National SCIENCE Challenges

SUSTAINABLE SEAS

Ko ngā moana whakauka

Kohunga Kūtai: Creating a sustainable supply of seed mussels using mātauranga Māori

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Summary

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NGĀTI MANUHIRI SETTLEMENT TRUST

New Zealand's mussel aquaculture industry relies heavily on using strong and durable plastic ropes for growing its mussels. Concerns have been raised about the potential release of plastic fragments from these ropes with the possibility of negative effects on the marine environment. Substituting plastic ropes with biodegradable alternatives for farming mussels would overcome any concerns from the use of plastic.

Prior to the advent of plastics, ropes and twines were all made from biodegradable materials, mostly from extracted plant fibres, including from jute, sisal, hemp, flax, cotton, as well as fibres from coconut husks, known as coir. In Aotearoa New Zealand there is an extensive range of native plants that continue to provide fibres that are used by Māori for making ropes and twines, including some that are used in the sea, such as for waka (boat) lashings, anchor ropes, and fishing lines.

Therefore, the overall aim of this research project was to assess the potential for using the natural fibres from native plants known to mātauranga Māori (Māori knowledge) for the replacement of plastic rope in mussel aquaculture. This approach is also consistent with some mātauranga Māori that indicates there is a natural association between mussels and some plants and their fibres.

An important constraint for using natural plant fibres in the sea is their potential for deterioration due to becoming waterlogged and the natural biological activity of seawater acting on the plant fibres. One of the key uses of plastic ropes in mussel aquaculture in Aotearoa New Zealand is the catching of wild seed mussels, or spat, that are used for seeding many coastal mussel farms to initiate the growing cycle (Fig. 1). Each year thousands of kilometres of plastic spat-catching rope is deployed into the sea for a period of 3-6 months in coastal places around the country to catch settling mussel spat. This spat settlement involves the swimming larval stage of mussels finding a suitable substrate on which to attach itself with an anchoring thread, a process known as settlement. The plastic rope used to catch settling mussel spat appears to be frayed or consist of loose loops, but these are features are built into the rope so that it mimics the filamentous strands of seaweed that the mussel spat naturally prefers to settle on. This relatively short period of deployment of spat-catching rope and their filamentous nature, are two key attributes that can be readily achieved with spat-catching ropes made from natural fibre.

A key first step for the research was to investigate the resistance of a variety of native plant fibres to degradation when submerged in the coastal waters for extended periods, as would occur if they were used to make mussel spat-catching ropes. Using mātauranga Māori, more than 18 different types of plant fibres were extracted and then soaked in coastal water for a period of over 6 months (Fig. 2). During this period the strength of samples of the fibres were regularly recovered from the sea and tested to determine which types of fibres were most resistant to degradation. This process identified three top performing natural fibres that were sourced from harakeke (flax), tī kōuka (tī or cabbage tree) and pampas (a commonly found invasive species from South America).

Fig. 1. Photograph of mussel spat-catching rope made of plastic that is often deployed by mussel farmers in Aotearoa New Zealand to catch the seed mussels used to stock their farms. The physical characteristics of the spat rope that are known to attract mussel larvae (ie fine, filamentous strands) can be replicated using natural fibres, which do not shed plastic fragments into the environment.

The second key step for the research was to investigate the effectiveness of these three types of plant fibres for catching mussel spat. The initial step was to fabricate sufficient spat-catching ropes for each of the three top performing natural fibres. However, this proved difficult for the pampas fibres because they were brittle and would break easily if folded or twisted, unlike the fibres for both harakeke and tī kōuka, which remained flexible. Consequently, it was not possible to advance pampas fibres further for the research.

Fig. 2. Photographs of natural fibre ropes manufactured by plaiting techniques by iwi project partners, Ngāti Manuhiri (left – harakeke, right - tī kōuka) that were used for assessing fibre resistance to seawater.

Two designs of spat-catching ropes were fabricated from both harakeke and tī kōuka. The plain design of spat-catching rope consisted of separating the fibres from the leaves coarsely with a dog hair comb, then processing the extracted fibres with a heavy wool carding machine, and then twisting the fibres with a spinner into a single strand of rope, which was then used in a reverse twist to form a two strand rope. The fluffy design of spat-catching rope was the same as the plain rope, but a serrated knife was run along the twisted ropes to loosen strands of fibre so they protruded from the rope. In this way, these ropes more closely resembled the design of plastic mussel-spat-catching rope.

