On a pathway to extinction?

An investigation into the status and management of the longfin eel

April 2013

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

Acknowledgements

The Parliamentary Commissioner for the Environment would like to express her gratitude to those who assisted with the research and preparation of this report, with special thanks to her staff who worked so tirelessly to bring it to completion.

Photography

Cover art courtesy of Michelle Freeborn.

This report and other publications by the Parliamentary Commissioner for the Environment are available at: **www.pce.parliament.nz**

Contents

Commissioner's overview

As this report was nearing completion I found myself describing the remarkable lifecycle of the longfin eel to an acquaintance. At the end of a long life, longfin eels leave their freshwater homes to journey for thousands of kilometres north through the Pacific to breed somewhere near Fiji. The eggs hatch into transparent leaf-like larvae which drift on ocean currents all the way back to New Zealand. The larvae turn into tiny 'glass eels' and begin to swim up rivers and streams. Glass eels become elvers and these small wriggling slender fish continue to swim upstream in shoals until they find a place to call home. Here they stay and grow for many years until heeding the call to breed. Then an almost magical transformation takes place to prepare them for their great sea journey – their heads become streamlined, their eyes turn blue, their bellies turn silver.

At this point my acquaintance, a recreational fisherman, stopped me aghast. He realised that the giant silver-bellied creature he had once caught in a harbour must have been a longfin eel, and that he had killed it just before it was about to breed after decades of growth. It was an ignominious end for a creature that had likely lived longer than most people, and that belonged to a species that exists nowhere else on earth and is so interwoven with our history.

The first Polynesians to arrive in New Zealand must have been astounded to find themselves dwarfed by moa. But lurking in the depths were more giants – snake-like fish they called tuna that would grow to the width of a man's thigh, up to two meters long, and live as long as a hundred years. Eels became an important food source for Māori, but it was a relationship that extended beyond nourishment to respect, and even reverence. Over time they were even thought of as protectors or guardians.

For many of us who grew up swimming in New Zealand rivers, 'guardian' was not the first term that sprang to mind. The best swimming holes were in the bends of the rivers – where the big eels lurked. It was a familiar childhood dilemma – swim in shallow water or risk getting your toes nibbled.

There are two kinds of freshwater eels living in New Zealand. Shortfins tend to live nearer the coast in muddy streams. Longfins – the subject of this report – generally travel further inland to find clearer water in which to grow to maturity. The New Zealand longfin is the largest freshwater eel in the world and, unlike the shortfin, is found in no other country.

For millions of years, longfin eels lived in the rivers and lakes of New Zealand in vast numbers. How could such a numerous species come to be threatened? We know from the rapid extinction of the passenger pigeons in North America that numbers alone are no guarantee of survival.

The burning and felling of forest that once covered most of the country led to soil being washed off land and covering stony riverbeds with sediment. This erosion still continues and the consequent loss of habitat is one cause of the decline of longfin eels. Another cause is the barriers that prevent many young elvers (and other native migratory fish) from swimming upriver. The turbines of hydroelectric dams also kill many mature eels as they swim downriver so they never get the chance to reach the sea to begin their journey to breed.

Another cause of decline that has fortunately stopped was the extermination campaigns that lasted for nearly a century right into my lifetime. A major factor stopping this senseless slaughter was the arrival of immigrants from the Netherlands where eels had long been a traditional dish. This meant that there was money in eels and a commercial fishery rapidly developed.

Over recent years, concern about the future of the longfin eel has been expressed by a variety of people and groups, including freshwater biologists and many Māori. The Department of Conservation lists the species as *'At risk/Declining'*. This investigation is a response to those concerns.

This report contains scientific information of different kinds on the state of the longfin eel population. From considering this information in its entirety, I have concluded that the weight of evidence reveals a species in trouble. Indeed, once I was satisfied with the peer review of the scientific evidence, I said publicly that the longfin eel was on a slow path to extinction – a slow path because longfin eels live so long that it would be many decades before there was no individual left alive.

Ironically, it is that long life that makes our special eel particularly vulnerable. Although all freshwater eels breed only once at the end of life, that life is especially long for the New Zealand longfin. A female longfin may wait as long as eighty years or more before getting the urge to breed, whereas a female European eel will begin its journey to the Sargasso Sea when it is as little as six years old. However, that much faster lifecycle has not protected them from overfishing and loss of habitat – the European eel is now ranked as *'Critically endangered'*.

Information presented in this report shows that the abundance and geographical distribution of longfin eels has decreased significantly over the last few decades. There is now a dearth of very small eels, pointing strongly to a decline in the resilience of the population. Over many years the number of mature adults that undergo the metamorphosis to 'silver eels' and successfully make their way out to sea to breed has clearly fallen.

Different government agencies have different responsibilities for the management and protection of eels. The Ministry for Primary Industries manages the eel fisheries under the Quota Management System. The Department of Conservation is the primary guardian of native species and has a particular responsibility for protecting fish passage – the ability of migratory fish to travel up and down rivers. Local government also oversees various activities that have impacts on eel habitat and fish passage.

The system under which the Ministry for Primary Industries manages the eel fisheries is the world-leading Quota Management System. Setting allowable catches at sustainable levels and trading quota is widely acknowledged as the best way to manage commercial fisheries. And, for most of us, there is nothing wrong with catching and eating eels. But the system must be operated well.

In this investigation it became evident that the scientific basis used by the Ministry for judging the sustainability of the longfin eel population is overly narrow and inadequate. For instance, there is heavy reliance on the 'catch per unit effort' indicator – an indicator that is far more suitable for judging the status of sea fisheries like hoki and snapper.

There are also inadequacies in the management of the eel fisheries. Despite a stated intent to set targets for measuring how successfully the eel fisheries are being managed, no targets have actually been set. And when there has been so much concern about the status of longfin eels, it is extraordinary that the South Island eel allowable catches have still to be split into separate longfin and shortfin allowable catches.

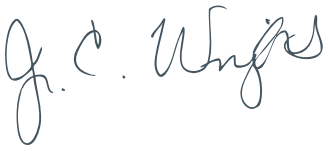
The Department of Conservation (DOC) has also failed to protect the longfin eel, despite categorising it as at risk and declining. Admittedly, the Freshwater Fisheries Regulations, which DOC is meant to administer, are dated. But there are other tools that can be used. For instance, from its inception, the department has had the power to develop a Freshwater Fisheries Management Plan, but has never done so. Such a plan would provide much-needed guidance to councils who vary greatly in the ways in which they oversee activities that affect eels and other fish.

Although commercial fishing of longfin eels is far from the only reason for their decline, I have recommended that it be stopped, at least for a time. No other action has the immediate potential to reverse the decline of the species. I hope that some means can also be found to reduce customary and recreational catches, should they be significant.

There are economic consequences too – a decline in the longfin population will inevitably mean a decline in the longfin fishery. I am hopeful that eel aquaculture may take some pressure off wild eel populations in the future.

Longfin eels are certainly not cute like kiwi, or comical like kea. Perhaps it is this, along with their familiarity, that has led to us being more blasé about their endangerment than we are about other similarly threatened species.

Near the beginning of this overview, I compared longfin eels to moa – the land-based giant birds that once roamed New Zealand. But because longfin eels are the top predator in our rivers and streams, a better comparison might be to the long-extinct Haast eagle. With a three metre wingspan, it is the largest eagle to have ever lived, and is thought to have killed moa, descending from above at terrifying speeds. I must confess I am glad I do not need to worry about such an airborne threat, but our longfin eel is a gentler creature. Our children and grandchildren would be poorer for its loss.



Dr Jan Wright
Parliamentary Commissioner for the Environment

1 Introduction

Snakelike and slimy with an ability to both swim and slither over land, eels are ancient beings that evolved over 50 million years ago.[1] They have fascinated people over the ages, and appear in the mythology and folklore of many countries.

Freshwater eels begin life in the sea, but unlike other eels such as conger and moray eels, they live most of their lives in fresh water before finally returning to the sea to spawn and die.

There are 15 species of freshwater eel found around the world.[2] However, this country is home to a freshwater eel that is found nowhere else – the New Zealand longfin eel.

Secretive and mainly nocturnal, 'our' eel is one of the largest freshwater eels in the world and the top native freshwater predator. A female can grow to nearly two metres long, and live to over a century. Indeed, there are likely to be longfin eels today in lakes and rivers that swam upriver as young eels before World War I. The longfin eel can live in a wide range of habitats, but prefers the clear flowing water of stony-bottomed rivers and streams. In comparison, its relative the shortfin eel is generally found in still muddy-bottomed waters, common in lowland rivers, lakes and wetlands.[3]

As the biggest native fish, tuna (eels) were a very important source of food for Māori before European settlement, providing both protein and fat. Tuna still hold great significance for Māori. Stories of tuna are interwoven into whakapapa and legends. Many marae are adorned with carvings of tuna alongside tūpuna (tribal ancestors) signifying their importance.

It is said that Tuna was a person from the heavens who frightened Hine Te Kaere, the wife of the demigod Māui. As punishment, Māui caught and cut Tuna into pieces. The head and tail landed in the sea and became the conger eel and the lamprey respectively. The body fell in a river and turned into the freshwater eel.[4]

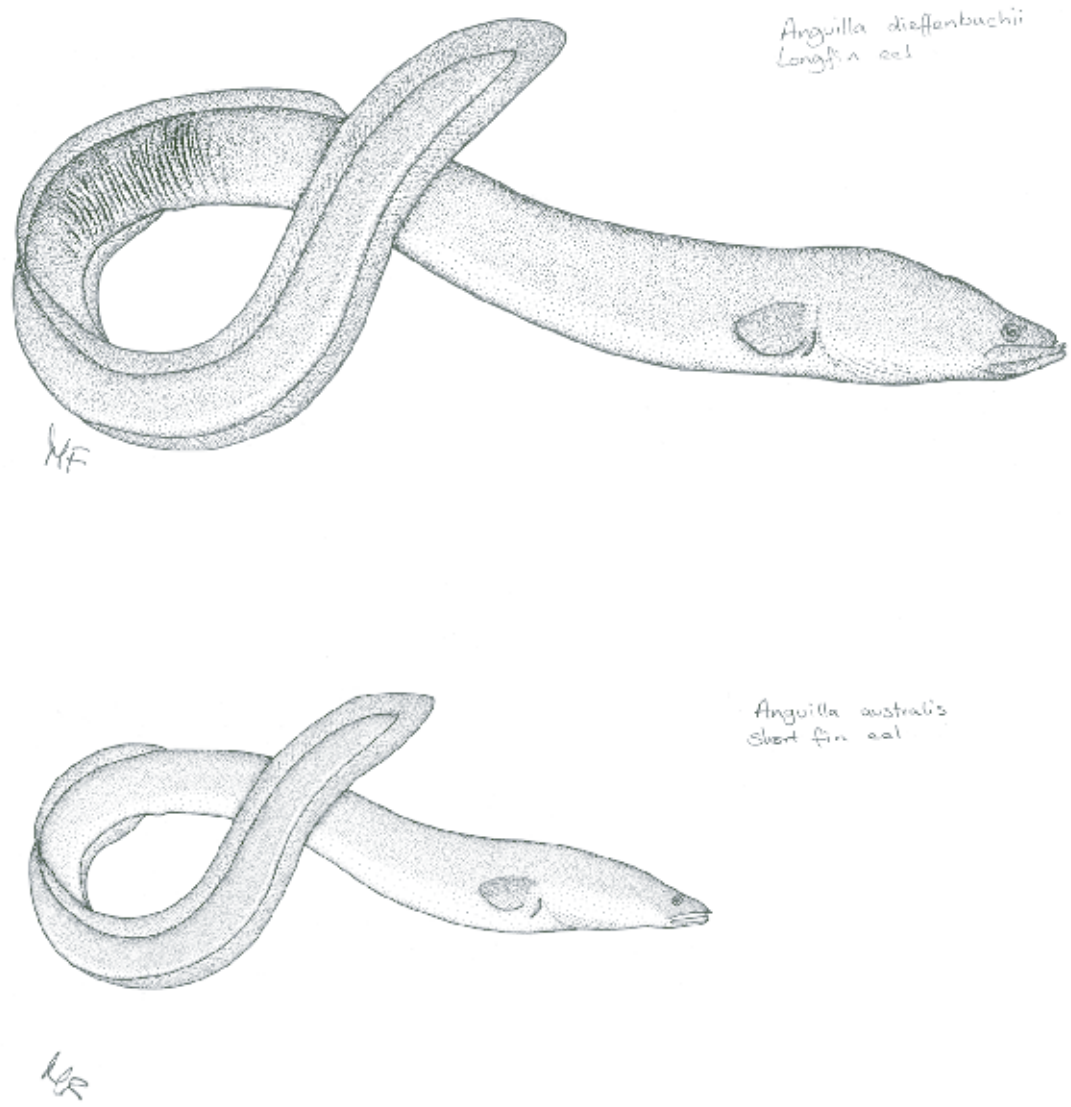
Source: Downes, Thomas William, 1868-1938. [Downes, Thomas William] 1868-1938 :[Catching the legendary eel at Tangahoe. 1938?]. Ref: A-076-016. Alexander Turnbull Library, Wellington, New Zealand. http://natlib.govt.nz/records/22331581

Figure 1.1 Catching the legendary eel at Tangahoe.

Historically eels have faced many challenges. For decades extermination campaigns against eels were waged to protect trout from these 'public vermin'. Hydroelectric dams were built that stopped young eels travelling upriver on their way to find a home where they could grow to maturity. At the other end of life, dam turbines killed mature eels as they swam downriver on their great journey to return to the sea to breed.

About 50 years ago, a commercial eel fishing industry began to develop, with the Netherlands as the main destination for exports. Indeed, the recognition that eels had commercial value would have been instrumental in stopping the extermination campaigns. Since then, large quantities of eels have been harvested by commercial fishers.

This investigation is focused on longfin eels because of increasing concern about their status. There is less concern about shortfin eels for a number of reasons. They grow faster and breed at an earlier age, and can thrive in the still and often muddy waters of lowland waterways. Their movement along rivers is less likely to be blocked by dams because they generally live nearer the coast. And, unlike longfin eels which are found only in New Zealand, the shortfin eel is also found elsewhere in the South Pacific, allowing for a buffer of extra breeding stock.[5]



Source: Michelle Freeborn

Figure 1.2 Picture of longfin and shortfin. There are several ways in which longfin eels (*Anguilla dieffenbachii*) can be distinguished from shortfin eels (*Anguilla australis*). Longfin eels grow much larger than shortfins. Longfins grow up to two metres long and can weigh more than 20 kilograms, whereas shortfins grow up to just over one metre long and weigh 3 kilograms. The fin on a longfin eel's back is longer than the fin on its underside, while on a shortfin, the back and underside fins are the same length. Longfin eels are generally dark-green or grey-black in colour, while shortfin eels are olive green. A longfin eel's skin will form loose 'folds' on the side of its body as it turns, while a shortfin eel's skin stays tight and smooth.[6]

Source: Parliamentary Commissioner for the Environment Archives

Figure 1.3 Tapestry and petition calling for moratorium on commercial fishing of longfin eels delivered to Parliament in March 2013.

1.1 Why investigate longfin eels?

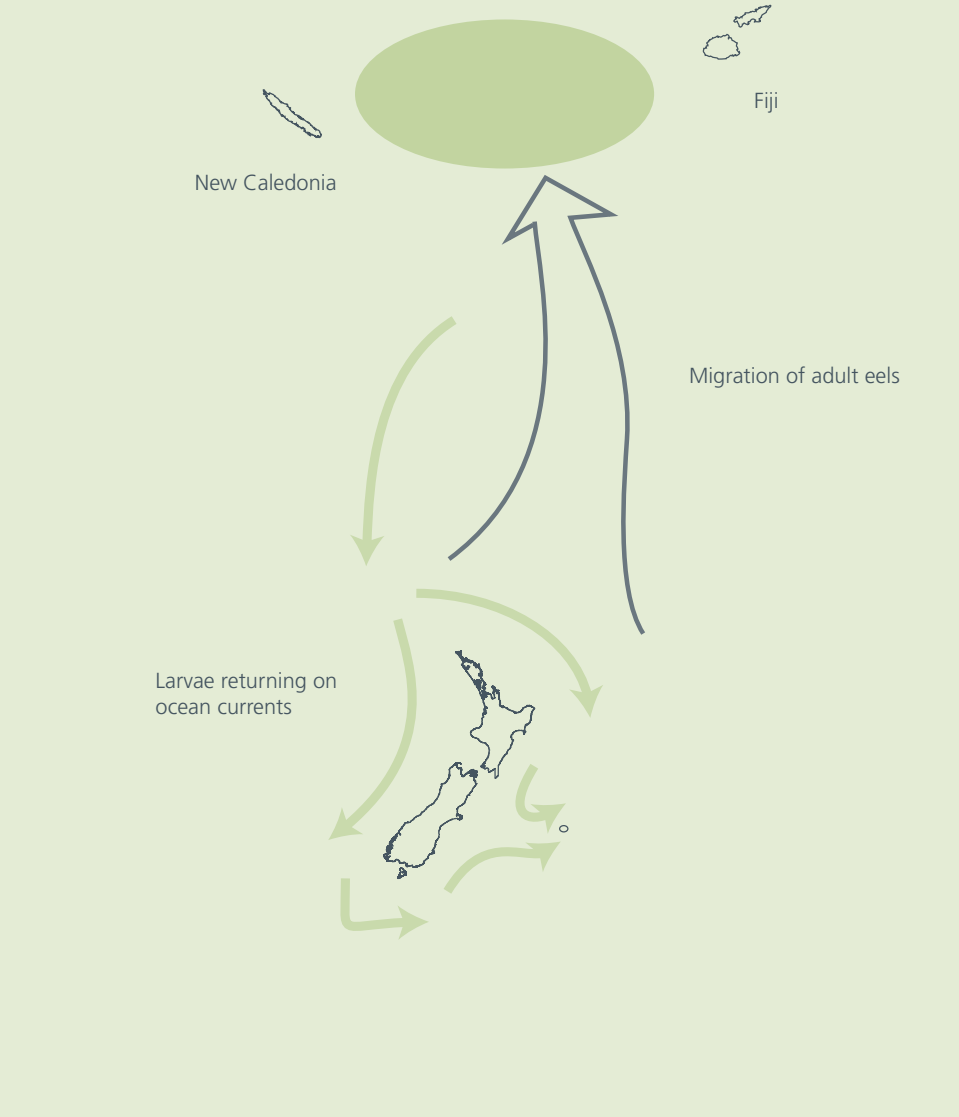
The Parliamentary Commissioner for the Environment (PCE) is an independent Officer of Parliament, with functions and powers granted by the Environment Act 1986. Her role allows a unique opportunity to provide Members of Parliament with independent advice in their consideration of matters that may have impacts on the quality of the environment.

Over recent years concern about the future of the longfin eel has been expressed by many Māori, environmental groups, the New Zealand Conservation Authority, and some scientists and local government representatives. The Department of Conservation currently classifies the longfin eel status as being '*At Risk/Declining*'.[7] A petition calling for a moratorium on commercial fishing of longfin eels was presented to Parliament in March 2013. This investigation began in response to this increasing public concern about the sustainability of the longfin eel fishery and the potential risk of extinction.

Freshwater eels are particularly difficult to manage. They are very long-lived, spend most of their life in freshwater in rivers and streams all around the country, and then migrate huge distances out to sea at the end of life to breed. These characteristics also make them especially difficult to monitor and understand.

The purpose of this report is to assess just how threatened the longfin eel is and to consider what actions might need to be taken in order to manage and protect this important species. The investigation covered the protection of eel habitat and fish passage as well as considering how well the fisheries management system deals with this unique species.

A report titled *The status of longfin eels in New Zealand – an overview of stocks and harvest* was commissioned from the National Institute of Water and Atmospheric Research (NIWA) as part of this investigation. It is available on the PCE website (www.pce.parliament.nz).



Source: NIWA

Figure 1.4 The path taken by longfin eels on their great Pacific odyssey. When longfin eels are ready to make this big journey to spawn, they undergo a number of physical changes to become 'silver eels'. These include becoming darker on the top and sides and silver on the belly to create a countershading pattern which makes it difficult for predators to see them. Their eyes become bigger and turn blue so they can see better in the dim light deep in the ocean.

1.2 The life of a longfin eel

Longfin eels breed only once – at the end of their lifetime. They begin their lives somewhere in the tropical Pacific Ocean.[8] Fertilised eggs hatch into transparent leaf-shaped larvae measuring just a few millimetres across. Drifting on ocean currents, they take about ten months to reach the shores of New Zealand.

Close to land, larvae develop into transparent glass eels and swim into estuaries and river mouths, usually between July and November. Slowly the glass eels turn greyish-brown and become elvers.

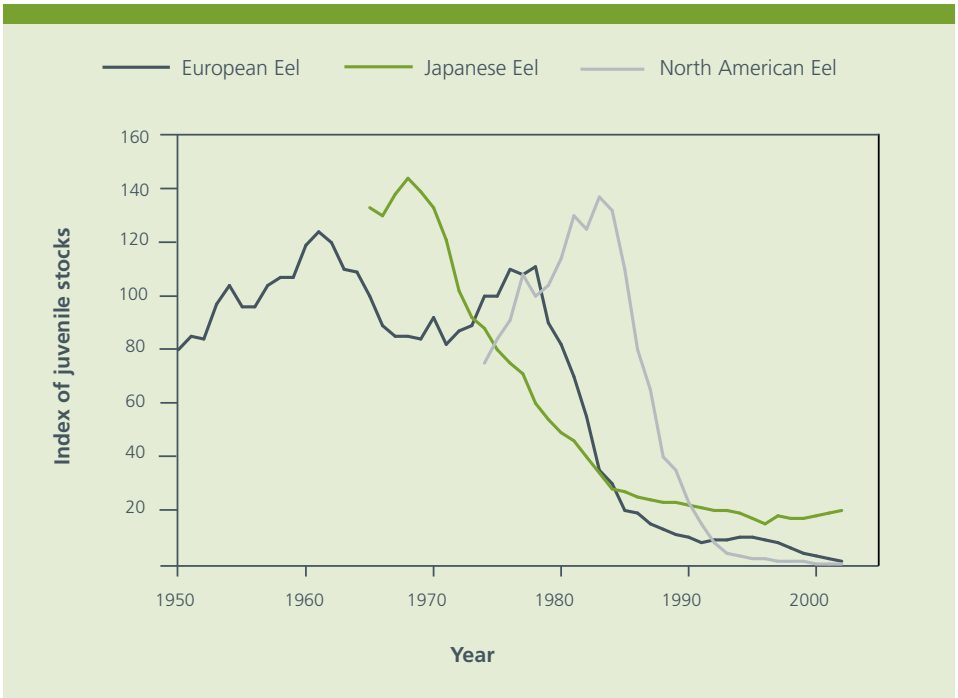
In summer the elvers gather into shoals and swim upstream. It may take several years for a young longfin eel to reach a suitable habitat in a clear lake or river where it can settle and spend most of its life.

