24 November 2021

climateconsultation2021@mfe.govt.nz

Submission: Ministry for the Environment – Emissions Reduction Plan Consultation

The New Zealand Marine Sciences Society (NZMSS) - Te Hunga Mātai Moana O Aotearoa is a professional society affiliated to the Royal Society of New Zealand - Te Apārangi. NZMSS has approximately 470 members. We are a non-profit organisation that provides access to, and within, the marine science community, and we identify emerging issues through annual conferences, annual reviews, a list serve and a website www.nzmss.org.nz. NZMSS membership covers all aspects of scientific interest in the marine environment and extends to the uptake of science in marine policy, resource management, the environment and the marine business sector. We speak for members of the society and we engage with other scientific societies as appropriate.

NZMSS recognises the science conducted by the Intergovernmental Panel on Climate Change (IPCC) and therefore supports urgent and ambitious climate action by the Aotearoa New Zealand Government. However, NZMSS identifies a crucial gap in MFE's draft emissions reduction plan, which is the lack of coverage on the marine environment.

The marine environment plays a crucial role in emissions reduction, particularly in relation to nature-based solutions as well as to developing a circular economy (e.g. in the food production, energy and waste sectors). We recommend that the government acts urgently to protect and restore vital marine carbon sinks and to promote and support marine-related sectors contributing to the circular economy. We also support the plan's reference to future research and we identify priority areas of research relating to emissions reduction in the marine environment.

Please contact me at the email address provided below for any further information regarding this submission. NZMSS has a panel of experts in marine and climate science who can assist with options and approaches in relation to this emissions reduction plan.

Kathy Walls
President, New Zealand Marine Sciences Society
Address for service:
Email: president@nzmss.org

Submission: 2021 Emissions Reduction Plan Consultation

General comments and submission overview

NZMSS welcomes the release of the draft emissions reduction plan (the Plan) for consultation. We note that the Plan is heavily weighted towards mitigating terrestrial sources of greenhouse gas emissions, and the need to improve policy settings in this domain to facilitate a more rapid reduction in emissions. Marine-related solutions are currently recognised in the Transport (i.e. coastal and maritime shipping) and Waste (i.e. fisheries biomass) sections of the Plan. However, we wish to draw the Ministry for the Environment's (MfE) attention to the general lack of coverage on the marine domain. The Plan does not mention the word "marine" at all, and "ocean" only twice (in the definitions of 'carbon sequestration/sink' and 'fossil gas'). This is a significant gap, particularly in context of 'nature-based solutions' being embedded within the Plan's guiding principles. In our submission, which builds on the previous NZMSS submission to the Climate Change Commission, we identify:

- Aotearoa New Zealand's marine environment
- The role of the ocean in carbon storage
- Human impacts on marine carbon storage
- Marine-related emissions reductions solutions for Aotearoa New Zealand.

NZMSS recommendations

Recommendation 1: NZMSS recommends that MfE's emissions reduction plan be revised to recognise the crucial role of the Aotearoa New Zealand's marine domain in emissions reduction. Regarding the Plan, we therefore recommend that the 'Agriculture and Forestry' category be extended to include 'Marine-Based Primary Industries' or similar wording.

Recommendation 2: That the Government acts urgently to protect and restore vital marine carbon sinks and to promote and support marine-related sectors contributing towards the circular economy. This includes implementing the following actions:

- Prohibiting large-scale disturbance of seafloor sediments, such as that currently caused by bottom-contact fishing methods and proposed seafloor mineral extraction.
- Protecting and restoring macroalgal forests by implementing ecosystem-based management of fisheries to restore balance to coastal ecosystems (e.g. by enabling snapper and crayfish populations to increase will likely result in reduction of sea urchin pressure on kelp forests). Other tools include establishing highly protected marine areas (including large no-take areas) and reducing human-caused sediment runoff from land.
- Protecting and restoring tidal wetlands (saltmarsh, seagrass and mangroves) by prohibiting damage to these habitats, allowing inland migration of tidal wetlands with sea level rise, reducing human-caused sediment and nutrient run-off from land to protect vulnerable habitats and implementing policy to facilitate tidal wetland restoration.
- Promoting and supporting marine-based contributions towards a circular economy in Aotearoa New Zealand.

Recommendation 3: NZMSS also supports the Plan's reference to future research, and we recommend the priority areas of research relating to emissions reduction in the marine environment outlined in Section 5 of our submission.

Recommendation 4: NZMSS invites MfE to engage with us to address the significant gap in this Plan. NZMSS has a panel of experts in marine and climate science who can assist with options and approaches in relation to this emissions reduction plan.

Specific comments

1. Aotearoa New Zealand's marine environment

Our marine environment is significant in size. The Exclusive Economic Zone (EEZ) covers approximately 420 million hectares, or about 15 times the land area of Aotearoa New Zealand (refer to Figure 1). The extended continental shelf encompasses about 21 times the land area[1]. This hosts a diverse range of ecosystems from the coast to the abyssal depths, along with over 12,800 species[2].

