

# HEALTHY COASTAL ECOSYSTEMS:

## ECOLOGICAL BENEFITS OF MUSSEL FARMS IN THE MARLBOROUGH SOUNDS

We are in the midst of a global awakening to the positive ecological contributions that shellfish aquaculture brings to marine ecosystems. Fuelled by a substantial body of local and international research, the world is realising that shellfish farming provides a range of environmental services, vital to the health of the planet as wild shellfish beds disappear and waterways continue to degrade.

To improve understanding of the contribution that Greenshell™ mussel farming makes to the Marlborough Sounds coastal environment, NIWA (National Institute of Water and Atmospheric Research) has reviewed all existing local and relevant international research to compile an authoritative review.

**This document provides a brief summary of findings from the NIWA review (Stenton-Dozey & Broekhuizen 2019)**

# THE SCIENCE BEHIND ASSESSING ECOLOGICAL AND ECOSYSTEM SERVICES

In considering how shellfish aquaculture contributes to the health of coastal ecosystems, the NIWA review considered:

- **Ecological services** - that benefit the marine ecosystem more generally, and
- **Ecosystem services** - that primarily benefit human well-being

Ecosystem services need to be assessed according to globally recognised criteria and in order to achieve this NIWA looked at:

- The current state of the marine environment in the Marlborough Sounds and how that has been modified and changed over time, and
- The ecological and ecosystem services that mussel farms provide within that environment

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## ECOSYSTEMS SERVICES PROVIDED BY MARLBOROUGH MUSSEL FARMS

### **Habitat and Supporting Services:**

The NIWA review considered the role that mussels growing on farms have in primary production, nutrient cycling, and nutrient regeneration, essentially contributing to 'life' throughout the water column. It also considered how the drop-off from mussel farms provides additional benthic (seabed) habitat for marine life by forming reef-like structures under farms, and the rain of organic matter from the overlying farms was generally found to increase the productivity of the animals living in/on the seabed. Mussel farm structures were also found to provide a variety of habitat types (e.g. roosting sites, foraging, and residential) for a wide range of marine species.

### **Regulating Services:**

Regulating services are those that help to keep the environment in a healthy status quo. The NIWA review considered how mussel farms help remove unneeded nitrogen on a localised scale. They assessed how farm drop-off stabilises the seabed and increases benthic biodiversity by reducing non-farming activities (e.g. bottom-trawling and dredging) that can degrade the seabed.

### **Provisioning for Human Consumption and Wellbeing:**

The NIWA review also assessed how mussel farms provide healthy, affordable food and nutraceutical products. A benefit from these services are jobs and employment opportunities in Marlborough and other regions.

