4 Piharau / Kanakana (Lamprey)

Family: Geotriidae

Species: *Geotria australis*

Lampreys are sometimes referred to as “primitive fish-like animals” (McDowall 1990) as they differ from true bony fishes in not having jaws, paired fins, swim bladders and true bones (they are cartilaginous) (Figure 25). While they lack features that characterise bony fishes, they do have seven pairs of external gill openings, and a third (or pineal) “eye” which is sensitive to light and is involved with the control of hormone production. Lamprey and hagfish (known as cyclostomes or agnathans) are the only living jawless vertebrates (Figure 26). Over 360 million years old, lampreys swam past herds of drinking dinosaurs, and have survived at least four mass extinctions. The brain of the lamprey is believed to be the closest example of our primal vertebrate ancestors, and lampreys provide important insight into the evolution of fins, jaws and the skeleton, plus vertebrate motor control, and immunology (Baker 2014).

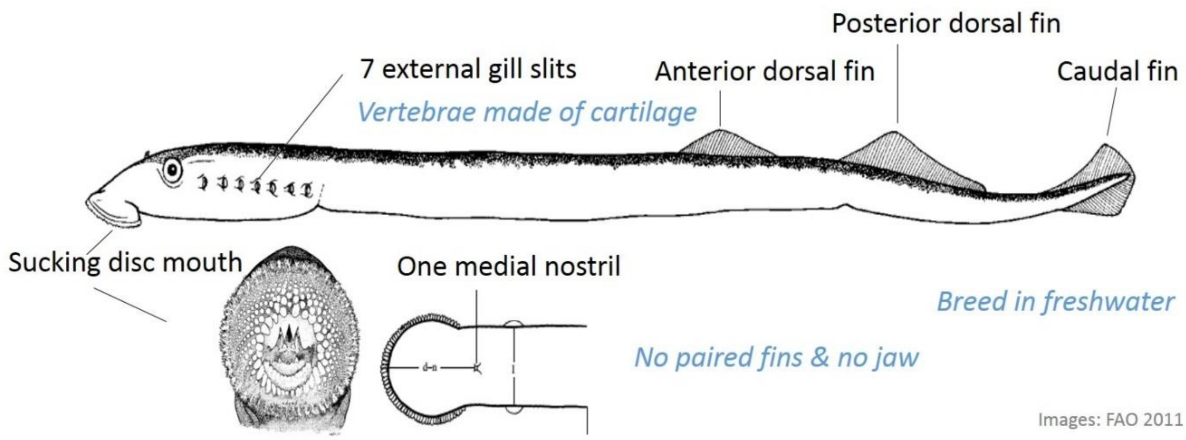


Figure 1: **Key features of a lamprey.** (Source: Kitson 2015).

4.1 Life Cycle

Not only are lamprey physiologically different from other Aotearoa-NZ fish, they also have a unique and specialised life history which requires them to complete parts of their life cycle in both the marine and freshwater environments (Figure 27).

In Aotearoa-NZ, adult lamprey grow to about 450–750 mm in length and migrate from the sea into fresh water between April and October each year (McDowall 2000). Upon entering fresh water, adults cease feeding as they travel upstream. Upstream migrations of more than 240 km have been recorded (James 2008) and mostly occur at night and are associated with the receding flood waters of both small and large flood flows. Lamprey spend up to 18 months in fresh water maturing sexually before spawning (James 2008, Baker et al. 2017). A male and female lamprey will make a nest underneath a large boulder (Figure 28), where the pair will spend seven weeks guarding and caring for the eggs after spawning (Baker et al. 2017). At present, it appears that the male has an active role in caring for the developing larvae and assists in hatching. Based on limited observations, the role the female takes during nesting is uncertain. However, both sexes survive spawning for three months, which is the longest documented post-spawning survival of any lamprey species worldwide.

