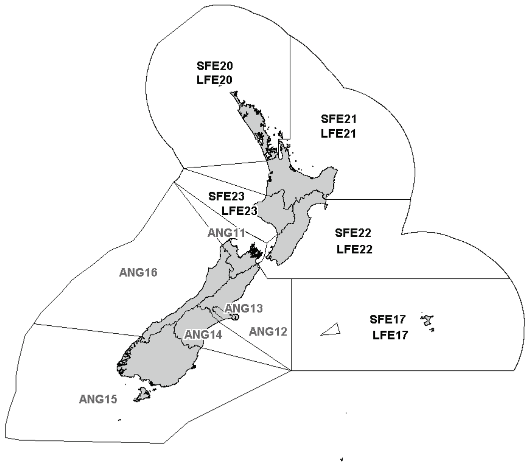
FRESHWATER EELS (SFE, LFE, ANG)

(Anguilla australis, Anguilla dieffenbachii, Anguilla reinhardtii)
Tuna



1. FISHERY SUMMARY

1.1 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.

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. Virtually all eels (98%) are caught with fyke nets. 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.

The South Island eel fishery was introduced into the Quota Management System (QMS) on 1 October 2000 with shortfin and longfin species combined into six fishstocks (codes ANG 11 to ANG 16). The Chatham Island fishery was introduced into the QMS on 1 October 2003 with two fishstocks (shortfins and longfins separated into SFE 17 and LFE 17, respectively). The North Island eel fishery was introduced into the QMS on 1 October 2004 with eight fishstocks (four longfin stocks LFE 20-23 and four shortfin stocks SFE 20-23). The Australasian longfin eel is combined as part of the shortfin eel stocks in the Chatham and North Islands, as this species has productivity characteristics closer to shortfins than longfins, and because the catch is not sufficient to justify its own separate stocks. The occasional catch of Australasian longfins is mainly confined to the upper North Island. The fishing year for all stocks extends from 1 October to 30 September except for ANG 13 (Te Waihora/Lake Ellesmere) which has a fishing year from 1 February to 31 January (since 2002).

Commercial catch data are available from 1965 and originate from different sources. Catch data prior to 1988 are for calendar years, whereas those from 1988 onwards are for fishing years (Table 1, Figure 1). Licensed Fish Receiver Returns (LFRRs), Quota Management Reports (QMRs), and Monthly Harvest Returns (MHRs) provide the most accurate data on landings over the period 1988–89 to 2007–08 for the whole of New Zealand.

There was a rapid increase in commercial 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. In 2000–01 landings dropped to 1070 t, and these were further reduced during 2001–02 to 2004–05 as eel stocks were progressively introduced into the Quota Management System (QMS). For the period 1991–92 to 2004–05, the North Island provided on average 65% of the total New Zealand eel catch (Table 2).

Table 1: Eel catch data (t) from for calendar years 1965 to 1988 and fishing years 1988–89 to 2007–08 based on MAF Fisheries Statistics Unit (FSU) and Licensed Fish Receiver Returns (LFRR), Quota Management Reports (QMR), and Monthly Harvest Returns (MHR).

Year	Landings	Year	Landings	Year	Landings	Year	Landings
1965	30	1976	1 501	1987	1 114	1997–98	1 210
1966	50	1977	906	1988	1 281	1998–99	1 219
1967	140	1978	1 583	1988–89	1 315	1999–00	1 133
1968	320	1979	1 640	1989–90	1 356	2000–01	1 071
1969	450	1980	1 395	1990–91	1 590	2001–02	962
1970	880	1981	1 043	1991–92	1 585	2002–03	804
1971	1 450	1982	872	1992–93	1 466	2003–04	738
1972	2 077	1983	1 206	1993–94	1 255	2004–05	708
1973	1 310	1984	1 401	1994–95	1 438	2005–06	771
1974	860	1985	1 505	1995–96	1 429	2006–07	730
1975	1 185	1986	1 166	1996–97	1 342	2007–08	660

● MFish data, 1965–1982; FSU, 1983 to 1989–90; CELR, 1990-91 to 1999-00; ECLR 2000-01 to 2003-04; MHR 2004-05-present.

