CHAPTER 7

LOSS OF HARVEST

7.1 A Fauna with Too Few Lovers

Each locality has its own unique body of Maori knowledge, and its own history of encounter with land clearance. At 1840 each hapu had a highly developed inventory of trapping techniques. Trapping was correlated with seasonal abundance and with eccentric habits, that is, hapu accommodated their social life to faunal activity. West Coast hapu would spend the spring on the coast fishing for whitebait and upokororo, and then disperse inland to eel-fishing camps for the summer.[1]

Freshwater fisheries were a staple component of hapu economy: eels, piharau (lamprey), upokororo (grayling), kokopu, inanga, waikaka (spring eels, mudfish), papanoko (torrentfish), and so on. Since 1840 the upokororo has become extinct, populations of koaro have become greatly reduced, and the survival of the shortjawed kokopu and giant kokopu are at risk. Practices of agriculture, forestry, industry, drainage, culverting and roadworks, hydro-electric dam construction, and foreign fish introductions have impoverished and destroyed Maori freshwater fisheries. What remains is possibly 10 percent of forest and 10 percent of wetland habitat within which competition from introduced species and deteriorating conditions further deplete harvesting.

Hapu lost their harvesting resources apace with their loss of whenua, their knowledge-base, and the role of caretakership (kaitiaki). The settlers who occupied their lands did so with an absence of protection for habitat and an absence of respect for hapu knowledge-base. The indigenous wildlife became a fauna with too few lovers.

7.2 Calendar of Faunal Abundance

Pakeha settlers described 'shoals of inanga . . . literally miles in length travelling downstream to the spawning grounds'.[2] Eels also 'may come in colossal numbers'. There have been reports of them coming upstream in shoals kilometres long and metres wide for hours without ending.[3] In 1845 Ligar recorded that kokopu were an

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1. A J Anderson, transcript of evidence presented at the Ngai Tahu Mahinga Kai hearing of the Waitangi Tribunal, Tuahiwi Marae, April 1988. The researches of R M McDowall are used throughout this chapter.
2. *Weekly News*, 15 November 1949
3. R M McDowall, *The New Zealand Whitebait Book*, Wellington, Reed, p 23

important food for Waikato Maori.[4] In 1848, the upokororo (grayling) was caught by Brunner in a seine net in the Buller River, in a shoal of 50.[5] Charles Douglas observed during the 1860s that the giant kokopu in South Westland was 'common all over the country wherever a bog hole or dark bush creek exists' and the koaro was even more so.[6]

Also during the 1860s, Captain Gilbert Mair described Maori trapping of adult koaro in the Hamurana Stream (Rotorua) at night. Two hours after the net was lowered 'several hundredweight of the fat little fish were emptied into the canoe. This process was repeated during the night till quite a ton weight had been obtained . . . Of course the introduction of trout was the death knell of the koaro'.[7] Pfaff recalled, 'The Grey River was very rich in whitebait in 1867. There was no difficulty in getting bucketsful in a very short time. Maori gathered it and sold it very cheaply'.[8] During the 1880s whitebait were taken from the Hutt River (Wellington) in 'cartloads'.[9] In 1869, the upokororo was so abundant that a mill wheel was brought to a 'standstill' because the channel was choked with thousands of fish.[10] The upokororo was described as 'the most common freshwater fish in many parts of New Zealand, which, before the introduction of the trout, was once taken by the cartload from the Wairau River in Marlborough'.[11] In 1874 the upokororo disappeared from the Waikato River,[12] and in 1884 it was reported to have disappeared from the Inangahua and Buller Rivers.[13]

In 1892 Spackman attributed the decline of grayling to trout,[14] while in 1899 Clarke reflected that it was 'piteous . . . to see the enormous quantities of young grayling which were destroyed' as a result of capture by West coast whitebaiters.[15] In 1901 Rutherford again attributed the decline of grayling to trout.[16] From 1930 there were no further sightings of upokororo. McDowall reflected on the faunal loss that had occurred by the 1940s:

> My grandfather, who farmed the banks of the Ohau from the early 1900s, took substantial [whitebait] catches – 20kg or more – from this river. When he took us whitebaiting in the 1940s, catches of 5 kg could be expected during good runs. By

4. C W Ligar, MS Diary 22 November 1845–19 November 1846, Auckland Public Library
5. T Brunner, *Journal of An Expedition to Explore the Interior of the Middle Island of New Zealand*, Nelson, Examiner Office, 1848
6. R M McDowall, 'Charles Douglas, Explorer: His Notes on Freshwater Fishes', in *Journal of the Royal Society of New Zealand*, vol 10, no 4, 1980, pp 311–324
7. McDowall, *The Whitebait Book*, p 91
8. C J Pfaff, *The Digger's Story*, Wellington, Wright and Carman, 1914
9. McDowall, *The Whitebait Book*, p 99
10. B G Moss, 'Upokororo, New Zealand's Mystery Fish', in *Ammohouse Bulletin*, vol 1, no 5, 1958, p 5
11. W J Phillips, Life-history of the New Zealand Grayling', in *New Zealand Journal of Science and Technology*, vol 6, no 1, 1923, pp 63–63
12. Elsdon Best, *Fishing Methods and Devices of the Maori*, Dominion Museum Bulletin, no 12, 1929
13. *Otago Daily Times*, 23 March 1910
14. W H Spackman, *Trout in New Zealand: Where To Go and How To Catch Them*, Wellington, Government Printer, 1892
15. Clarke, pp 78–91
16. A J Rutherford, 'Notes on Salmonidae and Their New Home in the South Pacific', in *Transactions and Proceedings of the New Zealand Institute*, vol 33, 1901, pp 240–249

> then the Ohau River ran through fully developed pastoral country. He had in the early 1900s cleared his property of dense tawa forest. The streams had probably once supported banded kokopu and giant kokopu and masses of inanga when there was still forest. By the time I was there we only saw a few inanga and the odd banded kokopu in the tiny patch of remaining bush.[17]

In 1952 the Marine Department offered the already extinct upokororo legislative protection; with hindsight Stockell blamed 'unrestricted commercial exploitation'.[18] Reflecting on the depletion in native fish stocks in 1984, McDowall pondered:

> what took evolution over a million years to accomplish has been reversed in a few short years by the efforts of a few well-meaning people introducing salmonids into southern hemisphere waters . . . it seems that the introduced trout have had quite disastrous effects on the galaxiids, extinguishing populations in some areas and causing a decline in population in others . . . Lake Taupo is now one of the finest rainbow trout fisheries in the world and although there are still koaro present, they are no longer there in the numbers that would make netting them worthwhile.[19]

In 1990, McDowall reviewed the fauna. In his assessment, lake populations of koaro 'were certainly once much more abundant than they now are and have been heavily reduced by introduced trout . . . Trout apparently accumulate near river mouths and feed there on the koaro'. Common smelt, in his assessment, 'have come to contribute a substantial proportion of the Waikato whitebait fishery as the populations of the more preferred *Galaxias* whitebait have declined'. The rapid development of the commercial eel fishery in the past 20 years:

> undoubtedly has caused a significant reduction in their abundance in many lakes and river systems . . . A very large proportion of the very large eels . . . has now been removed from many of our rivers and lakes . . . it will be many years before they are again present.

