SUMMER 2007

EXPLORE

EXPLAIN

COFS Scientists Go to Extremes

When it comes to research, scientists from the College of Ocean and Fishery Sciences will go to the ends of the earth — and beyond — to learn what they need to know.

School of Oceanography Professor Jody Deming travels to the Arctic to study organisms that exist in some of the coldest habitats on Earth. Oceanography Professor John Baross studies life in the ocean's deepest depths. Ray Hilborn, professor in the School of Aquatic and Fishery Sciences, spends time in Africa's Serengeti savanna, one of the globe's oldest ecosystems. And the data used by Kate Edwards, a physical oceanographer in the Applied Physics Laboratory, is literally out of this world, generated by orbiting satellites.

You're Getting Colder

Jody Deming has been studying cold-adapted marine bacteria for more than 30 years, focusing recently on certain strains that survive and grow in polar ice and unimaginably cold brine pockets. "It's an environment that provides an example of the limits of life on our planet," says Deming, who is also a member of the UW's Astrobiology Program.

What allows these cold-adapted bacteria, known as psychrophiles, to function under conditions of cold and high pressure in the deep sea or the extreme cold and saltiness of sea-ice pockets? Part of the answer, says Deming, lies in some of the unique enzymes that these microorganisms produce. She is particularly interested in the bacterial production of exopolymers — complex organic compounds made primarily of various sugar molecules. These compounds stabilize enzymes so they can persist in active form, even as water molecules freeze around them.

"The exopolymers act as antifreeze compounds, much like those we add to automobile fluids in wintertime," offers Deming. "Enzymes that are critical to bacterial survival in Arctic winter sea ice can continue to do their work if they are embedded in a cell coating of exopolymers that protect both the enzymes and the cells from freeze-damage."

Enzymes from cold-adapted microbes have great potential for practical human use. Cold-active enzymes can be especially useful as the active ingredients in cold-water laundry detergents, for breaking down the residue of oil spills at sea and for applications in the biotech field. With help from a grant from Washington Sea

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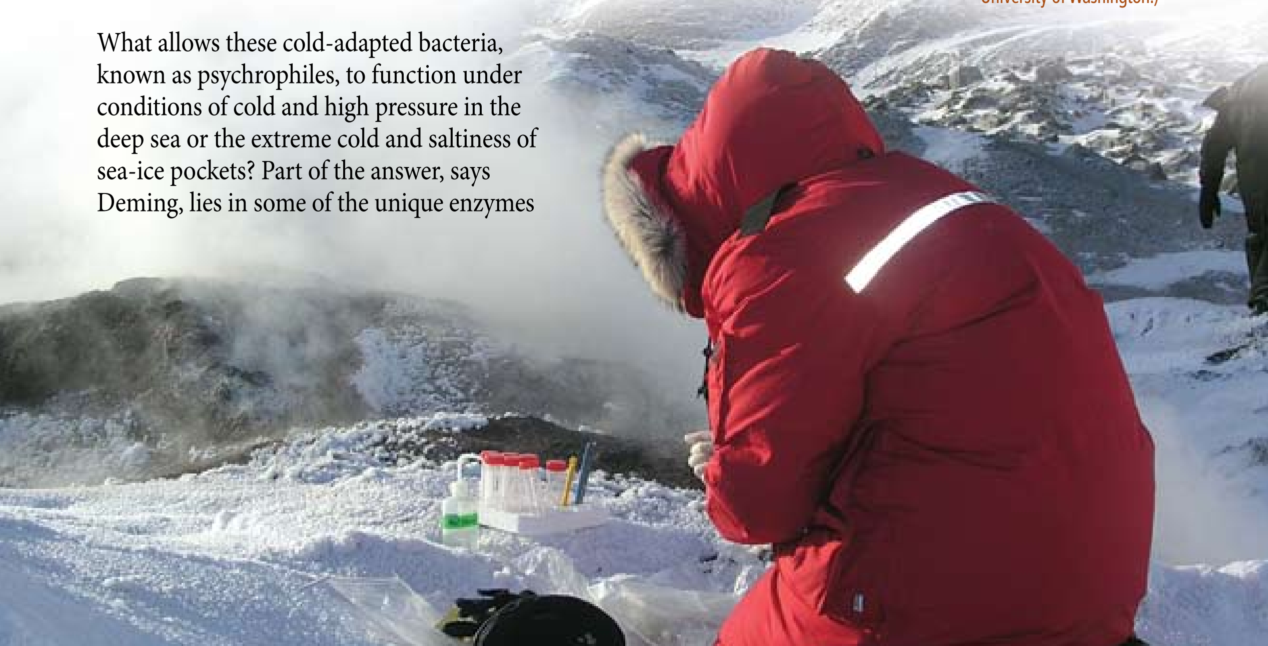
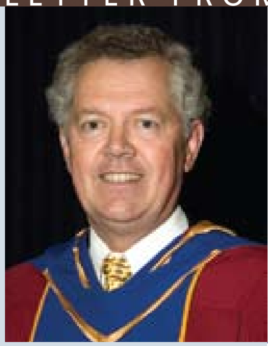