Males are generally ready to breed at about 25 years old but females are not ready until about 40 years old and may be much older. The age of the oldest eel recorded was 106 years - it was found in the South Island's Lake Rotoiti. Mature females are much larger than mature males; females can grow to two metres in length and weigh more than 25 kilograms.

Mature eels are this country's top native freshwater predator. Young eels hunt smaller species such as insect larvae and freshwater snails. As the eels grow larger they hunt larger prey – fish, freshwater crayfish (kōura) and even small birds. Known as an 'apex predator', eels help maintain the health of the freshwater ecosystem by controlling numbers of other species further down the food chain. They will even extend their domain further, venturing into surrounding forests and paddocks to forage in times of flooding, before returning with the subsiding river levels.

When an eel is ready to breed it undergoes a number of changes to prepare for its 5,000 kilometre journey through the deep ocean. Its belly turns silver, its eyes turn blue, its head becomes sleeker, its pectoral fins and reproductive organs enlarge, it stops feeding, and its stomach shrinks.

Heading downriver and out to sea on high water flows in autumn, these breeding 'silver eels' spend about six months on their great Pacific odyssey. The reproductive strategy is one of producing high numbers of offspring with no parental care – relying on a small percentage surviving. On reaching the spawning area, a female longfin eel releases between one million and 20 million eggs to be fertilised by male eels. The adults die, the eggs hatch into larvae and this extraordinarily slow cycle of life begins again.



Source: Adapted from Dekker et al. 2003

Figure 1.5 Populations of juvenile eels of the three main commercial species around the world have crashed in the last 20 years.[9]

1.3 What is happening to eels elsewhere in the world?

Freshwater eels have long been a valued food in many countries around the world.

In Sweden, eels are eaten with vodka in autumn. In Japan, kabayaki – marinated grilled eel – is a national dish, and *Doyo Ushi No Hi* is a day in late July dedicated to eating eel. And in London, jellied eels are a traditional, though vanishing, Cockney treat.

There are serious concerns about eels in other parts of the world

The scarcity of large wild eels has led to the majority of eel eaten around the world coming from aquaculture. Glass eels are harvested from the wild and grown in ponds, mostly in Japan and other Asian countries. There are no reports yet of eels being raised successfully from eggs.[10]

However, there are now very serious concerns about the state of the world's major eel stocks. The freshwater eel populations native to Japan, Europe, and America have all crashed in recent years. This is revealed by the dramatic decline in the abundance of young eels as shown in Figure 1.5.

The European eel

The European eel has been classed by the International Union for Conservation of Nature (IUCN) as critically endangered, which means it faces an extremely high risk of extinction in the wild.[11] Its decline is attributed to overfishing, habitat loss, pollution and the damming of rivers.

Concern about the state of the European eel has led to strict conditions being placed on its trade by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

> *"Eels are no longer the familiar sight in European and Caribbean waters that they once were … CITES cannot afford to fail the European eel."*[12]

All European Union countries are now required to develop eel management plans to increase the numbers of migrating and spawning eels to a target of 40 percent of original levels.[13]

The Japanese eel

The Japanese Environment Ministry has recently classified the Japanese eel as *"facing a high risk of extinction in the near future"* due to overfishing and habitat loss.[14]

Traditional kabayaki eel restaurants throughout Japan are now closing as they cannot get enough eel meat.[15] Thirty percent of eels eaten in Japan are grown there with the rest mainly supplied from eel farms in China.[16] Japan imports over 60 percent of all live eels worldwide.[17] The high demand for glass eels has created a 'gold rush' in North America to stock eel farms in Asia.[18]

Some marine experts in Japan have called for a ban on catching adult eels and tight limits on catches of young eels.[19]

The American eel

The American eel has followed the same population collapse pattern, with the decline attributed to factors including hydroelectric dams and overfishing.[20] The species has also been infected with a parasite brought to the United States by Japanese eels.[21]

The U.S. Fish and Wildlife Service decided not to list the American eel as a threatened or endangered species in 2007 under the Endangered Species Act, but this is currently being reconsidered.[22] In Ontario, Canada commercial and recreational eel fishing has been banned.[23]

1.4 What comes next

The remainder of this report is structured as follows.

Chapter 2 tells the story of the interaction between eels and people in New Zealand. It begins with a description of the relationship between Māori and tuna, and then explains how developments such as farming, hydroelectricity, and fishing have affected eels.

Chapter 3 provides a description of the main agencies responsible for controlling the harvesting and protection of eels, along with the legislation under which they operate.

Chapter 4 asks the question: Are longfin eels in trouble? The answer is provided by the cumulative weight of evidence after assessing all available data.

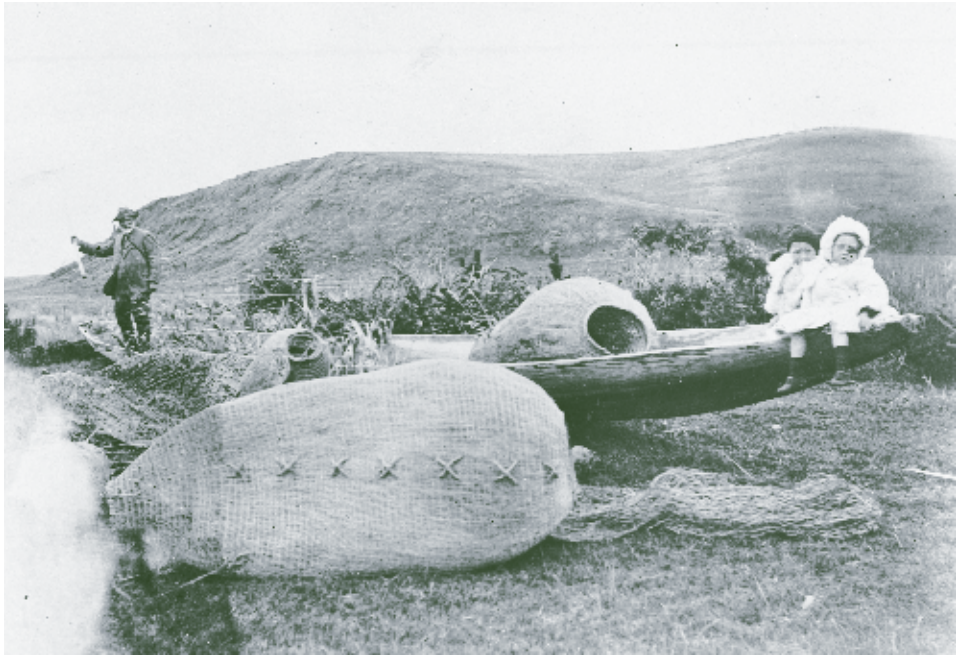
Chapter 5 contains an analysis of how well the longfin eel fishery is managed, and how well eel habitat and fish passage is protected.

Chapter 6 contains the conclusions and recommendations of the investigation.

1.5 What this report does not cover

This report does not cover (in any detail)

- the possible increased vulnerability of the shortfin eel should any change be made to the management of the longfin fishery
- variations in ocean currents due to global weather systems that affect the numbers of eel larvae that reach the coast of New Zealand
- future effects of climate change on eels and freshwater ecosystems
- the management and protection of eels in other countries.



Source: Photographer Jean Stanton, circa 1976. Courtesy Te Papa.

Figure 1.6 Eel fishing with hinaki (eel pot) on the Whanganui River in 1976.

2 The story of eels and people in New Zealand

Longfin eels are as old as New Zealand itself. Over millions of years, they have evolved to become the top predator in the country's rivers, lakes and streams, highly adapted to the local conditions. The interactions of longfin eels and people – first Māori and then European settlers – have occurred in a mere heartbeat of the long existence of the species.

This chapter outlines the impacts humans have had on eels. The clearance of forests, extermination campaigns, the construction of dams, and fishing have all affected the longfin population.

2.1 A taonga for Māori

For Māori, tuna (eels) are a taonga – an important cultural treasure. Māori have over 100 names for eels describing their different colours and sizes, and they are revered as a link to the gods. Over time, special traditions and protocols were developed around the harvest of eels.

Eels were a very important source of food and easily caught in almost any river or lake throughout the year. They were eaten fresh, or were smoked and preserved for winter.

Eels were caught using pā tuna (weirs) built in rivers to funnel eels into a hīnaki (trap). They were also hunted at night with spears or nets or caught on lines using carefully crafted flax 'bobs' that would snag the eel's backward-facing teeth. Another technique was reaching into eel holes and pulling them out by hand. At Lake Ōnoke in the Wairarapa and Lake Wairewa in Canterbury, Māori dug trenches in the gravel banks between the lake and the sea to capture eels migrating to breed.[24]

There is no evidence that pre-European Māori had any large impacts on eels. Early European settlers described huge numbers of small eels coming upstream in shoals that took hours to pass.[25] This low impact would have been due to the largely unmodified natural environment, the high abundance of eels, small numbers of people, and the lack of modern and highly efficient fishing and processing techniques.[26]

Today, the right of Māori to catch eels for customary non-commercial purposes – like tangi and other marae events – is established through the fisheries management system administered by the Ministry for Primary Industries. Kaitiaki are appointed to oversee the issuing of permits allowing Māori to fish for eels for customary purposes.[27]

Concern about longfin eels has become widespread among Māori, many of whom are expressing their distress at the decline in local populations of eels. For example, in the Bay of Plenty, Ngāti Manawa describe in their Deed of Settlement that:

> *"It is Ngāti Manawa's mana that has been eroded as a consequence of the building of hydro dams on their river. It is their traditional knowledge – values, tikanga and practice associated with the long finned tuna that is under threat."*[28]

In 2012, the Māori Committee of the Hawke's Bay Regional Council recommended that the council take a number of actions to protect longfin eels. These included lobbying Government to support a temporary ban on commercial eeling and seeking the support of local iwi to impose a rāhui (ban).[29]

Source: Og Dawson eeling. Photograph courtesy of Otago Daily Times Newspaper

Figure 2.1 Fishing for eels by hand.

2.2 Changing landscapes and polluted water

From the first settlements to the current day, people have changed the New Zealand landscape. Early Māori burned large areas of forest, and in drier areas the forest did not regenerate, leading to an increase in erosion.[30] European settlers felled trees for timber and later resorted to burning vast areas of forest to hasten the conversion to pasture. Without trees to hold topsoil it was washed off land by heavy rain – ending up in waterways. Successive Governments continued to subsidise the clearance of land until the 1980s.

Over time this caused widespread erosion and sedimentation of rivers, lakes, and wetlands. In much of the country, clear flowing streams with shaded stony beds – a favoured habitat for longfin eels – became open to the sun and smothered in sediment. Without roots and overhanging branches, longfin eels lost the shelter and holes in which they made their homes.

More habitat was lost when wetlands were drained, although this would have affected shortfin eels more because this still and muddy-bottomed environment was where they thrived. Where wetlands are being continually drained, such as parts of the Waikato, eels can be sucked into unscreened pump intakes.

By the 1980s around 70 percent of the country's native forest had been felled or burned.[31] Today, increased sedimentation of lowland rivers continues to affect eel populations, as do other farming practices such as irrigation.[32]

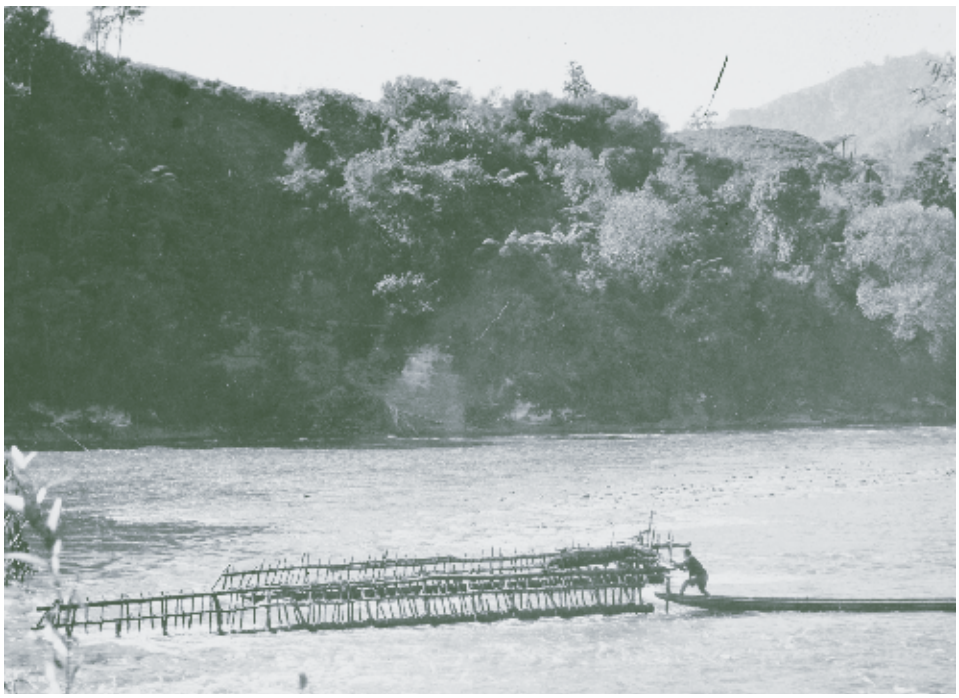
Source: Northwood brothers :Photographs of Northland. Ref: 1/1-006250-G. Alexander Turnbull Library, Wellington, New Zealand. http://natlib.govt.nz/records/22329783

Figure 2.2 Clearing of forest to plant pasture for sheep led to greatly increased amounts of sediment washed into rivers and lakes.

Irrigation often leads to more intensive land use, frequently resulting in greater concentrations of nutrients and sediment in the water, and thus poorer water quality.[33]

It is not the nutrient and sediment levels themselves that are the main problem for eels, who are quite resilient creatures. However the ensuing excessive plant growth can smother the stream bed, reducing both habitat and food for eels and other fish.[34] Sometimes toxic algae bloom, which while not killing eels directly, have made eels poisonous to eat.[35]

As lowland rivers have become muddier with their beds covered in sediment and weeds, they have become more suitable habitat for shortfins – and less suitable for longfins. Longfin eels are now much harder to find in the lower reaches of rivers and must travel further inland to find somewhere to live and grow.[36]



Source: Lamprey and eel weir, Whanganui River. McDonald, James Ingram, 1865-1935 :Photographs. Ref: PA1-q-257-76-1. Alexander Turnbull Library, Wellington, New Zealand. http://natlib.govt.nz/records/22867638

Figure 2.3 Eel weirs were very important assets to Māori families that owned them and were often passed from father to son. In the 1880s, there were more than 350 weirs in the Whanganui River. Settlers removed the weirs to make it easier to navigate the river. Despite petitions to the government by Māori to save their weirs, by the turn of the century almost all were gone.

2.3 Exterminating ‘public vermin’

As European settlers converted primordial forests and swamps to pasture, they longed for the familiar. Acclimatisation societies were set up that introduced a host of plants and animals including salmon and trout.

Eels were seen as the enemy of trout. Acclimatisation societies declared them to be ‘public vermin’, launching extermination campaigns with bounties for any eels killed that weighed over 10 pounds. In 1933, a society ranger advised *“Where infestation is bad it is possible to wade up a stream beheading the eels in one’s stride.”*[37] In 1943, the Wellington Acclimatisation Society printed on their fishing licenses that *“Every angler should make war on eels.”*[38]

Extermination campaigns killed hundreds of thousands of eels, which were heaped on riverbanks to die, or were buried.[39] In the 1960s, these campaigns tailed off as evidence emerged that the presence of eels could actually lead to bigger and better trout.[40] Around the same time, the emergence of an export market for eels saw them develop a commercial value.

Source: Eeling party. Jones, Frederick Nelson, 1881-1962 :Negatives of the Nelson district. Ref: 1/2-028987-G. Alexander Turnbull Library, Wellington, New Zealand. http://natlib.govt.nz/records/23095843

Figure 2.4 Eeling party in Nelson, 1910.

2.4 Closing off rivers and streams

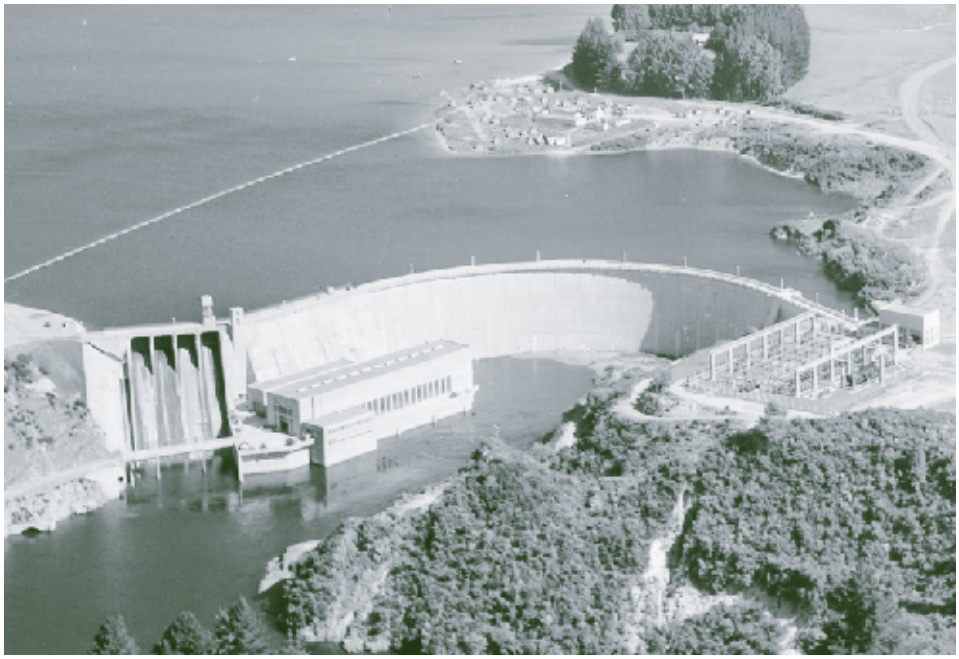
New Zealand is a country well suited to harnessing the power of its rivers for electricity generation. But hydroelectric dams can affect eels in two ways – by stopping young eels swimming upstream and by stopping adult eels from swimming downstream – a double interruption to their life cycle.

Longfin eels are much more affected by hydroelectric dams (and other river barriers) than shortfin eels because they tend to live higher up in catchments. They have been found in headwater streams and high country lakes more than 350 kilometres from the coast.[41]

Between the 1920s and 1950s, the upper catchments of many of New Zealand's largest rivers were blocked off by big dams. It was known at the time that dams impeded fish passage. In the 1930s, some dams were built with fish ladders although their purpose was to help salmon reach the headwaters to spawn, rather than to assist native fish.[42]

The first organised trapping and transfer of elvers up over a dam occurred at the Matahina Dam on the Rangitāiki River in 1983.[43] In the same year, regulations were introduced that required new dams to provide means for freshwater fish to pass.[44]

Today most large dams have trap-and-transfer programmes to help elvers up past dams.[45] Although millions of elvers have been successfully transferred upstream, most of them have been shortfins.[46]



Source: Lake Karapiro, power station and dam. Whites Aviation Ltd :Photographs. Ref: WA-17045-F. Alexander Turnbull Library, Wellington, New Zealand. http://natlib.govt.nz/records/23205906

Figure 2.5 Karapiro Dam on the Waikato River. One witness described the plight of elvers at this dam in 1956: *"We saw young eels … literally in millions, trying to climb up the spillway of the dam – they must have climbed sheer rock and we saw thousands that had perished in the dust… We were told that what we saw was nothing compared with what struggled to get up during the night."*[47]

Helping large eels down past a hydro dam and out to sea to breed is much more difficult than helping elvers up. Left to themselves, very few will survive the blades of the turbines.[48]

Some methods exist for helping large eels downstream. These include netting eels in headraces, and opening spillway gates at critical times. For instance, at the Patea Dam in Taranaki the bottom spillway gates are now opened for an hour after sunset following heavy autumn rains – a time when mature eels are most likely to migrate – to allow those gathered behind the dam to make their way safely downstream.

Hydro dams are not the only kind of dam that can block fish passage – a simple weir can prevent elvers and other young migratory native fish from swimming upstream. Culverts can also be barriers. Smooth long culverts create a very swift current, which young fish struggle to swim against. If the culvert has a sharp drop into space at the downstream end (known as a 'perched culvert'), young fish cannot get up into it.

In all, dams and other barriers have effectively 'closed off' about a third of the country's rivers and lakes to longfin eels.[49]

Localised extinctions have occurred in some catchments above hydro dams. For instance, there are now no longfin eels in tributaries of Lake Mahinerangi which was formed by damming the Waipori River in Otago in the early 1900s.[50]

Source: Alex James

Figure 2.6 Perched culverts prevent the upstream migration of eels.

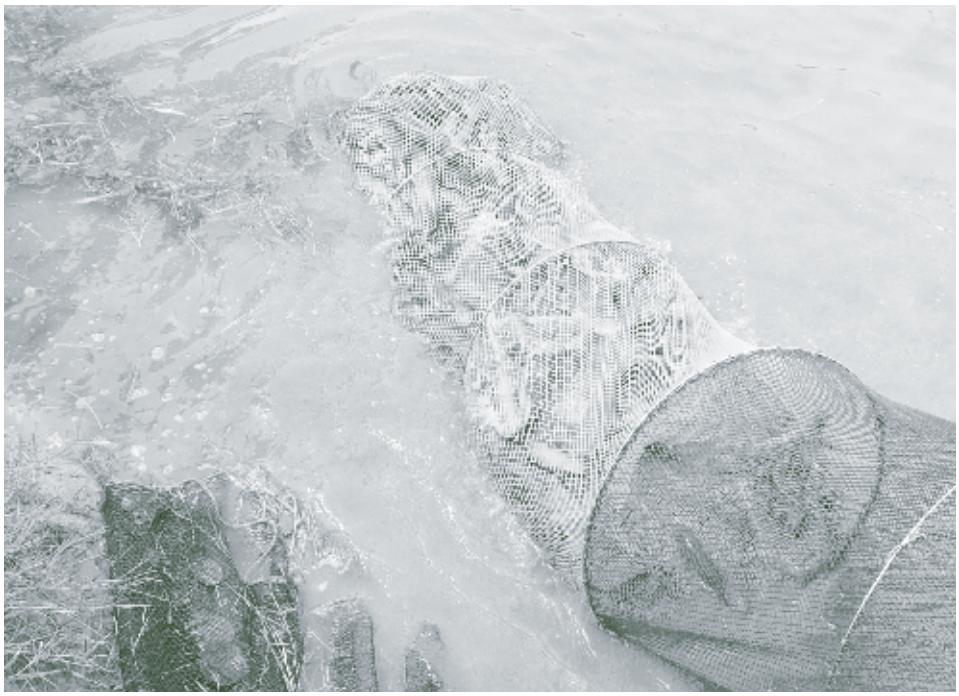
2.5 The growth of commercial eel fishing

In the 1960s large scale commercial eeling began, spurred in large part by the immigration of Dutch eel fishermen who brought their efficient fyke nets with them.