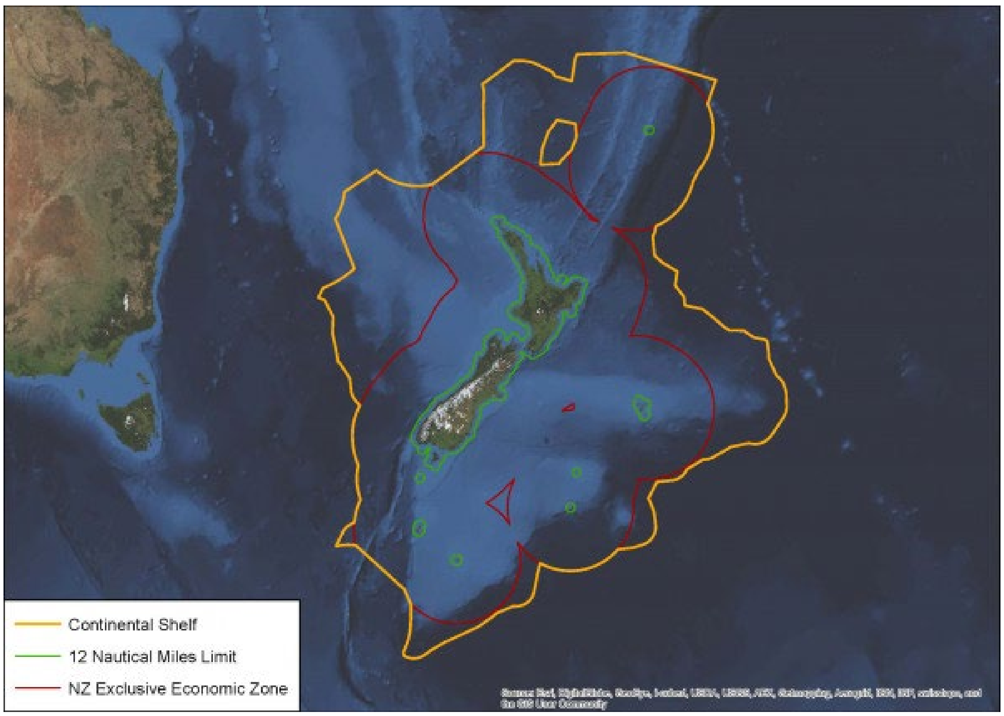


Figure 1: Aotearoa New Zealand's marine environment. Note: EEZ = 12- 200 NM exclusive economic zone (EEZ). Orange border = extended continental shelf covered by the EEZ and Continental Shelf (Environmental Effects) Act 2012. The small triangle-type shapes within the larger EEZ border are international waters. Source: *EPA website.*

2. Role of the ocean in carbon storage

Recent research has highlighted the essential role that the oceans play in mitigating the effects of climate change. Carbon is captured and sequestered in marine organisms and the seabed.

[1] Gordon et al 2010. Marine biodiversity of Aotearoa New Zealand. PLOS One https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0010905.

[2] Biodiversity in Aotearoa an overview of state, trends and pressures 2020. https://www.doc.govt.nz/globalassets/documents/conservation/biodiversity/anzbs-2020-biodiversity-report.pdf

The oceans have absorbed heat and carbon dioxide (CO_2) as global temperatures and CO_2 emissions have risen, which has buffered somewhat the effects of anthropogenic activities on the atmosphere and climate. Higher levels of biodiversity in the ocean can be associated with increased carbon storage through functioning ecosystems[3].

The carbon storage capacity of offshore shelf sediments, which cover roughly 9% of global marine area, has also received increasing recognition[4]. Marine sediments store more than twice the carbon in the top 1 metre than do terrestrial soils and represent a globally important carbon sink[5]. Most of the carbon-rich sediments (about 75%) are located in abyss/basin areas, and over 50% is within countries' exclusive economic zones. The long-term carbon storage within these areas is vulnerable to remineralisation into CO_2 as a consequence of human activities, which occur over significant areas of shelf seas[6].

