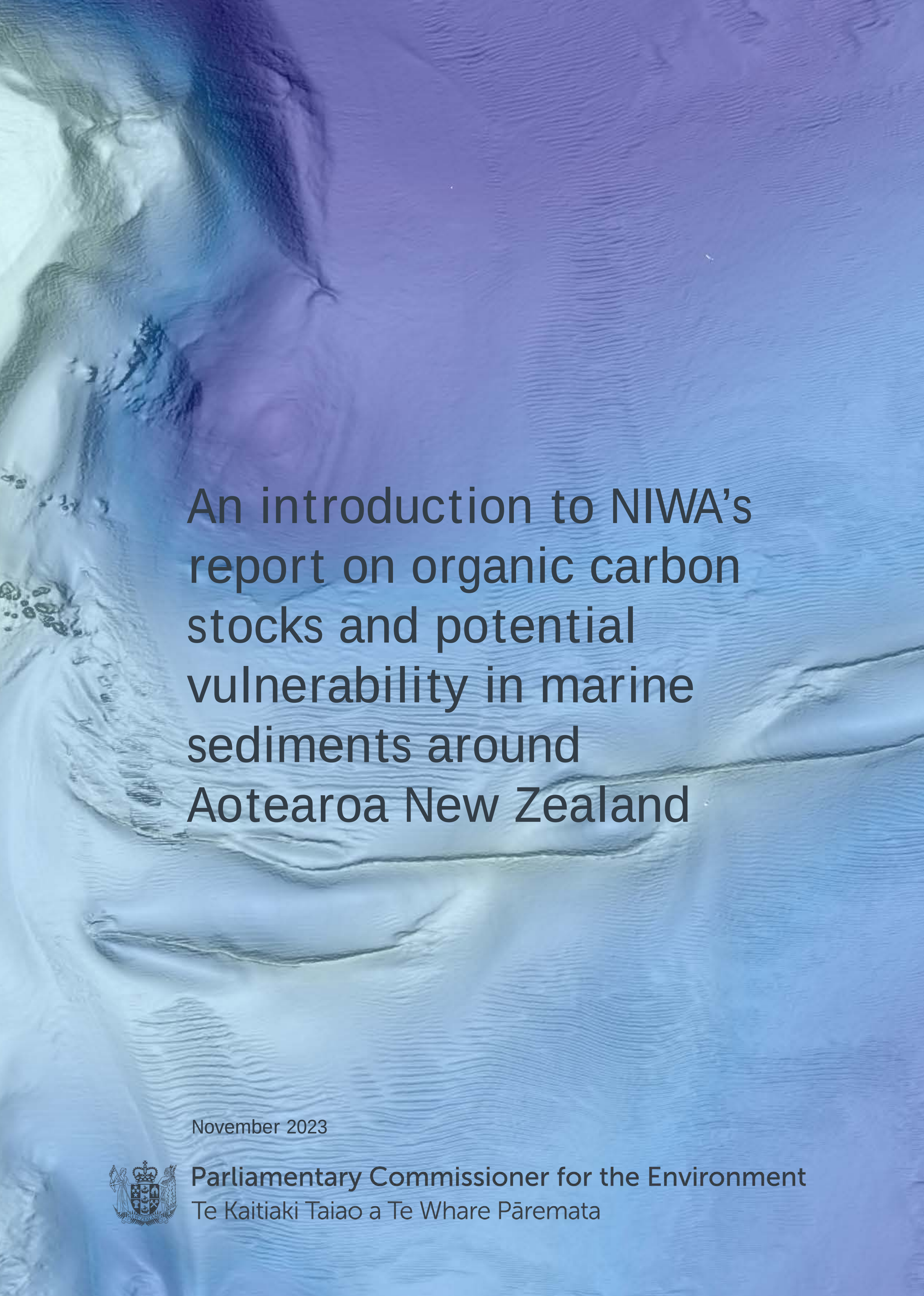


An introduction to NIWA's report on organic carbon stocks and potential vulnerability in marine sediments around Aotearoa New Zealand