The industry grew rapidly with the annual eel catch (longfins and shortfins) peaking at over 2,000 tonnes in 1972. At one time there were 23 processing factories; today there are four. Most of the catch has historically been exported to Europe – to the Netherlands, Belgium, Germany and the United Kingdom. In the last few years, the majority of the catch has been sent to two countries – Belgium and South Korea.[51]

Beginning in about 1980, government agencies have taken incremental steps to regulate the industry. A minimum size limit was introduced in 1981, part-time commercial fishers were excluded from the industry in 1982, and a moratorium placed on the issuing of new permits around 1984.

In the 1990s, the commercial industry and iwi, encouraged by fisheries managers, began developing cooperative management plans for eel fisheries in the South Island. These plans provided the information base for the next phase – the entry of eels into the Quota Management System (QMS). Not all eels entered the QMS at the same time: South Island eel fisheries entered the QMS in 2000; the Chatham Islands followed in 2003 and the North Island in 2004. Initial limits were based on historical catches. Entry into the QMS saw a further drop in the number of commercial eel fishers.[52]



Source: NIWA

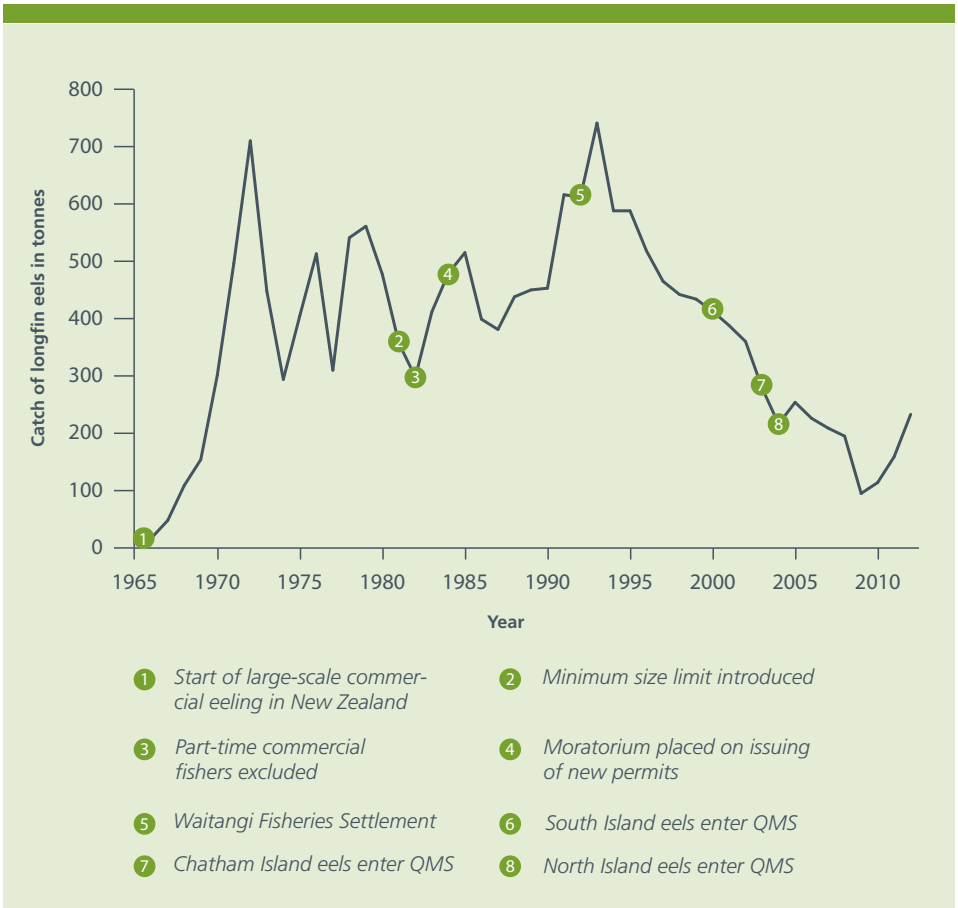
Figure 2.7 Fyke netting is so efficient that 75 percent of the eels in a fished area can be caught in a single night. It can take a decade or more for the eel population at such a site to recover. [53, 54]

The annual commercial catch of longfin eels is shown in Figure 2.8. A steep decline in the commercial longfin catch has occurred over the last two decades, although the catch has risen in the last three years.[55]

Longfins currently make up about 25 percent of the total commercial eel catch.[56]

International markets for shortfin and longfin vary and depend on the preferences of the countries to which they are being exported. Shortfins are more similar in size, quality and taste to overseas eel species, making them easier to market so they generally fetch a higher price.[57] While export prices for eels have been depressed in recent years, in the past year they have almost doubled.

The annual revenue from exporting eels (both longfins and shortfins) varies from year to year and has averaged around $5 million over recent years. In the last year, the combination of high export prices and a bigger catch resulted in revenue from the industry of just over $9 million. This is around 0.6 percent of the total export revenue for all fisheries.[58]



Source: Data from MPI

Figure 2.8 Commercial catch of longfin eels has totalled 17,600 tonnes since the early 1960s. The annual catch has declined steeply since the early 1990s although has risen in the last three years.[59]

2.6 Eel farming in our future?

Most of the eel exported around the world comes from aquaculture, although there are no commercial eel farms yet in New Zealand. Internationally, eel farms are stocked with wild glass eels that are then grown in ponds or tanks until they are large enough to sell.[60] Catching wild glass eels is very likely to be contributing to the decline of the freshwater eels in other parts of the world.

Farmed eel is preferred over wild eels in many countries because of differences in taste and texture. As a result, farmed eel tends to fetch a higher price.[61]

In New Zealand, research is being undertaken to find methods to spawn and breed eels in captivity. If this can be achieved it could form the basis of an abundant sustainable eel fishery. The Mahurangi Technical Institute in Warkworth has been able to produce and fertilise eggs from mature female eels, and hatch them into millions of eel larvae.[62] However, thus far, researchers have not been able to feed the larvae successfully – they die of starvation after about 12 days.[63]

This initiative has considerable economic potential and could reduce pressure of harvest on wild eel populations, although this would not address the loss of habitat and difficulties of fish passage discussed above. While researchers have hatched both longfin and shortfin eels, most research has been focused on shortfins. This is because shortfins are easier to handle in captivity, it is easier to determine their sex, and they mature at a younger age than longfins.[64]

It is unlikely that eels raised from eggs could be successfully released into the wild to enhance wild populations. It is thought that eels hatched and grown in captivity would lack the ability to find their spawning grounds in the Pacific.[65]

2.7 In summary

Longfin eels were once found in huge numbers in almost all of the rivers and streams of New Zealand. Today the situation is very different as will become clear later in this report.

This chapter has told the story of how humans have interacted with eels in this country. Although the extermination campaigns in which great numbers of eels were deliberately slaughtered belong to the past, the other downward pressures on eel populations remain. These pressures are the ongoing loss of habitat, the blocking of fish passage by barriers in rivers, and fishing.

The next chapter describes the local and central government agencies that have roles in managing and protecting longfin eels.

3

Who looks after longfin eels?

Populations of longfin eels have been severely depleted by the combined effects of changes to habitat and the quality of water; campaigns to eliminate them as pests; the blocking of their ability to swim up and down rivers, particularly by hydro dams; and fishing. So who is responsible for looking after longfin eels, and what laws and policies guide them?

There are a number of agencies involved.

- The **Ministry for Primary Industries** sets and enforces catch limits and rules around fishing.
- The **Department of Conservation** has responsibilities for the preservation of native species both within and outside the conservation estate.
- The **Ministry for the Environment** and **local councils** have responsibility for maintaining indigenous biodiversity under the Resource Management Act.

This chapter explains how each of these agencies operate in undertaking their responsibilities with regard to freshwater eels.

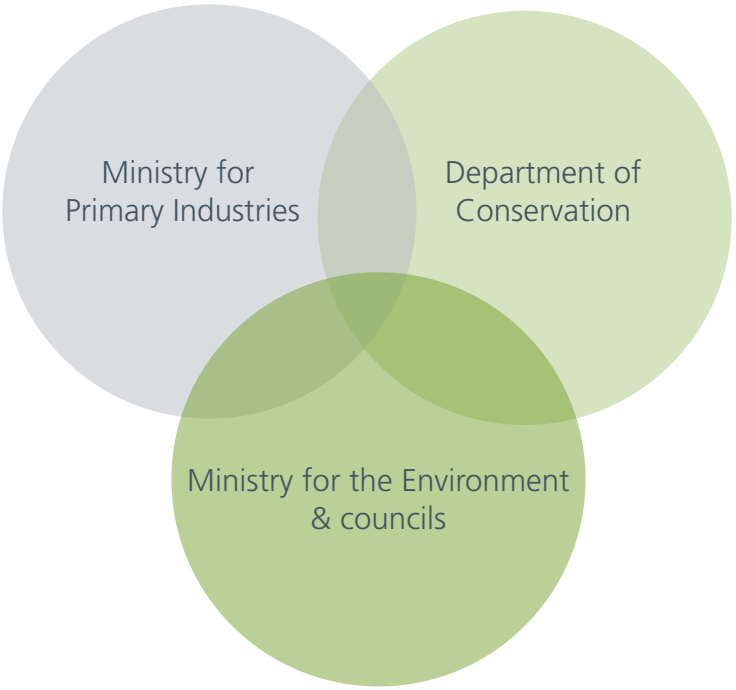


Figure 3.1 There are several agencies responsible for the management of longfin eels both at central and local government level. There is some overlap in their roles and responsibilities.

3.1 Ministry for Primary Industries: rules for fishing eels

The main agency with responsibility for overseeing the fishing of eels is the Ministry for Primary Industries (MPI), empowered primarily by the Fisheries Act 1996.[66] The purpose of this Act is *"to provide for the utilisation of fisheries resources while ensuring sustainability"*.[67] Consequently, MPI must attempt to simultaneously provide for the exploitation *and* the protection of eels.

In theory, there is no conflict. Sustainable fisheries are a prerequisite for a sustainable fishing industry. In practice, nature and the fishing industry may have different time horizons.

To further guide MPI, in 2009 the Government published *Fisheries 2030*, a *"goal and plan of action for future management of the country's fisheries"*. This strategic plan sets a longterm goal to have *"New Zealanders maximising benefits from the use of fisheries within environmental limits"*.[68]

The main mechanism for managing fisheries is the Quota Management System (QMS).[69] Most New Zealand fisheries are now in the QMS, including all freshwater eels. The Minister for Primary Industries sets total allowable catches for fisheries in the QMS.[70]

A Draft National Fisheries Plan for Freshwater was developed in 2011 setting out management objectives and guiding the production of annual operational plans and review reports.[71]

The Minister also sets various other rules controlling fishing. Limits have been set on the size of eels that can be legally caught and fishing for eels has been banned altogether in some eel reserves (see Box 3.1).

Box 3.1: Some restrictions on fishing for eels

Size limits

Limits have been set on the size of eels that can be caught by commercial fishers. A *minimum* size limit of 220 grams has been set for commercial fishers.[72] A *maximum* size limit of 4 kilograms has also been set; this is aimed at preventing the fishing of female eels that are reaching migration age.[73]

The industry has voluntarily adopted tighter restrictions, agreeing to a 300-gram minimum size and to the release of any migrating (silver) eels caught, even if they weigh less than 4 kilograms.[74]

There is no minimum size or length limit for customary and recreational fishers although a minimum net mesh size allows small eels to escape.[75] Kaitiaki can set size limits, or any other conditions, in customary permits.

Eel Reserves

In 1995, three North Island rivers were closed to commercial eel fishing – the Mōtū River in eastern Bay of Plenty, the Mōhaka River in northern Hawke's Bay, and much of the Whanganui River. National parks and some other categories of conservation land are also closed to eel fishing. In all, about 7 percent of the national stock of longfin eels is estimated to be in waters where commercial fishing is not allowed and migrating females are not blocked by hydro dams from escaping out to sea.[76]

MPI works with Māori to establish customary food gathering areas known as mātaitai that are closed to commercial fishing.[77] There are several mātaitai in the South Island, including on the Mataura River in Southland and at Okarito on the West Coast. In addition, MPI has established a number of other customary eel reserves using regulations under the Fisheries Act.[78]

Setting allowable catches for eels

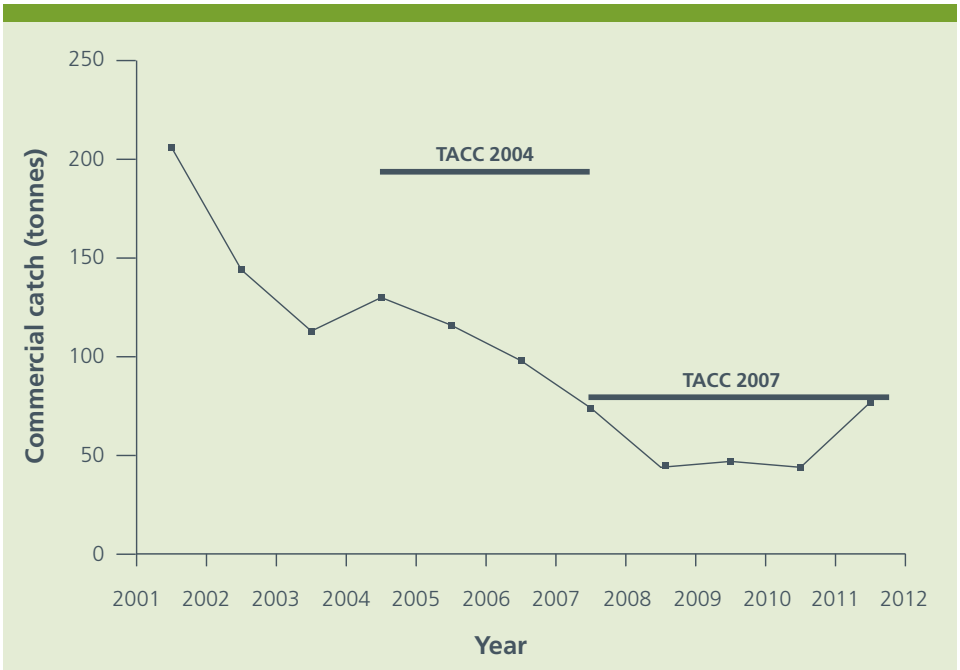
Under the QMS, the Minister sets upper limits on the amounts of different fish species that can be caught in a year. These limits are called total allowable catches (TACs). The longfin eel fishery is divided into 11 geographical management areas and TACs are set for each area.[79]

In setting TACs, the Fisheries Act requires the Minister to take into account a number of information principles, including using the best available information, and acting with caution when information is uncertain, unreliable, or inadequate.[80]

In many ways, the management of eels is no different to hoki, snapper or most other fish in the QMS. However, the Act treats eels differently by classing them with other species that for various reasons are particularly difficult to manage. Longfin and shortfin eels are listed with 13 other species in Schedule 3 of the Fisheries Act.[81] For these species, the Minister has more discretion when setting catch limits. Instead of needing to follow the usual process of calculating a 'maximum sustainable yield', the Minister can use any method to set catch limits *"that he or she considers appropriate to achieve the purpose of this Act"*.[82]

Longfin and shortfin eels are currently the only freshwater fish managed under the QMS.[83] In the South Island, the two species are managed as one fishery with one set of catch limits but with separate reporting for each species; whereas in the North Island and Chatham Islands, there are separate catch limits for longfins and for shortfins.[84]

An Eel Science Working Group has been established by MPI to oversee the quality of research and science information. Its membership includes fisheries scientists and representatives of iwi and commercial fishers. MPI also engages with Māori on the management of eels through its iwi forum network and has specific obligations under protocols and deeds of settlement with iwi, such as the Waikato River settlement.



Source: MPI

Figure 3.2 The actual commercial catch of longfin eels in the North Island over the last decade, relative to the Total Allowable Commercial Catches (TACC) since introduction into the QMS.[85] A major reduction in the TACC in 2007 brought it temporarily closer to the actual catch.

Allocating catch limits

Catch limits are allocated by the Minister to three groups of fishers – commercial fishers, customary fishers, and recreational fishers (see Appendix 1).[86]

The allowable catches for **commercial** eel fishing are divided into quotas, which are transferable – they can be bought and sold.[87] Commercial fishers are required to report their catches.

The allowances for Māori **customary** non-commercial eel fishing provide for eels to be caught for tangi and other hui, for koha, and for whānau or other purposes. Kaitiaki are appointed to oversee the issuing of permits allowing Māori to fish for eels for customary purposes.[88]

The amounts able to be caught for commercial and customary fishing are set for each of 11 quota management areas – four in the North Island, one in the Chatham Islands, and six in the South Island.

The amount that can be caught by **recreational** eel fishers is currently set at six eels per person per day.[89]

Māori have a particular interest in fisheries that is recognised in law. The Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 settled both commercial and non-commercial fishing rights by both allocating 20 percent of the commercial quota to Māori, and enabling allowances and rules for customary fishing. Māori hold large amounts of commercial eel quota, control the customary fishing of eels, and make up the majority of recreational eel fishers.

Actual catches of eels

It is important to distinguish clearly between *allowable* catches and *actual* catches. They are not necessarily the same. *Allowable* catches of both longfins and shortfins are shown in Appendix 1. *Actual* catches of both longfins and shortfins are shown in Appendix 2.

The actual **commercial** catch is accurately known because records must be kept and reported by commercial fishers and processors.

In the North Island, the commercial catch of longfin eels has fallen dramatically over the last decade. Figure 3.2 shows that commercial catches have usually been well below what was allowed. The exceptions were in 2007/08 when the allowable catch was significantly reduced, and in 2011/12 when the actual catch increased to 81 tonnes, just below the limit of 82 tonnes.

In the South Island, the commercial catch of longfins has been variable over recent years. In 2011/12, the most recent year for which data is available, 156 tonnes were caught – higher than for any year in the last decade.

In the South Island, the combined allowable catch means that in any given year the proportion of longfin and shortfin eels that are caught can vary.

The actual **customary** catch is much less clear.[90] The main customary fishing regulations require kaitiaki to regularly notify customary catches by making catch records available to MPI.[91] However, the catch records are not directly comparable with the customary allowance for three reasons. These are that most recording of catch is done by number of eels rather than by weight, some records do not differentiate longfin and shortfin species, and only a fraction of the North Island is as yet covered by the main customary regulations.[92] Nevertheless, based on the information available, MPI states *"It is reasonable to expect that generally customary catch would not exceed the allowances."*[93]

A survey of Māori within the Ngāti Maniapoto rohe in 1997 indicated that the annual amount taken by each customary fisher has fallen very significantly over time.[94] In some areas, Māori have decided not to catch their customary allowance (as well as some of their commercial quota) in an attempt to rebuild eel populations.[95]

The actual **recreational** catch is not monitored and is therefore unknown.[96]

3.2 Department of Conservation: protecting biodiversity

The Department of Conservation (DOC) has a specific legislative function to *"preserve so far as is practicable"* indigenous freshwater fisheries and freshwater fish habitats.[97] DOC has the greatest ability to achieve this function on public conservation land, but is also able to influence the protection of habitat and fish passage elsewhere.[98]

Figure 3.3 DOC's system for classifying the threat status of native plants and animals lists longfin eels as *"At risk/Declining"*. The little blue penguin has the same threat classification but is much cuter.

Complementing the legislation, DOC also has responsibilities for protecting biodiversity under the New Zealand Biodiversity Strategy 2000. In the Strategy, DOC is assigned overall responsibility as lead agency for making progress towards two objectives for freshwater species – one aimed at protecting threatened species and the other aimed at managing their harvest. (See Box 3.2)

Box 3.2: New Zealand Biodiversity Strategy

In 1993, New Zealand ratified the United Nations Convention on Biological Diversity. This requires New Zealand to develop a strategy to help halt the decline in global biodiversity.

The New Zealand Biodiversity Strategy was developed in the late 1990s and published in 2000. It sets out a vision, goals, and principles for managing biodiversity in New Zealand, and a series of action plans.

A key aim of the Strategy is to halt the decline of New Zealand indigenous species.[99] The Strategy also contains two objectives relevant to longfin eels.

An objective relevant to the **protection** of longfin eels:

"Enhance population numbers and ranges of indigenous freshwater species threatened with extinction and prevent additional species and ecological communities from becoming threatened."

An objective relevant to the **harvest** of longfin eels:

"Ensure that harvest of indigenous and introduced freshwater species and associated activities do not adversely affect indigenous freshwater biodiversity."[100]

A review of the Biodiversity Strategy in 2006 concluded that freshwater ecosystems and species should be given higher priority in implementation, and singled out the longfin eel as the harvested species most at risk.[101]

The Strategy must be reviewed at least every five years, and the Department of Conservation is currently in the process of '*refreshing*' it.[102]

The Minister of Conservation and DOC have direct control over activities that affect eels within the conservation estate.[103] Commercial fishing is effectively prohibited in national parks and reserves, although it can be allowed on other categories of conservation land if permission is given.[104] Such permission is known as a concession.

DOC can also play a role in protecting eel habitat and fish passage anywhere in the country, not just on the conservation estate. This can be done through:

- submitting on Resource Management Act plans and consent applications[105]
- setting and approving provisions for fish passage under the Freshwater Fisheries Regulations[106]
- establishing Freshwater Fisheries Management Plans under the Conservation Act.[107]

DOC can make submissions on **Resource Management Act plans and consent applications**, including on provisions and conditions that affect freshwater fish passage and habitat.[108] In addition, DOC can provide councils with technical guidance and other assistance to help with the drafting of plans.

