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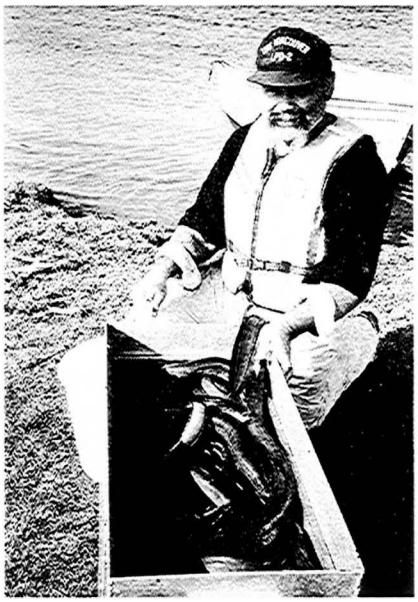
Ben L. Chisnall



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Abstract

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Maori customary eel fisheries, Lakes Taharoa and Harihari, were stocked with commercially under-sized eels (under 220 g) to replenish dwindling stocks. Pre-stocking surveys revealed predominantly shortfinned eel populations in relatively low abundance; distributions of length and age were skewed towards large and old eels. Bycatches showed that three eel prey species were relatively common; shrimp, common bully, and common smelt. Juvenile eels (N = 7600, 99% shortfinned eels) were captured from Lake Waahi in the lower Waikato, where eel densities are high. These eels were held at the Te Kauwhata eel factory before transfer, where 1634 shortfinned eels were tagged with coded-wire tags. Narrow otolith growth bands resulting from poor growth of Lake Waahi eels over recent years should provide reference markers in otoliths for future investigations of growth and survival of transferred eels.

Introduction

Maori wish to see certain waters restored to a state that satisfies their requirements for customary eel fisheries. A number of customary fisheries have been adversely affected by commercial fishing, exacerbated where recruitment has been adversely affected by manmade obstructions (e.g., Jellyman & Beentjes 1998).

This report forms part of a Ministry of Fisheries contract (MFish Project EEL9702) to further study eel enhancement opportunities from juvenile (sub-commercial sized) eels, i.e., 220 g or less, in the North Island. Similar transfer programmes have been carried out in the South Island (Jellyman & Beentjes 1998, Beentjes 1998).

Juvenile eels transferred from an area of low productivity (or high densities) to an area of high productivity (or low densities) should show accelerated growth and condition. The receiving waters were surveyed to determine species, size and age composition, and growth rates of the resident population before enhancement. The subsequent growth and survival of transferred eels could then be measured against these parameters in recapture studies. Juvenile eels for stocking were to be caught in an area of low productivity (or high densities) and growth and condition recorded from a representative sample before transfer. Tagging of juveniles by sequentially numbered coded-wire tags was required to assess the success of the transfer in future. An assessment of prey availability was also required.

Enhancement sites: Lakes Taharoa and Harihari

The Taharoa lakes are dune lakes on the west coast of the King Country (Figure 1). The three interconnected lakes, Lakes Taharoa, Numiti, and Rotoroa, are Maori owned and support an important present-day customary eel fishery. The lakes are mesotrophic, have mean depths of 3–4 m, a combined area of about 2.46 km^2, and are 3 km from the sea. Lake Harihari, also an historic Maori fishery, lies 4 km south of the interconnected lakes and less than 1 km from the sea. Its outlet stream can dry out during the summer, thereby limiting elver recruitment in some years.

Although each lake is surrounded by pastoral land, lake margins have extensive reed and raupo stands. The outlet from the interconnected lakes (Wainui Stream) has a dam with a fish-pass to allow fish and shrimp entrance to the lakes.

Poor recruitment to the eel population is thought to be due to lower residual flows from the lakes during migratory periods since the dam was built in 1971 (Chisnall & Bellingham 1998). Eel stocks in

Lake Harihari were severely depleted by unsanctioned commercial fishing in 1993. The eel population was low and few large eels were found in this lake in summer 1994 (Chisnall 1994). Shortfinned eels made up over 90% of the eel populations of Lakes Taharoa and Harihari (Chisnall 1994).

There is little information on the fish and invertebrate fauna in the Taharoa lakes before construction of the dam. Tangata whenua have described three substantial, historical fisheries for eels (both shortfinned, *Anguilla australis*, and longfinned, *A. dieffenbachii*), grey mullet (*Mugil cephalus*), and adult whitebait (primarily inanga, *Galaxias maculatus*). Other fish reported from the lake include common bully (*Gobiomorphus cotidianus*), common smelt (*Retropinna retropinna*), and whitebait – galaxiid species, mainly inanga, but with some banded kokopu (*Galaxias fasciatus*) and rarely koaro (*G. brevipinnis*). Catches since the dam construction have confirmed the presence of these species. Koura (freshwater crayfish, *Paranephrops planifrons*) and the estuarine shrimp *Paratya curvirostris* were also apparently abundant before the dam was built.

Investigations of the fish communities in the Taharoa lakes since installation of the dam (e.g., Strickland 1985) showed that common bullies, common smelt (probably lacustrine form only), and shrimp were relatively common.