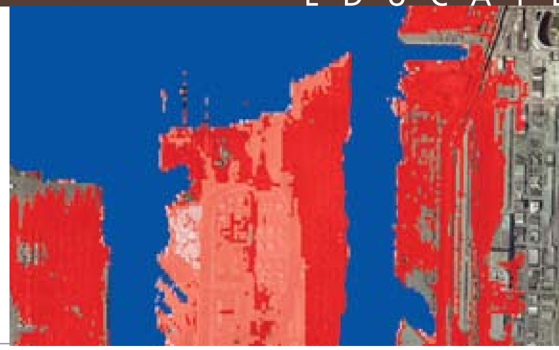
Jody Deming collecting Arctic ice that provides habitat for cold-adapted marine bacteria. (Photo courtesy of the University of Washington.)

THE NEWSLETTER OF THE COLLEGE OF OCEAN AND FISHERY SCIENCES

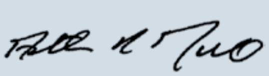
UNIVERSITY OF WASHINGTON



Right: Potential effects of a two-foot (light pink), four-foot (pink) and six-foot (red) rise in sea level on Seattle's Harbor Island and waterfront. Far right: Alexander Petersen.



This June the College honored more than 100 students at our annual Graduation Celebration. The event provides the opportunity to be inspired by the achievements of our students and their wide-ranging career goals, a reflection of both opportunity and the impact of our great faculty. I am particularly struck by the diverse nature of research programs in the College, but also by their shared themes. This issue of *Explore* focuses on the "extreme" nature of some of that research, on everything from microbes to megafauna, undersea to outer space. I hope you will find the stories in these pages as fascinating as I do.



Arthur R.M. Nowell
Dean, College of Ocean and Fishery Sciences

Undersea Seattle? COFS Student's Scenarios Shed Light on Sea Level Rise

What would happen to Seattle if the sea level were to rise two feet? What if the sea level rose four feet? What about five feet or more?

Alexander "Sascha" Petersen, a graduate student at the School of Marine Affairs, has been exploring these scenarios, examining the links between global climate change and sea level rise. As the climate gradually warms, the planet's glaciers and ice sheets are starting to melt, contributing meltwater to the already swollen oceans.

As part of his master's thesis work, Petersen has been studying the possible impacts of sea level rise to the shoreline of Puget Sound. He is using computer models to reveal the most vulnerable parts of the Puget Sound basin and, with help from King County and the City of Seattle and guidance from the UW's Climate Impacts Group, has identified several options for local decision-makers to deal with this phenomenon.

Exactly how much the sea will rise over this century is a subject of debate. Early in 2007, the Intergovernmental Panel on Climate Change (IPCC) released a summary document for policy-makers, suggesting that levels could rise from seven inches to about 23 inches by 2099. However, a second prediction by German professor Stefan Rahmstorf of Potsdam University, published in the journal *Science* that same year, was considerably more dramatic: from 20 inches to 4.6 feet by 2100. Adding to this uncertainty is the fact that sea level rise will manifest differently in locations around the globe.

