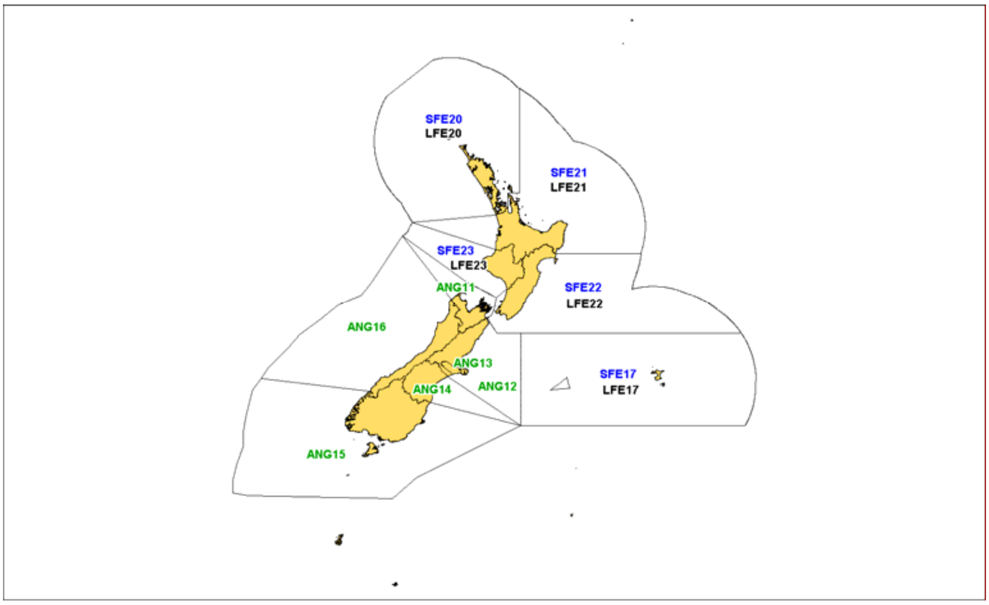
FRESHWATER EELS (SFE, LFE)

(Anguilla australis, Anguilla dieffenbachii, Anguilla reinhardtii)



1. SUMMARY

(a) Commercial fisheries

The freshwater eel fishery is distributed throughout the freshwaters (lakes, rivers, streams, farm ponds, tarns) and some estuarine and coastal waters of New Zealand, including the Chatham Islands. The contemporary commercial fishery dates from the mid-1960s when markets were established in Europe and Asia. Virtually all eels (98%) are caught with fyke nets. Baited fyke nets or hïnaki traps are commonly used.

Commercial catch data is available from 1965 from different sources. Catch data by calendar year is given in Table 1. Table 1 shows the rapid increase in catches that occurred during the late 1960s, with catches rising to a peak of 2077 t in 1972. Landings were relatively stable from 1983 to 2000, a period when access to the fishery was restricted, although overall catch limits were not in place. Annual catches have reduced since 2000 to under 1000 t, as eel stocks were progressively introduced into the Quota Management System (QMS). Catch data prior to 1983 was only available by calendar year. Catch data is more accurately presented by fishing year (1 October to 30 September) from 1988/89 using Licensed Fish Receiver Returns (LFRRs) (Table 2), which also reflects the seasonal nature of the fishery. Eel catches are greatly influenced by water temperature, flood events (increased catches) and drought conditions (reduced catches). Catches decline in winter months (May to September), particularly in the South Island where fishing ceases.

Table 1: Eel catch data (t) for calendar years 1965 to 2004 from MAF Fisheries Statistics Unit (FSU) and Licensed Fish Receiver Returns (LFRRs) 1965 – 1990 and Catch Effort Landing Returns (CELRs) 1991-2004.

Year	FSU	Year	LFRR/QMR/MHR/CELR
1965	30	1987	1114
1966	50	1988	1281
1967	140	1989	1315
1968	320	1990	1155
1969	450	1991	1278
1970	880	1992	1365
1971	1450	1993	1334
1972	2077	1994	1171
1973	1310	1995	1337
1974	860	1996	1295
1975	1185	1997	1066
1976	1501	1998	1243
1977	906	1999	1101
1978	1583	2000	954
1979	1640	2001	965
1980	1395	2002	818
1981	1043	2003	707
1982	872	2004	686
1983	1206	2005	621
1984	1401	2006	670
1985	1505		
1986	1166		

Table 2: Eel catch data (t) from 1988–89 to 2004–05 based on LFRRs, QMRs and MHRs).

Year	Landings
1988–89	1315.3
1989–90	1356.4
1990–91	1590.2
1991–92	1585.2
1992–93	1465.9
1993–94	1255.0
1994–95	1438.3
1995–96	1429.0
1996–97	1342.1
1997–98	1209.9
1998–99	1218.9
1999–00	1133.5
2000–01	1070.9
2001–02	962.3
2002-03	802.5
2003-04	736.8
2004-05	711.7
2005-06	773.8

LFRRs, Quota Management Reports (QMRs) and Monthly Harvest Returns (MHRs), provide the most accurate data on landings over the period 1988–89 to 2004–2005 for the whole of New Zealand (Table 2). Catches remained relatively stable over the period until 2000–2001 when landings dropped to 1070 t. Landings reduced further from 2001-02 to 200-05, as eel stocks were progressively introduced into the QMS. For the period 1991–92 to 2004-05, the North Island provided on average 65% of the total New Zealand eel catch (Table 3).

