Shores are eroding along this Cook Inlet estuary near Anchorage, Alaska.

PHOTO: AAAS/GAVIN STERN

The great Arctic experiment

Climate change is affecting the region's estuaries, politics, and what it means to go home

By **Gavin Stern**

Alaska's estuaries aren't home to many species. But a great diversity of life passes through these brackish, murky waters.

Climate change is altering these estuaries—which bridge freshwater ecosystems and the ocean—in ways that scientists lack the data to thoroughly understand. With the environment changing rapidly, there may not be much time to make baseline measurements.

"This is the experiment, the Arctic. Things are changing so fast, we may not be able to study it fast enough," said Todd Radenbaugh, assistant professor in environmental science at the University of Alaska Fairbanks. "Estuaries are a conduit between terrestrial rivers, mountains, and the ocean. If you're a fish traveling through that, you must go through an estuary."

The roles of species in these estuaries are not well understood, Radenbaugh said at the 2015 Arctic Science Conference, in large part because estuaries are difficult habitats to study. The environment is constantly changing with the tides and includes elements of both rivers and marine systems. Despite the unknowns, estuaries are among the most productive ecosystems in the world, used by many species for food, breeding, and migration.

The health and sustainability of estuaries in the face of climate change was the focus of the conference, the annual meeting of the AAAS Arctic Division. The University of Alaska Anchorage hosted the 1 to 3 October meeting, which was attended by researchers from the life, physical, and social sciences in addition to artists and educators.

The Arctic, which is warming twice as fast as in lower latitudes, according to the NOAA Arctic Report Card, is a bellwether for what will eventually occur in more populated southern regions, said Larry Duffy, executive director of the AAAS Arctic Division.

"What we see happening in the north within the biota and the physical environment will happen later at lower latitudes, but with a much bigger impact," said Duffy, who is also a professor of biochemistry at the University of Alaska Fairbanks. "When we talk here about a village of 500 people being eroded away, that's a problem. But when we talk about New York and New Jersey losing a portion of their coast due to sea-level rise—that's a big problem."

In Alaska's estuaries, climate change affects more than just water temperature. Melting glaciers change the water's chemistry and influence what species can survive, both in the ocean and further inland. Fish are particularly sensitive to chemical changes, which can affect how they navigate, Radenbaugh said.

Many of the scientists at the meeting agreed that the ecological effects of climate change on estuaries need further study and that these environments must be monitored. Since scientists don't have a good way to make predictions, they said that it is difficult to develop policies flexible enough to adapt to changing conditions, such as when to catch fish and when to let stocks recuperate.

The unknowns will have both tragedies and positive opportunities associated with them, said plenary speaker Daniel Schindler, an ecologist and professor at the University of Washington.

"We can make decent predictions about physical systems like the atmosphere and oceans. But our track record in ecological systems is pretty meager," Schindler said. "What we want is the ability to maintain flexibility so when one fish stock unexpectedly explodes, we have policies that let people go catch them, make a living off them, and eat them. Everything cannot be bad—there's no way."

HOW BEST TO ADDRESS GLOBAL CLIMATE CHANGE is to a large extent a political issue, with the East and West arguing over who is most responsible for greenhouse gas emissions. That argument is expected to take center stage at the 2015 United Nations Climate Change Conference in Paris beginning on 30 November.

Cumulatively, the United States and the European Union countries are responsible for about half of the emissions produced since the Industrial Revolution, while China lays claim to 11%, said plenary speaker Alexios Antypas, director of the Center for Environment and Security at Central European University in Hungary, citing data from the World Resources Institute.

But today, China is "by far" the biggest emitter of carbon dioxide, Antypas said, responsible for 24% of the global greenhouse gas output in 2011. That's about the same emissions as the United States (15%) and European Union (10%) combined.

"This is a real different place where we're at now. It tells you a lot about the bargaining power. By far the most powerful actor of this is China," Antypas said, noting that China and India will be responsible for much of the future load.

"Everyone else is either staying the same, growing slowly, or gradually decreasing," Antypas said, including the United States, which has seen a decline back to 1994 emissions levels.

But when adjusting for population, the most responsible party becomes less clear. With a population of 34.3 million, Canada was the clear frontrunner in per capita emissions in 2011, followed by the United States, Russia, Japan, and the European Union.