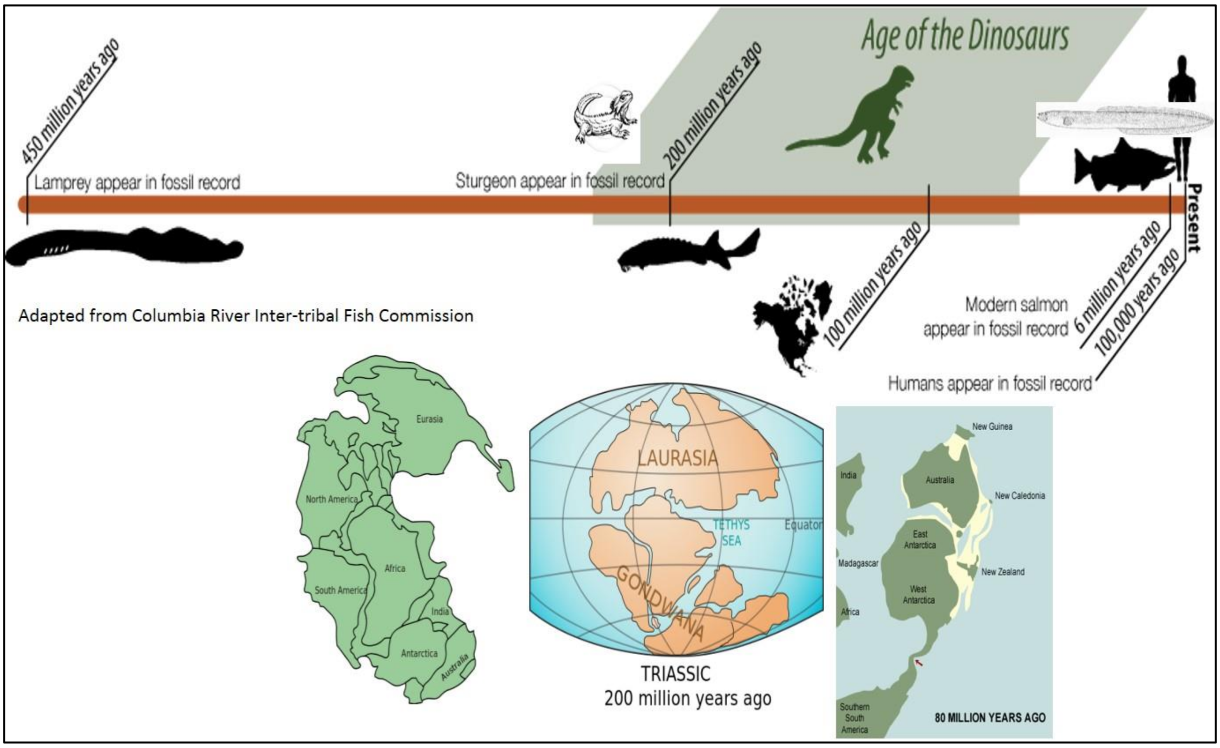


Figure 2: Visualisation of the evolutionary history of lamprey, compared to tuatara and tuna. (Sources: Kitson 2015, Baker & Kitson 2016).

