Wai 3325, #A62

IN THE WAITANGI TRIBUNAL **WAI 3325**
WAI 3262

IN THE MATTER OF	the Treaty of Waitangi Act 1975
AND	
IN THE MATTER OF	the Climate Change Priority Inquiry (Wai 3325)
AND	
IN THE MATTER OF	a claim by Emily Tuhi-Ao Bailey on behalf of herself and Climate Justice Taranaki

STATEMENT OF EVIDENCE OF ABIGAIL SMITH

Dated: 28 April 2025

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Waitangi Tribunal
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WELLINGTON

BENNION LAW

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INTRODUCTION

1. Kia ora. My name is Abigail Marion Smith. I live in Ōtepoti, Dunedin. I am a Professor of Marine Science at the University of Otago, where I have taught, researched, and worked as an academic since 1993. I was awarded a Bachelor's degree from Colby College in Maine, USA in 1982; a Master of Science from the Massachusetts Institute of Technology in Massachusetts, USA in 1984; and a Doctorate from the University of Waikato in 1992.

2. I am a biogeochemist with 33 years of research experience in the marine environment of Aotearoa New Zealand. I have authored 12 book chapters, 99 science journal articles, 16 refereed conference proceedings articles, and 53 professional reports. Since 2007 I have been actively researching the effects of Ocean Acidification on marine water chemistry, shell geochemistry, and living organisms in Aotearoa New Zealand; on that subject I have published two book chapters and 17 research papers in the international peer-reviewed literature. I was the Director of the Otago University Ocean Acidification Research Theme from 2013 to 2016; in 2015 we were awarded the Otago University Sciences Best Research Group of the Year award. I was a founding member of the New Zealand Ocean Acidification Community (NZOAC), and was elected to be the inaugural Chair of its Council in 2015-2016. In that role, I hosted and led two NZOAC annual workshops.

3. I have been asked to provide this will say statement by Climate Justice Taranaki (CJT).

4. I have read the Code of Conduct for expert witnesses,[1] and I agree to abide by these. I have prepared this statement of evidence in accordance with the expert code of conduct. I confirm that my statement is within my area of expertise, except where I state I am relying on the evidence of another person.

5. This statement will cover:

    a. Definition of Ocean Acidification

[1] High Court Rules 2016, Schedule 4.

b. Effects of Ocean Acidification on Marine Life

c. Ocean Acidification in Aotearoa New Zealand

d. Impacts of Ocean Acidification in Aotearoa New Zealand

What is ocean acidification?

6. The exchange of carbon dioxide (CO_2) across the ocean-atmosphere surface is a critical part of the global carbon cycle. It is in dynamic equilibrium, where the balance shifts depending on concentration. When more CO_2 is added to the atmosphere, some of that CO_2 is absorbed by the sea. Current models suggest that one-quarter to one-third of atmospheric CO_2 produced by human activity is absorbed by the ocean.[2]

7. When CO_2 interacts with water, it forms carbonic acid (H2CO_3), a relatively weak acid. This acid breaks down into bicarbonate (H_2CO_3), the latter of which combines with carbonate (CO_3) to form more carbonic acid. The net effect of increasing CO_2 in seawater is thus an increase in bicarbonate and hydrogen ions, with a corresponding decrease in pH and carbonate, a critical ingredient of most shells (made of $CaCO_3$).

8. The ocean is currently absorbing about 22 million tonnes of CO_2 per day, which lowers the overall pH of the global seas. Over the past 200 years, since the industrial revolution, average open ocean surface water pH has reduced from 8.2 to 8.1. Because pH is a logarithmic scale, that is a 30% increase in acidicty, measured by hydrogen ion concentration. At no other time in the last 800,000 years has ocean pH changed so rapidly – because at no other time has there been such a sudden, rapid, and enormous input of atmospheric CO_2. It has been suggested that the mean pH of waters around Aotearoa New Zealand will decrease to below the current minimum in 10 to 20 years.[3]

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2 Gruber, N., Clement, D., Carter, B.R., Feely, R.A., van Heuven, S., Hoppema, M., Ishii, M., Key, R.M., Kozyr, A., Lauvset, S.K., Lo Monaco, C., Mathis, J.T., Murata, A., Olsen, A., Perez, F.F., Sabine, C.L., Tanhua, T., Wanninkhof, R. 2019. The oceanic sink for anthropogenic CO2 from 1994 to 2007. Science 363(6432): 1193-1199, http://dx.doi.org/10.1126/science.aau5153