### **Cultural and Social Services:**

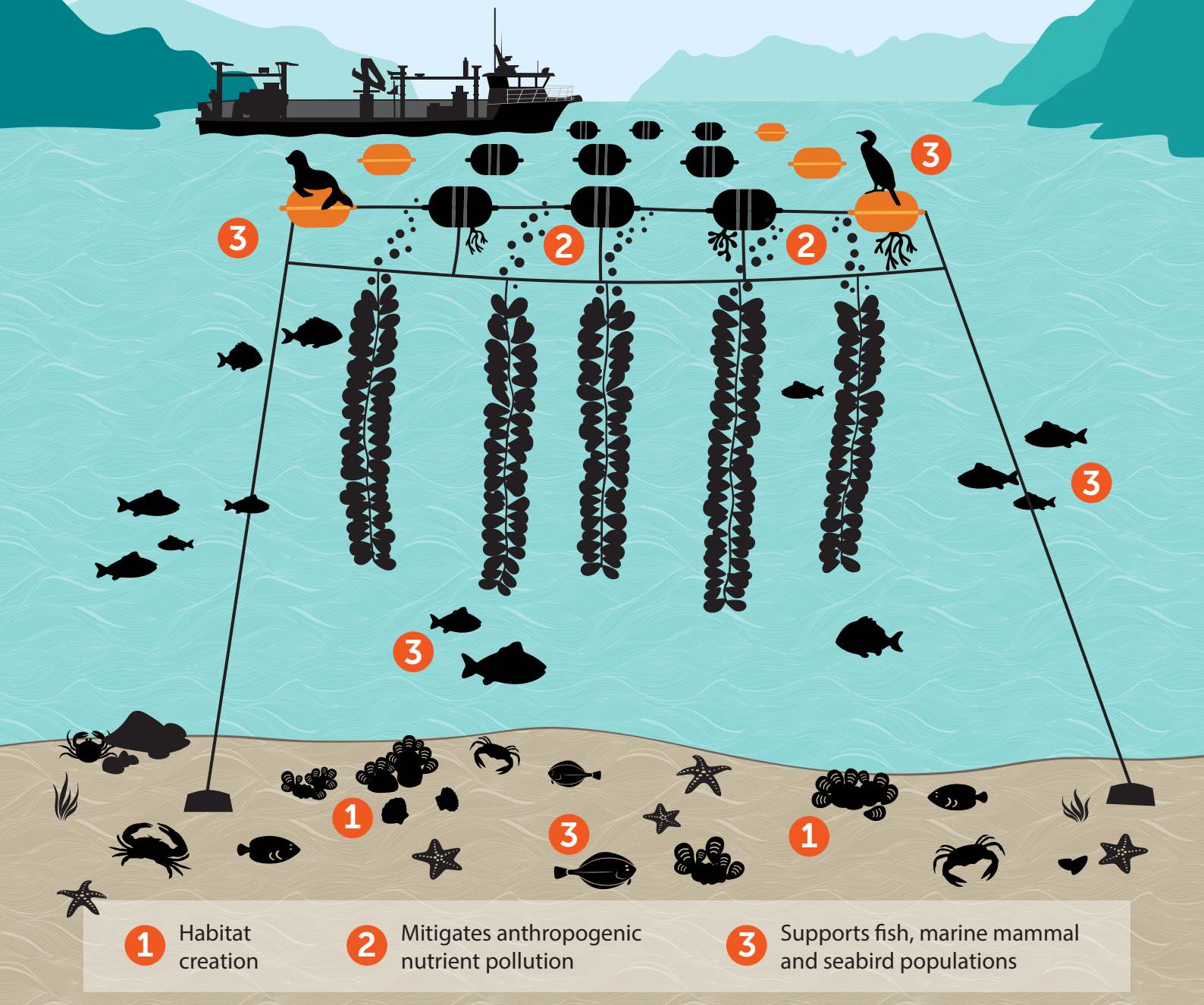
These services were not covered in the NIWA report, but mussel farms in the Marlborough Sounds do provide cultural and social services through the creation of artificial reefs that attract recreational fishers, tourists, and bird watchers.

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In their evaluation, the NIWA review seeks to understand to what extent mussel farms enhance the resilience and health of the Marlborough Sounds ecosystem, such that it is better able to withstand other stressors like climate change and sedimentation. By better understanding the benefits that mussel farming provides to the Sounds in the present day, the review aims to provide a scientific context for decision makers when considering the sustainability and future restoration of the Sounds' ecosystem.

# ECOLOGICAL & ECOSYSTEM SERVICES

PROVIDED BY MUSSEL FARMING IN THE MARLBOROUGH SOUNDS



1. **Habitat creation:** Mussel farms create three-dimensional habitat in the seawater column and on the seabed. Biodiversity in and around mussel farms is higher. The current industry scale is estimated to be similar to historic (now destroyed) wild mussel beds.

2. **Mitigates nutrients created by other human activities:** The mussels on mussel farms filter and clean similar volumes of water to historic wild mussel beds as well as removing nitrogen products from the water column. Mussel harvests remove approximately 50% of the nitrogen load originating from rivers flowing into the Sounds.

3. **Supports fish, marine mammal and seabird populations:** Mussel farms provide direct benefit to marine life by providing habitat, food and roosting/resting structures. Common and Bottlenose dolphins use farm structures to herd their prey (schools of fish), seals and seabirds use floatation equipment to roost. Recreational fish are always present around mussel farms but feed more actively during seeding and harvesting (and thereby attracting recreational fishers).

