OCEANWATCH

SPOTLIGHT

Canada's Changing Oceans: Impacts Of Climate Change

Ocean Wise, Neil Fisher | *Coastline outside of Pangnirtung, Nunavut.*

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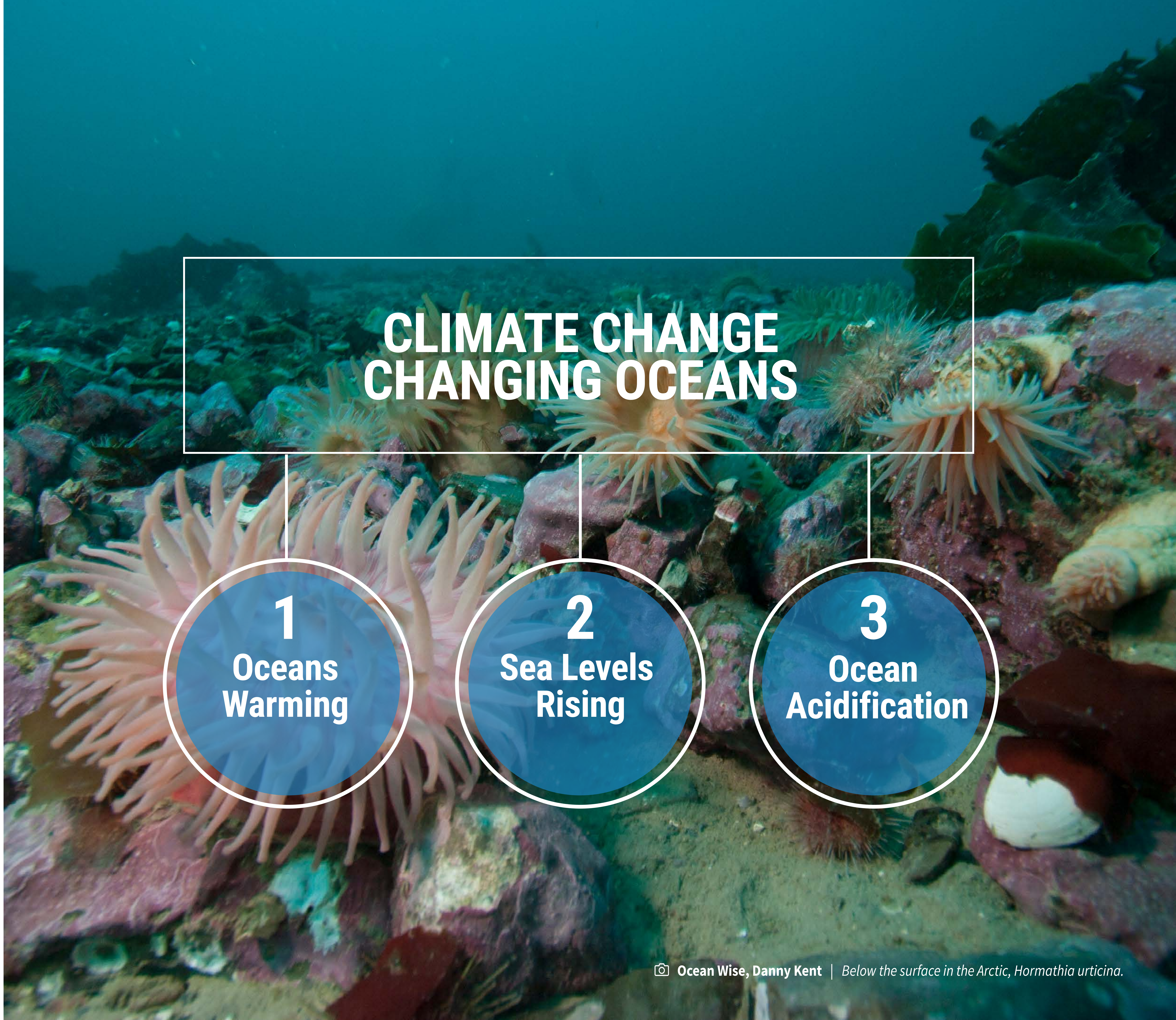
This report focuses on the impacts of climate change in our ocean rather than explaining what climate change is.

Overview

The ocean supports all life on Earth. However, climate change is causing ocean warming, ocean acidification and raising sea levels. All of which negatively impact biodiversity, habitats and ecosystems, along with the essential services they provide to human wellbeing.

This spotlight report looks at some of the impacts of climate change on our oceans, with a Canadian focus. We introduce and explore three climate change impacts using examples from Canadian oceans: ocean warming, sea level rise, and ocean acidification. We also highlight two Ocean Wise initiatives – ***Seaforestation:*** where researchers plan to both restore kelp and help kelp farms scale-up their production to increase biodiversity, protect shorelines from erosion, and sequester carbon as a climate change mitigation strategy; and ***The Changing Arctic Ocean***: where researchers continue their work alongside Northern Indigenous communities to monitor and track changes in sea ice, and the implications of reduced sea ice coverage on underwater noise, species, and habitats in the Arctic.

Restoring the health of our oceans requires widespread education and awareness of the issues being faced, along with motivation to improve the situation. Our spotlight report offers a list of actions anyone can take to reduce their personal carbon footprint and help care for our oceans.