A comparison with reports of whitebait catches of last century made it 'quite clear that their abundance has declined drastically in the past hundred years'. Attempts to locate and protect habitats suitable for conservation of the Canterbury mudfish had failed: 'Waters that are suitable are in land tenure that makes reservation difficult . . . longterm survival is unlikely given management strategies of the surrounding farmland'. McDowall found that mudfish are 'very prone' to the drastic ditch digging, drain clearance, and road grading that farmers and regional councils are permitted to undertake. Local populations of common river galaxias were being affected by the removal of water for irrigation. The dwarf inanga was in need of protection in the small, dune lakes of the north Kaipara.[20]

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17. McDowall, *The Whitebait Book*, p 122
18. R M McDowall, *New Zealand Freshwater Fishes: A Natural History and Guide*, Heinemann Reed and MAF Publishing, 1990, p 86
19. McDowall, *The Whitebait Book*, p 79
20. McDowall, *Natural History*, pp 57, 74, 113, 117, 127, 148, 502, 504

A species will show signs of dwindling for a while; and then suddenly decline because its population is no longer self-sustaining. In the 1930s, the public argued over which factor was responsible for the decline in whitebait catches: excessive take by whitebaiters; predation by sea birds, herrings, eels, trout; draining of swamps, backwaters, and creeks; or damage to estuarine spawning grounds by stock.[21] In the 1990s it is understood that the disappearance of native fish from the waterways is due to a combination of factors resulting in loss of haven. Among the factors are deforestation, sedimentation and flooding, wetland drainage, river modifications, hydro-electric schemes (dams), water abstraction (irrigation), and water pollution[22] – the practices of an extractive agricultural–industrial economy.

7.3 Loss of Harvest Due to Forest Clearance

Many native fish are denizens of forest. Steep, cold streams with rapids and pools, that still retain a heavy cover of native forest, support banded kokopu (in pools), short-jawed kokopu (needs plentiful instream cover to hide in), red-finned bully (in wider streams), longfin eel (needs deep pools, large bank overhangs, log piles), koaro (in clear streams), banded kokopu, and giant kokopu.

Koaro are now rare. They disappear from streams once the forest canopy has been removed. In occasional streams not modified by forestry and agriculture, koaro may still be found in very large and dense populations. Forested streams are probably the habitat required for spawning lamprey.[23]

Canopies of unlogged native forest control conditions of light exposure and water temperature, create stable stream beds and banks, stable pool-and-riffle sequences, and provide insect foods and instream cover such as logs; forest litter affects the chemical and nutrient quality of streams. There is a causal relationship between forest clearance, deterioration of freshwater environment, and loss of abundance:

> Clearing of forests has had a serious effect on populations of many native species . . . Removal of cover over streams increases both light penetration and temperatures, and also would have caused greater river instability, more serious flooding, and increased sedimentation. All of these would have affected the algal flora of the streams . . . It is not hard to imagine that numbers [of lampreys] have declined greatly, especially if, as we suspect, spawning took place in small, bush-covered streams; the loss of forest cover from the catchments of many New Zealand waterways has had profound effects on the fish fauna.[24]

Once the forest has gone from river catchments and has been replaced by pastoral farmland, the fish fauna changes abruptly:

21. McDowall, *The Whitebait Book*, p 183
22. McDowall, *Natural History*, p 473
23. Ibid, pp 105, 109
24. Ibid, p 331

> [Unforested streams] are prone to instability of banks and bed, they often flood badly, pool-riffle sequences are destroyed so that habitat diversity declines, temperatures are variable, and they are often polluted. Primarily all that remains of the native fauna are lamprey ammocoetes, longfin eels, sometimes shortfin eels, common bully, sometimes upland bullies, sometimes redfinned bullies, occasionally bluegilled bully and torrentfish. Banded kokopu and koaro usually disappear. Introduced brown trout appear.[25]

Deforestation was carried out without regard for Maori interests in freshwater fisheries.

7.4 Loss of Harvest Due to Deterioration in Water Quality

Native freshwater fish thrive in cold, clear, actively running water; they need a constant, organically clean, thermally and chemically stable water supply.[26] Koura need a high protein diet for optimum growth, and they are very susceptible to oxygen depletion.[27] However, mature eels in general appear to be capable of surviving in water of very low oxygen content. Glass (juvenile) shortfin eels prefer muddy and silty areas, while glass longfin eels are more numerous in clear, stony areas which support large amounts of water weed.[28] American studies found that stonefly, mayfly, and caddis-fly larvae, which are consumed by many native fish, are very sensitive to reductions in dissolved oxygen levels.[29]

Oxygen is depleted when water flows reduce and streams carry heavy loads of eroded soil. The burden of mud results from forest clearance which has been followed by erosion of catchments; erosion of stream banks by stock; construction of stop banks, which prevents deposition of silt loads onto the plains; and exposed earthworks.

When river floods invade surrounding farmlands, waterways become contaminated with chemical sprays and with silt from earthworks; and with run-off, sewage, and drainage from residential areas. Flood water serves as a medium for the transfer of disease: disease agents enter water from the faeces of infected humans and animals. [30]

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25. McDowall, *Natural History*, p 331
26. P M Hine and N C Boustead, *A Guide to Disease in Eel Farms*, Fisheries Research Division, Occasional Publication, no 6, Wellington, New Zealand Ministry of Agriculture and Fisheries, 1974, p 21
27. P Dinamani and R W Hickman, *Proceedings of the Aquaculture Conference*, Fisheries Research Division, Occasional Publication, no 27, Wellington, New Zealand Ministry of Agriculture and Fisheries, 1980, p 25
28. D R Morgan and E Graynoth, *The Influence of Forestry Practices on the Ecology of Freshwater Fish in New Zealand*, New Zealand Ministry of Agriculture and Fisheries, Fisheries Research Division, Occasional Publication, no 14, p 13
29. Morgan and Graynoth, p 16
30. Dinamani and Hickman, p 89. During 1978 the Ministry of Agriculture and Fisheries monitored Mahurangi Harbour and concluded that the source of pollution of oyster beds was run-off from surrounding farmland, particularly after moderate rain.

