TE WAIHORA/LAKE ELLESMERE

State of the Lake and Future Management

Edited by **KENNETH F.D. HUGHEY** and **KENNETH J.W. TAYLOR**

TE WAIHORA/LAKE ELLESMERE

State of the Lake and Future Management

Edited by KENNETH F.D. HUGHEY and KENNETH J.W. TAYLOR
Lincoln University Environment Canterbury

ISBN 978-0-473-14962-8

Published in New Zealand by

EOS Ecology
P.O. Box 4262
Christchurch 8140

Design and layout by

EOS Ecology, Christchurch

Printed by

Croft Print, Christchurch

Reference information

We suggest this publication be referenced as:
Hughey, K.F.D. and Taylor K.J.W. (eds). 2009. *Te Waihora/Lake Ellesmere: State of the Lake and Future Management.* EOS Ecology, Christchurch. 150pp.

Obtaining further copies

Further copies of this document may be obtained from:
Waihora Ellesmere Trust
PO Box 116,
Lincoln,
New Zealand
Phone:+64 (03) 353 9712
Email: admin@wet.org.nz

ACKNOWLEDGEMENTS

WE FIRST NEED TO THANK THE SPONSORS/SUPPORTERS OF THE 2007 LIVING LAKE SYMPOSIUM:

- Environment Canterbury
- Department of Conservation
- Christchurch City Council
- Fish and Game North Canterbury
- Biodiversity Advice Fund
- Independent Fisheries
- Lincoln University
- Lottery Grants Board
- National Parks and Conservation Fund
- NIWA
- Selwyn District Council
- Waihora Ellesmere Trust
- Te Rūnanga o Ngāi Tahu
- Taumutu Rūnanga
- Southern Woods Nursery
- Anonymous donors

The Canterbury Community Trust sponsorship helped greatly with publication of this book and we greatly appreciate that support. We also thank Environment Canterbury, the Department of Conservation, Fish and Game North Canterbury, Selwyn District Council and Christchurch City Council for contributing additional resources to this publication.

CONTENTS

SHELLEY McMURTRIE

SHUTTERSTOCK

01 INTRODUCTION

KENNETH F.D. HUGHEY Lincoln University **KENNETH J.W. TAYLOR** Environment Canterbury

Te Waihora/Lake Ellesmere[1] is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake, a debate long fuelled by rhetoric and informed by a body of science which highlights the lake's complexity as a biophysical system, but has many gaps. It is a debate that now has substantial statutory implications, arising from factors which include:

- the requirements of conservation, and indigenous needs and entitlements which are growing in prominence and statutory (including property rights based) legitimacy;
- public interest in legal processes associated with further major intensification of agriculture planned for the catchment;
- a recent Environment Court decision in which serious questions about the overall biological health of the lake were raised; and
- the consequences arising from the need for Environment Canterbury to obtain resource consents for the lake operating regime.

In addition, in recent times the Waihora Ellesmere Trust (WET), a community based group advocating for improved management of the lake, has been established. It is within these diverse contexts that this State of Te Waihora/Lake Ellesmere report has been prepared—it results from the 2007 Waihora/Ellesmere Living Lake Symposium, held from 31 October-3 November 2007 at Lincoln University, Canterbury. The symposium was initiated and organised by the WET (see www.wet.org.nz).

The Living Lake Symposium had several key objectives:

- To determine the overall state of the lake, by first defining the key value sets, and indicators that could be reported against;
- To suggest future management actions that would address key issues affecting the defined values;
- To provide a forum within which lay individuals, scientists and managers could openly debate issues; and
- To provide a launching pad for integrated and focused future management of the lake and its environs.

The programme incorporated three keynote speakers: Dr Larry Hildebrand from Environment Canada, Dr Hamish Rennie from Lincoln University, and Dr Bryan Jenkins from Environment Canterbury—their addresses made a major contribution to the symposium although none are included in this report, because it is focused primarily on the science and the management options associated with the lake.

The format of this report is designed to be readily updateable. Ten of the principal presentations in the main sessions of day two of the symposium are included in this report—two Power Point presentations (both regarding water quantity and related issues) are provided as appendices to improve completeness. Over time, however, topic areas not available as full papers for this report, e.g., surface water quantity, will be written up and included in detail. Similarly, the papers herein will themselves be updated as new and significant data become available. Each subject area will be reconsidered within the same structure and context as has been provided here. One paper, 'Te Waihora/Lake Ellesmere: An integrated view of the current state and possible futures', was presented on the final formal day of the symposium and it is included as the concluding chapter of this report.

Finally, the Waihora Ellesmere Trust and many of the others attending the symposium saw merit in reconvening the event around two years after the initial symposium, to report on progress with management, indicator monitoring, scientific understanding and other matters. We support that suggestion.

In terms of report format it is important that readers note the following:

- All authors were provided with 'briefs of work' and were requested to contextualise their work with that contained within the Taylor (1996) report on the lake—this was more easily achievable for some than others. Given some lack of consistency between symposium presentations and final papers it is our intention that a revised set of agreed indicators will be considered and included in any follow-up symposium and associated reports—some considerable work will be required in some areas to achieve this objective;
- Only the wildlife and integration papers included in this report have been formally peer reviewed; and
- All other papers have been standardised and style edited-some changes have been suggested by the report editors and made by the paper authors.