Ocean Wise, Danny Kent | *Below the surface in the Arctic, Hormathia urticina.*

Ocean Wise, Eric Solomon | *Ice berg floating in Pangnirtung, Nunavut.*

Introduction

Oceans cover around 70 per cent of Earth's surface. They provide many essential ecosystem services to humans – scientists estimate that 50-80 per cent of the oxygen production on Earth comes from the ocean;[1] they supply food for around 3.3 billion people[2] and jobs for at least 40 million people;[2] and allow international transportation of goods. Oceans regulate the climate, both locally and globally; they help absorb and store carbon dioxide produced by human activities; and absorb heat trapped in our atmosphere by greenhouse gases (GHG)[i]. However, since pre-industrial times (approximately 1850s onwards), many human activities that emit GHGs have dramatically increased, driving a process known as climate change[ii]. Left unchecked, climate change will have catastrophic global consequences.[3]

Canada has the longest coastline of any country in the world, bordered by three oceans – the Arctic, the Pacific, and the Atlantic Oceans. On average, Canada is warming at almost twice the rate of the rest of the world.[4] This accelerated warming is being felt just as much in our oceans as on land. Much like land-based heat waves, marine heatwaves[iii] are being observed more often, are lasting longer, and are becoming more intense.[5] Sea ice melt seasons are changing, the ice is becoming thinner, and coverage has decreased by 40 per cent since 1979.[6] Glaciers are melting faster than ever seen before in recorded history,[7] contributing to rising sea levels. The oceans are becoming more acidic than they have been in at least 20 million years.[8] These changes are making survival and reproduction more difficult for some species.

While there are other impacts of climate change occurring in our oceans, this spotlight report focuses on these three key impacts of climate change on our oceans – ocean warming, sea level rise, and ocean acidification – using examples from Canada's coastal marine environment to highlight each issue. We also highlight carbon sequestration as a potential natural climate solution to mitigate some of these impacts.

Oceans are intricately linked to weather and climate patterns, which affect everyone and everything. Understanding some of the key impacts of climate change on our oceans is crucial to know what actions we can take to mitigate and address the issues. A list of recommended actions is provided at the end of this report to help mitigate and adapt to some of the impacts of climate change in our oceans.

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i. Greenhouse gases (GHG) include, but are not limited to, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons.

ii. Climate change refers to shifts in long-term (i.e., 30 years or greater) patterns of weather, including variations in temperatures, precipitation levels and/or extreme weather events. And while climate changes naturally over long periods, it is now clear that human activities have been responsible for the majority of warming experienced over the past 150 years.[44]

iii. Marine heatwaves - When the temperature of the 90th percentile is exceeded for five straight days, this is considered a marine heatwave and is an extreme condition, like a heat wave on land. This is a rare occurrence.[13]

Issue 1

Oceans Warming

Human activities are producing GHG at a rate that has been rapidly increasing since the 19th century, resulting in more heat being trapped in our atmosphere. Oceans have absorbed approximately 90 per cent of this excess heat,[iv] resulting in unprecedented ocean warming, which is threatening life both on land and in the ocean.

In 2020, the average ocean temperature in the Northern Hemisphere was 0.99°C above the average for the 20th century, making it the warmest year on record since reliable record keeping began in 1880.[9] Most of this warming has been observed in the upper layers of the oceans[v, 9] however, it likely extends to much greater depths.[vi, 9] Because oceans play such a vital role in life on Earth, and their biology is strongly affected by temperature, warming ocean waters have direct and indirect negative impacts on many aspects of life both above and below water.

Marine heatwaves have become the new norm.[5] To escape not only these heatwaves, but also generally increasing water temperatures, marine species are migrating both to deeper waters[10] and towards the cooler polar regions.[11] For example, Pacific sand lance (*Ammodytes hexapterus*), a forage fish[vii] species, have expanded their natural habitat range from waters south of the Bering Strait to the Canadian Arctic where their presence could impact the stability of the local food web.[12] Other species are starving to death because their prey are migrating to deeper waters to escape warming. For example, between 2013-2016,[13] around one million marine birds along the Pacific coast starved to death after they could not find enough food during a prolonged marine heatwave because their prey largely disappeared, and competition with other predators increased for what little prey remained within foraging range.[14]

A vital implication of ocean warming is that warmer water holds less oxygen, leading to decreased oxygen content in the ocean, specifically in areas with very low oxygen concentrations – known as hypoxic or dead zones[viii]. Expansion of low oxygen areas can cause local reductions in biodiversity, and in extreme cases, extirpation.[ix] For example, in a mass mortality event in 2019 in the Atlantic, near Cape Cod Bay, U.S.A., in a zone where scientists found extremely low oxygen levels, commercial lobstermen pulled up dead lobsters, crabs and fish.[15] Because of the interconnectedness of different ecosystems, an overall decrease in dissolved oxygen production and content in oceans[16] could eventually have far reaching consequences beyond local biodiversity impacts.