Water temperatures can have a profound effect on fish diseases.[31] Conditions for diseases affecting freshwater fish are greatly heightened in the muddy, slow-flowing rivers and streams which currently cross the lowland plains of Hauraki and Waikato. In 1984 the medical officer of health advised against eating 'whitebait' (adult smelt) from the estuary of the Whanganui River; in 1984 the Patea River was listed as polluted; in 1982 during the whitebait season toxic ammonia from the Kapuni ammonia-urea plant leaked into the lower Kapuni Stream.[32]

7.5 Loss of Harvest Due to Irrigation

Irrigation of agricultural lands by drawing off water from streams can cause rapid alterations in stream flows and in exposure of bank vegetation, destroying fish habitats. Irrigation draw-off has sometimes reduced rivers to the point where they no longer flow to sea at a time when fish are ready to return. Irrigation sometimes spreads smolts (fish spawn) as well as water over the paddocks.[33]

7.6 Loss of Harvest Due to Disappearance of Insects

Studies during the 1980s demonstrated that 90 percent of native insects disappear when native forest is replaced with pasture.[34]

Insects are a major component of the food of freshwater fish. Native fish are deprived of this resource by forest clearance, agricultural pesticides, and competition from introduced fish. Command of territory is synonymous with command of food supplies: the aggressive salmonids displace native fish when both inhabit the same waterway. In 1920, the entomologist Tillyard reported to the Government that trout had caused serious declines in aquatic insects in the Rotorua–Taupo streams and lakes.[35]

An effect of agricultural spraying on native insect populations was clearly demonstrated in the 1960s. Koaro feed on aquatic larvae (simuliids, chironomids, mayfly, stonefly, caddis larvae), beetles and other invertebrates blown onto the water, eggs of the common bully, worms, wetas, midges, and smaller koaro. In the Lake Taupo catchment, green manuka beetles (kekerewai, *Pyronota festiva*) swarm during the summer and are carried by strong winds in vast numbers out of the teatree scrublands around the lake shores, and onto the lake water where they float in rafts, unable to lift their heavy bodies into flight. During the 1960s, when there

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31. For example, the parasite White spot (*Ichthyophthirius multifiliis*) is very common on native fishes, including eels. White spot takes 4–5 weeks to complete its life cycle at 10 degrees C. At 20–22 degrees C it takes only 4–5 days (Dinamani and Hickman, p 77).
32. McDowall, *The Whitebait Book*, pp 120, 122
33. Dinamani and Hickman, pp 9, 44
34. J C Watt, 'Beetles (Coleoptera) of Auckland', in *Tane*, vol 29, 1983, p 32
35. R J Tillyard, 'Report on the Neuropteroid Insects of the Hot Springs Region', in *Proceedings of the Linnean Society of New South Wales*, vol 45, pp 205–213

was extensive agricultural development of the Lake Taupo catchment, use of agricultural pesticides for the control of grass grub (*Costelytra zealandica*) decimated the populations of manuka beetle. When the use of DDT was discontinued, the manuka beetles returned in large numbers again.[36]

Riparian zones and marginal strips planted in native forest provide a productive source of insects for native fish.

7.7 Loss of Harvest Due to Dredging

As swamps have been drained, natural streams have been straightened and dredged, destroying the food resources, hiding places, and spawning gravels of native fish. Mature eels are abundant beneath undercut stream banks. Studies of the Rakaia River:

> revealed elvers to be abundant in the rapids, rifles and runs, living amongst the gravels where they sometimes occupied the same habitat as torrentfish and bluegilled bullies . . . As the eels grow larger they eventually hide beneath logs, overhanging banks, etc., and then it is the amount of cover available that limits the number of eels in a pool.[37]

Over miles of the Waikato and Hauraki plains, straight drains dredged by draglines through pastureland, often with no cover at all, have replaced meandering streams with overhanging banks, pools of varying depths, boulders, and logs which provide breeding grounds for aquatic snails and insect larvae, protective cover for fish, and spawning grounds. In clean-bottomed water-courses, flash floods, changing flow patterns, scouring, and re-dredging all prevent the formation of habitats for native fish.

Different techniques of dredging would create over-hanging banks; some compromise between farming and Maori interests would allow meandering stream courses.

7.8 Loss of Harvest Due to Swamp Drainage

River and lake fisheries are productive in relation to the areas of swampland they water. Before the clearance and drainage of the vast kahikatea forestlands, extensive tracts of swamp, with pools enclosed by flax and raupo, occupied gaps in the forest. Inanga in vast numbers, shortfin eels, and giant kokopu migrated into these habitats:

> The Manawatu was historically a great river but is no longer so . . . Its high productivity . . . was undoubtedly due to the vast areas of lowland swamps that once

36. McDowall, *Natural History*, p 194
37. Ibid, p 59

> characterised the Manawatu Plains. These provided extensive habitat for inanga, giant kokopu and banded kokopu. Now such tracts of land are among the most productive farming country in New Zealand. Swamps have been drained, streams channelised, the forest felled and the whitebait have largely gone.[38]

Waikaka, mudfish or mudeels,[39] are prized by some hapu as a food for presentation at feasts.[40] Waikaka live in swamps, creeks, and drains that tend to dry up in summer. Drainage of swamps for farmland has lowered watertables and fragmented their habitat; without a safe haven they are preyed on by shortfinned eels, trout, and perch. In 1979, Eldon drew attention to a configuration of adverse conditions which make survival of mudfish precarious: exaggerated flood/drought cycles, water abstraction, stream channelling, and introduction of exotic predators.[41]

The Canterbury mudfish 'is the most threatened' fish in the freshwater inventory.[42] In 1990, McDowall noted:

> efforts to re-collect [mud]fish from localities mentioned in earlier publications have frequently proved fruitless, usually because the locality has been 'developed' to pasture . . . The future of the species does not look good as further swamplands are drained and transformed . . . Longterm residents of Pirongia have described the steady decline in the black mudfish in that area, resulting from land development, drain clearance and the use of herbicides . . . The extensive low country of the lower Waikato undoubtedly had numerous swamps populated by black mudfish. The Hikurangi Swamp is effectively gone, converted to farmland, and plans are afoot to process peat from the Kaimaumau Swamp . . . one by one, the remaining habitats of the black mudfish are being lost.[43]

Several large rivers draining the Tararua and Rimutaka Ranges flow through Lake Onoke (Wairarapa) into the sea; the outlet of Lake Onoke was an important whitebait fishery. Large areas of swampland along the margins of the lake contributed to the productivity of this system, but in 1982 the swamp was to be drained for development.[44]

Maintaining swamps is vital to the productivity of whitebait fisheries. Vast areas of lowland fisheries have been lost to land clearance, drainage, and trampling by stock.

