The looming threat of rising sea levels—and what we can do about it

December 13 2019, by Alison Auld

Patricia Manuel, pictured on the Halifax waterfront boardwalk. Credit: Danny Abriel

For more than two decades, Patricia Manuel has watched the waters rise around her.

Whether in Atlantic Canada, the Netherlands, Iceland or along the eastern seaboard, the environmental planner has witnessed the range of damage done by encroaching tides, storm surges and rising water levels in coastal communities now increasingly vulnerable to oceans in flux.

The tally of losses includes everything from the ordinary to the exceptional: a newly built boardwalk swamped by swelling tides in western Newfoundland; drowned forests; a wharf submerged during the highest tides in a seaside Nova Scotia village, where rising water levels now encroach on historic shoreline buildings—often the heart of coastal towns now at increasing risk of tidal and storm surge flooding. Or the impact on her hometown of Halifax, where potent hurricanes have sent water surging onto the city's picturesque shoreline, damaging buildings, ripping up wharfs and flooding a road that feeds traffic into the downtown core, despite seawalls meant to fend off the rising tides.

For Dr. Manuel, a professor at Dalhousie University's School of Planning, they are all just signs of the growing threat posed by sea level rise and the pressing need for coastal communities to prepare for it. "Tides are reaching further in land at their highest extent," she says. "The tidal zone is moving land-ward and that means that areas where the tide had not previously reached are now being inundated."

An accelerating threat

The gravity of the challenge was recently outlined in an exhaustive report by the United Nations-led Intergovernmental Panel on Climate Change, which issued a stark warning about how the unprecedented rate of rise will only worsen if little is done to stem greenhouse-gas emissions and global warming.

The report found that the global sea level rose by around 15 centimetres during the 20th century, but "is currently rising more than twice as

fast—3.6 millimetres per year—and accelerating." The rate of rise was 2.5 times faster from 2006 to 2016 than it was for nearly all of the 20th century.

The report explains how sea level rise occurs when glaciers and ice sheets lose mass, with much of that meltwater coming from Greenland and Antarctica. The rise is also caused by the thermal expansion of warming waters and human activities, such as groundwater depletion. The authors caution that sea level will continue to rise for centuries and could go up by a metre by 2100, "even if greenhouse gas emissions are sharply reduced and global warming is limited to well below 2°C."

If emissions are left unchecked, scientists expect that billions of people could be displaced by sea levels that rise several metres by 2300. Rising seas and higher tides also threaten habitat for vulnerable species, historically significant sites—such as Fortress Louisburg, for example, in Nova Scotia—and could contaminate water supplies and agricultural lands.

In Atlantic Canada, it's predicted that relative sea level rise over this century is expected to outpace the global average and will come with a heavy price tag. According to an expert report commissioned by the Canadian government earlier this year, sea level rise and storm surges could cost billions in damages for the roughly 6.5 million people living along Canada's 243,000 kilometres of coastline.

The report, Canada's Top Climate Change Risks, warned that in some areas on the eastern coast a 50-cm rise in sea level "would inundate causeways, bridges, some marine facilities and municipal infrastructure, with replacement valued in the hundreds of millions of dollars."

"We have this historic waterfront in Halifax. It was built when sea level was about a metre lower. The buildings are now closer to the tideline and

are at sea level, so this is something that we need to be thinking about and how we are going to respond to sea level impacts," says Dr. Manuel.

On the west coast, thousands of hectares of agricultural, residential and industrial land are "vulnerable to inundation by a one-metre sea-level rise in the absence of protective structures," the report states. It adds that almost 300,000 people in greater Vancouver live at or below sea level, protected by 127 km of dikes not designed to accommodate sea level rise.

In financial terms, a 2016 report estimated that sea level rise and storm surges could reach more than $50 billion in present-value costs. Much of those were expected to be incurred in British Columbia at sites that may not be prepared for rising waters.

That is where Dr. Manuel comes in.

Collaborative solutions

Together with researchers at Canadian institutions, Dr. Maunel is studying the various ways municipalities can prepare for and adapt to sea level rise, while also providing guidance on how to better situate land-based activities with respect to the coast. She is working with Eric Rapaport, also with the School of Planning, Kate Sherren, an associate professor in Dalhousie's School for Resource and Environmental Studies, and Dr. Danika van Proosdij at Saint Mary's University on an initiative called "Making Room for Movement." Their work is funded by Natural Resources Canada.