November 2023

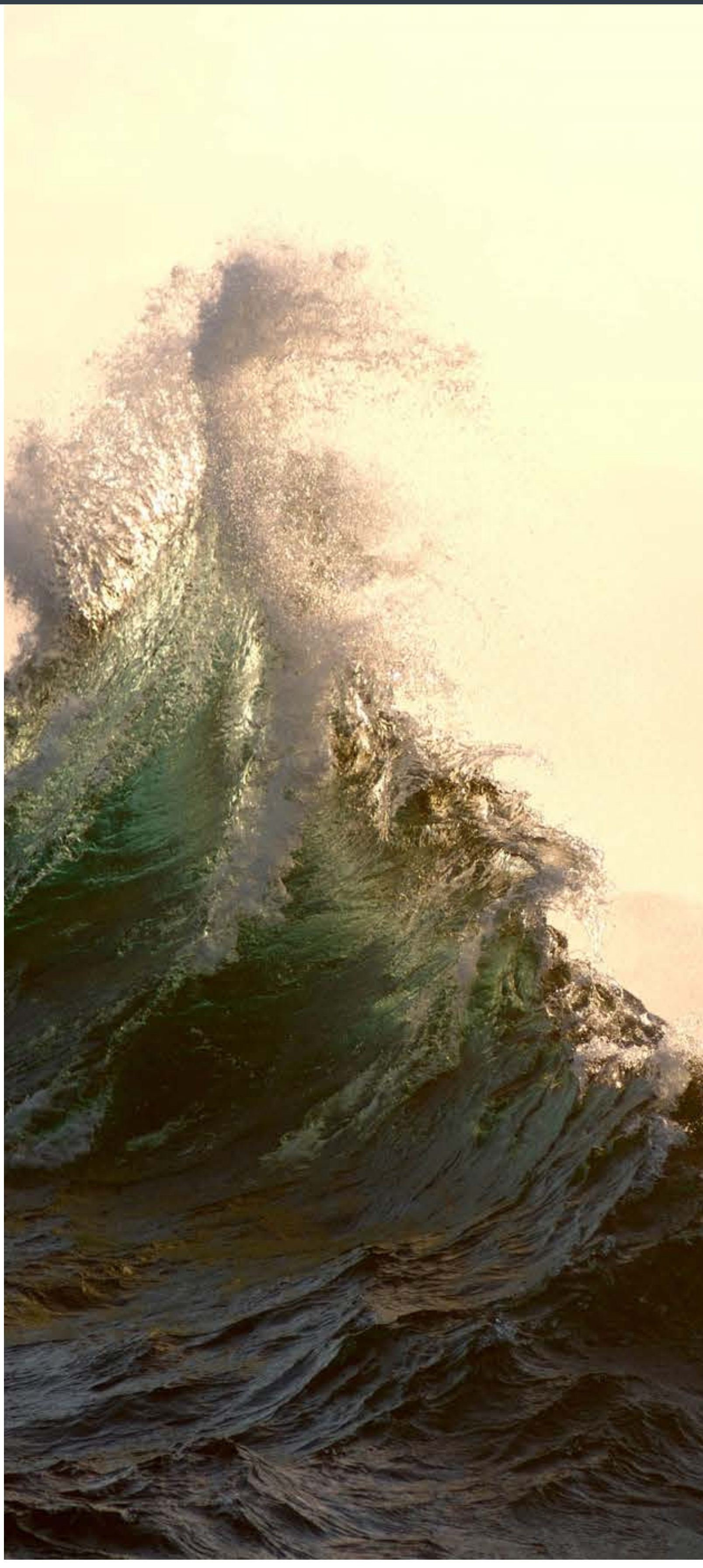
Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

The importance of marine sediments

Marine sediments are one of the largest stores of organic carbon on Earth. They play a vital role in regulating climate change by accumulating and burying carbon for up to millions of years – if left undisturbed. Despite the importance of marine sediments to the carbon cycle, there is still much to learn about how much carbon they store, and what happens when they are disrupted by human activities like bottom trawling, seabed mining, dredging and anchoring.

To understand more about these issues in the New Zealand context, the Parliamentary Commissioner for the Environment commissioned the National Institute of Water and Atmospheric Research (NIWA) to develop the first inventory of organic carbon in marine sediments for the New Zealand Exclusive Economic Zone (EEZ).