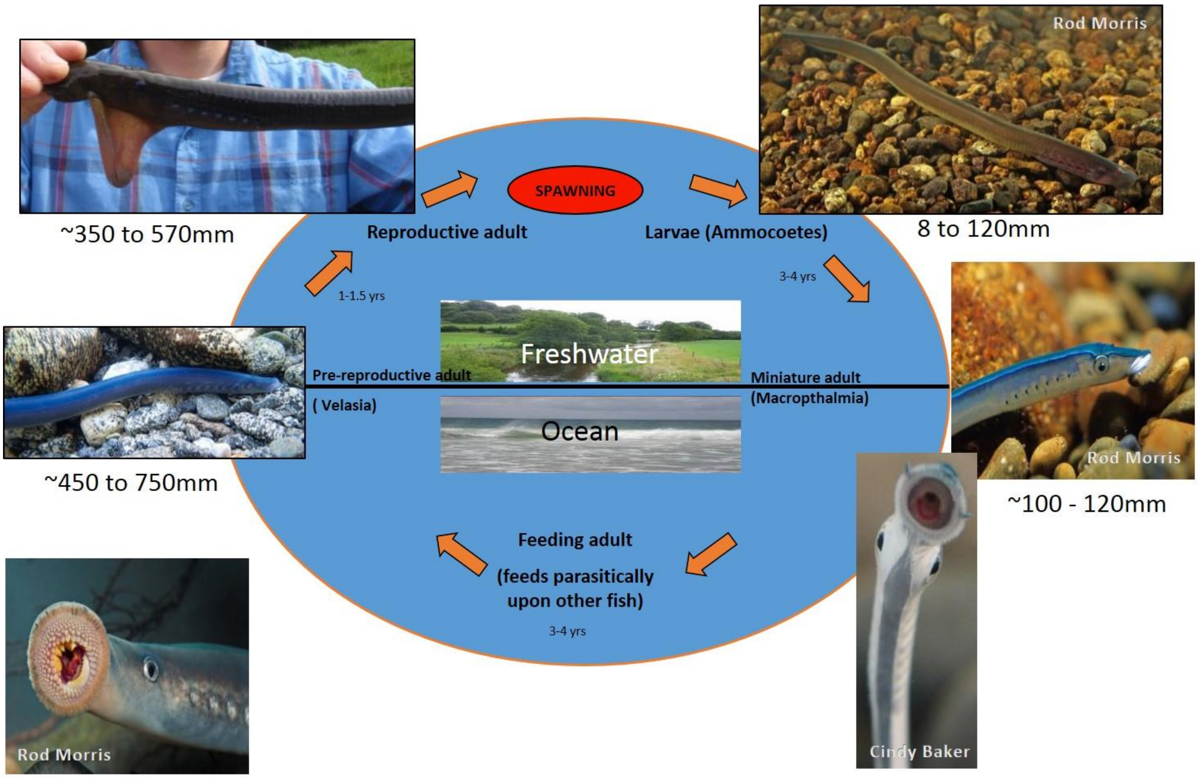


Figure 3: Life cycle of the lamprey. (Source: Cindy Baker).

Figure 4: Kinloch Stream, Banks Peninsula: Examples of the type of headwater stream habitat spawning lamprey seem to prefer. The yellow arrow indicates boulders where lamprey spawning nests have been located underneath. This is the first time lamprey spawning nests have been located in the Southern Hemisphere (Photos: Cindy Baker).

Their eggs hatch in fresh water, where the ammocoetes (larval lamprey) remain until metamorphosis (thought to be at least four years) (Figure 29). Ammocoetes are a dull brown colour, have no eyes, and live in burrows in the substrate while filter-feeding microorganisms from the water. These juveniles reside in soft sediment burrows often in backwaters or stream margins where flow is gentle, near adult spawning habitat (Jellyman & Glova 2002).