The elevation data for Petersen's project were compiled by David Finlayson, who earned a doctorate in oceanography at the UW. For the areas Petersen studied, much of the data comes from Light Detection and Ranging (LIDAR), a remote sensing system used for collecting topographic data. From these extremely accurate computer-generated maps, Petersen could demonstrate what might happen under moderate, intermediate and severe sea level rise scenarios, reflecting the IPCC's and Rahmstorf's predictions.

The results were eyebrow-raising, from a resident's or business owner's perspective. Petersen learned that, in the scenario of a four-foot sea level rise in Puget Sound, Seattle's Harbor Island and Port of Seattle area would be inundated.

"The base flood elevation in Seattle is slightly more than two feet above ordinary high water," says Petersen. "As such, there would be significant flooding in several places, including the land around Safeco and Qwest fields."

But that's not all. "Sea level rise will not be experienced as simple inundation," Petersen points out. "Rather, it will manifest itself as increased flooding events and physical changes to the flood plain." Flooding that previously occurred once in 100 years might become a once-in-10-years event. Other effects to King County from sea level rise might include landslides, increased rates of coastal erosion and seawater intrusions into freshwater aquifers.

All of these effects are worth identifying, so that actions can be taken to prevent or at least reduce any future losses of property, possessions and people's lives. Helping local government plan and prioritize form a large part of Petersen's studies, but the large degree of uncertainty associated with the impacts of climate change on sea level rise make it difficult for policy makers to use common approaches to addressing future problems, Petersen explains.

"Planners are in a difficult position. They can't say for sure what's going to happen, but they also can't adopt a 'sit back and wait' attitude. It may soon be too late for that. They need to formulate robust policies to address a range of possibilities."

Petersen is hopeful that his studies will help the region face this somewhat daunting task, well before Puget Sound's rising tides reach the two-foot, three-foot or four-and-a-half-foot mark.

Left:, left to right: SAFS Director David Armstrong, SAFS Professor Emeritus Ken Chew, Mae Chew, COFS Dean Arthur R.M. Nowell.

Below: Professor Marc Hershman, School of Marine Affairs.

College Announces Award of Chew Professorship

Colleagues and friends of professor emeritus Ken Chew have cause to celebrate, with the recent appointment of the first recipient of the Kenneth K. Chew Visiting Professorship in Aquaculture.

Dennis Hedgecock is the Paxson H. Offield Professor in Fisheries Ecology at the University of Southern California, where he is Interim Chair of the Department of Biological Sciences and head of its Marine Environmental Biology Section. He visited the UW on May 17 to deliver a presentation on the Top 5 Reasons for Loving Bivalves.

The Chew Professorship was created to enhance the University's ability to attract and retain distinguished faculty in the field of aquaculture. Ken Chew began his career at the UW in 1955 as a student at the College of Fisheries (now the School of Aquatic & Fishery Sciences). He earned his graduate degree in the study of shellfish and, immediately upon graduation, took a job with the College. He has held various positions at the UW, including director of the School of Aquatic & Fishery Sciences and of the Western Regional Aquaculture Center, a nationwide USDA-funded program located on campus.

Chew is a well-known authority on molluscan biology, contributing extensively to invertebrate research and helping develop the shellfish industry in the Pacific Northwest. In 1993, Chew received the Distinguished Undergraduate Teaching Award from the College of Ocean and Fishery Sciences. Prior to his retirement in 2001, he was awarded and recognized by the National Shellfisheries Association, the World Aquaculture Society and other high-level organizations.

Hedgecock's academic record, which couples his expertise in genetics with an understanding of the larger issues of marine ecosystems, made him a strong candidate for the visiting professorship. He has published more than 100 articles on the population and quantitative, evolutionary and conservation genetics of marine organisms, primarily Pacific oysters, white seabass and Pacific salmon.

Marc Hershman: Covering Ocean Policy, Coast to Coast

How does a law student from Philadelphia get interested in oceans?

