MANAGEMENT AND POLICY BRIEF

Exploring the Habitat Value of Kelp Aquaculture and Kelp-Shellfish Co-culture

A COMPARATIVE STUDY OF KELP FARMING SYSTEMS IN NORTHERN AND SOUTHERN COLD-TEMPERATE ECOSYSTEMS

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University of Auckland Waipapa Taumata Rau New Zealand | SCIENCE

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Background

With the right practices and in the right locations, certain aquaculture systems and species can provide a range of benefits to the broader environment. These benefits, known as ecosystem services, supplement aquaculture's primary benefit of providing food and raw materials. In particular, the farming of seaweed and shellfish species can support measurable benefits by providing habitat for species ranging from microbiota to megafauna[1]. However, while there is some scientific evidence of these benefits, experimental research on the extent of these effects and the general ecological and management principles that influence their occurrence remains limited, particularly for temperate seaweed species[2].

To bridge this gap and help contribute to the scientific understanding for temperate regions, researchers at the University of Auckland and the University of New England, with support from The Nature Conservancy, explored the habitat benefits of temperate kelp aquaculture and kelp-mussel co-culture in their respective geographies.

This project, *Understanding the Habitat Value of Kelp Aquaculture and Kelp-Shellfish Co-culture in Aotearoa and Maine*, was an in-water evaluation of the habitat value of temperate kelp and mussel culture and kelp-mussel co-culture in the Gulf of Maine, USA, and the Hauraki Gulf, Aotearoa (New Zealand). **The project aimed to identify and measure both the potential habitat benefits of kelp and mussel aquaculture for fish and invertebrates in the local environment as well as the general environmental and farming principles contributing to those benefits.**

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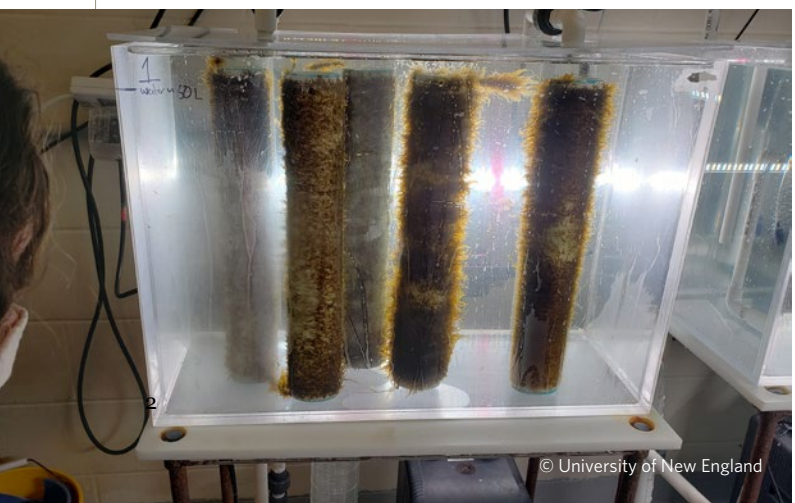
[1] Barrett, L.T. *et al.* (2022) 'Sustainable growth of non-fed aquaculture can generate valuable ecosystem benefits', *Ecosystem Services*, 53, p. 101396. Available at: **https://doi.org/10.1016/j.ecoser.2021.101396**.

Corrigan, S. *et al.* (2022) 'Quantifying habitat provisioning at macroalgal cultivation sites', *Reviews in Aquaculture*, 14(3), pp. 1671–1694. Available at: **https://doi.org/10.1111/raq.12669**.

[2] Theuerkauf, S.J. *et al.* (2022) 'Habitat value of bivalve shellfish and seaweed aquaculture for fish and invertebrates: Pathways, synthesis and next steps', *Reviews in Aquaculture*, 14(1), pp. 54–72. Available at: **https://doi.org/10.1111/raq.12584**.

Seaweed sporelings set to spools prior to deployment



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Researcher sorting epifauna collected from a seaweed farm in a laboratory


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KEY TAKEAWAYS

- Seaweed aquaculture sites in two distinct temperate and cold-water ecosystems both formed habitat, but the use of these systems by wild fauna differed from neutral in Maine, USA to positive in Aotearoa (Figure 1).