Under the **Freshwater Fisheries Regulations**, written permission from the Director-General of Conservation is required for structures that block fish passage.[109] For small structures like culverts or fords, the Director-General can use these regulations if resource management plans or consent conditions are inadequate.[110]

For larger structures like dams and diversions, the regulations empower the Director-General to require *"that any dam or diversion structure proposed to be built include a fish facility"* to assist fish passage. This is in addition to the Director-General being able to submit on consent applications for larger structures such as hydroelectric and irrigation water storage dams. Where dams are proposed on conservation land, a concession is also required and concession conditions can be imposed to protect fish passage.[111]

Freshwater Fisheries Management Plans can be prepared under the Conservation Act *"to implement general policies and establish detailed objectives for the management of freshwater fisheries within any area or areas"*.[112] However, to date DOC has yet to develop any such plan for any freshwater fish. If such a plan was created, councils must *"have regard"* for it when developing plans and considering consents under the RMA.[113] MPI must also have regard to a freshwater fisheries management plan when setting catch limits or any other sustainability measures under the Fisheries Act.[114]

3.3 Ministry for the Environment and councils: resource management

The **Ministry for the Environment** (MfE) is responsible for advising the Government on environmental matters and administers the Resource Management Act (RMA) which has specific provisions for maintaining indigenous biodiversity.

Under the RMA, the Minister for the Environment can give direction to **councils** through National Policy Statements.[115] A National Policy Statement for Freshwater Management came into effect in 2011 that directs councils on objectives for managing freshwater.[116] The Ministry is also currently preparing a report and recommendations on a proposed National Policy Statement on Indigenous Biodiversity.

In addition, in March 2013 MfE released a proposed set of reforms to the way freshwater is managed under the RMA. This includes setting environmental limits to protect the health of freshwater ecosystems.[117]

Councils have developed their own policies and rules

Under the RMA, councils are required to create plans that include policies and rules intended to protect freshwater fish habitats.[118] Councils are involved in overseeing many activities that affect the habitat and passage of longfin eels – from drain clearance and culvert installation to large hydroelectric dams and different land uses.

These activities are managed by individual councils, and each council has developed its own rules and policies. Where resource consents are required to undertake particular activities, councils may impose conditions on the consents to limit the impact of the activity on eels. Further, because eels are taonga for Māori, councils are required to recognise and provide for this.[119]

3.4 In summary

Three central government agencies, as well as councils, have roles in managing and protecting longfin eels. As often occurs, some roles are shared and the boundaries between jurisdictions and responsibilities are unclear. Nevertheless, all those with responsibilities for managing eels have a responsibility to protect them and to act when that protection is inadequate. Indeed, New Zealand's fisheries management system – the QMS – makes environmental, as well as economic sense, and is widely recognised as world-leading.

Fish, whether marine or freshwater, present significant challenges to both fisheries and conservation managers. They move around and are generally out of sight, so are difficult to count. Their numbers fluctuate according to environmental conditions, such as changeable currents or a lack or abundance of food. And some fish have particular characteristics that make them especially difficult to manage and protect.

The longfin eel, like other freshwater eels, has such unusual characteristics – single breeding at the end of a long life, a long journey north in the sea to breed, an equally long drift of the larvae back to New Zealand, the hazardous journey the elvers make upriver, and the slow growth to maturity in freshwater.

Consequently, there will always be less information about eels than we would like and it will be more uncertain than we would like. But this is often the case in public policy and decisions must still be made. In the next chapter, scientific information about the state of longfin eels is examined in order to reach a judgement about the state of this important and fascinating species.

4 Are longfin eels in trouble?

Concern over the status of the longfin eel population has become increasingly widespread over recent years. Clearly, the number of longfins has fallen dramatically over the last half century. The key question is whether the species is heading towards population collapse.[120]

Assessing the status of any fish population is challenging. But it is particularly difficult to model eel populations. One reason is their very slow lifecycle ending with just one spawning at the end of a long life – this is very different from most marine fisheries such as hoki and snapper. Another reason is the range of pressures on eels; hoki and snapper are not suffering an ongoing loss of habitat and neither are there any hydroelectric dams in the sea.

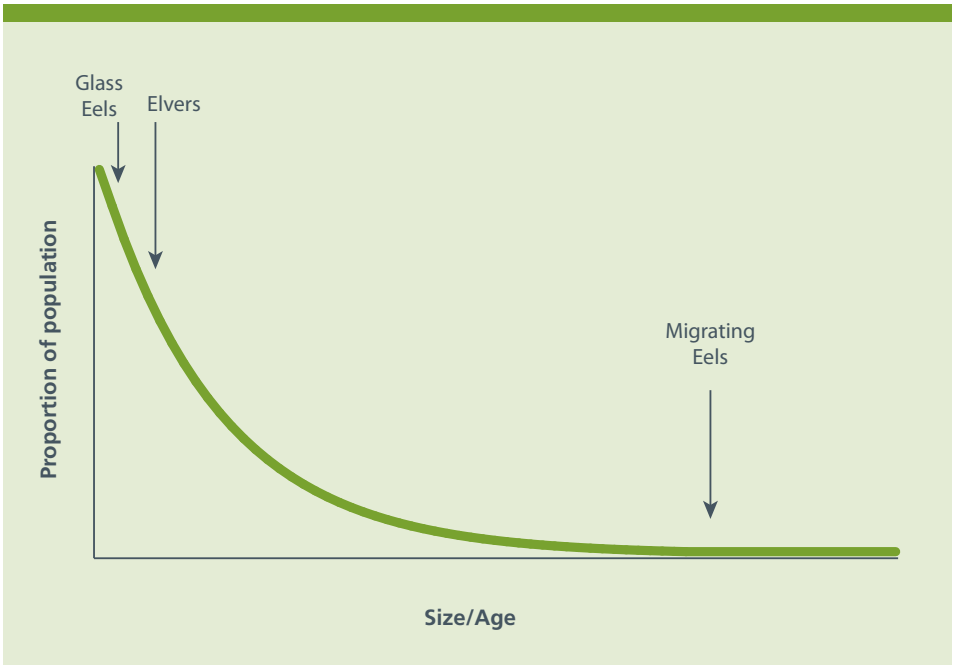
There is a variety of sources of information about the status of both eel species – longfins and shortfins. None are perfect and a degree of uncertainty will always remain. But, as the Prime Minister's Chief Science Advisor Sir Peter Gluckman often points out, science seldom provides certainty, but rather is in the business of reducing uncertainty.[121] Judgements must be made on the weight of evidence.

In this chapter, a range of information on the status of longfin eels is presented. Some is of higher quality than others. It includes information currently used by the officials who operate the QMS, but goes much further. At the end of the chapter, a judgement about the status of the longfin population is made by considering all this information.

4.1 Ideal information - breeding adults and the next generation

It is a precarious life being a longfin eel, even without the pressures from human activities. Only a tiny proportion of the larvae that hatch in the Pacific and float thousands of kilometres south to New Zealand are likely to survive to become mature migrating adults and make the return trip north to begin the slow cycle of life again. There are many natural hazards – including being eaten by bigger eels.

The survival of a species is critically dependent on there being enough breeding adults in the population. Therefore, a healthy eel population must contain enough young eels to ensure that, in turn, enough eels survive to breeding age to continue the survival of the species. To respond to this challenge eels have evolved a population structure that has large numbers of very young eels and progressively fewer eels as age increases (see Figure 4.1).



Source: Parliamentary Commissioner for the Environment

Figure 4.1 Eels have evolved a population structure that is characterised by very large numbers of small eels and fewer and fewer eels of larger sizes. This is because many of the young eels will not survive, although the chances of individual survival increase with age. This population structure is quite resilient to changes in the numbers of different aged eels, but there will be a point when it changes so much that the population cannot recover and collapse is inevitable.

The ideal way to assess the state of an eel population would be to measure how two population variables are changing over time, namely:

- the number of breeding adults that successfully make their way out to sea
- the number of young eels that have swum up rivers to replace breeding adults.

The numbers of mature longfins that make their way out to sea to begin the journey north to breed have never been counted in New Zealand. However, it has been estimated that the number of adult longfins migrating each year has fallen to about 20 percent of what it was in the 1930s.[122]

The number of breeding eels migrating each year has fallen

Counting the number of tiny glass eels that swim into the rivers and estuaries around the country would give the first indication of changes in 'recruitment'.[123] This is routinely done in countries where wild glass eels are caught to stock eel farms by simply recording the size of the catches. However, glass eels are not caught commercially in New Zealand, so this source of information does not exist.[124]

There has been some monitoring of glass eels in New Zealand, although the research has been intermittent and done over relatively short time periods.

Studies using data from three coastal streams showed that numbers of glass eels fell by nearly 80 percent between 1980 and 2000.[125] A more recent study using data from six sites showed no change over a shorter period – 1995 to 2006.[126] Another study showed that the numbers of longfin glass eels swimming up the Waikato River are now about a quarter of what they were in the 1970s.[127]

Although there are no direct measurements of the numbers of mature eels reaching the sea and few measurements of glass eels leaving the sea, good data does exist on the age structure of the population in the sites where eels live most of their lives.

As shown in Figure 4.1, an eel population is characterised by numbers of eels falling with increasing age. If an eel population deviates significantly from this pattern, there is cause for real concern.

4.2 Do we have enough eels of the right ages?

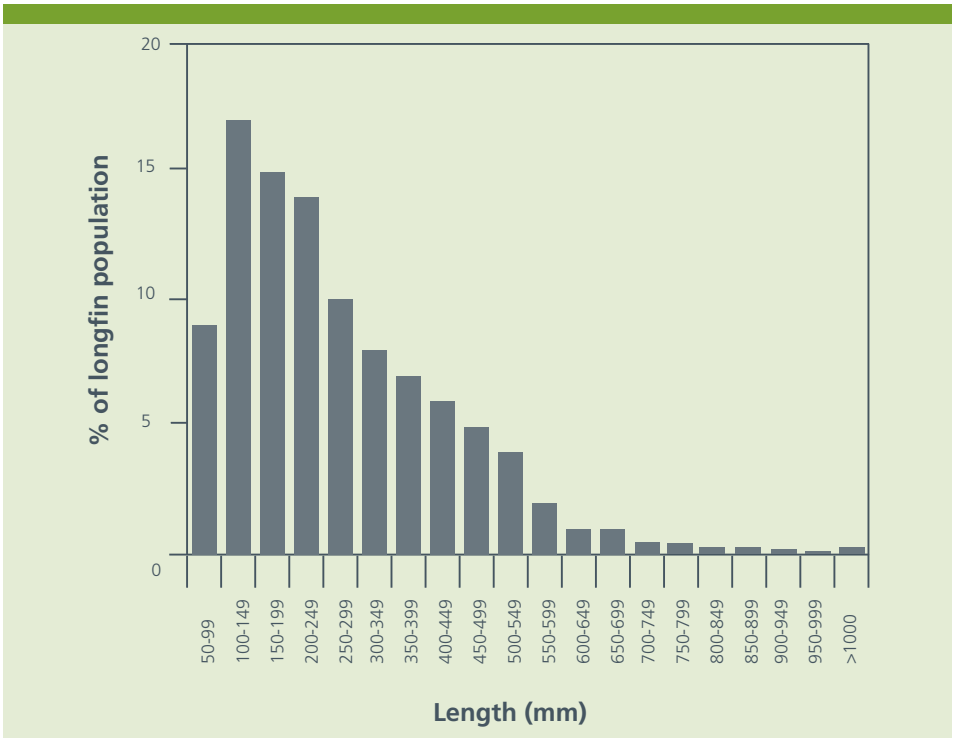
The current age structure of the longfin eel population is revealed by two sets of eel surveys. In both, longfin eels have been counted and measured using a technique known as 'electric fishing'. This involves running an electric current through the water to temporarily stun the fish, so they can be scooped up in a net, studied, and then released.

One set of surveys was undertaken by NIWA at a range of sites across the country. Another set of surveys has been undertaken in Waikato and Otago by the respective regional councils.

The NIWA surveys

Between 1996 and 2010, NIWA undertook nearly 30 surveys of both longfin and shortfin eels in 19 streams and rivers across the country.[128]

The eels were counted and measured and the results were divided into 50 millimetre length classes. The length of an eel is a good proxy for its age.[129] Over 10,000 longfins were measured. The results are presented in Figure 4.2.



Source: Jellyman, 2012

Figure 4.2 The size structure of the longfin eel population from the NIWA surveys undertaken across the country. The proportion of elvers (shown in the first bar) is much lower than would be expected and strongly points to a reduction in the resilience of the population. In contrast, the age structure of shortfin eels follows the pattern in Figure 4.1.[130]

The combined results from the NIWA surveys show that the age structure of longfins does not follow the pattern it should, shown in Figure 4.1. The absence of very small longfins is striking. In a healthy population of freshwater eels, the proportion of eels that fall into the smallest size class would be several times greater.[131]

This scarcity of small longfin eels does not yet show up in commercial catch records. It is illegal to catch eels that weigh less than 220 grams, so the fyke nets used by commercial fishers have escape tubes to allow these small eels to escape. A 220-gram eel is about 450 millimetres long. With an average growth rate of twenty to thirty millimetres per year it could easily take more than a decade before the current lack of small longfins becomes visible to commercial fishers.

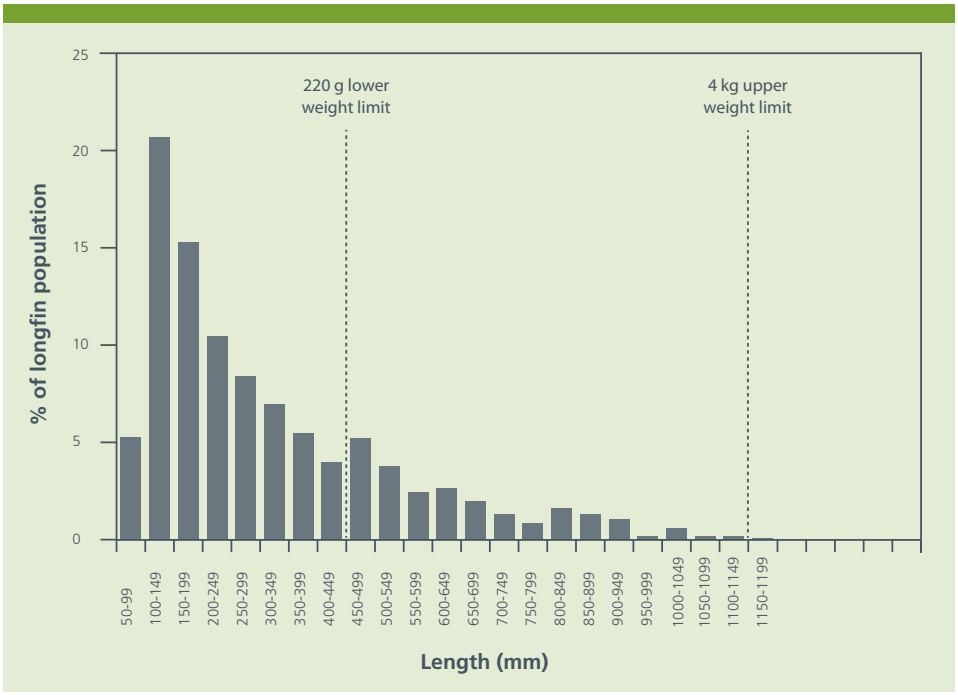
The Waikato and Otago surveys

In recent years Environment Waikato and the Otago Regional Council have undertaken electric fishing surveys to monitor eels and other fish at different sites in their regions.[132] These surveys have all been done using the latest approved protocols for electric fishing, including ensuring the length of river or stream sampled at every site was 150 metres long, and surveys were undertaken at both random and reference sites.[133]

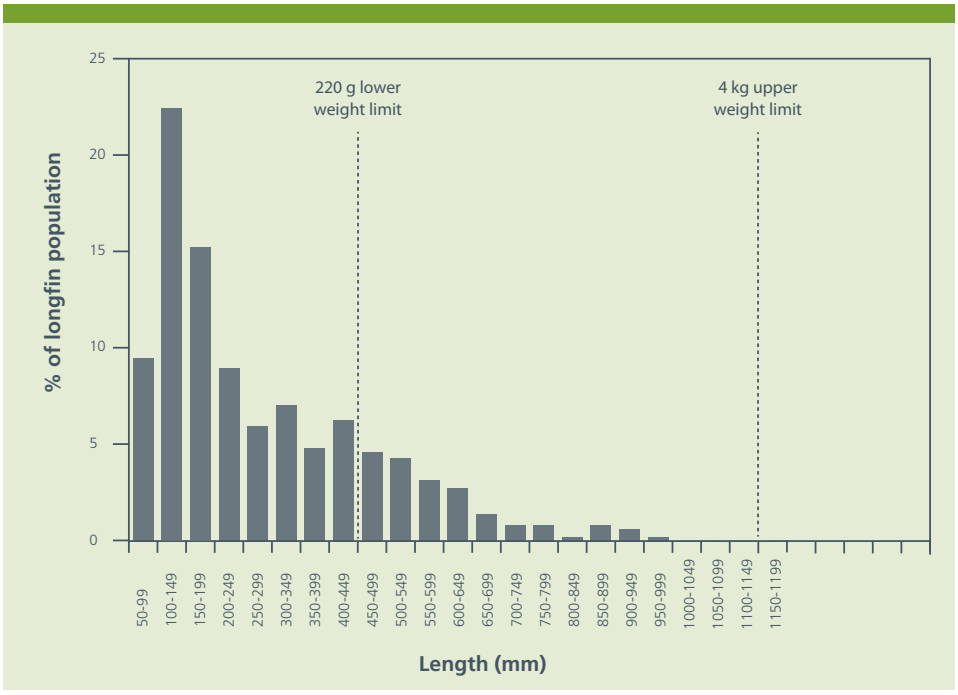
In each region, over 1000 longfins were measured.[134] The results are shown in Figure 4.3 and show the same pattern as the national surveys – a lack of elvers and a lack of large adult females.[135]

It is particularly worrying that no longfin elvers at all were found at more than half the sites in Waikato where they would be expected and where adult longfins were found.[136]

Moreover, only 11 mature female eels (weighing more than 4 kilograms) were found in the Waikato surveys and none in the Otago surveys. It is the big females weighing as much as 25 kilograms that are the most fecund – producing as many as 20 million eggs each.[137]



Source: Waikato Regional Council



Source: Otago Regional Council

Figure 4.3 The age structure of the longfin eel population from the Waikato (top) and Otago (bottom) surveys. In both, the proportion of very small eels (the first bar) is much lower than would be expected, indicating a major decline in recruitment into the population.[138]

4.3 Are longfins found where they should be?

The fact that longfin eels are becoming more difficult to find in their natural habitat points to a reduction in both their abundance and their distribution around the country. The Freshwater Fish Database contains information that can be used to estimate the probability of finding different fish in the rivers, lakes and streams of New Zealand.[139]

Records from this database have been analysed to reveal how the probability of finding native fish (including longfin eels) in their natural habitat has changed over time.

The analysis shows that the probability of finding at least one longfin in its natural habitat has fallen from 70 percent to 45 percent in the last 30 years – less than one eel generation.[140, 141]

Dr Don Jellyman summarises thus:

> *"Other migratory species also show a decline in occurrence over recent years … However, longfin eels show the most dramatic decline of any of the native fish species examined."*[142]

It could be argued that this decline in abundance and distribution of longfins, and the lack of very small elvers revealed in Figures 4.2 and 4.3, are not necessarily cause for concern because of what biologists call 'density-dependence'.

Source: Parliamentary Commissioner for the Environment Archives

Figure 4.4 Longfin eels prefer clear stony-bottomed streams with shelter from overhanging vegetation.

The growth in numbers of species is almost always controlled to some extent by its density – the number of individuals in a given space. For example, if the numbers of elvers going up a river is reduced, the remaining elvers may have a better chance of finding food and surviving. Similarly, an eel population may be able to withstand a reduction in the number of breeding females, because each female produces so many young.[143]

Density dependence may well be a factor affecting longfin eels and there may be some increased survival of remaining elvers. However, the probability of finding at least one longfin in its natural habitat – where there is food and space – has fallen dramatically over the last 30 years. Density dependent responses are not offsetting the loss of recruitment.

It is very difficult to predict just how low the numbers of elvers and breeding females can fall before the population of longfins becomes unsustainable. There will be limits beyond which a population collapse is inevitable.[144]

4.4 Information used by fisheries managers

The Ministry for Primary Industries currently uses three main types of scientific information to manage the longfin and shortfin eel fisheries. The main indicator used is the catch per unit of effort, as for other fish species managed under the quota system. The second indicator uses the number of elvers trapped at a set of hydro dams as a basis for estimating recruitment into the population. The third indicator is the modelled estimate of mature eels reaching the sea to begin their migration to spawn.

The effort required to catch longfins

Catch per unit effort (CPUE) indicators are a major source of information used by MPI about the state of a fishery. If the same effort is put into fishing for a species but the catch falls over time, it can indicate that the population is falling.

For eels, CPUE is measured as the weight of eels caught for a given amount of effort.[145]

In the North Island between 1991 and 2007, CPUE for longfins decreased almost everywhere, with particularly steep declines in Rangitikei/Whanganui, Hauraki and Hawke's Bay.[146] In the South Island, CPUE for longfins appears to have been more stable.[147]

Care needs to be taken when assessing trends in CPUE as many factors other than the population of fish can affect the index. For instance, catch is measured solely by weight and does not take into account the total number of fish caught.[148]

For eels, there is also a particular problem of 'serial depletion' where fishers move around an area and fish new sites. The extra effort involved in moving to new sites is not captured in the CPUE calculation. Consequently, the CPUE may stay stable or rise when the number of eels in the area is actually falling.[149]

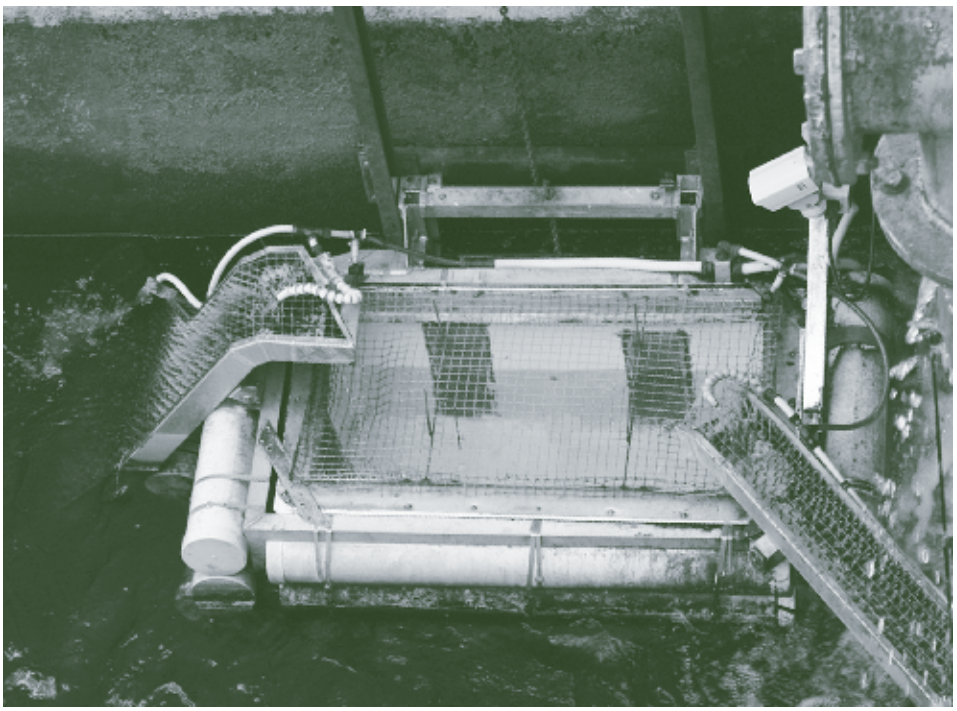
Another problem with CPUE is that when no eels have been caught, the effort is not recorded – again leading to a measure of CPUE that is higher that it should be.