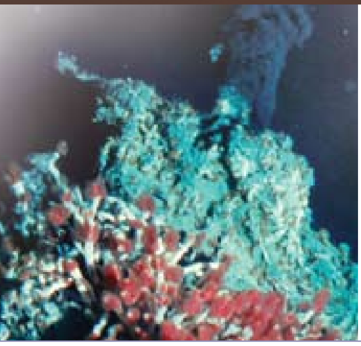
In Marc Hershman's case, it's as simple as family boating vacations on the Delaware and Chesapeake bays. By the time he got to law school, the former Sea Scout knew that he would turn his professional attention to maritime and environmental law. It is this blend that has led Hershman to a prominent role in shaping regional and national ocean policy.

"Eighteen states now have some sort of ocean policy activity going on," Hershman says. "The driver is the growing recognition that oceans and coasts are of enormous economic and recreational importance, and that they are under threat from a suite of problems."

In 2001, President Bush appointed Hershman to the U.S. Commission on Ocean Policy (USCOP). USCOP issued its report, *An Ocean Blueprint for the 21st Century,* in 2004, presenting more than 200 recommendations to improve ocean resource management and policy.

Hershman has been a catalyst for development of ocean policy in Washington state. In 2005, Gov. Christine Gregoire created the Ocean Policy Work Group (OPWG), which included representatives from state agencies, local governments, universities, tribes and other groups. Hershman was a member of OPWG, and he led a group of 20 School of Marine Affairs (SMA) students that provided research and writing support for the working group.

Hershman looks for opportunities to involve students in the policy process, as evidenced by SMA's involvement with OPWG. "We place a strong emphasis on being active in the professional arena," he says. "SMA is building those bridges between what we learn in school and what we do in the world. Students get opportunities to work in real-world situations. They bring it back to the classroom, study it and learn from it, and then take what they learn back out into the community."



Extremes • continued from page 1

Above, left to right:
A Pacific Ocean sulfide chimney known as a black smoker. (Photo courtesy of the University of Washington.)
Oceanography Professor Jody Deming,
Oceanography Professor John Baross,
SAFS Professor Ray Hilborn,
APL Oceanographer Kate Edwards.

Below: Tanzania's Serengeti National Park. (Photo by Ray Hilborn.)

Grant, Deming is currently exploring new techniques to recover exopolymers from psychrophiles without altering the structure or properties of the compounds.

You're Getting Warmer

While Deming studies bacteria adapted to cold and ice, John Baross examines life that exists in conditions of extreme heat and pressure: microscopic sulfur-eating bacteria and other microbes that live around thermal vents on the ocean floor. The water that flows from these vents can reach 570 degrees Fahrenheit, while the pressure can exceed 7,000 pounds per square inch.

In 1979, Baross became one of the first scientists to begin collecting high-temperature microbes near thermal vents for further studies in the lab. Like Deming's psychrophiles, Baross's deep-sea extremophiles have practical potential. "The properties of these extremophiles have potential for use in a number of so-called 'green' industrial processes — environmentally friendly methods for mining metals, extracting oil or making paper from wood pulp, for example," Baross says.

But Baross is also looking at ways that such microbes might have shaped life on our planet. Conditions in Earth's primordial seas might have been similar to those now surrounding hydrothermal vents, favoring the birth and evolution of organisms that can survive under high heat and pressure.

"It's somewhat of an oversimplification to say that the extremophiles we study — in particular, the microbes collectively known as archaea — are 'living fossils.' Even these organisms have undergone gradual change over the millennia," Baross says. "Nonetheless, the archaea are deeply rooted in our evolutionary tree."

In fact, Baross and his then-graduate student Mausmi Mehta have helped cement the evidence that points to high-temperature archaea as the first life on earth. They recently discovered an archaeon capable of fixing nitrogen at a surprisingly hot 92 degrees Celsius. Nitrogen fixation is the process by which nitrogen is taken from its gaseous state and converted into nitrogen compounds useful to land and sea plants, which, in turn, are eaten by higher animals. Baross and Mehta's heat-loving archaeon may represent Earth's earliest lineages of organisms capable of nitrogen fixation.

From Microbes to Elephants

SAFS professor Ray Hilborn's work with population dynamics in the ancient Serengeti ecosystem dates from the late 1970s. He has been traveling to that region regularly since 1991 to conduct research.