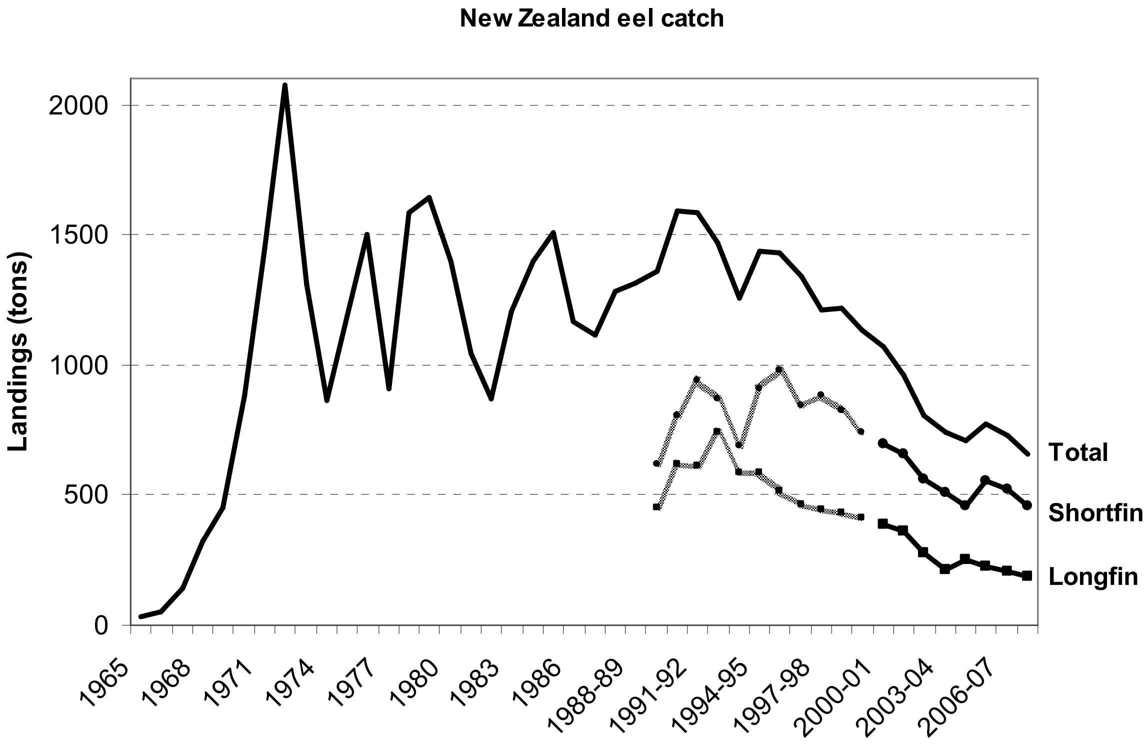


Figure 1: Total eel landings from 1965-2007/08, as well as separate shortfin and longfin landings from 1989-90 to 2007-08. The gray lines represent estimates for the period prior to the introduction of Eel Catch Landing Return (ECLR) forms, and were generated by pro-rating the unidentified eel catch by the LFE:SFE ration (see below).

Table 2: North and South Island eel catch (t) compiled from data from individual processors 1991–92 to 1999–00 and LFRR/QMR/MHR 2000–01 to 2007–08. Numbers in parentheses represent the percentage contribution from the North Island fishery.

Fishing year	North Island	South Island	Total individual processors	LFRR/QMR/MHR Total NZ (excluding Chatham Islands)
1991–92	989	631	1 621 (61%)	
1992–93	865	597	1 462 (59%)	
1993–94	744	589	1 334 (56%)	
1994–95	1 004	510	1 515 (66%)	
1995–96	962	459	1 481 (65%)	
1996–97	830	418	1 249 (66%)	
1997–98	795	358	1 153 (69%)	
1998–99	804	381	1 185 (68%)	
1999–00	723	396	1 119 (65%)	
2000–01	768	303		1 071 (72%)
2001–02	644	319		962 (67%)
2002–03	507	296		803 (63%)
2003–04	454	282		737 (62%)
2004–05	426	285		712 (60%)
2005–06	497	285		781 (64%)
2006–07	440	285		725 (61%)
2007–08	372	288		660 (56%)

Prior to the 2000–01 fishing year, three species codes were used to record 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. Pro-rating the EEU catch by the ratio of LFE : SFE by fishing year provides a history of landings by species (Table 3), although it should be noted that pro-rated catches prior to 1999–00 are influenced by the high proportion of EEU from some eel statistical areas (e.g., Waikato) and therefore may not provide an accurate species breakdown. The introduction of new 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 since 2000-01 with shortfins comprising 64-71% of catches each year.

