Sea Change Canada

OCEAN ACIDIFICATION IN CANADA

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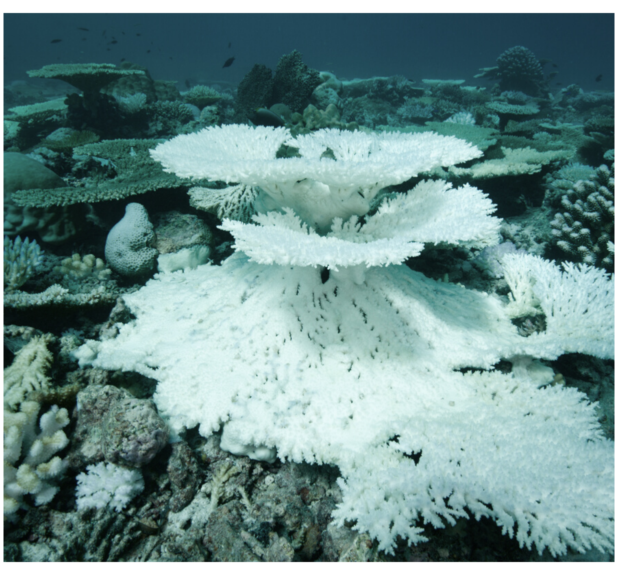
INTRODUCTION

Since the Industrial Revolution, human activities have increasingly depended on fossil fuels which release carbon dioxide (CO_2) when burned, resulting in substantial increases of CO_2 in the atmosphere (Hardford, 2017). Some of this excess CO_2 is dissolved, captured, and stored by the ocean through a process called sequestration (DFO, 2019). While this is a naturally occurring process, the levels of CO_2 being absorbed is altering the – normally very stable – pH of our oceans (DFO, 2018). As CO_2 concentrations in the ocean increase, pH decreases, leading to ocean acidification (Figure 1).

Upwelling, river discharge, nutrient run-off, and sewage are other factors that contribute to lower pH levels of the ocean (Hardford, 2017). This happens mainly in coastal regions where rivers empty into the sea, however, increasing CO_2 levels are by far the leading cause of global ocean acidification (DFO, 2019). Therefore, anthropogenic CO_2 and additional inputs are driving critical changes in ocean chemistry.

Ocean Acidification is the "long term change of ocean chemistry as CO2 is absorbed from the atmosphere"
-Deborah Harford
(Hardford, 2017)

In the Pacific Marine Region, the levels of dissolved carbon in the northeast Pacific are naturally high because of the global ocean's meridian overturning circulation patterns (Greenan, 2019). This means that water beneath the surface of the ocean has been traveling throughout the ocean's interior and accumulating organic matter particulates, which contain carbon and lowers pH (Figure 2). The northeast Pacific already has high levels of dissolved carbon in its waters that are further being lowered by anthropogenic climate change (DFO, 2018). Temperature stratification of the ocean keeps more carbon dioxide in the surface layers than in the deep ocean, and in equatorial regions, the ocean has already reached its capacity to absorb CO_2 due to higher surface temperatures (DFO, 2019). Since the equatorial regions are at capacity, polar regions are expected to see some of the biggest changes in ocean pH levels as waters warm and atmospheric CO2 increases – meaning that Canadian marine environments are going to be profoundly impacted (Qi et al. 2022).



The following sections of this report will discuss the ecological and social impacts of ocean acidification. Both ecological and social impacts are important to analyze since the ocean provides a fast amount of resources used by people around the world on a daily basis. Therefore, if our ocean becomes too acidic for marine species to survive, coastal communities may also be severely impacted.