## CHANGES IN THE MARLBOROUGH SOUNDS OVER TIME:

1. The Marlborough Sounds are a continually evolving network of landforms, waterways and ecosystems that have been significantly altered by human activities over time.
2. Since European settlement began, increased sedimentation has been identified as potentially the most important land-based stressor in the Sounds marine environment. Land-based farming and forestry activities have increased the sediment accumulation rate ten-fold during this time.
3. By 1970 benthic (seabed) disturbance (trawling for bottom-dwelling fish and dredging for mussels and scallops) and sediments from deforestation had destroyed most of the biogenic (animal and plant derived) reefs in both the Pelorus Sound and Queen Charlotte Sound. These reefs and mussel beds have not recovered.
4. It is probable that by the early 1970s, when mussel farming was first trialled, the seabed had already changed from sandy sediments interspersed with biogenic reefs to a muddy / silt terrain with infrequent reef patches.
5. The loss of hard surfaces upon which many invertebrate species settle, is likely to have reduced food availability for several ecologically and economically important fin fish species (e.g. blue cod, snapper and hāpuku).
6. The abundance of many top predators like large fish and marine mammals in the Marlborough Sounds ecosystem has been greatly reduced by human fishing and hunting. However, marine mammal numbers have generally increased since being fully protected in the early 1980s.
7. It is likely that the seabird abundance in the Sounds also declined after human settlers introduced predators such as rats, stoats and cats.
8. Besides the removal of top marine predators, seabirds, and marine mammals, last century the Sounds also underwent a bottom-up ecosystem change with the removal of benthic suspension feeders lower in the food web (e.g. mussels, scallops, horse mussels, sponges, and tubeworms) through dredging, trawling, and increased sedimentation. This change goes beyond impacts on the food web because most of these species are also bioengineers that create essential habitat for other animals (e.g. spawning grounds).
9. Sounds-wide water quality monitoring for bacterial contaminants and toxic algae is now done to ensure high quality aquaculture production.

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Because historic wild green-lipped mussel beds provided multi-faceted ecological and ecosystem services, their loss from the Marlborough Sounds ecosystem is likely to have had far-reaching food web effects. Though suspended within the water-column rather than lying on the seabed, the mussel crop provides services that are qualitatively similar to those once provided by the former natural shellfish beds. However, because we do not know the exact total area of historic biogenic seabed habitats (e.g. algal, tubeworm, and shellfish beds), it is not possible to fully quantify the extent of service “substitution” provided by mussel farms.

## COMPENSATING FOR LOST NATURAL HABITATS

One of the main benefits of mussel farms, in terms of ecological services, is that they provide partial substitution for the historic mussel beds and biogenic reefs, which were destroyed through dredging, trawling and sedimentation over the course of the last century.

Mussel farms support an increased abundance of organisms, similar to those that would have been plentiful among the now-destroyed wild habitats. The species diversity found on mussel droppers is comparable to those found associated with mussel reefs, algae meadows, rhodolith beds, bryozoan thickets and calcareous tube worms elsewhere.

The NIWA review calculated that if (theoretically) mussel droppers were laid on the seabed, this area together with the area of mussel-culture derived reefs under farms provide an equivalency of 3693 ha versus around 2000 ha of historical wild mussel

beds. A total of 139 taxa were identified as being associated with suspended mussel farm structures. Most were suspension feeders (ca. 61%) followed by scavengers, predators, and detritivores. Ascidians (filter-feeding sea-squirts) contributed the most diversity, followed by seaweeds, sponges, crustaceans (amphipods, isopods and crabs), cnidarians (hydroids, sea anemones and bryozoans), and annelids (tube worms, feather-duster worms and carnivorous polychaetes) and other bivalves (shellfish). This community of animals and plants provides food for fish and other large animals.

Although not a perfect analogue, biofouling communities on mussel farms, together with the cultured green-lipped mussels, contribute a substantial standing biomass to the Sounds ecosystem that may go some way to compensate for that lost in the past.



## CONCLUSION AND THE WAY FORWARD

Mussel farms benefit the Marlborough Sounds by contributing a substantial amount of habitat and biomass to the ecosystem, and by providing a form of substitution for the historic mussel beds and biogenic reefs that were destroyed last century by dredging, trawling, and sedimentation.

The NIWA review provides evidence that the environmental cumulative effects of mussel farms in the Marlborough Sounds are usually subtle or benign, particularly for benthic and water-quality properties measured to date.

This work contributes to a global awakening around the positive ecological contributions that shellfish aquaculture brings to marine ecosystems and to the health of the planet.

The NIWA review identifies additional underpinning data that are required to fully quantify some of the ecological services provided by mussel farming. Key areas that require further investigation are biochemical pathways (especially denitrification on and beneath mussel lines), consistent biodiversity measures, food web dynamics, discard biomass and associated reef formation, and sound scientific studies on the interactions between mussel farms and fish, seabirds, and marine mammals.

By framing the ecological services provided by mussel farms within the present state of the environment of the Marlborough Sounds, the NIWA review is a first step towards developing an ecosystem services-based approach to underpin future ecosystem-based management.



### Full review reference:

J. Stenton-Dozey, N. Broekhuizen (2019) Provisioning of ecological and ecosystem services by mussel farming in the Marlborough Sounds: A literature review in context of the state of the environment pre-and post-mussel farming. NIWA Client Report No: 2019020H. 141 pp

Full review can be downloaded here: [www.marinefarming.co.nz/public/environment/](http://www.marinefarming.co.nz/public/environment/)