Infectious diseases, such as those caused by the marine bacteria *Vibrio* species, are increasing around the world,[17] because warmer waters provide optimal conditions for rapid bacterial replication.[18] The season for infections with these bacteria, traditionally seen in summer months, is now starting earlier and lingering longer.[19] Harmful algal blooms, which produce a variety of biotoxins that can be harmful and even fatal to various wildlife and humans, are becoming more frequent and persisting longer due to rising temperatures.[20]

Another significant impact of warming ocean waters is thermal expansion, whereby warmer waters take up more space, and contribute to sea level rise, along with melting glaciers and sea ice (discussed further in the next section). However, it is in the Arctic that ocean warming is the most visible. In the Canadian Arctic, sea ice provides habitat and/or food for most species. This region is warming at a rate and magnitude never seen before – almost three times the global average.[21] Year after year, sea ice coverage is rapidly decreasing, the sea ice melt season is starting earlier and finishing later, and sea ice thickness is decreasing, making the ice less stable for those animals that rely on it for survival.[6, 22, 23]

Ocean Wise, Eric Solomon | *Coburg Island pack ice in the Arctic.*

iv. Between 1971 and 2010
v. Upper layers of the Oceans considered as depths of 0-700m (for reference Mount Everest is 8,848m high).
vi. Depth >2000m
vii. Forage fish - small schooling fishes, that provide abundant food for upper trophic feeders, such as salmon, birds, and seals.
viii. Hypoxic zones can be created by increased nutrient run off and/or decaying organisms, such as dead phytoplankton sinking to the bottom after a bloom dies, using oxygen in the decay process; warming waters hold less oxygen, which exacerbates this situation.
ix. Extirpation – local extinction of a species.

Spotlight 1

Walruses On Thin Ice

Once, walruses (*Odobenus rosmarus rosmarus*), the largest of the pinnipeds[x], could be found along the entire Northwest Atlantic coastline. However, their natural range has contracted, primarily due to hunting. Today, Canadian populations are only found in the High, Central and Low Arctic, where they are considered a species of Special Concern[xi]. Climate change further threatens their survival.

A study by Dr. David Rosen (2020), in collaboration with Ocean Wise, looked at the metabolism of two juvenile walruses under human care[xii] to better understand how a warming climate could impact the energy requirements of young walruses in the wild. Information on energy demands in walruses was previously unavailable. Earlier studies relied on data collected from other pinniped species, such as Steller sea lions, to inform about energy requirements of walruses.

Despite their size, walrus prey typically consists of bivalve molluscs and other benthic[xiii] invertebrates, for which they must leave the ice to swim and forage.

Due to the immobile nature of their prey, it was assumed that walruses would have a lower energetic demand when swimming compared to other pinnipeds. However, this was not the case. Although walruses have a lower resting metabolic rate than other juvenile pinnipeds after taking various factors into account, such as body size and shape, they use considerably more energy than other pinnipeds when swimming. Thus, receding sea ice means walruses must swim further and spend longer foraging to meet these increased energy demands, leaving them more vulnerable to predation and with less energy for growth and reproduction.

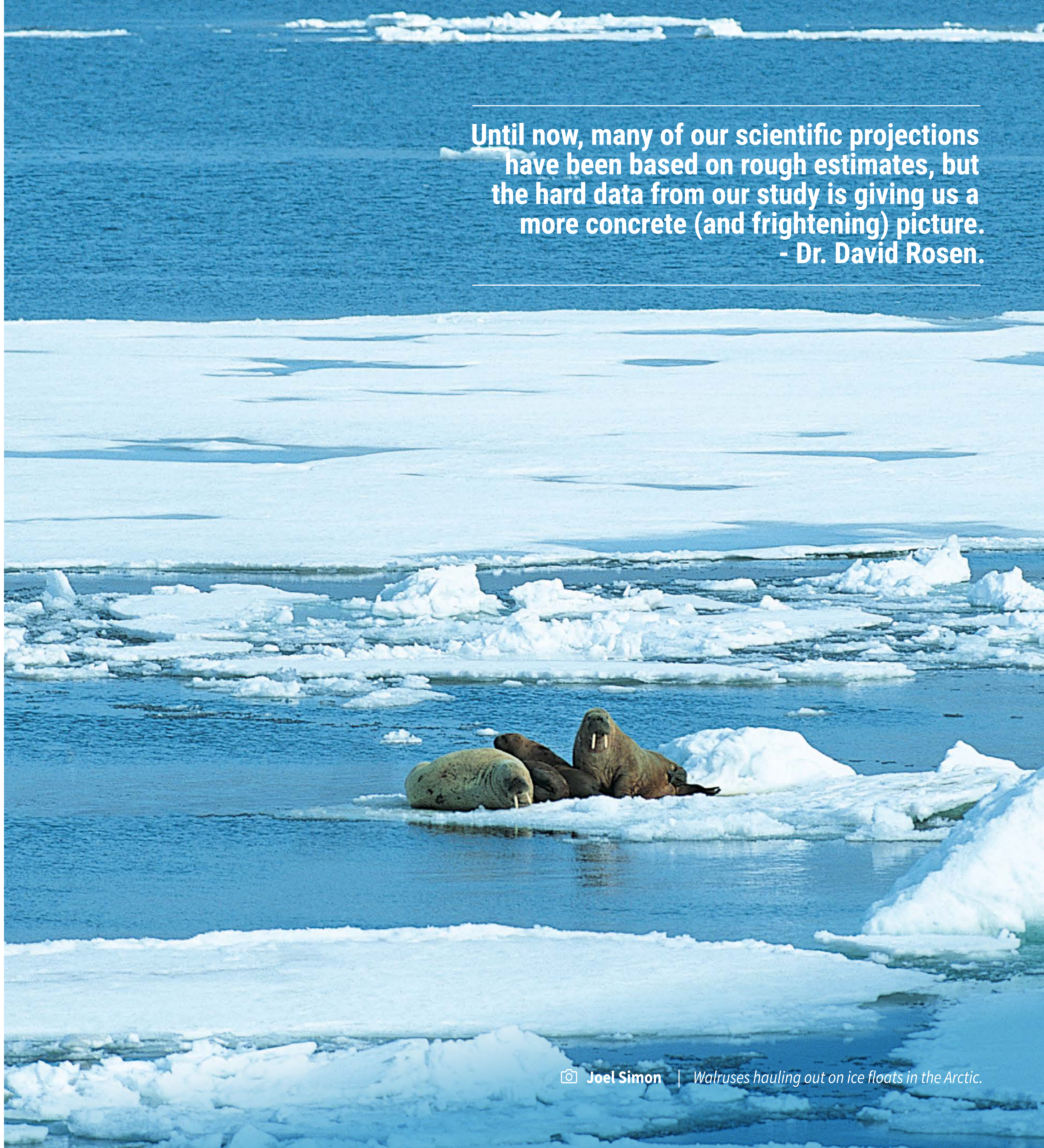
Warming oceans contribute to retreating sea ice, meaning walruses must swim further - and use more energy - to obtain food, leaving less energy for growth and reproduction.