Finally, because CPUE is based on commercial fishing records, it only captures eels that are within the catchable size range. It provides no information on the numbers of young eels on which the future of the species is so dependent.

The elvers arriving at hydro dams

A second type of information used by MPI is numbers of elvers caught and transferred upstream over seven hydro dams. This information is used to estimate the numbers of elvers arriving at hydro dams, which is then used as an indicator of how many young eels have been 'recruited' into the population.[150]

The longest data series is for the Karapiro Dam and runs for 16 years from 1996 to 2011. It is only the last seven years however that data has been available for all seven monitoring sites. Many more shortfin elvers than longfin elvers are being trapped at the monitored sites.



Source: Mighty River Power

Figure 4.5 Elver lift on Mighty River Power's Karapiro Dam. Elvers climb the ramps into the box, are trapped, and then transported over the dam.

Only two sites showed any statistically significant trend - and increase in the number of longfin elvers.[151] But this should not be read as a positive indicator for the status of the longfin population, because their are major limitations in the quality of the information. This makes it difficult to draw any firm conclusions.

The sampling effort at these sites has not been consistent from year to year due to changes in the types, numbers and locations of traps. It is also not possible to tell from this short time series and small number of monitoring sites how the overall number of elvers coming up rivers compares with historical levels, or to predict long-term trends from this data.

This information on elvers is much less useful than that collected in the surveys in section 4.2. These surveys came from sites all around the country, and counted and measured eels in the habitat where they actually live and grow to maturity.

Mature eels reaching the sea

The number of mature eels that successfully make their way out to sea to begin the long journey north to spawn would be one of the ideal indicators of the state of the population (see section 4.1). Such measurements have not been done in New Zealand; indeed, it is not clear how such measurements could be done. However, fisheries officials have commissioned scientists to estimate this important indicator.

This indicator is typically expressed as a percentage of the number of migrating eels before the advent of major pressures on the species. In New Zealand the number of migrating eels is now estimated to be about 20 percent of what it was before the construction of big dams and commercial fishing.[152]

4.5 How much trouble are longfin eels in?

Over recent decades, the evidence suggests that fewer and fewer mature longfins have made the great migration north to spawn and begin the new generation. Large areas of their habitat have been altered or destroyed, vast numbers were killed as pests, many have been caught and eaten, and more have died trying to get past hydro dams and other barriers.

As described early in this chapter, the state of an eel population is ideally assessed by measuring changes in the number of breeding adults and the number of young eels returning into the population.

Fisheries managers have made some effort to measure these two variables. The change in the number of breeding adults has necessarily been estimated using a complex model. Instead of measuring young eels arriving at sites with suitable eel habitat, the number of elvers arriving at some hydro dams is used as an index of recruitment.

The other indicator of the status of the longfin eel population used by fisheries managers is based on the effort required to catch them.

Catch per unit effort is a key indicator used for assessing the state of commercial fisheries, but its value for assessing freshwater eel fisheries is questionable.

Legislation requires that decisions about fisheries management are based on the *"best available information"*.[153] Because of their unusual biology and lifecycle, eels are particularly challenging to manage and protect. This is recognised by MPI in its operational plan for freshwater fisheries – *"Because of the eels' life history, biological characteristics and vulnerability to habitat change and loss, management needs to be relatively cautious."*[154]

The complete absence of elvers at more than half the sites in Waikato is particularly disturbing

This chapter contains information that has thus far not been used by MPI in making decisions about the management of eel fisheries.

In recent years, NIWA has undertaken surveys in which thousands of longfin eels have been not only counted, but measured in a range of sites around the country. The dearth of very small longfins is striking and points strongly to a decline in the resilience of the population.

As this investigation was drawing to a close, the results from freshwater fish surveys undertaken by the Waikato and Otago regional councils became available. Not only do these surveys yield the most up-to-date information available on the population structure of longfins, they were done using the latest approved protocols.

In the Waikato surveys, the complete absence of longfin elvers at more than half the sites that were typical longfin habitat is particularly disturbing.

Further evidence of a decline in abundance and geographical distribution comes from analysis of records collected in the Freshwater Fish Database. Over the last 30 years the probability of finding even one longfin eel in its natural habitat has fallen dramatically.

When all of this information is considered as a whole it points clearly to a species that is in trouble. Individual longfins live so long it would take many decades for the species to vanish. The evidence today shows that the species may have entered a downward spiral that could lead to such an extinction.

Longfin eels need urgent help from the agencies that are responsible for their management and protection. The next chapter examines how well different government agencies are acting to preserve the fishery, to protect eel habitat, and to assist their passage both up and down rivers.

5

How well are longfin eels being managed and protected?

The cumulative weight of the scientific evidence has led to the judgement that longfin eels are in trouble. So how well are longfin eels being managed and protected?

The roles of the different government agencies with responsibilities for the management and protection of eels have been outlined in Chapter 3. In this chapter, the performance of these agencies is examined.

- The Ministry for Primary Industries (MPI) manages the eel fishery under the Fisheries Act.
- The Department of Conservation (DOC) has responsibilities for protecting eel habitat and fish passage under the Conservation Act and under the Biodiversity Strategy.
- Councils, overseen by the Ministry for the Environment, set rules and conditions on activities that affect eels.

5.1 How well is MPI managing the fishing of longfin eels?

> *"Managing stocks sustainably means ensuring that they are harvested in a manner that maintains their potential to meet the reasonably foreseeable needs of future generations".*
>
> Ministry of Fisheries (now part of MPI), 2011a.

MPI aspires to make its management of freshwater eel fisheries *"more transparent, more accountable and more accessible"*.[155]

In 2007, the Minister of Fisheries was provided with advice which acknowledged that *"there is a high risk that current exploitation levels of longfins are unsustainable"*.[156] After consultation, the Minister reduced the total allowable commercial catches for North Island longfins by 60 percent. This illustrates that the system has, and can, respond to the vulnerability of the longfin eel. However, as can be seen in Figure 3.2, the actual commercial catch of longfins in the North Island only fell by about 20 percent. This was because the actual catch had been far below the allowable catch for the preceding five years.[157]

This, taken together with no reduction in catch limits for the South Island, suggests an inadequate response to a *"high risk"*. Analysis of MPI's management of longfin eels carried out during this investigation has raised three main areas of concern. Each is now discussed in turn.

Source: Parliamentary Commissioner for the Environment Archives

Figure 5.1 Ministry for Primary Industries head office, Wellington.

The scientific assessment of the state of the longfin population

Each year the state of the freshwater eel fisheries is reviewed in the Fisheries Assessment Plenary (along with other fisheries in the QMS).[158]

As described in Chapter 4, the scientific assessment of the state of both the longfin and shortfin eel populations relies heavily on three indicators. Problems with these three indicators – effort in catching eels, elvers arriving at hydro dams, and mature eels reaching the sea – have already been described. In summary:

Indicator #1: Effort in catching eels (CPUE)

- Effort is underestimated because it does not account for eel fishers moving around and fishing new sites.
- Effort is not recorded when no eels are caught.
- The indicator does not provide information about the number of smaller eels that escape from nets – information that is needed in order to plan effectively for their future management.

MPI's main conclusions about the state and trends in the longfin eel population hinge on this indicator.

Indicator #2: Elvers arriving at hydro dams

- Sampling only takes place at seven dams and has been done for different lengths of time at different dams.
- The methods used for collection are different between dams and have changed over time.
- Sampling at dams gives no indication of how many elvers are actually making it to their final destination and surviving there to mature.

This inconsistent monitoring has resulted in a short 'noisy' data series that does not provide a strong basis for robust and meaningful conclusions.

Indicator #3: Mature eels reaching the sea

- Reliance is placed on estimates of the numbers of migrating eels, rather than counts from sampling.

However, MPI has begun to work with commercial fishers in the South Island to collect information on the number of eels weighing more than four kilograms that have been caught and released because this could give an indication of the number of migrating females.[159]

MPI has developed five principles for ranking the quality of the different scientific information it uses for providing advice about fisheries.[160] This year a quality ranking is to be given to the first two indicators discussed above, and it is expected both indicators will receive the highest ranking of 1.[161]

No indicator of the state of a fish species can be perfect, especially for a species that leads a life as complicated as the longfin eel. However, other information that provides a much richer and deeper understanding of the plight of the longfin eel is presented in Chapter 4. Most of this data has been available but not used by MPI.

The age structure data collected by NIWA has been available for some time, although the Waikato and Otago data only became available as this report was being finalised. With regard to the NIWA data, MPI considers *"that such data and analysis does not constitute best available information, and notes such data has been rejected by the Eel Working Group."*[162] However, the minutes of the relevant meeting of the Eel Working Group record that the Group noted these were *"unexpected results"* and was clearly concerned.[163] Such a contradiction does not engender confidence.

An analysis of electric fishing results from the Freshwater Fish Database has also been used in this report and shows a significant decline in the abundance and distribution of longfins. It is encouraging that MPI has acknowledged that such analysis *"showed promise"*.[164]

It is also encouraging that MPI has commissioned an independent review of the status of longfin eels. However, it appears that MPI will rely on the Eel Working Group to review this study; the meeting to discuss this is expected to be on 23 April 2013.[165]

In addition to the Eel Working Group, MPI has a range of options available for the peer review process. One of these is an independent expert peer-review panel. Such independent panels can be convened when research *"findings are controversial"* or *"the implications for fisheries management decisions are substantial."*[166] The longfin eel would appear to be a very fitting candidate for this approach. The extra degree of rigour and independence would be appropriate given the findings of this report.

The absence of targets for measuring management success

Sustainable management of a fishery requires setting targets and assessing performance against those targets.[167] MPI acknowledges the need for such targets for eels, stating that one of the performance measures will be: *"Stock size (or agreed indicator) is at or above an established target reference level…"*[168] However, such targets have yet to be set.[169]

When setting management targets for species that are vulnerable to overfishing, the internationally recommended practice is to set a target of keeping the breeding population at 30 percent of the original 'unfished' population – measured in terms of biomass. The 30 percent is a default – the target should be higher if the species is particularly vulnerable. When assessed against the international guidelines for vulnerability, the longfin eel scores *"very high"*.[170]

The biomass of breeding longfins has been estimated to be less than 20 percent of the levels in the 1930s – before hydro dam construction and commercial eel fishing.[171] MPI has suggested that eel recruitment might be maintained at half this level – only 10 percent of the original biomass.[172] But MPI's own definition of a fishery that should be considered for closure is one where the biomass has fallen to 10 percent of historical levels.[173, 174]

The International Union for Conservation of Nature (IUCN) is currently evaluating the status of the longfin eel for inclusion in its Red List of Threatened Species. To do this, it uses numerical benchmarks in judging the threat status of different species. Box 5.1 shows how the longfin eel might compare with the critically endangered European eel.

Box 5.1: Comparing longfin eels with the critically endangered European eel

The IUCN uses a set of criteria for ranking the conservation status of threatened fish. Currently, the New Zealand longfin eel is being evaluated using these criteria.[175] The table below shows some of the key reasons why the European eel has been ranked as 'Critically Endangered'. It also shows how the longfin eel might be compared with the European eel using information collected in the course of this investigation.

	European eel	New Zealand longfin eel
Decline in glass eels	95%[176]	77%[177]
Decline in breeding eels	>80%[178]	80%[179]
Decline in catch	76%[180]	78%[181]

The combination of longfin and shortfin eels in the South Island quota

Longfin and shortfin eels in the South Island are currently combined into one fishery despite being different species. In contrast, longfins and shortfins are managed separately in the North Island. This means that the total allowable catch for longfins can be reduced in the North Island (as it was in 2007), but not in the South Island. The question must be asked: Why has MPI not split the South Island eel fishery?

Eels in the South Island were introduced into the QMS in 2000 as a combined fishery, but with the intention that longfin and shortfin fisheries be separated in time.[182] MPI has yet to begin a process for separation because it is not considered a priority.[183] The delay is not attributed to a lack of information.[184]

The Fisheries Act gives the Minister the power to separate fisheries where this is deemed necessary to *"ensure sustainability"*.[185] This investigation has found that there are very good reasons to be concerned about the sustainability of the longfin eel – as a species and as a fishery. Separating the management of the two species of eels in the South Island should be a priority.

5.2 How well is DOC protecting longfin eels?

DOC is the main central government agency responsible for the protection of New Zealand's native species and ecosystems, and as such, has a number of roles to play under its enabling legislation – the Conservation Act. However, as described in Chapter 3, DOC has been given two particular responsibilities relevant to the protection and harvest of eels in the New Zealand Biodiversity Strategy 2000.

The Strategy designates DOC as the lead agency with respect to:

- the **protection** of freshwater fish threatened with extinction
- ensuring that the **harvest** of freshwater species does not affect biodiversity.

Currently, DOC has classified the status of the longfin eel population as '*At Risk/ Declining*', clearly viewing longfins as threatened. As the top freshwater predator, longfins are very important for maintaining biodiversity.

This section contains an evaluation of how well DOC is carrying out its responsibilities regarding the protection and harvest of longfin eels. **Harvest** is discussed first because this follows on from the previous section, and **protection** leads more naturally into the last section in this chapter.

Harvesting longfin eels on the conservation estate

Longfin eels are not protected everywhere within the conservation estate. Commercial fishing for eels is effectively prohibited in national parks and reserves – about 40 percent of all the land managed by DOC.[186]

However, commercial eel fishing can take place on other categories of conservation land if permission – known as a concession – is given (see Figure 5.2). Three concessions have been granted on the West Coast in recent years. Concession decisions are made at the local conservancy level and have been inconsistent.

On one hand, the review of the application for one of the West Coast concessions excluded consideration of the effect of harvest on eels, stating: *"Decisions concerning the sustainability of the harvest of eels, and the sustainability of fisheries stocks are the functions of the Ministry of Fisheries not the Minister of Conservation".*[187]

This view is also held at the national level. In the 2011/12 Financial Review of DOC, the answer to a supplementary question included the statement: *"As long finned eels are managed as a commercial fishery under the Fisheries Act, the responsibility for considering the conservation benefits of reducing the commercial catch of long finned eels is a role of the Ministry for Primary Industries."*[188]

On the other hand, the review of an application for a concession in Wairarapa stated that the Minister of Conservation *"can and should consider the effect of fishing upon eels".*[189]

Source: Otago Regional Council

Figure 5.2 Concessions for commercial eeling may be given on up to 60 percent of conservation land.

In 2010, the Chair of the New Zealand Conservation Authority wrote to the Director-General of Conservation expressing concern about the granting of eel fishing concessions.[190] This seems to have resulted in the development of guidance for conservancies considering applications for such concessions, and should lead to more consistent decisions.

However, the guidance states that only the effects of fishing on the eel population in the *actual* conservation area being fished can be considered.[191] This is at odds with the biology of eels – which function as a single population.

Fishing for eels anywhere will affect eel numbers everywhere. Unlike salmon, for instance, eels have no homing instinct. When an eel spawns far up in the Pacific Ocean, the larvae that hatch from its eggs drift on ocean currents back to New Zealand. If any of the glass eels that result begin to swim up the same river as either of their parents, that is pure coincidence. And they certainly have no idea if the river they are swimming up is inside or outside conservation land.

The guidance also appears to be at odds with DOC's responsibilities as lead agency under the Biodiversity Strategy. There remains a lack of clarity – and at times an abdication of responsibility – about how DOC ensures that the harvest of longfin eels does not affect biodiversity.[192]

Protecting eel habitat and passage up and down rivers

Under the Biodiversity Strategy, DOC also has a responsibility to act as the lead agency in protecting the longfin eel – a freshwater fish threatened with extinction. There are three ways in which DOC can act to protect both the habitat of longfin eels and their ability to travel up and down rivers and streams, navigating around dams and other barriers.

As outlined in Chapter 3, DOC can:

- submit on **Resource Management Act** plans and consent applications
- approve provisions for fish passage under the **Freshwater Fisheries Regulations**
- establish **Freshwater Fisheries Management Plans** under the Conservation Act.

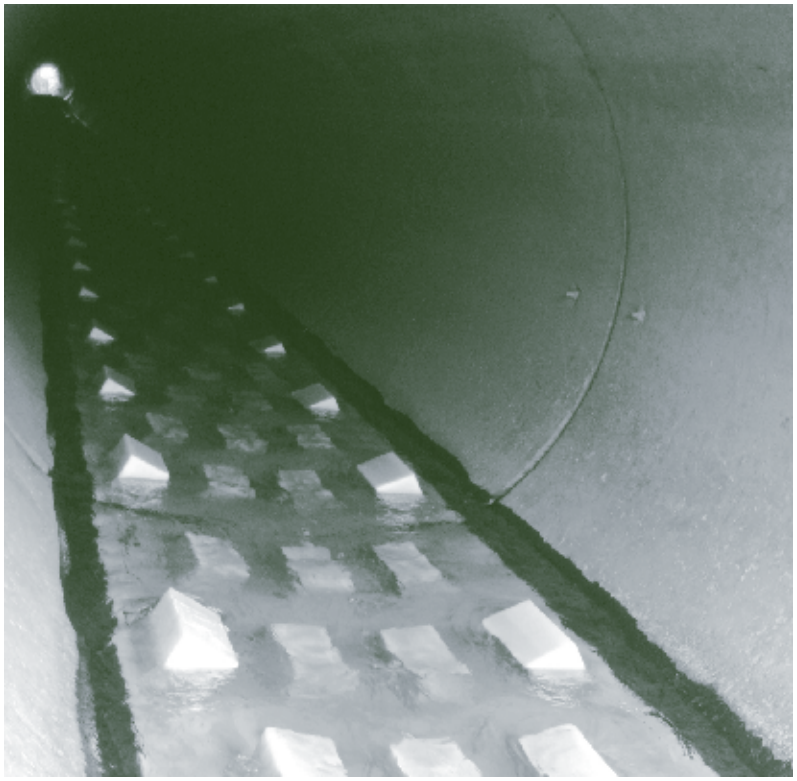
Under the **Resource Management Act**, DOC is able to submit on council plans and on applications for resource consents. For structures (like dams) that require consents and could affect fish passage, DOC is considered an 'affected party' because of its freshwater responsibilities.

This investigation has found that there is considerable variation in the ways that different regional councils deal with protecting freshwater fish habitat and passage. In many cases there will be no good reason for such variation.[193] One useful approach to fulfilling DOC's responsibilities has been adopted in the Wellington Conservancy. A Memorandum of Understanding has been established that clarifies when DOC will, and will not, submit on resource consent applications being processed by the Greater Wellington Regional Council.[194]

Under the **Freshwater Fisheries Regulations**, DOC has long had the power to require such consistency with regard to fish passage. For instance, one regulation requires that culverts be constructed so that they do not impede fish passage, unless the Director-General has given written permission to do otherwise.[195]

These regulations appear to have been more honoured in the intention than the observance.[196] DOC states on its own website that *"many installers of fords and culverts in particular are unaware"* that it has this regulatory role.[197]

In Otago, the regional plan requires fords or culverts to comply with the Freshwater Fish Regulations.[198] However, the specific rules on culverts do not mention fish passage, no design guidelines are provided, and constructing a culvert does not require a resource consent.[199] Therefore, given the lack of awareness of the Freshwater Fish Regulations and DOC's lack of enforcement, culverts may have been built in Otago – and perhaps elsewhere in the country – with no allowance at all for fish passage.[200]



Source: Michelle Archer

Figure 5.3 Cementing paving bricks to the bottom of a concrete culvert can be all that is needed to help elvers get through.

In 1999, DOC published a review which provides guidelines on culvert design.[201] Currently, work is underway to develop guidance on drain clearance and road culvert design.[202]

The third – and potentially the most effective – way in which DOC can act to protect the habitat and passage of longfin eels is through developing a Freshwater Fisheries Management Plan. Councils could then incorporate provisions into regional plans, thus providing nationwide consistency.[203] However, no such plan has been developed for any freshwater fish, despite DOC stating that such plans are *"currently the most appropriate document to guide future freshwater fish management."*[204]

Developing a Freshwater Fisheries Management Plan for longfin eels is one way in which DOC could really begin to take up the challenge of being the lead agency for protecting this threatened species. Both MPI and councils must *"have regard for"* such plans when they are carrying out their own functions.[205]

5.3 How well are councils protecting longfin eels?

Overall, it appears that on land outside the conservation estate, DOC has largely left the responsibility for protecting eel habitat and providing fish passage past barriers to councils.[206]

Under the RMA, councils must protect freshwater fish habitats and manage the impacts of any construction or disturbance on waterways. Councils are involved in overseeing many activities that affect the habitat and passage of longfin eels – from drain clearance and culvert installation all the way up to large hydroelectric dams and changing land use. This section raises some issues associated with these duties.

Variation in council protection of eel habitat and fish passage

There are many common activities that directly affect **longfin eel habitat**. These include:

- constructing stop banks and other river works to control floods
- straightening streams
- clearing vegetation
- building drains to improve farm land
- maintaining drains
- taking water for irrigation and water supply.

Longfin eels thrive in clear flowing stony-bottomed streams, so generally must travel further inland than shortfin eels to find good habitat. Consequently, they are more likely to encounter small barriers to upstream **fish passage** such as culverts and weirs.

The common activities listed above are generally managed by councils using rules in plans, so resource consents are seldom required. However, as noted in the previous section, different councils deal differently with these activities in their plans.