Table 3: North and South Island eel catch (t) compiled from data from individual processors 1991–92 to 1999-00 and LFRR/QMR 2000–01 to 2004-05.

Fishing year	North Island*	South Island*	Total	LFRR/QMR/MHR Total NZ (excluding Chatham Islands)
1991–92	989.2	631.7	1620.9	1585.2
1992–93	865.3	597.1	1462.3	1465.9
1993–94	744.1	589.8	1333.8	1255.0
1994–95	1004.4	510.8	1515.2	1438.3
1995–96	962.4	459.6	1480.9	1429.0
1996–97	830.3	418.4	1248.7	1342.1
1997–98	794.6	358.6	1153.1	1209.9
1998–99	804.2	381.2	1185.4	1218.9
1999–00	723.2	396.0	1119.2	1133.5
2000–01	767.5	303.4		1070.9
2001–02	643.6	318.8		962.3
2002-03	506.7	295.8		802.5
2003-04	454.4	282.4		736.8
2004-05	426.3	285.4		711.7
2005-06	458.9	282.2		741.1

The New Zealand eel fishery is based on the two temperate species of freshwater eels occurring in New Zealand, the shortfin eel *Anguilla australis* and the longfin eel *A. dieffenbachii*. A third species of freshwater eel, the Australasian longfin (*Anguilla reinhardtii*), identified in 1996, has been confirmed from North Island landings. The proportion of this species in landings is unknown but is thought to be small.

Catch effort landing returns (CELR) provide landings by Quota Management Area. Prior to the 2000-2001 fishing year, three species codes were used to records species landed, SFE (shortfin), LFE (longfin) and EEU (eels unidentified). A high proportion of eels (46% in 1990/91) were identified as EEU between the fishing years 1989-90 and 1998-99. Prorating the EEU catch by the ratio of LFE:SFE by fishing year provides a history of landings by species (Table 4), although it should be noted that prorated catches prior to 1999/00 are influenced by the high proportion of EEU from some eel statistical areas and may therefore not provide an accurate species breakdown. The introduction of new Eel Catch Effort Return (ECELR) and Eel Catch landing Return (ECLR) in 2000/01 improved the species composition information with the deletion of the EEU code. The species proportion has remained relatively constant from the 1995/96 fishing year until the introduction of the North Island fishery into the QMS in 2004. (South Island catch limits are set for SFE and LFE combined). Shortfins are the dominant species in the fishery, on average constituting 66% of catches between 1995/96 and 2004/05.

Table 4: Total NZ eel landings by species (CELR landed) and Fishing Year.

Fishing year	Longfin (LFE)	Shortfin (SFE)	Total CELR landings
1989-90	452.5	616.7	1069.2
1990-91	615.6	808.4	1424.0
1991-92	611.9	941.2	1553.1
1992-93	740.7	872.4	1613.1
1993-94	587.8	691.5	1279.3
1994-95	587.9	909.2	1497.1
1995-96	517.7	977.1	1494.8
1996-97	465.2	841.4	1306.6
1997-98	441.7	881.2	1322.9
1998-99	433.9	824.4	1258.3
1999-00	413.0	741.2	1154.2
2000-01	387.7	698.0	1085.7
2001-02	360.0	660.0	1020.0
2002-03	278.7	560.3	839.0
2003-04	215.6	509.9	725.6
2004-05	253.7	459.6	713.3
2005-06	221.2	552.6	773.8

The species proportion of the landings varies by geographical area. From analysis of landings made into eel processing factories and estimated catch from CELRs, longfins are the predominant species in most areas of the South Island except for a few discrete locations such as lakes Ellesmere and

Brunner, and the Waipori Lakes, where shortfins predominate in the landings. Prior to the QMS, in the North Island there has been a general decline in longfin landings relative to shortfin landings over a 13 year period from 1990-91 to 2002-03. Estimated longfin catches declined from about 340 t to 140 t over this period, while shortfin landings fluctuated between 360 t and 600 t, but showed no decline in landings. The eel fishery catches predominantly pre-migratory feeding eels with the exception of Lake Ellesmere where significant quantities of seaward migrating adult eels are taken during the period February to March.

The South Island eel fishery was introduced into the QMS on 1 October 2000 with species combined under fishstock codes ANG 11 to ANG 16. The fishing year for all fisheries extends from 1 October to 30 September except for ANG 13 (Lake Ellesmere) which has a fishing year from 1 February to 30 January (beginning 1 February 2002). The TAC, customary and recreational allowances, TACC and reported catch for the South Island eel stocks by fishing year are shown in Table 5.