Finally, an attempt has been made to present the papers in a logical sequence of 11 chapters: chapter 1 sets the scene; chapters 2-7 cover the biophysical science dimensions (groundwater, water quality, native vegetation, native fisheries, trout, wildlife); chapters 8-10 deal with the human dimensions (Ngāi Tahu, recreation, economics); and chapter 11 deals with integration of the findings from the previous chapters and setting the scene for future management.

[1] Note that the Geographic Place Names Board has defined the name as Lake Ellesmere (Te Waihora). It is not our intention to debate the nomenclature, but rather to put the focus where we consider it should lie, within the lake's initial historical and cultural context for indigenous Maori.


GREG KELLY

05 NATIVE FISH and fisheries

DONALD J. JELLYMAN NIWA CLEM G. SMITH Taumutu

Te Waihora/Lake Ellesmere supports diverse and substantial fish stocks. In addition to important commercial fisheries, the lake supports very important customary fishery values. Key species are shortfin eels, flounders (black, sand, and yellowbelly), and yelloweye mullet. The trends in these fisheries are reviewed, and the importance of spring lake opening is emphasised. Management indicators and goals are presented.

5.1 Introduction

Te Waihora/Lake Ellesmere is a large (20 000 ha) shallow coastal lake in Canterbury formed by the longshore drift of gravel that has created a barrier bar (Kaiterete Spit). The lake has a maximum depth of 2.5 m (Irwin et al. 1989), is highly turbid (Secchi depths < 0.2 m; Glova and Sagar 2000), and salinity normally ranges between 5-10 ppt (Lineham 1983; Gerbeaux 1989). The lake is a taonga to Ngāi Tahu and provides a major source of mahinga kai and mana (Te Rūnanga o Ngāi Tahu and Department of Conservation 2005). As part of the Ngāi Tahu Claims Settlement Act 1998, the Crown vested the bed with Ngāi Tahu. The Department of Conservation (DoC) administers significant other lands adjoining the margins of the lake, and with Ngāi Tahu developed a Joint Management Plan (Te Rūnanga o Ngāi Tahu and Department of Conservation 2005) that outlined policies to maintain or enhance the significant values of the lake.

In recognition of its outstanding value as a wildlife (waterfowl) habitat, a National Water Conservation Order was granted in 1990. This order provides for the present summer and winter opening trigger levels, (1.05 and 1.13 m asl respectively), but has provision for an additional opening during 15 September–15 October pending the granting of resource consents to an interested party.

The lake maintains important customary and commercial fisheries, as well as providing a conduit for recruitment of diadromous fish to the Selwyn and other tributaries. A wide range of fish species has been encountered within the lake or Selwyn catchment (Table 1), including a group of marine species that opportunistically enter the lake during prolonged openings. Species lists have been compiled by Ryan (1974), Hardy (1989), and Taylor (1996). Important mahinga kai and commercial species are flounders (3 main species–black, sand, and yellowbelly), shortfin eels, and yelloweye mullet. A recreational whitebait fishery exists at the mouth of the lake and in several tributaries when there is a spring opening.

TABLE 1. **Fish species recorded from Te Waihora/Lake Ellesmere, and the Selwyn catchment.**

Common name	Scientific name	Te Waihora	Selwyn catchment
Freshwater/estuarine species			
Yelloweye mullet	*Aldrichetta forsteri*	***	*
Shortfin eel	*Anguilla australis*	***	***
Longfin eel	*Anguilla dieffenbachii*	**	**
Goldfish	*Carassius auratus*	**	*
Torrentfish	*Cheimarrichthys fosteri*	*	*
Giant kokopu	*Galaxias argenteus*	?	
Koaro	*Galaxias brevipinnis*	*	
Banded kokopu	*Galaxias fasciatus*	*	
Inanga	*Galaxias maculatus*	**	*
Canterbury galaxias	*Galaxias vulgaris*		**
Lamprey	*Geotria australis*	*	*
Upland bully	*Gobiomorphus breviceps*		***
Common bully	*Gobiomorphus cotidianus*	***	**
Giant bully	*Gobiomorphus gobioides*	*	*
Estuarine triplefin	*Grahamina* sp.	*	
Canterbury mudfish	*Neochanna burrowsius*		*
Common smelt	*Retropinna retropinna*	**	*
Stokells smelt	*Stokellia anisodon*	*	
Black flounder	*Rhombosolea retiaria*	***	
Koura	*Paranephrops* spp.		*
Perch	*Perca fluviatilis*	*	*
Brook char	*Salvelinus fontinalis*		*
Brown trout	*Salmo trutta*	*	**
Rudd	*Scardinius erythrophthalmus*	*	
Catfish	*Ameiurus nebulosus*	?	
Tench	*Tinca tinca*	*	
Chinook salmon	*Oncorhynchus tshawytscha*	*	
Marine species			
Kahawai	*Arripis trutta*	*	
Yellowbelly flounder	*Rhombosolea leporina*	***	
Sand flounder	*Rhombosolea plebeia*	***	
Greenback flounder	*Rhombosolea tapirina*	*	
Common sole	*Peltorhamphus novaezelandiae*	*	
Sprat	*Sprattus antipodum*	*	
Hake	*Merluccius australis*	*	
Sand stargazer	*Crapatalus novaezelandiae*	*	
Estuarine stargazer	*Leptoscopus macropygus*	*	
Sand eel	*Gonorynchus gonorynchus*	*	
Red cod	*Pseudophycis bachus*	*	
Basking shark	*Cetorhinus maximus*	*	
Rig	*Mustelus antarcticus*	*	
Elephant fish	*Callorhynchus milli*	*	
Spiny dogfish	*Squalus acanthias*	*	
Skate	*Raja nasuta*	*	
Globefish	*Contusus richei*	*	
Spotty	*Pseudolabrus celidotus*	*	
Warehou	*Seriolella brama*	*	
Red gurnard	*Chelidonichthys kumu*	*	