Isn't that a little off track for a scientist who's probably best known for working with Pacific salmon? Perhaps. "But after all, I started out in the mouse business," Hilborn notes. (An early research paper of his is entitled *Similarities in Dispersal Tendency among Siblings in Four Species of Voles*.)

Hilborn has modeled the population dynamics of elephants, wildebeest, buffalo, lions and other African species, and he maintains it's not a stretch for a fish guy. "It's similar to fish," he says, "except with fish, you know the catch but have few estimates of the population. In the Serengeti, you have excellent estimates of the population but not the catch."

The tricky variable on the "catch" side of the Serengeti equation is poaching, which occurs on a multi-species basis and is hard to measure accurately. As many as a million wildebeest migrate annually through protected and non-protected areas of the Serengeti, and thousands are harvested illegally each year by local villagers for food. The pressure for poaching is likely to increase as the human population in the region increases.

What is the potential growth rate and impact of illegal harvesting on the wildebeest population? Would increasing the legal harvest of the animals reduce the pressure for poaching and ultimately help conserve this living resource? These are some of the questions that Hilborn's research helps answer.

Thanks to an improved Tanzanian economy, more anti-poaching patrols in the national park, and effective marketing restrictions on ivory and rhinoceros horns, poaching has declined significantly since the mid-1980s, Hilborn says. His research has helped show a definite link between anti-poaching enforcement and recoveries of animal populations, further supporting enforcement as a resource-management tool.

For the well-traveled Hilborn, it's all a labor of love. He looks forward to continuing his work in what he calls "the greatest place I've ever been."

Above It All

When it comes to studying the ocean, Kate Edwards gets a bird's-eye view. The APL physical oceanographer studies air-sea interactions and seasonal fluctuations in the California Current, a biologically diverse and productive ecosystem linked to currents along the Pacific Coast of the United States. Much of her data comes from satellites.

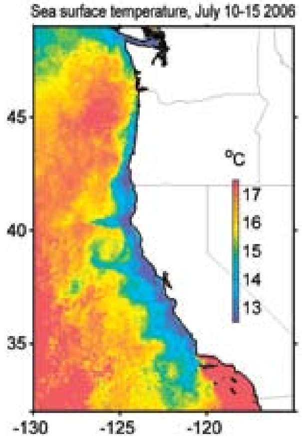
Satellites can measure key ocean surface variables over vast areas, including water temperature, wind speed, and currents. These are derived from satellite-observed quantities like the roughness of the sea surface or the subtle changes in the height of the ocean surface caused by the earth's rotation. Edwards uses those variables to help calculate the transport of heat in specific areas of water.

"Heat is continually exchanged by the ocean and air," Edwards says. "The satellite data help me understand how heat in the ocean is moved around in the California Current. If you extend the current's latitude band all the way around the world, net heat put into the ocean at that latitude is greatest in the California Current."

The upwelling of cooler, nutrient-rich water along the coast supports large populations of whales, seabirds and important fisheries. But there's fragility in this ecosystem. El Niño events can disrupt the current, leading to cascading effects throughout the food chain. The current's sardine fishery collapsed in the 1950s. So it's important to understand how climatic trends may affect the current and its resources.

Edwards also uses data from probes, deployed by container ships, which provide subsurface water temperatures at different depths. "The probes tell you how much heat is contained in a section of ocean. Combining that with satellite data tells you how much heat is moving through a specific section of the ocean."

When Edwards puts all these pieces together, she can develop a picture of the changes in heat in the California Current over the course of a season or a year. Her analysis helps evaluate and correct computer simulations, which have few datasets for validation at this scale, Edwards notes. The U.S. satellite system that observes the earth is a great tool for Edwards and other ocean researchers, but there is concern over future gaps in data collection. Unless funding increases, the number of satellite missions will fall by a third by 2010.



Top: Serengeti elephants. (Photo by Ray Hilborn.)
Above: An infrared satellite image showing water-temperature ranges in the California Current. Red is warmer, blue is colder. (Image courtesy of Kate Edwards.)

Eric Collins (far left) studies bacterial communities in sea ice. Billy Brazelton's work focuses on the microbiology of the Lost City hydrothermal field.