[x] Pinnipeds – seals, sea lions, and walruses.

[xi] *Special Concern: COSEWIC (Committee on the Status of Endangered Wildlife in Canada) Status.* 'A wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats.' From https://www.cosewic.ca/index.php/en-ca/assessment-process/wild-life-species-assessment-process-categories-guidelines/status-categories Cosewic / Cosepac - Status categories.

[xii] Disclaimer – The walruses in this experiment were under human care and therefore the results have been extrapolated to determine the impacts to walruses in the wild.

[xiii] Benthic – living at the surface of, or in the sediment.



Joel Simon | *Walruses hauling out on ice floats in the Arctic.*

Issue 2

Sea Level Rise

Warming oceans and air temperatures are melting sea ice and glaciers. And as ocean waters warm, they also expand. These factors are resulting in an inevitable increase in the volume of water in our oceans, causing average global sea levels to rise.

Approximately 750 gigatonnes[xiv] of water is added to oceans every year,[24] which, in conjunction with thermal expansion, has resulted in a global average sea level rise of over 20 cm since 1880.[25] In Canada, sea level is expected to rise by 1m by 2100 on both the East and West coasts. Beyond 2100, sea levels will continue to rise to 2m and beyond, depending on various GHG emissions scenarios, and geographical/ geological factors.[4,26]

Local variation in sea level rise is impacted by tectonic factors such as uplift/subsidence[xv] rates[27] or compaction of sediments.[24] Due to this variation, some parts of the Eastern Coast of Canada are expected to experience the largest impacts. Areas around Halifax, Saint John, and Charlottetown are examples of places experiencing 2 to 4 mm of rise per year.[28] Low lying areas are most vulnerable.