The Taharoa lakes were selected for stocking for several reasons: the low densities of eels associated with poor recruitment; iwi desire for improvement of the customary fishery; and the respect generally afforded to the Taharoa lakes by commercial eelers avoiding fishing there.

Source site: Lake Waahi

As the Taharoa lakes are within the Tainui rohe, a source of juvenile eels within the Waikato region was preferred. Many Waikato lowland waters are potential sources of juvenile eels, but Lake Waahi was considered likely to benefit from "thinning" of the large quantities of small shortfinned eels it contains (e.g., Chisnall *et al.* 1992), although the quantity to be transferred (5000–10 000) was small. The lake is easily accessed and close to Te Kauwhata where the small eels were to be held for tagging before transfer.

Documentation on the eels in Lake Waahi (Chisnall & Hayes 1991, Hayes *et al.* 1992, Chisnall 1996, Chisnall & West 1996) shows an eel population that is of mainly sub-commercial sized shortfinned eels in high densities. Catch rates with the same fine-meshed nets have increased from 88 eels per net per night in 1992, to 150 in 1994, and 200–300 eels in 1996 (NIWA, unpublished data).

Migratory shortfinned male eels taken from the Huntly power station intake screens in 1997 were thought to have come from Lake Waahi. They were 14–16 years old, small (mean size 350 mm), and gonad development was negligible compared with that observed in migrants elsewhere (e.g., Beentjes & Chisnall 1998). The otoliths of these eels showed poor growth over the previous 6–8 years, dating back to 1990 when the mysid shrimp food base collapsed (Chisnall *et al.*1992). Such stunted growth is typical of high population density.

Methods

Survey of receiving waters

Lake Taharoa was fished with eight unbaited large fine-meshed fyke nets (Chisnall & West 1996) on 8 May 1998. All nets were set on the lake-margin (*see* Figure 1) and left to fish overnight. Catches were emptied into holding bins to process on the shore. Other fish and shrimp species were identified

and counted. All eels were anaesthetised using Aqui-S™ and their length and weight recorded. Owing to access difficulties during poor weather, Lake Harihari was fished later (19 May 1998) using similar methods but with six nets (*see* Figure 1). As recent growth information for eels in both lakes was available, eels were released after measurement.

Capture methods

The contract stipulated that 5000–10 000 juvenile eels be transferred into receiving waters. Twelve large fine-meshed fykes and 25 standard fykes (with escapement tubes blocked off) were baited with ox heart and set from the lake margins to fish overnight on 18–21 May. The nets were lifted each morning, and sub-commercial sized eels (under 220 g) roughly counted and retained in holding bins or immersed fine-meshed nets. Eels 220 g or over were returned to the lake.

At the end of each day, eels were transferred to the Te Kauwhata eel factory (New Zealand Eel Processing Co. Ltd) and held in tanks with a flow-through system and additional aeration from water sprayed into the tank. Low dosages of formalin were added to the holding tanks to minimise fungal infection from skin damage inflicted during handling. About 7600 juvenile eels (99% shortfinned) were captured and retained at the factory.

Tagging and transfer

Between 19 and 21 May 1998, 1634 shortfinned eels were tagged using a procedure similar to that described by Jellyman & Beentjes (1998). Eels were tagged dorsally in the head and scanned for tag retention before release into the holding tanks. During tagging, a length-stratified subsample of eels (up to eight eels per 1 cm size group) was measured and had otoliths removed for later ageing.

On 19 May 1998, about 6000 eels (100 of them tagged) were transferred by tanker to Lake Taharoa: mortality was minimal (n = 13). The remaining eels were tagged (a random selection from those captured), and 1000 transferred to Lake Taharoa and 600 to Lake Harihari on 22 May.

Ageing

Otoliths were prepared for reading using the crack-and-burn technique, modified after Hu & Todd (1981), and read under a binocular microscope and side illumination. Each otolith half was read and age was recorded from each as the number of completed annuli, ignoring the central zone of larval growth. Age from the most readable fragment was taken as the total freshwater age. Age-at-length was modelled using least-squares linear regressions. The mean length of glass eels recruiting to the lower Waikato (60 mm) was subtracted from the total length in the models.

Results

Pre-stocking surveys – Lakes Taharoa and Harihari

Catch rates, species compositions, and size distributions

Catch rates in Lake Taharoa ranged between 8 and 56 eels per net per night (mean 28): 95% were shortfinned eels (Figure 2). These figures compare well with samples taken from Lake Taharoa in 1993: 18 eels per net per night and 94% shortfinned eels (Figure 2). However, the size distribution in 1998 appeared skewed towards large eels, with few smaller than 500 mm compared with 1993 (Figure 2a). In 1998, eels ranged between 360 and 860 mm (Table 1). One longfinned eel from Lake Taharoa

was confirmed as *Anguilla reinhardtii*, the Australian longfinned eel (Jellyman *et al.* 1996).

Only eight eels were caught in Lake Harihari (Table 1) (1.3 eels per net, per night), probably because a rapid decline in water temperature preceded sampling (from 16 to 11 °C in 3 days). In contrast, in summer 1994, the mean catch rate was 14 eels per net per night, of which 92% were shortfinned eels (Figure 2c). Most eels captured were under 450 mm, reflecting the effects of commercial fishing. This lake was previously known for its large "duck-taking" eels (local farmer, pers. comm.).