Table 5: TACs, TACCs, allowances and commercial landings (t) for South Island freshwater eels.

Fishstock	**ANG 11 Nelson/ Marlborough**	**ANG 12 North Canterbury**	**ANG 13 Lake Ellesmere**	**ANG 14 South Canterbury**	**ANG 15 Otago/ Southland**	**ANG 16 West Coast**	**South Island Total**
TAC	51.29	54.80	156.32	45.00	150.85	80.41	538.67
Customary Allowance	10.26	10.96	31.26	9.0	30.17	16.08	107.73
Recreational Allowance	1.03	1.10	3.13	0.90	3.17	1.61	10.79
TACC	40.00	42.70	121.93	35.10	117.70	62.70	420.10
Landings Fishing year							
2000–01	23.99	26.43	107.82	15.80	87.96	41.36	303.36
2001–02	22.57	22.16	69.4*	20.41	100.71	46.26	318.18
2002–03	19.46	15.83	92.8	20.20	82.47	32.13	295.80
2003–04	10.5	7.04	121.5	18.29	77.35	30.73	282.37
2004-05	5.5	4.5	121.9	9.0	95.3	44.2	285.4
2005-06	15.1	14.8	121.7	13.4	75.2	31.6	271.8

* for the transition from a 1 0ctober to 1 February fishing year, an interim TACC of 78 t was set for the period 1 October 2001 to 31 January 2002. From January 2002 the Lake Ellesmere fishing year started 1 February to 31 January.

The Chatham Island fishery was introduced into the QMS on 1 October 2003 as fishstocks SFE 17 and LFE 17. The TACs, TACCs and allowances, and landings for 2003/04, 2004/05 and 2006/06, are shown in Table 6.

Table 6: TACs, TACCs, allowances and commercial landings (t) for Chatham Island freshwater eels.

Fishstock	**TAC**	**Customary allowance**	**Recreational allowance**	**Other mortality**	**TACC**	**Landings 2003/04**	**Landings 2004/05**	**Landings 2005/06**
SFE 17	15	3	1	1	10	0.7	1.3	2.7
LFE 17	3	1	1	0	1	0.2	0	0.1

The North Island eel fishery was introduced into the QMS on 1 October 2004 as fishstocks SFE 20 – 23 and LFE 20 – 23. The TACs, TACCs and allowances, and landings for 2004/05 and 2005/06 are shown in Table 7.

Table 7: TACs, TACCs, allowances and commercial landings (t) for North Island freshwater eels

Fishstock	**TAC**	**Customary allowance**	**Recreational allowance**	**Other mortality**	**TACC**	**Landings 2004/05**	**Landings 2005/06**
SFE 20	211	30	28	4	149	78.48	93.24
LFE 20	67	10	8	2	47	27.42	23.74
SFE 21	210	24	19	4	163	122.95	144.33
LFE 21	92	16	10	2	64	53.52	41.18
SFE 22	135	14	11	2	108	80.59	106.9
LFE 22	54	6	5	2	41	23.86	31.64
SFE 23	50	6	5	2	37	14.95	31.46
LFE 23	66	14	9	2	41	24.52	24.19

(b) Maori customary fisheries

Eels are a very important food source for Maori. Maori developed simple and effective methods of harvesting, and a good understanding of the habits and life history of eels. Fishing methods included ahuriri (eel weirs), hinaki (eel pots) and other methods of capture. Maori exercised conservation and management methods, which included seeding areas with juvenile eels and imposing restrictions on harvest times and methods. The customary fishery declined after the 1900s but in many areas Maori retain strong traditional ties to eels and their harvest.

In the South Island, Lake Forsyth (Waiwera) and its tributaries have been set aside exclusively for Ngai Tahu. Other areas, the lower Pelorus River, Taumutu (Te Waihora), Wainono Lagoon and catchment, the Waihao catchment, the Rangitata Lagoon and the Ahuriri Arm of Lake Benmore, have been set aside as non-commercial areas for customary fisheries. In the North Island, commercial fishing has been prohibited from the Taharoa lakes, Whakaki Lagoon, Lake Poukawa and the Pencarrow lakes (Kohangapiripiri and Kohangatera) and catchments in recognition of the special value of these areas for customary Maori purposes.

Customary fishers desire eels of a greater size, over 750 mm and 1 kg. Currently, there appears to be an absence of larger eels in the main stems of the major river catchments throughout New Zealand, which limits customary fishing access. Consequently the access to eels for customary purposes has declined over recent years in many areas. There is no overall assessment of the extent of the current or past customary take. For the introduction of the South Island eel fishery into the QMS, an allowance was made for customary harvest set at 20% of the TAC for each QMA, equating to 107.3 t. For introduction of the North Island fishery into the QMS, the customary take was estimated to be 73 t for shortfins and 46 t for longfins. For the Chatham Islands, the catch estimate associated with customary take was 4 t.