- This research identified that the habitat benefits provided by seaweed farms are highly context dependent. Local environmental conditions appeared to be the primary driver of whether additional habitat value was provided as well as the type and extent of the benefit.

- In the Gulf of Maine – where a seaweed industry for sugar kelp, *Saccharina latissima*, has been operating for more than 10 years – four sites sampled between November 2020 through August 2022 (across growing and non-growing seasons), did not appear to either positively or negatively impact biodiversity (Schutt *et al.,* 2023). Further benefits or secondary effects, such as contributions to productivity, may have been present but were not sampled and assessed.

- As seaweed farming in the Gulf of Maine is seasonal and all gear and biomass is required to be removed from the water in spring, these results provide important evidence that the current industry does not have a direct negative effect on mobile fish and invertebrates. If Maine seaweed farms were providing significant habitat benefits during the winter, there could be potential for negative impacts from removing biomass and gear from the water, as any fauna associated with the farms would lose the availability of this habitat in the spring.

- In the Hauraki Gulf in Aotearoa (New Zealand), two mussel and kelp-mussel farming systems studied during the Austral summer in 2020-21 were providing a habitat benefit, with wild fish found to be foraging and recruiting within the farms (Underwood and Jeffs, 2023; Underwood *et al.,* 2023; Underwood *et al.,* 2024). For mussel aquaculture, these benefits were equivalent to or greater than those provided by nearby wild habitat. Snapper foraging in the mussel farms, sampled at two established farm and two non-farm sites in May and June 2022, were also found to be in better nutritional condition than those living and feeding outside the farm. This suggests that extensive mussel farming occurring in Aotearoa could be a significant positive contributor to the productivity of this important fish species and its fisheries.

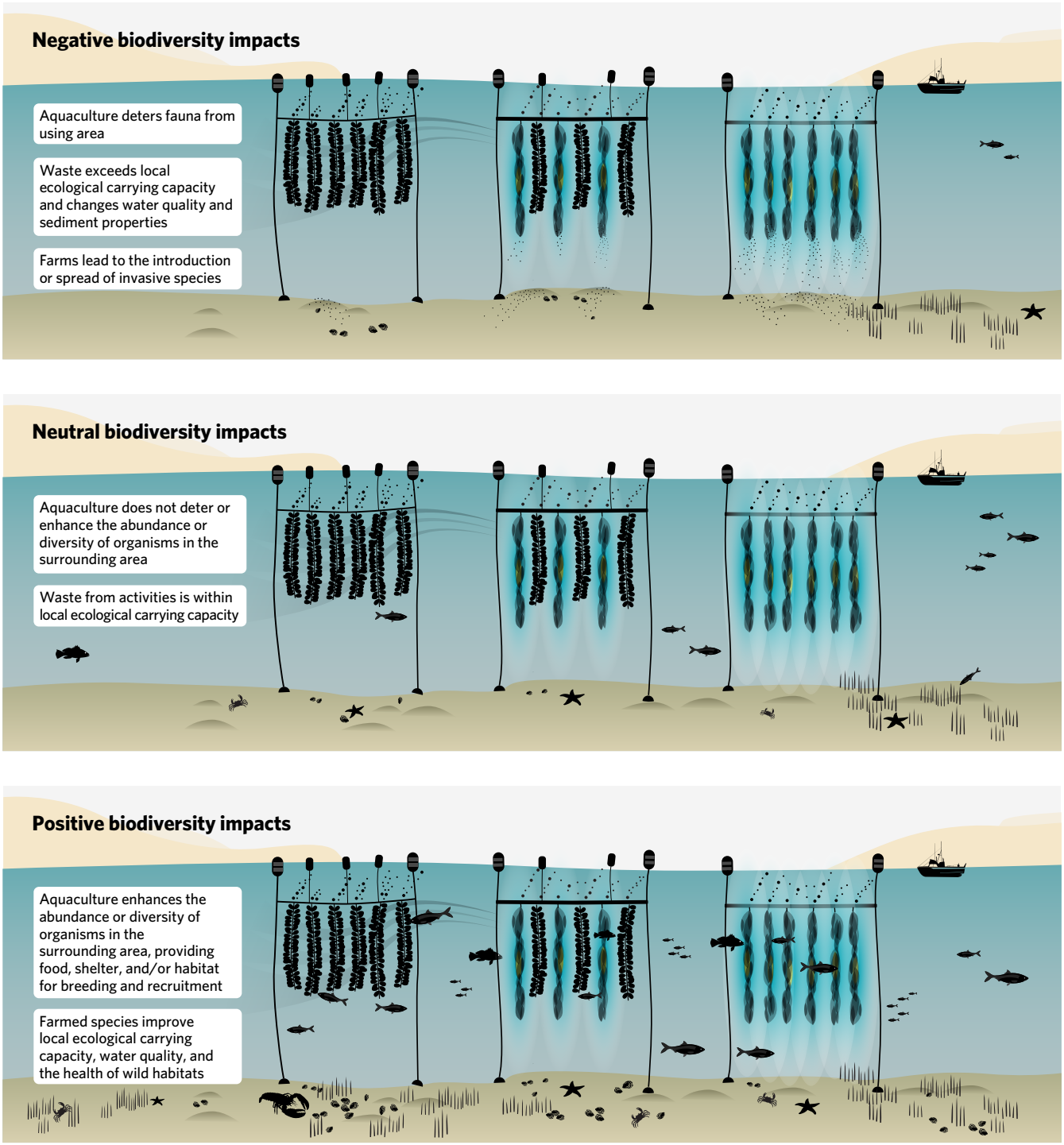
- The experimental nature of kelp farming in Aotearoa limited the capacity to determine the extent of its positive effects more precisely. However, experimental sites using transplanted individuals of common kelp, *Ecklonia radiata*, had similar abundance and diversity of invertebrates living within the aquaculture habitat as adjacent natural habitats (McArthur, 2023).