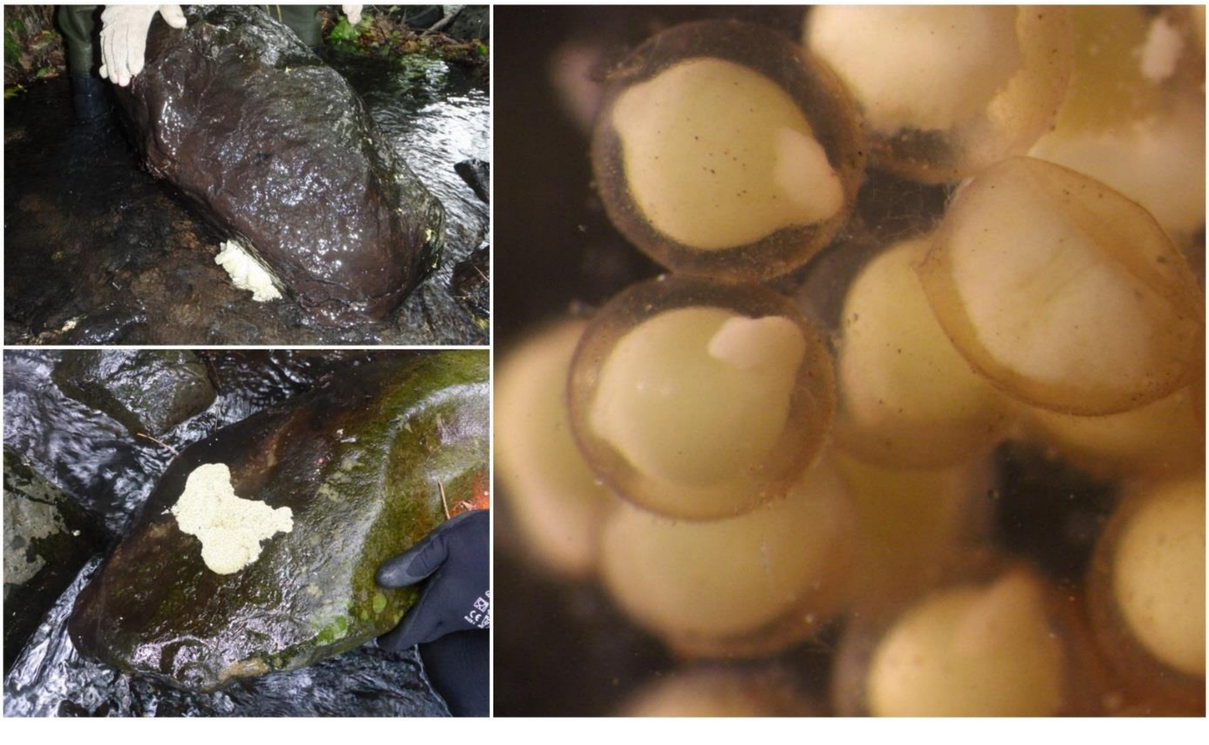


Figure 5: (Left) Overturned boulder showing lamprey egg mass; and (Right) Close up of lamprey eggs. See Baker et al. (2017) for more information. (Photos: [Left] Cindy Baker, [Right] Shannan Crow)

It may take more than four years for the ammocoetes to grow from less than 8 mm long at hatching to about 100 mm; at this size, they transform to a miniature adult form, known as macropthalmia. The transformation includes colouration to a brilliant blue and silver, the development of eyes, and the development of a sucking disk and teeth. Once transformed, macropthalmia juveniles head out during winter and spring to the open ocean to grow into pre-reproductive adults. At sea, they attach onto the gills or flesh of other fish and marine mammals and live as parasites (McDowall 1990). Very little is known about the distribution of the marine phase, but they are thought to travel large distances before returning to fresh water to spawn. Their complete life history is estimated to take nine years.

Piharau/kanakana is native to the Southern Hemisphere; however, very little research has been completed into Southern Hemisphere stocks to confirm they are indeed all one species. Previous studies in the 1980's suggest the pouched lamprey may indeed comprise different stocks (Neira et al. 1988). This knowledge gap has implications for management, for example, if Aotearoa-NZ lamprey are in fact a different genetic stock there is no fall back for replenishing populations from other countries should fish stocks significantly decline.

Environmental attributes that are important for supporting lamprey populations are summarised in Figure 30. Research is seeking to address several key knowledge gaps, including, the timing of adult spawning migrations, the chemical cues (pheromones) used by adult lamprey to select spawning (breeding) streams (Stewart et al. 2011, Stewart & Baker 2012), the location of the spawning nests (Baker et al. 2017), and the distribution of populations (Baker et al. 2016a; 2016b). This research has shown that lamprey migrate mainly at night, although there were some movements during the day. Most of this movement is linked with high river flows and floods. Most fish have been found in faster flowing waters and when lamprey are not migrating they tend to hide underneath large rocks/boulders within the stream. The fact that adult lamprey seek out cover during the day was well known to Māori who used a range of techniques that exploited this behaviour, including laying fern fronds which kanakana use as cover and can then be harvested by hand.

- **Physical habitat**
  - Habitat heterogeneity (pool, run & riffle)
  - Hydraulic habitat (depth, velocity)
  - Substrate composition (fine sediments for ammocoetes, boulders for spawning)
  - Cover for adults (e.g. undercut banks, boulders, large wood debris)
- **Organic detritus**
- **Flow regime**
  - Floods/freshes as migration cues
  - Flood magnitude to enable passage past obstacles
  - Fine sediment deposition and movement (impacts on ammocoete habitat)
  - Habitat provision at low flows (reduction of ammocoete habitat)
- **Pheromone cues**
- **Fine sediment**
- **Water quality**
  - Temperature, dissolved oxygen (DO), pH, ammonia, nitrate toxicity
  - Other toxicants (e.g., heavy metals)
- **Habitat connectivity (passage between ocean & spawning sites)**

Figure 6: Environmental attributes that are important for supporting lamprey populations. The text contained in the red boxes indicates where NIWA (and partners) are currently undertaking MBIE-funded research in a five-year programme called Habitat Bottlenecks for Freshwater Fauna (Source: Baker & Kitson 2016).