? **status uncertain**
* **recorded**
** **often found**
*** **common**

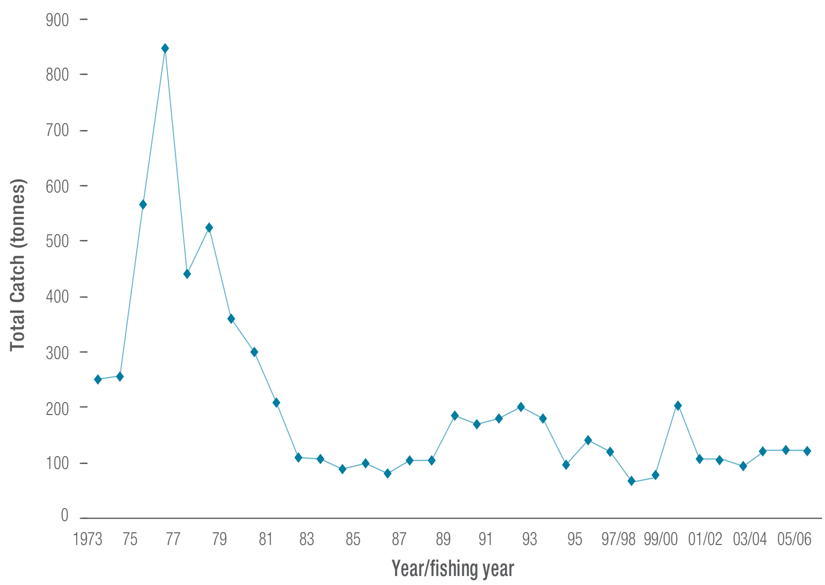

FIGURE 1. Trends in commercial catch of eels from Te Waihora/Lake Ellesmere.

5.2 Data sources

Data from the commercial fisheries were obtained from the Ministry of Fisheries. Te Waihora/Lake Ellesmere comprises one of the six South Island Eel Return Areas. However, for flatfish and mullet, Te Waihora/Lake Ellesmere is part of a wider return area, comprising a significant part of the east coast of the South Island. Further, flatfish recorded by Licenced Fish Receivers (LFR's) are recorded under a generic "flatfish" code. To obtain data on species proportions, we accessed the Catch Effort Landing Return database (compiled from individual fishers' catch estimates) where species are recorded. Any "unidentified flatfish" were allocated to species on a pro-rata basis according to the portion of the catch where species were identified.

The size and age composition of the commercial eel fishery has been part of the Ministry of Fisheries periodic catch-monitoring programme (Beentjes 1999; Beentjes and Chisnall 1997, 1998). Likewise, trends in the catch-per-unit-effort (CPUE) have been analysed (Jellyman 1993; Beentjes and Bull 2002), and the status of the fishery assessed (Jellyman et al. 1995, 2003a). Data on customary harvest from the lake are compiled by Ngāi Tahu from permits issued by lake kaitiaki.

5.3 Commercial eel fishery

Development of the fishery

The eel fishery commenced in the early 1970s and rapidly rose to be the largest single fishery in 1976 (Figure 1), when it comprised almost half of the total New Zealand eel catch. Because of concerns over declining catches, the lake was declared a controlled fishery in December 1978, with the initial Total Allowable Catch (TAC) set at 256 t (which did not include migratory eels) and allocated to 17 fishers. The TAC was reduced to 136.5 t in 1986 and distributed among 11 fishers. Although the lake had an initial size limit of 150 g (1994), this was progressively increased at 10 g/year to reach the national minimum size of 220 g.

A concession area and period was introduced at Taumutu in 1996, whereby fishers could target migrating shortfin males that were less than the legal minimum size. This regulation continues and the migrant eel fishery is generally targeted at 90-100 t per year. This is the only targeted fishery for migrating eels in New Zealand (migrating eels are normally released by fishers as a conservation measure), and capture of these males eels reduces the pressure on the remainder of the TACC (Total Allowable Commercial Catch), which is a fishery for non-migratory (feeding) shortfin females (as males do not exceed 220 g).

The merits of targeting male eels has been advocated by Jellyman and Todd (1998) as a means of conserving females, and utilising the extensive common bully population of the lake which form the major prey of larger eels (Kelly and Jellyman 2007). With the entry of South Island eels into the Quota Management System (QMS) in 2000, the TAC was reviewed and allocations made for customary and recreational use (customary = 31.26 t, recreational = 3.13 t). There are presently five commercial eel fishers on the lake, and the TACC (121.93 t) is almost invariably caught.

Changes in species composition, sizes, and growth rates of eels

Unfortunately, there are few historic data on species composition. In common with other lowland lakes, shortfin eels were always the dominant species in Te Waihora/Lake Ellesmere (Trevor Gould, former commercial fisher and processor, pers. comm.). As longfins prefer flowing water (Jellyman et al. 2003b), there will always have been substantial numbers of longfins in the lower reaches of tributaries and associated lake margins. During initial research surveys (NIWA unpubl. data), a higher proportion of longfins was recorded than in subsequent years, i.e., 1974-82, N = 6961, longfins = 4.3%; 1997-98, N = 1242, longfins = 0.5% (Beentjes 1999).