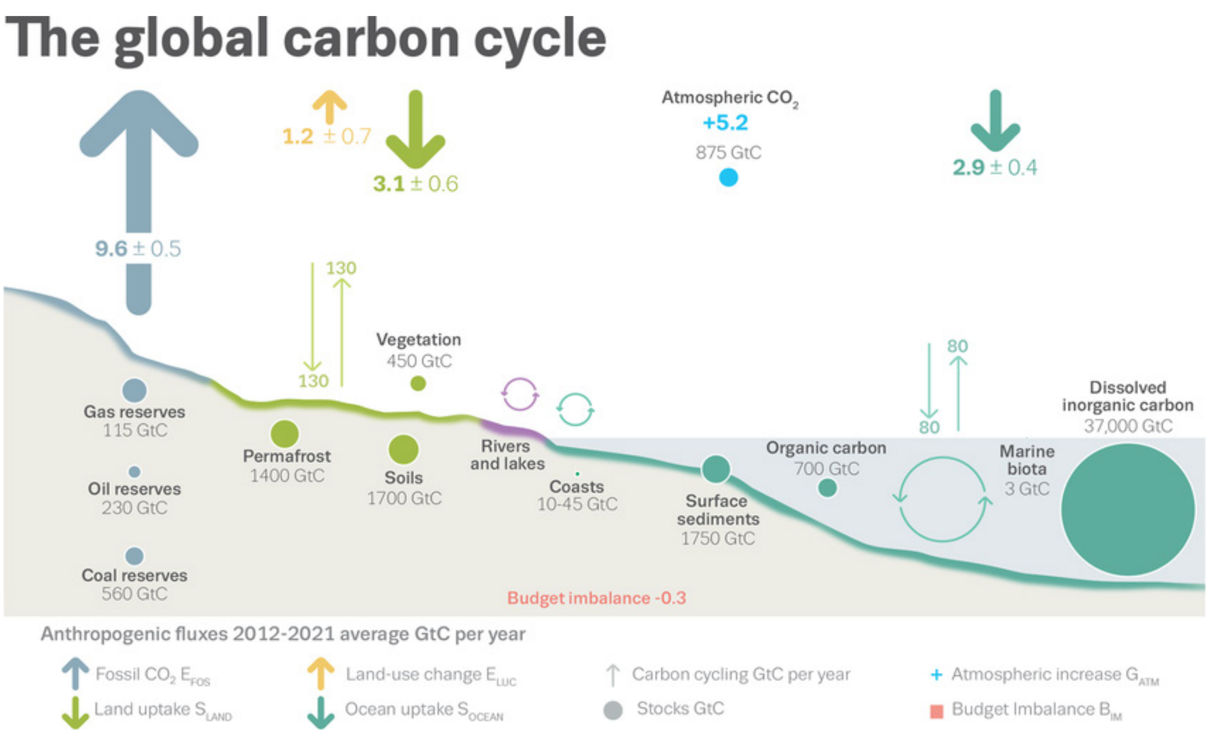
Photo, right: Peter Marriott, NIWA.
Cover photo: Sandwaves on Cook Strait Raukawa Moana seafloor, Marlborough District Council, image generated by NIWA.



The carbon cycle

Current concerns about climatic disruption have been focused on rising concentrations of carbon dioxide (CO2) and other greenhouse gases in the atmosphere, and the key role they play as a driver of average global temperatures.

Carbon dioxide represents a fraction of the cocktail of gases that make up our planet's atmosphere, and it has varied as part of a natural cycle for millions of years. But over little more than 200 years, human activities have severely disturbed that cycle and we are now seeing the consequences around the world.



Source: Pierre Friedlingstein et al., Global Carbon Budget 2022

Global carbon flows caused by human activity (thick arrows) and stocks (coloured circles). Thin arrows represent the natural carbon cycle. These processes are measured in gigatonnes of carbon (GtC) and are averaged globally between 2012 and 2021.

Carbon moves between the Earth's crust and its surface, oceans and atmosphere over different time frames. They can be very rapid – such as the movement of carbon between vegetation and the atmosphere through photosynthesis, or very slow – such as the incorporation of carbon into the Earth's crust through geological processes. Combustion of fossil fuels has dramatically increased the quantity of carbon being released into the atmosphere, as have activities such as deforestation and drainage of peat swamps.

The largest stock of terrestrial organic carbon is stored in soil on land, and keeping it there is critical if we are to limit the amount of carbon dioxide being released into the atmosphere. This makes good management of organic carbon stocks an important climate objective. Soil organic carbon is reasonably well researched and understood, though accurately estimating changes in soil carbon stocks over time remains a challenge. Estimating the carbon stored in sediments below the ocean floor is much harder and has received far less attention from researchers to date.