Length-weight relationships are given in Table 2. The condition of eels from Lakes Taharoa and Harihari, as indicated by the regression model constants *a*, was similar for each of the years sampled.

Age and growth

Otoliths were considered to be easily readable. Growth rates for shortfinned eels were about 16 mm per year from Lakes Taharoa and Harihari, and 27 mm per year for longfinned eels from Lake Taharoa (Table 3, Figures 3, 4).

Age frequencies from these random samples (4 net's catches from the 10 used in each lake, Chisnall 1994) showed that Lake Taharoa had few eels under 15 years, whereas in Lake Harihari most eels were under 15 years (Figures 3, 4).

Bycatch

In Lake Taharoa a few fish and shrimp were caught in all nets. Catches of common bullies ranged from 10 to 40 per net, common smelt 2–10 per net, and shrimp up to 50 per net. Regurgitated remains of koura were also found in nets.

Common bullies were the only species caught in Lake Harihari, and numbers were low with an average of 25 per net. This catch rate is lower than in summer 1994 (mean 38 per net), but common smelt were also present in low numbers then (Chisnall 1994).

Source site: Lake Waahi

Catch rates and mortality

Despite sampling being undertaken in May when water temperatures were cooler than in early autumn (sampling had been initially scheduled for March, but was delayed), catch rates were high at 100–200 eels per fine-meshed net per night. Less than 3% of eels caught were of commercial size, and these were returned to the lake.

Forty eels died during handling before transfer to the factory, 45 died before tagging, and 17 died during the transfer (these were frozen for future identification and reading of tags). Total mortality was 102 eels (1%).

Size distribution and species composition

The eel population in Lake Waahi has been intensively investigated since the mid 1980s (e.g., Hayes *et al.* 1992). Size distributions of eels were recorded between 1996 and 1998: most of the population was under 500 mm (sub-commercial size), and longfinned eels made up less than 1% (Figure 5a) (NIWA, unpublished data).

Of the 7600 juvenile eels taken from Lake Waahi, 1619 were tagged and successfully transferred to Lakes Taharoa and Harihari. All tagged eels were shortfinned (*see* Table 1). Most shortfinned eels were 350–450 mm and 50–150 g (Table 1, Figure 5b). The length-weight relationship for these eels is given in Table 2. Clearly, the condition of eels in Lake Waahi has deteriorated considerably over the last few years, as indicated by the reduction in constant *a* in the length-weight regression from 14.72 in 1996 to 11.36 in 1998.

Age and growth

The length-stratified sample of undersized eels (30–213 g) retained for ageing (n = 90) ranged in length from 227 to 535 mm (mean, 409 mm). Ages ranged from 9 to 23 years. The length-age relationship showed considerable scatter (Figure 6a) and the slope of the linear regression line was not significantly different from zero. The modal size of transferred eels – 400 mm (*see* Figure 5b) – equated to about 14 years old. Eels older than this appear not to have grown much (Figure 6a).

The age-length relationship for shortfinned eels taken from Lake Waahi in 1996 (NIWA, unpublished data) was compared with that from the present stocks (*see* Table 3, Figure 6b). The slope of the regression for shortfinned eels in 1996 provided a growth rate of 26 mm per year, although the most recent sample indicates that the growth rate is slower (Figure 6a).

Discussion

The eel population in Lake Taharoa shows evidence of diminished recruitment. In contrast, in 1994, the size and age structure of eels in Lake Harihari was skewed towards small and young eels, and few large eels were captured, a reflection of the earlier commercial fishing that had occurred (Chisnall 1994). In both lakes in 1998, eels were in good condition; the stocks were predominantly shortfinned eels, typical of New Zealand dune lakes. Growth rates for shortfinned eels were lower than for longfinned eels, and appear lower than for Lake Waahi in 1996. However, the size distribution for eels from Lake Taharoa was skewed towards large eels, which often grow more slowly in length than small eels.

The modal length of tagged shortfinned eels from Lake Waahi was 400 mm (*see* Figure 5b), a size attained by eels from Lake Taharoa at only 11 years (*see* Figure 4) compared with eels from Lake Waahi at 14 years (*see* Figure 6a). The 1996 growth data are similar to those reported for 1988 from Lake Waahi (28 mm per year, Chisnall & Hayes (1991)), but that study did not subtract elver size from length, i.e., growth rates in 1996 would be lower than in 1988. The 1998 sample from Lake Waahi indicates a distinct slowing in growth with size (*see* Figure 6a). Male migrants from Lake Waahi examined in 1997 had declined in growth over the previous 6–8 years, probably in response to diminishing food availability and increasing competition from high eel densities. Capture rates and size distributions from this transfer programme also indicate high eel densities in Lake Waahi. Similar aged male migrant shortfinned eels in Lake Ellesmere have become smaller over the last 20 years, possibly due to changing environmental conditions within the lake (Jellyman & Todd 1998).

