Fisheries New Zealand
Tini a Tangaroa

A summary of New Zealand mussel and seaweed restoration initiatives

Purpose

This document provides a summary of seaweed and shellfish habitat restoration projects underway in New Zealand. It is intended to support future restoration opportunities and connect readers to restoration groups and key learnings from earlier restoration initiatives. This document focuses on mussel and seaweed restoration because of the linkages with aquaculture in New Zealand (industry and science) and the potential for aquaculture activities and methods to contribute to restoration.

Shellfish reefs and seaweed habitats provide a range of important ecosystem benefits. Shellfish and seaweed restoration may be regarded as a 'bottom-up' approach to improving the health of the marine environment. This is in contrast to protection of existing seaweed and shellfish habitat.

Several mussel and seaweed restoration projects have been conducted in New Zealand, with others being planned. Marine restoration may become increasingly important in New Zealand where mussel and seaweed populations have not recovered from both direct and indirect human impacts such as fishing, sedimentation, predation, and climate change.

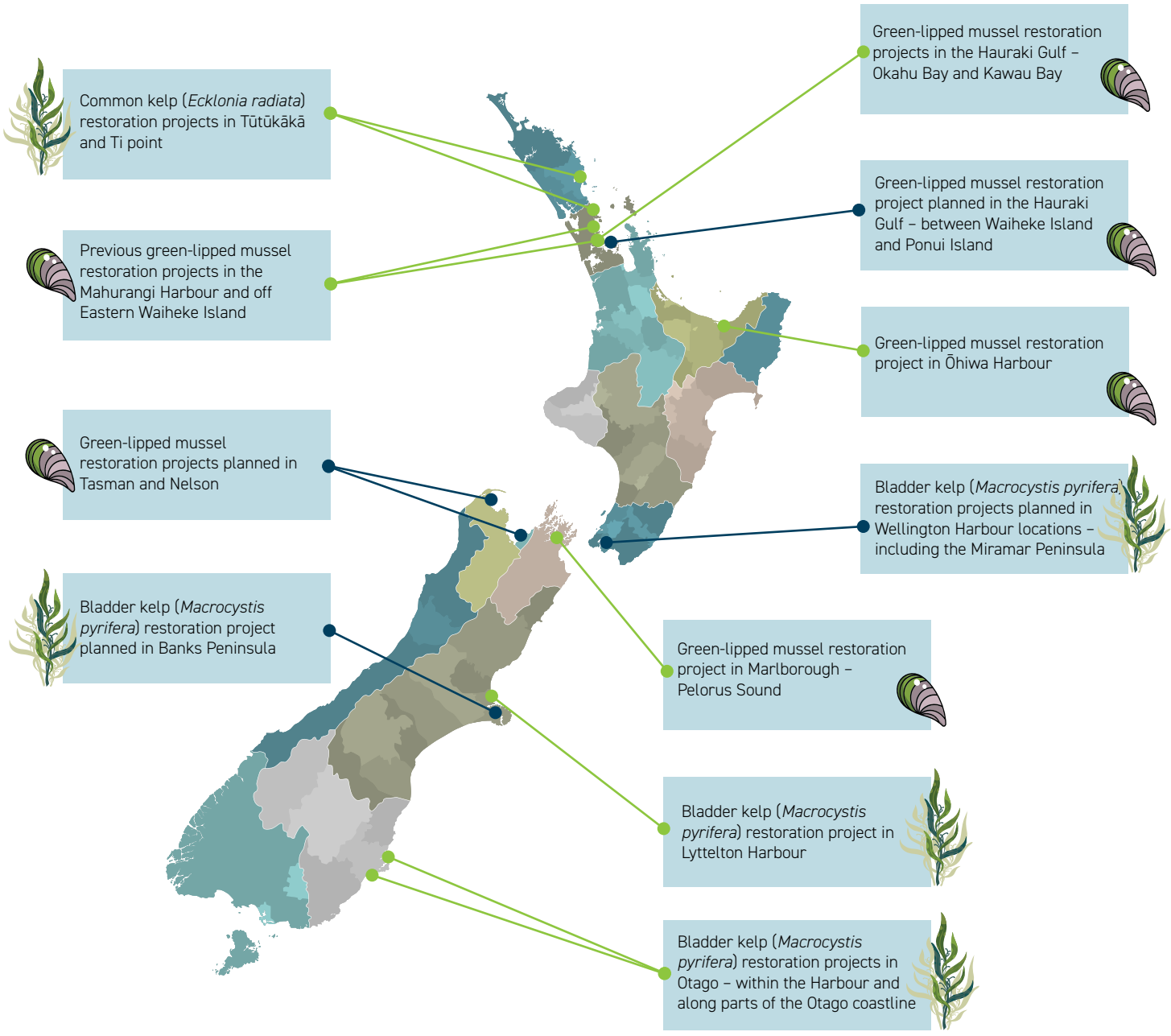
Although marine habitat restoration is still a relatively new field in New Zealand, restoration projects in New Zealand and overseas have provided important learnings and experience to support future activities. Successful restoration projects often require a multi-pronged approach that goes beyond replanting of a target species.