- In both locations, seasonality and the types of fish and invertebrates within the local area and their behavior (e.g. the seasonal presence of certain species, schooling fish as opposed to benthic fish species) may have influenced the overall abundance of taxa. Winter samples were found to have lower overall abundance.
- To adequately assess the habitat benefits of kelp and kelp-shellfish aquaculture, future research should account for the influence of local environmental conditions, (Figure 2) ideally sampling across multiple seasons, water temperatures, key biophysical factors such as tidal flow and wave exposure, and other seasonal or ecosystem influences. At this time, habitat interactions will be best quantified by using a combination of sampling methods and should include methods that detect mobile fauna, such as fish and crabs, as well as smaller invertebrates that may be living amongst the farmed biomass and equipment.
- Novel research through ecosystem services education and a consumer awareness survey found that, regardless of the product or the respondent's demographics, consumers indicated that they were willing to pay more for the same products after seeing the educational video on potential ecosystem services from seaweed aquaculture (Bolduc *et al.*, 2023).
- In managing the aquaculture industry to provide habitat and wildlife benefits, industry and supporting organizations need to understand how these facilities respond to local environmental conditions and potentially help operations make adjustments to maximize the positive environmental outcomes.

University of Maine researchers collecting samples

Adult kelp kept in a laboratory to produce gametophytes

Figure 1. **Biodiversity impacts of aquaculture.**



Recommendations for research, policy, and management

RESEARCH:

