10 Kākahi / Kāeo (Freshwater mussels)

Family: Hyriidae

Species: *Echyridella menziesii, Echyridella aucklandica, Echyridella onekaka*

Freshwater mussels are widespread throughout Aotearoa-NZ, in habitats ranging from small, fast-flowing streams to rivers and lakes. *Echyridella menziesii* (Figure 72), previously known as *Hyridella menziesi*, is one of three species of freshwater mussels native to Aotearoa-NZ. Shell morphology can vary significantly in response to environmental conditions, which has complicated freshwater mussel taxonomy in Aotearoa-NZ for over 100 years. That is, until the research of Fenwick (2006) and Marshall et al. (2014) which provided clear taxonomic designations for Aotearoa-NZ freshwater mussels. Freshwater mussels have a unique relationship with a midge (or chironomid, *Xenochironomus canterburyensis*) (Figure 72), because the larvae develop within the layers of the freshwater mussel shell (Forsyth 1983). The midge larvae can sometimes be seen in "blisters" on the inside of the shell. Roper and Hickey (1994) found that dead chironomids can become embedded and result in severe shell deformities and flaking. Shell morphology appears to also vary with water quality, flow, and wave action, making it difficult in some locations to tell the species apart (Phillips 2006).

Figure 1: (Left) The kākahi, *Echyridella menziesii*; and (Right) The chironomid, *Xenochironomous canterburyensis*. The chironomid larvae can sometimes develop within the layers of the kākahi shell and is visible as "blisters" on the inside of the shell (Photos: [Left] Ngaire Phillips; and [Right] Mark Fenwick).

Freshwater mussels are filter-feeders (e.g., Figure 73), as well as deposit-feeders, and feed on a variety of suspended particulates in the water, including bacteria, phytoplankton, detritus and micro-zooplankton, as well as deposited organic material (e.g., dead plankton, fine silt). Freshwater mussels lack the byssal threads (or "beard") that some marine mussel species use to attach themselves to substrates; instead they usually partially bury themselves into soft sediments. In some instances, kākahi leave tell-tale trails in the soft substrates when they move along the bottom of lakes, rivers and streams.

10.1 Life Cycle

Kākahi have a unique life cycle (Figure 74) that relies on fish to be successful. Briefly, males release their sperm into the water in spring where it is taken in by the females to fertilise their eggs which are held inside a special brood pouch in the gill. The tiny eggs develop into larvae known as glochidia (less than half a mm long) and shaped like a "pac-man" (Figure 75). In spring and summer the glochidia are released into the water column, possibly when the female senses the presence of a suitable fish host. The larvae attach themselves to a host fish (including fish like kōaro, tuna, bullies, banded kōkopu) using a little tooth on their shell edge. The best attachment location is thought to be the gill, but they are often found on the fin tips, lips and skin of fish. The glochidia are parasites on the fish host (Fritts et al. 2013) while they transform completely into a juvenile mussel. After about two or three weeks they drop off the fish, presumably into soft, sandy sediments in lake and river beds to develop further.

Figure 2: (Left) Kākahi in the Styx River showing the inhalant (Kai In) and exhalant siphons (Waste Out) that the mussels use to filter feed; and (Right) Close up view of the inhalant siphon. (Photos: [Left] Duncan Gray and Greg Burrell; [Right] Sue Clearwater). The photo on the right shows the inhalant siphon fringed with tentacle-like papillae that help sort food from other particles. Particles are delivered to the gill (glimpsed in white inside the inhalant siphon) which generates the feeding current (approximately 1 litre per mussel per hour) and does further food-sorting and delivery to the mouth.