4.2 Distribution

The NZFFD records contain a mixture of juvenile and adult observations. The largest numbers of lamprey observations in the South Island are located around Banks Peninsula, Otago, Southland and the West Coast. Most of the observations in the North Island are located around Wellington, Hamilton and Taranaki (Figure 31). That said, lamprey are not commonly recorded in the NZFFD and the use of this database to describe lamprey distribution comes with a few caveats. The low numbers of observations recorded in the NZFFD are likely to be due to the difficulties in capturing this species. Juveniles occupy the substrates of river beds and are difficult to capture with an electric-fishing machine. Adults migrating back from the sea to spawn also bury themselves in river substrates and are difficult to capture. Thus, lamprey tend to be underrepresented in standard fish surveys so their distribution may be more extensive that the NZFFD suggests.

4.3 State and Trends in Abundance

Lamprey state and trends in abundance were unable to be assessed by Crow et al. (2016) because of a lack of sufficient observations in the NZFFD. NIWA have developed a pheromone sampler that absorbs the chemical odours released by larval lamprey and this could be used as a proxy for population abundance measures in the future; however, to date this approach has only been trialled in a few places (e.g., Baker et al. 2016a; 2016b).

Lamprey are an important taonga species and a prized delicacy for many Māori communities. In the past, they were seasonally abundant in many Aotearoa-NZ rivers and they were at times taken in huge quantities. Only fresh run lamprey were taken, as they were considered to be inedible after they had moved further inland (once their heads enlarged and a pouch formed below the eye). Lamprey were dried to provide food in winter and they were also used in bartering. In places along the Whanganui River, utu piharau are still used to capture this traditional fishery. The efforts and knowledge of piharau/kanakana fishers could be one way to address the lack of information on species abundance and distribution. Concern over the state of the customary fishery has led some mana whenua to initiate examining customary harvest methods as a way to monitor lamprey abundance (e.g., Te Ao Marama Inc and Waikawa Whanau 2010, Kitson et al. 2012).

4.4 Threat Ranking

The latest New Zealand Threat Classification System assessment classified *G. australis* as being 'Threatened–Nationally Vulnerable', with a total area of occupancy ≤100 ha (1 km^2), and predicted population decline of 10–50% (Goodman et al. 2014). In 2014, IUCN assessed *G. australis* as being 'Data Deficient' stating there is "no specific information is available on the population of this species, although it has undoubtedly declined through recent history" (Closs et al. 2014) (Table 7).

Table 1: Threat rankings for Aotearoa-NZ lamprey species 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
Geotria australis	Threatened–Nationally Vulnerable	Data Deficient[1]

[1] http://www.iucnredlist.org/details/197275/0

Figure 7: Locations of NZFFD records where lamprey are present (black circles) and absent (grey circles). Locations of lamprey include both adult and juvenile (i.e., macropthalmia and ammocoete) stages of the life cycle.

4.5 Pressures on Populations

To date there has been very limited research undertaken in Aotearoa-NZ investigating key drivers influencing presence, distribution, and density of lamprey populations in our waterways. As a significant portion of their life cycle occurs out in the marine environment where we have little control, while they are in fresh water, habitats for their sensitive juvenile life stages and sexually maturing adults need to be provided for. Lamprey also need free passage between the ocean and fresh waters to be successful (Figure 32).

From the work undertaken to date, maintaining migration cues may have an important control over adult populations and successful breeding within waterways. Northern Hemisphere sea lamprey have been shown to select spawning streams based on a migratory pheromone mixture released by larvae living upstream as well as a sex pheromone released by males at the nest sites (Johnson et al. 2015). Studies show migratory adults in Aotearoa-NZ are attracted to the same pheromone mixture as that identified for the Northern Hemisphere sea lamprey. Field investigations have also found that stream selection by migratory lamprey matches the relative level of larval pheromone cue present (C. Baker, unpub. data). Therefore, we need to be aware of pressures that impact water flows (e.g., abstraction) and the ability of lamprey to detect/follow migratory pheromones as this could reduce adult entry and breeding within waterways.