The contribution of coastal marine vegetation on the ocean carbon cycle has been the subject of ongoing research over the past two decades[7] and is currently a fast-moving field of research. A recent study estimated the organic carbon storage in tidal wetlands (mangroves, salt marsh, seagrasses) in Australia, and calculated that loss of these biodiverse vegetated coastal habitats would result in an increase in emissions of between 12-21% annually[8]. Equally the opportunity of global carbon storage of tidal wetlands if maintained is high, with storage of 138 ± 38 g $C/m^2/yr$ (equal to 5.1 $CO^2/ha/yr$ in seagrasses), 218 ± 24 g $C/m^2/yr$ (equal to 8.0 t $CO^2/ha/yr$ salt marsh) and 226 ± 39 g $C/m^2/yr$ (equal to 8.3 t $CO^2/ha/yr$ in mangroves)[9]. However, carbon sequestration of tidal wetland habitats in Aotearoa New Zealand may be lower (e.g. for salt marsh, Perez et al. 2017[10]) or higher (e.g. for mangroves, Lovelock et al. 2010[11]) than this, based on limited data. In Aotearoa New Zealand, the organic carbon stocks of tidal wetland habitats have been shown to range from 90 t/ha to 27 t/ha [12], with the overall area of saline wetlands calculated as 47, 018 ha[13]. Notably, the estimates above exclude kelp forests and other seaweeds, which are important marine habitats throughout Aotearoa New Zealand's

---

[3] Sala et al. 2021. Protecting the global ocean for biodiversity, food and climate. Nature 592: 397–402.

[4] Diesing et al. 2017. Predicting the standing stock of organic carbon in surface sediments of the North-West European continental shelf. Biogeochemistry 135: 183-220. Luisetti et al. 2019. Quantifying and valuing carbon flows and stores in coastal and shelf ecosystems in the UK. Ecosystem Services 35: 67-76.

[5] Atwood et al. 2020. Global patterns in marine sediment carbon stocks. Frontiers in Marine Science doi: 10.3389/fmars.2020.00165

[6] Sala et al. 2021. Protecting the global ocean for biodiversity, food and climate. Nature https://doi.org/10.1038/s41586-021-03371-z

[7] Duarte et al. 2004. Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences Discussions 1: 659-679. Laffoley, D.d'A. & Grimsditch, G. (eds). 2009. The management of natural coastal carbon sinks. IUCN, Gland, Switzerland.

[8] Serrano et al. 2019. Australian vegetated coastal ecosystems as global hotspots for climate change mitigation. Nature Communications https://doi.org/10.1038/s41467-019-12176-8.

[9] Mcleod et al. 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. Front Ecol Environ 2011; 9(10): 552–560, doi:10.1890/110004.

[10] Pérez et al. 2017. Changes in soil organic carbon accumulation driven by mangrove expansion and deforestation in a New Zealand estuary. Estuar. Coast. Shelf Sci. 192:108–116. doi: 10.1016/j.ecss.2017.05.009

[11] Lovelock et al. 2010. Mangrove forest and soil development on a rapidly accreting shore in New Zealand. Ecosystems 13: 437–451 DOI: 10.1007/s10021-010-9329-2.

[12] Bulmer et al. 2020. Blue carbon stocks and cross-habitat subsidies. Front. Mar. Sci. 7:380. doi: 10.3389/fmars.2020.00380.

[13] Dymond et al 2021. Revised extent of wetlands in New Zealand. New Zealand Journal of Ecology 45(2): 3444.

coastline, and have been estimated to sequester between 4000 and 1.5 million tons of carbon per year in different parts of the world[14].

Carbon storage timeframes vary with the type of carbon sink. For example, soil organic carbon in tidal wetlands can be sequestered for very long periods (centuries to millennia[15]). Carbon within individual living organisms is sequestered for shorter periods (e.g. for seaweeds - up to a decade), but storage can be sustained over time by maintaining populations. Carbon originating from marine organisms such as seaweeds also has potential to be sequestered for longer periods (e.g. up to thousands of years) in seafloor sediments or the deep ocean[16].

3. Impacts of human activities on marine carbon storage and emissions reduction.

Human impacts and opportunities overview

The ability to capture carbon is being directly affected by the way we currently use our marine environment. For example, carbon-rich sediments are frequently disturbed over significant areas by fishing activities such as bottom trawling and port-related dredging activities in some areas of the coastal zone, and international research has shown (refer to details in the following section) that carbon stores can be remineralised back into seawater, exacerbating the effects of climate change and ocean acidification.

In 2019, the 14 member nations of the High Level Panel for a Sustainable Ocean Economy[17] issued an expert report on the mitigation potential of a suite of ocean-based activities and the potential future contribution from carbon storage[18]. It was identified that the ocean naturally contains nearly 150,000 $GtCO_2e$, which dwarfs the 2,000 $GtCO_2e$ in the atmosphere and 7,300 $GtCO_2e$ in the land-bqa biosphere.

The panel assessed a number of ocean-based interventions and selected mitigation options for their potential contribution towards reducing emissions and enhancing the ocean's ability to store carbon more effectively. These included: ocean-based renewable energy; ocean-based transport; emissions from fishing vessels; emissions from aquaculture; increasing ocean-based proteins in human diets; recovery of biodiversity and biomass; restoration and protection of 'blue carbon sinks' (mangroves, salt-marsh, seagrasses); seaweed production; and carbon storage in the seabed (refer to Appendix 1).

