

FRESHWATER ECOLOGY

Decline of the kakahi – identifying cause and effect

Bob McDowall

A new look at the reasons for the decline of the freshwater mussel – kakahi – challenges one of the presumed causes of the decline.

Among cultural concerns of contemporary Maori is a perceived decline in the abundance of kakahi, or freshwater mussels, *Hyridella menziesii*. These once formed extensive beds in New Zealand lakes and rivers, and were harvested as a food by pre-European Maori. Decline in kakahi is largely unquantified, but seems likely in some waterways, and discussion has taken place about the cause and how it can be mitigated.

Some years ago, NIWA (then DSIR) scientist Mark James noted decline in mussel populations in Lake Taupo and especially a lack of juveniles, and thought that the population was not maintaining itself. He summarised known or likely global causes of declines in freshwater mussels, listing influences of sediment type, food supply, water quality (pollution and eutrophication), water velocity, bed slope and presence of fish hosts for the parasitic life stage. He concluded that increased sediment, pollution and eutrophication were unlikely causes in Lake Taupo. However, conclusions may be different for lakes exhibiting more obvious declines in water quality and sedimentation, and deoxygenation may sometimes be an issue.



Freshwater mussel
Hyridella menziesii
(actual size: approx.
50 mm long).

Kakahi and phytoplankton blooms

It is easy to link declines in kakahi to lower water quality in lakes, and to blame phytoplankton blooms ("green water"), which are often attributed to higher nutrient levels. However it may be simplistic to attribute kakahi decline to increased nutrients alone. As is so often the case, there could be multiple causes for changes in abundance. It is even possible that phytoplankton blooms are in some instances a symptom rather than cause of kakahi decline.

How can this be? Is there a precedent for turning the cause-effect relationship on its head? I think so.

In recent decades the zebra mussel has invaded the shallows of North American lakes. It has occupied water intake structures for thermal power stations, restricting water flows and becoming a serious pest, especially in the Great Lakes. However, things were not all bad. Biologists discovered that they could see the bottoms of lakes in areas hitherto hidden by water turbidity. The change in water clarity was attributed simply to millions of zebra mussels filtering phytoplankton from the water.

Is a comparable but reverse phenomenon taking place in our lakes? Has decline in kakahi resulted in less water being bio-filtered, allowing phytoplankton to increase and an apparent deterioration in water quality in our lakes?

This is difficult to prove as there is no historical information on abundance of kakahi. Critics of the hypothesis might also ask: "If loss of kakahi has contributed to increased phytoplankton in our lakes, what caused the decline in kakahi?" That is a fair question. I think there may be a partial answer.

A connection with fish

It is little known that kakahi, like most freshwater mussels, have a glochidium larva that is parasitic on fish in the early part of its life before moving to soft, sandy sediments in lake and river beds. So has decline in kakahi resulted, at least in part, from reductions in fish abundance?

Again, we have no quantitative information on historical abundance of fish species in lakes. However, we do know that in pre- and early European settlement Maori harvested whitebait from Lake Taupo and are said to have taken koaro whitebait (*Galaxias brevipinnis*) by the hundredweight using big seine nets. Artist C.F. Angas painted a picture of Maori catching whitebait from a canoe with long-handled dip nets, so the fish must have been very abundant. Tuwharetoa historian J. te H. Grace described how Maori picked up adult koaro from leeward shores of the lake following storms. Early European visitors, such as Governor George Grey, were offered whitebait as food when visiting Maori villages around the lake. There is no doubt, therefore, that koaro whitebait were important in the diet of Maori living around the lake. Similar scenarios probably applied to other lakes. Today, however, it is hard to find a single shoal

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of koaro in Lake Taupo or other lakes, let alone catch such numbers. What has happened?