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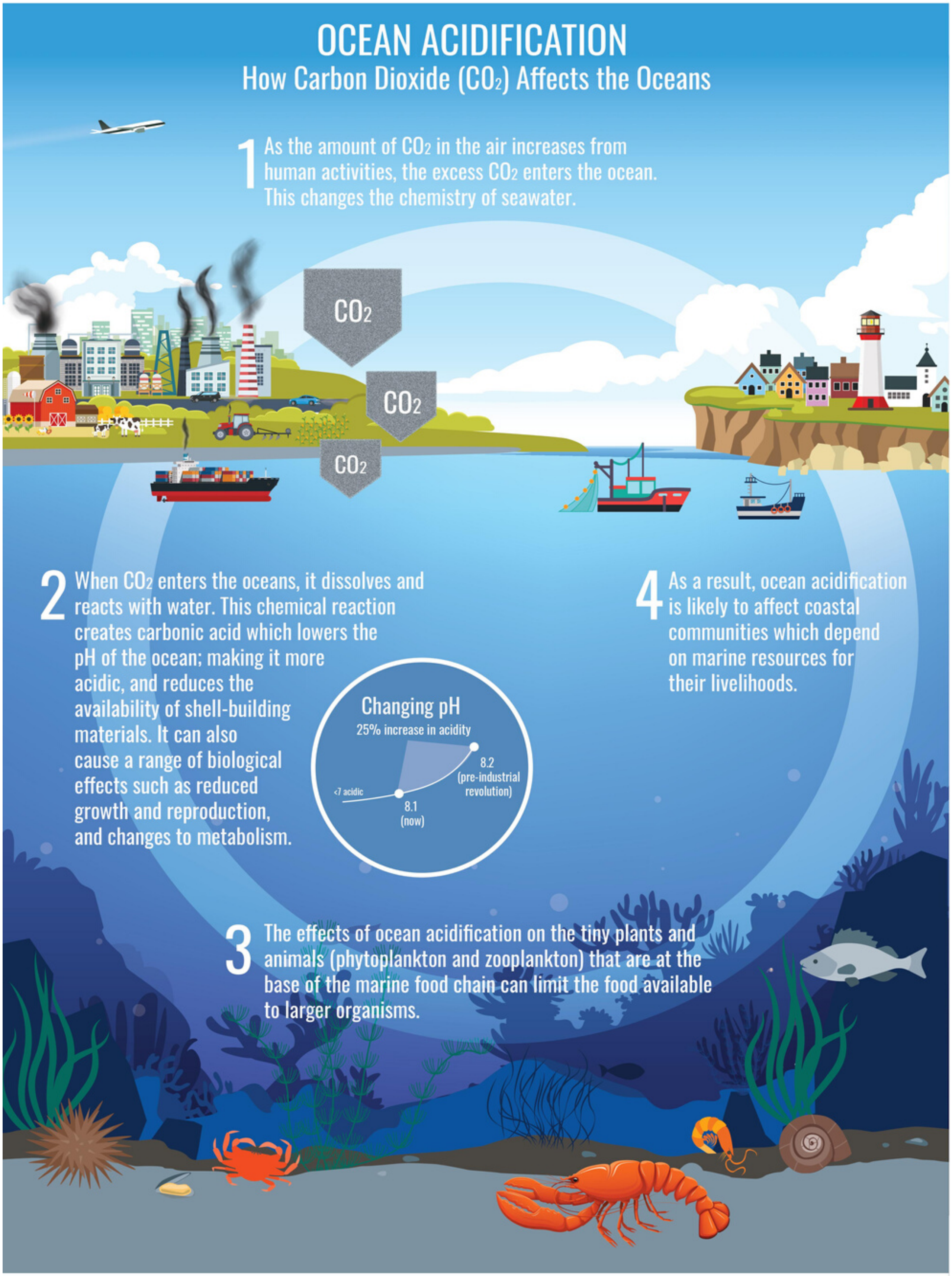


Figure 1. How carbon dioxide affects the oceans and causes ocean acidification. (DFO, 2019)

Canada

ECOLOGICAL IMPACTS

Decreasing pH levels have detrimental impacts on the availability of nutrients in the ocean, which are fundamental for the survival of marine species (Niemi et al. 2021). Phytoplankton for example is a critical type of algae that relies on nitrogen, silicon, and other nutrients near the surface of the water to survive (Greenan, 2019). Therefore, when ocean acidification remove nutrients, phytoplankton survival is greatly impacted (Greenan, 2019). This is concerning since phytoplankton are the base of marine food webs, meaning ocean acidification could indirectly impact the survival of larger creatures such as fish – who depend on phytoplankton as a food source.

Changes in the fundamental chemistry of the ocean further harms species like oysters, mussels, and lobsters that use calcium carbonate to form their shells and exoskeletons (Niemi et al. 2021). More energy is required to build calcium carbonate shells when the ocean is more acidic, and once the acidity reaches a certain point, the shells will begin to disintegrate (Wilson, 2021). The full impacts of acidification on different marine organisms are still being studied, but in general, lower survival rates, greater vulnerability to predators, and generally poor health are all likely (Wilson, 2021).