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How's the Work Going? Hot and Cold

Eric Collins and Billy Brazelton share an interest in extremophiles and an office in the Marine Sciences Building, but their field studies are at opposite ends of the temperature spectrum. A student of Jody Deming, Collins has spent six weeks on a ship frozen into Arctic sea ice. Studying under John Baross, Brazelton cruised to the Lost City, a cluster of hydrothermal chimneys in the mid-Atlantic that spews fluids reaching 160 degrees Fahrenheit.

Collins is studying the diversity and survival rates of bacterial communities in sea ice. In winter 2004, he collected samples from Franklin Bay, Northwest Territories, Canada — about 1,500 miles due north of Seattle. He left the ship, a Canadian icebreaker intentionally frozen into the ice, once a week to collect ice cores. Back on board the ship, he melted the ice and studied the single-cell bacteria and archaea that had been trapped within it.

Collins was looking for different kinds of these microbes and how they might change over the course of the winter. He tracked the same communities over the course of 12 weeks, working on the hypothesis that some types would not fare as well as others over the course of the winter as conditions worsened. "But I didn't find a significant change in diversity over that period," Collins says. "All the groups seemed to be surviving at the same rate."

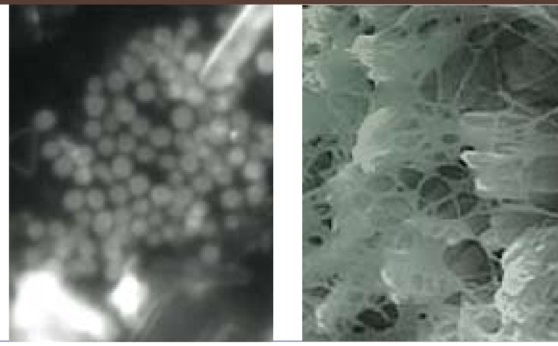
This gave rise to another hypothesis: that all the groups could be benefiting from each other's survival mechanisms, perhaps taking advantage of each other's exopolymers — protective mucous coatings they produce. In fact, his study found an increasing presence of exopolymers in the ice as the winter wore on. In the winter sea ice, Collins identified about 30 different operational taxonomic units, or OTUs, which is a term for a microbe that hasn't yet been assigned a species status.

Back on campus, Collins is now exploring how bacteria might exchange DNA. Working with a sequenced genome (from a bacterium first isolated by another Jody Deming student), he'll look for genes with "abnormal" signatures that might have come from an outside source, yet are helping the bacteria survive. He'll compare such genes with those in other sequenced genomes to see if he can pinpoint their origin. It's not unusual for microbes to pick up foreign DNA, and sea ice is a good medium for that exchange, says Collins. As seawater freezes and chills even further during winter, its impurities — bacteria, viruses, nutrients, etc. — become concentrated in a shrinking volume of liquid within the ice. "With microbes, it's all part of the evolutionary shuffling of genes over a long period of time," Collins notes.

At the UW, Collins works with lab equipment like a food-freezer-sized chest that has been modified to provide a range of temperatures at which he can incubate his salt-requiring bacteria. It allows Collins to determine the optimal temperature at which the bacteria will multiply. It's a far cry from the minus-30 degrees Celsius, 40-knot winds and winter darkness of Franklin Bay. Still, Collins says, he has good memories of the research cruise, including what it's like to be on a frozen planet at a party celebrating the year's first sunrise.

Ice is definitely not the milieu of the microbes being studied by Collin's office-mate, Billy Brazelton. His doctoral work is on the microbiology of the Lost City, a network of volcanic chimneys or vents beneath the Atlantic. He is focusing on the most abundant microbial life there, known as the Lost City Methanosarcinales. The Methanosarcinales are a family of Archaea bacteria known to metabolize methane. Brazelton's particular microbe, one type of Methanosarcinales, doesn't have an official species name yet, because it hasn't been isolated and cultured in a lab — which, for reasons to be explained, is quite difficult to do.

On a research cruise, Brazelton collected samples of the carbonate mineral from the chimneys of the Lost City. His microbes are so abundant there, they coat the



Above left: Eric Collins collecting ice cores at Franklin Bay, Northwest Territories, Canada. (Photo by Nathan VanderKlippe.)