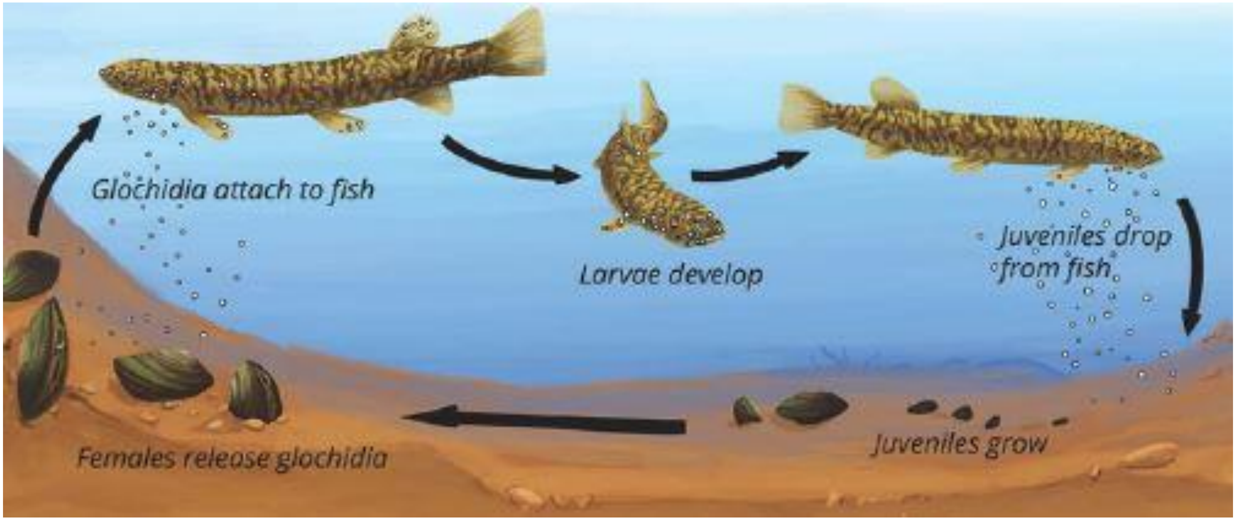

Figure 3: Life cycle of the kākahi. (Source: Rainforth 2014) While kōaro is shown as the fish host in this graphic, where present, species like tuna and common bullies can also fulfil this role in the kākahi life cycle.

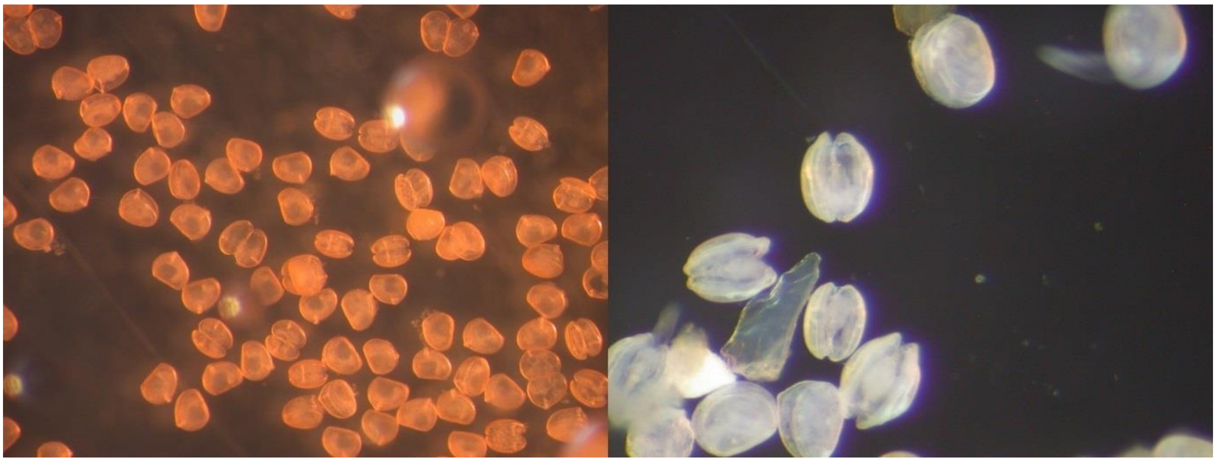

Figure 4: The glochidium (plural glochidia) is the microscopic larval stage of kākahi. (Photos: [Left] Brian Smith; and [Right] Karen Thompson).

In Aotearoa-NZ, *E. menziesii* longer than 30 mm dominate population studies and it is rare to find juvenile mussels (Grimmond 1968, James 1985, Roper & Hickey 1994). Adult freshwater mussels can live a long time and individuals of more than 100 mm length have been recorded in previous studies (Ogilvie 1993, Sorrell et al. 2007). Populations in Lake Waipori had a mean age of 20–25 years old (Grimmond 1968), with some individuals aged at over 50 years. In other locations, the oldest mussels were 13 years old (61 mm) in Taupō-nui-a-Tia (James 1985) to 33 years (84 mm) in the Waikato River (Roper & Hickey 1994). The long-life span of freshwater mussels can be problematic because adult mussels may be present in a lake or river but might not be a viable, self-sustaining population because of low juvenile survival. This would be known as a “geriatric” population at risk of local extinction. There is potential that juvenile mussels occur in a different habitat (upstream) from the adults and undergo a migration into adult habitat as they develop (Phillips 2006). For example, Grimmond (1968) found juvenile mussels near the mouths of inflowing rivers.