The panel found that, should more ecologically sustainable activities and management occur over time, the ocean could contribute an estimated 6% to 25% reduction in emissions needed by 2050 to achieve the 1.5°C reduction in global temperatures called for under the Paris Agreement. While there were a number of caveats to the analysis; nevertheless a compelling

[14] Eger et al 2021. The economic value of fisheries, blue carbon, and nutrient cycling in global marine forests. EcoEvoRxiv.

[15] Duarte et al. 2005. Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences, 2, 1–8. Lo Iacono et al. 2008. Very high-resolution seismo-acoustic imaging of seagrass meadows (Mediterranean Sea): Implications for carbon sink estimates. Geophysical Research Letters, 35.

[16] Paine et al 2021. Rate and fate of dissolved organic carbon release by seaweeds: A missing link in the coastal ocean carbon cycle. Journal of Phycology. doi:10.1111/jpy.13198

[17] https://www.oceanpanel.org/. Member Nations: Australia, Canada, Chile, Fiji, Ghana, Indonesia, Jamaica, Japan, Kenya, Mexico, Namibia, Norway, Palau, Portugal, and the United Nation's Special Envoy for the Ocean.

[18] Hoegh-Guldberg et al. 2019. "The Ocean as a Solution to Climate Change: Five Opportunities for Action". World Resources Institute. Washington DC. Available online at http://www.oceanpanel.org/climate.

and urgent argument was made that policy to mitigate climate change needs to specifically account for activities on and within the ocean.

On the other hand, if the ocean continues to absorb more CO_2 and becomes more acidic, this will reduce its ability to buffer climate change, disrupt ecosystems, and increase food insecurity. In this respect, as a consequence of human activities, approximately 10 billion tonnes of CO_2, or about 25 to 30 % of anthropogenic CO_2 emissions, enters the ocean (Global Carbon Project 2018).

Further details of human impacts (including in context of Aotearoa New Zealand)
Physical disturbance of seafloor sediments causes resuspension into the water column, leading to exposure to oxygen and heterotrophic metabolism that can result in remineralisation[19], exacerbating the effects of climate change and ocean acidification. For example, a recent study in the Mediterranean compared carbon storage in trawled and untrawled deep-water areas, finding that continuous erosion and sediment mixing in trawled areas led to an approximately 30% loss of organic carbon and a 52-70% loss of labile compounds through degradation[20]. Such disturbance of marine sediments occurs on a significant scale in Aotearoa New Zealand, with over 335 million ha exposed to bottom-contact fishing methods between 1990-2016[21]. These frequent and intense disturbances also contribute to ocean acidification, a significant threat to Aotearoa New Zealand's marine ecosystems[22].

Land use activities are also resulting in damage to coastal vegetation by the smothering of seagrass, limiting light for benthic primary producers such as kelp forests, and loss of shellfish beds from excessive terrigenous sedimentation[23] (Figure 2). The ongoing adverse effects on coastal ecosystems are likely to be exacerbated by future clearfell harvesting of radiata pine, planted on marginal hill country to mitigate climate emissions and stem erosion as well as use of intensified agricultural practices that require high fertiliser inputs. On coastal margins, degradation of tidal wetland habitats can have deleterious consequences for climate mitigation. For example, drained salt marsh can emit greenhouse gases including carbon dioxide and methane[24].

Productivity and carbon storage of coastal ecosystems in Aotearoa New Zealand is also indirectly impacted by fishing. For example, decades of research on coastal reefs have shown that fishing has led to a shift from highly productive kelp forests to barren landscapes dominated by sea urchins[25] (Figure 3). Furthermore, new research has shown that increases in the

---

[19] For example, as described in Bianchi et al. 2016. Redox effects on organic matter storage in coastal sediments during the Holocene: a biomarker/proxy perspective. Annual Review of Earth and Planetary Sciences 44: 295–319.
[20] Paradis et al. 2021. Persistence of biogeochemical alterations off deep-sea sediments by bottom trawling. Geophysical Research Letters, 48, e2020GL091279. https://doiorg/10.1029/2020GL091279.
[21] Ministry for the Environment and Statistics New Zealand. 2019. Our Marine Environment.2019. New Zealand's Environmental Reporting Series. NZ Government.
[22] MacDiarmid et al. 2012. Assessment of anthropogenic threats to New Zealand marine habitats. New Zealand Aquatic Environment and Biodiversity Report No. 93. Ministry for Primary Industries, Wellington, NZ. 255p.
[23] Thrush 2004. Muddy waters: elevating sediment input to coastal and estuarine habitats. Frontiers in Ecology and the Environment, 2(6): 299–306.
[24] Kroeger et al 2017. Restoring tides to reduce methane emissions in impounded wetlands: A new and potent Blue Carbon climate change intervention. Scientific reports, 7(1), 1-12.
[25] Shears, Babcock 2003. Continuing trophic cascade effects after 25 years of no-take marine reserve protection. Marine Ecology Progress Series, 246, 1–16.

frequency and magnitude of marine heatwaves, as a result of climate change, can further weaken the resilience of coastal ecosystems to local stressors and, in some cases, remove coastal vegetation all together[26]. This loss of coastal vegetation has vast implications for carbon storage.