Eels may be harvested for customary purposes under the authority of permits issued under fisheries regulations. Kaitiaki are in place for some areas and estimates of customary harvest can be expected in future.

(c) Recreational fisheries

In October 1994, a recreational individual daily bag limit of 6 eels was introduced throughout New Zealand. There is no quantitative information on the recreational harvest of freshwater eels. The recreational fishery for eels includes any eels taken by people fishing under the amateur fishing regulations and includes any harvest by Maori not taken under customary provisions. The extent of the recreational fishery is not known although the harvest by Maori might be significant.

(d) Illegal catch

There is no information available on illegal catch. There is some evidence of fishers exceeding the amateur bag limit, and some historical incidences of commercial fishers operating outside of the reporting regime, but overall the extent of illegal take is considered to be not significant.

(e) Other sources of mortality

There is no information on the level of fishing related mortality associated with the eel fishery. The fishing methods used in the fishery are passive and catch eels in a live state. However eels are subject to significant sources of mortality due to non-fishing activities. The actual mortality from non-fishing activities has not been quantified. Direct mortality occurs through the mechanical clearance of drainage channels and damage by hydro-electric turbines and flood control pumping. Hydroelectric turbine mortality is affected by eel length, turbine type and turbine rotation speed. The mortality of larger eels (specifically longfin females), is estimated to be 100%. Given the large area of water in hydro lakes, this source of mortality could be significant and reduces spawner escapement. In addition to these direct sources of mortality, eel populations are likely to have been significantly reduced since European settlement from the 1840's by wetland drainage (wetland areas have been reduced by up to 90% in some areas), and habitat modification brought about by irrigation, channelisation of rivers and streams and the reduction in littoral habitat. On-going drain maintenance activities by mechanical means to remove weeds may cause direct mortality through physical damage or by stranding and subsequent desiccation.

2. BIOLOGY

World-wide there are 15 species of freshwater eel, with the majority of species occurring in the Indo-Pacific region. New Zealand freshwater eels are regarded as temperate species, similar to the Northern Hemisphere temperate species, the European eel *A. anguilla*, the North American eel *A. rostrata*, and the Japanese eel *A. japonica*. Freshwater eels have a life history unique among fishes that inhabit New Zealand waters. All *Anguilla* species are catadromous, living predominantly in freshwater and undertaking a spawning migration to an oceanic spawning ground. The major part of the life-cycle is spent in freshwater or estuarine/coastal habitat. Spawning is presumed to take place in the south-west Pacific. Progeny undertake a long oceanic migration to freshwater where they grow to maturity before migrating to the oceanic spawning grounds. Eels are presumed to spawn once and die after spawning. The longfin eel is endemic to New Zealand and is thought to spawn east of Tonga. The shortfin eel is also found in South Australia, Tasmania, and New Caledonia; spawning is thought to occur northeast of Samoa. Larvae (leptocephali) are transported to New Zealand via the South Equatorial Current, and the metamorphosed juveniles (glass eels) enter freshwater from August to November. The subsequent upstream migration of elvers (pigmented juvenile eels) distributes eels throughout the freshwater habitat. The two species occur in abundance throughout New Zealand and have overlapping habitat preferences with shortfins predominating in lowland lakes and muddy rivers, while longfins prefer stony rivers and penetrate further inland to high country lakes.

<u>Growth</u>

Age and growth of New Zealand freshwater eels was reviewed by Horn (1996). Growth in freshwater is highly variable and dependent on food availability, water temperature and eel density. Eels, particularly longfinned eels, are generally long lived. Maximum recorded age is 60 years for shortfins and 106 years for longfins. Ageing has been validated. Growth rates determined from the commercial catch sampling programme (1995–97) indicate that in both the North and South Islands, growth rates are highly variable within and between catchments. Shortfins often grow considerably faster than longfins from the same location, although in the North Island longfins grow faster than shortfins in some areas (e.g. parts of the Waikato catchment). South Island shortfins take, on average, 12.8 years (range 8.1–24.4 years) to reach 220 grams (minimum legal size), compared with 17.5 years (range 12.2–28.7 years) for longfins, while in the North Island the equivalent times are 5.8 years (3–14.1 years) and 8.7 years (range 4.6–14.9 years) respectively.

Growth rates are usually linear. Sexing immature eels is difficult, but from length at age data for migratory eels, there appears to be little difference in growth rate between the sexes. Age at migration may vary considerably between areas depending on growth rate. Males of both species mature at a smaller size than females. Migration appears to be dependent on attaining a certain length/weight combination and condition. The range in recorded age and length at migration for shortfin males is 5–22 years and 40–48 cm, and for females 9–41 years and 64–80 cm. For longfinned eels the range in recorded age and length at migration is 11–34 years and 24–67 cm for males, and 27– 61 years and 90–158 cm for females. However because of variable growth rates, eels of both sexes and species may migrate at younger ages.