38. McDowall, *The Whitebait Book*, p 122
39. *Neochanna apoda*, brown mudfish; *Neochanna burrowsius*, Canterbury mudfish; *Neochanna diversis*, black mudfish.
40. J W Phillipps, *The Fishes of New Zealand*, New Plymouth, Avery, 1940
41. G A Eldon, 'Breeding, Growth, and Aestivation of the Canterbury Mudfish', in *New Zealand Journal of Marine and Freshwater Research*, vol 13, no 3, 1979, pp 331–346
42. McDowall, *Natural History*, p 142
43. McDowall, *Natural History*, pp 142, 143, 151
44. I Buchanan, 'Eastern Lake Wairarapa – A Wetland Under Threat', in *Freshwater Catch*, vol 15, 1982, pp 20–22; McDowall, *The Whitebait Book*, pp 122–123

7.9 Loss of Harvest Due to Pine Forestry Practices

When pine forests replace native forests they create a new environment around streams. Their shade is darker and less dappled, their variety of vegetation is narrower, and the chemical composition of their leaf litter is toxic. In contrast to most native forests, mature pine forests characteristically have a sparse undergrowth. The intense shade from pine forests can prevent the growth of stabilising vegetation along stream banks, which are then easily eroded and this results in a wide, shallow, and silted stream bed.[45] The dense shade of a pine plantation creates a different quality of light from native forest. As pine plantations mature and are felled, extremes of light exposure and light reduction occur, and many native fish disappear. Pine plantation has not provided a substitute for native forest cover:

> These changes in light intensities can have profound effects on the stream flora and fauna . . . The galaxiids *Galaxias fasciatus* [banded kookopu] and *G postvectis* [shortjawed kookopu] are probably less common than before the clearance of lowland forests, since they are usually found in forest streams . . . *Galaxias postvectis* is probably very sensitive to removal of bush cover and stream modification . . . *Galaxias brevipinnis* [koaro] is usually found in streams which are heavily overgrown with bush, and it may form dense populations in streams unmodified by clearing of the forest . . . *Galaxias fasciatus* is typically found in stable streams which possess good pools or abundant shelter and are more or less completely overhung by trees, and particularly undisturbed native bush.[46]

Some native fish depend on particular kinds of stream-bank vegetation for successful spawning, which a bed of pine needles does not replicate.

Inanga, *Galaxias maculatus,* usually spawns among fairly long, thickly growing grasses. During the 1930s Captain Hayes advised the Marine Department that exotic deciduous trees ‘render the ground beneath them unsuitable for the herbage which is necessary to afford cover for the spawn’.[47]

The brown mudfish, *Neochanna apoda*, ‘has been observed to deposit its eggs above the waterline in captivity. These eggs dehydrate unless kept moist and therefore in the normal habitat suitable terrestrial vegetation may be necessary for the survival and development of the eggs.’[48] Maori in Northland recognise the intricate mesh of conditions for the wellbeing of native fauna, observing that there is a life-cycle connection between landsnails and the kokopu.[49]

Forestry practices of burning, bulldozing, roadbuilding, and hauling modify the physical structure of streams. Rapids, riffles, flats, shallow gravels, deep pools, and overhanging banks provide the habitats in which native fish forage, hide, and breed.

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45. Morgan and Graynoth, p 11
46. Morgan and Graynoth, pp 17–18
47. McDowall, *The Whitebait Book*, pp 18, 183, citing Marine Department files
48. McDowall, *Natural History*, p 18
49. Personal observation, 1987. Possibly, both lay their eggs in the same habitat.

Forestry practices disturb stream banks and stream beds, and load stream flows with sediment.[50]

Forestry practices disrupt nutrient cycles and alter the chemical composition of streams as slashed vegetation rots, as phosphorus, nitrogen, and potash enter streams after burning, as forests are sprayed with chemicals and fertilisers, as mills discharge effluents, as toxins leach out of sawdust and waste woods, as slime fungi suffocate the fauna.

Road building, logging, clear-felling, and burning usually increase soil erosion rates and may lead to exceptional amounts of sediment entering streams, with consequent depletion in oxygen and fatalities to both fish and their food organisms. Lampreys commonly lay their eggs in coarse gravel nests; common smelt spawn behind sandy riffles in the stream bed; and whitebait spawn among stream bank vegetation. Silt covering spawning grounds limits the survival of ova and fry of many native fish, decreases their customary foods, and destroys their habitat: 'Large increases in bedload due to logging may be expected to decrease the abundance of certain Galaxiidae [kokopu, and so on], Eleotridae [mudfish], and Anguillidae [eels], which favour stable stream beds'.[51]

Burning may directly heat stream water, resulting in death of aquatic fauna. A sudden increase in temperature to 17 or 20 degrees celsius would kill koaro.[52]

The effects of logging on stream sediment loads were known to the New Zealand Forest Service by the 1940s. Advice to the Crown on proper road construction, logging methods, and leaving riparian strips to reduce the sedimentation of stream gravels began in the 1950s.[53]

In 1978, Morgan and Graynoth voiced the growing concern over the effects of forestry practices on the native freshwater fish fauna. They repeated again and again that adequate studies of forestry practices on New Zealand native fauna had not been undertaken.[54]

7.10 Loss of Harvest Due to Unprotected Riparian Zones and Marginal Strips

Waikato, Mokau, Manawatu, and Clutha are sluggish, lowland rivers which fish follow for 30 to 40 kilometres upstream. Protection of margins is vital to inanga,

50. During the 1970s global studies of forestry practices documented stream disturbance. In 1978, Morgan and Graynoth reviewed international literature for the New Zealand Forest Research Institute. In one study 'scouring, canalisation, and siltation caused by forestry operations reduced the area of spawning gravels by 56 percent and 100 percent' (Morgan and Graynoth, p 15).
51. Morgan and Graynoth, pp 9, 11, 12, 13, 16
52. Ibid, p 19
53. An American study published in 1948 by Lieberman and Hoover, 'Protecting Quality of Streamflow by Better Logging' was quoted in a Forest Research Institute report to the New Zealand Forest Service (no 65). The report was not released. Another report by Lieberman and Hoover, also in 1948, 'Uncontrolled Logging Damages Water Quality', was cited in *Forestry Abstracts 10*, no 893 (Morgan and Graynoth, p 10).
54. Morgan and Graynoth, pp 5, 7, 9, 12, 13, 15, 16, 17, 20, 22, 24

common bully, and shortfin eels. Clear-flowing inland rivers with gravels and boulders, where swift flows alternate with pools, support inanga, bullies, torrentfish, juvenile and adult longfin eels. All these species require stream bank vegetation or instream cover such as logs and boulder heaps. In swamps, maintaining abundant native vegetation along margins is vital to shortfin eels and giant kokopu.

Banded kokopu are economically important to Maori, as part of the whitebait catch. When streams flood and over-run their banks, banded kokopu spawn in forest litter on stream banks and in sedges on stream deltas. The eggs are deposited well above normal stream levels.

