which they periodically move over the vent to give them access to the hydrogen sulfide gases. Other animals that exist in these vents include giant clams, large mussels, white crabs, transparent shrimp, microbial mats, and many others. There is a strong zonation of life in these vents, because the ones that live right next to the vent must be extremophiles, able to sustain extremely hot temperatures. As you move further from the vent, the temperatures will cool off substantially, and the organisms will quickly change to those that cannot handle high temperatures. These vents usually last for a few years before either an eruption barbecues the residents, or the energy source disappears – the vent stops. Larval organisms are carried by water currents and if they are lucky, they will arrive at and populate a new vent. Some organisms, such as bacteria and certain larvae, can lie dormant in the sediment until a new vent appears.

Similar types of organisms exist around cold seeps as well as new ones. Microbial mats, seastars, shrimp, crab, clams, mussels, fish, limpets, snails, brittle stars, anemones, and tube worms. Chemosynthetic bacteria are also the base of the food chain. However extremophiles are absent. The water is cold. And the energy source usually is methane exclusively or both methane and hydrogen sulfide. To date, cold seeps have been found near hypersaline seeps, subduction zone seeps, and hydrocarbon seeps.

Hypersaline seeps are typically found at the base of the continental slope, where it meets the abyssal plain. Out of the seafloor seeps super-salty brines that have similar temperatures to the surroundings but salinities as high as 46.2 ppt. Because of the high salinity, they also are highly dense and don't mix with the surrounding water. They form an underwater lake. These seeps form because of buried salt beds that formed tens to hundreds of millions of years ago along shallow seas and lagoons along a continental margin. These salt-rich sediments have now been buried deeply and as seawater penetrates the crust, the water dissolves some of the salt and becomes more saline. The water also picks up the gases formed from decomposition of organic material that would have been deposited alongside. Therefore, hydrogen sulfide and methane gases are associated with these seeps, and you will find communities of tube worms and chemosynthetic bacteria and their predators lining the shorelines of these lakes. There are some well-studied hypersaline seeps on the bottom of the Gulf of Mexico as shown here.

Hydrocarbon seeps are typically nearby hypersaline seeps, because hydrocarbons form when shallow seas and intertidal wetlands, are buried and decomposed without oxygen. They also produce primarily methane and hydrogen sulfide gases, but also oil and tar. These liquids and gases are less dense than the surroundings, and they will rise up cracks and bubble out onto the seafloor. When they do this on land, we call them tar pits. On the seafloor, they create large asphalt strips that are surrounded by unusual seep communities, much like those found at hypersaline seeps. Many of these seeps are currently found and studied near the oil and gas reservoirs in the Gulf of Mexico as shown here in this image.

Subduction zone seeps occur within trenches and form as methane gas seeps up cracks in the rocks. Methane forms during decomposition, especially decomposition that happens after rocks have been buried, and thus there is no oxygen. This gas is low density, so it prefers to rise up cracks as they form. In areas where cracks concentrate, there can be large amounts of seeping methane gas and thus, again, large communities of organisms surrounding these seeps and basing their food web on chemosynthesis. Subduction zone seeps have been found along the Japan Trench, Peru-Chile Trench, and just offshore of Oregon along the Cascadia Subduction Zone.

Pause now.

Please follow the website's extra resource links to see live footage of hydrothermal vents and cold seeps and see what are truly some of the most remarkable sights on the bottom of the seafloor – including a lake, with a shore and waves – but on the bottom of the ocean, and what looks like an underwater, naturally produced parking lot.

Deep Sea Vent and Seep Communities
Produced by Katryn Wiese
City College of San Francisco

<u>Nekton & Benthos Series:</u>
Nekton: Whales, Fish, and More
Benthos: Intertidal Zone
Benthos: Crabs, Corals, and More
Deep Sea Vent & Seep Communities

All media produced by Katryn Wiese unless indicated below:
**Intro and exit music: used with permission © Alexis Harte*
**Review music: used with permission © Proceed With Caution*
**Global vent/seep distribution – Woods Hole Oceanographic Institution (WHOI) – Stace Beaulieu*
**Chimney formation – NOAA*
**All vent and seep images and models – NOAA except for the following:*
**Gulf cold seep tube worms – Lamellibrachia lymesi, including model of energy use – Charles Fisher –CC BY 2.5*
**MARUM TV footage – MARUM - Center for Marine Environmental Research; University of Bremen, Germany*
**EVNautilus.org – Life at Extremes: Biology of Brine Pools and Methane Seeps*