The project is looking at nature-based strategies—an ecosystem-inspired approach to sea level rise that is gaining traction around the world. It can involve conserving or restoring coastal ecosystems, like dunes, wetlands and reefs, as a way to provide natural shoreline protections. Wetlands,

for example, can reduce the force of waves and act as obstacles to storm surges, while also trapping sediment and stemming erosion. They also serve as important carbon stores, but it's estimated that roughly half of the world's coastal wetlands have been lost over the last 100 years to human activity and extreme weather events.

The nature-based approach is appealing because it can be cheaper and more effective than building walls or other hard surfaces meant to keep rising seas at bay.

"We can build hard barriers, we can put in dams, we can put in sea walls, we can put in revetments to protect against erosion—but that stuff breaks down and you have to be renewing it and building it up higher as sea level rises," says Dr. Manuel, who has been teaching and researching environmental planning since the late 1980s and began work on planning approaches for sea level rise adaptation to sea level rise in the mid-2000s.

"There is more and more recognition that allowing natural processes to occur and also using natural structures in place of hard infrastructure is more of a long-term strategy, where instead of hardening the shoreline you keep it natural or reintroduce nature back into the shoreline because if given enough space it will help in the long term."

A team, led by Saint Mary's University and involving Dal researchers, is evaluating that strategy in Nova Scotia's Annapolis Valley, a region known for iconic dike lands that span the coast and are a cultural treasure for local residents. They are at the heart of research that Kate Sherren is doing as one part of a national $5.5-million project funded by the Natural Sciences and Engineering Research Council that will monitor so-called ecosystem services, or the benefits people get from nature.

SEA LEVEL RISE
BY THE NUMBERS:

Estimate of residual damage costs under a high-end sea level rise scenario:

$1.7 TRILLION - $5.5 TRILLION (USD) OVER THE 21ST CENTURY.

From Responding to Rising Seas, (OECD) 2019

Region in Canada that will see greatest relative sea level rise over the century:

THE ATLANTIC

From Canada's Top Climate Change Risks, 2019

Greatest source of global mean sea level (GMSL) rise:

GLACIER AND ICE SHEET LOSS

Sea level rise since 1880:

23 CM

Average annual rise in sea level since 2000:

3.2 MM

Percentage increase in the frequency of high-tide flooding on the U.S. coast compared to 50 years ago:

300% - 900%

Number of the world's largest cities that are near the coast:

8 OUT OF 10

Projected global average sea level rise by 2100 if greenhouse gas emissions are sharply reduced:

30 TO 60 CM

IPCC: Special Report on the Ocean and Cryosphere in a Changing Climate, 2019

Credit: Dalhousie University

Dr. Sherren's team will spend five years studying the cultural value of dike lands, the ecosystem services they provide, how they protect the coastline and which, if any, could be restored to salt marshes. Some of that work will involve talking to people about their ties to the dikes, which the Acadians began converting from salt marshes to rich agricultural lands in the 1600s.

The challenge now is that much of the 240 km of dikes that protect 17,400 hectares of residential, industrial, recreational and commercial land in Nova Scotia aren't robust enough to cope with increased sea levels and storm surges, Dr. Sherren says.

"What we're doing is leading a science campaign to understand how dikes and salt marshes provide ecosystem services over time and we're going to put all of that together into modelling and decision-making, so it's going to be important," she says, adding that the work may also involve changing perceptions around nature-based protections.

"We know that salt marsh and wetlands provide a buffering protection, but we don't know how to trust them yet and that's very much a mindset —we trust things that we build, we don't trust things that build themselves."

Ultimately, the researchers will provide their findings to the Nova Scotia Department of Agriculture as it determines the fate of the dike lands and whether they should be reinforced, realigned or restored as salt marshes.

A sinking feeling

There is an added urgency to the threats posed by sea level rise in parts of the East Coast, where a geological phenomenon called isostatic adjustments cause the land to sink, dealing a double blow to communities grappling with rising seas. In Halifax, for example, sea level rose at a rate of about 3.3 mm per year during the 20th century, giving it one of the most severe rates in the country. About half of the increase is global sea level rise and the other half is a result of subsidence.