Inanga, also part of the whitebait catch, spawn on spring tides, amongst vegetation on estuarine banks. Damage to whitebait spawning grounds is a significant factor in whitebait declines. During the 1930s, Captain Hayes advised the Marine Department that 'the trampling of grazing stock and the annihilation of possible spawning-grounds as the result of grazing have been found to occur in practically all the localities investigated'.[55]

7.11 Loss of Harvest Due to Dam Constructions

Between 1850 and 1937, just in the kauri forests of the Coromandel peninsula and other northern areas alone, about 3000 massive wooden dams were built across small streams.[56] After heavy rain, the dams were released and thousands of logs tumbled downstream to the sawmill booms. In the process, banks lost protective vegetation and stream beds were often scoured down to rock bottom, destroying foraging resources, hiding places, spawning gravels, and habitats of freshwater fauna. These dams were short-lived.[57]

During the twentieth century, many of the larger rivers have been impounded by hydro-electric dams. These permanent impoundments have changed upstream waters from riverine into lacustrine environments, and have prevented much of the upstream movement of migratory fishes. In attempting to climb the dams fish may become exhausted, to the extent that survival is reduced, and spawning may be delayed, resulting in high ova and fry mortalities because the opportunity of suitable environmental conditions have been missed.[58] Hydro dams impassable to homing fish deny access to spawning grounds. Hydro lakes inundate spawning streams.[59]

Koaro and common bully have survived as landlocked populations. However, introduced brown trout have also established landlocked populations above dams,

55. McDowall, *Natural History*, pp 98, 466; McDowall, *The Whitebait Book*, p 183, citing Marine Department files
56. T E Simpson, *Kauri to Radiata: Origin and Expansion of the Timber Industry of New Zealand*, Auckland, Hodder and Stoughton, 1973
57. Morgan and Graynoth, p 14
58. Ibid
59. Dinamani and Hickman, p 9

where they are predatory on koaro and other native fish. The construction of dams has land-locked populations of common smelt (*Retropinna retropinna*) in lakes where they have successfully displaced koaro from the surface waters of the lake, possibly because smelt compete with koaro for zooplankton.[60]

The Wairehu canal was constructed to divert water down from the upper Whanganui River system into Lake Taupo. To prevent fish migrating upstream, out of Lake Rotoaira and into the diversion canal, a velocity barrier was constructed. During spring and summer, koaro achieve their upstream migration by avoiding the forceful sheet of water and climbing along the damp, vertical concrete walls in the splash zone above the flow of water. They grip with the surface of their fins which, unusually, face downwards. By this long and slow journey they reach the gently flowing water of the diversion canal. Their urge to migrate upstream, and their negotiation of obstacles, 'verges on the incredible'.[61]

Where a dam is kept moist, some longfin eels, koaro, banded kokopu, shortjawed kokopu, and redfinned bully make their way upstream 'past formidable barriers', but many become exhausted or die in the attempt, and populations above dams are probably much reduced. Dams are preventing longfin eels from returning to Wanaka and Ohau lakes. Bluegilled bully, shortjawed kokopu, and eels cannot maintain populations in landlocked waters; eels are very longlived, but will die out above dams.[62]

Elvers are able to make their way up the walls of the hydro dam on the Arnold River below Lake Brunner, climbing 14 metres; up the Karapiro dam on the Waikato River, climbing 30 metres; up the Arapuni dam on the Waikato River, climbing 43 metres; and up the Waitaki dam on the Waitaki River, climbing 21 metres. In 1956 elvers were described climbing the Karapiro dam:

> We saw young eels from three to five inches long – literally 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 on the temporary bridge facing the spillway.[63]

By 1980 there had been only two attempts, both unsuccessful, to provide fishways or fish ladders at hydro dams:

> In any country where hydro-electric power and irrigation are planned by non-government agencies they would be forced by law to provide fish hatcheries, fish-ways, stream improvement, and other ways of restoring the habitat of fish disturbed by the hydro or irrigation schemes. In New Zealand these schemes have been planned by government which also has had the responsibility for managing the fisheries, but which did not impose habitat restoration on itself.[64]

60. McDowall, *Natural History*, pp 113, 466
61. E J Cudby, personal communication, in McDowall, *Natural History*, pp 110, 111
62. McDowall, *Natural History*, pp 332, 333, 493
63. D H Graham, *A Treasury of New Zealand Fishes*, Wellington, Reed, 2nd ed. 'The climbing ability of eels provides a simple method of constructing fish passes to allow eels to migrate upstream past dams . . . In recent years a system using a large 'bottle-brush' inside a PVC tube . . . was successfully constructed on the face of the dam on the Patea River to a height of 75 m' (McDowall, *Natural History*, p 55).
64. Dinamani and Hickman, p 44

7.12 Loss of Harvest Due to Culverts

Native fish migrating upstream get past swift and turbulent falls typically not by jumping (as salmonids do), but by climbing. As streams deepen their beds, a disparity develops between the height of the culvert and the stream bed; small fish cannot make the leap up into the culvert to continue their migrations into feeding grounds and protective habitats. Where the migrating shoals do enter a culvert, there is another barrier: culverts made of cylindrical concrete pipes and placed in streams create a sheet of water passing over a smooth surface; small fish do not have the strength to swim for long against this current without ledges to rest in. 'There are probably thousands of kilometers of small streams to which access by fish is prevented by careless and unknowingly damaging construction of culverts'.[65]

7.13 Loss of Harvest Due to Modifying Estuaries

After hatching, many native fish are washed out to sea, where they spend about five months of the winter growing on the richer food supplies that the ocean provides. They then migrate into freshwater streams, possibly to escape marine predators, and possibly locating their natal streams by the smell of the water. Glass eels move into estuaries where they settle and may be found in huge numbers in the mud and sand or under stones. Adult eels also inhabit estuaries, usually skulking beneath undercut banks, logs, or other cover.[66] Estuaries provide a transitional habitat which reduces the shock to migrating fish of changing from fresh water to salt water.[67]

Seventeen species of native fish pass through estuaries. Estuaries polluted by oil and discharges from ship's engines; disturbed by jet boats and water skiing; and estuary expanses limited by marinas and tip reclamations, greatly reduce the numbers of small fish which survive the transition.

After reaching maturity in the headwaters of streams, some native fish return to estuaries to spawn. Margins of estuaries at and just above high tide mark are vital to the spawning of inanga. McDowall noted the 'extensive decline in whitebait catches in most parts of New Zealand', and attributed this to removal of forest, draining of swamps, and degradation of river estuaries, as being prime causes of decline.[68]

Thus estuaries are places where small fish congregate in thousands, where they are most intensely predated by birds and humans, where the abundance of the next generation is determined. If spawning is delayed by disturbance or blocked passage, high ova and fry mortalities may result because of unsuitable environmental conditions.[69]

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65. McDowall, *Natural History*, p 493
66. McDowall, *The Whitebait Book*, p 24
67. Dinamani and Hickman, p 44
68. McDowall, *Natural History*, p 434
69. Morgan and Graynoth, p 14

7.14 Loss of Harvest Due to Game Fish Introductions

There are very few New Zealand waters that do not carry stocks of brown trout. Some brown trout go downstream to the sea, where they wander quite widely, and after introduction in 1867, brown trout colonised many streams on their own initiative.[70] Brown trout compete with native fish for territory and food; and they consume eggs and juveniles of native fish, especially at river mouths as the small fish migrate in from the sea.[71]