This reduction will be largely associated with onset of commercial fishing (longfins are more vulnerable to fyke net capture than shortfins; Jellyman et al. 1995; Jellyman and Graynoth 2005), but possibly also associated with the loss of aquatic macrophytes that resulted from the Wahine Storm in 1968. Some longfins are still present in the lower reaches of tributaries and nearby lake margins, as indicated by sampling in early 2007 where no longfins were caught at Timberyard Point (n = 152) but 11 % of eels from the Harts Creek Reserve were longfins (n = 313).

Fishery independent surveys have been used over a number of years, to monitor trends in the sizes of eels, and their growth rates. Eels are aged from their otoliths (earbones), and the average annual growth increment is calculated as:

increment = (length - 60mm)/age

where 60 mm represents the average length of glass eels.

The onset of commercial fishing has the potential to rapidly alter the size structure of eel populations, as evidenced by the changes in the length-frequency of eels sampled from Kaituna Lagoon in 1974 (commercial harvest just commencing in this area) and 1977 when fishing had been underway for 3 years (Figure 2). However, samples from Timberyard Point (Table 2) show virtually no changes in average sizes of shortfins over time. Migrating males have shown a marked decline in average size over time, although this decline has been arrested in recent years (Figure 3).

Although there has been little change in the average size of shortfins, there has been a marked increase in growth rates (Table 3); thus in 1974, shortfins (feeding eels) averaged 24 mm /year, but by 2007, the rate had increased by 63 % to 39 mm/year. The growth rate of migrating males does not appear to have changed much over the years (Table 3), but the growth rate and average size (Table 3, Figure 3) of (migratory) females have both increased substantially between the 1970s and 1998. Presumably, conditions for growth of larger eels have improved over time, possibly as a result of a reduction in overall numbers.

Female eels show accelerated growth rates with increasing size, associated with their change in diet from invertebrates (Kelly and Jellyman 2007) to fish (Jellyman 2001). However, the growth rate of juvenile eels is slow (Graynoth and Jellyman 2002) and this shows in the smaller annual growth increment for migrating males relative to females (Table 3) as males are too small to eat fish.

Movements of feeding eels

Recaptures of tagged eels have shown that most eels do not move extensively within the lake-a total of 1982 of 9956 tagged eels were recaptured over a period of five years, and most were caught at, or adjacent to, their original site (Jellyman et al. 1996). Transplanted eels showed a tendency to home to their original capture site. Likewise, eels sampled in 2007 from within the Hart's Creek Wildlife Management Reserve, were significantly larger than eels from Timberyard Point ($p < 0.05$), a distance of only 3 km, again indicating limited movement between the areas.

Catch rates of eels

Catch-per-unit-effort (CPUE, measured as kg of eels/net/night) analyses of Te Waihora/Lake Ellesmere commercial catches have not shown significant changes over the 9 years for which consistent data are available (Beentjes and Bull 2002). Similarly, when catches are adjusted for the influence of climate, season, and fisher (standardised CPUE), there was still no significant change. As fishers use larger nets than elsewhere in the country, the CPUE between 1990-91, and 1998-99 ranged between 113 and 247 kg/net/day.

TABLE 2. Mean length (mm) and weight (g) of feeding eels from Timberyard Point, for various years.

Species	Year	Number	Length		Weight	
			Mean	SE	Mean	SE
Shortfin	1974	230	466	6.2	234	9.7
	1975	1208	456	2.6	209	4.1
	1994	265	437	6.3	208	13.8
	2007	150	469	7.7		
Longfin	1974	215	392	4.4	164	11.9
	1975	81	415	9.4	182	35.7
	1994	8	543	55.2	483	203.9

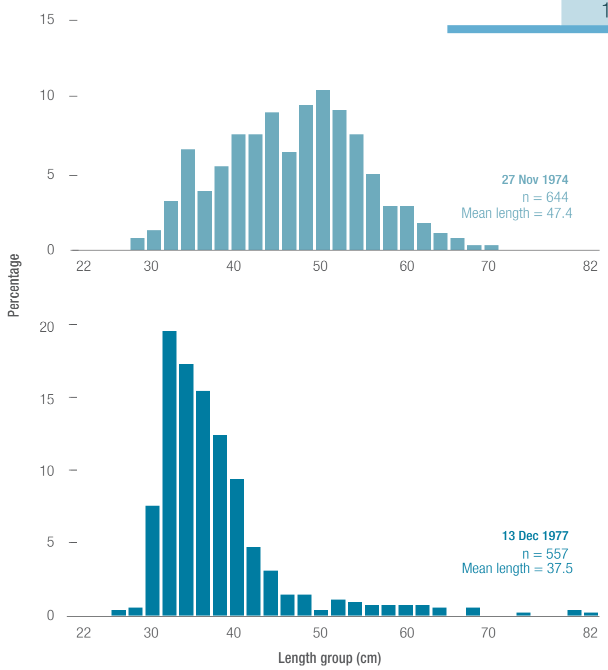

FIGURE 2. Kaituna Lagoon – length-frequency of two samples of shortfin eels collected three years apart.

TABLE 3. Mean annual growth increment (mm/year) for feeding eels from Timberyard Point, and migrating eels from Taumutu, for various years.