Marine species which are more tolerant to rising CO2 levels and are mobile, such as algae, jellyfish, crabs, and shellfish, may benefit due to ocean acidification (University of Plymouth, 2015). These species are known to become invasive in some areas, causing problems such as toxic jellyfish blooms and rotting algal mats (University of Plymouth, 2015). Higher rates of invasive species in oceanic ecosystems may be detrimental to marine environments as new species can drive increased competition for food, increase predation on struggling species, introduce new diseases and parasites, and more (DFO, 2019). The potential spreading of harmful marine species should be taken into consideration when assessing the risks of rising CO2 emissions (University of Plymouth, 2015).

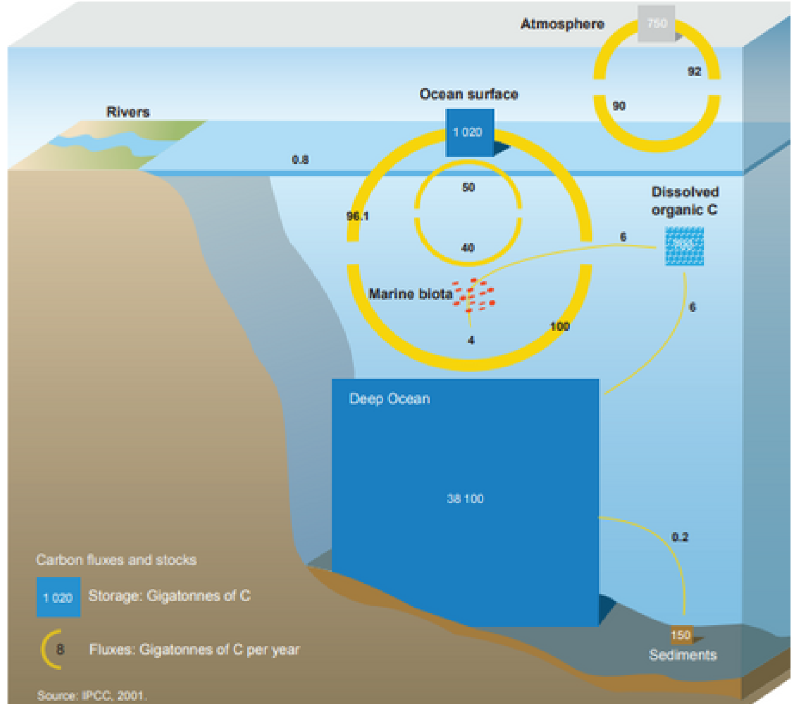
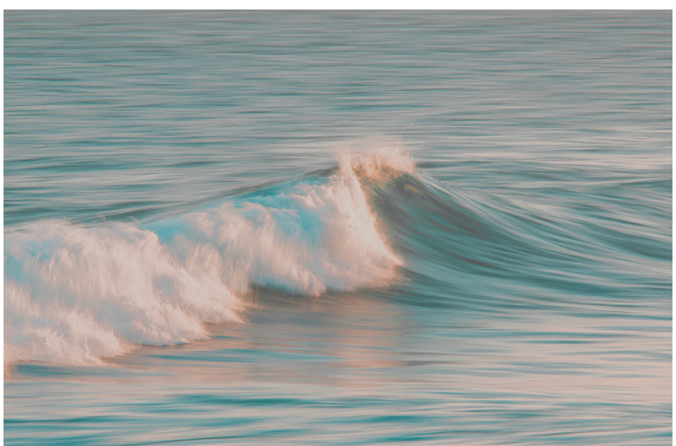


Figure 2. Ocean water carbon cycle. (Greenan, 2018)

One Canadian example of increased invasive species due to ocean acidification is eelgrass beds and green crabs (*Carcinus maenas*) (Eelgrass, 2022). Eelgrass beds are vital for maintaining coastal beach structure, help in coastal restoration, and act as nursery areas for young fish and shellfish (Eelgrass, 2022). Due to the changing ocean water chemistry, a significant number of green crabs have migrated from the Northern colder waters and have become established in the Pacific Marine region (Tyler & Wilson, 2021). The green crabs are a problem as they uproot eel grass beds, having a domino effect on the entire marine ecosystem (Tyler & Wilson, 2021).