Table 3: Total NZ eel landings by species and fishing year. Numbers in bold represent data collected following the introduction of the ECLR forms, whereas all others are pro-rated as described above. Numbers in parentheses represent the longfin proportion of total landings.

Fishing year	Shortfin (SFE)	Longfin (LFE)	Total landings
1989–90	617	453	1 069 (42%)
1990–91	808	616	1 424 (43%)
1991–92	941	612	1 553 (39%)
1992–93	872	741	1 613 (46%)
1993–94	692	588	1 279 (46%)
1994–95	909	588	1 497 (39%)
1995–96	977	518	1 495 (35%)
1996–97	841	465	1 307 (36%)
1997–98	881	442	1 323 (33%)
1998–99	824	434	1 258 (34%)
1999–00	741	413	1 154 (36%)
2000–01	**698**	**388**	**1 086 (36%)**
2001–02	**660**	**360**	**1 020 (35%)**
2002–03	**560**	**279**	**839 (33%)**
2003–04	**510**	**216**	**726 (30%)**
2004–05	**460**	**254**	**713 (36%)**
2005–06	**553**	**226**	**774 (29%)**
2006–07	**524**	**209**	**733 (29%)**
2007–08	**456**	**195**	**651 (30%)**

The species proportion of the landings varies by geographical area. From analyses of landings to eel processing factories and estimated catch from ECLRs, longfins are the dominant species in most areas of the South Island except for a few discrete locations such as lakes Te Waihora (Ellesmere) and Brunner, and the Waipori Lakes, where shortfins predominate in the landings. Shortfins are dominant in the North Island. In the North Island there has been a general decline in longfin landings relative to shortfin landings over a 17 year period from 1990–91 to 2006–07. Estimated longfin catches declined from around 340 t to 98 t over this period, while shortfin landings fluctuated between 300 t and 600 t, but showed no decline in landings. Landings in 2007-08 were affected by the reduction in TACCs in the North Island introduced on 1 Oct. 2007. The eel fishery catches predominantly pre-migratory feeding eels with the exception of Te Waihora (Lake Ellesmere) where significant quantities of seaward migrating adult eels are taken during the period of February to March.

The Total Allowable Commercial Catch (TACC) and reported commercial landings for the South Island eel stocks are shown in Table 4 from 2000-2001 (when eels were first introduced into the QMS) to 2007-08.

Table 4: TACCs and commercial landings (t) for South Island eel stocks.

Fishing Year	ANG11		ANG12		ANG13		ANG14		ANG15		ANG16		Total landings
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	
2000-01	24	40	26	43	108	122	16	35	88	118	41	63	303
2001-02	23	40	22	43	69*	122	20	35	101	118	46	63	281
2002-03	19	40	16	43	93	122	20	35	82	118	32	63	262
2003-04	11	40	7	43	121	122	18	35	77	118	31	63	266
2004-05	6	40	5	43	122	122	9	35	95	118	44	63	280
2005-06	15	40	15	43	122	122	13	35	75	118	32	63	272
2006-07	15	40	8	43	122	122	12	35	80	118	49	63	286
2007-08	19	40	8	43	122	122	15	35	91	118	33	63	288

*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 Te Waihora (Lake Ellesmere) fishing year started 1 February to 31 January.

The TACCs and commercial landings for the Chatham Island and North Island shortfin and longfin eel stocks are shown in Tables 5 and 6. The Chatham Island and North Island fisheries were first introduced into the QMS in 2003-04 and 2004-05, respectively. Note that from 1 October 2007 the TACCs were reduced for all North Island shortfin and longfin stocks.