10.2 Distribution

Echyridella menziesii is widespread throughout Aotearoa-NZ, and is locally common in some places. To date *E. aucklandica* has mostly been found in northern Aotearoa-NZ and *E. onekaka* has a very restricted range in northwest Nelson (Figure 76).

Now that the research of Fenwick (2006) and Marshall et al. (2014) has provided clear taxonomic designations for Aotearoa-NZ freshwater mussels, more research is required to confirm the distribution of *E. aucklandica* that has an interesting and somewhat bizarre distribution from the north of the North Island to the south of the South Island but with vast gaps between populations. These species also often occur together (in other words, side-by-side in the sediment) which may indicate that their ecological relationship is more complex than is currently understood. For example, recent surveys have shown the two species, *E. menziesii* and *E. aucklandica,* are usually found within one location (e.g., Lake Wairarapa, Lake Hauroko, west coast Waikato streams) (Marshall et al. 2014, Greater Wellington Regional Council 2015, Hamer et al. 2015).

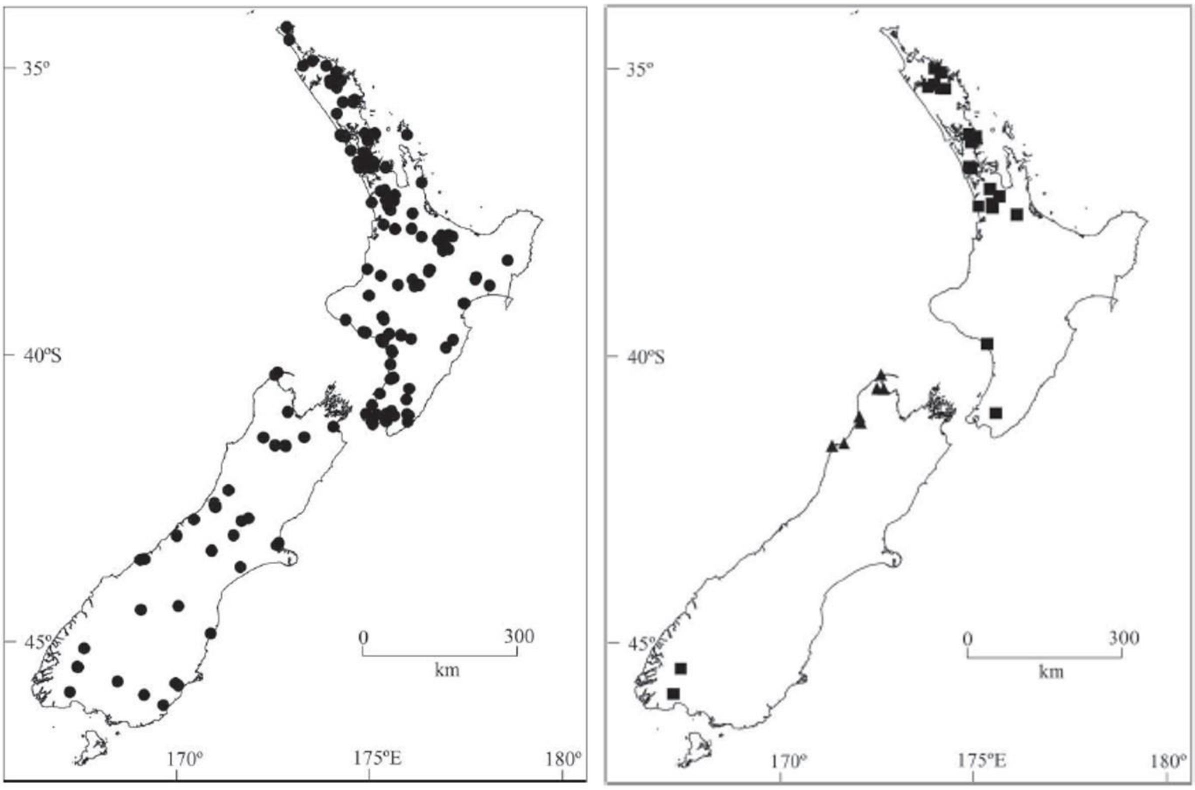

Figure 5: Distribution of *E. menziesii* (Left), and (Right) *E. aucklandica* (squares) and *E. onekaka* (triangles). (Source: Marshall et al. 2014).