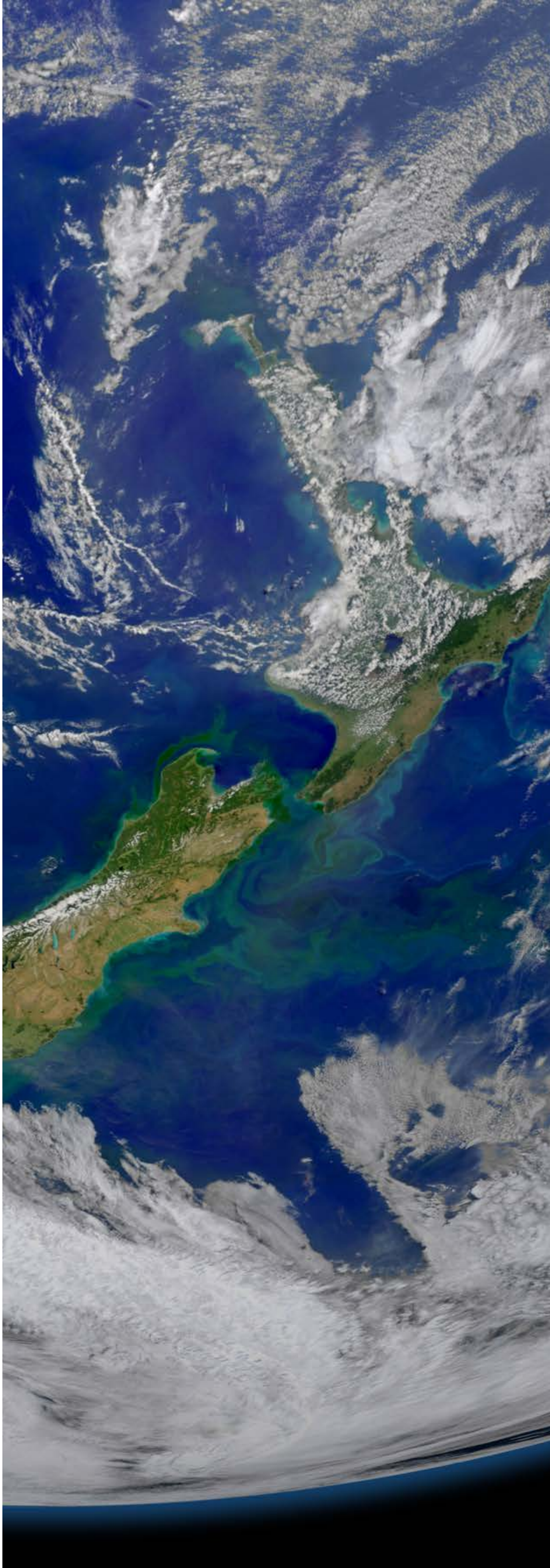


Photo: Aotearoa New Zealand by NASA Goddard Space Flight Center, Flickr.

Organic carbon in marine sediments

Like plants on land, the carbon in marine organisms ultimately comes from the atmosphere. When these organisms die, they break down, sink to the seafloor and add to the stocks of organic marine carbon. If disturbed, either by natural processes such as ocean current scouring or landslides, or by human activities such as dredging or trawling, marine sediments can become mixed and resuspended into the water column. Once resuspended, oxygen and bacterial metabolism can break down the organic carbon so it is released once again as carbon dioxide.

Recent research has attempted to quantify how much organic carbon is stored in marine sediments found in the first metre beneath the ocean floor. Researchers estimate that this may be twenty times larger than the stock of organic carbon found in terrestrial soils. However, there are very large uncertainties around the amount of carbon stored in marine sediments globally and around New Zealand because we have relatively limited data.

Our EEZ is about 15 times as large as our land area and is one of the largest in the world. Currently, only a few global evaluations of carbon in marine sediments have been attempted and they do not take into account the specificity of New Zealand's vast, complex and diverse seascape. We need rigorous estimates of the stock of marine organic carbon using the best data available. There is a need to also measure and monitor marine environments that have not yet been impacted by human activities, particularly deep-water habitats, which remain the greatest repository of organic carbon on Earth.

Photo: Red gurnard kumukumu, Wellington, Dr Sophie Mormede.