Above right: Images of biofilm created by Methanosarcinales, the subject of Billy Brazelton's research. (Photos courtesy of NOAA and Deborah Kelley.)

chimneys with a biofilm, filling every hole and fissure. Marine biofilms usually contain many different types of microbes, but this one is unique for its formation by a single type. The biofilm hardens quickly when removed from the sea. Back at the UW, Brazelton laboriously extracted the microbes' DNA from his samples and submitted a request to the U.S. Department of Energy's Joint Genome Institute to have DNA sequenced. His request was granted, and Brazelton will complete his doctorate by analyzing the biofilm's genome sequence.

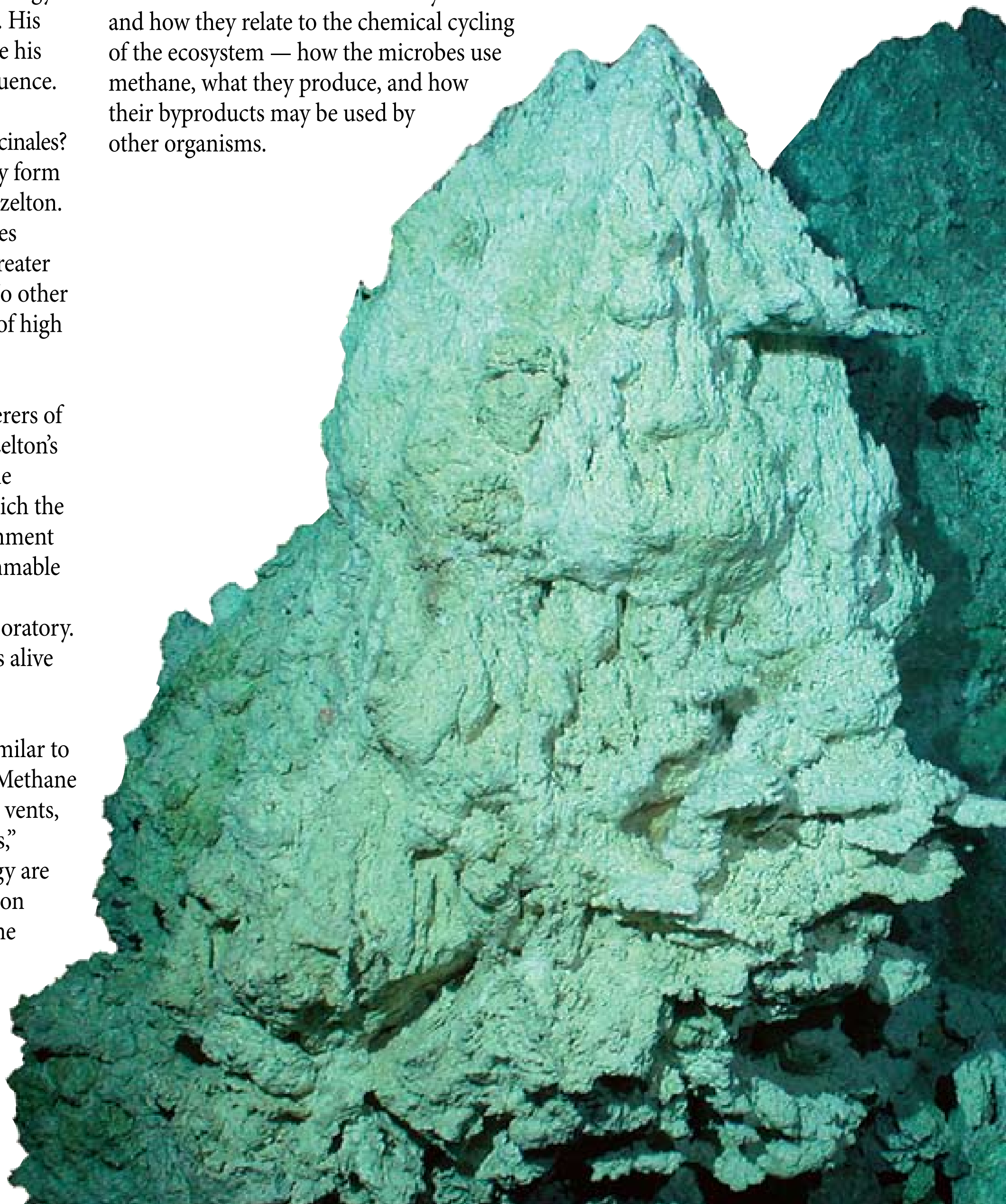
What is so special about the Lost City Methanosarcinales? "They are microorganisms so abundant that they form a mass you can see with the naked eye," says Brazelton. And they do so in water that can reach 90 degrees Celsius, with a pH of 10. (Solutions with a pH greater than seven are considered basic, or alkaline.) "No other marine microbes can grow at that combination of high temperature and pH," says Brazelton.