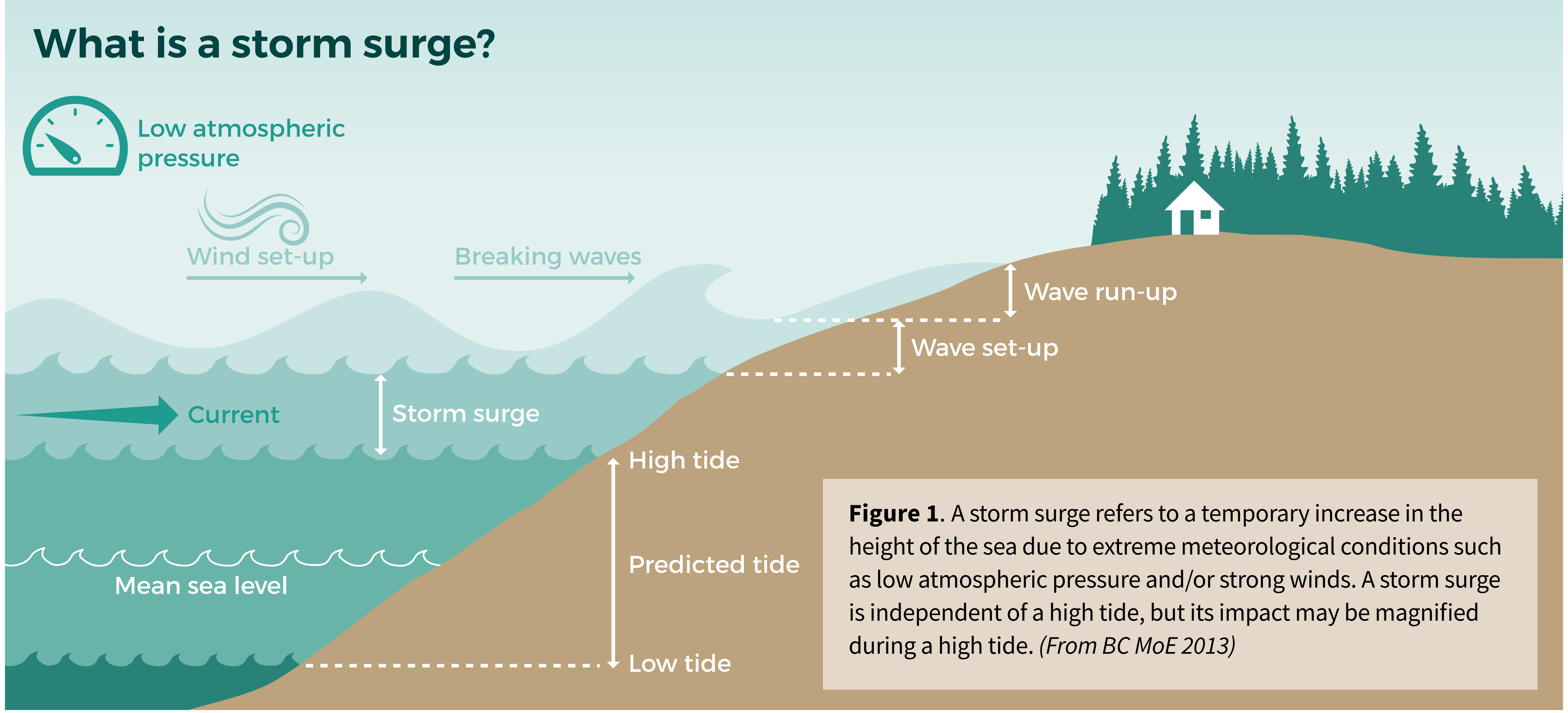


Figure 1. A storm surge refers to a temporary increase in the height of the sea due to extreme meteorological conditions such as low atmospheric pressure and/or strong winds. A storm surge is independent of a high tide, but its impact may be magnified during a high tide. *(From BC MoE 2013)*

Rising sea levels across the Pacific and Atlantic coasts increase the risks of coastal flooding and storm surges (see Figure 1). With more frequent and intense storms occurring in conjunction with sea level rise, we already see coastal erosion, damage to infrastructure, loss of property, contamination of groundwater (and therefore irrigation and drinking water), as well as impacts to coastal habitats, such as wetlands, marshes, estuaries, eelgrass gardens and kelp forests. The economic costs of damage from these events may reach $14 trillion USD globally by 2100 if we surpass the 2°C warming threshold.[xvi, 29] By 2050 China, India and Canada could be impacted the most by rising seas.[3]

As sea levels rise and threaten shorelines, properties, and infrastructure, various methods of shoreline protection have been employed. Hard armoring of shorelines refers to the use of hard materials such as rip rap[xvii], seawalls, or dikes as a method of shoreline protection; however, hard armouring often results in unintended erosion and loss of natural habitats. Options for soft shore armoring such as placing sand and gravel along shorelines, building dunes, constructing wetlands, revegetating or preserving shoreline vegetation such as kelp beds, and/or constructing offshore reefs, is often more cost effective and more environmentally friendly. Hybrid systems are also effective, such as the ReShore project, combining traditional breakwaters with farming such as oysters and kelp beds.[30] Soft armoring can help mitigate wave energy, protecting infrastructure from damage. It also allows the retention of specialized habitat such as eelgrass beds and fish spawning habitat as they migrate naturally inland along with the shoreline. Projects are ongoing to sustainably protect coastlines using natural methods.

iv. Between 1971 and 2010
xiv. One gigatonne is equal to one billion metric tonnes.
xv. Uplift/subsidence rates affecting sea level rise in B.C. is outside of the scope of this work.
xvi. A 2°C warming threshold was the limit decided by world leaders in the Paris Agreement beyond which consequences would be catastrophic. It refers to the temperature increase above pre-industrial levels that should be reached by the year 2050. World leaders agreed that 1.5°C should be the target to limit impacts as much as possible.
xvii. Rip rap – a human-made shoreline consisting of boulders and rocks.

Spotlight 2

Nova Scotia Salt Marsh Restoration

Nova Scotia, along Canada's east coast, is one of the Canadian regions most vulnerable to sea level rise.[31] Buildings and infrastructure are built close to high tide lines, the land is subsiding due to geological factors, and dikes are failing.[31] These factors, along with rising sea levels, and more frequent and intense storms causing larger storm surges, are wreaking havoc for many towns in the area, where coastal erosion and infrastructure damage is becoming commonplace.

Salt marshes were once naturally occurring in many coastal regions of Nova Scotia prior to the installation of dikes. Dikes were put in place from the 17th century, turning native coastal wetland into rich agricultural farmland, resulting in the loss of over 50 per cent of salt marshes throughout Nova Scotia.[32] Now, dikes are failing to keep up with sea level rise. The cost of replacing them is high, and benefits will only be short to medium term, which is why many towns are looking to return their coastlines to a more natural state.