NIWA's research

Given the very large amount of organic carbon estimated to be stored in marine sediments, any disruptions, from either naturally occurring processes or human activities, could have a major impact on an already seriously disturbed carbon cycle. To help assess the risk of carbon being released from marine sediments in New Zealand's EEZ, the PCE asked NIWA to answer the following two questions:

- How much carbon is stored in marine sediments in the New Zealand EEZ?
- How much of this organic carbon stock is at risk of ending up in the atmosphere as carbon dioxide because of human interference?

For this report, NIWA developed the first inventory of organic carbon in marine sediments for the New Zealand EEZ. The methodology used was based on a statistical approach originally developed for the United Kingdom, which was modified to suit Aotearoa's unique marine realm. The inventory focused on the top ten centimetres of sediments, where the stored organic carbon is likely to be the most vulnerable to natural or human disturbances.

NIWA also considered what the fate of this carbon might be if the marine sediments are disturbed. Would it resettle rapidly onto the seafloor and become reincorporated into sediments? Would it directly or indirectly contribute to ocean acidification or warming? Would it reach the sea–air interface and be released back into the atmosphere as a greenhouse gas, contributing to further global warming? While it is likely to be a mix of these outcomes, we need to know in what likelihood or proportion.

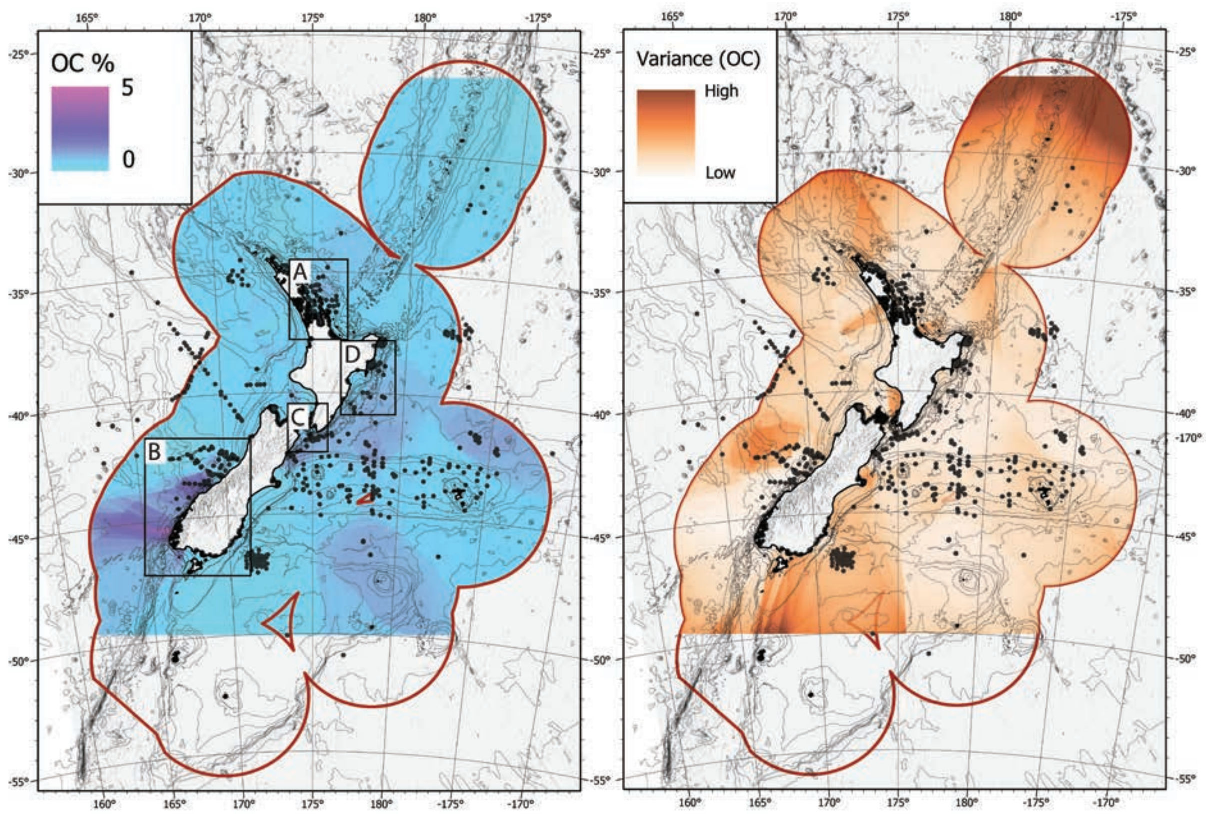
Research limitations

A limitation of the method was that the number of usable marine sediment samples available did not provide good coverage of our EEZ. Only 11,030 sediment samples were available for an area greater than 4 million square kilometres. Furthermore, most samples were from shallower depths closer to the coast and on submarine plateaus, with very few to no samples in distant and deep regions. For instance, there were no samples south of 50°S, so the estimate produced for that region had to be extrapolated. In other regions with low sample numbers, the uncertainty of the average amount of organic carbon calculated per unit area of seafloor was very high.