Species	Status	Year	Number aged	Mean increment (mm/year)	SE
Shortfin	Feeding	1974	230	24.0	0.3
		1975	1208	25.6	0.2
		1994	265	31.2	0.6
		1996/97*	116	35.3	0.5
		2007	65	38.9	1.0
	Migrant males	1975-82	2389	25.1	0.1
		2006	39	26.4	0.6
	Migrant females	1972-80	181	25.8	
		1998	50	47.3	
Longfin	Feeding	1974	215	24.9	0.4
		1975	81	25.3	0.6
		1994	8	32.4	4.2
		2007**	13	25.2	2.3

* Beentjes and Chisnall 1998

** sample from Harts Creek reserve.

5.4 Commercial flatfish fishery

Trends in the fishery

The flounder fishery has a history of extreme variability (Figure 4), with catches in adjacent years varying up to 10 fold. While this variability is thought to be largely due to the timing and duration of lake openings (Jellyman 1992; Taylor 1996), it also reflects the variability of recruitment of juvenile flatfish generally (Annala and Sullivan 1997). In 1959, there were 39 vessels and 55 fishers engaged in flounder fishing on the lake. Flounders were declared a quota species in 1986, and currently only eight fishers engage in commercial fishing.

Species composition

The catch is dominated by three main species - black flounder, yellowbelly flounder, and sand flounder. Occasionally small quantities of greenback flounder are recorded. Although juvenile common sole frequently enter the lake, they do not survive to enter the fishery. The species proportions vary considerably from year to year (Figure 5), but blacks provide the bulk of the catch (58% over past 23 years), followed by sands (22%) and yellowbellies (20%). While these are the proportions derived from fishers estimates, we are surprised at the putative high proportion of sand flounders, as our experience indicates sand flounders have normally been a relatively minor component of the catch (e.g. < 5%); we suspect coding errors have led to an over-representation of sand flounders.

Relationships with lake opening

Although Taylor (1996) reported a significant relationship ($R^2 = 0.39$, $p < 0.005$) between annual flatfish catches and the duration of lake openings (August-November) 3 years previously, we found no such predictive relationships, despite having a larger database, and investigating a variety of lags. The best relationship we found was for the % of days open between August and November, lagged by 2 years ($R^2 = 0.042$, $p > 0.05$). Seemingly, the relationship between lake openings and flounder abundance is not a simple cause-and-effect one, but will also reflect the national situation where strong year classes of flatfish are common. For example, for the past 16 years, there was a significant correlation between lake catches of yellowbelly flounders and catches for the rest of New Zealand ($p = 0.05$), although the same relationship for sand flounders was not significant ($p = 0.42$). As the lake produces over 2/3 of the total New Zealand catch of black flounders, this relationship was highly correlated ($p < 0.000$).

As the fishery is based on 2- and 3-year old fish (Gorman 1960), loss of a year's recruitment will have a profound effect, unlike eels where fish are typically > 10 years at entry into the commercial fishery.

Movements

Apart from the spring recruitment of juveniles, mature adults emigrate from the lake to spawn at sea. The spawning season in flounders can be prolonged, from August-November (Colman 1973). In Te Waihora/Lake Ellesmere, maturing flounders migrate from the lake during any opening in winter; yellowbellies and sands often have pronounced ovaries throughout long periods of the year, indicating extensive breed-

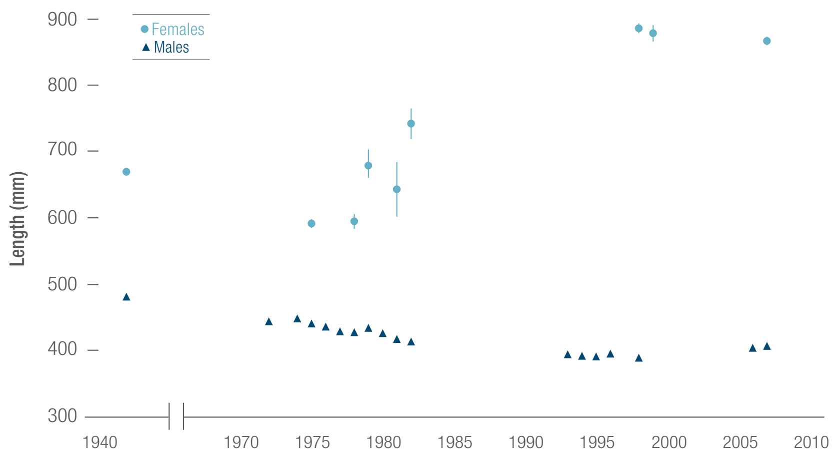

FIGURE 3. Changes in the average length of migratory male and female shortfin eels (bars = SE).