Table 5: TACCs and commercial landings (t) for Chatham Island (SFE17) and North Island shortfin stocks.

Fishing Year	SFE17		SFE20		SFE21		SFE22		SFE23		Total landings
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	
2003-04	<1	10	–	–	–	–	–	–	–	–	-
2004-05	1	10	78	149	123	163	81	108	15	37	298
2005-06	3	10	93	149	144	163	107	108	31	37	378
2006-07	<1	10	108	149	114	163	91	108	30	37	343
2007-08	0	10	76	86	125	134	83	94	16	23	200

Table 6: TACCs and commercial landings (t) for Chatham Island (LFE17) and North Island longfin stocks.

Fishing Year	LFE17		LFE20		LFE21		LFE22		LFE23		Total landings
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	
2003-04	<1	1	–	–	–	–	–	–	–	–	–
2004-05	0	1	27	47	54	64	24	41	25	41	130
2005-06	<1	1	24	47	41	64	32	41	24	41	121
2006-07	0	1	27	47	30	64	26	41	15	41	98
2007-08	0	1	17	19	31	32	18	21	7	9	73

1.2 Customary non-commercial fisheries

Eels are an important food source for use in customary Maori practices. Maori developed effective methods of harvesting, and hold 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, such as the lower Pelorus River, Taumutu (Te Waihora), Wainono Lagoon and its 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 associated catchments.

Customary non-commercial 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 non-commercial fishing access. Consequently the access to eels for customary non-commercial purposes has declined over recent decades in many areas. There is no overall assessment of the extent of the current or past customary non-commercial take. For the introduction of the South Island eel fishery into the QMS, an allowance was made for customary non-commercial harvest set at 20% of the TAC for each QMA, equating to 107 t (Table 7). For the introduction of the North Island fishery into the QMS, the customary non-commercial allowance was set at 74 t for shortfins and 46 t for longfins (Tables 8 and 9). For the Chatham Islands, the customary non-commercial allowance was 3 t for shortfin and 1 t for longfin eels (Tables 8 and 9).

Table 7: TACs, and customary non-commercial and recreational allowances (t) for South Island eel stocks. Note that an allowance for other sources of fishing-related mortality has not been set.

	ANG 11 Nelson/ Marlborough	ANG 12 North Canterbury	ANG 13 Te Waihora Lake Ellesmere	ANG 14 South Canterbury	ANG 15 Otago/Southland	ANG 16 West Coast
TAC	51	55	156	45	151	80
Customary Non-Commercial Allowance	10	11	31	9	30	16
Recreational Allowance	1	1	3	<1	3	2

Table 8: TACs, and customary non-commercial, recreational, and other fishing-related mortality allowances (t) for the Chatham Island and North Island shortfin stocks. Data cover the periods from 2003-04 (Chatham) and 2004-05 (North Island) to 2007-08. Numbers in parentheses reflect the current TACs following a review of catch limits for October 2007 for all North Island eel stocks.

	SFE17	SFE20	SFE21	SFE22	SFE23
TAC	15	211 (146)	210 (181)	135 (121)	50 (36)
Customary Non-Commercial Allowance	3	30	24	14	6
Recreational Allowance	1	28	19	11	5
Other fishing-related mortality	1	2	4	2	2

Table 9: TACs, and customary non-commercial, recreational, and other mortality allowances (t) for the Chatham Island and North Island longfin eel fisheries. Data cover the periods from 2003-04 (Chatham) and 2004-05 (North Island) to 2007-08. Numbers in parentheses reflect the current TACs following a review of catch limits for October 2007 for all North Island eel stocks.