"Certainly, throughout all of Nova Scotia we are subsiding—some places more than others—and water is rising," says Dr. Manuel. "There are other places in the world where that is happening, but it does make our situation more difficult."

That poses critical questions for municipal planners on how to best protect existing infrastructure on the city's popular waterfront and control future development. As Dr. Manuel puts it, the shoreline has long been considered an an amenity sought after by developers and homeowners. But she says that thinking may have to change as the risks from rising sea levels, storm surges and shifting tide lines continue to mount.

"Let's face it, there are certain things that need to be at the shore, but do you need your condominium right on the shoreline? Do you need an art gallery right on the shore?" she says. "We love our coast and that's the problem. We love it too much and then we do things that imperil us and cause problems for others."

The Department of Oceanography at Dalhousie has a longstanding interest in the scientific aspects of sea level rise and the long-term implications for coastal communities when it comes to coastal flooding

caused by extreme weather.

Keith Thompson, a jointly appointed professor in the Department of Oceanography and the Department of Mathematics and Statistics, brings a unique perspective to the issue. His research looks at the physics that explains the way storm surges are generated and interact with the tides, and also the development of statistical methods for quantifying the changing risk of flooding under future scenarios of sea level rise.

Dr. Thompson worked with a former Dalhousie graduate student, Natacha Bernier, to create a computer model that could accurately forecast surges from the northern tip of Labrador to the Gulf of Maine. A modified version of the model is being used by Environment Canada and Climate Change to provide five-day forecasts of East Coast flooding on a daily basis.

The same surge model has been used to quantify changes in the probability of coastal flooding 50 to 100 years into the future, taking into account uncertainty in global sea level rise associated with, for example, the melting of land-based ice from Greenland and Antarctica.

"In the short-term, changes in the frequency and strength of storms can be an issue, but the relentless increase of global sea level is the big, scary monster when you start looking 50 to 100 years into the future," he says. "And that's where the Halifax waterfront could be in real trouble—a global sea level increase of about a meter would be like adding another spring tide to the highest flood levels we've experienced in Halifax over recent decades."

Kevin Quigley, director of the MacEachen Institute for Public Policy and Governance at Dalhousie University, says the extensive damage and widespread power outages caused by increasingly powerful storms, like hurricanes Juan and Dorian, reinforce the need for smart coastal

planning.

"What we do need to think about in the medium term is how do we build communities that are not so directly exposed to risk of flooding because of increased flood levels," he says. "We need to stop building in flood-prone areas and we need to start thinking about compensation programs for properties that are just not inhabitable."

It is a forbidding prospect for low-lying jurisdictions around the globe now forced to consider the possibility that their communities may no longer be safe if sea levels continue to rise.

Research published this fall suggests that land now occupied by 300 million people could be affected by floods at least once a year by 2050 unless carbon emissions are significantly reduced and coastal defences strengthened. The new figure is more than three times higher than a previous estimate of 80 million people being affected, with most of those in developing countries in Asia. In Indonesia alone, 23 million people are now considered to be at risk of coastal flooding. The estimate comes after the government recently announced it was relocating the capital of Jakarta because it is sinking at an alarming rate and that part of it could be entirely submerged by 2050.

Dr. Manuel says people living in delta states or small islands in developing nations are particularly vulnerable because there is little room for retreat and they may not have enough money for protective engineering work.

"Such situations could lead to climate-change refugees," she says. "How do we respond? Opening up new territory to development in highly vulnerable places is folly and not responsible."

The stark projections serve as a call for scientists in various disciplines,

municipal planners and policy makers to work together in addressing the complex problem, says Anya Waite, scientific director of the Ocean Frontier Institute at Dalhousie.

It is particularly important that researchers talk to each other because of the multiplicity of issues contributing to rising sea levels—subsidence, glacial melt, warming waters and greenhouse gas emissions, she says.

"It's the interaction of all of those things that we need to understand to really protect coastlines and that's why you need natural scientists working closely with and talking regularly to the social scientists who are working on aspects such as mitigation, like Dr. Manuel," says Dr. Waite. "Even just shifting that conversation is success and at the OFI we are moving towards that success by facilitating ocean conversations across disciplines."

Provided by Dalhousie University

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