Lake Taharoa had three common potential prey species: shrimp, common smelt, and common bullies. This species composition has not changed since 1994. Only a few common bullies were captured in Lake Harihari, but low water temperatures may have contributed to lowered catch rates of bullies and the failure to catch smelt or shrimp.

A prevailing El Niño weather pattern caused higher temperatures throughout the summer of 1998 and delayed the onset of winter, allowing the successful capture of sufficient quantities of juvenile eels from Lake Waahi in May. Their poor condition may reflect the high population densities in the lake

and lower food availability, as described above. Poor condition may also reflect the long dry summer preceding our sampling, with limited terrestrial food input from waterways. If the programme had taken place earlier, higher temperatures would probably have caused much higher mortalities than the 1% experienced.

The transfer of 6600 eels into Lake Taharoa and 1000 into Lake Harihari has started the replenishment of a declining Maori customary fishery. Monitoring the growth and survival of the tagged eels should demonstrate the benefit of transferring juveniles from heavily populated parts of the intensive fishery. The recent narrowing of growth bands during the past 6–8 years should provide a recognisable zone in the otoliths of the stocked eels, so that growth rates of non-tagged eels can also be determined.

Acknowledgments

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References

Beentjes, M.P. 1998: Enhancement of Lake Hawea eel stocks by transfer of juveniles. *NIWA Technical Report 41*. 15p.

Chisnall, B.L. 1994: Eel stock evaluation in Lakes Harihari, Numiti and Rototapu. NIWA Consultancy Report BHP001. (Unpublished report held by NIWA, Hamilton, New Zealand. 20 p.)

Chisnall, B.L. 1996: Habitat associations of juvenile shortfinned eels (*Anguilla australis*) in shallow Lake Waahi, New Zealand. *New Zealand Journal of Marine and Freshwater Research 30*: 233–237.

Chisnall, B.L. & Bellingham, M. 1998: Review of the operation of the Taharoa fish-pass and associated fisheries issues. NIWA Consultancy Report BHP90202. (Unpublished report held by NIWA, Hamilton, New Zealand. 36 p.)

Chisnall, B.L. & Hayes, J.W. 1991: Age, growth and condition of shortfinned eels (*Anguilla australis*) in the lower Waikato Basin, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 25*: 71–80.

Chisnall, B.L. & West, D.W. 1996: Design and trials of a fine meshed fyke net for eel capture, and factors affecting size distribution of catches. *New Zealand Journal of Marine and Freshwater Research 30*: 355–364.

Chisnall, B.L., West, D., & Boubée, J.A.T. 1992: Structure of the eel population in Lake Waahi, Part 1. Report to New Zealand Coal Corporation. *New Zealand Freshwater Fisheries Miscellaneous Report No. 124*. 24 p.

Hayes, J.W., Rutledge M.J., Chisnall B.L., & Ward F. 1992: Effect of elevated turbidity on shallow lake fish communities. *Environmental Biology of Fishes.35:* 149–169.

Hu, L.C. & Todd, P.R. 1981: An improved technique for preparing eel otoliths for ageing. *New Zealand Journal of Marine and Freshwater Research 15*: 445–446.

Jellyman, D.J. & Beentjes, M.P.1998: Enhancement of the eel stocks of Coopers Lagoon, Canterbury, by transfer of juvenile eels. *NIWA Technical Report 22.* 18 p.

Jellyman, D.J. & Todd, P.R. 1998: Why are migrating male shortfinned eels (*Anguilla australis*) in Lake Ellesmere, New Zealand, getting smaller but not younger? *Bulletin Français de la Peche et Pisciculture 349:* 141–152.

Jellyman, D.J., Chisnall, B.L., Dijkstra, L.H., & Boubee, J.A.T. 1996: The first record of the Australian Longfinned eel, *Anguilla reinhardtii,* in New Zealand. *Australian Journal of Marine and Freshwater Research 47*: 1037–1040.

Strickland, R. 1985: Fisheries aspects of the Taharoa lakes and Wainui stream. *Fisheries Environmental Report 66.* 48 p.

Table 1: **Size range of eels sampled in Lakes Taharoa and Harihari and eels captured for transfer from Lake Waahi in May 1998. [1], tagged; [2], not tagged; -, no data**

Location	n	Length range (mm)	Weight range (g)
Shortfinned			
Lake Taharoa	229	360–860	98–1056
Lake Harihari	5	312–552	-
Lake Waahi [1]	1 634	259–528	42–228
Longfinned			
Lake Taharoa	11	440–862	204–1917
Lake Harihari	3	420–523	-
Lake Waahi [2]	13	350–412	80–149

Table 2: **Weight-length relationships of eels sampled from Lakes Taharoa, Harihari, and Waahi. Relationship form of ln weight (g) = *b* ln length (mm) - *a*. [1], Chisnall 1994; [2], NIWA unpublished data**