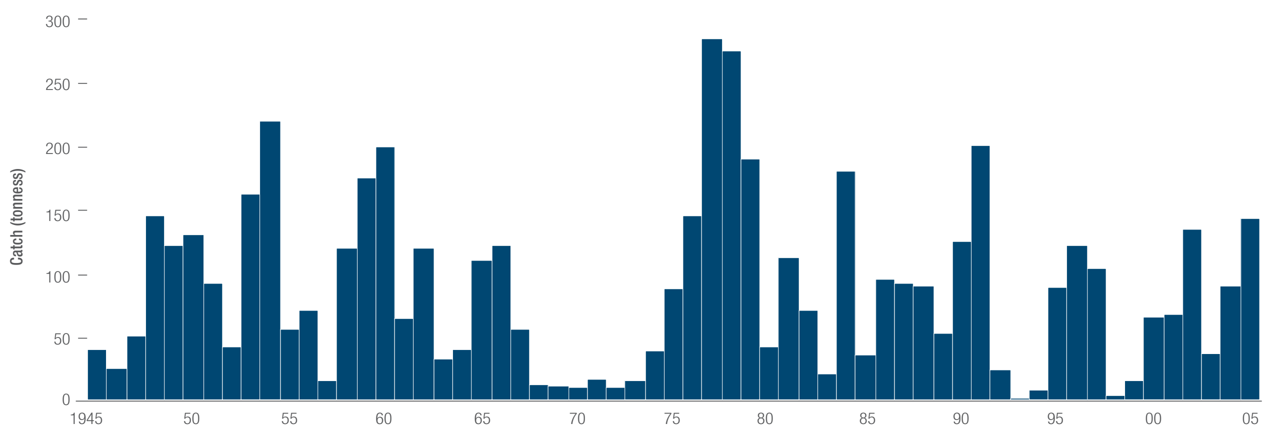

FIGURE 4. Te Waihora/Lake Ellesmere: commercial flounder catches, 1945-2005.

ing seasons, while blacks appear to mature more rapidly, with nearly mature fish congregating at Taumutu in July and August. As flounders are essentially shallow-water species, spawning grounds will be inshore (Paul 2000).

Movements of tagged flounders within the lake showed no obvious pattern (Gorman 1960), with some moving from Taumutu to Halswell within 10 days, while others showed no overall movement three weeks after liberation. Six were recaptured at sea, of which one black flounder was caught off Nugget Point, Otago, a distance of 320 km achieved in 175 days.

5.5 Commercial yelloweye mullet fishery

The mullet fishery is also rather variable, with fluctuations reflecting both recruitment from the sea, and also market demands. Over the past 18 years, the annual catch has averaged 6.4 t (SE 1.4 t), with a maximum of 22.8 t in 1992. The fishery is essentially a winter one, with an average of 2/3 of the catch taken between June and August inclusive and 92% between May and September.

5.6 Customary fisheries

A review of the historic and present-day importance of Te Waihora/Lake Ellesmere to Ngāi Tahu is outside the scope of this paper. The extent of customary harvest over the past 4 seasons (Table 4) indicates up to 5 t of patiki (flounder) and tuna (eels) have been harvested per year. For eels, these figures are well within the 31.26 t allocated for customary harvest by the TAC process. Such levels of harvest are obviously well below historic levels.

5.7 Discussion

Fish behaviour

Wind has a major influence on lake ecology, by resuspending sediment and reducing water clarity (and thus limiting opportunities for macrophyte re-establishment (Sagar et al. 2004), but also by influencing movements of fish. Eels, flounders, and mullet all move with the wind, possibly taking advantage of wind-derived currents. Feeding shortfin eels are inactive at water temperature < 12 °C, but once temperatures exceed this, they commence feeding and moving, especially in spring and early summer. Although the activity of feeding eels can be adversely affected by bright moonlight, migrating eels are more sensitive to moonlight and also to wind, and a northeast wind will move them to Taumutu in large quantities. Should a strong southerly produce waves that overtop the spit, then eels become very active and may even wriggle across the bar to reach the sea.

Flounders move with the wind at all stages of their lifecycle. The most obvious movements are the arrival of mature black flounders at Taumutu in July and August during northeast winds, whereas they move away during a southerly. Mullet move with the wind in summer, but imto the wind in winter-they are also affected by cold weather and frosts result in them forming schools.

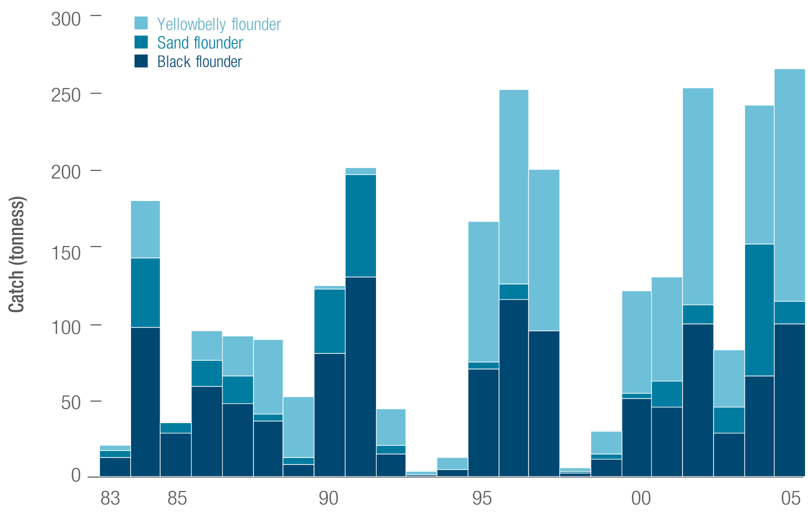

FIGURE 5. Te Waihora/Lake Ellesmere flounder catches – species proportions, 1983–2006.