The four types of spat-catching ropes were deployed into a mussel spat-catching area on the coast alongside conventional plastic spat-catching rope. After two months all the experimental spat-catching ropes, were recovered and some were sampled for attached spat, and the balance of the ropes were transferred to a mussel farm on the coast near Coromandel township in the same manner that commercial spat-catching ropes would be transferred to mussel farms. After a further month, all the ropes were recovered and their remaining attached spat counted and measured.

The results of the experiment confirmed that spat-catching ropes made of both types of natural fibre and for both designs successfully caught mussel spat, but these catches were much lower than for the plastic spat-catching rope – more than 15 times lower (Fig. 3). This result can be partly explained by the differences in the overall size and surface area of the ropes available for spat settlement, as the plastic rope had a much large diameter (12 mm versus 5 mm), which equates to more than double the surface area.

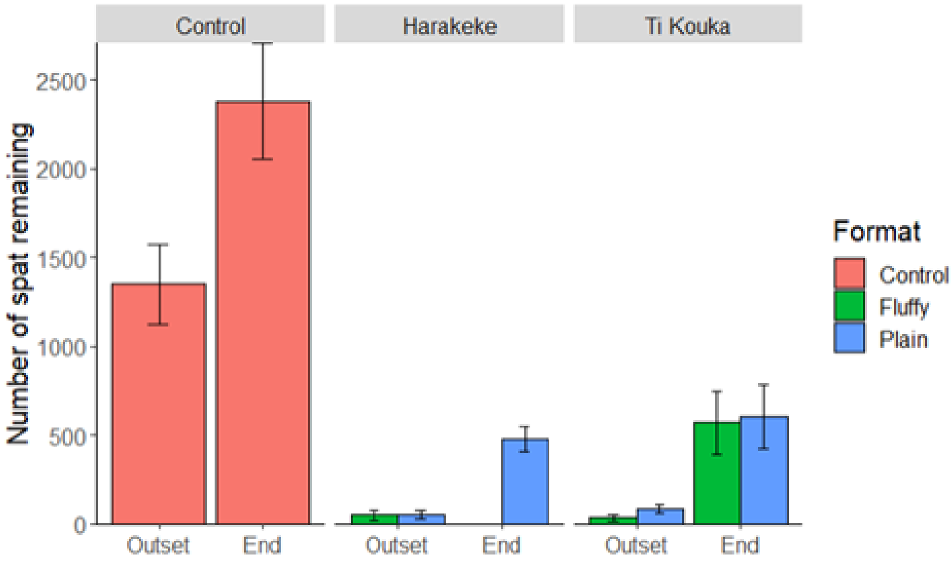

Fig. 3. Mean (± SE) number of spat attached per metre of experimental rope for plastic spat-catching rope (ie control) and two natural fibres (ie harakeke and tī kōuka) prepared into two rope designs (ie fluffy and plain) after being at a spat-catching site for two months (ie outset) and after transfer to a coastal mussel farm.

The transfer of the experimental ropes to a coastal mussel farm for a month had mixed results, partly because mussel spat were continuing to settle onto most of the ropes at this site also. This continual settlement made it difficult to interpret whether mussel spat that were transferred with the experimental ropes to the coastal mussel farm remained attached to their ropes and were growing because new small mussel spat were settling in amongst them at the same time.

Among the two natural fibres and two rope designs, there were no differences in the number of spat caught, suggesting ropes manufactured from both harakeke and tī kōuka are equally suitable for catching mussel spat. Furthermore, the lack of a difference in spat catches among natural fibre ropes of different designs (ie plain or fluffy) would appear to suggest that further designs to increase the structural complexity of the rope designs would be unlikely to further increase mussel-spat-catching performance of natural fibre ropes.

An investigation into the comparative costs of plastic versus natural fibre spat-catching ropes, found that the plastic rope is a relatively low-cost product that can endure multiple spat-catching seasons. In contrast, the growing, harvesting, processing and fabrication of natural fibre spat-catching rope that is useful for only one spat-catching season would be markedly more costly than the plastic alternative. This cost difference might be reduced by chemical treatment of the natural fibres to make them more resistant to degradation in seawater to increase their working life. Alternatively, future research may confirm the extent of an environmental cost associated with using plastic ropes for mussel farming, which may alter the prospects for the substitution of plastic spat-catching rope with natural fibre alternatives.