Location	Year	n	Length range (mm)	Weight range (g)	*a*	b ± s.e.	r^2
Shortfinned							
Lake Taharoa	1993[1]	312	296–549	42–940	13.32	3.03 ± 0.04	0.95
Lake Taharoa	1998	65	360–860	98–1 056	13.87	3.12 ± 0.07	0.97
Lake Harihari	1994[1]	69	170–620	10–450	14.23	3.16 ± 0.08	0.99
Lake Waahi	1996[2]	78	195–750	8–845	14.72	3.23 ± 0.05	0.98
Lake Waahi	1998	1 634	259–528	42–228	11.36	2.66 ± 0.04	0.77
Longfinned							
Lake Taharoa	1993[1]	20	342–720	84–967	13.61	3.11 ± 0.12	0.98
Lake Taharoa	1998	11	440–862	204–1 917	15.38	3.91 ± 0.10	0.99
Lake Harihari	1994[1]	6	410–570	140–500	18.34	3.86 ± 0.58	0.92
Lake Waahi	1996[1]	15	317–670	50–710	13.5	3.06 ± 0.29	0.91

Table 3: **Length-at-age relationships of shortfinned and longfinned eels sampled from Lakes Taharoa, Harihari, and Waahi. Relationship form of length (mm) = *a* + *b*age. [1], Chisnall (1994); [2], NIWA unpublished data; [3], sample of captured eels transferred (this report); -, regression not significant**

Location	Year	N aged	Age range (yr)	*a*	b ± s.e.	r^2
Shortfinned						
Lakes Taharoa & Numiti	1993[1]	131	5–33	193.7	16.0 ± 1.0	0.68
Lake Harihari	1994[1]	66	5–35	112.2	14.1 ± 0.7	0.86
Lake Waahi	1996[2]	78	6–21	55.8	26.2 ± 2.8	0.53
Lake Waahi	1998[3]	90	9–23	-	-	-
Longfinned						
Lake Taharoa	1993[1]	25	10–28	91.8	27.2 ± 5.9	0.3
Lake Harihari	1994[1]	6	10–21	-	-	-
Lake Waahi	1996[2]	15	6–16	118.3	25.0 ± 7.0	0.49

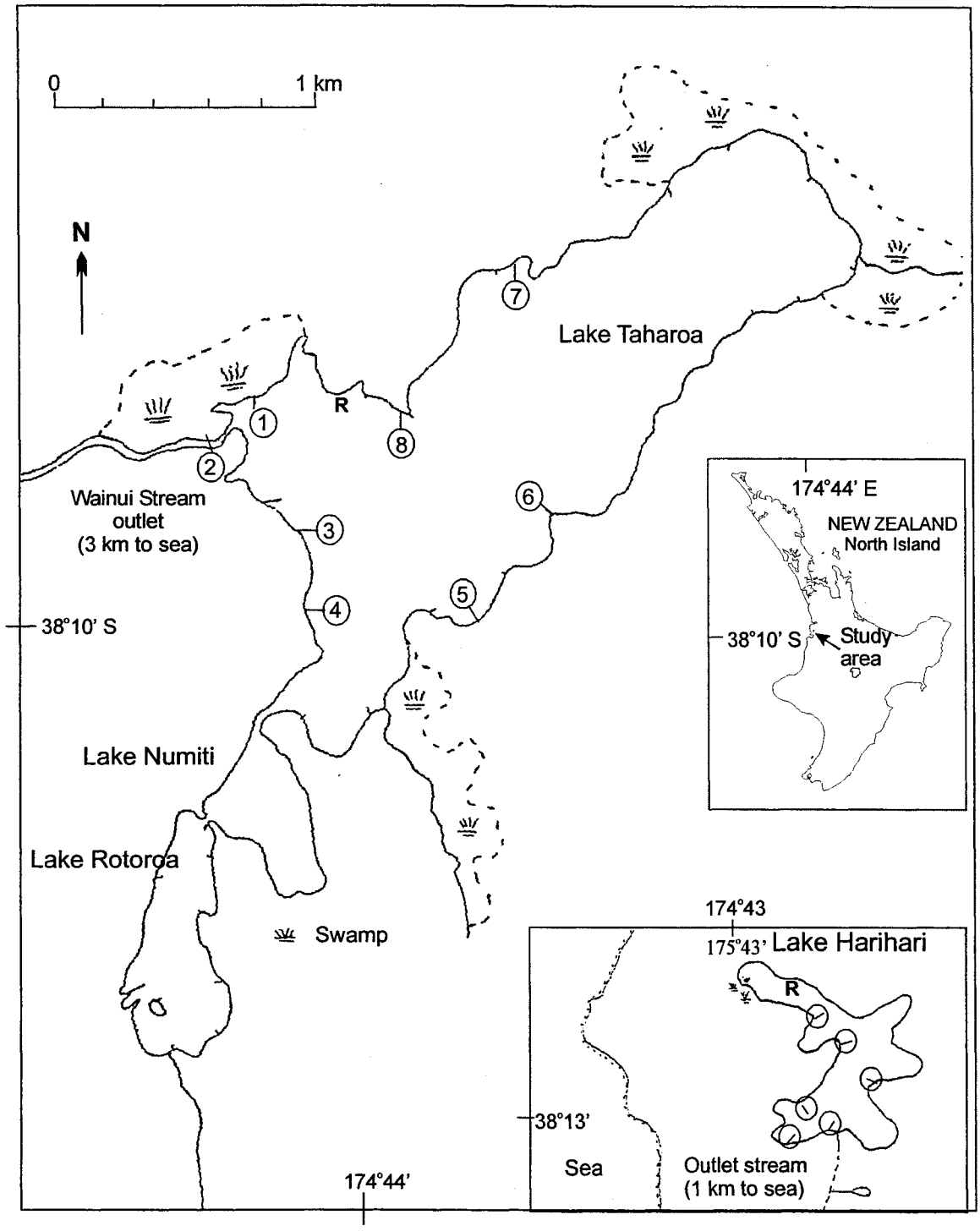

Figure 1: **Lakes Taharoa, Numiti, Rotoroa, and Harihari in the western King Country, showing net positions used in pre-stocking surveys, May 1998, and release points (R) for transferred eels.**

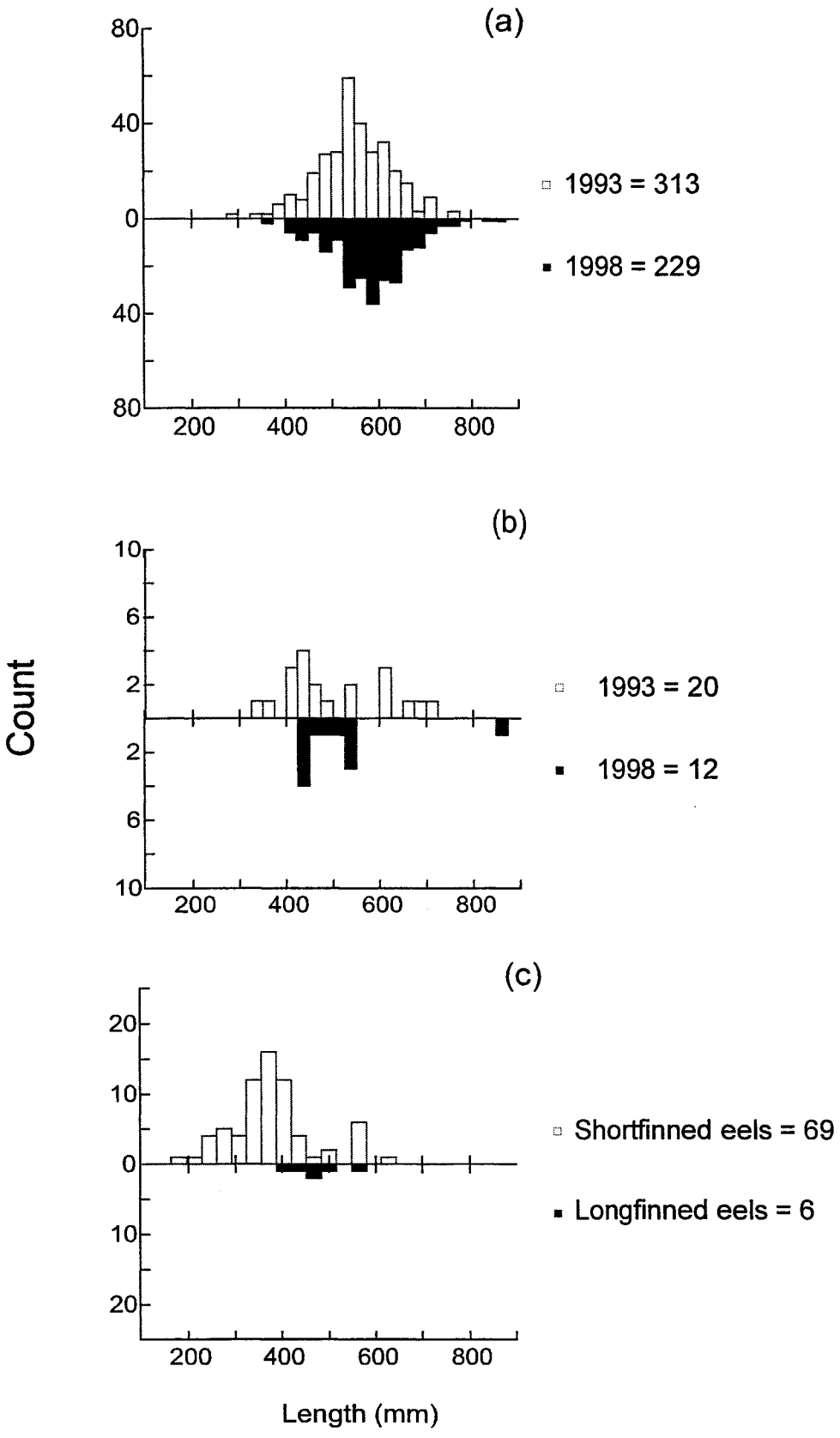

Figure 2: **Size distribution of shortfinned (a) and longfinned (b) eels sampled from Lake Taharoa in February 1993 (Chisnall 1994) and May 1998, and Lake Harihari in 1994 (c) (Chisnall 1994).**

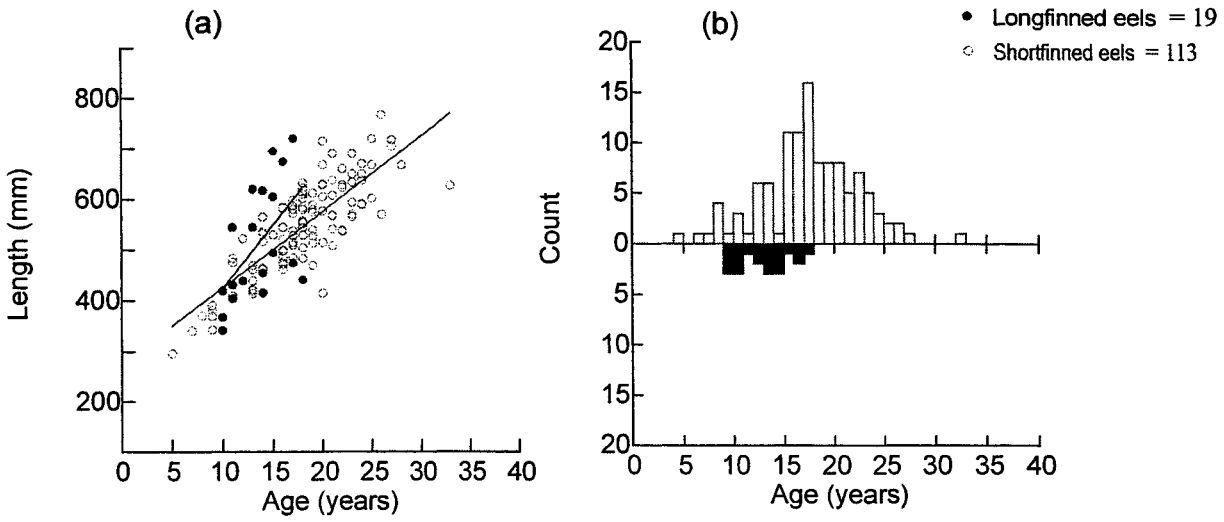

Figure 3: **Length-at-age (a) age frequency (b) of longfinned and shortfinned eels sampled from Lake Taharoa in February 1993 (Chisnall 1994).**

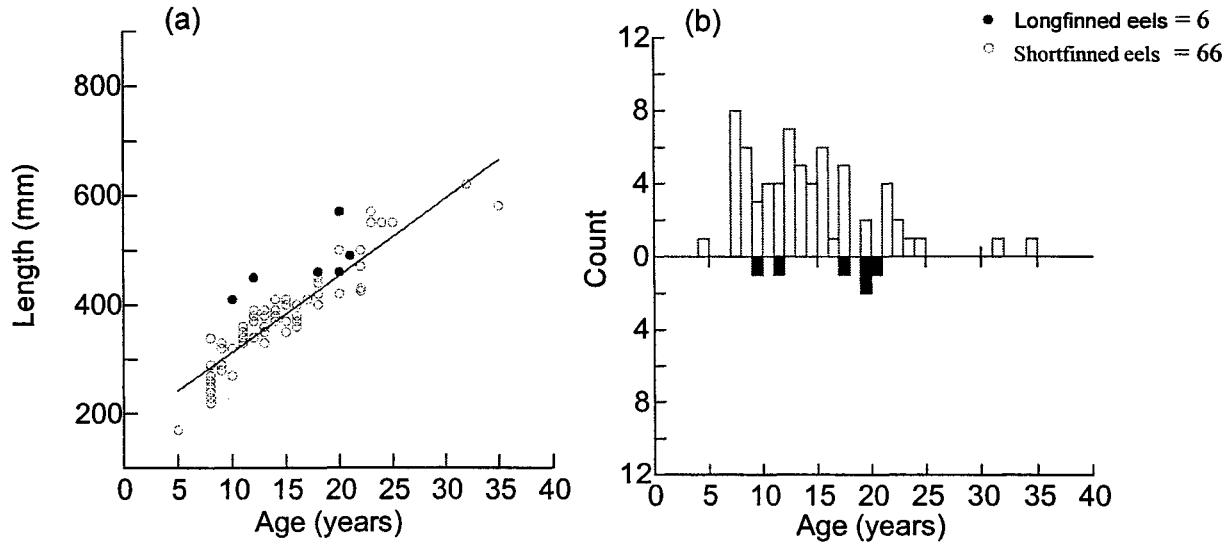

Figure 4: **Length-at-age and age frequency of longfinned and shortfinned eels sampled from Lake Harihari in 1994 (Chisnall 1994).**

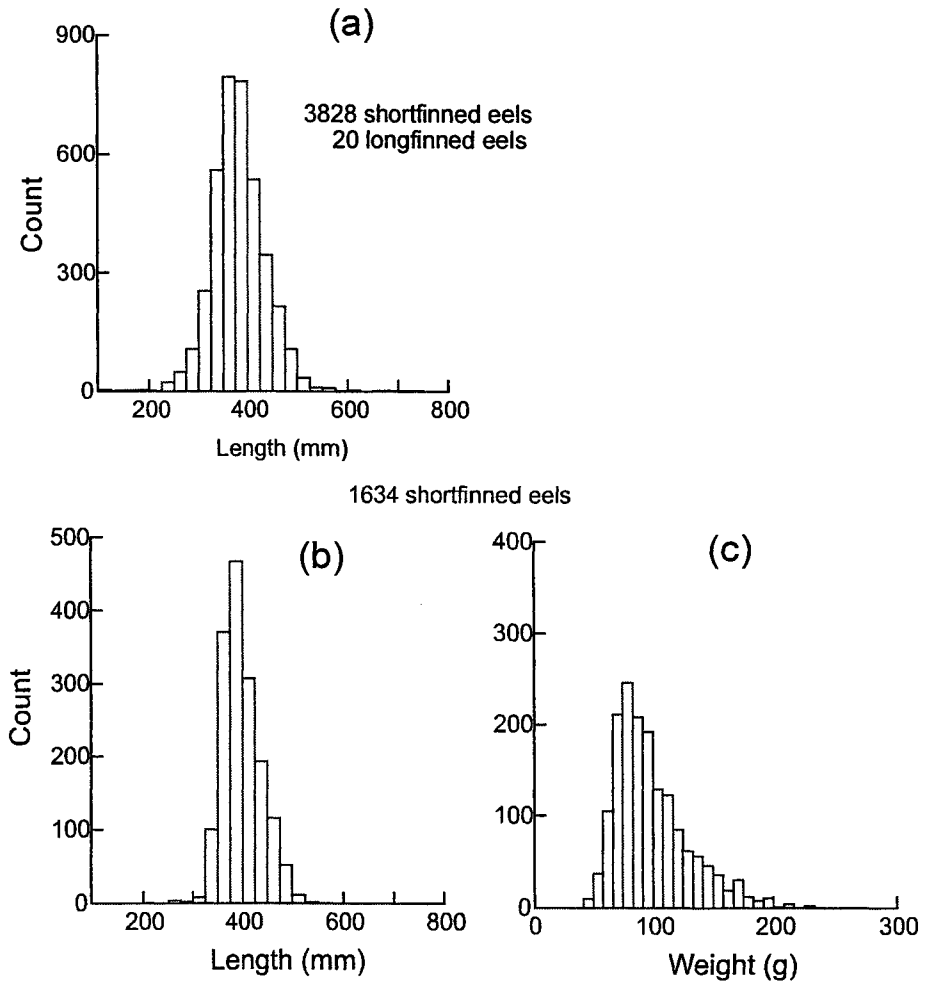

Figure 5: **Size distribution of shortfinned and longfinned eels sampled from Lake Waahi between 1996 and 1998 (NIWA unpublished data) and tagged shortfinned eels in 1998 (b).**

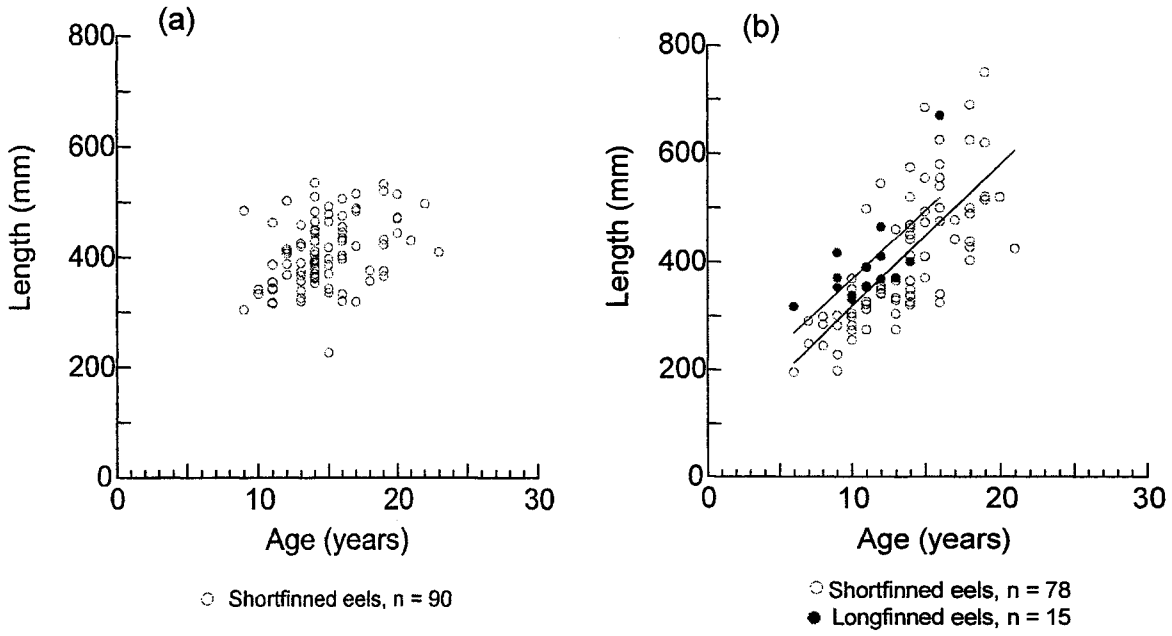

Figure 6: **Length-at-age relationships of shortfinned and longfinned eels sampled from Lake Waahi in 1996(a) (NIWA, unpublished data) and from shortfinned eels captured for transfer in 1998 (b).**

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