10.3 State and Trends in Abundance

Kākahi state and trends in abundance were unable to be assessed by Crow et al. (2016) as freshwater mussel abundance is not recorded by the NZFFD.

Kākahi once formed extensive beds in lakes and rivers, and were harvested as a food by pre-European Māori. Many customary fishers perceive that there has been a decline in the abundance of kākahi (e.g., NIWA 2010). Trends in the relative abundance of the three freshwater mussel species are not presently known. This is largely associated with species identification challenges and an absence of information on the abundance of each species.

Surveys of freshwater mussel populations are sometimes undertaken as part of small research or restoration projects (e.g., James 1985, Ogilvie & Mitchell 1995, Happy 2006, Butterworth 2008, Rainforth 2008, Greater Wellington Regional Council 2015), and resource consent and biosecurity evaluation/monitoring processes (e.g., Kusabs 2006, Sorrel et al. 2007, Otago Regional Council 2013, Hofstra 2013; 2015, Baker et al. 2014). Together these studies, and similar unpublished data sources, suggest that freshwater mussel populations are being lost from many shallow lakes and small streams, especially those affected by urban and agricultural development. To the best of our knowledge, there is no one organisation or centralised data management system collating the information for the benefit of assessing state and trends in freshwater mussel distribution and abundance in the future.

10.4 Threat Rankings

Freshwater mussels are under threat and are declining, both in Aotearoa-NZ and worldwide (Walker et al. 2001). Recognition of the potential threats to kākahi populations is reflected in the New Zealand Threat Classification System assessment (Grainger et al. 2014). Because *E. onekaka* has a restricted range, this species has been classified as 'At Risk – Naturally Uncommon' with an additional qualifier of Data Poor as very few live populations have been identified (S. Clearwater, unpubl. data). *Echyridella menziesii* has been classified as 'At Risk – Declining' with a total area of occupancy >10,000 ha (100 km^2), and predicted decline 10–70%. *Echyridella aucklandica* has been classified as 'Threatened – Nationally Vulnerable' with ≤15 subpopulations, ≤500 mature individuals in the largest subpopulation, a predicted decline 10–50%, and with 'recruitment failure' and 'sparse' as qualifiers (Grainger et al. 2014) (Table 15).

In 2013, the IUCN ranked *E. menziesii* as being of 'Least Concern'; however, they recognise that there is very little information on juveniles and rates of recruitment, which means it could take a while to notice any decline in populations. The species is thought to be in decline due to reduced recruitment of riverine populations, and lowland lake populations are also likely to be in decline, however some large upland lake populations may be stable (Moore 2013) (Table 15). IUCN have also ranked *E. onekaka* as being of 'Least Concern' because this species has a restricted range (northwest Nelson). Despite potential localised threats, no major declines are known for this species, and it is expected to be present in many locations (based on separate sub-basins). Development in the area is low, and Moore (2013) considered that much of the known range falls within a Protected Area. That said, the range for this species has only been characterized from specimens held in Te Papa Tongarewa (Museum of New Zealand), most of which were collected in the first half of the 20th century (Table 15).

Table 1: Threat rankings for Aotearoa-NZ kākahi according to the New Zealand Threat Classification System and IUCN. (see Section 2.3 for more information about these assessment methods).

Species	DOC Ranking	IUCN Ranking
Echyridella menziesii	At Risk–Declining	Least Concern[1] (Populations decreasing)
Echyridella aucklandica	Threatened–Nationally Vulnerable	Not assessed
Echyridella onekaka	At Risk–Naturally Uncommon	Least Concern[2] (Unknown population trend)

10.5 Pressures on Populations

To date there has been limited research undertaken in Aotearoa-NZ investigating key drivers influencing presence, distribution, and density of kākahi in streams, rivers and lakes. Aotearoa-NZ based studies have investigated kākahi ecology (James 1985; 1987, Roper & Hickey 1994, Butterworth 2008, Cyr et al. 2016, Collier et al. 2017), reproduction (Clearwater et al. submitted), growth and energetics (Grimmond 1968, Nobes 1980), contaminants (Hickey et al. 1995; 1997, Clearwater et al. 2012; 2014), and potential use of kākahi for bioremediation (e.g., Ogilvie & Mitchell 1995, Phillips 2007). The decline of freshwater mussels both nationally and internationally has been attributed mainly to the loss and degradation of suitable habitat through land use and land management activities, and the loss of host fish species upon which the completion of their life cycle depends (Figure 77).