Restored mussel reef in Pelorus Sound/Te Hoiere.

Patch of planted *Ecklonia radiata* at Ti Point.

Mussel and seaweed restoration across New Zealand

This map shows the location of some of the restoration projects in New Zealand. It is not necessarily a comprehensive list of all mussel and seaweed restoration activities which have occurred.



Why is marine restoration important?

Seaweed (kelp forest) restoration

Seaweeds are a diverse range of marine plant species. Restoration activities have focused on the large brown seaweeds often referred to as kelp. Kelp forests perform ecosystem services and are important to the health of the marine environment.

Internationally (including in New Zealand) kelp forests are reported to be in decline. A range of potential impacting factors have been identified – including the frequency and intensity of marine heat wave events, increased sedimentation, and trophic cascades.

Successful kelp forest restoration is important as it can help to promote positive feed-back mechanisms in the marine environment. The presence of established kelp forests can help to create favourable conditions for further kelp or shellfish growth.

Kelp forest habitats provide many benefits to the ecosystem and for human communities including:

- nutrient cycling – uptake of nutrients (such as nitrogen) from the water and making them available for other species;
- enhancing food sources for other organisms including finfish and grazing invertebrates;
- improving water quality;
- biodiversity enhancement – provide habitat, sheltered environment, and structure in the marine environment;
- increasing biodiversity improves quality of experience for recreational users and tourism;
- importance for cultural heritage and values;
- enhancing fishing opportunities – including commercially and culturally valued fisheries such as pāua; and
- reducing wave energy – protects coastal land.

Durvillaea antarctica in the intertidal zone at Moeraki, North Otago.

Shellfish (bivalve) reef restoration

Shellfish reefs deliver a range of ecosystem services and form important habitats which support many other marine organisms.

Internationally (including in New Zealand) shellfish reef habitats are under increasing pressure from factors such as: fishing, increased sedimentation, and climate change impacts.

Restoration activities look to re-establish shellfish populations at target locations.

Shellfish habitats provide many benefits to the ecosystem and for human communities including:

- nutrient cycling – enhancing food sources for marine organisms including finfish and crustaceans;
- reducing nutrient load and improving water clarity;
- reducing resuspension of sediments by stabilising the substrate;
- enhancing broader shellfish populations through potential spill-over effects (restored reefs spreading to other areas);
- biodiversity enhancement – reefs provide habitat, sheltered environments, and structure;
- increasing biodiversity improves the quality of experience of recreational users;
- important for cultural heritage and values;
- enhancing fishing opportunities;
- reducing shoreline erosion – protects coastal land.

Blue cod at Pelorus Sound mussel restoration project.