	LFE17	LFE20	LFE21	LFE22	LFE23
TAC	3	67 (39)	92 (60)	54 (34)	66 (34)
Customary Non-Commercial Allowance	1	10	16	6	14
Recreational Allowance	1	8	10	5	9
Other fishing-related mortality	0	2	2	2	2

Eels may be harvested for customary non-commercial purposes under an authorization issued under fisheries regulations. Such authorizations are used where harvesting is undertaken beyond the recreational rules. Customary fisheries reports for Te Runanga o Ngai Tahu (which covers the majority of the South Island) showed that for the 2005–06 fishing year, 5503 individual eels and 500 kg of eels were harvested respectively under customary authorization. For the 2006–07 fishing year the reported harvest was 2256 eels and 100 kg. No harvest was reported in the fishing years 2003–04 and 2004–05. The majority of eels were harvested from ANG 12 (North Canterbury) and ANG 13 (Te Waihora/Lake Ellesmere). Customary regulations were only extended to freshwaters of the Chatham and North Islands in November 2008.

1.3 Recreational fisheries

In October 1994, a recreational individual daily bag limit of six 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.

1.4 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 not considered to be significant.

1.5 Other sources of mortality

There is no information on the level of fishing-related mortality associated with the eel fishery (i.e., how many eels die while in the nets). However, it is not considered a major problem given that the fishing methods used are passive and catch eels in a live state.

Eels are subject to significant sources of mortality due to non-fishing activities. Although 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. Survival of eels through hydroelectric turbines 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 number of eels in hydro lakes, this source of mortality could be significant and reduce 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

Species and general life-history

There are 16 species of freshwater eel world-wide, 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.

Growth

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 longfins, 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. Australasian longfin growth is generally greater than that of New Zealand longfins and closer to that of shortfins.

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. Sex determination in eels appears to be influenced by environmental factors and by eel density, with female eels being more dominant at lower densities. Age at migration may vary considerably between areas depending on growth rate. Males of both species mature and migrate 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 the variable growth rates, eels of both sexes and species may migrate at younger ages.

Recruitment

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 than 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 few 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 and has focused 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. 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 glass eels exceeded that of longfins for any one year but the annual trends for both species were generally similar.

Long-term data series on either glass eel or elver abundance is necessary to assess trends in recruitment. Therefore, 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 10 and Figure 2). The largest runs of elvers monitored occur at the Karapiro Dam on the Waikato River and the Matahina Dam on the Rangitaiki River. Results from the 2007–08 season show a substantial increase in elver numbers at both sites, with numbers exceeding all previous years of records (since 1992–93). Except for 1997-98, the number of longfin elvers in 2007-08 was also the highest that has been recorded in the past 16 years.

Table 10: Estimated numbers (1000s) of elvers trapped at elver recruitment monitoring sites by season (Dec-April) 1992–93 to 2007–08. Figures in brackets represent the % of longfins present, whereas those in italics are incomplete records. (n/a) = sampling discontinued.

Year	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	1 155 (29)	144	–	–	–	–	–
1996–97	1 220 (20)	*14 (29)*		*2.1 (0)*	–	0.3 (100)	–
1997–98	*1 699 (51)*	615 (22)		*7.3 (6)*	–	11 (100)	–
1998–99	1 097 (31)	*1 002*		*3.1 (13)*	–	7.4 (100)	–
1999–00	892 (10)	*2 001*		2.6 (1.9)	–	–	–
2000–01	782 (20)	*2 054*	495	6.0 (2.7)	*20.6*	–	–
2001–02	1 596 (15)	619 (4)	754 (6)	4.1 (10.4)	-	1 (100)	–
2002–03	1942 (9)	1 484 (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	1 333 (10)	1 117 (1)	*450 (-)*	8.1 (5.6)	1.5 (100)	(n/a)	28 (26)
2005–06	2 177 (22)	1 193 (19)	562 (15)	2.7 (5.3)	4.7 (100)	(n/a)	14 (57)
2006–07	1296 (14)	485 (33)	896 (6)	4.2 (8)	3.3 (100)	(n/a)	107 (48)
2007–08	2728 (26)	3378 (27)	857 (11)	5.7 (18)	57.6 (100)	(n/a)	186 (42)