Salt marshes are being restored in multiple coastal areas throughout Nova Scotia. Groups including Ducks Unlimited Canada, TransCoastal Adaptations, and Clean Foundation Nova Scotia have undertaken salt marsh restoration projects throughout Nova Scotia and beyond. From 2000-2020, over 350 hectares of wetlands were restored in the upper Bay of Fundy alone.[33] These valuable coastal wetlands provide natural protection against sea level rise through the stabilization of sediments, and help to mitigate wave energy from storm events, thereby reducing shoreline erosion. Salt marshes are also valuable carbon sinks,[34] contributing to the reduction of GHGs. Some locations are combining salt marsh restoration with new dikes located landward for extra protection in low lying areas. This approach of soft shore armoring is more sustainable and more economically feasible, with longer term impacts for defending against the impacts of sea level rise.

Nature-based soft shore armoring is a sustainable way to protect coastlines from the impacts of rising seas.

©Ducks Unlimited Canada/Leigh Patterson | *Salt marshes in Nova Scotia, Canada.*

Issue 3

Ocean Acidification

At the same time as oceans are warming, they are also becoming more acidic, a phenomenon known as ocean acidification. Ocean acidification is a direct consequence of carbon dioxide emissions from human activities.

Oceans absorb about one quarter of human produced carbon dioxide emissions[16] – approximately 22 million tons of carbon dioxide per day.[35] On one hand, this helps to reduce atmospheric carbon dioxide concentrations, slowing the rate of GHG-driven warming. On the other hand, oceanic absorption of excess carbon dioxide has led to ocean acidification, whereby the carbon dioxide bonds with sea water to form carbonic acid, causing marine waters to become more acidic.[36]

Average global oceanic pH has dropped from 8.2 prior to the industrial revolution, to 8.1 in modern times (lower pH meaning higher acidity – Figure 2).[37] Although this may sound like a small amount, the pH scale is logarithmic[xviii] so this means acidity has actually increased by about 30 per cent,[37] with significant impacts to the ocean's habitats and biodiversity that have evolved to survive in specific conditions.[17] There are a lot of unknowns about exactly how ocean acidification will continue to impact ocean health, especially because oceans simultaneously face a myriad of other challenges and these changes are not occurring at the same speed everywhere.

Many marine creatures, such as plankton, coral, crustaceans, and shellfish, use carbonate to produce their shells and skeletons. Under more acidic conditions, less carbonate is available. This is because the carbonic acid formed by absorbed carbon dioxide likes to bond with carbonate to form bicarbonate. This means the more carbon dioxide taken up by sea water, the less available carbonate in sea water, which limits animals' ability to make their shells and skeletons. In very acidic conditions, existing shells and skeletons can even be dissolved/corroded.[38]

Repercussions from the impacts of ocean acidification include the cascading effects that will be felt throughout entire food webs. Researchers have been examining impacts of ocean acidification on important commercial fish species, such as Atlantic cod. Under conditions of increased acidity, Atlantic cod larvae allocated energy to growth, to the detriment of the development of other vital organs.[39] Ocean acidification has also been shown to impair the sensory systems of some fishes, affecting their ability to find home, search for food, and detect and avoid predators.[40] Changes like this could spell economic trouble for commercial fisheries, not to mention the affected species themselves.