Following the introduction of rainbow trout in the 1880s, a policy of stocking New Zealand lakes and rivers was pursued vigorously and it now forms the basis for 'important and valuable recreational fisheries'. In some lakes where rainbow trout do not spawn, stocks have been maintained by acclimatisation societies and fish and game councils, through hatchery releases: for example Lakes Tarawera, Otomangakau, Okaro, Tikitapu, Ngapouri, Okataina, Rotoma; and rivers and lakes of Northland.[72]

Rainbow trout are carnivorous. In lakes they feed at the surface on floating insects and small fish. When first introduced, they depleted populations of native koaro. They now feed mainly on the native common smelt, *Retropinna retropinna*, which was introduced into some water systems by acclimatisation societies specifically to support recreational trout fisheries. Rainbow trout also feed at the bottom on native common bullies (*Gobiomorphus cotidianus*), and on native koura (*Paranephrops planifrons*).[73]

Some native fish are continuing to survive in habitat dominated by trout, but are extensively preyed on by the trout: bullies, common smelt, Stokell's smelt, young eels, lampreys, and torrentfish. In the 1960s rainbow trout were introduced to the Dargaville lakes (Northland), which were habitats of the dwarf inanga (*Galaxias gracilis*). In Lake Waingata there was a rapid decline in dwarf inanga, koura, and crab; in Lake Taharoa dwarf inanga are now rare. The giant kokopu has disappeared from areas now occupied by brown trout. The dwarf galaxias retreats into hill streams, where it inhabits localities above barriers to the upstream migration of brown trout. The common river galaxias of Canterbury rivers seems to survive where it has habitat above the reach of brown trout. Mudfishes are seldom found in habitats accessible to brown trout.

In lakes and rivers trout compete with native fish for floating insects, aquatic larvae (especially dragonfly nymphs, fly, caddis, mayfly, and stonefly larvae), and native aquatic snails and molluscs, especially in winter when food sources are

70. Brown trout, *Salmo trutta*, is a native of Europe, Iceland, Scandinavia, and north Africa. It was one of the first game fishes introduced into New Zealand waters, in 1867. Brown trout are currently found in most river systems south of Coromandel, often much more abundantly than is evident; not found in the Chatham islands and in Stewart Island (McDowall, *Natural History*, pp 466–467). In 1990 there were 20 introduced species of fish, including seven predatory salmonids.
71. McDowall, *Natural History*, pp 167, 466–467
72. Rainbow trout, *Oncorhunchus mykiss*, is a native of North America (the Pacific coast from Alaska to Mexico). It is now established in inland waters south of the Waikato River system, and in most upland and alpine lakes and many rivers (McDowall, *Natural History*, pp 186, 188).
73. McDowall, *Natural History*, pp 466–467

meagre. Small longfinned eels living amongst the river gravels feed on aquatic larvae (caddis and mayfly), snails, and midges; their food is so similar to those of trout that competition is likely.[74]

The impact of trout on native fish was quickly observed and was the subject of much public discussion from the 1890s on.

7.15 Loss of Harvest Due to Smelt Introductions

From 1907 on, a native fish, common smelt (*Retropinna retropinna*) was progressively released into lakes by acclimatisation societies as food for the trout they had introduced. From 1905 to 1974 the releases were to a substantial number of lakes in diverse parts of New Zealand.[75]

Fisheries inspectors allowed the transfers of smelt because the Crown gave priority to interests in game fish, ahead of the economic interests of Maori in koaro, a fish Maori at that time preferred. Although this was known in 1921, introductions of smelt into lakes with koaro populations continued into the 1970s.[76]

McDowall has suggested that 'failure of the koaro populations to recover in lakes like Taupo is because the smelt populations have occupied the habitat that originally belonged to the koaro whitebait'.[77]

7.16 Loss of Harvest Due to Course Fish Introductions

Up to 1990 the impact of recently introduced course fish had not been studied and critical data on which the Crown might intervene, had not been collected. McDowall commented:

> In the lower Waikato eel fishermen have expressed concern that the spread and increased abundance of catfish are depressing the eel populations. Mosquito fish are often described as aggressive, fin-nipping and egg-eating predators. Their increasingly widespread occurrence could be a cause for concern with regard to the black mudfish, which is already much reduced in range. The recent establishment of koi carp in the lower Waikato, with its known propensity for severe habitat disruption, is a matter for serious concern . . . The escape of grass carp into the lower Waikato could have harmful consequences.[78]

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74. McDowall, *Natural History*, p 194
75. Ibid, pp 69–71
76. Te Rangi Hiroa (P Buck), 'Maori food supplies of Lake Rotorua, With Methods of Obtaining Them, and Usages and Customs Appertaining thereto', in *Transactions and Proceedings of the New Zealand Institute*, vol 53, pp 433–451
77. McDowall, *The Whitebait Book*, p 175
78. McDowall, *Natural History*, p 468

7.17 Loss of Harvest Due to Vermin Destruction Campaigns

Acclimatisation societies had begun to form by the 1860s. Membership included Prime Ministers, ministers of the Crown, members of Parliament, provincial superintendents and councillors, mayors, judges, lawyers, newspaper editors, merchants, landowners, and scientists. 'The acclimatisation societies were, from the outset, of high social and political importance in the colony. Lists of people involved in either stimulating formation of societies or as members of their founding councils were a 'who's who' of colonial New Zealand of the time'. As McDowall commented: 'No other agencies in New Zealand have ever been to the same extent self-regulating in a statutory sense, with such minimal government oversight', nor elected by such an 'exclusive user group' who are the sportsmen 'controlling the management of the resources they exploited'.[79]

The acclimatisation societies were funded from grants made by provincial and colonial governments, from membership fees of hunters and anglers, and from licences for hunting both introduced and indigenous fauna. Initially licences were sold by Government agencies (Collector of Customs, Post Offices). The acclimatisation societies objected, and from around the 1920s to 1990 the Societies 'assumed total control over licences sales and the revenue from them'.[80]

In 1966 the New Zealand Fish and Wildlife Investigation Movement advised that freshwater fisheries and wildlife were being unwisely managed, and were gravely threatened by land use, industrial development, and intensive settlement. In 1968 Burnet published his findings that eels were not detrimental to trout stocks.[81] The Hunn Commission investigated freshwater fisheries in 1968. The acclimatisation societies opposed the commission's recommendations, and none was instituted.[82]