TABLE 4. **Approximate customary harvest (data supplied by Ngāi Tahu). Weights of fish assume average weights of 450g and 1 kg for flounders and eels respectively.**

Year	Patiki (Flounders)		Tuna (eels)	
	Number	Approx weight (kg)	Number	Approx weight (kg)
2003	1200	540	1400	1400
2004	2200	990	800	800
2005	11400	5130	4700	4700
2006	2700	1215	1700	1700

Overall status of exploited fish stocks

Eels

The extent of commercial harvest is set by the TACC process, and is subject to annual review by the Ministry of Fisheries. Historical yields from the lake were excessive, but the present TACC appears sustainable, although this could be jeopardised by inadequate recruitment. Emphasis on capture of migrating male eels is an important measure to reduce the harvest of females.

The Te Waihora Management Board (representing customary fishers) remain concerned about an overall reduction in eels of sufficient size (e.g. > 0.5 kg), and their access to such eels. Because there is arguably a lower biomass of eels of both species than was present at the onset of commercial fishing, the condition of eels has improved markedly over time; whereas previous researchers (Hobbs 1947) mentioned the presence of "stockwhip" eels (eels in very poor condition), such eels are no longer seen. Stocks of longfins have become

Photo **A large (1.45 m, 12.5 kg) migratory female longfin eel from Te Waihora.** Photographer **Greg Kelly, NIWA.**

Photo **Black flounder provide the bulk of the commercial flatfish fishery catch, but sand flounder** Top **and yellowbellies** Bottom **are also important** Photographer **Shelley McMurtrie.**

reduced within the lake, and reserve areas (adjacent to mouths of the Selwyn River, Harts Creek, Irwell, and LII) are important refuges for this species.

Flounders

There are no specific TACCs set for the lake as it is part of Fishstock FLA 3 (east coast and southern South Island). Also, for fishery management purposes, all species of flatfish are combined into a generic species code. The lake flatfish stocks are usually dominated by black flounders, and the availability of flounders reflects lake opening regimes, and the success of New Zealand-wide spawning of the three main species (blacks, sands, yellowbellies).

Yelloweye mullet

Mullet are also a quota species, but Te Waihora/Lake Ellesmere is part of Fishstock YEM 3, east coast South Island. Stocks will reflect favourable opening times for entry of juveniles and pre-spawning adults, usually in spring-early summer.

Key indicators of change

Eels

The commercial fishery is mainly monitored via trends in size and CPUE. Establishing annual recruitment indices would be a significant advance, as would developing an index of the number of migrating female eels of both species. Customary harvest "satisfaction" will be evaluated via a customary indicators survey presently underway. Increased numbers of longfins would be an important biodiversity measure.

Flounders

Recruitment index monitoring is needed to predict future yields-annual variability in catch indicates the dynamic nature of the fishery.

Key drivers

Satisfactory recruitment of eels, and especially flounders, is dependent upon a suitable spring lake opening regime. Invertebrates, especially chironomid midge larvae, are the primary food source for juvenile eels, and flatfish (Kelly and Jellyman 2007), so maintaining water quality conditions that promote production of midges is critical. Higher summer lake levels would reduce the likelihood of excessive summer water temperatures, while maintaining larger marginal foraging areas for eels. At present, flounders die in set nets if there is a prolonged spell of calm weather that results in low levels of dissolved oxygen. Commercial fishery harvests, and targeted customary fishing of migrating eels, can influence the numbers of female eels that successfully migrate each year.

Management goals

The eel fishery must be managed sustainably; periodic adjustments to the TAC may be necessary, depending on recruitment strength, growth, and mortality (mainly fishing mortality). Spring opening of the lake is essential to enable recruitment of key species, while an autumn opening (mid March-May) would allow escapement of migrating female shortfins and longfins of both sexes. Consideration should be given to a nil harvest for longfins.

The present fish species diversity, both within the lake and tributaries, should be maintained, and preferably enhanced. The pros and cons of attempting to re-establish macrophyte beds should be evaluated, and, depending on the outcomes, a trial area established. Greater protection should be afforded to remaining wetland areas, and consideration given to establishing new areas by inundation of low-lying margins and suitable sections of tributaries. Habitat for rare species like giant kokopu should be enhanced. Reduced nutrient loads to the lake might reduce the probability of future blooms of blue-green algae (small blooms occur, but not to the extent they occur in Wairewa with attendant fish and stock deaths).

Required management actions

Establishing a regular spring opening regime is of major importance. There needs to be resolution of management "overlaps" between stakeholders and crown agencies, notably Ngāi Tahu and the Ministry of Fisheries. Likewise, the merits and feasibility of attempting to re-establish significant macrophyte beds needs to be evaluated.

5.8 Acknowledgments

Thanks to Nigel Scott, Ngāi Tahu, for the information on customary harvest. Trevor Gould, Ross Wilson, Gary Pullan, and Frank Lambie provided useful comments about historical aspects of the commercial fisheries.

5.9 References

Annala, J.H., Sullivan, K.J. 1997. Report from the fishery assessment plenary, May 1997: stock assessments and yield estimates. Unpublished report, New Zealand Ministry of Agriculture and Fisheries 381 p.

Beentjes, M.P. 1999. Size, age, and species composition of commercial eel catches from South Island market sampling, 1997-98. NIWA Technical Report 51: 51.

Beentjes, M.P., Bull, B. 2002. CPUE analysis of the commercial freshwater eel fishery. New Zealand Fisheries Assessment Report 2002/18. 55 p.

Beentjes, M.P., Chisnall, B.L. 1997. Trends in size and species composition and distribution of commercial eel catches. New Zealand Fisheries Data Report 89: 71.

Beentjes, M.P., Chisnall, B.L. 1998. Size, age, and species composition of commercial eel catches from market sampling, 1996-97. NIWA Technical Report 29: 124.