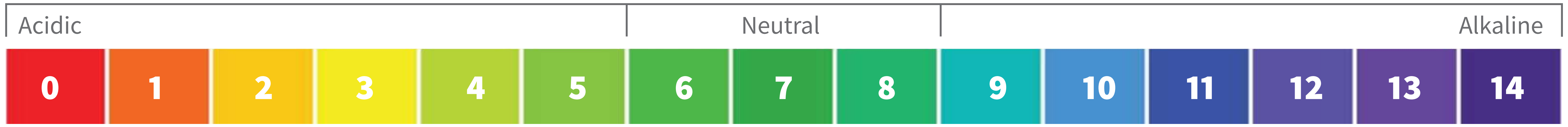
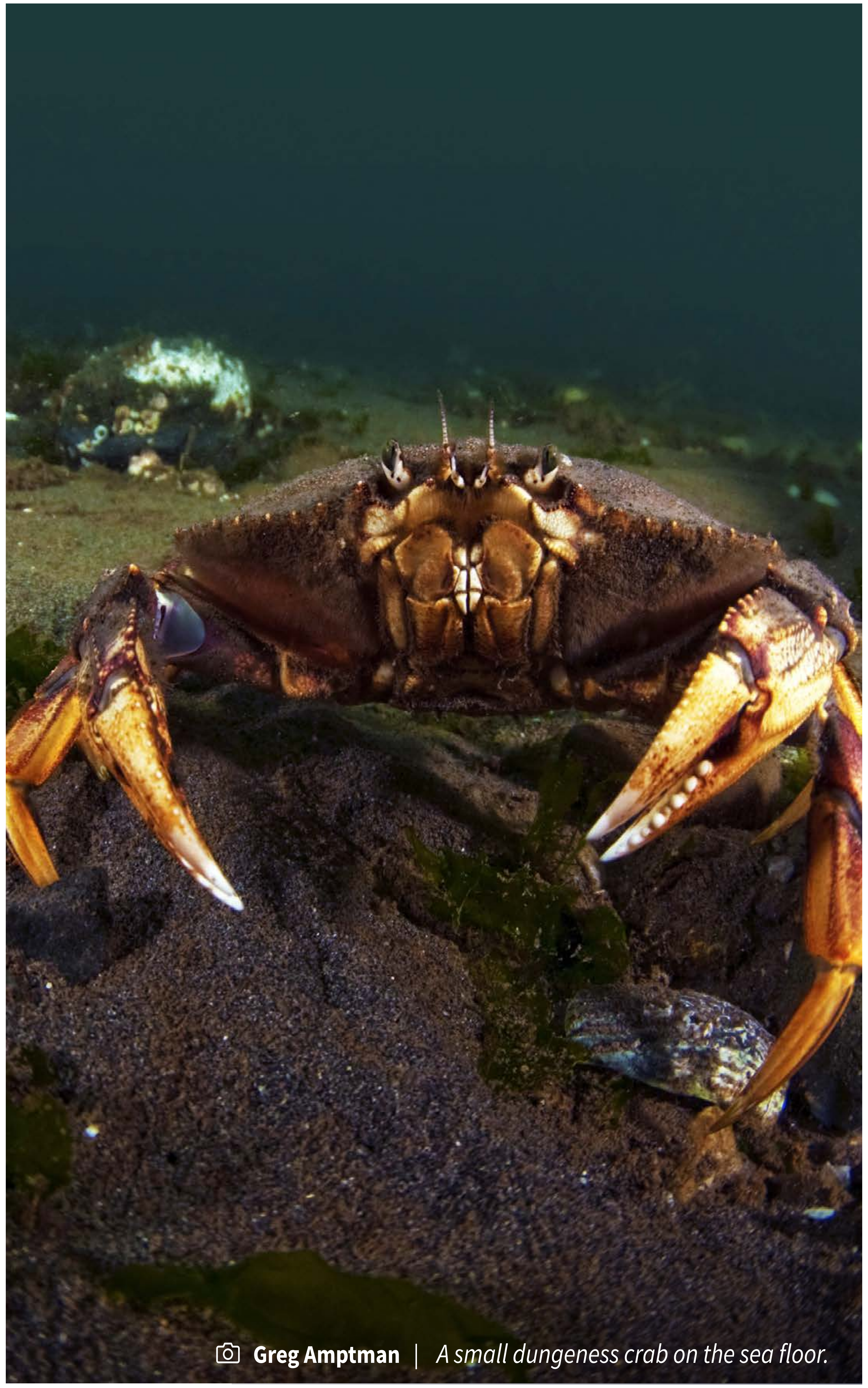


Figure 2. The pH scale. Lower values indicate higher acidity.



Greg Amptman | *A small dungeness crab on the sea floor.*

xviii. Logarithmic – growing exponentially, each increment is double the previous one.

Spotlight 3

Acidifying Arctic And Delicate Sea Butterflies

The waters of the Canadian Arctic are acidifying roughly twice as fast as most other regions in the world because cold water absorbs and holds more carbon than warmer waters. Scientists have already observed impacts of ocean acidification on one of the regions smaller inhabitants, the sea butterfly, a small swimming marine snail (pteropod, *Limacina helicina*). Dissolution[ixx] of sea butterfly shells has been used as an indicator of acidification in other regions,[41] so scientists examined how they are faring in the Canadian Arctic.

In the Beaufort Sea, these snails are finding their environments devoid of carbon, a basic and necessary building block for their shells. Up to 70 per cent of the population is undergoing shell dissolution in areas of high acidification.[42] Sea butterflies are eaten by animals from small krill to juvenile North Pacific salmon, and even whales. Clearly, the decline of even a single species in the food web has cascading effects all the way through to the top of the web.

Russ Hopcroft | *Arctic Ocean Diversity, Census of Marine Life.*

Up to 70 per cent of sea butterflies – small marine snails – are suffering from shell dissolution due to ocean acidification, causing a ripple effect through the food web.

ixx. Dissolution – the dissolving or break down of material.

Conclusion

Oceans play a critical role in Earth's climate system and are being heavily impacted by climate change. Our oceans have gone through many changes in Earth's history, but the speed at which they are changing today is unprecedented.

We are seeing increasing global average ocean temperatures, increasing volumes of water entering the oceans leading to sea level rise, and changes in ocean chemistry resulting in increasing acidification of oceanic waters. These changes are pronounced in Canada's three oceans and impact the habitats and species that live there, as well as shorelines and coastal communities. Importantly, these stressors are not the only threat to our ocean. Rather, they often act synergistically to exacerbate the many other human-induced threats facing marine life and ecosystems, such as over exploitation of resources, pollution, and habitat destruction.

Scientific knowledge on climate change is growing rapidly. We are learning that local, nature-based solutions may provide some climate change mitigation, such as carbon sequestration and storage. However, the effectiveness of such solutions will be more effective if we can achieve the Paris agreement targets, to limit global warming to 1.5°C relative to pre-industrial concentrations, by rapidly curtailing our GHG emissions.[43] Nonetheless, the benefits of actions taken to mitigate climate change and reduce GHG emissions will only be seen in the longer term. Many actions are necessary at a local, provincial, and federal level to break our reliance on a fossil fuel-based economy so we can help our oceans and our Earth recover.

Ocean Wise, Eric Solomon | *Melting ice berg in the Arctic.*

What can you do?

The list below is a small subset of the many actions that need to be taken to both mitigate and adapt to climate change. A more comprehensive list of possible actions to take can be found in the article The path to zero carbon municipalities.