79. Early members of the Auckland Acclimatisation Society were Thomas Gillies, lawyer, politician, later judge of the supreme court; Frederick Hutton, Auckland provincial geologist; Albin Martin, Provincial Councillor; Richard Ridings, Provincial Councillor. Later members were Thomas Kirk, botanist, secretary of the Auckland Institute, curator of the Auckland Museum, and later chief inspector of forests; Thomas Cheeseman, botanist, secretary of the Auckland Institute. Early members of the Wanganui Acclimatisation Society were Richard Taylor, missionary; Walter Buller, ornithologist, magistrate; John Ballance, Premier. Early members of the Nelson Acclimatisation Society were Charles Elliot, Nelson Provincial Councillor; Edward Stafford, Superintendent of the Nelson Province, later Premier; John Robinson, Nelson Superintendent; David Munro, later speaker of the House of Representatives. Early members of the Canterbury Acclimatisation Society were Julius von Haast, geologist, later director of the Canterbury Museum; Archdeacon Mathias; John Cracroft-Wilson, Canterbury Provincial Councillor, later member of Parliament; William Travers, naturalist, member of Parliament; Thomas Potts, naturalist, later member of Parliament; Samuel Bealey, Provincial Superintendent. Early members of the Otago Acclimatisation Society were James Hector, Otago provincial geologist, later founder of the New Zealand Institute, chancellor of the University of New Zealand; Julius Vogel, Superintendent of the the Otago Province, later Premier. First president of the Southland Acclimatisation Society was John Taylor, superintendent of the Southland Province. Early members of the Hawke's Bay Acclimatisation Society were Donald McLean, Provincial Superintendent and member of Parliament, later Native Secretary; John Ormond, Provincial Councillor, later Superintendent of Hawke's Bay Province, member of Parliament, member of the Legislative Council; Thomas Tanner, Provincial Councillor, member of Parliament. Early members of the Wellington Acclimatisation Society were James Hector (above); Alfred de Bathe Brandon, Provincial Solicitor; John Plimmer, Provincial Councillor; C H Izard, City Councillor; Jonas Woodward, Provincial Councillor. Governor George Grey was patron of the Otago and Southland Acclimatisation Societies (R M McDowall, *Gamekeepers for the Nation: The Story of New Zealand's Acclimatisation Societies*, Christchurch, Canterbury University Press, 1994, pp 18–23, 32).

The Waitangi Tribunal was advised in 1988 that acclimatisation societies were 'akin to local government, discharging a statutory role'.[83] McDowall confirms that the societies carried out on behalf of Government a:

> significant enforcement and statutory role . . . considerable sums of public money were given by the colonial and provincial governments to support society work in introducing and establishing species brought here . . . the country as a whole must accept much responsiblity for bad decisions, and for damage which has ensued and which is now regretted.[84]

The right of acclimatisation societies to kill indigenous fauna in order to protect introduced game and game fish was claimed under the absence of protection provided in the Protection of Animals Act 1861, 1865, and in the Salmon and Trout Act 1867, and thereafter under the schedules of the Animals Protection Acts 1867–1922, the Wildlife Act 1953, and the Fisheries Act 1983. From 1866 to 1968, acclimatisation societies paid a bounty on native fauna predatory on introduced game. Kingfishers, gulls, wekas, and moreporks were briefly eradicated. Eels, shags, and hawks were killed as vermin for 100 years, from the 1860s to the 1970s. To Maori as at 1840, tuna (eels) were an economic staple. Kotare (kingfishers) were an economic resource for some hapu, harvested as young. Ruru (morepork) were an economic resource for some hapu, preserved and presented ceremonially, and an omen for others. Kawau (shags) were an economic resource for some hapu, the young harvested at named shaggeries, and proverbially respected by others. Weka were an economic resource and proverbially respected. Kahu (hawk) were an economic resource and respected in myths and proverbs. Karoro (seagulls) were tamed and tethered in kumara gardens to eat caterpillars.[85]

Campaigns of eel destruction, in order to protect stocks of trout, had begun by 1903, sponsored by both acclimatisation societies and Government departments. In 1928 'a heap of dead eels' was displayed on the Waitaki River bank as a result of an acclimatisation society extermination campaign, and in 1933 an acclimatisation society ranger advised, 'Where infestation is bad it is possible to wade up a stream beheading the eels in one's stride'. In 1930, A E Hefford, Chief Inspector of Fisheries, expressed reservations about the policy then being proposed of exterminating eels from waterways. None the less, in 1948 the Public Works Department destroyed 2000 mature eels in one night as they crossed a dam, on their seaward migration to spawn.

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80. McDowall, *Gamekeepers for the Nation*, pp 65, 68
81. A M R Burnet, *A Study of the Relationships Between Brown Trout and Eels in a New Zealand Stream*, New Zeland Marine Department, Fisheries Technical Report, no 26, 1968
82. McDowall, *Gamekeepers for the Nation*, p 123
83. McDowall, *Gamekeepers for the Nation*, citing W B Johnson
84. McDowall, *Gamekeepers for the Nation*, p 36. In 1990 acclimatisation societies became fish and game councils.
85. Elsdon Best, *Forest Lore of the Maori*, Wellington, Government Printer, 1942, pp 175–178, 330–337, 343–344, 352

In 1963, Max Burnet, Marine Department scientist, demonstrated that trout attain larger size, though fewer in number, when sharing territory with eels.[86] None the less, campaigns of eel destruction continued into the 1970s. Acclimatisation societies had paid a bounty on eels over 10 pounds, and through this policy large eels were specially targeted in extermination campaigns. As eels grow slowly, occasionally living to 60 years, the long-term effects of the policy are becoming apparent. Since 1975, eel captures for export have been declining.[87]

Campaigns of shag destruction, to protect stocks of trout, had begun by 1875. In 1890, the Otago Acclimatisation Society called for a 'more determined onslaught' and by 1904 it was paying a bounty on shags. In 1915, the ornithologist Edgar Stead advised that only one species, the large black shag, preyed on trout, and in 1929 he again advised that shooting of shags was not justified. In 1926, the ornithologists Guthrie-Smith and Stead further advised that shags did more good than harm. None the less, in 1927, the Auckland Acclimatisation Society reported 1500 shags shot on Lake Waikare alone. In 1932, the ornithologist Robert Falla recommended complete protection for the spotted shag and blue shag; in 1941, the little black shag was protected by statute. In 1982, seasonal protection for the black shag was sought to counter its continuing destruction by shooters. For 100 years, acclimatisation societies had paid bounties on shags, conducted annual shooting expeditions to destroy shaggeries during the breeding season, and destroyed nests. Society staff, local councillors, anglers, and shooters participated in these campaigns.[88]

Campaigns of native hawk destruction, to protect introduced pheasants and quail, had begun by 1867, when the (North) Canterbury Acclimatisation Society reported paying bounties on 659 native harrier hawks, and the Auckland Society on 659 hawks. In 1915, the Minister of Internal Affairs protected the native harrier hawk, but opposition from acclimatisation societies prevailed. 'From these beginnings developed perhaps the most extraordinary war, ever, upon any of New Zealand's supposed vermin populations'. Between 1922 and 1942 the Auckland Society paid bounties on nearly a quarter of a million native hawks; during 1946 to 1949 the South Island vermin control board's tally exceeded 53,000 hawks. Campaigns against native hawks continued to 1959.