3 Law, C.S., Rickard, G.J., Mikaloff-Fletcher, S.E., Pinkerton, M.H., Behrens, E., Chiswell, S.M., Currie, K.I., 2017. Climate change projections for the surface ocean around New Zealand. New Zealand Journal of Marine and Freshwater Research 52(3): 309-335. https://doi.org/10.1080/00288330.2017.1390772

9. Ocean acidification has been called “the other climate change problem” but actually it is more like global warming’s evil twin. The absorption of CO_2 by sea water reduces the greenhouse gas effect, and thus moderates warming, but with the consequence of changing sea-water chemistry. The changing pH of sea water is not technically “climate change,” because climate is defined as dominantly atmospheric,[4] though the ocean is an important component of the whole-Earth climate system. The two are intimately linked, but distinct.

Effects of ocean acidification on marine life

10. Many marine organisms operate a carefully balanced acid-base chemistry, and are vulnerable to changes in environmental pH, with effects on growth, calcification, development, and/or survival. Others are quite resilient to pH changes because they are able to self-regulate the water immediately around them. Some marine organisms even thrive in lowered pH waters. This nonuniform response has been called a “winners and losers” scenario.

11. Organisms that make a calcium carbonate ($CaCO_3$) shell or skeleton (such as molluscs, barnacles, sea urchins, crustaceans, bryozoans, corals, some sponges) are usually “losers”. They have been shown to respond to changing sea-water carbonate chemistry by growing more slowly, or by decreasing (or in rare cases increasing) the size, thickness, composition, or complexity of their shells. This effect is particularly marked in the larvae or juveniles, which can be deformed or show development delays – so becoming a “bottleneck” in the lifecycle.

12. Small marine phytoplankton form the basis of the marine food web and are essential oxygen-producers. When they die, they sink, an important mechanism for removing carbon from upper ocean waters. There are planktonic “winners” who benefit from increased carbon and “losers” who cannot make their small calcium carbonate shells. Marine macroalgae, too, may grow faster under ocean acidification, because they use the extra CO_2 in photosynthesis. Calcified coralline algae (the “glue” that holds many reef communities together) are a clear exception, disappearing in low-pH environments.

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4 See, e.g., Encyclopaedia Britannica: https://www.britannica.com/science/climate-meteorology

13. It has been shown that lowered pH seawater affects the brain chemistry of small tropical fishes, so that they lose some sensory functions and show changes in behaviour that are usually deleterious (e.g., swimming towards predators instead of away). Ongoing research in New Zealand is investigating temperate fishes, with preliminary results suggesting they too show some behavioural changes in low-pH water. Effects on seabirds, seals, dolphins and whales are not known.

14. In summary, bacteria, some plankton and algae, and a few invertebrates may be "winners" under ocean acidification – they are able to utilise the increased CO_2, and/or they are resilient to pH change. Many organisms that produce a $CaCO_3$ shell are "losers", because they can't produce robust shells, or because the extra energy required to maintain their shells is diverted from other processes, and because juvenile and larval forms are particularly susceptible.[5] Unexpectedly, small prey fish may also be "losers" and we don't know much about other, larger marine organisms.

15. While we know a bit about the response of some species and groups to acidification, we know much less about the responses of whole ecosystems. Natural communities are both complex and interactive, which could make them resilient or vulnerable to changes in seawater chemistry. The undersea volcanic vents at Whakaari White Island provide a possible "natural lab" where marine ecosystems occur at elevated temperatures and CO_2 concentrations. Abundance and diversity, especially of shell-producing organisms, is somewhat lower in these waters than in similar non-volcanic environments.[6]

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5 Law, C.L., Bell, J.J., Bostock HC, Cornwall CE, Cummings V, Currie K, Davy SK, Gammon M, Hepburn CD, Hurd CL, Lamare M, Mikaloff-Fletcher SE, Nelson WA, Parsons DM, Ragg NLC, Sewell MA, Smith AM, Tracey DM. Ocean Acidification in New Zealand waters. New Zealand Journal of Marine and Freshwater Research, 52: 155-195, 2017. doi: 10.1080/00288330.2017.1374983

6 Zitoun, R., Connell, S.D., Cornwall, C.E., Currie, K.I., Fabricius, K., Hoffmann, L.J., Lamare, M.D., Murdoch, J., Noonan, S., Sander, S.G., Sewell, M.A., Shears, N.T., van den Berg, C.M.G., Smith, A.M. A unique temperate rocky coastal hydrothermal vent system (Whakaari/White Island, Bay of Plenty, New Zealand): constraints for ocean acidification studies. Marine and Freshwater Research 71(3): 321-344 (2019), doi.org/10.1071/MF19167

Ocean acidification in Aotearoa New Zealand

16. Aotearoa New Zealand is a maritime country with a large Exclusive Economic Zone. We have considerable investment in and dependence on functional marine ecosystems, including shellfish and finfish aquaculture, wild fisheries, and broader ecosystem services.