<u>Recruitment</u>

There are few data on the recruitment of glass eels and elvers into New Zealand freshwaters. Glass eels enter rivers and streams around New Zealand between August and December. Regional differences in mean size and condition show an arrival pattern from the north in an anti-clockwise dispersal pattern around New Zealand. There is evidence of annual variation influenced by the El Nino Southern Oscillation (ENSO), with the arrival route of glass eels from the northwest being stronger during the La Nina phase and stronger from the northeast during the El Nino phase. The most likely primary vector for larval transport from the northwest is the East Australian current. A more direct arrival route from the northeast, via the trade wind drift, may be more important during the El Nina phase. The recent discovery of the Antarctic Circumpolar Wave that effects how the ENSO cycles develop could also provide a further mechanism for the periodic alteration of glass eel recruitment. Rather that a fixed spawning ground, it has been suggested that the tropical spawning grounds may not be geographically fixed but associated with thermal fronts that might move.

There are no glass eel data or long term data sets on elver migrations in New Zealand, such as are available in the Northern Hemisphere for *A. anguilla* and *A. rostrata*, which provide some information on recruitment. Northern Hemisphere stocks have shown substantial declines in recruitment over recent decades. Available information on recent recruitment trends of New Zealand eels is equivocal. Research on recruitment has investigated available information on glass eel recruitment, elver migrations, age class structure of juvenile eels and length frequency data from commercial catch sampling. From the age composition of juvenile eels there is evidence that glass eel recruitment has declined in two North Island and three South Island waters. Glass eel runs are estimated to be a quarter of the size of runs prior to the early 1970's. There is anecdotal evidence that glass eel runs are now substantially smaller in the Waikato River that in the 1970's. Specific studies on the variability and temporal abundance of glass eels over a seven-year period from 1995 to 2002 at five sites showed no decline in recruitment for either species. The density of shortfin eels exceeded that of longfins for any one year but the annual trends for both species were generally similar.

Changes in recruitment for longfin eels due to a reduction in population size could take many years to manifest themselves because of the long generation time. The establishment of a long-term data series on either glass eel or elver abundance is required to assess trends in recruitment. Current research on recruitment is aimed at establishing a time series of relative abundance of elvers at key locations in New Zealand where the upstream passage is restricted by hydro dams (Table 8). The largest runs of elvers monitored occur at the Karapiro Dam on the Waikato River. The catch of elvers during 2003-04 at Karapiro was the highest recorded since accurate records began in 1995/96 (excluding 1997/98). The numbers of longfin elvers recorded appear to have been declining since 1999/00 and the proportion of longfin as a percentage of the total catch has reduced from around 25% -30% over the period 1995/96 to 1998/99, to around 9%-10% from 2002/03 to 2004/05. In 2005/06, the percentage of longfins increased to 22% of the total catch. A reduction in the percentage of longfin elvers in the total catch has been observed at the Matahina Dam (22% in 1997-98, reducing to between 1% to 8% 2001/02 to 2004/05), but increasing to 19% in 2005/06. At the Patea Dam longfin elvers declined from 6% of the catch in 2001/02 to 0.3% in 2003/04, but increased to 15% in 2005/06. Preliminary results for the Matahina Dam during the 2005/06 season indicate an increase in the percentage of longfin elvers to about 20%. The decline in absolute numbers of longfin elvers at the Patea Dam from 48 000 in 2001/02 to 1000 in 2003/04 indicates that recruitment into the upper catchment above the dam would not be sufficient to maintain longfin eel population.

At the Waitaki Dam where longfin elvers predominate (99%-100% of the total elver catch), total elver numbers in the last three seasons have only been in the low thousands whereas anecdotal evidence suggest much larger numbers congregated below this dam in the past.

Table 8: Estimated numbers (1000s) of elvers trapped at elver recruitment monitoring sites by season (Dec-April)1992-93 to 2005-06. Figures in brackets % longfins. Figures in italics are incomplete records. (n/a = sampling discontinued).

Site	Karapiro Dam	Matahina Dam	Patea Dam	Piripaua Dam	Waitaki Dam	Roxburgh Dam	Arnold River Dam
1992–93	92	32 (6)	–	–	–		
1993–94	518	215	–	–	–		
1994–95	282 (34)	39	–	–	–		
1995–96	1155 (29)	144	–	–	–		
1996–97	1220 (20)	*14 (29)*		*2.1 (0)*	–	0.3 (100)	
1997–98	*1699 (51)*	615 (22)		*7.3 (6)*	–	11 (100)	
1998–99	1097 (31)	*1002*		*3.1 (13)*	–	7.4 (100)	
1999–00	892 (10)	*2001*		2.6 (1.9)	–		
2000–01	782 (20)	*2054*	495	6.0 (2.7)	*20.6*		
2001–02	1596 (15)	619 (4)	754 (6)	4.1 (10.4)	-	1 (100)	
2002–03	1942 (9)	1484 (8)	380 (2)	10.2 (1.8)	0.0056 (100)	0.1 (100)	
2003–04	2131 (9)	945 (7)	391 (0.3)	4.9 (4.1)	4.6 (99.8)	1.4 (100)	
2004-05	1333 (10)	1117 (1)	*450 (-)*	8.1 (5.6)	1.5 (100)	(n/a)	28 (26)
2005-06	2177 (22)	1193 (19)	797 (15)	2.7 (5.3)	4.7 (100)	(n/a)	14 (57)