[1] http://www.iucnredlist.org/details/198678/0
[2] http://www.iucnredlist.org/details/198679/0

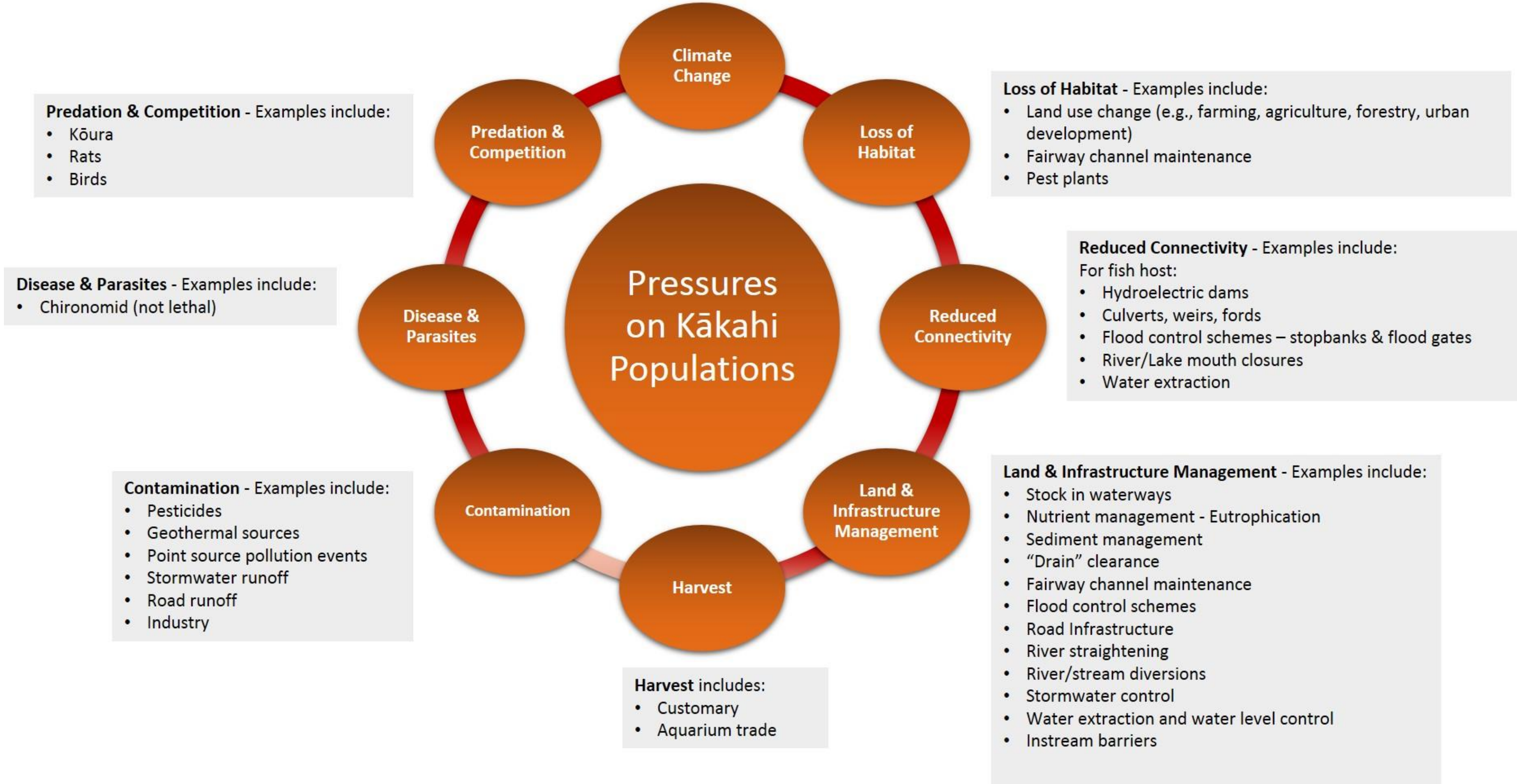

Figure 6: Examples of some of the pressures on Aotearoa-NZ kākahi populations.