4.5.1 Loss of Habitat

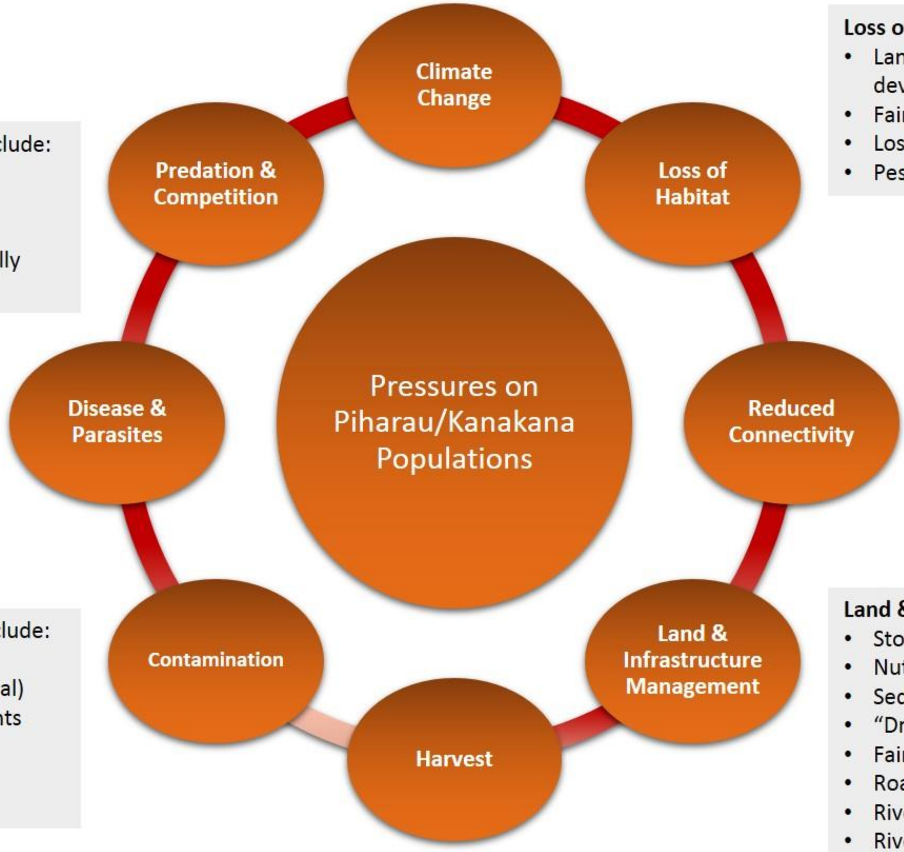
Although spawning has only been documented in one stream within Aotearoa-NZ, the boulder habitat utilised for spawning and nesting is expected to have been reduced nationwide through conversion of most of forest to farmland (Closs et al. 2014) and the installation of hydroelectric dams. If lamprey can't adapt to spawning in other habitats, which is the focus of current NIWA research, this will have had a profound effect on the distribution and abundance of this species, as it has on other freshwater fish species (Closs et al. 2014). Should adults be forced to travel further upstream to find suitable spawning habitat, this could in turn negatively impact the condition of the adults.

4.5.2 Reduced Connectivity

The main threats to this species include the installation of hydroelectric dams, which has affected the abundance and distribution of this species by preventing access to large parts of its former upstream range (James 2008). Trap and transfers from below dams to areas upstream may benefit this species (Closs et al. 2014, Baker et al. 2016b). Although lamprey are able to climb short vertical surfaces (Figure 33), poorly designed instream barriers like culverts, weirs and fords can impact the upstream migration of adult fish.