17. Ocean Acidification is a global issue, driven by atmospheric CO_2. The Earth's atmosphere is a rapidly stirred fluid -- emissions from a particular place may or may not affect the seawater nearest to it. There are, however, regional variations in local Ocean Acidification, particularly in coastal waters, related to location and ocean circulation. pH is affected by CO_2, temperature, salinity and pressure. Open-ocean data collected around Aotearoa New Zealand indicates that we are in step with the rest of the planet, with a local regional pH of 8.088, declining steadily.

18. We know that CO_2 has been increasing in Aotearoa New Zealand offshore waters, with consequent lowering of pH, because the Munida Transect (65 km long, located off Otago Peninsula) has been sampled and its seawater measured almost bimonthly since 1998, the longest-running such transect in the Southern Hemisphere. The Munida data show an annual average increase in pCO_2 of 1.28 µ-atm, with pH decreasing at a rate of 0.0013 per year.[7]

19. Since 2015, coastal monitoring stations around Aotearoa New Zealand have been contributing to the New Zealand Acidification Observing Network, so that we are developing a localised understanding of the complicated and fluctuating nearshore environment. For example, photosynthesis and respiration of marine algae in kelp beds can result in sea-water pH varying up to 0.94 within a single day. Seasons, too, influence coastal pH, with maximum pH in late winter and minimum in late summer, at least in some places. Phytoplankton blooms, sudden freshwater inputs from floods, agricultural pollution and eutrophication can reduce pH, to as low as 7.7 in places. Consequently, long-term trends in coastal pH have to include consideration of natural short-term variation.

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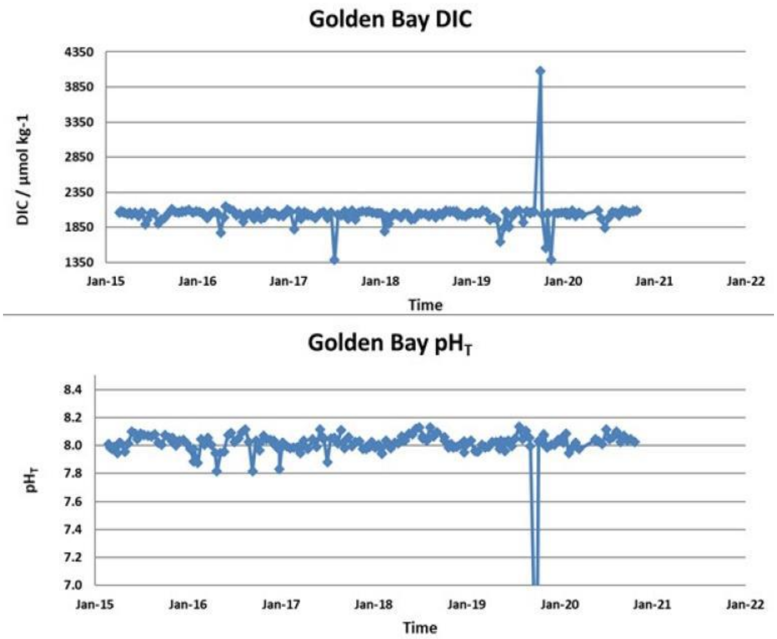
7 Bates, N.R., Y.M. Astor, M.J. Church, K. Currie, J.E. Dore, M. González-Dávila, L. Lorenzoni, F. Muller-Karger, J. Olafsson, and J.M. Santana-Casiano. 2014. A time-series view of changing ocean chemistry due to ocean uptake of anthropogenic CO2 and ocean acidification. Oceanography 27(1):126–141, http://dx.doi.org/10.5670/oceanog.2014.16.

20. The closest NZOA-ON monitored site to Taranaki is at Golden Bay, ~220 km SE of New Plymouth. Like most places without kelp around coastal NZ, the pH varies mostly around 8. We cannot see a decrease in pH over the short time in which monitoring has been undertaken. (The single massive dip on the graph is currently unexplained; it could reflect a short-term regional event, or perhaps operator error.)