Drain clearance illustrates this variation between plans. When farm drains are cleared, eels and other fish can be scooped out and left to die, and habitat can be degraded. In the Wellington regional plan, there is no mention of protecting fish when drains are cleared, whereas in Southland, stranded fish must be returned to the water. In Marlborough clearing weeds from natural or modified water courses must be staged so that suitable ecological habitat is always retained. But there are no rules around the clearance of farm drains, which may also provide eel habitat.[207]

Councils are also inconsistent in how they deal with small barriers to fish passage. There are many such barriers. A survey of culverts, fords, diversion structures, weirs and dams in Waikato found that about half restricted fish passage in some way due to poor design or installation.[208]

As discussed in section 5.2, culverts built in Otago may be built in a way that restricts the migration of young eels and other native fish. In Auckland and Waikato, culverts must allow for fish passage and technical guidelines for their design are provided. In Southland, culverts must allow for fish passage but no technical guidelines are provided.[209]

The existence of strong provisions for fish passage and habitat protection in council plans and consents does not, of course, mean they are enforced. One of the difficulties is that checking minor activities like drain clearance and the myriad of small structures that block fish passage is not likely to be a priority for council resources.

Hydro dams and fish passage

Hydroelectric dams create a double barrier to fish passage by:

- stopping young eels from swimming upriver on their search for somewhere to live and grow
- stopping large adult eels from swimming downriver on their way to the sea to begin their long journey north to breed.

Because longfin eels live so long, some large adults living in catchments above hydro dams will have swum up before the dams were built.

Requirements to help migrating fish get past hydro dams are relatively recent. As noted in Chapter 2, it is relatively easy to help elvers up past dams through trap-and-transfer. But helping large eels down past dams is far more difficult and much less successful.

The big dam building era in New Zealand began when eels were still considered to be a pest. The last of the big dams – the Clyde – was completed in 1992 and it was built without any requirements for fish passage.[210]

Today under the RMA, councils must pay particular consideration to fish passage when assessing consent applications for a proposed dam. For example, the consent conditions for the now-withdrawn Mōkihinui dam proposal would have been likely to require that measures were implemented to help big eels down past the dam – such as placing screens on the intakes to ensure eels were not sucked into the turbines.[211, 212]

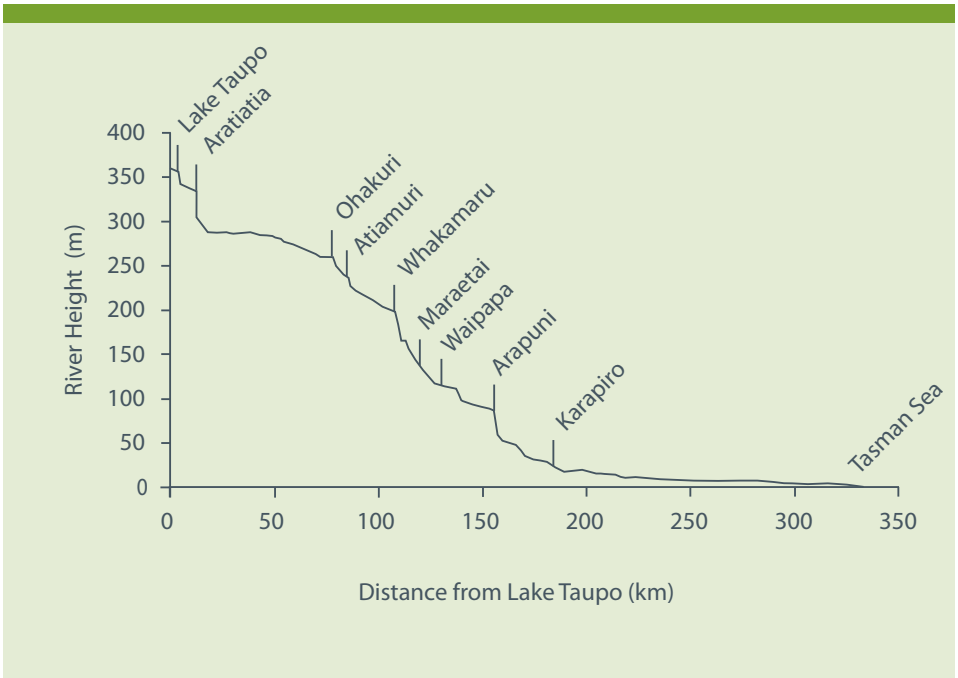
Source: Fish & Game NZ

Figure 5.4 Few eels survive the blades of hydroelectric turbines.

When resource consents for dams are renewed, requirements to provide for fish passage are sometimes included in consent conditions. These are generally focused on the easier challenge of helping elvers up past dams.

It is important to understand that trapping and transferring elvers does lead to some eels living and growing in catchments above dams, but it does very little for the long-term sustainability of the population. The probability of mature migrating eels getting down past an old dam with no modifications is effectively zero. Even if the dam is particularly 'eel-friendly', the probability is 20 percent at most.[213]

The system of eight hydroelectric dams along the Waikato River is a case in point. The resource consents for seven of the eight dams require the trap-and-transfer of elvers upstream, but there are no requirements for helping mature eels downstream. However, the owner, Mighty River Power, voluntarily constructed an experimental bypass on the lowest dam, the Karapiro, in 2011. Unfortunately, no eels were recorded using the bypass in 2012, although it will be operated again in 2013 once the migratory season begins with the autumn rain.[214]



Source: Adapted from Boubée et al. 2003

Figure 5.5 Elvers are trapped at the Karapiro Dam on the Waikato River and transferred to the reservoirs above.[215]

Protection of water quality

The decline of water quality in lowland areas of New Zealand has degraded the habitat for eels, particularly for longfins which prefer to live in flowing clear water. It is unlikely that council decisions on the protection and use of water will rest on the welfare of eels. Nevertheless, councils have an obligation to protect eels and their habitat.[216]

One promising development is contained in the Government's proposed reforms to the way freshwater is managed. It is proposed that all water bodies must meet a minimum water quality standard for *"ecosystem health and general protection for indigenous species"*. This proposal should be supported and encouraged, although its effectiveness relies on the standard being set at a level that actually protects eels and other species.

Monitoring eels – a very valuable contribution from councils

Regional councils are required to prepare 'state of the environment' reports every five years, publishing data from their monitoring programmes. As part of monitoring water quality, they are increasingly conducting fish surveys, although not necessarily in a standardised way.[217]

The fish surveys that have been undertaken by the Waikato and Otago regional councils provided extremely valuable information for the evaluation of the status of the longfin eel population in Chapter 4 of this report. Not only did each council survey fish at several hundred sites, they did so in accordance with the latest approved protocols for electric fishing. It is very encouraging that some other councils are now following their lead, although others have yet to do so.

5.4 In summary

Longfin eels are a complex and challenging creature. So too is the system by which they are managed.

For MPI, 'sustainable management' is fundamental to the operation of the QMS. Judgements on the sustainability of particular fisheries rely on scientific data and analysis. The indicators used by MPI to assess the sustainability of freshwater eel populations are inadequate, and it is hoped that the information presented in this report will be used in making decisions about the management of eel fisheries.

Further, it appears that there is a high level of reliance placed upon the Eel Working Group as part of this decision-making process. In the case of longfin eels, MPI's own guidance on good science practice points to the need for a wider and truly independent review.

But MPI is only responsible for the fishing of longfin eels, and has no direct control over other pressures on longfin eels – the loss of habitat and the barriers to fish passage. These are the responsibility of DOC and councils. In particular, DOC needs to step up to the leadership roles it has been given in the Biodiversity Strategy. Allowing the harvest of longfin eels – a species categorised as *at risk/declining* – on the conservation estate is no longer acceptable. And the development of a Freshwater Fisheries Management Plan might well be the best way to achieve more consistent protection of eels and other fish by councils.

6 Conclusions and recommendations

"There are times when we need to stop, let things rebuild, replenish. We believe it is one of those times for eels."

Rawiri Smith, Ngāti Kahungunu, Wairarapa

Like kiwi and tuatara, longfin eels are extraordinary creatures that are found only in New Zealand. If we do not take much greater action to arrest their decline, it is not just a loss to this country, but to the world.

In Europe, in Asia, and in North America, freshwater eel populations have crashed. A contributing factor is the unusual lifecycle of these fish. They begin their lives in the sea and spend many years living in rivers, lakes, and streams. Finally, they are physically transformed as they take to the sea again to spawn and produce a new generation.

The lifecycle of the New Zealand longfin eel is particularly slow. A mature longfin eel only breeds at the end of what can be a very long life. Each eel that is captured in a net, or chopped up by the turbines of a hydro dam, or left to die by the side of a cleared drain is an eel that will never breed. Similarly, an elver stopped from reaching safe habitat will never get the opportunity to begin the decades of growth needed to reach breeding age.

The weight of the scientific evidence summarised in this report is strong. Without much more active intervention, the longfin fishery will steadily shrink and the largest freshwater eel in the world will continue on its slow path to extinction.

In contrast, the shortfin eel population appears to still be in relatively good shape, although this could change, especially if there is increased pressure to harvest them because of the collapsing populations of eels in other parts of the world.

As with many environmental issues the current problem has been many years in the making. The decline in habitat and water quality, the increasing difficulties in travelling up and down streams and rivers, the extermination campaigns of the past and the growth of a commercial fishing industry have collectively combined to undermine the future of longfin eels. It is impossible to take things back to how they used to be; therefore, a way forward must be found if the longfin eel is to survive and thrive in the future.

It will take the combined efforts of central and local government, iwi groups, and individuals to set the longfin eels on a more sustainable path.

This chapter contains three recommendations, covering the following:

- Commercial fishing of longfin eels
- Protection of habitat and fish passage
- The provision of scientific advice on longfin eels

6.1 Suspend the commercial catch of longfins

For many years, the number of longfins that have been able to grow to maturity and make the trip downriver and out to sea to breed has been steadily falling. The result is that the number of very small longfins has become alarmingly low. The evidence shows that around the country there are sites where not only are there no young eels, there is also a lack of mature eels of breeding age.

Of the three types of catches for longfin eels, it is only the commercial catch that is consistently recorded. Little is known about the actual size of the customary and recreational catch. What is clear is that the commercial catch is significant and is contributing to the decline of this species.

In order for the longfin population to recover, placing a moratorium on the commercial harvest is the only way to make a difference reasonably quickly. A moratorium is a suspension of activity for a period of time, not a permanent ban. At some time in the future, it may well be possible to restart commercial harvesting. Spawning and farming eels in captivity may also provide an opportunity to take the pressure off wild eel populations and supply a valuable international market.

Currently, allowable catches for eels in the South Island combine both shortfins and longfins. A prerequisite for suspending the commercial harvest of longfins is separating allowable catches into those for shortfins and those for longfins.

During this investigation, some Māori have spoken of the desire to place rahui (bans) on the catching of eels in particular places, but it has seemed pointless because commercial fishers would not be bound by the rahui.

Decisions on changing total allowable catches are made by the Minister for Primary Industries. In law there are two stages in the decision-making process. The first is the setting of the overall total allowable catch and the second is the apportioning of this into commercial, customary and recreational allowable catches. In practice, the Minister proposes both kinds of changes in a single document that is used as the basis for the required consultation with affected parties. And as part of those discussions the significance of customary and recreational catches should also be considered.

I recommend that:

1. **The Minister for Primary Industries suspends the commercial catch of longfin eels until longfin eel stocks are shown to have recovered.**

6.2 Protect eel habitat and fish passage

Historical and current changes in land use continue to reduce eel habitat and put pressure on eel populations. For instance, eels love to live in bends in creeks under overhanging trees, so simply straightening out creeks to enable better drainage and clearing banks has an impact. But decisions on land use are very unlikely to be made with the protection of eels in mind.

Barriers to fish passage – the ability for elvers to travel upriver and for mature eels to travel downriver – are another cause of the decline of longfin eels. These barriers vary greatly in scale – from massive hydroelectric dams to small culverts and weirs. Some relatively small changes can help preserve fish passage, although getting large migrating eels down past hydro dams will always be a challenge.

There appears little consistency in the rules governing fish habitat and fish passage in council plans, or presumably in the conditions placed on resource consents. There is a need for greater oversight and co-ordination, learning from the very good work done by some councils. Some of the current proposals for reforming freshwater management and amending the Resource Management Act provide the opportunity to lift performance.

The Department of Conservation is well placed to take on a leadership role for protecting this threatened species. It already has the lead agency role under the Biodiversity Strategy, and has a range of tools at its disposal – in particular, the ability to prepare a Freshwater Fisheries Management Plan to give guidance to councils and others. Such a plan has never been developed.

A Freshwater Fisheries Management Plan could include:

- guidance for designing and improving culverts and other barriers to eel passage
- guidance on the best ways to protect eels from the effects of activities such as drain clearance and water pumping
- the relationship between the Resource Management Act and the Freshwater Fisheries Regulations, clarifying the circumstances in which each would apply.

DOC also needs to lead by example and ensure that longfin eels are not fished on the conservation estate, at least until it is clear that the species can be harvested sustainably.

I recommend that:

2. **The Minister of Conservation directs his officials to use the policy mechanisms available to them to increase the protection for longfin eels and other threatened migratory fish.**

6.3 The provision of scientific advice on longfin eels

New Zealand's extensive Quota Management System is impressive – setting sustainable harvests and trading quota is widely acknowledged as the best way to manage commercial fisheries. The plans and processes outlined in the various documents that govern the management of the eel fisheries should ensure good outcomes. But despite these plans and processes the future prospects for the longfin eel are not good. Indeed, it has been one of the surprising aspects of this investigation that, at least in recent times, MPI appears to have developed an entrenched and narrow selection of the scientific information on the status of the longfin eel population.

The three main indicators used by MPI have serious limitations. Indeed all scientific information is limited and uncertain to some extent. That is why in this report the widest selection of indicators available on the status of longfin eels was used, and extensive notes and sources have been provided to make the analysis as transparent as possible.

The first recommendation in this report is that commercial fishing of longfin eels cease at least for a time. However, the Fisheries Act requires that the Minister for Primary Industries consider advice from his officials before he makes such a decision.

This investigation has raised a number of questions about both the quality of the scientific advice and the management decisions based on it. The conclusions of this report differ from those which MPI has held up to now.

Where there is substantial uncertainty and a range of conflicting scientific opinions (among other things), the Ministry's Research and Science Information Standards state that independent expert peer review should be undertaken. This is clearly the case for the longfin eel.

Such an independent review would allow for greater transparency and public trust. It may be necessary to include at least one international freshwater eel scientist given the similar concerns overseas.

The results of this independent review will allow the Minister to consider the first recommendation in this report.

I recommend that:

3. **The Minister for Primary Industries directs his officials to establish a fully-independent expert peer review panel to assess the full range of information available on the status of the longfin eel population.**

Notes

1 The origin of anguillid eels has been dated to 60–50 million years ago; Aoyama, 2003, p. 25. The ancestors of modern New Zealand eels (like *Anguilla dieffenbachii*) arrived in New Zealand at least 23 million years ago (around the early Miocene); see http://www.doc.govt.nz/conservation/native-animals/fish/facts/eel/

2 Crook, 2010, p. 2.

3 The shortfin eel has a shorter lifecycle and does not grow as big as the longfin. It is also found in Australia and several Pacific islands, so are not endemic to New Zealand. A third species, the Australian longfin eel (*Anguilla reinhardtii* – the spotted eel) is sometimes found in the upper North Island, but is not common.

4 Te Taumutu Rūnanga, 2003, p. 103.

5 This is consistent with advice from the Ministry for Primary Industries that longfin eels are *"more susceptible to overexploitation than shortfins because of their limited geographic distribution (confined to New Zealand and offshore islands) and greater longevity".* Ministry for Primary Industries, 2012a.

6 The third eel species found in New Zealand – the Australian longfin eel – has speckled colouring on its back, making it quite different in appearance.

7 Allibone et al., 2010, p. 277. The threat status of New Zealand aquatic organisms is currently being reviewed: see http://www.doc.govt.nz/getting-involved/consultations/current/new-listing-of-the-threatened-status-of-nz-aquatic-organisms/

8 The lifecycle of shortfin eels is the same as that of longfin eels except they do not live as long and it is thought that they spawn in different places.

9 Dekker et al., 2003. For each series, the index is relative to the pre-exploitation average population size.

10 In Japan the eel lifecycle has been completed in captivity, but they are still unable to produce large numbers of eels that could support a commercial eel farming enterprise (Japan Fisheries Association, 2010, and Paul Decker from the Mahurangi Technical Institute, pers. comm. 19 March, 2013). http://www.suisankai.or.jp/topics_e/isaribi/isaribi_66.pdf

11 The IUCN Red List of Threatened Species. *Anguilla anguilla.* http://www.iucnredlist.org/details/summary/60344/0 [Accessed 25 February 2013].

12 Statement by Secretary-General of CITES. Press release 13 March 2009. *CITES gets to grips with slippery problem.* http://www.cites.org/eng/news/pr/2009/090313_eel.shtml [Accessed 25 February 2013].

13 European Commission regulation, EU 1100/2007. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:248:0017:0023:EN:PDF [Accessed 25 February 2013].

14 The Japanese eel was added to the endangered category of the Japanese Red List. *The Daily Yomiuri Online*. 2 February 2013. Japanese eel now endangered. http://www.yomiuri.co.jp/dy/national/T130201005387.htm [Accessed 25 February 2013].

15 *The Economist.* 11 August 2012. Japan and the world's troubled eels, slip-sliding away. http://www.economist.com/node/21560303 [Accessed 25 February 2013].

16 Fisheries Agency. 2012. *Japan's fishery at a glance*. p. 10. http://www.jfa.maff.go.jp/j/kikaku/23zudemiru_en2.pdf

17 Figure from between 1997 and 2007. Crook, 2010, p. 18.

18 *Reuters*, 16 May 2012. A 'gold rush' for Maine's baby eel fishermen. http://www.reuters.com/article/2012/05/16/us-usa-eels-maine-idUSBRE84F14K20120516 *The Post and Courier*, 15 July 2012. Tiny, elusive eels like 'gold'. http://www.postandcourier.com/article/20120715/PC16/120719466/1072/tiny-elusive-eels-like-gold

19 Westlake, 14 September 2012. Japanese eel added to Environment Ministry's 'vulnerable' list. *Japan Daily Press.* http://japandailypress.com/japanese-eel-added-to-environment-ministrys-vulnerable-list-1412167

20 Richkus and Whalen, 2000.

21 MIT Sea Grant Coastal Resources. June 2006. *American eel fact sheet.* http://massbay.mit.edu/seafood/americaneel.pdf

22 U.S. Fish and Wildlife Service. 21 December 2011. *Newsroom: The American eel.* http://www.fws.gov/northeast/newsroom/eels.html

23 The sport fishing of eels has also been banned everywhere in Ontario. Ontario Ministry of Natural Resources' Species At Risk in Ontario (SARA) list classifies American eels as threatened http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/276722.html [Accessed 25 February 2013].

24 Saunders, 1965, p. 27. This practice is still used at coastal lakes such as Wairewa (Lake Forsyth, Canterbury). Keane, B. *Te hopu tuna – eeling. Eel migrations – heke tuna*. Te Ara – the Encyclopedia of New Zealand. Updated 22 September 2012. http://www.teara.govt.nz/en/te-hopu-tuna-eeling/page-8

25 As late as 1941, one scientist recorded a shoal of glass eels coming up the Waikato River that was 4.5 metres wide and 3 metres deep, and took 8 hours to pass by. Cairns, 1941, cited in Jellyman, 2012, p. 30.

26 McDowall, 2011, p. 399.

27 Kaitiaki are Authorising Representatives until such time as the customary regulations are implemented.

28 Deed of Settlement of Historical Claims, Ngati Manawa and the Sovereign in Right of New Zealand. http://nz01.terabyte.co.nz/ots/DocumentLibrary%5CNgatiManawaDeedofSettlement.pdf

29 Meeting of the Hawke's Bay Regional Council Māori Committee Tuesday 28 August 2012. Hawke's Bay Regional Council Environment and Services Committee, Wednesday, 20 February 2013, Subject: Longfin eel – update on progress to date.

30 Fires were set deliberately for various reasons such as to encourage edible plants and to make travel easier. Some of the burning may have been accidental. McWethy et al., 2010.

31 Ministry for the Environment, 1997

32 In addition, use of surface water for irrigation – from streams, rivers and lakes – can reduce the amount of water that remains. This can lead to higher water temperatures and, in severe cases, can lead to longer and more frequent events where the waterway dries up in the summer.

33 New Zealand Government, 2013. *Freshwater reform 2013 and beyond* p. 13.

34 Excessive growth of weeds and algae can cause large fluctuations in the amount of oxygen dissolved in the water – due to the plants producing oxygen in the day as they photosynthesise and using it up at night as they respire. In extreme situations, oxygen levels can drop low enough to kill fish. How low dissolved oxygen levels drop in a river, and how long they stay low, are the critical factors determining invertebrate and fish survival. To kill fish, dissolved oxygen levels need to be very low (10-30%) for some time – generally a period of days (Landman et al. 2005).

35 Gibbs, 2009. Proposed One Plan – Section 42A report of Mr Max Martin Gibbs. Horizons Regional Council; Wood et al. 2010. New Zealand guidelines for cyanobacteria in recreational fresh water: Interim guidelines. Ministry of Health and MfE.

36 Jellyman, 2009, p. 50

37 Pond, 1997, p. 139.

38 *The Dominion*, 9 August 1943. War on eels, Acclimatization Society's decision.

39 In 1948 the Hāwera Māori Welfare Officer warned that Māori might go hungry if acclimatisation societies destroyed any more eels in South Taranaki. Park, 2001, p. 551.

40 An important study showed that removing as many eels as possible from an isolated stretch of the Waimakariri River led to a big increase in the population of trout. However, the trout grew much more slowly and their condition was poor. The eels had been playing a valuable role culling the eggs and tiny trout. Burnet, 1968. Extermination campaigns did continue until 1977. McDowall, 1994, p. 124.

41 There are also natural barriers that prevent eels swimming upstream. One is the Huka Falls and consequently there have never been eels living in the catchment of Lake Taupō. Another is the Ōkere Falls on the Kaituna River which prevents eels from accessing Lakes Rotoiti and Rotorua and their tributaries. See Graynoth et al., 2008, p. 20.

42 A fish ladder was built at the Waitaki Dam in 1934, but was unsuccessful. A fish pass was installed at the Arnold Dam in 1932 but this was closed in 1938 to reduce the eel population and improve the trout fishery. In the 1970s, thousands of elvers still frequently invaded the Arnold River powerhouse – unable to migrate past the dam. Martin et al., 2009. p. 4.

43 Graham, 1974, p. 130.

44 Jellyman, 2012, p. 25.

45 By the provision of 'facilities' such as fish ladders or by trapping and transferring fish. Freshwater Fisheries Regulations 1983. The first regulations dated from 1906 although these were focused on getting trout and salmon past barriers. Regulations in 1947 emphasised the desirability of passage for these fish, whilst maintaining the barriers to eels. With the passing of the Resource Management Act in 1991, the owners of existing dams were required to provide better fish passage for native fish when resource consents came up for renewal.