In 1979, the Wildlife Service declined the native hawk protection. From 1982 to 1996 it received protection during the duck shooting season only.[89]

The extermination campaigns proceeded without research into relationships between game and predators. In 1977, after a hundred years of eradication campaigns against eels, the Nelson Acclimatisation Society advised that there was 'not clear evidence that a moderate eel population has a detrimental effect on an established trout population'.[90]

86. A M R Burnet, *A Study of the Inter-relation Between Eels and Trout*, New Zealand Marine Department, Fisheries Technical Report, no 36, 1969
87. McDowall, *Gamekeepers for the Nation*, pp 120–124
88. Ibid, pp 117, 124–128
89. Ibid, pp 116, 128–130
90. Ibid, p 124

7.18 Loss of Harvest Due to Squandering and Overexploitation

Maori ethos in regard to exploitation of wild life is proverbially 'We do not fish to kill fish, we fish for food'.[91]

In 1899 Clarke commented that it was 'piteous . . . to see the enormous quantities of [unwanted] young grayling (upokororo) which were destroyed' as a result of capture by West Coast whitebaiters, and he also noted that 'often I have seen the surface of the Chinamen's gardens . . . for several acres each in extent covered some inches in depth with [whitebait] fry used as topdressing manure'.[92] In 1928, Hope expressed concern at the decline in whitebait catches, at over-exploitation, and at lack of action from the Government: 'Commercial interests were ruling the whitebait industry'.[93] In 1984, McDowall noted that the migrating young of the blue-gilled bully are known to whitebaiters on the West Coast as 'whalefeed' or 'Dan Doolin spawn'. 'They are occasionally caught by whitebaiters in very large numbers, but are not regarded as of any food or fisheries value'.[94]

During the extermination campaigns conducted by the acclimatisation societies, hundreds of thousands of eels had been eradicated and buried in the ground, or exposed in heaps on river banks, or electrocuted at dams.

7.19 Loss of Harvest Due to Lack of Research

Fisheries scientists have been outspoken on the neglect of research that would ensure good management of the resource. In 1922, the Chief Inspector of Fisheries, A E Hefford, held the view that the whitebait fishing regulations 'made in the past have been mainly for the purpose of adjusting matters between competing fishermen rather than from the point of view of conservation of the stock'.[95]

In 1941, the naturalist Gerald Stokell voiced concern at the absence of conservation policy for indigenous freshwater fish: 'the native fishes except those that are of economic value and subject to fisheries regulations are entirely unprotected'. He urged 'the cessation of chaotic and blindfold fishery control'.[96]

In 1966, the New Zealand Fish and Wildlife Investigation Movement noted that freshwater fisheries and wildlife were being managed without sound research data.[97] Marine Department research into the migrations of whitebait did not begin until 1968.[98]

91. *Report of the Seminar on Fisheries for Maori Leaders*, Auckland, University of Auckland, Centre for Continuing Education, 1976
92. Clarke, 'Notes on New Zealand *Galaxidae*', pp 78–91
93. *The Press*, 5 September 1928; McDowall, *The Whitebait Book*, p 185
94. Strickland found no record of Maori names for blue-gilled bully. It is distinctive in occupying swiftly flowing waters along with the torrentfish, and in penetrating further upstream than most other fish (McDowall, *Natural History*, pp 304, 307).
95. McDowall, *The Whitebait Book*, p 130, quoting Marine Department files
96. G Stockell, *Wild Life Control. Defects in Present Scheme Exposed. Some Constructive Suggestions*, Wellington, Blundell, 1941
97. McDowall, *Gamekeepers for the Nation*, pp 405–406
98. McDowall, *The Whitebait Book*, p 72

Introductions of exotic fish began in 1860s and continued for a hundred years before Government scientists began research on their impact on the native fauna. In 1990, McDowall noted, 'Even now, in spite of greatly increased research effort, there has been only minimal explicit study of the relationship between the indigenous and exotic fish faunas'.[99] In 1991, McDowall commented:

> So little is known [about the life cycles of the five white bait species] that biologically based management of the fishery and its species is impossible . . . Nothing is known about how they live [at sea] . . . how they disperse at sea, or how they navigate back to fresh waters . . . Absolutely nothing is known about levels of escapement from the fishery . . . In short, managers of the fishery have never had much idea how much fish was caught. There has never been any ability to relate catches to populations, to estimate the impact of fishing on the stocks, or any of the other, fundamental parameters/measures that would be required if the fishery was to be managed on sound, biologically based principles. Management has always been a hit and miss, ad hoc affair.[100]

In summary, Maori had rigorous practices for preventing pollution of waters, and for placing protection over vulnerable stocks; a complex knowledge-base prevented inadvertent destruction of crucial habitat; the technology was productive while enabling stocks to rebuild. The Crown did not require agricultural and industrial practices to match the standards set by Maori and during the nineteenth and twentieth centuries the economy of colonial settlement was established at the expense of the faunal abundance which Maori had harvested over many centuries as the self-sustaining basis of their forest-river economy.

Since the claim was lodged in 1991, Government has signed international legislation moving wildlife resources further from Maori control; the Department of Conservation has directed its habitat protection to offshore refuges; indigenous forests are on the edge of sudden decline; and elders who can retrieve knowledge of an interactive natural world may be the last generation. Statutes have been manipulated to support the interests of mining companies; regional bodies have granted discretionary resource use permits to agriculture, forestry, industry, and urban development; Government has committed the country to international agreements; medical legislation has excluded the exercise of Maori knowledge; and resource legislation has excluded the exercise of Maori management. Many of these decisions were made by bodies whose members were themselves the interested parties. Advice from New Zealand scientists at the Department of Scientific and Industrial Research and at the National Institute of Water and Atmosphere that remaining forests, wetlands, and mangrove swamps – as nurseries for wildlife – would provide a greater economic return per hectare than agriculture and pine forestry, have gone largely unheeded. Yet with combined public will, the loss of harvest is in some measure recoverable:

99. McDowall, *Natural History*, p 461
100. R M McDowall, *Conservation and Management of the Whitebait Fishery*, Wellington, Department of Conservation, Science and Research Series, no 38, 1991, pp 4–9

Queen Victoria proclaimed protection to riparian zones by defining the 'Queens chain' so that access through private land would be maintained. These are now called 'marginal strips', linear stretches of public land that sometimes extend across the lowlands linking the mountains and the sea. Sadly, despite widespread public belief in the 'Queens chain', it has largely been ignored. Nevertheless, the impact has been to encourage rivers as boundary markers so that multiple ownership is characteristic. This means that no single owner dominates the riparian zones of larger rivers and therefore community interest is an underlying factor in overall management. For all these natural and cultural reasons, the riverbanks of New Zealand offer an unexcelled potential for ecological restoration.[101]

101. P Simpson, *Ecological Restoration in the Wellington Conservancy*, Wellington, New Zealand Department of Conservation, 1996