10.5.1 Land and Infrastructure Management

Several physical factors influence the density of mussels. Sediment type and stability have been suggested as dominant factors, but bed slope, wave action, temperature, oxygen availability and presence of toxins are also important (James et al. 1998, Butterworth 2008). The presence of macrophyte beds is also known to limit the available habitat for kākahi (James 1985). Although kākahi need sediment to bury in, increased fine silt and organic matter has been found to impact mussel filtration rates (James 1985; 1987, Rainforth 2008). For more information about the pressures on fish host populations, which also impact kākahi populations in waterways where they coexist, please see Sections 3.5 and 6.5.

There are few published studies in Aotearoa-NZ that have attempted to quantify or document the effects of mechanical or chemical drain clearing on mortality of kākahi. Photographic evidence of this permitted activity occurring in a Murihiku catchment indicates that kākahi are scooped out of drains by mechanical excavators (Figure 78) and dumped on the stream/drain bank where they die.

Figure 7: Drain clearing activities in a Murihiku catchment impacting waikākahi (freshwater mussel) populations. (Photos: Jane Kitson). During this incident, in just over 500 m of stream drain clearing, over 200 waikākahi between 65–110 mm were removed from this tributary, which was also close to a nohoanga and mātaitai reserve (J. Kitson, unpub. data.).

Drain Maintenance Technical Guidance (Greer et al. 2015) has been produced by DOC for RMA and concession applications and provides the following recommendations for conditions and mitigation activities of relevance to kākahi:

- During weed cutting and mechanical excavation operations the consent holder shall ensure any stranded fish, kōura and kākahi are returned to the waterway. All fauna shall be released upstream of the affected section of waterway, or, where this is impractical (e.g., appropriate upstream release sites cannot be easily accessed), in a downstream section of the waterway that is below the mixing zone and does not have elevated levels of suspended sediment—to avoid exposing fauna to sediment-induced anoxia (lack of oxygen) when returned to the water.
- If a species listed as threatened under the New Zealand Threat Classification System is recovered during excavation or weed cutting in a waterway that is not previously known to contain that species, works in the area the fish was discovered shall cease immediately.
- If Threatened or At Risk fish are known to be present in the waterway, or the waterway is known or expected to contain a large fish population, a person shall be present at all times to return any stranded fish to the waterway.

The relocation of freshwater mussel populations impacted by land management activities is mandatory in North America. It is possible that diggers drivers and landowners do not know much about the life cycle of kākahi, or that they are listed as 'At Risk' species. A targeted education campaign could help to improve this situation in the future.

10.5.2 Water Quality and Contaminants

Butterworth (2008) found that the highest densities of kākahi in Lake Rotokākahi consistently occurred at intermediate depths (5 and 10 m) compared with shallower (1 m) and deeper (15 m) sites encompassed by each transect. Dissolved oxygen, temperature and algal fluorescence were the most highly correlated variables with *E. menziesii* density and biomass in the lake. These results have important implications for other deep lakes where eutrophication has resulted in a trend of declining dissolved oxygen in deeper waters when these lakes undergo seasonal thermal stratification.

Surveys have found elevated concentrations of the heavy metals mercury and arsenic in kākahi from selected locations within the upper Waikato River and Te Arawa fisheries areas (Hickey et al. 1995, Phillips et al. 2011, Phillips et al. 2014). In Harts Creek, a tributary of Te Waihora, the lead concentration in kākahi (1.96 mg/kg) was at the maximum limit of 2 mg/kg set by Food Standards Australia New Zealand, suggesting potential concern in respect to lead concentrations in these freshwater mussels (Stewart et al. 2014). While kākahi are consumed by whānau members today, they are not as popular or as important as they were in the past (e.g., Tipa et al. 2010). This may be due to the taste of the kākahi rather than a decline in harvestable quantities. However, their known propensity to accumulate pollutants may prejudice the opinion of harvesters (I. Kusabs, pers. comm., Walker et al. 2001, Tipa et al. 2010) and this may be another reason why kākahi are no longer exploited by Māori on a large scale.

10.5.3 Predation

Kōura have been reported to prey on juvenile mussels (C. Hickey, unpubl. data). It is likely that birds and fish take this species, as reported for other mussel species internationally (e.g., Zahner-Meike & Hanson 2001). Rats also predate kākahi, with records of "bitten off" shells from Lake Rototoa, Lake Harihari and in some Northland lakes, shell piles/middens from Lake Tūtira (Figure 79, Hofstra 2013).