Highlighted key learnings from restoration projects

Regulations

It is important from early on to understand regulatory requirements before undertaking restoration activities. Connecting with relevant Councils, Fisheries New Zealand, and Biosecurity New Zealand is the best way to ensure understanding of regulatory requirements. These agencies can assist to scope and design marine restoration projects in a way which is authorised and does not add new risk to the environment.

Making a Difference

Restoration projects offer one way to improve the health of the marine environment, but there are important things to consider for restoration to make a difference. Marine ecosystems do not occur in isolation. Land and sea are interconnected. Collective management of terrestrial factors (such as sediment input) connected to human land-use and freshwater health is crucial to the state of marine ecosystems and the success of restoration projects. Scale is an important consideration. Restoration activities need to be conducted at sufficient scale to successfully achieve meaningful restoration goals.

Restoration projects can be challenging and expensive to plan and operate. Finding a sustainable and repeatable method of conducting restoration at scale is important. Securing access to continuous funding, or a model where the initiatives become self-funding is essential for restoration projects to succeed.

It is important to ensure that a suitable monitoring approach is designed to learn from restoration projects.

Restoration projects take time and expectations need to be realistic – "restoration is a marathon and not a sprint".

Mussel reef restoration

The success of mussel reef restoration is not dependent on substrate type. Live mussels transferred onto hard shell surfaces did not necessarily survive better than soft-sediment conditions.

Restored mussel reefs, once established, may not be self-sustaining. A range of factors may be negatively affecting mussel recruitment processes. More research is required to understand successful recruitment for restored mussel reefs.

Seaweed restoration

Kelp restoration is best achieved in habitats that have previously been kelp forests.

For kelp restoration to be successful, the factors which originally caused kelp loss need to have been rectified. For example, the sediment load needs to be reduced or the proliferation of grazers (such as Kina) needs to be addressed. Many kelp restoration activities have involved the removal of predators (such as Kina) to allow regeneration of the forest.

Some kelp restoration has been attempted by seeding out kelp, using a variety of methods and with mixed success.

Credit: Paul South, Cawthron Institute

Macrocystis pyrifera and *Durvillaea antarctica* recruits in the intertidal zone at Moeraki, north Otago.

Marine restoration activities in New Zealand

The following section is a summary of some of the completed and current restoration activities underway or in development in New Zealand.

Green-lipped mussel restoration activities

Background

Green-lipped mussels (*Perna canaliculus*) are an endemic species to New Zealand. Green-lipped mussel beds were subject to commercial harvesting throughout the 1900s. The commercial supply of green-lipped mussels via wild-harvest was eventually replaced by the aquaculture industry – predominantly using longline farming techniques. Despite the end of commercial harvesting of mussels, mussel beds have not recovered. It is unclear what factors are impacting the recovery of mussel populations. Mussel beds now cover a much smaller area than they used to.

Completed projects

Mussel restoration projects in New Zealand have involved transporting farmed adult mussels into restoration locations and depositing them on the seafloor. At targeted restoration sites, mussels which survive attach to form a bed on the seafloor.

In 2013 and 2014, adult mussels from marine farms were transported to restoration sites near Eastern Waiheke. This project was led by the Mussel Reef Restoration Trust and involved University of Auckland researchers. These were some of the first mussel restoration activities to be performed at scale in New Zealand, with 70 tonnes of mussels reseeded.

In 2015 the Ministry of Primary Industries (MPI) provided funding support to the Mussel Reef Restoration Trust to build on their earlier restoration work in the Hauraki Gulf.

Parts of the Mahurangi Harbour were identified as the next restoration sites. Live mussels were sourced from Coromandel marine farmers. Led by the Mussel Reef Restoration Trust, this project also involved community groups, mana whenua, and oyster farmers who provided staff time and barges to transport the mussels. Several batches of mussels have been deposited into restoration sites in the Mahurangi Harbour. Restored mussel reefs (from surviving mussels) have not managed to self-recruit.