SOCIAL IMPACTS

Ocean acidification is having serious impacts on marine ecosystems and humans are a big part of that ecosystem (Greenan, 2018). In Canada, many human livelihoods are reliant on oceanic ecosystem services (DFO, 2021). Fishing communities are especially reliant on the ocean and will be most at risk from the impacts of ocean acidification as they rely on marine resources for their economic and social livelihoods, posing risks for small communities that are heavily reliant on the fishing sector to fulfill dietary and employment needs (Wilson, 2021). For example, seafood & shellfish production in Atlantic Canada supports over 85% of Canada's commercial fishing fleet, providing a significant source of food for the country and employing most people who live in small communities (Wilson, 2021). American lobsters, northern shrimp, and sea scallops are some of the main shellfish species fished in this region, and each is expected to experience extreme declines due to changes in pH levels (DFO, 2021).



RECOMMENDATIONS

Most of the current proposed solutions for ocean acidification issues focus on adapting to the impacts of ocean acidification. Since ocean acidification increases atmospheric CO_2, an effective long-term solution requires pushing for carbon emission reductions (DFO, 2018). One suggestion for ocean acidification adaptation is shifting to alternative fishing methods on land such as land-based fish farming, a controlled method of cultivating fish and other marine resources that will not contaminate our oceans. While land-based fish farms may provide a way to mitigate the impact on food production, employment, and abundance of some marine species, land-based fish farms will not address the large-scale problem of ocean acidification on their own. Strong and effective policies must be in place to support land-based fish farms and remove fish farms currently in our oceans.

Strict legislative changes enforced by the Canadian Government that address waste disposal and activities producing mass pollution (such as fish farms) have the potential to help reduce ocean acidification. However, the Canadian Government must listen to coastal communities and non-profits and focus on removing current fish farms and transitioning to land-based methods.

CONCLUSION

Tackling the impacts of ocean acidification must involve cross-disciplinary collaboration between the marine sciences, the political sphere, the non-profit sector, big business, and everyday citizens. Proper governance for ocean acidification must require sharing knowledge with the public to promote the involvement of more stakeholders and individuals, not just the experts, in protecting our oceans. There need to be fundamental governance adaptations to the way we use and manage the health of our oceans.

REFERENCES

Department of Fisheries and Oceans Canada. (2021). Fisheries and Oceans Canada's 2020-21 Departmental Sustainable Development Strategy Report. Retrieved from: https://www.dfo-mpo.gc.ca/sds-sdd/2020-2021/index-eng.html

Department of Fisheries and Oceans Canada. (2019). Changing ocean chemistry. Retrieved from: https://www.dfo-mpo.gc.ca/science/oceanography-oceanographie/accasp-psaccma/chemistry-chimie/index-eng.html

Department of Fisheries and Oceans Canada. (2018). What is ocean acidification? Retrieved from: https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2012/page02-eng.html

Eelgrass. (2022). Retrieved from South Coast Conservation Program: http://sccp.ca/species-habitat/eelgrass

Greenan, B. J. (2018). Changes in Oceans Around Canada. Retrieved from Natural Resources Canada: Gov. of Canada: https://www.nrcan.gc.ca/ sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR-Chapter7-ChangesInOceansSurroundingCanada.pdf

Hardford, D. (2017). New Paper: Ocean Acidification in Canada's Coastal Waters. Retrieved from ACT Action on Climate Team: https://actadapt.org/new-paper-ocean-acidification-in-canadas-coastal-waters/

Niemi, A., Bednarsek, N., Michel, C., et al. (2021). Biological impact of ocean acidification in the Canadian Arctic: widespread severe pteropod shell dissolution in Amundsen Gulf. Frontiers in Marine Science, 8(600184):1-16.

Qi, D., Ouyang, Z., Chen, L., et al. (2022). Climate change drives rapid decadal acidification in the Arctic Ocean from 1994 to 2020. Science, 377(6614):1544-1550.

Tyler J. B., & Wilson, S. R. (2021). Potential socioeconomic impacts from ocean acidification and climate change effects on Atlantic Canadian fisheries. Retrieved from Plos One: https://journals.plos.org/ plosone/article?id=10.1371/journal.pone.0226544

University of Plymouth. (2015). Marine invasive species benefiting from rising carbon dioxide levels: Territories changing due to ocean acidification. ScienceDaily. Retrieved from: www.sciencedaily.com/releases/2015/11/151106113732.htm

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