UW scientist Deborah Kelley, one of the discoverers of the Lost City, describes the environment of Brazelton's microbe as "boiling liquid Drano." Because of the presence of large amounts of methane, upon which the microbes subsist, Brazelton says that the environment "is not only boiling liquid Drano, it's highly flammable boiling liquid Drano." Understandably, this is a condition that is difficult to reproduce in the laboratory. Brazelton has been unable to keep his organisms alive in the lab for more than a couple of months.

In fact, these unusual conditions may be very similar to those found in other parts of the solar system. "Methane is part of the geologic process that produced the vents, and the exact same process is occurring on Mars," says Brazelton. "The implications for astrobiology are obvious. A huge mass of microorganisms living on methane and hydrogen — it's not hard to imagine such life existing deep in the subsurface of Mars or the ocean of Europa, a moon of Jupiter."

The actual surfaces of both Mars and Europa are deeply frozen, linking the work of these two office mates. Collins has detected some microbes in his Arctic ice that may also be methane consumers.

Brazelton's microbes represent a single species, but with variations. Like Collins, Brazelton is interested in whether there is some cooperation or exchange mechanism within the community that helps the organisms adapt to and exist in their strange environment. His dissertation will also explore the metabolic activities of the Lost City Methanosarcinales and how they relate to the chemical cycling of the ecosystem — how the microbes use methane, what they produce, and how their byproducts may be used by other organisms.



Below: A carbonate chimney pinnacle from the Lost City hydrothermal field in the Atlantic Ocean. (Photo courtesy of the University of Washington.)

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Summer (Working) Vacations in Alaska

COFS students don't have to be doing postdoctoral work to find excellent and exotic research opportunities. Two enterprising undergraduate students in the School of Aquatic & Fishery Sciences (SAFS) will travel north to Alaska this summer, expanding their academic and geographic horizons.

Benjamin Frable just completed his freshman year. This summer, he will serve as an intern with the Alaska Fisheries Science Center of the National Oceanic and Atmospheric Administration. Frable will help conduct research on the ecology of the deep-sea coral *Paragorgia arborea* in the Aleutian Islands.

Frable received a SAFS recruitment scholarship in 2006-07 and has been awarded another scholarship for 2007-08. A well-rounded student, to say the least, he is majoring in biology: ecology and evolution, with a minor in classical and ancient history.

Frable is grateful for a chance to take a two-week research cruise and study coral that can live at ocean depths of more than 4,000 feet. His choice to pursue studies at SAFS was natural. "I have loved the ocean and its inhabitants since I was seven years old, and I want to devote my life to it," he says.

Junior William (Will) Atlas is headed to Lake Iliamna, where he'll work with the SAFS Alaska Salmon Program. He says he's looking forward to gaining experience in fieldwork and managing field biology and data collection. He's grateful for the research opportunity, adding, "I'm really excited about seeing Alaska and one of the most productive salmon ecosystems in the world."

At Lake Iliamna, Alaska's largest lake, Atlas expects his research group to be "pretty well outnumbered by grizzlies." The group will be collecting data in creeks where bears are actively foraging on spawning salmon.

Like Frable, Atlas has a long-standing interest in his subject matter. "I wanted to study fisheries because of a lifetime passion for the outdoors and an interest in freshwater ecology," he says.

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