4.5.3 Parasites, Disease and Predation

In the spring of 2011, Lamprey Reddening Syndrome (LRS) (Figure 34) was observed to cause a mass mortality of pre-reproductive adults during their upstream migration in the Mataura River catchment, Southland. The cause of this syndrome is yet to be discovered, but LRS may pose a real threat to declining lamprey populations in Aotearoa-NZ as it occurs across Southland, which is where adult lamprey are thought to be in the highest abundance (Closs et al. 2014). Lamprey Reddening Syndrome has been observed in Southland, Otago, Canterbury and Taranaki.



Loss of Habitat - Examples include:
- Land use change (e.g., farming, agriculture, forestry, urban development)
- Fairway channel maintenance
- Loss of riparian vegetation
- Pest plants

Predation & Competition - Examples include:
- Shags
- Trout
- Tuna
- Marine predators unknown, potentially includes seals

Reduced Connectivity - Examples include:
- Hydroelectric dams
- Culverts, weirs, fords
- Flood control schemes – stopbanks & flood gates
- River/Lake mouth closures
- Water extraction

Disease & Parasites - Examples include:
- Lamprey Reddening Syndrome

Land & Infrastructure Management - Examples include:
- Stock in waterways
- Nutrient management
- Sediment management
- “Drain” clearance
- Fairway channel maintenance
- Road infrastructure
- River straightening
- River/stream diversions
- Stormwater control
- Water extraction
- Instream barriers

Contamination - Examples include:
- Pesticides?
- Geothermal sources (natural)
- Point source pollution events
- Stormwater runoff
- Road runoff
- Industry

Harvest includes:
- Customary
- Recreational
- By-catch of whitebait and tuna fishers

Figure 8: Examples of some of the pressures on Aotearoa-NZ piharau/kanakana populations.

Figure 9: Piharau/kanakana using their circular mouth to climb vertical surfaces. (Photos: Andrew Thomas).

Figure 10: Lamprey Reddening Syndrome. (Photo: Jane Kitson).

As of December 2013, MPI ruled out all known exotic organisms as a causative agent and laboratory results support the hypothesis of a multifactorial cause for LRS observed in lamprey in Southland rivers; no exotic or emerging pathogen has been detected in affected kanakana and several key pathogens of concern have been ruled out. The pathology of LRS is consistent with effects of significant mechanical damage but the cause of such damage is unknown.

It is possible that trout predation on juveniles is a threat to lamprey populations (B. David, pers. obs. in Closs et al. 2014). There are also accounts of lamprey being preyed upon by tuna and seals (J. Kitson, pers. comm.). Lamprey can be caught as bycatch in whitebait (J. Kitson, pers. comm.) and commercial eel (Brangenburg et al. 2013) nets. Threats to the adult marine stage are unknown but are likely to include predation, and potentially, the accumulation of contaminants.

4.6 Management

No commercial fishery for lamprey exists in Aotearoa-NZ. Lamprey have a daily bag limit of 30 in Southern and Fiordland areas, through the Amateur Fishing Regional Fisheries (Southland and Sub-Antarctic Areas Amateur Fishing) Regulations 1991 (MPI undated). The **Ngāi Tahu Claims Settlement Act** prohibits the targeted commercial harvest of "Kanakana/Ute – southern lamprey (*Geotria* *australis*)". The **Ngāti Ruanui and Ngāti Mutunga** Treaty settlements specifically prohibit the commercial harvest of lamprey within their Protocol areas unless the Minister can demonstrate a commercial harvest is sustainable.

In Southland, the two mātaitai that encompass fresh water (Mataura and Waikawa/Tumu Toka) were put in place over areas of significant kanakana customary fisheries. Bylaws for the Mataura River Mātaitai Reserve prohibits the taking of kanakana without customary authorisation from the reserve's tangata tiaki/kaitiaki. Current research (see Figure 29) in the Waikawa/Tuma Toka Mātaitai reserve will inform future bylaws.

Lamprey are listed as one of the 150 priority threatened species listed in DOC's draft **Threatened Species Strategy** (see Section 11.2).

Te Wai Māori Trust are seeking to facilitate a multi-agency roopu (e.g., iwi, MfE, DOC, NIWA) to develop a piharau/kanakana Restoration Strategy that will progress research initiatives to improve knowledge and management of piharau/kanakana, and support and facilitate greater iwi involvement.