Figure 8: Evidence of rat predation on kākahi. (Left) Lake Rotoroa, and (Right) Lake Tūtira. (Photos: Mary de Winton and John Clayton, respectively).

10.5.4 Aquarium Trade and Pond Enthusiasts

MPI (undated) notes that small quantities of kākahi are taken for personal use, mostly for home aquaria or back yard ponds and also for consumption. Kākahi are a desirable species because of their ability to filter out large amount of algae in ponds and many pond enthusiasts recommend adding a few mussels into the pond for that purpose. This species is also used in the aquarium trade, although the scale is unknown (Moore 2013).

10.6 Management

The main agencies involved in the management of kākahi are DOC (e.g., Conservation Act 1987) and Regional Councils (e.g., Resource Management Act 1991, Soil Conservation and Rivers Control Act 1941). There are no species-specific conservation measures in place for kākahi. There is a daily combined bag limit of 50 that applies to shellfish that do not have specific limits, such as freshwater crayfish, freshwater mussels and freshwater shrimp (MPI undated).

Environment Canterbury have a project to map all records or habitats of threatened freshwater species (fish, mussels and crayfish) with a view to providing bespoke protection for them within their planning framework. Stage 1 of this project is to create a database of known historical and current populations across Canterbury. Stage 2 involves field work to assess if historical populations remain and the health of current populations (e.g., Figure 80). Stage 3 will involve either the development of planning rules to protect populations or the instigation of population restoration and protection initiatives (Gray 2015).

Figure 9: Freshwater mussel populations in the lower Styx River, August 2017. (Photos: Duncan Gray and Greg Burrell).

Various iwi around the country are progressing formal management arrangements for their kākahi fisheries. For example, the **Ngāi Tahu Claims Settlement Act** prohibits the targeted commercial harvest of "Kākahi/Koaru – freshwater mussels". As part of the **Te Arawa Lakes (Fisheries) Regulations 2006** the Mahire Whakahaere or Te Arawa Lakes Fisheries Plan is required under the Regulations to provide for the sustainable management of customary fisheries, including kākahi, in the Te Arawa lakes.

During the 2014 Freshwater Sciences Society Conference a group of freshwater scientists and stakeholders met and agreed upon the content of a New Zealand Freshwater Mussel Conservation Strategy intended to enable/add momentum to the efforts of various organisations to understand and restore our three species of native freshwater mussels and their habitat. At this conference '**Freshwater Mussel Conservation Aotearoa**' was formed to provide a communication network about mussel-related activities and to address the first part of the strategy to “work together – increase cooperation and communication amongst entities that study, manage, conserve or restore freshwater mussels”. The nine key goals of the New Zealand National Freshwater Mussel Conservation Strategy as suggested by the Freshwater Mussel Conservation Aotearoa group are listed in Table 16. The strategy that this informal group suggests is based on the National Strategy for the Conservation of Native Mussels developed in North America (National Native Mussel Conservation Committee 1997, Haag & Williams 2014).

Table 2: Goals of the New Zealand National Freshwater Mussel Conservation Strategy, 9 September 2015. (Adapted from Haag & Williams 2014).

Goal No.	Description
1	Work together, increase cooperation and communication amongst entities that study, manage, conserve or restore freshwater mussels.
2	Increase knowledge of mussel population status and trends, including: a. Develop basic monitoring protocols (e.g., community groups). b. Develop detailed monitoring protocols for use nationally. c. Include traditional and local knowledge. d. Provide website for both presence/absence records, and data collection tailored to national protocols. e. Provide website on mussel information, updates (e.g., quarterly) on this process and contacts.
3	Grow knowledge of their biology (especially reproduction and host requirements) and habitat requirements (especially for juveniles).
4	Protect and reverse the decline of quality mussel habitat
5	Determine what are the key mechanisms of mussel decline in shallow lakes; what are the mechanisms of their probable decline in streams? Develop restoration guidance from the findings of this research.
6	Enhance public and government understanding and support for freshwater mussel conservation and habitat protection (e.g., flagship species for water conservation?)
7	Develop and trial techniques for holding and translocating large numbers of adult mussels.
8	Develop and trial techniques for reseeding juveniles on a large scale.
9	Increase available funding levels and develop other means to increase mussel conservation efforts.