The longfin eel has been classified as in "gradual decline" following a review in 2002 of the threat status of native flora and fauna undertaken by the Department of Conservation. The "gradual decline" classification is the lowest threat ranking and indicates an expected decline of 5–30% over the next ten years and into the future if current threats continue. There is no threat of extinction. Factors leading to the classification were the data suggesting poor recruitment in some years, fishing pressure, loss of habitat and the implications of a sex ratio bias in one area of the South Island. The combination of these factors is thought to place the species at risk of decline. The threat ranking can be reassessed when new information is available and the threatened status removed if this indicates that the longfin population has stabilised or is increasing. Since the introduction of longfin eels into the QMS, factors contributing to the threat status of longfin eels have been reduced by the reduction in commercial landings and closing areas to allow for spawner escapement.

<u>Spawning escapement</u>

As eels are harvested before spawning, the escapement of sufficient numbers of eels to maintain a spawning population is essential to maintain recruitment. Egg production per recruit, or spawning per recruit, is vulnerable to exploitation of the adult stock, since eels breed only once and at a relatively advanced age. For shortfin eels the wider geographic distribution for this species (Australia, New Zealand, south-west Pacific) means that spawning escapement occurs from a range of locations throughout its range. In contrast, the more limited distribution of longfin eels (New Zealand and offshore islands) means that the spawning escapement must occur from New Zealand freshwaters and offshore islands.

Based on GIS modelling it has been established that for longfin eels, 5% of habitat throughout New Zealand is in water closed to fishing where there is protected egress to the sea to ensure spawning escapement. A further 10% of longfin habitat is in areas closed to fishing in upstream areas but where the spawning migration could be subject to exploitation in downstream areas. An additional 17% of longfin habitat is in small streams that are rarely or not commercially fished. About 30% of longfin habitat in the North Island is either in a reserve or in rarely/non- fished areas, and 34% in the South Island. Biomass estimates of migrant longfin females in reserve and rarely/unfished areas suggest that these areas are sufficient to maintain present longfin stocks but insufficient to rebuild stocks.

However, these conclusions are subject to assumptions based on limited data on density, growth and sex composition of longfin eel populations in various habitat types. In addition the modelling does not take into account habitat reductions caused by hydro development and habitat loss. If these factors are included, and based on biomass estimates from several South Island rivers, it is estimated that the biomass of longfin eels above the minimum weight at migration is less than 20% of historical values.

Biological parameters relevant to stock assessment are given in Table 9.

Table 9: Estimates of biological parameters.

Fishstock	Estimate	Source
1. Natural mortality (M)		
Unexploited shortfins (Lake Pounui)	M = 0.038	D. Jellyman (unpub. data)
Unexploited longfins (Lake Pounui)	M = 0.036	D. Jellyman (unpub. data)
Unexploited longfins (Lake Rotoiti)	M = 0.042	D. Jellyman (1995a)
2. Weight (gm) of shortfin and longfin eels at 500 mm total length		
	Mean weight	**Range**
Shortfins Lake Pounui	263	210–305
Shortfins Waihora	250	210–303
Longfins lake Pounui	307	250–380

3. STOCKS AND AREAS

The life-cycle of each species has not been completely resolved but all evidence supports the proposition of a single (panmictic) spawning stock for each species. Longfins are endemic to New Zealand and are assumed to be a single stock. Biochemical evidence suggests that New Zealand and Australian shortfins are a single biological stock. Within a catchment, adult eels undergo limited movement until their seaward spawning migration. Therefore once glass eels have entered a catchment, each catchment effectively contains a separate population of eels. For management purposes, the South Island fishery has been divided into six fishstocks (species combined). The Chatham Island fishery comprises two fishstocks and the North Island eight fishstocks (species separate). The Australasian longfin eel is included in the shortfin fishstocks for the North Island.

4. STOCK ASSESSMENT

There is no formal stock assessment available for freshwater eels. Each species comprises a single stock. TACs for North Island eel stocks are set under s 14 of the Fisheries Act 1996 which allows for the setting of TACs where it is not possible to estimate the maximum sustainable yield (MSY) for a fish stock.

(a) Estimates of fishery parameters and abundance

The only data on population densities apply to small areas and have limited application to the rest of New Zealand (Table 10).

Table 10: Estimates of fishery parameters.

Fishstock	Estimate	Source
1. Total mortality (Z)		
Lake Ellesmere shortfins	0.1 – 0.3	Jellyman et al. (1995b)
Lake Ellesmere longfins	0.09	Jellyman et al. (1995b)

Standardised CPUE analysis has been conducted for all Eel Statistical Areas (ESAs) for the period 1990-91 to 1998-99, and for selected areas for the period 1990-91 to 2000-01. CPUE for the North Island ESAs was updated in 2004 to provide a standardised CPUE for all the North Island from 1990-01 to 2002-03. For the South Island, shortfin CPUE showed a statistically significant decline in ESA 14 and 16 (Marlborough, North Canterbury).