Effective management of fishing and land practices can therefore greatly increase the contribution of marine ecosystems to carbon sequestration.

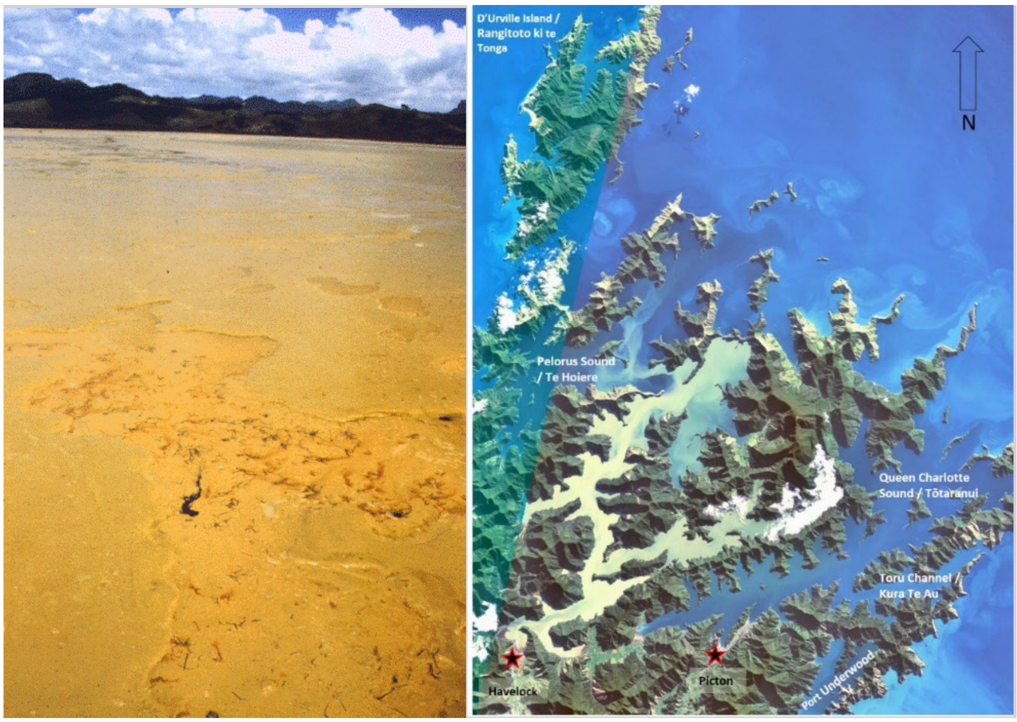


Figure 2: (Left) Terrigenous sediment dump smothered a carbon-sequestering seagrass bed in an estuary. Photo credit: Michele Wilkinson. (Right) Sediment discharge into Pelorus/Te Hoiere Sound after an estimated 1 in 3.1 year rainfall event in July 2018. Photo credit: Ben Knight.

[26] Smale 2020. Impacts of ocean warming on kelp forest ecosystems. New Phytologist 225(4): 1447-1454.

Figure 3: An urchin barren (Left) and kelp forest (Right) in the Hauraki Gulf. Photo credit: Nick Shears.

4. Marine-related emissions reductions solutions for Aotearoa New Zealand

Nature-based solutions and management tools

We support the concepts of nature-based solutions and environmental protection already embedded within guiding principles for Government decisions on emissions reduction (in the Plan, Table 5 on page 20). However, we wish to highlight the crucial role that the marine environment can play in respect to this. This relates to the human activities that threaten marine carbon storage described in the previous section. Various management tools used to protect and or restore marine carbon sinks are available to enable implementation of these nature-based solutions (see Table 1 for examples). We note that some of these management tools align with the recommendation in the Climate Change Commission's 2021 report[27] around preventing further loss of carbon from organic soils, particularly due to the degradation of drained peatlands and the destruction of wetlands. Given that some of the management tools in our submission relate to fishing and other marine-based primary activities, we suggest that the 'Agriculture and Forestry' category in the Plan be expanded to include 'Marine-Based Primary Industries' or similar wording.