46 PCE questionnaire to hydro power companies, March 2013.-

47 Boubée and Jellyman, 2009, Figure 1.

48 The risk of death is lower on the Karapiro and Waipapa dams due to a different turbine design. Also, eels usually migrate when rivers are high which means if water is flowing down spillways there is a chance some will make it downstream.

49 Graynoth et al., 2008.

50 Allibone, 1999.

51 Jellyman, 2012, pp. 6, 51.

52 Email from MPI, 28 March 2013.

53 There is only limited data on how frequently sites are fished. One study in Southland found that the main branch of the Mataura River was fished several times each year, major tributaries were fished once a year, and smaller streams were not fished at all (Graynoth et al., 2008). Other information from the South Island suggests that large lakes and rivers are fished each year, while smaller sites could be fished less frequently (for example, once every 3, 5, or 10 years), depending on the experience of the fisher (Bill Chisholm, pers. comm.)

54 Information in this section from Jellyman, 2012, pp. 12, 13–15, 54–57.

55 See Appendix 2 for more detail of commercial catches of longfin and shortfin eels for the North and South Islands since their introduction into the QMS.

56 Data from Ministry for Primary Industries, 2012a, p. 229.

57 Bill Chisholm, Chisholm Associates, pers. comm., 15 March 2013.

58 Seafood New Zealand, 2013. Between 2005 and 2010 total revenue from eel exports was $29.2 m (Jellyman 2012).

59 Data from Ministry for Primary Industries, 2012a, p. 230. 60 This can take as little as 2 years. NIWA. n.d. *Eel.* http://www.niwa.co.nz/our-science/aquaculture/aquaculture-species/eel

61 Paul Decker, Mahurangi Technical Institute, pers. comm., 19 March 2013.

62 *Rodney Times*. 9 February 2012. Eel farming could be the way ahead.

63 Paul Decker, pers. comm., 25 July 2012.

64 Although longfin eels tend to be slower growing in the wild, they would probably grow at a similar rate to shortfins in captivity where temperature and feeding can promote faster growth.

65 Paul Decker, Mahurangi Technical Institute, pers. comm., 19 March 2013.

66 The Ministry of Agriculture and Forestry was renamed the Ministry for Primary Industries in 2012, following a merger of the Ministry of Fisheries and the Ministry of Agriculture and Forestry in 2011.

67 Fisheries Act 1996. The phrase 'ensuring sustainability' is defined in s 8 as *"maintaining the potential of fisheries resources to meet the reasonably foreseeable needs of future generations; and avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment"* and is backed by a set of environmental principles in s 9.

68 Ministry of Fisheries, 2009, p 5.

69 The QMS was first introduced in 1986 and is built around the concept of Individual Transferable Quotas. Similar systems are used to manage fisheries in a number of other countries including Australia and the United States.

70 While the Fisheries Act and its QMS are administered by the Ministry, it is the Minister for Primary Industries who is responsible for making final decisions. However, the Minister makes decisions based on advice provided by MPI, following consultation with interest groups.

71 Ministry of Fisheries, 2011a. The Draft Plan states on page i that *"The Plan has not been finalised. It will be trialled for one to two years and feedback and input will be collected to improve and finalise the Plan."* As of April 2013, the Plan has not yet been finalised.

72 Fisheries (Commercial Fishing) Regulations 2001, reg 31(4), 52, 75. Commercial eel fishers are required to fit fyke nets with minimum-sized escape tubes to allow smaller eels to escape. The minimum size is 25 mm in the North Island and Chatham Islands and 31 mm in the South Island. Commercial fishers in the North Island have been using 31mm escape tubes voluntarily. MPI has released a discussion paper proposing to make the 31mm escape tubes mandatory in the North Island also (Amendments to commercial freshwater eel fishing regulations, MPI Discussion Paper No: 2013/07).

73 Fisheries (Commercial Fishing) Regulations 2001, s 50. Four kilograms is the **average** weight of a migrating female, so this limit does not prevent the fishing of all migrating females. Commercial fishers have recently begun to record the number of eels weighing 4 kg or more that are caught and released.

74 MPI has also begun to work with commercial fishers in the South Island to collect information on the numbers of eels weighing more than four kilograms that have been caught and released.

75 Fisheries (Amateur Fishing) Regulations 1986, s 6.

76 A further 17 percent of the national stock is estimated to be in waters that are in reserves in the upper reaches but where migrating eels could be fished lower down. Fishing can be permitted in some of these reserves. Another 25 percent of the national stock is estimated to be in small streams that appeared to be fished only rarely (Graynoth et al., 2008).

77 Mahinga mātaitai (areas managed by tangata whenua, usually reserved for customary fishing only) are established under s 186 of the Fisheries Act, the Fisheries (Kaimoana Customary Fishing) Regulations 1998, ss 18–32, and Fisheries (South Island Customary Fishing) Regulations 1999, ss 17–29.

78 These areas include the interconnected Lakes Taharoa, Numiti, Rotoroa and Lake Harihari, south of Kawhia; Whakaki Lagoon, east of Wairoa; Lake Poukawa (Te Hauke), near Hastings; and Lake Kohangapiripiri and Lake Kohangatera (Pencarrow Lakes), and their respective tributaries, Wellington.

79 There are four North Island quota management areas (QMAs) for longfins (LFE20-23); six South Island QMAs for longfin and shortfin combined (ANG11-16); and one Chatham Island QMA (LFE17).

80 Fisheries Act 1996, s 10.

81 Fish species can be added to Schedule 3 if:

- *it is not possible, because of the biological characteristics of the species, to estimate maximum sustainable yield; or*
- *a national allocation for New Zealand has been determined as part of an international agreement; or*
- *the stock is managed on a rotational or enhanced basis; or*
- *the stock comprises 1 or more highly migratory species.*

82 Fisheries Act 1996, s 14.

83 Some coastal fish spend time in freshwater are also in the QMS (e.g. grey mullet and black flounder).

84 Chatham Island stocks are also managed within the QMS but have had little reported catch to date, according to Ministry of Agriculture and Forestry, 2012.

85 Data from Ministry for Primary Industries, 2012a, pp. 231–232. "Fishing years" end on 30 September. In this figure, the year 2005, for instance, refers to the year from 1 October 2004 to 30 September 2005.

86 In practice, the Minister makes decisions on allocation of catch limits in the same process as decisions on the total allowable catches. The Minister may make an allowance for other sources of fishing-related mortality, such as predation by other eels within fyke nets.

87 More formally, the quantity of catch that an individual commercial fisher may take is expressed in the form of an Annual Catch Entitlement, or ACE. ACE is derived from the fisher's quota shares in a stock, of which there is always 100,000,000 shares in every fish stock in New Zealand. If a commercial fisher owns 5% of the quota shares for a stock, then that person's ACE will be 5% of the total allowable commercial catch set for the relevant stock.

88 Customary fishing in the South Island is covered by the Fisheries (South Island Customary Fishing) Regulations 1999. In the North Island, customary fishing is covered by the Fisheries (Kaimoana Customary Fishing) Regulations 1998 if kaitiaki have been appointed, otherwise by the Fisheries (Amateur Fishing) Regulations 1986. There are two exceptions. As a result of the Waikato-Tainui co-governance arrangement, customary fishing in the Waikato River is governed by the Waikato-Tainui (Waikato River Fisheries) Regulations 2011. Likewise, as a result of the Te Arawa Lakes Settlement Act 2006, customary fishing in the Te Arawa Lakes is governed by the Te Arawa Lakes (Fisheries) Regulations 2006.

89 Fisheries (Amateur Fishing) Regulations 1986, s 6A. The total allowable recreational catch for the North Island has been set at a relatively high level, as a way to account for the fact that many Māori may be catching eels outside the customary harvest regulations.

90 Te Ohu Kaimoana is currently taking steps to develop systems iwi and hapu can use to improve their information on customary harvesting including an online system for issuing customary permits and reporting catch. (Meeting with Te Ohu Kaimoana, 19 March, 2013).

91 Fisheries (Kaimoana Customary Fishing) Regulations 1998, s 39; and Fisheries (South Island Customary Fishing) Regulations 1999, s 36. The Fisheries (Amateur Fishing) Regulations 1986 do not require reporting of customary catch.

92 Ministry for Primary Industries, emails to PCE, 21 February and 11 March 2013. Customary fishing reports for Te Rūnanga o Ngāi Tahu (which covers the majority of the South Island, and is for longfin and shortfin combined) showed that for the 2005 fishing year, 5,503 individual eels and 500 kg of eels were harvested under customary authorisation. For the 2006 fishing year, the reported harvest was 2,256 eels. According to MPI, it is not possible to draw comprehensive conclusions about customary harvest in the North Island and Chatham Islands because information is insufficient (Email from MPI, 28 March, 2013).

93 Ministry for Primary Industries, email to PCE, 21 February 2013. In another email to PCE on 19 March 2013, MPI stated that there is insufficient data for most North Island eel stocks to indicate whether customary needs are being met, but that there are sufficient numbers of eels to meet customary needs in the South Island except in one area.

94 Ministry of Fisheries, 2004, p. 55.

95 Jellyman, 2012, pp. 10–14.

96 Ministry for Primary Industries, 2012a, p. 232.

97 Conservation Act 1987, s 6(ab).

98 The Minister of Conservation is also responsible for the New Zealand Coastal Policy Statement, which relates to the day-to-day management of the coastal environment (RMA 1991, s 28). This includes management of estuaries and tidal reaches of rivers where glass eels begin their transition to freshwater. It is also the last stop for migrating eels on their return journey to the breeding grounds.

99 Department of Conservation and Ministry for the Environment, 2000, Part 2, pp. 6, 45.

100 Department of Conservation and Ministry for the Environment, 2000, p. 54.

101 Green and Clarkson, 2006b, p. 22.

102 Department of Conservation, 2013, p. 5.

103 The Minister is the decision-maker under the Act, granting concessions and approving plans. However, in practice, concession decisions are often delegated to DOC officials. The New Zealand Conservation Authority advises the Minister on plans and on concessions in national parks.

104 Under Policy 4.4(g) of the General Policy for National Parks, commercial eel fishing in national parks can be granted in cases where historical commercial eeling legally occurred before the national park was created. Customary and recreational fishing for eels on some of the conservation estate can also be approved by the Minister. For example, customary fishing using traditional methods is allowed in Te Urewera National Park; Department of Conservation, 2003, p.135. Permission has never been given for recreational fishing on public conservation land.

105 The Conservation Act mandates DOC to 'advocate' for conservation in RMA and other processes. Because of this, the Director-General is generally considered an 'affected party' when there are notified consents for activities that could affect freshwater fish.

106 Freshwater Fisheries Regulations 1983, Part 6.

107 Conservation Act 1987, Part 3A, s 17J. Under the Conservation Act, DOC can also use other tools such as General Policy statements, although these only apply to DOC land.

108 Submissions were formerly done independently by each conservancy, but after recent restructuring they are now done by a 'shared services' team under the direction of DOC's national office. DOC generally submits on all Regional Plans and some District Plans.

109 The Environment Court has ruled that *"[w]here an approval by [DOC] is required, that approval is still required even if an RMA approval [by a plan or a consent] has been given"*. Department of Conservation, 2011, 'Guidance on managing fish and biota passage in freshwater and estuarine systems', Draft.

110 Freshwater Fisheries Regulations 1983, Part 6: *"no person shall construct any culvert or ford in any natural river, stream, or water in such a way that the passage of fish would be impeded, without the written approval of the Director-General incorporating such conditions as the Director-General thinks appropriate"*.

111 For example, the concession conditions for Trustpower's Matiri hydro dam on stewardship land bordering Kahurangi National Park includes eight provisions specifically aimed at protecting fish passage. DOC Concession NM-28243-OTH for New Zealand Energy Ltd, 29 June 2011.

112 Conservation Act 1987, Part 3A, s 17J.

113 Resource Management Act 1991, s 61(2)(a)(i) and s 66(92)(c)(i) for regional councils; and s 74(2)(b)(i) for territorial authorities.

114 Fisheries Act 1996, s 11(2)(b).

115 Resource Management Act 1991, s 45.

116 For example, Objective A1 of the National Policy Statement on Freshwater Management is to *"safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water, in sustainably managing the use and development of land, and of discharges of contaminants."*

117 Ministry for the Environment 2013.

118 Resource Management Act 1991, s 6(c) provides for the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna. S 7(h) provides for the protection of the habitat of trout and salmon – this includes most places where eels do or could live. Councils are subject to these provisions when writing policies and rules. At the district level, for instance, Method 16.4.4 in the Dunedin City District Plan identifies areas of significant indigenous vegetation and significant habitats of indigenous fauna (Areas of Significant Conservation Value) for inclusion in a Schedule for protection. At the regional level, Rule 13.2 of Otago's Regional Water Plan regulates effects of structures on waterways, such as building a dam on a river.

119 Resource Management Act 1991, s 6(a), (c), (e), s 7(h), s 13. These requirements are also reflected in local government plans. For instance, Policy 4.13.7 in Otago's Regional Water Plan recognises the importance to Kāi Tahu cultural and spiritual beliefs of mahika kai (food gathering) species that are migratory and at different stages of their lifecycle in different habitats throughout a catchment. In response, the Regional Water Plan has set Objective 5.3.2 to maintain or enhance the spiritual and cultural beliefs, values and uses of significance to Kāi Tahu, identified in Schedule 1D, as these relate to Otago's lakes and rivers.

120 Even if longfin eels are in serious decline, it will be many decades before they are biologically extinct because they live so long. But they could well be in danger of 'functional extinction'.

121 See for instance: *"It is wrong to assume that science is about certainty, for in most of science certainty is not possible; rather, it is largely about reducing uncertainty."* Science and New Zealand's future: Reflections from the Transit of Venus Forum: A report to the Prime Minister from Sir Peter Gluckman, p. 4.

122 Graynoth et al., 2008.

123 More correctly, it is possible to weigh a catch of glass eels. And because glass eels are all the same size, the number is proportional to the weight.

124 Jellyman, 2012, pp. 29–31.

125 Jellyman et al., 2000.

126 Jellyman, 2012, pp. 29–30.

127 The time taken for a shoal to pass has fallen by 75% (Jellyman et al., 2009). The same study found that the proportion of glass eels that were longfins had declined from 12% to 3%.

128 A total of 28 surveys were conducted for longfin eels, while shortfins were surveyed 25 times (Jellyman, 2012, Appendix A.)

129 The exact age of eels can be determined by analysing their otoliths – a small ear bone.

130 Note that these surveys do not provide information on the numbers of glass eels in the populations, as any young eels have grown into elvers (>70mm in length) by the time they reach the habitats that were surveyed.

131 A number of criticisms of this analysis have been made by MPI and outlined in an email to the Commissioner's office (20 February 2013). For instance, it is suggested that because the data comes from many different rivers and streams, it is unreliable. However, it is precisely because over 10,000 longfins have been measured in many different sites across the country that the evidence for the overall pattern is so strong. The Eel Working Group concluded that electric fishing *"may not effectively capture smaller longfin elvers, although it did capture smaller shortfins"*. This appears to be in direct contradiction to their criticism of the analysis done using the Freshwater Fish Database, in which they suggested that electric fishing captures mostly elvers. The explanation proposed by the Eel Working Group is that longfin elvers may burrow deeper into the stream bed and therefore not be stunned by the electric current. There is no evidence for this theory. Further, the New Zealand Freshwater Fish Sampling Protocols for wadeable rivers and streams state that electric fishing is an unbiased method for longfin or shortfin eels, and does not under-sample either species (Joy et al., 2013, p. 8). These protocols were developed in consultation with 16 fish experts.

132 Unpublished data provided to PCE by the councils in March 2013. The surveys have been done as part of a standardised state of the environment monitoring programme. Surveys were done at 90 sites in Waikato over the last three years and at 44 sites in Otago over the last six years.

133 Joy et al., 2013.

134 In the Waikato samples, 1,059 longfins were measured. In the Otago surveys, 1,026 longfins were measured.

135 Females grow to larger sizes than males. In the Waikato surveys, 1,450 shortfins were also measured. As for the longfins, the proportion in the smallest size class (51–100 mm) is less than the proportion in the second smallest size class (101–150 mm). But the difference is much smaller than for longfins. In the Otago samples, 297 shortfins were measured, with the same patterns observed as for the Waikato shortfins.

136 These were sites deemed to be typical longfin habitat because they contained at least twice as many longfins as shortfins.

137 Larger female fish are generally much more fecund (produce many more eggs) than smaller females of the same species. For example, one study of red snapper showed that one female produced the same number of eggs as 212 smaller females (Cochrane and Garcia, 2009).

138 In both the Waikato and Otago surveys, the proportion of **shortfin** eels with a length between 50 and 100 mm (the first bar) is smaller than the proportion with a length between 100 and 149 mm (the second bar), although the difference is much smaller. This suggests that the sustainability of the shortfin eel population cannot be taken for granted.

139 The Freshwater Fish Database contains over 30,000 records of where different species of fish have been found across the country over the past 60 years. It contains data on the location of sample sites, the fish species present, abundance and size of fish, sampling methods and a physical description of each site. Records are contributed voluntarily by staff from NIWA and other Crown Research Institutes, the Department of Conservation, regional councils, environmental consultants, universities, Fish and Game New Zealand, schools, and members of the public.

140 Jellyman, 2012, pp. 39–40. The results are strongly statistically significant ($R^2 = 0.43$, $p < 0.001$). The analysis used only samples that were obtained through 'electric fishing' and that contained a full species list for the site. The proportions of surveyed sites that contained longfins were calculated for each year.

141 A number of criticisms of this analysis have been made by MPI and outlined in an email to the Commissioner's office (20 February 2013). For instance, it was suggested that electric fishing operations catch mostly small eels, which appears to be in direct contradiction to their criticism of the results represented in Figure 4.2. It was also suggested that changes over time such as the kinds of sites or the effort expended could have introduced bias into the results. However, the data was screened for such trends and none that affect the conclusions were found. Another suggestion was that there has been an increase in the recording of dry sites which would *"obviously result in an increase in zero catches over time"*. It is the case that since 2005, NIWA staff have started entering survey sites that were dry at the time of the survey – such as streams that dry up in the summer – and where no fish were recorded. These amount to 1% of the sites in the database (NIWA Database Administrator, pers. comm., 12 March 2013) and do not affect the strong trend detected in the analysis. In addition, sites above barriers like hydro dams, which would contain fewer or no eels, were excluded from the analysis. The conclusion that the spatial distribution of longfin eels is shrinking is robust.

142 Jellyman, 2012, p. 40.

143 Several studies have demonstrated density-dependent changes in survival in eel populations (see Bevacqua et al., 2011; Ibbotson et al., 2002; Vollestad and Jonsson, 1988).

144 Ultimately, if numbers get too low, not enough male and female eels will make it to the spawning grounds to ensure that individuals can find each other to fertilise the eggs and produce the next generation. This type of phenomenon is known as the "Allee effect".

145 The calculation of CPUE for eels is standardised using a statistical analysis that incorporates information on the recent flow conditions at the fishing site, the numbers of nets used, and the experience and equipment of the fisher. Over 90,000 records have been included in the analyses. See Beentjes and Dunn, 2013 for a more detailed explanation.

146 Beentjes and Dunn, 2010.

147 Beentjes and Dunn, 2013.

148 For a discussion of the problems associated with using CPUE data to assess the status of fisheries, see Maunder et al., 2006.

149 As an alternative example, CPUE estimates are calculated for tītī (sooty shearwaters) caught by Māori as part of a customary harvest on islands around Rakiura/Stewart Island. In the case of tītī, the same people harvest the same sites each year, so serial depletion is not an issue. The measure of effort includes the number of people harvesting, the time they spend harvesting, and the time taken to process the birds into the 'finished' product. (See McKechnie et al., 2010).

150 Information in this section has been taken from Jellyman, 2012, pp. 31–36.

151 These are Piripāua Dam, below Lake Waikaremoana on the East Cape of the North Island and Māraroa Weir, below Lake Manapōuri in Fiordland. Jellyman states that the results of linear regression analysis on the numbers of elvers at the seven monitoring sites indicate a strong trend towards increased abundance of longfins and shortfins (Jellyman, 2012, p. 35). This is not correct because so few of the results are statistically significant.

152 Graynoth et al., 2008.

153 Fisheries Act 1996, s 10 (a). *"Best available information"* is defined in s 2(10*)* as *"the best information that, in the particular circumstances, is available without unreasonable cost, effort, or time."* None of the information presented in this chapter required new research of any kind.

154 Ministry for Primary Industries (MPI). 2012b.

155 Ministry of Fisheries, 2011a, Foreword. The quotation above is from p. 9. The Ministry of Fisheries was subsumed into the Ministry of Agriculture and Forestry (MAF) in 2011. MAF was subsequently renamed Ministry for Primary Industries (MPI) in 2012.

156 Ministry of Fisheries, 2007, p. 214.

157 MPI has stated that catches of New Zealand eels have been limited by reduced market value during the last few years and not the inability of fishers to catch the TACC (Email from MPI 19 March 2013). However, in the 2007 Final Advice Paper, the then Ministry of Fisheries stated that the *"on-going trend of reduced commercial catches in the North Island is more likely to be linked to the depleted state of the fishery, rather than other factors that might affect fishing success."* (Ministry of Fisheries, 2007). Based on the analysis in this report, it is difficult to determine which of the Ministry's interpretations of trends in actual commercial catch is correct.

158 In 2012 the first "Annual Review of Freshwater Fisheries" was produced by MAF (now MPI). This also contained some assessment of the state of the eel fisheries.

159 Email from Bill Chisholm, 19 February 2013.

160 Ministry of Fisheries, 2011b. The five principles are: independent scientific *peer review* should be carried out, information should be *relevant* to fisheries management; information should have high *integrity,* including identification of any uncertainties; information should be reported *objectively* without bias; and should *reliably* reflect the true situation.

161 Email from MPI to PCE, 12 March 2013. "… there is no reason to believe that the CPUE and elver data will not get a ranking of 1."

162 Letter from Deputy Director-General of MPI to PCE, 26 February 2013.

163 Final Note, Eel Working Group Meeting, 11 October 2012. The Working Group noted (inter alia) *"Low proportion of 0–9cm longfin eels in all of the samples, regardless of stream or sampling year, was an unexpected result. It is not clear whether this is the result of a lack of recruiting longfin eels when sampling was done or whether this had something to do with catch method. Extensive sampling of riffles (primary habitat of young longfin eels) and high proportions of 0–9cm shortfin eels suggest that method may not be the issue."*

164 Email from MPI to PCE, 20 February 2013.

165 Dr Don Jellyman has been commissioned to produce an *"assessment of the status of longfin eel stocks, integrating all the latest research results and other information."* Letter from MPI to PCE, 30 October 2012. The meeting to assess Dr Jellyman's report is scheduled for 23 April 2013. (Email from MPI, 26 March 2013).

166 Ministry of Fisheries, 2011b.

167 *"The Plan provides for transparent and accountable management by setting out objectives and describing how performance against these objectives will be measured and how the objectives will be achieved."* Ministry of Fisheries, 2011a, Foreword.

168 Ministry of Fisheries, 2011a, p. 18.

169 Ministry of Agriculture and Forestry, 2012, p. 11. In such cases, MPI states that default target of 40% of the original un-fished population should apply. (Email from MPI, 26 March 2013). This target is not widely stated or used in their reporting.

170 Cochrane and Garcia, 2009. The current target for the European eel is 40% (EU Directive, 2007), although Box 4.1 shows that breeding European eels have already fallen to 20% of 'unfished' levels.

171 Graynoth et al., 2008.

172 Ministry for Primary Industries, 2012a.

173 Ministry of Fisheries, 2008, p. 9. The 10% is a 'hard' limit. There is also a 20% 'soft' limit for harvested fish species which triggers a formal, time-constrained rebuilding plan. http://fs.fish.govt.nz/Doc/16543/harveststrategyfinal.pdf.ashx

174 Of further concern is MPI's intent to set management targets for eel fisheries based primarily on the CPUE indicator, rather than setting a target based on biomass (Ministry of Agriculture and Forestry, 2012, p. 22).

175 Email from Claudine Gibson, Auckland Council, Convenor of the IUCN process for ranking longfin eels.

176 Decline over a 24-year period. IUCN Red List of Threatened Species. n.d. *Anguilla anguilla*. http://www.iucnredlist.org/details/60344/0

177 Estimated decline over a 20-year period. As noted previously, glass eels are not measured in New Zealand because they are not caught commercially. This estimate is based on Jellyman et al., 2000.

178 International Union for Conservation of Nature, 2010. In Sweden, spawning escapement has been estimated to have fallen by 87%. Dekker et. al., 2011, p. 45. http://www.slu.se/Documents/externwebben/akvatiska-resurser/Sidan%20Publikationer/Aqua%20reports%202011_2.pdf

179 Graynoth et al., 2008.

180 This decline in catch took place over 37 years from its peak in 1968 to its level in 2005. IUCN Red List of Threatened Species. n.d. *Anguilla anguilla.* http://www.iucnredlist.org/details/60344/0

181 This decline in catch took place over 18 years from its peak in 1993 to its level in 2011. Ministry for Primary Industries, 2012a, p. 230.

182 *"The 1997 Deed of Settlement between the Crown and Ngai Tahu of 1997 records that shortfin and longfin should be managed separately where practicable."* Ministry of Fisheries, 2007, p. 246.

183 MPI email to PCE, 19 March 2013.

184 *"There is sufficient science information now available to redefine the combined eel stock into shortfin and longfin for the quota management areas of the South Island"*. Ministry for Primary Industries, 2012a.

185 Fisheries Act 1996, s 25. The Minister can *"alter a quota management area or quota management areas"* (which includes separating species) in two ways: with the agreement of 75% of quota holders (s 25A) or unilaterally if it is required to ensure sustainability (s 25B).

186 MPI notes on its website that management measures for longfin eels include *"commercial fishing in National Parks and Reserves being generally prohibited"*. However, it is then stated that *"this provides significant protection to eels as about 33% of New Zealand is within protected areas"*. These statements are confusing. Only about one-eighth of New Zealand lies within national parks and reserves, and fish passage to the sea is blocked in some cases by waterfalls and dams, further reducing the amount of eel habitat that is actually protected. Ministry for Primary Industries. n.d. *Sustainable management of longfin eels* http://www.mpi.govt.nz/news-resources/news/sustainable-management-of-longfin-eels

187 West Coast Tai Poutini Conservancy: Review of a new Application for Eel Fishing. File PAC 11 17 01. However, the same advice states that *"One of the functions of the Department is, subject to relevant legislation and directions of the Minister, to preserve so far as practicable all indigenous freshwater fisheries…"* (p. 24)

188 DOC Financial Review 2011/12, Supplementary Question 137.

189 First Determination Report to the Conservator, Wellington Hawke's Bay, Application for concession by Graham Higginson (p. 15). This application was for a concession to fish for shortfin eels (and black flounder) and was rejected.

190 Letter from the New Zealand Conservation Authority to DOC, 1 July 2010.

191 Guidance on Processing Applications to Undertake Commercial Eeling, 28 July 2010, DOC. *"If eeling within public conservation land … would be likely to cause problems for a population of eels outside of public conservation land, that effect would not be a relevant consideration…"*

192 Between 2004 and 2011, DOC and MPI undertook a jurisdictional review of their respective roles and responsibilities for managing freshwater fish under the Conservation Act and the Fisheries Act. Unfortunately, the review largely ignored eels because DOC regarded that "their jurisdiction is relatively clear" – eels being "a quota species under the Fisheries Act". DOCDM-1130591 JR Updated Draft Briefing to Steering Group (no date).

193 A laudable goal in the current proposed amendments to the RMA is to reduce needless variation between council plans. For instance, the Minister for the Environment has pointed out that there is no reason for different councils to specify different ways of measuring noise levels.

194 Memorandum of Understanding for processing consent applications between the Department of Conservation and the Greater Wellington Regional Council, 2006. This appears to be the only such Memorandum of Understanding that is active; elsewhere there may be informal arrangements in place.

195 Freshwater Fisheries Regulations 1983, r 42(1).

196 Based on conversations with DOC staff who were unable to cite any cases where the regulations had been applied.

197 Department of Conservation. n.d. *New Zealand Conservation Authority & boards – Protecting New Zealand's rivers – Freshwater Fisheries Regulations 1983.* http://www.doc.govt.nz/publications/getting-involved/nz-conservation-authority-and-boards/nz-conservation-authority/protecting-new-zealands-rivers/03-protecting-rivers-using-conservation-legislation/freshwater-fisheries-regulations-1983/

198 Policy 8.5 Otago Regional Council Freshwater Plan. It should be noted that a new plan is currently under development.

199 Rule 13.2.1.7 – Regional Plan: Water for Otago.

200 There is no clarity on how the RMA process and the Freshwater Fisheries Regulations should interact, despite the Environment Court finding that both should apply.The Environment Court has ruled that *"[w]here an approval by [DOC] is required, that approval is still required even if an RMA approval [by a plan or a consent] has been given"*. Department of Conservation, 2011., 'Guidance on managing fish and biota passage in freshwater and estuarine systems', Draft.

201 Boubée et al., 1999

202 DOC email 8 April 2013.

203 These plans would not be limited to DOC land.

204 Department of Conservation Financial Review 2011/12, Supplementary Question 135.

205 Conservation Act 1987. Part 3A, s 17J. Councils (RMA 1991, Part 5) and MPI (Fisheries Act 1996, s 11) must *"have regard for"* a Freshwater Fisheries Management Plan, but like any plans developed under the Conservation Act, such a plan cannot override any policies or plans developed under other laws.

206 DOC has interpreted an Environment Court ruling to mean that it does not need to grant permissions for dams or other structures if it is satisfied that provisions imposed by councils under the Resource Management Act are appropriate and sufficient (*Transit New Zealand v Auckland Regional Council*, A100/00 (5 NZED 814).

207 Regional Freshwater Plan for the Wellington Region (updated January 2012) Rule 39. Regional Water Plan for Southland (March 2010), Rule 46. Marlborough Sounds Resource Management Plan, Rule 26.1.6.1

208 Kelly and Collier, 2006. A similar survey of the Upper Manawatū River found 91 potential barriers to fish passage, of which 15 were ranked as high priority for modification to provide passage for fish (James and Joy, 2008).

209 Auckland Council Regional Plan: Air, Land and Water, Rule 7.4.16. Waikato Regional Plan, Objective 3.6.3. Regional Water Plan for Southland – Rule 24(c)(v).

210 Contact Energy written response to PCE questions, 8 March 2013.

211 An expert witness stated that the proposed mitigation measures *"if well designed and implemented , should substantially reduce the potential adverse effects [of the dam] on eel stocks in the Mokihinui River"* (Statement of Evidence of Donald John Jellyman on behalf of Meridian Energy Limited).

212 If a new dam is built on conservation estate, a concession to gain access and use the land must first be granted by the Minister of Conservation. This can include conditions such as protection for migrating eels. For example, the concession for the Matiri dam in the Buller catchment included ten conditions on eel passage. Department of Conservation, 2010, p. 17.

213 Jellyman, 2012. Sometimes bypasses are used but the migrating eels tend to use the main current to shoot down the river. Sometimes trap-and-transfer is used (as for elvers in the other direction), but getting nets to stretch across bigger rivers can be very difficult and it is difficult to know when the eels are coming.

214 Mighty River Power written response to PCE questions, 11 March 2013.

215 Jellyman, 2012, p. 30.

216 Under sections 5(2)(b), 6(c), 7(h), and 30(1)(ga) of the RMA 1991. Under the National Policy Statement for Freshwater Management, councils are also required to set quality limits for all bodies of fresh water in their regions that will, amongst other things, safeguard indigenous species including eels (National Policy Statement for Freshwater Management 2011, P. 6).

217 RMA, s35. In 2001, only one council was doing fish surveys, but this increased to six by 2009. See Parliamentary Commissioner for the Environment, 2010.

References

Allibone, R. M. 1999. Impoundment and introductions: Their impacts on native fish of the upper Waipori River, New Zealand. *Journal of the Royal Society of New Zealand* 29: 291–299.

Allibone, R., David, B., Hitchmough, R., Jellyman, D., Ling, N., Ravenscroft, P. and Waters, J. 2010. Conservation status of New Zealand freshwater fish, 2009. *New Zealand Journal of Marine and Freshwater Research* 44: 4, 271–287.

Aoyama, J. 2003. Origin and evolution of the freshwater eels, genus *Anguilla. In:* K. Aida et al. (eds.), *Eel biology*, Tokyo: Springer-Verlag.

Beentjes, M.P. and Dunn, A. 2010. *CPUE analysis of North Island commercial eel fishing 1990/91 – 2006/07.* New Zealand Fisheries Assessment Report 2010/5. Wellington: Ministry for Primary Industries.

Beentjes, M.P. and Dunn, A. 2013. *Catch per unit effort (CPUE) analyses and characterisation of the South Island commercial freshwater eel fishery, 1990–91 to 2009–10.* New Zealand fisheries assessment report 2013/11. Wellington: Ministry for Primary Industries.

Bevacqua, D., Melia, P., De Leo, G. A. and Gatto, M. 2011. Intra-specific scaling of natural mortality in fish: the paradigmatic case of the European eel. *Oecologia* 165: 2, 333–339.

Boubée, J., Chisnall, B., Watene, E., Williams, E., Roper, D., and Haro, A. 2003. Enhancement and Management of Eel Fisheries Affected by Hydroelectric Dams in New Zealand. *American Fisheries Society Symposium* 33: 191–205.

Boubée, J., and Jellyman, D. 2009. Facilitating the upstream and downstream passage of indigenous fish at large dams. *In:* E. McSaveney (ed.), *Dams – Operating in a regulated environment.* IPENZ Proceedings of Technical Groups 35/1: 57–63.

Boubée, J., Jowett, I., Nichols, S. and Williams, E. 1999. *Fish passage at culverts: A review, with possible solutions for New Zealand indigenous species*, NIWA and Department of Conservation.

Burnet, A.M.R. 1968. *A study of the relationships between brown trout and eels in a New Zealand stream*. Fisheries technical report.

Cairns, D. 1941. Life-history of the two species of New Zealand freshwater eel. *New Zealand Journal of Science* 23: 53–72.

Cochrane, K.L. and Garcia, S.M. 2009. *A Fishery Manager's Guidebook,*

Second Edition. United Kingdom: The Food and Agriculture Organization of the United Nations and Wiley-Blackwell.

Crook, V. 2010. *Trade in Anguilla species, with a focus on recent trade in European eel A. anguilla*. TRAFFIC report prepared for the European Commission.

Dekker, W., Casselman, J., Cairns, D.K., Tsukamoto, K., Jellyman, D., and Lickers, H. 2003. Worldwide decline of eel resources necessitates immediate action: Quebec Declaration of Concern. *Fisheries* Vol. 28, No. 12.

Dekker, W., Wickstrom, H. and Andersson, J. 2011. *Aqua reports 2011:2 – Status of the eel stock in Sweden in 2011.* Drottningholm: Swedish University of Agricultural Sciences.

Department of Conservation (DOC). 2003. *Te Urewera National Park Management Plan*. Wellington: DOC.

Department of Conservation (DOC). 2010. *Notified concession final report to decision maker, application for concession, New Zealand Energy Limited*. Wellington: DOC.

Department of Conservation (DOC). 2013. *Briefing to the incoming Minister of Conservation.* Wellington: DOC.

Department of Conservation (DOC) and Ministry for the Environment (MfE). 2000. *The New Zealand Biodiversity Strategy: Our chance to turn the tide*. Wellington: DOC.

Graham, D.H. 1974. *A treasury of New Zealand fishes*. 2nd ed. Wellington: Reed.

Graynoth, E., Jellyman, D.J. and Bonnett, M.L. 2008. *Spawning escapement of female longfin eels*. New Zealand fisheries assessment report 2008/7. Wellington: Ministry of Fisheries.

Green, W. and Clarkson, B. 2006. *Turning the tide? A review of the first five years of the New Zealand Biodiversity Strategy, the synthesis report.* Wellington: DOC.

Hoyle, S.D. and Jellyman, D.J. 2002. Longfin eels need reserves: Modelling the effects of commercial harvest on stocks of New Zealand eels. *Marine and Freshwater Research* 53: 887–895.

Ibbotson, A., Smith, J., Scarlett, P. and Aprhamian, M. 2002. Colonisation of freshwater habitats by the European eel *Anguilla anguilla. Freshwater Biology* 47: 1696–1706.

International Union for Conservation of Nature. 2010. The IUCN Red List of Threatened Species: *Anguilla anguilla.* Cambridge: IUCN http://www.iucnredlist.org/details/60344/0 [Accessed 4 December 2012].

James, A. and Joy, M. 2008. *A preliminary assessment of potential barriers to fish migration in the Manawatu catchment, North Island, New Zealand.* A report prepared for Horizons Regional Council. Palmerston North: Massey University. http://www.envirolink.govt.nz/PageFiles/396/437-HZLC45.pdf [accessed 4 March 2013]

Japan Fisheries Association. 2010. Japanese researchers develop the world's first full-cycle eel cultivation technology. *ISARIBI No. 66.* Tokyo: Japan Fisheries Association.

Jellyman, D.J. 2009. Forty years on – the impact of commercial fishing on stocks of New Zealand freshwater eels (Anguilla spp.). *American Fisheries Society Symposium* 58: 37-56.

Jellyman, D.J. 2012. *The status of longfin eels in New Zealand – An overview of stocks and harvest.* Report prepared for Parliamentary Commissioner for the Environment. NIWA.

Jellyman, D.J., Booker, D.J. and Watene, E. 2009. Recruitment of *Anguilla* spp. Glass eels in the Waikato River, New Zealand: Evidence of declining migrations? *Journal of Fish Biology* 74: 2014–2033.

Jellyman, D.J., Graynoth, E., Francis, R.I.C.C., Chisnall, B.L. and Beentjes, M.P. 2000. *A review of evidence for a decline in the abundance of longfinned eels (Anguilla dieffenbachii) in New Zealand.* Ministry of Fisheries research project EEL9802.

Joy, M., David, B. and Lake, M. 2013. *New Zealand freshwater fish sampling protocols: Part 1 – Wadeable rivers and streams*. Massey University.

Kelly, J. and Collier, K. 2006. *Assessment of fish passage within selected districts of the Waikato region.* Environment Waikato Technical Series 2007/03.

Landman, M.J., Van Den Heuvel, M.R. and Ling, N. 2005. Relative sensitivities of common freshwater fish and invertebrates to acute hypoxia. *New Zealand Journal of Marine and Freshwater Research*, 39: 1061-1067.

Martin, M., Stevenson, C., Boubee, J. and Bowman, E. 2009. *Recruitment of freshwater elvers, 1995-2009*. NIWA for the Ministry of Fisheries. New Zealand Fisheries Assessment Report 2009/58.

Maunder, M.N., Sibert, J.R., Forteneau, A., Hampton, J., Kleiber, P. and Harley, S.J. 2006. Interpreting catch per unit effort data to assess the status of individual stocks and communities. *ICES Journal of Marine Science* 63: 1373–1385.

McDowall, R M. 1994. *Gamekeepers for the nation*. Christchurch: Canterbury University Press.

McDowall, R.M. 2011. *Ikawai: Freshwater fishes in Maori culture and economy*. Christchurch: Canterbury University Press.

McKechnie, S., Fletcher, D., Newman, J., Scott, D., Bragg, C. and Moller, H. 2010. Modeling harvest intensity of sooty shearwater chicks by Rakiura Māori in New Zealand. *The Journal of Wildlife Management* 74: 4, 828–842.

McWethy, D.B., Whitlock, C., Wilmshurst, J.M., McGlone, M.S., Fromont, M., Li, X., Dieffenbacher-Krall, A., Hobbs, W.O., Fritz, S.C. and Cook, E.R. 2010. Rapid landscape transformation in South Island, New Zealand following initial Polynesian settlement. *Proceedings of the National Academy of Sciences* 107: 50, 21343–21348.

Ministry for the Environment (MFE). 1997. State of the Environment Report. Wellington: MfE

Ministry for the Environment. 2013. *Freshwater reform 2013 and beyond.* Wellington: Ministry for the Environment.

Ministry for Primary Industries (MPI). 2012a. *Fisheries Assessment Plenary, May 2012: Stock assessments and yields estimates*. Wellington: MPI. pp. 231–232.

Ministry for Primary Industries (MPI). 2012b. *Annual Operational Plan for Freshwater Fisheries 2012/13.* Wellington: MPI.

Ministry of Agriculture and Forestry (MAF). 2012. *Annual review of freshwater fisheries 2010/11, March 2012*. Wellington: MAF.

Ministry of Fisheries. 2004. *Setting of sustainability and other management controls for stocks to be introduced into the Quota Management System on 1 October 2004: North Island shortfin and longfin eels (SFE, LFE).* Final advice paper 25 June. Wellington: Ministry of Fisheries.

Ministry of Fisheries. 2007. *North Island eels (SFE 20-23, LFE 20-23) – Final advice: Review of sustainability measures and other management controls for 1 October 2007*. Final advice paper 5 September. Wellington: Ministry of Fisheries.

Ministry of Fisheries. 2008. *Harvest strategy standard for New Zealand fisheries.* Wellington: Ministry of Fisheries.

Ministry of Fisheries. 2009. *Fisheries 2030*. Wellington: Ministry of Fisheries.

Ministry of Fisheries. 2011a. *Draft national fisheries plan for freshwater, July 2011.* Wellington: Ministry of Fisheries.

Ministry of Fisheries. 2011b. *Research and science information standard for New Zealand fisheries.* Wellington: Ministry of Fisheries.

Park, G. 2001. *Effective exclusion? An exploratory overview of Crown actions and Maori responses concerning the indigenous flora and fauna, 1912–1983.* Wellington: Waitangi Tribunal.

Parliamentary Commissioner for the Environment (PCE). 2010. *How clean is New Zealand? Measuring and reporting on the health of our environment.* Wellington: PCE.

Pond, W. 1997. *The land with all woods and waters.* Waitangi Tribunal Rangahaua Whānui Series, p. 139.

Richkus, W.A. and Whalen, K. 2000. Evidence for a decline in the abundance of the American eel, Anguilla rostrata (LeSueur), in North America since the early 1980s. *Dana* 12: 83–97.

Saunders, T.V. 1965. The eels of Lake Wairarapa. *Te Ao Hou: The Maori Magazine,* No. 51.

Seafood New Zealand. 2013. *New Zealand Seafood Exports Report 10a: Seafood exports by species by country, Calendar year to December 2012.* Wellington: Seafood New Zealand.

Te Taumutu Rūnanga. 2003. *Te Taumutu Rūnanga Natural Resource Management Plan*. Christchurch: Te Taumutu Rūnanga.

Vollestad, L.A. and Jonsson, B. 1988. A 13-year study of the population dynamics and growth of the European eel *Anguilla anguilla* in a Norwegian river: Evidence for density-dependence mortality, and development of a model for predicting yield. *Journal of Animal Ecology* 57: 983–997

Appendix 1

Allowable catches of longfin and shortfin eels

This table details the current total allowable catches for commercial, customary and recreational fishers for longfin and shortfin eels. Source: Ministry for Primary Industries, 2012, pp. 232–233.

North Island and Chatham Island allowable catches – tonnes per year of eels		
	Longfins	**Shortfins**
Commercial	82	347
Customary	47	77
Recreational	33	64
Fishing-related mortality*	8	11
Total	170	499

South Island allowable catches – tonnes per year of eels	
	Longfins and shortfins combined
Commercial	421
Customary	107
Recreational	11
Total	539

* Fishing-related mortality is an additional allowance made to cover all other mortality to the stock caused by fishing.

Appendix 2

Commercial catches of longfin and shortfin eels

This table details the commercial catches of longfin and shortfin eels since 1989. The catch landing data prior to 2001 includes pro-rating of a third species code (eels unidentified) between longfin and shortfin. Actual customary and recreational catches are unknown, so are not included in the table. Source: Ministry for Primary Industries, 2012, p. 230, and Ministry for Primary Industries, unpublished data for fishing year 2011-12.

New Zealand commercial catch - tonnes of eels				
Fishing year*	**Longfins**	**Shortfins**	**Total**	**Longfin as % of total catch**
1989–90	453	617	1070	42
1990–91	616	808	1424	43
1991–92	612	941	1553	39
1992–93	741	872	1613	46
1993–94	588	692	1280	46
1994–95	588	909	1497	39
1995–96	518	977	1495	35
1996–97	465	841	1306	36
1997–98	442	881	1323	33
1998–99	434	824	1258	34
1999–00	413	741	1154	36
2000–01	388	698	1086	36
2001–02	360	660	1020	35
2002–03	279	560	839	33
2003–04	216	510	726	30

2004–05	254	460	714	36
2005–06	226	553	779	29
2006–07	210	520	730	29
2007–08	196	470	666	29
2008–09	95	424	519	18
2009–10	114	441	555	20
2010–11	159	440	599	26
2011–12	237	521	758	31