The Mussel Reef Restoration Trust and University of Auckland have continued to be involved in mussel restoration projects in New Zealand.

Current projects

Hauraki Gulf – Revive Our Gulf

In 2018, The Nature Conservancy joined alongside the Mussel Reef Restoration Trust and University of Auckland as key partners of the **Revive Our Gulf** project with an initiative to conducting mussel restoration in the Hauraki Gulf.

In 2021, Auckland Council granted a 35-year resource consent for mussel reef restoration in the Hauraki Gulf. This was important for the Revive Our Gulf project because it meant that individual resource consents in different restoration sites would not be required on each separate occasion.

Mussel restoration projects in the Hauraki Gulf have involved a highly collaborative approach across many different groups. Along with the core partners in the Revive Our Gulf Project (The Mussel Reef Restoration Trust, University of Auckland, The Nature Conservancy), other partners include Ngāi Tai Ki Tāmaki, Ngāti Manuhiri Settlement Trust, Ngāti Whātua Ōrākei, the mussel farming industry, and other funding organisations.

Including deposits of mussels into Ōkahu Bay and Kawau Bay, up to 372 tonnes of mussels have been deployed to date in the Hauraki Gulf. 1200m^3 of shell hash were deposited into Ōkahu Bay to assess whether shell substrate provides benefits to mussel survival and for the settlement of marine organisms.

There is ongoing involvement from University of Auckland researchers to monitor and conduct studies around the restored mussel reefs (including measuring mussel survival).

Marlborough – Pelorus Mussel Restoration Project

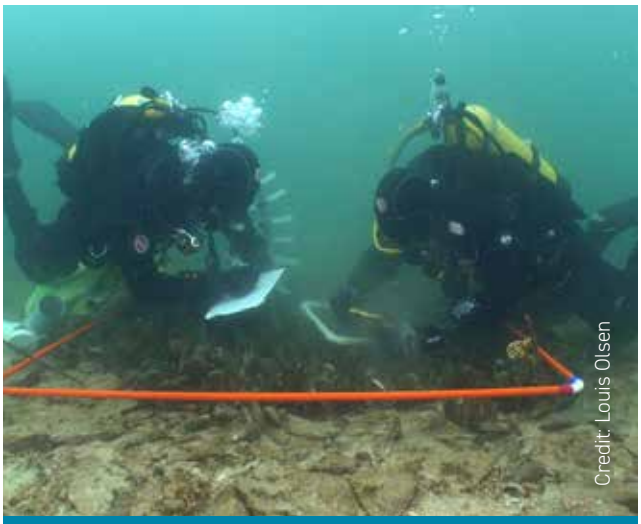
The **Pelorus Mussel Restoration Project** was developed by the Marine Farming Association (the industry body representing aquaculture interests in the top of the South Island) in collaboration with The Nature Conservancy and the University of Auckland (with research support from NIWA). In 2019, the project was supported by MPI's Sustainable Farming Fund.

Part of the motivation behind mussel restoration in Marlborough is that in addition to ecosystem services provided by mussel beds, it could create a secondary benefit of wild spat settlement onto nearby mussel farms.

Mussel shells were deposited into the Pelorus Sound which formed a hard-shell substrate bottom in those areas. Shell substrate techniques have been used for oyster restoration. To date, up to 45 tonnes of live adult mussels have been taken from mussel farms and deposited on to restoration sites.

Part of the project was focused on comparing survival of restored mussel populations on hard-shell substrate to "bare" soft substrate conditions. Mussel survival was not found to be affected by substrate type.

Aroma NZ performing a mussel restoration deployment in Pelorus Sound/Te Hoiere



Divers monitoring restored mussel reefs in Pelorus Sound/Te Hoiere.