Several statistical approaches were tested to find the best proxy for organic carbon from the information gathered from the available samples. One approach established a reasonably robust relationship between estimates of sediment organic carbon concentration and sediment grain size.

How much carbon is stored in marine sediments in our Exclusive Economic Zone?

Putting aside these caveats, the results indicate there could be in the order of 2,240 million tonnes of organic carbon stored in marine sediments in the New Zealand EEZ. For context, this represents approximately 1% of estimated global organic carbon stocks in marine sediment, though this estimate is highly uncertain for the reasons outlined above. New Zealand's marine sediment stocks are distributed unevenly. Shallow coastal and continental shelf environments account for about 7% of New Zealand's total organic carbon stocks, while continental slopes store 26%, and about two-thirds are accounted for in areas deeper than 1,500 metres. The Fiordland fjords alone account for 8% of national marine sediment organic carbon stocks, highlighting the importance of this area as an organic carbon repository. Mud-filled bays, such as Tīkapa Moana o Hauraki Firth of Thames, which are heavily impacted by nutrient and terrestrial sediment inputs, also have high organic carbon values.



Modelled percentage of organic carbon (percentage of organic carbon, left panel; variance, right panel), excluding fjords, in top 10 centimetres of marine sediments from the continental shelf and deeper within the New Zealand EEZ and territorial seas (200 nautical miles, red line). Black dots represent samples used in organic carbon proxy model development. See the NIWA report for more details.

What is the risk that human activities will release carbon stored in marine sediments?

Fishing activities that disturb the seabed pose one of the greatest risks to our marine sediments. When considering the risk of carbon being released back into the water column from seafloor disturbance, NIWA only considered the impact of bottom trawling. Bottom trawling is a pervasive and repetitive activity throughout the New Zealand EEZ. Other human impacts such as port infrastructure and cable and pipeline installations only physically disturb the seabed once during their construction or assembly.

Bottom trawling is also the only activity with comprehensive datasets available for use. Data provided by Fisheries New Zealand show that 11.3% of the New Zealand EEZ was exposed to bottom trawling between 1989 and 2021. Nearly half (44%) of our EEZ and territorial seas shallower than 400 metres have been trawled at least once between 1990 and 2011. Much of the continental shelf and slopes have been trawled multiple times, as have deep-water environments of the Chatham Rise, Challenger Plateau and Campbell Plateau.