Advancement of technology or knowledge is not required to implement these management tools, although future research could offer improvements in this space. In terms of economic feasibility, a recent economic analysis of the nature and extent of bottom trawling in Aotearoa New Zealand has indicated that the economic costs of transitioning [to alternative methods of fishing for demersal species] would be significant, but that the costs would diminish over time as fishers became more efficient at using different fishing methods[28]. There is also existing legislation that enables the implementation of most (potentially all) of these management tools. In some cases, however, the legislation could benefit from being strengthened in this respect. For example, estuaries (and coastal wetlands) could be fully integrated within freshwater management units in the National Policy Statement for Freshwater Management to require

[27] Recommendations from Ināia tonu nei: a low-emissions future for Aotearoa. https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/

[28] Cox et al 2021. An economic analysis of bottom trawling in New Zealand November 2021. Report for the The Ministry for Primary Industries (MPI) provided by the Business and Economic Research Limited (BERL). Report released under the Official Information Act 1982.

councils to limit terrestrial impacts on coastal ecosystems[29]. Coastal wetlands could also be specified as a key ecosystem to protect within The New Zealand Coastal Policy Statement (Policy 11). The Government could also implement policy for highly protected marine areas of the EEZ.

Any lack of local estimates of carbon storage and emission reduction from these marine nature-based solutions should not prevent these tools being implemented now. We note that 'managing risk and uncertainty' is already an inherent part of the emissions reduction plan and the New Zealand Coastal Policy Statement also outlines situations where a precautionary approach should be adopted.

As recognised as a risk in the Plan (e.g. page 119), we stress that nature-based solutions (including those relating to the marine environment) should not be seen as a substitute for reducing gross emissions in other sectors. We also understand that, due to policy wording, some of the marine nature-based solutions for reducing emissions may not currently be able to contribute to meeting Aotearoa New Zealand's international climate obligations under the Paris Agreement. However, New Zealand's Nationally Determined Contributions document (dated November 2021) does state that '*New Zealand looks forward to considering methodologies introduced by the 2013 IPCC Wetlands Supplement*[30] *and the 2019 Refinement to the 2006 IPCC Guidelines*[31] *in the future'*, noting that wetlands were defined to encompass 'coastal wetlands including mangrove forests', 'tidal marshes' and 'seagrass meadows'. Regardless, given the magnitude of carbon that is (and can be) stored in marine systems, marine nature-based solutions are a powerful tool that should be used to contribute to addressing the global climate crisis.

Co-benefits are an important advantage of nature-based solutions, given that other crises (such as biodiversity loss) are occurring alongside climate change. The many co-benefits of marine nature-based solutions relate to the environment, society, culture and economy. There can also be positive feedback loops between co-benefits and climate resilience, for example high biodiversity can mitigate the impact of ocean acidification[32].

---

[29] Managing Our Estuaries 2020. Parliamentary Commissioner for the Environment. https://www.pce.parliament.nz/media/197063/report-managing-our-estuaries-pdf-44mb.pdf

[30] 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.

[31] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

[32] Rastelli et al. 2020. A high biodiversity mitigates the impact of ocean acidification on hard-bottom ecosystems. Scientific Reports 10:2948 https://doi.org/10.1038/s41598-020-59886-4 1

Table 1: Overview of nature-based solutions for the marine environment including ecosystem type (and carbon sink) and management type and tools. This is a high-level summary; NZMSS can provide further details upon request.

Ecosystem type (Carbon sink)	**Management Type** Protect an existing carbon sink and/or restore one	**Management Tools** Examples only
Ocean seafloor (sediments)	Protect and/or restore	Prohibit large-scale disturbance of seafloor sediments, such as that currently caused by bottom-contact fishing methods and proposed seafloor mineral extraction.
Macroalgal forests and other marine communities (living biomass, but also some likely to be sequestered in ocean sediments)	Protect and/or Restore	Implement ecosystem-based management of fisheries stocks to restore balance to coastal ecosystems, e.g., increasing snapper and crayfish populations to reduce sea urchin pressure on kelp forests. Implement highly protected marine areas e.g. larger area of no-take. Reduce human-caused sediment runoff from land.
Tidal wetland habitats e.g. salt marsh, mangrove and seagrass. (living biomass and soil carbon)	Protect	Prohibit damage to/destruction of tidal wetland habitats. Allow inland migration of tidal wetlands with sea level rise. Reduce human-caused sediment and nutrient run-off from land to protect vulnerable habitats.
	Restore	Implement policy to facilitate tidal wetland restoration (e.g. through re-wetting, re-vegetation etc.).

Contributing towards a circular economy

In section 'Moving Aotearoa to a circular economy' (page 48), the Plan promotes a circular economy operating within planetary boundaries. We therefore identify various marine-related solutions in Aotearoa New Zealand that can (and do already) contribute towards this goal:

- Sustainable aquaculture has an important role to play, especially in the production of protein[33]. Regarding the Plan, and as previously mentioned, we therefore recommend that the 'Agriculture and Forestry' category be extended to include 'Marine-Based Primary Industries' which include aquaculture.

[33] https://www.oceanpanel.org/ . Member Nations: Australia, Canada, Chile, Fiji, Ghana, Indonesia, Jamaica, Japan, Kenya, Mexico, Namibia, Norway, Palau, Portugal, and the United Nation's Special Envoy for the Ocean.