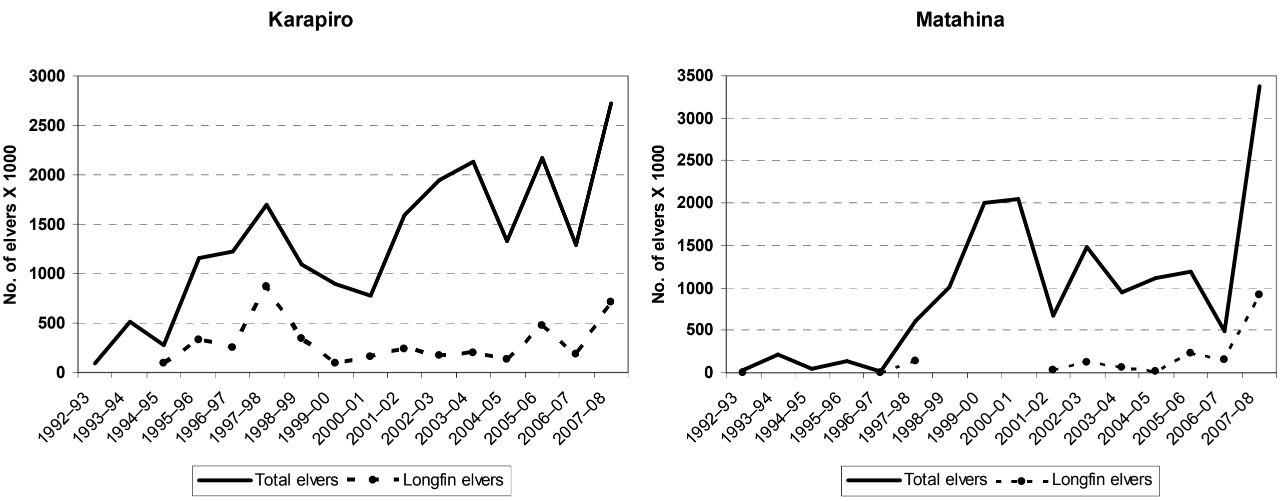


Figure 2: Trends in total elver numbers for the Karapiro and Matahina dams, together with the number of longfin elvers.

Spawning

As eels are harvested before spawning, the escapement of sufficient numbers of eels to maintain a spawning population is essential to maintain recruitment. 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.

3. STOCKS AND AREAS

The lifecycle of each species has not been completely resolved but all evidence supports the proposition of a single (panmictic) stock for each species. Biochemical evidence suggests that shortfins found in both New Zealand and Australia form a single biological stock. Longfins are endemic to New Zealand and are assumed to be 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 each eel species. The quota management areas mostly reflect a combination of these catchment areas. The broader provincial areas had previously been used since the 1980s to manage access under the non-QMS management framework (ie, area conditions on fishing permits).

Shortfin and longfin eel have different biological characteristics in terms of diet, growth, maximum size, age of maturity, reproductive capacity, and behavioural ecology. These differences affect the productivity of each species, and the level of yield that may be sustainable on a longer term basis, as well as their interactions with other species. In order that catch levels for each species is sustainable in the longer term, and the level of removals does not adversely affect the productivity of each species, it is appropriate that the level of removals of each species is effectively managed.

For management purposes, this has been achieved in the Chatham Islands and North Island where separate stocks for shortfin and longfin eels were introduced into the quota management system (QMS) in 2003 and 2004 respectively. When eel stocks in the South Island were introduced into the QMS, there was insufficient information on the South Island species composition of the commercial catch to implement stock definitions and catch limits based on each species. However, there is sufficient science information now available to redefine the combined eel stock (ANG) into shortfin (SFE) and longfin (LFE) stocks for the quota management areas of the South Island.

4. STOCK ASSESSMENT

Conventional stock assessment techniques are inappropriate for freshwater eel stocks because of their biology and stock structure. As a result, there is no formal stock assessment available for freshwater eels. Each species comprises a single stock. Eel stocks can be more appropriately managed using an alternative to the maximum sustainable yield (MSY) approach, which is available under s.14 of the Fisheries Act 1996.

The only data on population estimates apply to small areas and have limited application to the rest of New Zealand (Table 11).

Table 11: Estimates of fishery parameters.

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

4.1 Catch-per-unit-effort analyses

Standardised catch-per-unit-effort (CPUE) analyses have been conducted for the commercial shortfin and longfin eel fisheries from 1990-91 to 2003-04 for all North Island Eel Statistical Areas (ESAs) and to 2005-06 for all South Island ESAs (Tables 12 to 14).