REDUCING EMISSIONS

Individual and Organization Actions

- ❑ Switch to an electric car for your next vehicle purchase.
- ❑ Carpool whenever possible.
- ❑ Use public transit, walk or ride your bicycle where possible.
- ❑ Reduce air travel.
- ❑ Upgrade house hold appliances to eliminate natural gas ranges, furnaces and heating.
- ❑ Replace household appliances at the end of their life to more energy efficient models.
- ❑ Eat less meat. Start with one meat-free meal per week, and decrease meat portion sizes.
- ❑ Eat local and support local producers.
- ❑ Reduce your food waste.

Government Actions and Policy

- ❑ Eliminate subsidies for fossil fuels and transition/promote climate-friendly energy sources.
- ❑ Increase carbon taxes to further limit fossil fuel use.
- ❑ Increase subsidies for electric vehicles and charging grids.
- ❑ Increase funding for investments in public transit with the goal to reduce, and then remove commuter traffic.

FACILITATING ADAPTATION OF NATURAL SYSTEMS

Government Actions and Policy

- ❑ Phase out hard shore armouring techniques in favour of soft shore armouring.
- ❑ Incentivise sustainable shoreline stabilization of public assets.
- ❑ Fund the research, protection, and revegetation of riparian areas and coastal habitats, especially marshes, wetlands, kelp forests, seagrass meadows.
- ❑ Begin planning for opportunistic retreat of key facilities and infrastructure from high flood hazard areas at the end of their service life.
- ❑ Limit and manage development projects in areas near the high tide line, and consider local sea level projections for the future.
- ❑ Incorporate latest climate change hazard assessments into emergency response planning.

Resources

Canada's Changing Climate Report by Bush and Lemmen (2019) is available from: https://changingclimate.ca/CCCR2019/

The Intergovernmental Panel on Climate Change (IPCC) is a United Nations body that summarizes and synthesizes the state of knowledge about climate change globally. Find a list of their reports here: https://www.ipcc.ch/reports/

Canada's Ocean Now is a Fisheries and Oceans Canada resource: Public Report – Canada's Oceans Now: Arctic Ecosystems, 2019 https://www.dfo-mpo.gc.ca/oceans/soto-rceo/arctic-arctique/publications/pub-lic-report/index-eng.html

For more information on hypoxia (low oxygen zones in the ocean): https://oceanfdn.org/ocean-and-climate-change/

The Government of Canada lists many resources on climate change here: https://www.canada.ca/en/services/environment/weather/climatechange.html

Learn about the benefits of soft shore armouring at Green Shores, Stewardship Centre for BC Greenshores: https://stewardshipcentrebc.ca/green-shores-home/

Learn more about historic wetland loss in Nova Scotia: https://novascotia.ca/nse/wetland/

Learn more about wetland restoration in Nova Scotia by Ducks Unlimited Canada: Keeping tidal forces at bay https://www.ducks.ca/stories/atlantic/keeping-tidal-forces-at-bay/

Seaforestation

Carbon sequestration, or carbon drawdown, is the process by which carbon is removed from the atmosphere by plants, which use it in photosynthesis. In the oceans, kelp forests can grow up to 30 times faster than terrestrial trees and plants, fixing atmospheric carbon in their fronds as they grow. When these fronds die, a proportion sinks to the ocean floor, locking away this carbon. Through carbon sequestration, kelp forests also have the potential to act as local buffers to ocean acidification. Additionally, kelp forests mitigate wave energy, therefore protecting shorelines from erosion, and provide valuable habitat for many species, helping to increase local biodiversity. It has also been found that by enriching livestock feed with kelp, digestive GHG emissions by cattle can be significantly reduced.

Seaforestation is the act of restoring, planting, managing, and caring for underwater seaweed forests. Ocean Wise Conservation Association is working hard to spearhead a Canada-led coalition to take Seaforestation to scale as a nature-based climate solution. Working with local and global leaders in the seaweed farming, restoration, and sequestration space, Ocean Wise is bringing together key experts in the field to map out and implement a path for Seaforestation at a scale that will help mitigate climate change.

Maxwel Hohn | *Bull kelp along the shores of Vancouver Island, B.C.*

The Changing Arctic Ocean

The Arctic ocean is warming at more than double the global rate. Nearly 80,000 square kilometres of sea ice disappears annually, and the remaining ice is much thinner. As a result, new pathways are available to vessels, and traffic is increasing rapidly. This introduces threats such as invasive species, black carbon on ice and snow, resulting in even faster melting, and increased underwater noise that interferes with local wildlife.

Continuing to work alongside Northern Indigenous communities, Ocean Wise Conservation Association and our community partners plan to establish a northern network that combines community-driven vessel and wildlife observations, Indigenous knowledge, scientific methodologies, leading technology, and industry to understand and mitigate vessel impacts in the Arctic. This initiative will empower Inuit communities and key partners with the tools and skills to lead the collection, documentation and interpretation of local Indigenous knowledge and new data on vessel traffic, wildlife, underwater noise, black carbon deposition and invasive species monitoring. The resulting knowledge will inform decision making and action to protect Arctic wildlife and the people whose lives and livelihoods depend upon it.

Ocean Wise, Neil Fisher | *Sampling on the ice.*

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