Colman, J.A. 1973. Spawning and fecundity of two flounder species in the Hauraki Gulf, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 7: 21-43.

Gerbeaux, P. 1989. Aquatic plant decline in Lake Ellesmere: a case for macrophyte management in a shallow New Zealand lake. Unpublished Ph D thesis. Lincoln College and University of Canterbury, *New Zealand.*

Glova, G.J., Sagar, P.M. 2000. Summer spatial patterns of the fish community in a large, shallow, turbid coastal lake. *New Zealand Journal of Marine and Freshwater Research* 34: 507-522.

Gorman, T.B.S. 1960. Preliminary report on flatfish: Lake Ellesmere. Special Report, Department of Agriculture and Fisheries, Christchurch, New Zealand 26. p.

Graynoth, E., Jellyman, D.J. 2002. Growth, survival, and recruitment of juvenile shortfinned eels (*Anguilla australis*) in a large New Zealand coastal lake. *New Zealand Journal of Marine and Freshwater Research* 36: 25-37.

Hardy, C.J. 1989. Fish habitats, fish, and fisheries of the Ellesmere catchment. Christchurch, New Zealand Freshwater Fisheries Report 104. 152 p.

Hobbs, D. F. 1947. Migrating eels in Lake Ellesmere. *Transactions and Proceedings of the Royal Society of New Zealand* 77: 228-232.

Irwin, J., Main, W., Burrows, M.W. 1989. Lake Ellesmere bathymetry 1:25 000. New Zealand Oceanographic Institute chart, lake series

Jellyman, D.J. 1992. Lake Ellesmere - an important fishery with an uncertain future. *Freshwater Catch* 48: 3-5.

Jellyman, D.J. 1993. A review of the fishery for freshwater eels in New Zealand. New Zealand Freshwater Research Report 10: 51.

Jellyman, D.J. 2001. The influence of growth rates on the size of migrating female eels (*Anguilla australis*) in Lake Ellesmere, *New Zealand. Journal of Fish Biology* 57: 725-736.

Jellyman, D.J., Bonnett, M.L., Sykes, J.R.E., Johnstone, P. 2003b. Contrasting use of daytime habitat by two species of freshwater eel (*Anguilla* spp.) in New Zealand rivers. In D. A. Dixon (ed.) Biology, Management and Protection of Catadromous Eels. American Fisheries Society Symposium 33, Bethesda, Maryland, USA. 63-78.

Jellyman, D.J., Chisnall, B.L, Todd, P.R. 1995. The status of the eel stocks of Lake Ellesmere. NIWA Science and Technology Series 26: 62.

Jellyman, D.J., Glova, G.J., Todd, P.R. 1996. Movements of shortfinned eels, *Anguilla australis*, in Lake Ellesmere, New Zealand: results from mark-recapture studies and sonic tracking. *New Zealand Journal of Marine and Freshwater Research* 30: 371-381.

Jellyman, D.J., Graynoth, E. 2005. The use of fyke nets as a quantitative capture technique for freshwater eels (*Anguilla* spp.) in rivers. *Fisheries Management and Ecology* 12: 237-247.

Jellyman, D.J., Graynoth, E., Beentjes, M.P., Sykes, J.R.E. 2003a. A review of the eel fishery in Te Waihora (Lake Ellesmere). New Zealand Fisheries Assessment Report 2003/51 56. 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 Pêche et de la Pisciculture* 349: 141-152.

Kelly, D.J., Jellyman, D.J. 2007. Changes in trophic linkages to shortfin eels (*Anguilla australis*) since the collapse of submerged macrophytes in Lake Ellesmere, *New Zealand. Hydrobiologia* 579: 161-173.

Lineham, I.W. 1983. Eutrophication of Lake Ellesmere: study of phytoplankton. Unpulished Ph D thesis. University of Canterbury, New Zealand.

Paul, L.J. 2000. New Zealand fishes. Identification, natural history and fisheries. Reed Books, Auckland. 253 p.

Ryan, P.A. 1974. The fish of Lake Ellesmere, Canterbury. *Mauri Ora* 2: 131-136.

Sagar, P.; Hawes, I.; Stephens, S.; Jellyman, D.; Kelly, D. 2004. Lake Ellesmere (Te Waihora): a review of water clarity, and the potential of macrophyte growth, and the benthic invertebrates, fisheries and birds, and their feeding relationships. NIWA Client Report CHC2004-068. 55 p.

Tau T, Goodall A, Palmer D, Tau R 1990. Te Whakatau Kaupapa. Ngāi Tahu resource management strategy for the Canterbury Region. Wellington, Aoraki Press.

Taylor, K.J.W. (ed.). 1996. The Natural Resources of Lake Ellesmere (Te Waihora) and its Catchment. Canterbury Regional Council, Christchurch. Report 96(7): 322 p.

Te Rūnanga o Ngāi Tahu and Department of Conservation. 2005. Te Waihora joint management plan. Mahere Tukutahi o Te Waihora. 219 p.

Te Waihora/Lake Ellesmere is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake.

This book serves to quantify the nature of this debate by documenting changes to lake values, both over time and spatially. It provides a standardised approach to reporting these changes, set against indicators that are value-specific. Ultimately, it provides a template for thinking about future management scenarios for the lake and its environs. Given this approach the book ultimately serves as a resource for helping understand the ever-changing and current and possible future states of the lake, under a variety of management requirements and implications.