Declines in longfin CPUE were shown in ESA 17–19 (North Canterbury, Waitaki, Otago), and particularly ESA 20 (Southland). For the North Island declines in shortfin CPUE were significant in ESA 3-6 (Hauraki, Waikato, Bay of Plenty and Poverty Bay) and most significantly in ESA 7 and 10-12 (Hawke Bay, Manawatu, Wairarapa and Wellington). Longfin CPUE declined in all North Island ESA over the period 1990-91 to 2002-03. Interpretation of total catch (SFE, LFE and EEU) is complicated because CPUE analyses for shortfin and longfin individually, sometimes resulted in very different trends in data. The removal of the EEU code (from February 2000) and the introduction of new eel fishery catch effort landing forms (which occurred from 1 October 2001) will improve the quality of data over time. The Eel Working Group noted that while the CPUE analysis did not necessarily represent a trend in overall eel abundance, the trends did reflect a decline in the fishery in fished areas.

(b) Biomass estimates

Estimates of current and reference biomass for any eel fish stock are not available. Some biomass estimates have been made for longfin eels stocks but these are based on limited data on density, growth and sex composition of longfin eel populations in various habitat types.

Conventional stock assessment techniques are difficult to apply to freshwater eels stocks because of their biology and stock structure. No stock assessments are available for any eel stock. MCY cannot readily be estimated for any eel stock because of the inability to estimate non-fishery induced mortality and the division of a single biological stock into several management units. Eel stocks can be more appropriately managed using an alternative to the MSY approach, which is available under s 14 of the Fisheries Act 1996.

(c) Estimation of Maximum Constant Yield (MCY)

Previous reports have presented an MCY estimate based on commercial landings. The Eel Working Group considered it inappropriate to include estimates of MCY in this report.

(d) Estimation of Current Annual Yield (CAY)

In the absence of accurate current biomass estimates, this could not be estimated.

(e) Other yield estimates and stock assessment results

No information is available.

(f) Other factors

Yield-per-recruit

Yield-per-recruit (YPR) models have been run on Lake Ellesmere and Lake Pounui data to test the impact of increases in size limit. Results indicated that an increase in minimum size should result in a small gain in YPR for shortfins in Lake Ellesmere and longfins in Lake Pounui, but a decrease for shortfins in Lake Pounui.

A practical demonstration of the benefits of an increase in size limit has been reported from the Waikato area where a voluntary increase in minimum size from 150 to 220 g in 1987 resulted in decreased CPUE for up to 18 months, but an increase thereafter.

Spawning escapement

Eel stocks provide opportunities for rotational fishing and/or enhancement activities that are not available to most other wild fish stocks as a means of improving yields. A key component to managing an eel stock is to maintain spawner escapement. The current assessment of spawning escapement for longfin eels is that escapement is possibly sufficient to maintain existing depleted stocks but not sufficient for rebuilding stocks. However there is uncertainty in this assumption. The importance of adequate spawner escapement for eels is evident from the three northern hemisphere (*Anguilla anguilla, A rostrata and A. japonica*) species, which are all extensively fished and are subject to a variety of anthropogenic impacts similar to the situation in New Zealand. There has been a substantial decline in recruitment for all three northern hemisphere species from the mid 1970's with less than 1% of juvenile resources remaining.

The relationship between spawning escapement and recruitment is not known. Modelling has suggested that longfin eels may be severely recruitment overfished and only the absence of fishing in some productive areas is likely to maintain at least 50% of spawning per recruit. The model requires qualification because it makes predictions using an average exploitation rate operating on the entire longfin or shortfin population. This average exploitation rate will include both exploited and unexploited populations of either species and is presently unknown.

Sex ratio

The shortfin fishery is based on the exploitation of immature female eels. Most shortfin male eels migrate before reaching the minimum size of 220 g. The longfin fishery is based on immature male and female eels. A study on the Aparima River in Southland focused on assessing the longfin spawning escapement from a fished area of the main stem river and lightly fished areas of tributary streams. The study found that female longfins were rare in the catchment. Only five of 738 eels sexed were females.

This is in contrast to a predominance of larger female longfins in southern rivers established by earlier research in the 1940s and 1950's, prior to commercial fishing. The sex ratio in other southern catchments, determined from analysis of commercial landings, also show a predominance of males. In contrast some other catchments (Waitaki River, some northern South Island rivers) showed approximately equal sex ratios. The predominance of males in the size range below the minimum legal size of 220 g cannot be attributed directly to the effects of fishing. The sexual differentiation of eels can be influenced by environmental factors. It is possible that changing environmental factors are responsible for the greater proportion of male eels in these southern rivers. Interpretation of this study and the issue of sex ratio is subject to ongoing research.