Seawater pH and Dissolved Organic Carbon at Golden Bay, as measured by NZOA-ON (data sourced from NIWA; https://marinedata.niwa.co.nz)

Impact of Ocean Acidification on Aotearoa New Zealand

21. Ecosystems in Aotearoa New Zealand are already grappling with the effects of massive inputs of anthropogenic CO_2, and the marine environment is no exception. Increasing ocean temperatures, lowering oxygen levels, and decreasing pH combine with each other to produce a “triple whammy”.[8] In addition, organisms around Aotearoa New Zealand are facing more frequent

8 Gruber, N. 2011. Warming up, turning sour, losing breath: ocean biogeochemistry under global change. Philosophical Transactions of the Royal Society A 369(2011): 1980-1996. Doi: 10.1098/rsta.2011.0003

and stronger marine heatwaves,[9] increased erosion from deforestation, and changing weather patterns.

22. We already see marine organisms redistributing themselves around the planet, as tropical species move poleward. Food webs are changing. Vertical distributions of plankton are adjusting to changes in temperature, light, nutrients and circulation in the open ocean.

23. Valuable and important aquaculture and wild-caught fisheries may be affected by ocean acidification, including the green-lipped mussel (kuku, *Perna canaliculus*, Greenshell™) and pāua (*Haliotis iris*, NZ black-footed abalone). While they have been shown to be fairly resilient to lowered pH as adults, it comes at a cost. In low-pH settings, they expend more energy on maintaining their shells, and have less available for growth and reproduction. Even more important, their tiny larvae are highly vulnerable to low-pH, with low survivorship and increasing deformity.

24. Ocean acidification is going on, and on-going. We can't stop it now. The only practicable mechanism for slowing it down is the reduction of CO_2 emissions. A lowered-emission mitigation scenario (RCP2.6) could result in almost no further decrease, whereas a high-emission scenario (RCP8.5) would bring mean ocean surface pH in Aotearoa New Zealand to 7.7 -- a level that will have considerable effect on marine ecosystems, aquaculture and fisheries in Aotearoa New Zealand.

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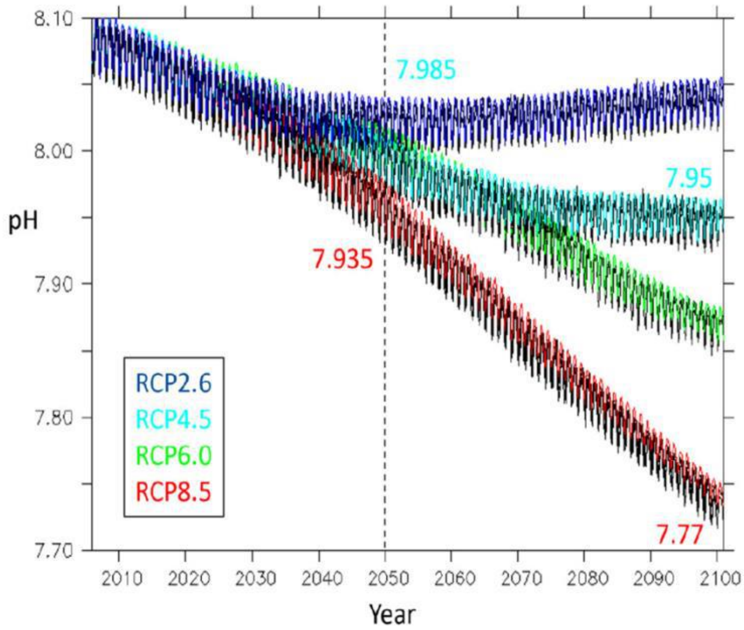
9 Salinger, M.M., Renwick, J., Behrens, E., Mullan, A.B., Diamond, H.J., Sirguey, P., Smith, R.O., Trought, M.C.T., Alexander, L., Cullen, N., Fitzharris, B.B., Hepburn, C.D., Parker, A.K., Sutton, P.J. 2019. The unprecedented, coupled ocean-atmopshere summer heatwave in the New Zealand region 2017/18: drivers, mechanisms and impacts. Environmental Research Letter 14(4): 044023 Doi: https://doi.org/10.1088/17489326/ab012a



Projected surface seawater pH for the NZ region under different emission scenarios (Law et al., 2018)[10]

Abigail Marion Smith

10 Law, C.S., Rickard, G.J., Mikaloff-Fletcher, S.E., Pinkerton, M.H., Behrens, E., Chiswell, S.M., Currie, K.I., 2017. Climate change projections for the surface ocean around New Zealand. New Zealand Journal of Marine and Freshwater Research 52(3): 309-335. https://doi.org/10.1080/00288330.2017.1390772