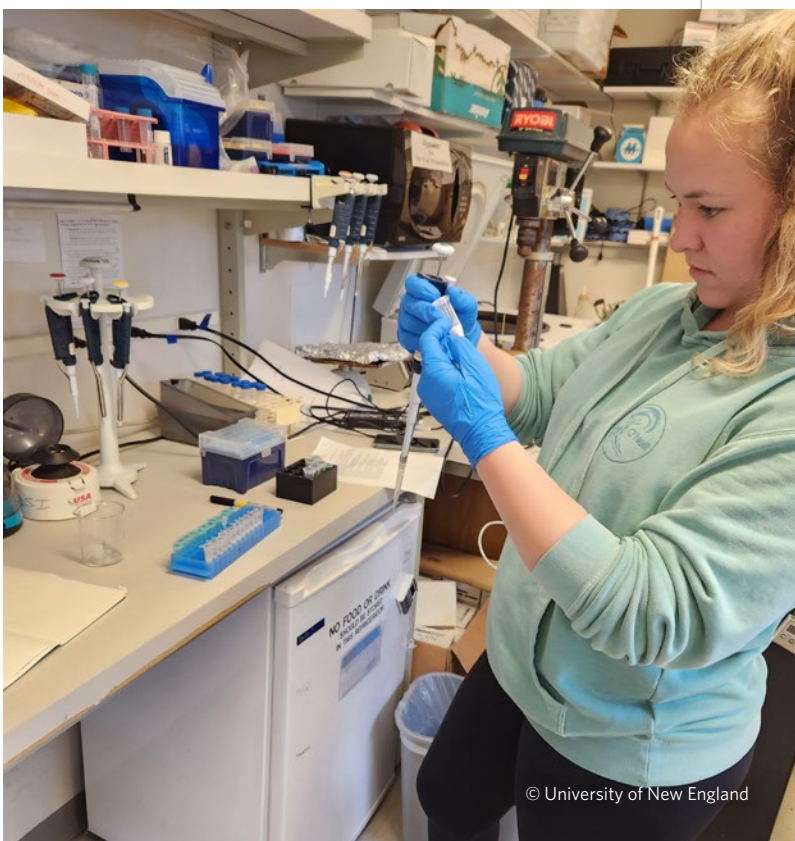
This project found that habitat benefits from kelp and kelp-mussel aquaculture can be highly context dependent. Local environmental conditions, seasonal movement of species, and the timing of farming to coincide with the requirements of species using aquaculture habitats all play a key role in determining what type of habitat can be provided (e.g. habitat for foraging, shelter, recruitment) and to what extent (Figure 2). To adequately assess the potential habitat benefits of kelp and kelp-shellfish aquaculture, future research should account for the influence of local environmental conditions, ideally sampling across multiple seasons, water temperatures, and other seasonal or ecosystem influences. A combination of sampling methods will also be needed. In this research, the use of eDNA sampling was tested; while there was a degree of coherence between eDNA and visual methods (GoPro cameras), eDNA samples were not always able to detect less commonly occurring species seen via visual sampling.

Additionally, research in more locations and geographic and environmental settings is needed. This research should aim to study a representative portion of farms within a bay (e.g. 10% of farming activities) while also focusing on sampling as many distinct locations and regions as possible. It should also aim to sample farm areas that are larger in size and produce more biomass as well as farms that are smaller in scale or less established. This will increase the available data on the influence of ecological variables on aquaculture's ecosystem services and work toward understanding whether the scale of farming (large, small, high density, low density) is equally important in shaping the benefit provided, painting a more comprehensive picture of common ecological and farming principles that may apply. In this research, a consistent approach to sampling should be taken so that data can be successfully compared across studies and locations.

POLICY AND MANAGEMENT:

In managing aquaculture activities to provide habitat for wild fauna, industry and supporting organizations will need to