The Chinese are well aware that much of their greenhouse gas output is due to American companies outsourcing their production, Antypas said. Fortunately, there are two clear leaders who can shape emissions policies.

"The rest of the world will go where the U.S. and China go—if they go together," Antypas said. "China is in a position to lead the rapidly developing countries, and the U.S. is in a position to lead the developed countries."

Climate change takes a psychological toll on Arctic communities, said social worker Mary Dallas Allen.

SEVERAL SESSIONS AT THE CONFERENCE were dedicated to the effects of climate change on human settlements. About 4 million people call the Arctic their home, many in indigenous communities that have lived in connection with the land for many years. They rely in large part on subsistence hunting and fishing.

As melting ice leads to new possibilities for shipping, drilling, and other industrial activities, "a lot of people are looking at the economic opportunities. But people up here are looking at some very significant threats," said Diane Hirshberg, director of the Center for Alaska Education Policy Research at the University of Alaska Anchorage. "The immediate change has already happened for indigenous communities—people falling through the ice when they're using traditional ice routes. Whalers have lost their lives or had to be rescued because the ocean is unpredictable. Animals aren't migrating in the same patterns, which causes food insecurity."

Arctic communities are facing an increased frequency and severity of extreme weather events, changes in seasonality, and impacts on their terrestrial and marine ecosystems. Traditional ice paths are disappearing, tree lines are increasing, and riverbanks are eroding, according to Mary Dallas Allen, associate professor at the University of Alaska Anchorage School of Social Work.

Later freezing and earlier breakup of ice disrupts travel, infrastructure, and subsistence hunting activities. Food that is traditionally stored in cellars is going bad. Parents are deciding that it's not safe to take their children on hunting and other traditional food-gathering outings, resulting in cultural loss.

Arctic communities are losing what it means to be home, Allen said, which is having significant social, emotional, and psychological effects.

Even for children to get to school, many communities rely on stable ice to get across rivers that have always been frozen, Allen said. With unstable ice, children miss school. Or, getting to school is scary and unsafe.

"Climate change is affecting people's lives every day," Allen said. "When people are losing homes, livelihoods, and the safety net of their communities, there are associated mental health challenges. They experience depression, anxiety, posttraumatic stress, increased substance abuse, and higher rates of suicide." ■

Awards honor early-career women in the chemical sciences

The inaugural AAAS Marion Milligan Mason awards recognized four outstanding chemists and mentors

By **Kathy Wren** *and* **Andrea Korte**

Luisa Whittaker-Brooks wants to create a material that can be used to harvest ambient heat—from our bodies, for example—and turn it into electricity.

This material will need to be a good electrical conductor, but it mustn't be thermally conductive or the heat would escape from the system. So Whittaker-Brooks, an assistant professor of chemistry at the University of Utah, is working on integrating organic and inorganic materials—essentially, plastics and semiconductors—at the nanoscale. Because these two types of materials "don't like each other," as she says, Whittaker-Brooks must manipulate the interfaces between the particles to encourage them to mingle.

This is just part of a master plan, whose ultimate goal is creating a device that can capture and store both thermal and solar energy, to continuously produce electricity. Such ambitious research can be tricky for early-career scientists, who too often find themselves in a Catch-22–like situation with regard to funding, especially when they want to do "high-risk, high-reward" research that could potentially lead to major breakthroughs.

"As an early-career scientist, this is very difficult at times, to get the funding for high-risk research," said Alison Fout, an assistant professor of chemistry at the University of Illinois at Urbana-Champaign. "We need preliminary results, we need data, we need publications, and then we need to get that funding. And as you can imagine, all that takes time, and time costs money."

Fout and Whittaker-Brooks now have the means to tackle this problem, however, because they and two other early-career chemists have won the first AAAS Marion Milligan Mason Awards for Women in the Chemical Sciences. The group—which also includes Kristin Parent, an assistant professor of biochemistry and molecular biology at Michigan State University, and Katherine Mackey, an assistant professor of Earth system science at the University of California, Irvine—was recognized at a 15 October award ceremony at AAAS.

The awards, made possible by a $2.2 million bequest to AAAS, provide each chemist with $50,000 to ramp up their research projects while mentoring their own students.

A chemist and long-time AAAS member, the late Marion Tuttle Milligan Mason wanted to support the advancement of women in

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