Seaweed restoration activities

Current projects[1]

***Ecklonia radiata* – Tutukaka Kelp Regeneration Project and Ti Point**

Background

The common kelp (*Ecklonia radiata*) is a brown seaweed species native to New Zealand. In Northern parts of the country with warmer water temperature, common kelp is the dominant marine forest forming species. Kelp forests provide important habitat and food for many other marine species. Adult plants can grow to a height reaching approximately one meter tall. The common kelp can be found throughout New Zealand.

Common kelp restoration projects have involved Massey University of New Zealand researchers in collaboration with mana whenua and local charitable trusts such as Te Wairua O Te Moananui-Ocean Spirit Charitable Trust. Mana whenua have led the identification of potential restoration sites for common kelp.

In 2022, small quantities of common kelp were sourced from local wild stocks and brought into land-based seaweed hatcheries/laboratories to produce juveniles that can be transferred to marine restoration sites.

In the hatchery, seaweed propagules were seeded onto small pieces of rock (also sourced locally) to produce 'green gravel'. Green gravel was grown in the hatchery under controlled conditions until the attached seaweed reached a suitable size for transfers into sea.

When green gravel planting is successful, juvenile kelp on green gravel outgrows the rock and eventually the holdfast attaches onto substrate below as the kelp grows into an adult. Up to 200 pieces of green gravel were planted at a time onto the seafloor as part of pilot restoration trials.

The planted green gravel was monitored over time – including through underwater photography. Contribution by volunteers have been crucial to the monitoring process. Some of the adult kelps at restoration sites are now over a year old. Different restoration techniques were tested – including seeding kelp onto ropes and lines to be deployed at sea. Predator exclusion and removal methods targeting kina have also been trialled to determine whether they support kelp restoration activities.

Initial common kelp restoration activities at Tūtūkākā have been impacted by severe weather events during December 2022 – January 2023 with many of the planted green gravel being dislodged from the area.

Two-month-old kelp on green gravel in the nursery.

Nursery for juvenile common kelp growing on green gravel.

Green gravel planted on the seafloor.

Monitoring of planted kelp at Ti Point.

Holdfast outgrowing green gravel and attaching onto seafloor.

Planted kelp growing at Ti Point.

1 To our knowledge, we are not aware of previous seeding of seaweed at scale for the purpose of habitat restoration

Macrocystis pyrifera

Background

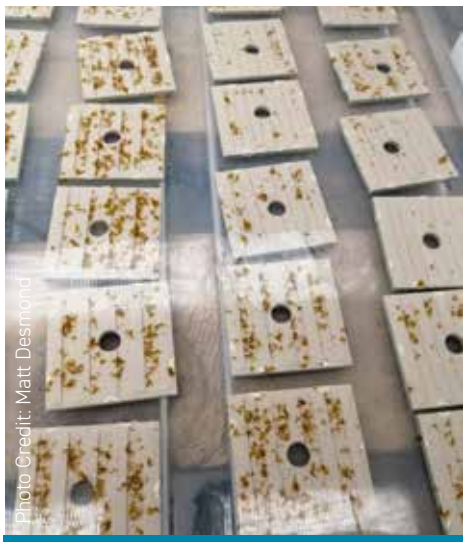
Bladder kelp (*Macrocystis pyrifera*) is a brown seaweed species native to New Zealand which also occur in other temperate regions of the world – including North America, Australia, and Chile. The bladder kelp (also known as 'giant kelp') is the dominant forest forming species in Southern parts of New Zealand with colder water. Bladder kelp is known to form large distinctive forests and can have rapid growth rates. Adult bladder kelp plants are some of the largest seaweeds in the world and can potentially grow to reach 20 metres long.

Initial work by University of Otago researchers documented where bladder kelp forests used to occur and reasons why these forests might be declining in parts of the country, which includes rising sea temperatures. University of Otago researchers have catalogued bladder kelp around the New Zealand and developed a seedbank to safeguard genetic diversity against potential loss of kelp populations. Kelp forest restoration was a potential method of complementing fisheries restoration (e.g. providing benefits to pāua in terms of habitat and food), and a "positive" additive approach to fisheries management.