- In terms of the energy sector, increasing the number of options available for renewable energy production could help the energy sector move away from fossil fuels. Offshore wind energy technology is already used overseas[34] and therefore is relevant for inclusion within the Plan (especially within the timeframe of 15 years covered by the Plan). Marine-generated energy, such as from tides and ocean waves, requires further research and development (see following section) but could be viable within relevant timeframes. In relation to energy, we also note that allowing future oil and gas extraction would not align with the concept of a circular economy defined in the Plan as '*an economic system based on designing out waste and pollution, reusing products and materials, and regenerating natural systems*'.

- Within relevant timeframes, there may also be other ways that the marine environment can contribute to the circular economy in other sectors outlined in the Plan. For example, in the waste sector (besides fisheries biomass already included in the Plan) the use of seaweeds to create bioplastic[35] could help with decarbonising plastic.

As part of the Plan, Government should therefore undertake actions to promote and support the above contributions towards a circular economy in Aotearoa New Zealand. This aligns with other intentions, for example the Government's Aquaculture Strategy.

5. Recommended future research science and innovation

NZMSS supports investment into research as outlined by the Plan in the Research, Science and Innovation section (page 42). In relation to emissions reduction in the marine environment, we recommend that research is urgently undertaken to:

- Quantify the mass balance of carbon stored in the marine environment, e.g. for the purpose of reducing uncertainty in emissions reduction estimates.

- Advance technology or knowledge where needed to improve/support management tools for marine nature-based solutions.

- Advance technology or knowledge that further contributes to developing a circular economy. For example, in relation to sustainable aquaculture, renewable energy (e.g., wave and tidal) production and waste-related options.

6. Summary

NZMSS supports the work done by MfE to draft the emissions reduction plan. However, we identify a significant gap and call on MfE to include the marine environment and relevant management actions in the final Plan to mitigate greenhouse gas emissions, as follows:

---

[34] Hoegh-Guldberg et al. 2019. "The Ocean as a Solution to Climate Change: Five Opportunities for Action". World Resources Institute. Washington DC. Available online at http://www.oceanpanel.org/climate.

[35] Lim et al. 2021. Bioplastic made from seaweed polysaccharides with green production methods. Journal of Environmental Chemical Engineering, 9(5), 105895. doi:10.1016/j.jece.2021.105895

Urgency: Emissions reduction is urgently needed to limit global warming below 1.5 degrees. The oceans are in trouble, and are warming, rising, and acidifying. Marine ecosystems and biodiversity are under threat from cumulative and multiple stressors.

Relevance: The ocean has great capacity to sequester and store carbon, far in excess of terrestrial environments. The marine environment can also contribute towards a circular economy in relation to sectors such as food production, energy and waste.

Management: Human activities on land and in the ocean are directly impacting on the carbon storage and retention capacity of the marine environment. These activities are avoidable and management tools must be implemented to protect and restore marine carbon sinks. There are also marine-related opportunities for contributing towards a circular economy.

NZMSS recommendations

Recommendation 1: NZMSS recommends that MfE's emissions reduction plan be revised to recognise the crucial role of the Aotearoa New Zealand's marine domain in emissions reduction. Regarding the Plan, we therefore recommend that the 'Agriculture and Forestry' category be extended to include 'Marine-Based Primary Industries' or similar wording.

Recommendation 2: That the Government acts urgently to protect and restore vital marine carbon sinks and to promote and support marine-related sectors contributing towards the circular economy. This includes implementing the following actions:

- Prohibiting large-scale disturbance of seafloor sediments, such as that currently caused by bottom-contact fishing methods and proposed seafloor mineral extraction.
- Protecting and restoring macroalgal forests by implementing ecosystem-based management of fisheries to restore balance to coastal ecosystems (e.g. by enabling snapper and crayfish populations to increase will likely result in reduction of sea urchin pressure on kelp forests). Other tools include establishing highly protected marine areas (including large no-take areas) and reducing human-caused sediment runoff from land.
- Protecting and restoring tidal wetlands (saltmarsh, seagrass and mangroves) by prohibiting damage to these habitats, allowing inland migration of tidal wetlands with sea level rise, reducing human-caused sediment and nutrient run-off from land to protect vulnerable habitats and implementing policy to facilitate tidal wetland restoration.
- Promoting and supporting marine-based contributions towards a circular economy in Aotearoa New Zealand.

Recommendation 3: NZMSS also supports the Plan's reference to future research, and we recommend the priority areas of research relating to emissions reduction in the marine environment outlined in Section 5 of our submission.

Recommendation 4: NZMSS invites MfE to engage with us to address the significant gap in this Plan. NZMSS has a panel of experts in marine and climate science who can assist with options and approaches in relation to this emissions reduction plan.

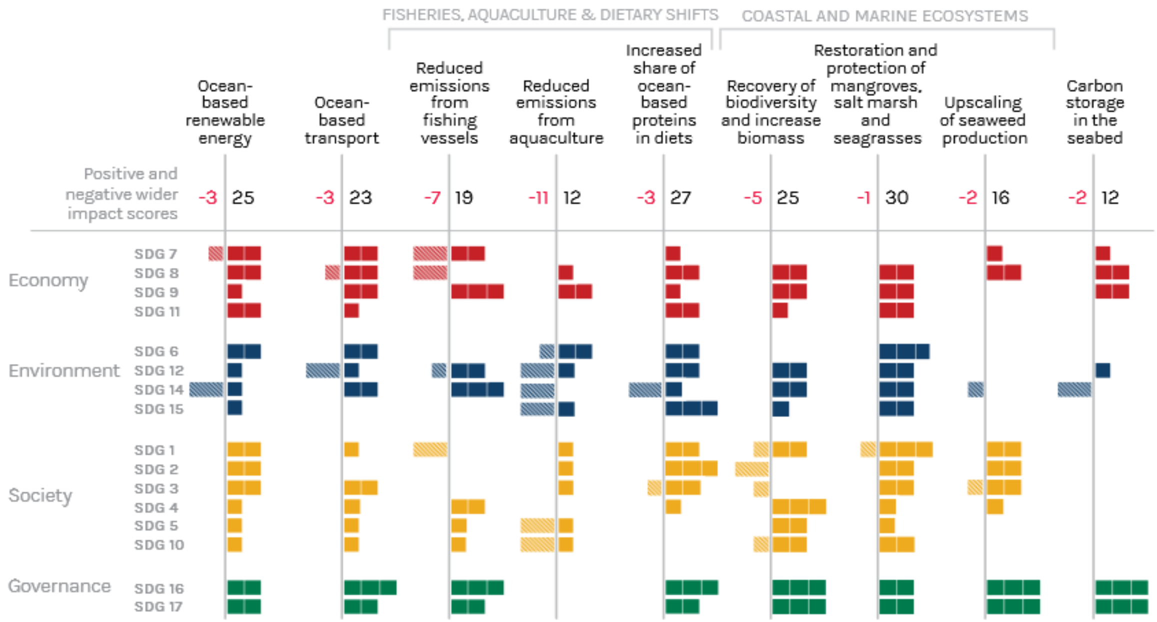
Appendix 1: Assessment of ocean-based climate action. From: Hoegh-Guldberg et al. 2019. "The Ocean as a Solution to Climate Change: Five Opportunities for Action". World Resources Institute. Washington DC. http://www.oceanpanel.org/climate.

Table ES-1. Summary of Global Mitigation Potential Offered by Each Area of Ocean-based Climate Action

AREAS OF OCEAN-BASED CLIMATE ACTION	2030 MITIGATION POTENTIAL ($GTCO_2E$/YEAR)	2050 MITIGATION POTENTIAL ($GTCO_2E$/YEAR)
1. Ocean-based renewable energy	0.18–0.25	0.76–5.40
2. Ocean-based transport	0.24 – 0.47	0.9 – 1.80
3. Coastal and marine ecosystems	0.32–0.89	0.50–1.38
4. Fisheries, aquaculture, and dietary shifts	0.34–0.94	0.48–1.24
5. Carbon storage in the seabed (Action in this Area Requires Further Research Prior to Implementation at Scale)	0.25–1.0	0.50–2.0
Total	1.32–3.54	3.14–11.82
Total percentage contribution to closing emissions gap (1.5°C pathway)	4–12 %	6–21%
Total percentage contribution to closing emissions gap (2°C pathway)	7–19%	7–25%

Source: Authors

Figure 7. Linkage Scores of Ocean-based Interventions and Selected Mitigation Options across the Wider Impact Dimensions



List of Sustainable Development Goals reviewed:

Source: Authors

Notes: Wider-impact dimensions cover various sustainable development dimension as well as 2030 Sustainable Development Goals (SDG). The figure shows the relative strength of the relationship between a selected set of ocean-based mitigation options and the SDGs. For each mitigation option, the positive linkage score with a particular SDG (depicted with solid bars) is shown in the right-hand column and negative linkage score (depicted by shaded bars) in the left-hand column. Scores range from +3 (indivisible) to –3 (cancelling) (Nilsson et al. 2016). A zero score (no bar and no colour) means no impact was found in this review of the literature. Each colour represents a particular wider impact dimension: Red bars for economy (SDG 7, 8, 9, 11); blue bars for environment (SDG6, SDG12, SDG14, SDG15); yellow bars for society (SDG1, SDG2, SDG3, SDG4, SDG5, SDG10) and green bars for Governance (SDG 16, SDG 17). Further information on the linkage scores and the associated confidence levels are provided in the Annex.