Introduction of brown trout, *Salmo trutta*, and rainbow trout, *Oncorhynchus mykiss*, was clearly a prime cause for decline of koaro in Lake Taupo. The trout thrived and reproduced to generate one of the world's great trout fisheries. However, by the early 1900s trout condition had deteriorated in parallel with their increasing abundance. The trout had so eaten down the food supply that they were starving. Tonnes of trout were netted to reduce the population and enable those left to regain condition.

Rotorua Maori expressed early opposition to trout introductions into their lakes, fearing trout impacts on traditional food supplies. The food at the centre of their concerns was koaro.

Eventually, common smelt, *Retropinna retropinna*, were introduced as a substitute food (for the trout!). They thrived in the lakes, and for some reason have sustained prolonged trout predation. The trout are now in good condition, though partly because angler harvest controls trout abundance.

What has all this to do with kakahi? Well, as noted above kakahi have a larval stage that is parasitic on fish. Which fish? With little doubt, in Lake Taupo and also the Rotorua lakes, the fish was originally the koaro. Adult koaro were abundant and probably lived near the lake bed. They would have been accessible to the mussel glochidia liberated by breeding mussels into waters close to the lake bed, and the glochidia would have attached themselves to the nearest koaro. Today – as we have seen – koaro are largely gone from Lake Taupo, replaced by smelt and common bullies, *Gobiomorphus cotidianus*. If the hypothesis presented above is correct, then decline in kakahi in Lake Taupo, which Mark James documented in the 1980s, may be attributable, at least in part, to reduced numbers of koaro.

While Lake Taupo is probably too big for kakahi to make much difference to water clarity, in smaller and shallower lakes kakahi may have played a role in filtering phytoplankton (as zebra mussels do). So deterioration in lake water quality may, at least in part, be a *symptom* of the loss of kakahi rather than a *cause*.

The host–parasite relationship

A final question is, why didn't the glochidia larvae of kakahi in Lake Taupo turn their



Koaro
Galaxias brevipennis
(actual size: approx.
150 mm long).

attention to other fish species – smelt, common bullies, even trout, and perhaps also catfish that are now common? This question needs study, but some observations seem pertinent.

Firstly, most of the replacement fish species in Taupo (trout, smelt and bullies) may be less accessible to kakahi glochidia than the koaro were. Smelt and trout are mid- and surface-water fish species and bullies seem commonest in Taupo around rocky shores in the lake shallows, where there are few kakahi. (It might be interesting to see if the mussel glochidia have found brown bullhead catfish *Ameiurus nebulosus*, which commonly live near the lake bed and on sandy substrates, a suitable replacement host.)

Secondly, there may be a close host–parasite relationship between kakahi and their fish hosts that is not transferable to other species (particularly exotic fish like trout and catfish). Hosts and parasites commonly co-evolve to the extent that only traditional host species are acceptable to parasites. This could be true of kakahi and is another question for research.

Implications for research and management

If the initial hypothesis is correct it implies that attempts to relate decline in kakahi populations to changes in water quality may sometimes fail. Or, a survey might show that kakahi abundance correlates closely with lake water quality (i.e., declines in both water quality and kakahi abundance). However, if the cause–effect relationship hypothesis is different from what seems intuitive (the idea that water quality decline causes kakahi decline is sometimes wrong – and I am suggesting that it sometimes may be), then efforts to clean up lakes to facilitate recovery of kakahi populations may fail. It would, of course, be nice to have cleaner lakes, but the expectation that kakahi populations will then recover may result in disappointment. They may not, especially if populations of fish in the lakes – like koaro, which act as hosts for mussel glochidia – are much reduced. ■

Teachers: this article can be used for Biology L7 A.O. 7.1a. See other curriculum connections at www.niwa.co.nz/pubs/wa/resources

Further reading

Walker, K.F.; Byrne, M.; Hickey, C.W.; Roper, D.S. (2001). Freshwater mussels (Hyriidae) of Australasia. In: Bauer, G.; Wächtler, K. (eds). Evolution of the freshwater mussels Unionoida, pp. 5–31. *Ecological Studies* Vol. 145. Springer-Verlag, Berlin, Heidelberg.