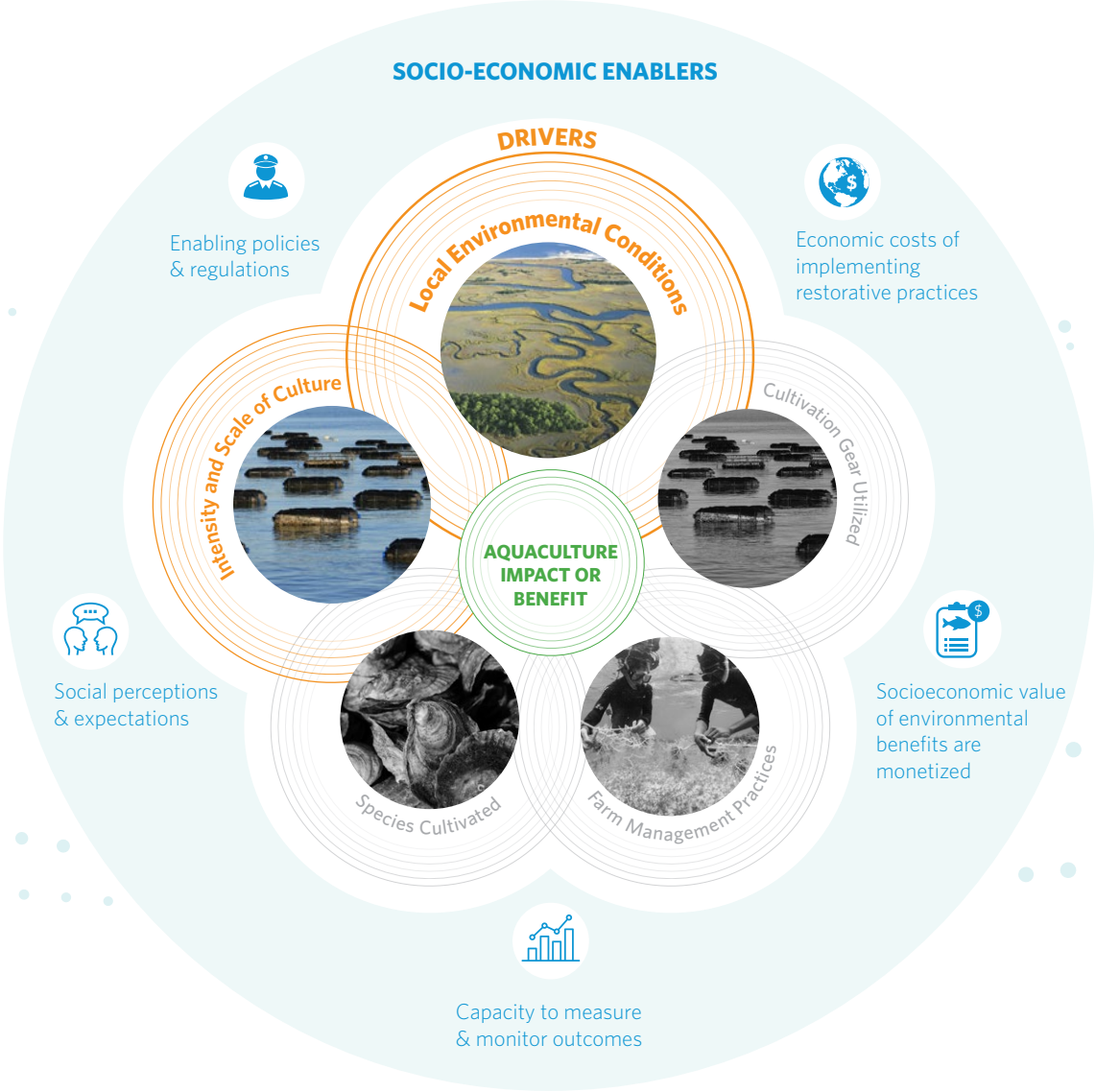
Researcher extracting eDNA in a laboratory



understand how these facilities respond to local environmental conditions and potentially help operations make adjustments to maximize positive environmental outcomes. Not all farms will provide a noticeable benefit for biodiversity, but all farms can be managed to effectively mitigate negative impacts if the interaction between aquaculture facilities with the local environment, species, and other users is understood.

Policy and management approaches that aim to acknowledge ecosystem services from these aquaculture systems and species should explicitly consider that farms could display high, low, or no benefit, depending on their location, and that the benefits provided could vary markedly from season to season. They will also need to avoid introducing unanticipated consequences, such as attracting fish species that then use the area for spawning but may be negatively affected when kelp is harvested.

Figure 2. **Ecological drivers and local environmental factors influence the habitat benefit of seaweed and shellfish aquaculture.**



Publications

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Yellowtail kingfish swimming among mussel aquaculture lines in New Zealand