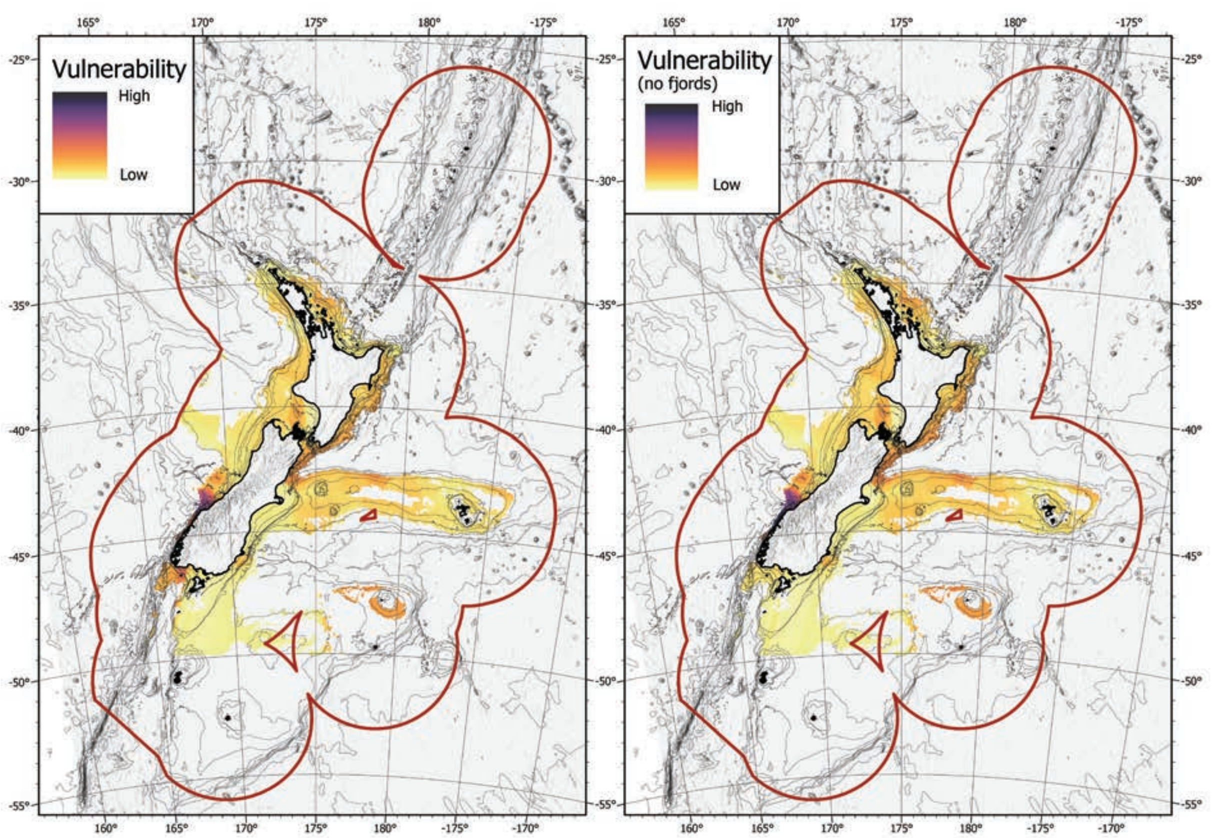
Photo: Factory trawler, Lyttelton, Bernard Spragg, Flickr.

For the report, NIWA developed New Zealand's first vulnerability index for organic carbon to bottom trawling at water depths less than 1,500 metres. To do this, NIWA combined bottom trawling data with sediment type, organic carbon lability (the fraction of carbon that moves rapidly through the carbon cycle), particle sinking speeds and organic carbon degradation rates.

The report includes numerous maps showing the distribution of organic carbon vulnerability, and seafloor areas that are least and most vulnerable to potential disturbance by bottom trawling and other human activities.

Although the modelling was limited by the distribution of bottom trawling and the uncertain amount of stored organic carbon, it found that bottom trawling is likely to have an impact on carbon stocks, especially on the continental shelf and slope.

It also emphasises the likely impact of trawling on organic carbon stocks further offshore along the deeper continental slope environments, particularly off south Westland, central northern Chatham Rise and along the east coast from Kaikōura to Hawke's Bay.



Vulnerability indices for sedimentary organic carbon relative to bottom trawling activity within the New Zealand EEZ (200 nautical miles, red line). Left panel: all data, including fjords; right panel: all data, excluding fjords.

More studies are needed to better understand the risk

While it is clear that marine sediments represent a huge stock of organic carbon, the vulnerability of these stocks to human perturbation is unknown. Further discussions are needed on the role of marine protected areas in securing organic carbon stored in marine sediments, and the need to limit or mitigate human activities that increase the risk of releasing that carbon into the ocean and potentially the atmosphere.

In the same way that we need to conserve soil carbon on land, we need to restrict activities that release carbon from marine sediments. If we are to mitigate the impact of human activity on global organic carbon stocks and repositories, we need to develop accurate carbon budgets that include carbon stored in marine sediments.

This study — a first for New Zealand — should be viewed as a pilot from which more accurate measurements and quantitative approaches can be adopted in the future. It can only be the start of a much larger process, in which long-term monitoring and scientific analysis of ocean carbon will help determine if ocean uptake of carbon dioxide and storage of carbon can keep pace with human-induced carbon emissions. This will help us plan how best to anticipate, mitigate and adapt to potential future changes. Effective stewardship of this important carbon resource and the ecosystem services that marine sediments deliver is also essential.

Photo: Examining deep sea sediments, Geoffroy Lamarche.

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

PO Box 10 241
Wellington 6140
Aotearoa New Zealand
Phone +64 4 495 8350
Email pce@pce.parliament.nz
Web pce.parliament.nz

November 2023

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata