

GIGABLUE

Marine Carbon Removal in New Zealand's EEZ

Stakeholder Document



Contents

This document introduces Gigablue and Microalgae Carbon Fixation and Sinking technology (MCFS). It provides information about:

- How the process works
- its environmental impacts and benefits
- the trial programme for New Zealand
- economic, scientific, and legal matters.

This document also outlines the regulatory updates needed for New Zealand to benefit from this new technology.

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1. Executive Summary

To minimise the negative impacts of climate change, humanity needs to use a range of tools to reduce emissions, adapt to change, and to stabilise and, ultimately, reduce carbon dioxide levels in the atmosphere and oceans. Marine carbon dioxide removal (mCDR) tools are being developed in a number of countries to reduce the accumulation of carbon dioxide in the oceans, which, if unchecked, will contribute to accelerated warming and disruption of ecosystems through ocean acidification.

Gigablue is developing a controlled marine carbon sequestration system designed to capture and transport carbon to long-term ocean storage called Microalgae Carbon Fixation and Sinking (MCFS). This technology has the potential to make a sizable difference to climate change and ocean acidification, removing millions of tonnes of carbon dioxide from the atmosphere and ocean, safely and economically.

Gigablue is undertaking a research programme in New Zealand to develop MCFS towards commercial application. This is an opportunity for New Zealand to be at the forefront of an exciting new technology, which will create thousands of well-paid jobs and promote local science and innovation. Early trials in New Zealand have been promising and Gigablue is moving towards commercialisation in a carefully planned and considered manner. For further research and trials to take place in New Zealand, existing permitted framework needs to be applied and regulatory modifications should be completed with this innovative technology in mind.

HOW MCFS WORKS

MCFS mimics the natural process through which carbon is transferred to deep ocean sediments for long-term storage. Natural phytoplankton photosynthesis breaks down carbon dioxide but <1% is permanently sequestered when organic carbon sinks to the ocean floor. MCFS deploys engineered Carbon-Carrier Pods made from a cellulose substrate containing essential minerals for photosynthesis in an insoluble form. The Pods export captured carbon to deep ocean sediments for long-term storage while supporting controlled photosynthetic carbon capture within the pod structure. After carbon is captured, the Pods descend through the water column to deep ocean sediments, where the carbon can remain stored for centuries. MCFS is distinct from ocean iron fertilisation because the essential minerals remain bound within the Pods in low-solubility form rather than dispersing freely into the surrounding water.

MCFS development is scientifically and commercially rigorous. Carbon removal and MCFS methodology are independently certified by Puro.earth, one of the world's leading carbon credit verifiers.

Additionally, within New Zealand, independent research by Earth Sciences NZ and assessment by environmental consultants Tonkin+Taylor found preliminary evidence of environmental effects to be negligible to low at the current trial scale.



GIGABLUE'S NEW ZEALAND RESEARCH PLAN

Gigablue is working through a careful, multi-year set of field trials in New Zealand, alongside lab studies to develop MCFS towards commercialisation. This research and verification processes will ensure that the technology is effective, safe, and commercially viable before large-scale deployment. Gigablue's strategic approach promotes regional economic development and strong regional and local engagement.

Gigablue has been undertaking a series of scientific trials in New Zealand's Exclusive Economic Zone. The primary deployment zone is the Bounty Trough, where the water is ~1,200m deep, approximately 170 kilometres south-east of Dunedin.

NEW ZEALAND'S OPPORTUNITY

New Zealand's Southern Ocean is a High Nutrient, Low Chlorophyll zone but lacks key mineral inputs. These are optimal conditions for MCFS and Gigablue's technology. New Zealand's EEZ is also the only jurisdiction where the company can operate at scale in deep water within an EEZ rather than international ones, allowing for responsible oversight.

The economic case is substantial. An independent assessment by Insight Economics identifies two components:

- The development phase generating 5,000 full-time equivalent years of work, around \$465 million in wages and salaries, and an \$818 million contribution to GDP.
- At the operational scale, the annual GDP contribution is projected at \$585 million, with around 4,000 ongoing jobs and a further \$9(2)(b)(ii) in wages and salaries.

The trial operation runs out of Port Chalmers, and the economic benefits flow primarily to Otago and Southland. Gigablue already procures regionally across shipping, engineering, logistics, and scientific services with that footprint growing as operations increase.

Establishing New Zealand as an early mover in marine CDR builds the infrastructure that a growing global industry will need — in marine instrumentation, specialist vessel operations, and environmental consulting. These are high-value, export-capable industries, and New Zealand's position in emerging international marine carbon markets strengthens alongside them.



UPDATING
REGULATIONS

Gigablue's work in New Zealand has identified outdated and not fit for purpose regulations. The current EEZ regulatory framework was designed before mCDR was being developed. As a result, mCDR activities are not clearly classified and this has caused ongoing issues and delays. Gigablue has spent significant resources on

investigating this matter and regulatory modifications are needed to enable mCDR scientific research and larger-scale MCFS trials.

The regulatory modifications are not radical: amendments to two existing regulations, creating a defined 'permitted activity' and 'non-notified discretionary activity' pathway for mCDR. New Zealand took a similar permitted activity regulatory approach for the space launch sector with Rocket Lab. This approach provides clarity and appropriate rigour for the method and activity needs.

The need is urgent. Gigablue needs to conduct its next trials in the 2026/27 Southern Hemisphere summer. Missing that window means at minimum a twelve-month delay to the research programme. Gigablue already lost its 2025/26 season trials due to an uncertain regulatory environment. 9(2)(b)(ii)

If a workable permitted activity framework is not in place before the 2026/27 summer, Gigablue will not be able to proceed in New Zealand because the science requires ocean access at a scale that the regulations and regulations do not currently provide for. Gigablue is actively developing or evaluating operations in Australia, Canada, Alaska, and Chile. The marine carbon dioxide removal sector will develop regardless of what New Zealand does. The question is whether New Zealand is part of it.



2. Marine Carbon Fixation and Sinking

Oceans and Climate Change

The world's oceans absorb nearly a quarter of the carbon dioxide that humanity releases into the atmosphere through the burning of fossil fuels and other activities each year. Additionally, 90% of the additional heat in the atmosphere ends up as additional heat in the oceans.

The oceans absorb carbon dioxide through two primary processes.

THE 'PHYSICAL PUMP'

Carbon dioxide from the atmosphere is directly dissolved into surface seawater, forming carbonic acid and bicarbonate.

As the oceans absorb more and more carbon dioxide in this manner, the acidity of the oceans has measurably increased - by 30% since the beginning of the Industrial Revolution. This change impairs the life cycles of some key marine life: it is harder for calcifying plankton to grow their shells/skeletons in more acidic water, disrupting food webs that rely on these plankton, and, ultimately, undermining our own food security.

THE 'BIOLOGICAL PUMP'

Phytoplankton use photosynthesis to break carbon dioxide into carbon and oxygen, using the carbon to build their bodies, just like plants on land.

Phytoplankton do this on a massive scale, accounting for half the photosynthetic carbon dioxide absorption and oxygen production on Earth, and forming the foundation of the oceans' food webs. As phytoplankton progress through their life cycle, a small portion of the carbon (<1%) falls to the ocean floor, where it becomes buried in sediments, removing it from the short-term carbon cycle. This process led to the formation of the fossil oil and gas deposits humanity uses today.

The oceans' absorption of carbon dioxide has performed an important role in reducing atmospheric heating, but at a cost to the health of marine ecosystems, which humans ultimately rely on for much of our food. The oceans' ability to continue absorbing carbon dioxide is limited: both chemically and because warmer water cannot dissolve as much carbon dioxide.



GLOBAL WARMING

Ocean heat is at record levels and global warming is the culprit. Why care? Let's break it down.

1

Unsustainable human activities (primarily the burning of fossil fuels) have dramatically increased greenhouse gases in our atmosphere.

2

Greenhouse gases, such as carbon dioxide, trap the sun's heat in the Earth's atmosphere.

3

The **ocean absorbs** more than 90% of the **excess heat** in the climate system and 25% of all carbon dioxide.

A warmer ocean means:

- Sea level rise
- Shrinking polar ice caps
- Marine heatwaves
- Extreme weather events
- Coastal flooding & erosion
- Toxic algae
- Ocean acidification

The consequences



On land

- Food insecurity
- Job losses
- Livelihoods of coastal communities



Below water

- Dying coral reefs
- Reduced marine biodiversity



Gigablue's MCFS Technology

Gigablue's MCFS technology increases the amount of carbon dioxide that is pulled out of the oceans and safely stored in ocean floor sediments, enabling the ocean to absorb more carbon dioxide from the atmosphere - combatting both climate change and ocean acidification. It is part of a growing group of climate solutions that work with the ocean to remove carbon dioxide from the atmosphere while supporting ocean health.

Gigablue's marine carbon dioxide removal approach is designed to return carbon to long-term storage in ocean sediments. The ocean's biological carbon pump captures around 50 gigatonnes of CO₂ each year through natural phytoplankton activity, and Gigablue's technology is intended to work with and mimic aspects of this natural process. MCFS deposits carbon-carrier pods at the ocean surface in controlled settings. Each 8-by-8 millimeter pod carries oxide forms of micronutrients within it, preventing dispersal into the water, yet allowing the phytoplankton that enters the pod to consume it and capture CO₂ through photosynthesis. After phytoplankton fix carbon through photosynthesis, the pods are designed to sink rapidly to the deep ocean floor, carrying the carbon with it for storage over centuries. Thus, the entire process - capture and export - occurs within the carbon carrier pods. Each 18-day operational cycle is designed around natural energy inputs, including sunlight and gravity — making the technology unusually cost-efficient relative to other carbon removal approaches.

Gigablue is working through a careful, multi-year set of field trials and lab studies to develop MCFS towards commercialisation. This work will ensure that the technology is effective, controlled, continuously monitored, and aligned with conservative operational and environmental thresholds, and commercially viable before large-scale deployment.

We've developed a geo-targeted substrate with a gravity core for responsible deep-ocean carbon sequestration

Its shell promotes phytoplankton growth for added capture.

This innovative approach champions nature-inspired, cost-effective carbon capture solutions and sets a new standard of integrity in ocean-based CDR efforts

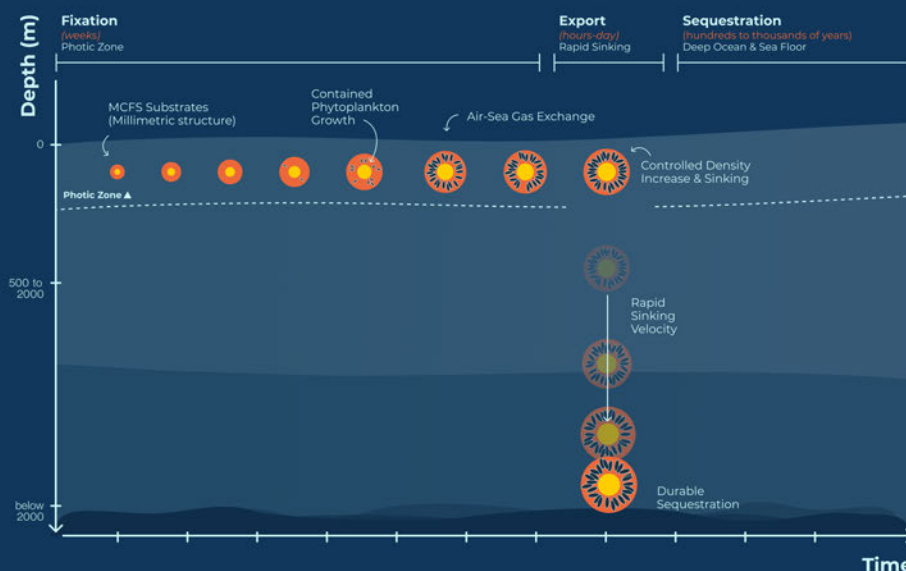


Controlled Sinking Core™

The gravity core allows optimal timing of CO₂ export and removal

Contained Nutrient Shell

Nutrient cocktail remains within the shell, and is bio-available for micro-algae



MCFS is not ocean iron fertilisation

A paper by Tonkin & Taylor and ESNZ lays out the differences between MCFS and ocean iron fertilisation, as does legal advice received by Gigablue (see Legal framework and Regulatory Updates section). The two approaches both involve phytoplankton and nutrients such as iron oxides with the similarity ending there. MCFS is specifically designed to avoid the environmental pitfalls of ocean iron fertilisation and dramatically improve effectiveness of carbon sequestration. Ocean iron fertilisation involves the uncontrolled release of nutrients to increase the biomass of phytoplankton in the hope that some will fall to the ocean floor, in contrast MCFS is a controlled process of capturing carbon using phytoplankton and expressly exporting it out of the ecosystem to the ocean floor.

Ocean iron fertilisation was considered an opportunity to capture carbon by increasing oceanic biomass through stimulating massive phytoplankton blooms by seeding oceans with iron. It is widely seen as a failure. Ocean iron fertilisation disperses nutrients freely into surface waters, often triggering uncontrolled algal blooms that may persist for weeks or months, thereby risking harm to ecosystems, and does not necessarily result in increased sequestration of carbon in the ocean floor. For that reason, international law seeks to prevent large-scale ocean iron fertilisation, except for scientific trials.

The international legal definition of “ocean fertilisation” is found in the 2013 amendment to the 1996 Protocol To The Convention On The Prevention Of Marine Pollution By Dumping Of Wastes And Other Matter, 1972 (the London Protocol):

OCEAN FERTILISATION

1 Ocean fertilisation is any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans. Ocean fertilisation does not include conventional aquaculture, or mariculture, or the creation of artificial reefs.

In contrast, the MCFS approach does not fertilise the ocean but instead grows phytoplankton in a controlled and contained manner within mineral-rich pods containing trace iron oxides. These pods sink after predictable times and actively export carbon from the oceanic ecosystem to the oceanfloor sediments. MCFS ensures the following components that are key to avoiding environmental harm and effective carbon removal and storage at the same time:

- Nutrients remain bound in the structure, preventing uncontrolled leaching into the ocean.
- Photosynthetic carbon capture occurs inside the engineered structure, rather than drifting in surface waters.

Rapid, controlled descent ensures efficient export of carbon fixated by phytoplankton to deep ocean sediments below the surface within days (maximum 30 days), minimising ecological disruption and maximising sequestration efficiency.



3. Economic Benefits and Opportunities

Gigablue's Start-Up Model

Marine carbon dioxide removal is emerging as a significant global market, representing a small but growing slice of a potential \$1.2 trillion carbon removal market (McKinsey, 2023).

Gigablue's business model works by selling certified carbon credits credited by the sequestration of carbon through MCFS in the international durable carbon removal market. Voluntary carbon markets have emerged as a critical instrument in enabling humanity's transition to net-zero emissions. Carbon markets provide a mechanism for organisations to procure independently verified durable carbon removal, allowing organisations to compensate for emissions that cannot yet be eliminated through technological or economic means.

Puro.earth has established itself as one of the leading independent verification companies and sets the standard for engineered carbon removal. The Puro Standard is distinguished by its emphasis on durable carbon storage, full life-cycle accounting, consideration of environmental effects, and third-party verification. This Standard aligns with international expectations that removals used toward net-zero targets must be measurable, reportable, and verifiable.

By verified tonnes sold, Gigablue is the market leader in its sector, with over 300,000 tonnes of future carbon removal sold and independently certified. These sales are helping to fund Gigablue's research and trials on the pathway to commercialisation.

This is outside of the New Zealand Emissions Trading Scheme, which does not recognise ocean sequestration. This is positive for the functioning of the ETS. It means that Gigablue's sequestration activities in New Zealand waters will not create new credits in the ETS, which could depress the carbon price. Instead, these credits are sold to companies abroad to meet their voluntary carbon reduction targets. This creates economic activity in New Zealand and tax revenue for the Government.

New Zealand is Gigablue's first choice to prove its technology, ensure best practice, and when ready, undertake commercial scale activities. MCFS offers a strategic opportunity for New Zealand to address several national priorities through one science-based approach, including:

- reducing the impact of climate change
- reducing ocean acidification to support healthy marine ecosystems, fisheries, and long-term ocean resilience
- supporting economic growth
- developing the high-tech economy.

New Zealand provides optimal marine conditions for MCFS with a large exclusive economic zone, encompassing deep waters New Zealand's Southern Ocean is a High Nutrient, Low Chlorophyll zone, meaning it has the conditions for significant natural carbon sequestration but is deficient in micronutrients that allow phytoplankton to grow. The mineral-rich pods deployed in MCFS provides essential minerals in an insoluble form, making them bioavailable for photosynthesis while remaining attached to the Carbon-Carrier Pods, where phytoplankton utilise them within the pods.

New Zealand's Exclusive Economic Zone alone has the theoretical capacity to support over 100 million tonnes of CO₂ removal per year (for reference, New Zealand's net emissions were 55 million tonnes in 2023). Gigablue's long-term target is one million tonnes annually.



New Zealand also has a strong international reputation and environmental credentials that means overseas observers can be confident work is carried out in an environmentally responsible and scientifically rigorous manner.

Economic Benefits For New Zealand

Insight Economics' Economic Assessment (peer reviewed by NZIE) concludes that the proposal is expected to provide clear and quantifiable economic benefits to New Zealand.

Insight Economics assessed the estimated economic impact of both the development phase and operation phase based on the scale up research programme and intended scale of operations once fully established (from 2030). The results are indicative of the scale and nature of economic activity that could be sustained over time, subject to market conditions, regulatory settings, and the maturation of carbon removal markets:

- The development phase - covering infrastructure, manufacturing, and equipment - is estimated to generate 5,128 full-time equivalent years of work, around \$465 million in wages and salaries, and an \$818 million contribution to GDP.
- At the operational scale, the annual GDP contribution is projected at \$585 million, with around 4,000 ongoing jobs and a further \$9(2)(b)(ii) in wages and salaries. Activity would be concentrated in the high-value sectors of maritime operations, science, technology, and environmental monitoring.

The economic benefits extend beyond Gigablue's direct footprint. Establishing New Zealand as an early mover in marine CDR builds the infrastructure that a growing global industry will need — in marine instrumentation, specialist vessel operations, and environmental consulting. These are high-value, export-capable industries, and New Zealand's position in emerging international marine carbon markets strengthens alongside them. Operations would likely be serviced from South Island ports (such as Dunedin, Timaru, and Bluff) and supported by local manufacturing, research, and monitoring activities. Gigablue already procures locally across shipping, engineering, logistics, and scientific services, with that footprint growing as operations scale.

Beyond direct economic activity, MCFS can also deliver broader strategic and economic benefits:

Acceleration of the Blue Economy

The project strengthens New Zealand's position in ocean-based innovation, building capability in marine science, engineering, and monitoring systems.

Efficient Use of National Assets

Leverages New Zealand's vast EEZ, scientific expertise, and existing port infrastructure, while minimising competition for onshore land and resources.

Value-added Manufacturing Activity

Supports domestic manufacturing, integration, and deployment of specialised pods and marine carbon-removal systems.



Knowledge Generation

Extensive monitoring and verification, validated by ESNZ, will improve New Zealand's understanding of ocean carbon dynamics and provide valuable data for future marine management.

Global Climate Leadership

Supplying high-integrity, durable CRUs positions New Zealand as a credible leader in emerging carbon markets, attracting investment into advanced climate technologies.

New Zealand's measurable marine economy currently contributes around \$4.6 billion to GDP and employs more than 39,000 people, with activity concentrated in fishing, aquaculture, shipping, and offshore minerals. Gigablue's operations would extend this base by stimulating demand for specialist services such as vessel chartering, engineering, offshore deployment logistics, and environmental analytics, alongside long-term monitoring and scientific research. As production scales, new linkages are expected to emerge between maritime industries, agriculture, and materials science, broadening New Zealand's marine manufacturing and research capacity. The ongoing jobs supported by the proposal are expected to generate benefits that extend beyond employment counts.



Blue Economy Principles

A blue economy for Aotearoa

Marine activities that generate economic value and contribute positively to ecological, cultural, and social well-being



Accountable

Adopting decision making and reporting frameworks that consider natural, social, and cultural effects of all proposed and actual uses of ocean resources.



Te Mana o te Moana

Prioritising the health and wellbeing of the moana informed by a Tiriti o Waitangi-led approach where the rights and responsibilities of tangata whenua are provided for.



Regenerative

Adopting practices that actively support and restore marine ecosystem health.



Inclusive

Engaging with communities to achieve multiple benefits for people and the environment.



Intergenerational

Empowering holistic governance and management that support the moana to provide for long term social, cultural, environmental, and economic well-being.



Prosperous

Actively transitioning towards resource use that is productive, sustainable, resilient and enhances the ocean and ocean-dependent livelihoods.



4. Engagement with iwi and stakeholders

Engagement and collaboration are critical in all aspects of Gigablue's operations in New Zealand.

Gigablue's activities are regulated by the EEZ Act which recognises the Crown's responsibility to give effect to the principles of the Treaty of Waitangi, including by specifically providing processes for iwi notification and consultation. Gigablue acknowledges and respects Te Tiriti o Waitangi and the role of tangata whenua as kaitiaki of the oceans. Gigablue has an active relationship with Te Rūnanga o Ngāi Tahu, whose takiwā encompasses the current operational area. Engagement continues on aligning Gigablue's planned activities with Ngāi Tahu environmental and climate research priorities, and potential Ngāi Tahu involvement and benefits from operations in their takiwā. Dedicated Gigablue advisers support this relationship. It is ongoing and will deepen as the programme expands.

Key elements of this engagement include

- Appointment of Cherie Tirikatene (Ngāi Tahu, Ngāti Māmoë), a respected Ngāi Tahu leader and Rekohu/Chatham Islands general manager for Tāmata Hauhā, as Gigablue's Director Strategic Partnerships and Cultural Engagement.
- Early and transparent consultation on research plans and trial activities.
- Regular discussions on how Ngāi Tahu whānau and rangatahi can benefit through employment, training, research opportunities, and economic participation.
- Field involvement of iwi representatives in operations.

In addition to iwi engagement, Gigablue maintains open dialogue with local stakeholders in Otago and Southland, scientific partners such as ESNZ and Cawthron Institute, and regulatory agencies. Experimental plans are shared proactively, and results are made available to support transparency.



5. Research programme

Gigablue's research programme began in 2023. It combines laboratory, mesocosm, and open-ocean field experiments with desktop analysis of scientific literature and modelling. Open-ocean experiments are essential to validate laboratory and mesocosm findings and to collect baseline environmental data. The programme is organised into three primary areas:

1) Environmental and Oceanographic Research

This focuses on characterising baseline conditions and assessing potential environmental interactions across the surface ocean, water column, and seabed. A key priority is establishing a robust environmental baseline within the Area of Interest (AOI) to understand natural variability, identify sensitive ecosystems, and set safe operational thresholds for the deployment of MCFS pods.

2) Measurement, Monitoring, Reporting, and Verification (MMRV) Methods

This area focuses on the development and validation of techniques required to assess any potential effects on the environment, ensure ecosystem health, quantify carbon fixation, track pod transport, and verify durable carbon storage. MMRV methods are required for all three phases (floating, sinking and post-sinking) and includes development of techniques and sensors to track and map the sunken pods on the seafloor.

3) MCFS Technology Research and Development

This focus is on the design, testing, and continuous improvement of pod systems and associated operational technologies.

These three areas are closely linked. Environmental studies inform operational thresholds and site suitability, MMRV methods provide the measurement framework to ensure ocean health, quantify outcomes and verify performance, and technology R&D improves pod design and deployment efficiency. Together, they support the responsible advancement of MCFS while maintaining compliance with environmental safeguards and methodological requirements.

The following parameters will be defined based on existing available data, research undertaken to date by Gigablue, as well as further research proposed to be conducted:

- Water current patterns characterisation to understand surface and subsurface transport dynamics that influence pod dispersion and transport.
- Ventilation time of deep water characterisation to confirm the ocean circulation patterns that support long-term carbon storage of hundreds to thousands of years, and not less than 200 years.
- Baseline characterisation of the water column: Includes surface water chemistry and biology.
- Baseline characterisation of sediments: Includes sensitive species distribution, dissolved oxygen (DO) reduction sensitivity, organic carbon fate and remineralisation rates.



- Setting operational thresholds, based on environmental conditions and modelling results, ensure pod densities remain well within environmentally safe thresholds.
 - a) Threshold setting for water column local nutrient depletion.
 - b) Threshold setting for pod deposition - benthic smothering
 - c) Threshold setting for sediment deposition - dissolved oxygen depletion in deep water.

Evidence-based Approach to Scaling

Gigablue has adopted a cautious, evidence-based approach to scaling. The research follows an adaptive management framework with the following core principles: small-scale trials, full regulatory compliance, independent third-party verification, and post-trial scientific and regulatory review.

The research strategy is designed to support the gradual development of MCFS activities from early experimental deployments toward larger operational scales.

The progression is structured as a phased and evidence-based scale-up, in which each stage of deployment is supported by targeted research designed to address specific scientific uncertainties. Early-stage activities focus on establishing environmental baselines, validating monitoring methods, and testing technological performance. Subsequent phases involve larger deployments designed to monitor potential environmental impact at scales sufficient to produce detectable signals. Throughout the programme, experimental design will ensure that research activities are capable of effectively answering the scientific questions under investigation.

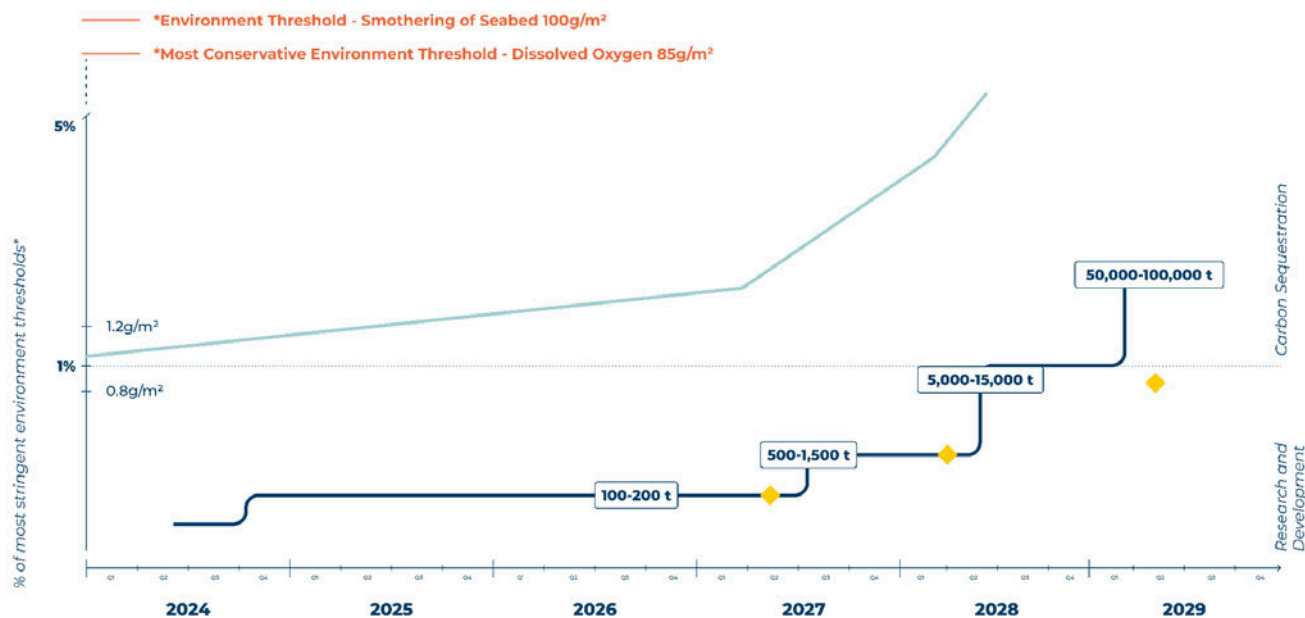
Progression to the next scale depends on meeting defined confidence benchmarks in environmental understanding, monitoring capability, and technological performance. Before each field deployment and subsequent scaling, new findings from laboratory, modelling, mesocosm and prior in situ studies are reviewed to determine if operational plans, thresholds, or experimental designs require adjustment. Any emerging knowledge gaps or research questions will be incorporated into the ongoing plan to ensure that scale-up decisions remain evidence-based, scientifically robust, and environmentally safe. The programme is committed to sharing findings with the scientific community and relevant local stakeholders.



Research Increasing Knowledge

Demonstration only

◆ Validation Point
— Knowledge growth



New Zealand Ocean Trials

Gigablue has conducted three ocean research trials in the New Zealand Exclusive Economic Zone (EEZ) to date. Each trial has been undertaken as a permitted activity in accordance with the EEZ and Continental Shelf (Environmental Effects—Permitted Activities) Regulations 2013, and reference numbers have been allocated by the New Zealand Environmental Protection Authority (EPA), as is standard practice for marine scientific research permitted activities notified to the EPA. These reference numbers are GIGPA01, GIGPA02 and GIGPA05.

Reference	Location	Scale	Findings
GIGPA01 First physical properties trial 18- 24 May 2024	37 km to the southeast of Kaikoura Peninsula	Five releases of 3–5 m ³ wet vermiculite	Test acoustic detection of sinking plumes. Conclusion that ship-mounted echosounders will be unlikely to detect vermiculite plumes down to 1,000 m depth. Resulting plumes observed using an echosounder (38 and 120 kHz), and an aerial video drone. Plumes detected to a maximum depth of 200 m, before dispersing to below the detection threshold of ~0.2 pods per m³.
GIGPA02 Second physical properties trial 17-26 October 2024	Deepwater (~1,500 m) area 640 km south of Wellington	45 kgs of vermiculite pods with trace iron and manganese oxides	Assessing pod tracking methodologies and environmental impacts. Included testing booms/pens for the containment of pods over 6 days. Testing methods included: echosounder; current profiling; multibeam systems; profiling conductivity, temperature, depth with associated sensors and water sampling bottles; tracking of drifting buoys; measurement of surface water properties'; and sinking with an remotely Operated Vehicle.
GIGPA05 Containment pen trial 16 - 28 March 2026	150 nautical miles east of Dunedin, within the Bounty Trough / Bounty Plateau region	9.5 kgs of inert pods within containment pens	Inconclusive. Two significant weather events resulted in damage to the pens structure and the decision was made to retrieve the damaged pens and conclude the experiment early.



2026-2030 research programme

The research programme sets out the proposed experiments from 2026 to 2030 and will guide the development, validation, and responsible scaling of MCFS operations during that time. The research programme is structured through a series of operational cycles from Q4 of a given year through to Q3 of the following year. This structure aligns with the seasonal nature of operations, with in situ field activities conducted during Q4–Q1 (Austral spring and summer), and the remaining period dedicated to laboratory work, data analysis, modelling, and desktop studies. A set of defined confidence benchmarks must be met to enable progression to the subsequent phase and support responsible scale-up of operations.

Q4 2026 – Q3 2027 – 100 to 200 tonnes and associated tests and verification.

Q4 2027 – Q3 2028 – scale up to 500-1,500 tonnes and associated tests and verification.

Q4 2028 – Q3 2029 – scale up to 5,000-15,000 tonnes and associated tests and verification.

Q4 2029 – Q3 2030 – scale up to 50,000-100,000 tonnes and associated tests and verification



GIGPA04 Proposal

GIGPA04 is the largest planned deployment and was notified to the EPA in 2025. The trial is designed to improve understanding of key oceanographic characteristics in the mixed layer and deep-sea areas (water depths, expected current speed, nutrients, temperature) and the interaction of the pod with those characteristics. The EPA's view was that this was not a permitted activity under the current regulatory settings. As a result, this trial has not been undertaken yet, and will not be able to progress without changing this position.

GIGPA04 proposes up to five releases of up to 200 tonnes each of pods (8mm in diameter) to a maximum total of 1,000 tonnes. The pod volumes used in the previous trials were found not to be sufficient to allow for effective physical tracking into the deep ocean, or a detectable change of biogeochemical properties. Modelling and analysis undertaken by ESNZ showed a pod concentration of at least 10 pods per m³ would be required for acoustic detection at depth, requiring four times the 45 m³ of pods released for GIGPA02. The pod for GIGPA04 is composed of cellulose and contains trace amounts of iron oxides ($\text{Fe}_2\text{O}_3 \cdot 0.5\text{H}_2\text{O}$, FeHO_2 , Fe_2O_3 , Fe_3O_4) bound within it.

Research undertaken by Gigablue indicates that following release, the pods will float at the surface for a period of ~18 days (up to 21 days) before sinking to the seabed. Modelling predicts the pods may travel ~130 km, and up to a maximum of 360 km horizontally between release and sinking locations, depending on sea conditions and currents. During the floating and sinking phases the pods will be tracked and a variety of scientific observations made relating to the ocean currents, water chemistry and other parameters. Following the initial floating phase, saturated pods are expected to sink at approximately 1.5 cm/s, meaning a depth of ~1,300 m could be reached within ~24 hours.



6. Safeguarding our Oceans

Gigablue's purpose is to help reduce the impact of climate change on the world and care for our oceans. As such, we work to ensure Gigablue technology is designed within conservative operational and environmental thresholds in which it is used.

Potential environmental impacts for New Zealand are identified and assessed by independent experts consistent with the purpose of the EEZ Act to promote the sustainable management of natural resources and to protect the environment from pollution. Consideration of potential environmental impacts is broad and conservative. Aspects of the marine environment that are assessed include (but are not limited to):

Physical environment

Geographic and geological setting; seabed characteristics; geohazard assessment; meteorology and currents as well as water quality. Effects assessed include acidification; deoxygenation; greenhouse emissions; toxification and ocean currents; turbidity; harmful algal blooms; benthic organic matter increases; and dimethyl sulphide production.

Biological environment

Marine environmental classification; marine invertebrates; sensitive environments and biogenic habitats; phytoplankton and zooplankton; fish; marine reptiles; marine mammals; and seabirds.

Research is designed to improve the understanding of key oceanographic parameters, including ocean currents, pod dynamics, marine fauna behaviour, and air-sea gas exchange processes.

For each activity, Gigablue and its consultants go through a process of refining the spatial area for the purposes of avoiding and minimising effects on ecological values and sensitive environments. Data on the deep-sea environment is inherently limited and the true distributions of sensitive environments are not always available. Where there is limited knowledge or literature available, a high level of conservatism is applied. Ecological monitoring is also undertaken and will add to the body of knowledge of ocean environments and their ecosystems.

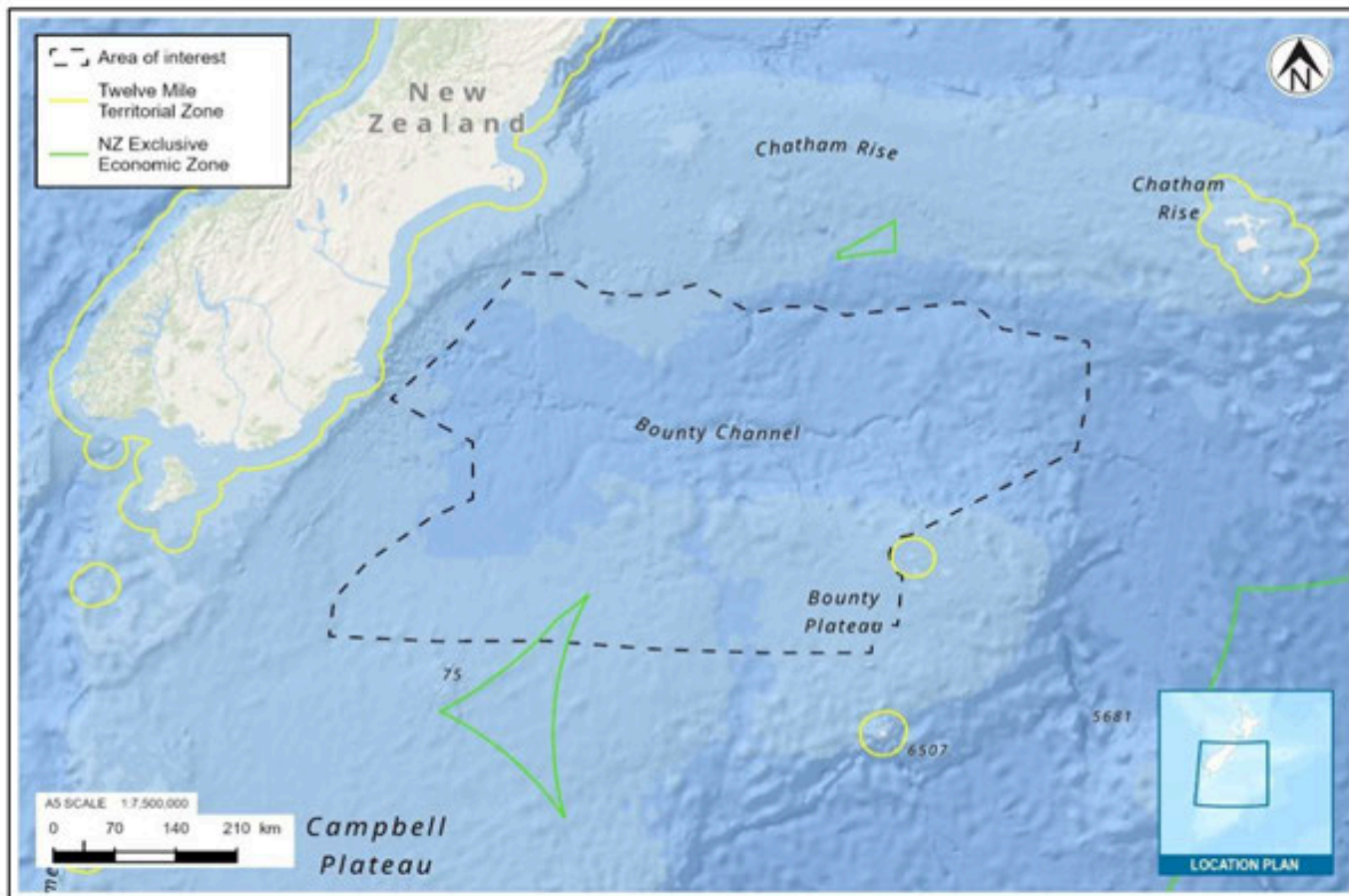
The MCFS pods must undergo extensive testing and analysis to confirm its eligibility for deployment, focusing on its physical properties, chemical composition, toxicity, and performance kinetics. These tests and analyses, defined by the Puro.earth MCFS methodology, ensure the pod promotes carbon fixation efficiently while minimising potential environmental harm.

Gigablue modelling estimates the pod footprint density under various release scenarios. Key variables influencing the characteristics of the footprint include the distance over which the pods are released, the time over which the pods are released, and the environmental conditions at the time of release. Increasing the area and time over which the pods are released increases the size of the footprint but reduces the overall settlement density. Gigablue ran over 622,000 simulated pod releases to assess the potential extent of surface dispersion and deposition of pods on the seabed. Modelling was undertaken based on two scenarios:



1. A single, conservative, 200 tonnes deployment over 24 hours in a single transect.
2. An extreme, non-realistic scenario of a total volume of 1,000 tonnes deployed in a single deployment over 24 hours in a single transect.

Models were run using conditions from 240 historical November-January dates over a 10-year period, with 18-day trajectories. Of these modelled releases, ~31.6% ended within the recommended settlement area. These models were filtered to identify locations with a suitably high probability (>75%) of settling within the desired settlement area. A total of 178 locations had their trajectories ending within the settlement area. These 178 locations are predominately concentrated at the central-western extent of the recommended release area.



Site selection – release area and settlement area

A semi-systematic literature review was undertaken to describe the existing environment within the broader area of interest (AOI) for GIGPA04, between the Bounty Trough and the northern edge of the Campbell Plateau, and to identify potential effects of the trial on the environment.

The literature review identified preferable locations for avoiding and minimising effects on ecological values and sensitive environments at both initial release and final settlement. Using the limited, available benthic ecology information the most suitable areas for pod settlement were identified, avoiding areas with particularly sensitive and vulnerable organisms.

An initial recommended targeted settlement area was selected to minimise potential interaction with these observed and predicted habitat areas at depths of >1,000 m. Release and early floating phase areas were determined based on marine mammal, fish, and seabird distributions. Data limitations on potential distributions of many marine mammal and seabird species cover large parts of the proposed trial area meant further refinement of the recommended release area focused on avoiding NABIS (2025) marine fauna hotspots was needed.

The following criteria were used in the refinement exercise:

- **Settlement area**
 - A minimum depth of 1,000 m (indicated by bathymetry data).
 - Avoiding marine seamounts (biodiversity hotspots).
 - Avoidance of biogenic habitats at known locations, and of locations with high modelled habitat suitability for Vulnerable Marine Ecosystems.
- **Release area**

Avoidance of predicted fisheries, marine mammal, and seabird hotspots for the most vulnerable species (NABIS database).

Minimising potential effects

Operational measures proposed to minimise potential effects of a trial include:

- Limiting the volume and frequency of pod deployments to the minimum amount required for effective monitoring. The minimum amount required for echosounder monitoring through the water column is approximately 10 pods per m³ while sinking.
- Deploying pods across a defined transect length to manage the size and density of the plume to minimise both the overall area of effect and the magnitude of effect on any impacted environments.
- Limiting the area over which the bulk of pods will settle on the seabed to approximately 976 – 1,371 km², as indicated by representative modelling.
- Utilising pods designed to sink quickly following their floating stage, thereby minimising the duration and magnitude of visibility interference within the water column.



- Selecting inert materials that carry minimal toxicological risk to marine organisms.
- Avoiding deploying pods in areas where there is obvious marine fauna activity, and exploring the use of a hydrophone to monitor for marine mammals prior to release.

The EIA concluded residual environmental effects from GIGPA04, even under worst-case-scenario conditions, are expected to be minimal. Modelling and experimental results indicate negligible acidification and oxygen depletion, with any minor increases in surface pH temporarily improving ocean habitability. No toxic effects are expected from the cellulose-based pods or the iron components, which are at concentrations well below ecotoxicological effects thresholds. Turbidity and/or light reduction effects are predicted to be minor, localised, and short-lived due to the pods' large size and rapid dispersion and settling.

Effects on individual marine species groups are expected to be low to negligible, and phytoplankton may be positively affected through growth within the pod, with only minor impacts on nutrient availability. Zooplankton and marine invertebrates are unlikely to ingest pods due to their size, and both bioaccumulation and ecotoxicity risks are low.

Benthic communities may experience slight enrichment from organic matter, but without smothering or oxygen stress occurring. Though there is some risk of fish, marine mammals, and seabirds consuming pods, no ecotoxicity effects are expected to occur, and potential adverse effects on the digestive system are anticipated to be low to negligible, primarily due to the favourable physical properties of the pod. There is also some evidence that seabirds may actively avoid the pod plume, and the diets of the more vulnerable albatross species suggest they would be unlikely to actively target pods.

The release location and methodology have been informed by the environmental setting and the potential environmental effects to avoid and mitigate adverse effects. Additionally, the experiments and models which have informed this assessment were generally based on worst-case deployment scenarios for a 1,000 to 10,000 tonne deployment with deposition densities and concentrations utilising the maximum volume of pods. The actual total release volume for this trial will be no more than 1,000 tonnes total and could be as small as 50 tonnes per release with a maximum of five releases. As such, the GIGPA04 EIA represents a very conservative assessment of potential effects relative to what is actually expected for the trial.

The combination of careful site selection, predictive modelling, conservative effects assessment, and operational safeguards should therefore ensure that a trial as outlined in GIGPA04 could proceed with minimal ecological disturbance. As such, the GIGPA04 EIA concludes that the residual adverse environmental effects from the trial are expected to be low to negligible.



Limitations

- Due to the large spatial extent of the AOI within the marine environment, aspects of the environmental setting assessment were generalised across the AOI.
- The marine species identified are also not an exhaustive list of species which may be present within the AOI, but are based on a mixture of the best available modelled and observed distributions.
- All models inherently carry some uncertainty. But the scale and depth of the modelling dataset significantly reduces statistical uncertainty, making the available information well-suited for assessing potential impacts on the marine environment.
- Given the novel composition and dimensions of the pods in the context of the marine environment, limited comparable research has been undertaken regarding the potential behavioural and physiological responses of marine fauna.



7. Legal framework and Regulatory Updates

Gigablue is scrupulous in applying guidance from international law and international standards to the design, testing and governance of MCFS in New Zealand and other countries.

The precautionary principle in international law requires countries to act carefully where there is uncertainty, apply proper oversight and regulation, and assess both risks and benefits before activities take place. This principle does not block climate innovation but provides a practical framework to ensure new approaches like MCFS are developed responsibly, transparently, and based on sound science. The international community increasingly recognises that delaying climate action also carries significant risks. New Zealand and other countries should not let uncertainty slow down responsible, well-designed research and innovation when climate impacts are already harming the ocean.

Under international standards, marine carbon dioxide removal projects are expected to move step-by-step, starting with research and small-scale trials. Before any activity takes place, environmental assessments are required to understand potential impacts on marine ecosystems and to design safeguards. Climate benefits must be assessed alongside environmental risks, allowing decision-makers to weigh the full picture rather than only potential downsides.

By aligning with recognised verification frameworks such as Puro.earth which independently verifies environmental performance as well as carbon sequestration, Gigablue aims to demonstrate integrity, build trust, and ensure that claimed climate benefits are real and measurable. This approach supports international confidence in new climate technologies while protecting the ocean.

The London Protocol

New Zealand is a Party to the London Protocol on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. Under non-binding resolutions currently in effect (notably LC-LP.1(2008) and LC-LP.2(2010)), ocean fertilisation activities other than legitimate scientific research are strongly discouraged, where:

Ocean fertilisation is any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans..."

This definition has been intentionally drafted to not capture every activity in which photosynthesis occurs in seawater or sequesters carbon in the marine environment. Rather the definition is designed to avoid deleterious effects associated with projects involving large-scale, unregulated introduction of soluble nutrients to induce free-water-column plankton blooms and increase primary productivity in the oceans, such as algal blooms. That is the natural sense in which ocean fertilisation was understood: adding or redistributing substances so that the surrounding ocean water mass becomes more biologically productive. MCFS is not designed to do that.

The definition has three main elements that do not encompass MCFS:

"principal intention" ... "stimulating primary productivity" ... "in the oceans".



Puro.earth developed the MCFS methodology, and Gigablue pioneered its application, carefully designing a controlled carbon export system with bounded deployment and measurable sequestration to earlier ocean fertilisation approaches. It does not seek to “fertilise” the surrounding ocean so that an open water mass produces a bloom. The principal intention of MCFS is to support controlled photosynthetic carbon capture within deliberately engineered pods with micronutrients embedded in controlled, low-solubility form. The pods provide a physical and functional boundary between the productive process and the surrounding water column. This is rapidly followed by export of the fixed carbon (as attached biomass) from the surface ecosystem to the deep ocean, which means that primary productivity in the oceans is not increased.

The different methodological approach, application and aims of MCFS and ocean fertilisation provide a clear basis for distinguishing MCFS from ocean fertilisation.

International regulatory developments

Peer jurisdictions such as the United States, the United Kingdom, Singapore, and Canada have advanced the permitting and authorisation of mCDR research, pilot projects, and demonstration facilities, and they have done so under existing regulatory architectures, rather than bespoke mCDR statutes.

In the United States, mCDR projects have been permitted under the federal Marine Protection, Research and Sanctuaries Act (MPRSA) and the federal Clean Water Act (CWA), depending on the type and location of the activity. Recent mCDR permitting precedents include the United States Environmental Protection Agency’s (EPA) issuance of research permits under the MPRSA for the LOC-NESS Wilkinson Basin Study (controlled sodium hydroxide additions) and the Carboniferous, Inc. Research Project (deep-ocean biomass placements), and Washington State Department of Ecology’s issuance of an individual permit under the CWA for Ebb Carbon’s Project Macoma in Port Angeles Harbor (a two-year electrochemical ocean alkalinity enhancement project). These examples show that diverse mCDR activities can reach the permitting stage in the United States.

In the United Kingdom, mCDR work is also advancing through conventional permitting and public-funding channels. DESNZ recently authorised the SeaCURE plant (acidification of seawater). The SeaCURE Phase 2 final report states that the project’s objectives—including construction and operation/trial of a greenhouse gas removal pilot in a real-world environment—were delivered between May 2022 and June 2025 with just under £3 million in DESNZ funding. Prior to SeaCURE, the United Kingdom authorised a Planetary Technologies field trial in St Ives Bay in 2022 involving the addition of magnesium hydroxide to wastewater that was then released offshore through an existing outfall.

Singapore’s national water agency PUB is currently co-funding and collaborating with American start-up Equatic on Equatic-1, a Tuas-based demonstration plant using electrochemical seawater carbon dioxide removal and mineralisation technology. PUB states that the system is designed to remove 3,650 metric tons of carbon dioxide per year and produce 105 metric tons of carbon-negative hydrogen. Public reporting in 2025 projected that Equatic-1 would begin operations in the first quarter of 2026. Following the Equatic-1 demonstration in Singapore, a larger commercial-scale plant is planned for Quebec, Canada, with a target operational window of 2026–2027.



Canada's treatment of Planetary Technologies' Nova Scotia Mineral OAE project provides an example of how early-stage mCDR field activity may proceed through existing industrial discharge infrastructure and permit controls. The project involves the controlled addition of alkaline material—described in public trial materials as magnesium hydroxide slurry mixed with seawater—into the cooling-water outfall at Nova Scotia Power's Tufts Cove Generating Station in Halifax Harbour. Planetary states that the alkalinity addition is being carried out "in consultation with all applicable regulatory bodies" and "under existing permits held by Nova Scotia Power," although the publicly available materials do not identify the permit numbers. Operational materials further describe the trial as dosing alkaline material into an existing ocean outfall while monitoring both the outfall and receiving marine waters, with compliance tied to regulatory limits and adaptive stop triggers.

In Italy, the Port System Authority of the Eastern Sicilian Sea publicly noticed a maritime state-domain concession under Article 36 of the Italian Navigation Code requested by Limenet S.r.l. Società Benefit for approximately 891 square metres at the commercial port of Augusta, Sicily, for the purpose of realizing and maintaining a plant to produce decarbonised calcium hydroxide for a four-year term. Limenet separately describes the Augusta project as a TRL 7 ocean alkalinity enhancement/carbon-removal plant with capacity to remove 800 tons of CO₂ per year, or 100 kg/hour, developed with local institutional support from the Municipality of Augusta and the Port Authority. Italy therefore reinforces the same practical point reflected in the United States, United Kingdom, Singapore, and Canada: early mCDR/OAE projects are being advanced through ordinary authorisation pathways, rather than bespoke mCDR legislation.

Updating New Zealand's Regulatory Framework

New Zealand's current framework does not yet provide a comparable clear pathway for MCFS. Without timely adaptation, New Zealand risks falling behind peer jurisdictions that are actively supporting responsible innovation in this emerging sector. In New Zealand, activities within New Zealand's exclusive economic zone are regulated by the EEZ Act.

The current regulatory framework under the EEZ Act was not designed with technologies such as MCFS in mind. Gigablue's activities are not clearly classified under existing categories, and this lack of a dedicated pathway has contributed to delays. Discussions with the EPA have made it clear the framework is not well-suited for larger-scale MCFS trials beyond small pen tests and a new pathway is needed.

The regulatory update required is not radical: an amendment to two existing regulations to create a defined 'permitted activity' and 'non-notified discretionary activity' pathway for MCFS. New Zealand took a similar permitted activity regulatory approach for the space launch sector. This combined pathway is, in Gigablue's view, the most viable option for enabling continued activities in New Zealand.

To enable innovation in marine based climate solutions in New Zealand, Gigablue has identified that amendments to the EEZ Act regulations are urgently needed to create a tailored pathway for marine carbon dioxide removal activities. The changes would enable (a) appropriate near-term R&D and small-scale mCDR activities in the EEZ and (b) in the medium/long-term, an appropriate tiered approach to authorising future mCDR activities via appropriate marine consent processes. Gigablue feels strongly that any regulatory changes should ideally support a range of mCDR activities, not just MCFS, provided there is sufficient scientific confidence of the ability to appropriately avoid environmental impacts.



(a) Amendment to the Permitted Activity Regulations – new Regulation 8B

Gigablue suggests amending the Permitted Activities Regulations to insert a new Regulation 8B, which would insert a new category of permitted activity for certain mCDR activities. This category of permitted activity would authorise low/negligible impact activities, including research activities (for example, of the nature set out in the MCFS research plan that has been provided to MfE).

Gigablue envisages that this new Regulation 8B could be based on the existing activity-specific Regulation 8A, which applies to space vehicles, and could use the same or similar drafting structure. For example, as with Regulation 8A, a new Regulation 8B for mCDR activities could specify clear and objective thresholds/criteria within which the activity would be required to operate (e.g., constraints would apply to the spatial extent of the activity, exclusion of operations in sensitive areas, duration and frequency of activities, and any volumetric/density or product content limits etc). These thresholds/criteria would be science-based and designed to be appropriately precautionary to ensure the permitted activity would have low/negligible environmental impacts. As with Regulation 8A, any activity that relied on the new Regulation 8B would be required to meet specific pre-activity requirements (e.g., notifications to the EPA and iwi), and post-activity and quarterly reporting requirements (e.g., reporting on monitoring undertaken during the activity and the advances in scientific knowledge that resulted from the activity).

As noted above, that this new regulation 8B category of activity could relate to a range of mCDR activities, not limited to MCFS, provided those other activities also had sufficient scientific evidence to support their activity-specific criteria/thresholds and establish that they would ensure (on a precautionary basis) that the activity would have low/negligible impact. This permitted activity category would help mCDR developers, like Gigablue, build a scientifically robust knowledge base to inform any future planning and assessment of larger scale or commercial mCDR activities.

(b) Amendment to the Non-notified Activity Regulations – Regulations 5 and 6

In the longer term, Gigablue also envisages the need for a more streamlined process for seeking marine consents for larger scale or commercial mCDR activities, including MCFS. This could be supported by establishing a second tier of precautionary environmental impact thresholds/criteria that are less restrictive than the permitted activity thresholds/criteria envisaged in proposed Regulation 8B above, but which are still science-based and designed to ensure any impacts of the mCDR activity are no more than minor. Gigablue considers that it is appropriate for those activities to be required to obtain a marine consent and be subject to specific assessment by the EPA, but notes that the current fully notified process (involving 12+ month timelines and ~\$1M costs - see here) would likely be prohibitive for mCDR activities to locate in New Zealand.

The EEZ Act does already envisage some activities following a more streamlined consenting process, for example, non-notified activities under the Non-notified Activity Regulations. Regulation 5 of the Non-notified Activity Regulations provides that activities associated with exploration drilling for petroleum are non-notified. Those petroleum-related activities are then subject to certain operational conditions (set out in Regulation 6) related to the spatial extent of the activity. Gigablue suggests that mCDR activities should be afforded the same process cost/time benefits as petroleum exploration activities. Gigablue considers that Regulation 5 could be amended to also confer non-notified activity status on certain mCDR activities and Regulation 6 could be amended to insert specific, objective and science-based thresholds/criteria that would be designed on a precautionary basis to ensure that effects are no more than minor.



The third tier of the regulatory treatment of mCDR activities would be the current EEZ Act process – i.e., the activity would be assessed via the fully notified marine consent process under the current provisions of the EEZ Act. That third-tier process would apply to any mCDR activities that could not achieve the thresholds/criteria that would apply to the proposed Permitted Activity or Non-notified Activity Regulations (and therefore relate to mCDR activities that involve potential more than minor environmental impacts)

Summary

The table below provides a high-level summary of how Gigablue's envisaged mCDR regime would regulate mCDR activities.

Source of Regulations	mCDR Activity Status	Impact level to be achieved by specific thresholds/criteria	Authorisation process
Permitted Activity Regulations – proposed new Regulation 8B	Permitted Activity	Low/negligible environmental impacts	Pre-activity notification, and post-activity reporting required
Non-notified Activity Regulations – proposed amended Regulations 5 and 6	Non-notified Discretionary Activity	No more than minor environmental impacts	Marine consent required via EPA non-notified process
EEZ Act – section 20(2) (unchanged)	Discretionary Activity	More than minor environmental impacts	Marine consent required via fully notified Board of Inquiry consent process

As noted above, this sort of tiered approach is intended to be precautionary and proportional to scale of environmental impacts. Gigablue considers it would assist mCDR developers like it to see a clearer pathway to investment in New Zealand and would support a more scientifically robust knowledge base to better inform planning and assessment of future mCDR activities.