Enhancement

The transfer of elvers and juvenile eels has been established as a viable method of enhancing eel populations and increasing productivity in areas where recruitment has been limited. Elver transfer operations are conducted in summer months when elvers reach river obstacles (e.g., the Karapiro Dam on the Waikato River) on their upriver migration. Elvers were collected at Roxburgh Dam and transferred to Lake Dunstan for the first time in 1997.

In 1992–93 and 1993–94 there were estimated to be between 1200–1500 elvers per kg for elvers collected at Karapiro Dam. In 1994–95 and 1995–96 the averages were 830 and 800 respectively. In 1996–97 the numbers of elvers per kg at Roxburgh Dam, determined by sampling, was 218.

To mitigate the impact of hydro turbines on migrating eels, a catch and release programme for large longfin females has been conducted from Lake Aniwhenua with release below the Matahina Dam since 1995. A capture and release programme has also been conducted from Lake Manapöuri to below the Mararoa Weir on the Wairau River, Southland by Waiau Mahika Kai Trust since 1998. Adult eel bypasses have been installed at the Wairere Falls power station on the Mokau River since 2002 and controlled spillway openings have been undertaken at Patea Dam during rain events in autumn (when eels are predicted to migrate downstream) since the late 1990s.

Several projects have been undertaken to evaluate the enhancement of depleted customary fisheries through the transfer of juvenile eels. In 1997, 2009 juvenile eels (100–200 g) were caught from Lake Ellesmere, tagged and transferred to Coopers Lagoon a few kilometres away. Only ten tagged (coded wire tag implanted in the top of the head) eels, all females, were recovered in 2001. It is likely that a large number of eels migrated to sea as males following the transfer. Another project in 1998 transferred 7600 (21% tagged) eels weighing less than 220 g from Lake Waahi in the Waikato catchment to the Taharoa Lakes near Kawhia. No tagged eels were recovered when the lakes were surveyed in 2001. It is considered that a large number of eels migrated from the lake as males following the transfer. The conclusion from these two transfers is that transplanted eels need to be females, requiring that eels larger than 220 g and above the maximum size of migration for shortfin males need to be selected for transfer. In 1998 approximately 10 000 juvenile eels were caught in the lower Clutha River, tagged and transferred to Lake Hawea. In 2001, 19.4% of the tagged eels were recovered. An estimated 80% of transferred eels survived after three years. The transferred eels showed accelerated growth and the mean annual growth in length was almost double that of eels from the transfer site.

Working Group meetings have discussed the stock status of longfin eels, which are more susceptible to over exploitation than shortfins because of their limited geographical distribution (confined to New Zealand and offshore islands) and longevity. The standardized CPUE index for longfins shows a decline in CPUE in all longfin ESAs. Coupled with the length frequency distributions in fished areas, longfin eel populations can be considered to be substantially depleted from historical levels. The recruitment data shows some decline in longfin elvers and poor recruitment into some catchments. The number of longfins recruiting is substantially less than for shortfins. Whether this is a historical relationship or is a function of reduced spawner escapement for longfin eels is not known. Areas closed to fishing and areas lightly fished are likely to be insufficient to maintain the recruitment of longfin eels to rebuild depleted populations.

5. STATUS OF THE STOCKS

Estimates of current and reference biomass are not available.

The Working Group recognizes that there are no stock assessments, or reliable data or time series on which to base specific recommendations on catch levels. Given the biology of eels, there is a high risk that the current exploitation levels for longfin eels in particular, coupled with past and present anthropogenic impacts, are not sustainable. Based on available information, the Working Group does not consider that the same risk applies to shortfin eels, although caution is required given the nature of eel biology and exploitation before spawning escapement.

The Working Group considers that more specific management action is required to improve the spawner escapement of longfin eels. It is not possible to recommend specific reductions in TACs but measures are required to increase the spawner escapement of longfin eels to improve recruitment. Measures could include reductions in catch levels, changes to size limits and area closures.

Table 11 provides a summary of TACCs and reported landings for the 2005-06 fishing year for each eel stock.

Table 11: Summary of TACC (t) and reported landings for freshwater eels from the most recent fishing year.

Fishstock	2004-05 TACC	Reported landings 2005-06	Fishstock	2004-05 TACC	Reported landings 2005-06
North Island			**South Island**		
SFE 20	149.0	78.48	**ANG11**	40.0	5.55
LFE 20	47.0	27.42	**ANG 12**	42.7	4.55
SFE21	163.0	122.95	**ANG 13**	121.9	121.9
LFE 21	64.0	53.52	**ANG 14**	35.1	9.0
SFE 22	108.0	80.59	**ANG 15**	117.7	95.3
LFE 22	41.0	23.86	**ANG 16**	62.7	44.2
SFE 23	37.0	14.95	**Chatham Islands**		
LFE 23	41.0	24.52	**SFE 17**	10.0	1.3
			LFE 17	1.0	0

6. FOR FURTHER INFORMATION

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