Small amounts of bladder kelp were collected locally and brought into land-based hatcheries to produce juvenile kelp. Different restoration techniques have been tested, including deployments of tile pieces and lines seeded with bladder kelp.

Restoration trials have taken place in both sheltered areas and more exposed open coastlines (up to one kilometre offshore). Bladder kelp restoration has been challenging in exposed locations with greater wave energy.

Bladder kelp restoration in Lyttelton Harbour is coupled with land management projects, recognising that terrestrial inputs (such as sediment) can play an important role in seaweed survival. Some of the bladder kelp germplasm has been shared with other kelp restoration groups to support their projects.



Tiles seeded with bladder kelp grown at the Portobello Marine Laboratory.

Lines seeded with bladder kelp being prepared in the hatchery.

Daniel Pritchard deploying seeded tiles (secured onto rock) in Whakaraupō/Lyttelton Harbour.

Bladder kelp holdfast growing over and securing onto ropes.

Project in development – Love Rimurimu

- The Love Rimurimu restoration project is aiming to pilot seaweed regeneration in Wellington.
- Love Rimurimu was initiated by Mountains to Sea Wellington. The project has a collaborative approach – including involvement of members from Taranaki Whānui, NIWA, and Victoria University of Wellington.
- Bladder kelp is the initial species targeted for restoration activities, but other seaweed species present in Wellington will also be considered.
- As of May 2023, Love Rimurimu is in the process of applying for resource consent to conduct seaweed restoration in Wellington harbour with some proposed restoration sites based around the Miramar Peninsula.
- Love Rimurimu places emphasis on public outreach and engagement with all stakeholders involved to communicate the importance and motivation behind seaweed restoration.

Where to go from here?

Mussels – recruitment

For mussel restoration projects, future projects should focus on investigating the keys to successful ongoing mussel recruitment in restored areas. It is important for restored mussel beds to be able to be naturally self-sustaining – which has not been achieved thus far. There may be biological and environmental bottlenecks affecting recruitment of current and previously restored mussel beds.

Seagrass and seaweeds may have an important role in green-lipped mussel recruitment, and this is likely related to the primary settlement of mussel larvae which may require filamentous substrates for success. A decline in the supply and availability of filamentous settlement substrate (e.g. from some seaweeds or seagrass) in coastal New Zealand waters could be impacting mussel recruitment. Research is underway to investigate the relationship between mussel larvae settlement and different types of seaweed.

Seaweeds – technique and scale

It is important to be able to rectify the factors which originally led to the decline of kelp forests.

For kelp seeding, there needs to be further work on techniques which are suited for higher wave energy environments.

Kelp restoration activities need to be trialled at larger scale in New Zealand. Projects to date have been pilot operations. Consideration to the financial model for large scale projects will be important.

Future climate resilience

Climate change resilience could be an important consideration for future restoration projects in terms of selecting for resilient traits. If restored species (such as certain seaweeds) are not likely to thrive under future climate conditions, this may limit the effectiveness of restoration projects in the long-term.

Where to go for more information on marine restoration projects?

MPI can connect you with people who have undertaken restoration initiatives and to Government funding sources.

MPI can be contacted via email – **Aquaculture@mpi.govt.nz**

Organisations

- **Revive Our Gulf**
- **Pelorus Mussel Restoration Project**
- **The Nature Conservancy**
- **Love Rimurimu**
- University of Auckland – **Dr. Jenny Hillman Dr. Andrew Jeffs Dr. Emilee Benjamin** (Green-lipped mussel projects)
- Massey University of New Zealand – **Dr. David Aguirre** (Common kelp projects)
- University of Otago – **Dr. Matthew Desmond Dr. Chris Hepburn** (Bladder kelp projects)

Pelorus Sound mussel restoration project.