In the North Island, the ESAs with the largest longfin commercial catches (ESAs AA, AD, and AH) all showed declines of 25-75% in CPUE indices in 2003-04 when compared to 1990-91, with the largest reduction occurring in ESA AH (Rangitikei-Wanganui). In ESAs AA and AD, the longfin CPUE index was relatively stable from 1990-91 to approximately 1998-99, thereafter declining until 2003-04, whereas the decline in ESA AH was generally more continuous over the 14 year period.

For shortfins, the North Island ESAs with the largest commercial catches (ESAs AA, AD, and AG) showed a generally increasing CPUE index for ESA AA (Auckland) over the same period, whereas those for ESA AD (Waikato) and AG (Hawke's Bay) generally decreased. In 2003-04, the CPUE index for ESA AA was almost 1.5 times that estimated in 1990-91, whereas the indices for ESA AD and AG declined by 10% and 50%, respectively.

By contrast, although the main commercial longfin eel fisheries in the South Island (ESAs AX, AV, and AW) had either relatively stable or decreasing CPUE indices from 1990-91 to 2000-01 (the year eels were introduced into the QMS on the South Island), these generally increased from 2001-02 to 2005-06. Similar patterns were seen for the main shortfin eel fisheries (ESAs AX, AR, AV, AW, and

AS), with the greatest increases in CPUE indices from 2000-01 to 2005-06 occurring in ESAs AX and AS.

Table 12: New Zealand Eel Statistical Areas (ESAs). Areas were given a numeric designation prior to Oct. 2001, at which point letter codes were assigned.

ESA	Letter code	Numeric code
Northland	AA	1
Auckland	AB	2
Hauraki	AC	3
Waikato	AD	4
Bay of Plenty	AE	5
Poverty Bay	AF	6
Hawke's Bay	AG	7
Rangitikei-Wanganui	AH	8
Taranaki	AJ	9
Manawatu	AK	10
Wairarapa	AL	11
Wellington	AM	12
Nelson	AN	13
Marlborough	AP	14
South Marlborough	AQ	14
Westland	AX	15
North Canterbury	AR	16
South Canterbury	AT	17
Waitaki	AU	18
Otago	AV	19
Southland	AW	20
Te Waihora (outside-migration area)	AS1	21
Te Waihora migration area	AS2	21
Chatham Islands	AZ	22
Stewart Island	AY	23

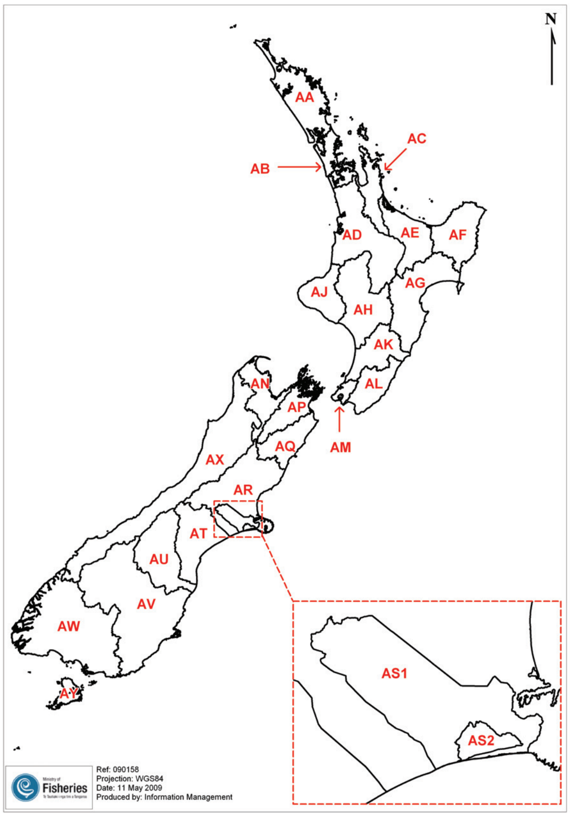


Table 13: CPUE indices for shortfin eels according to Eel Statistical Area (ESA). For the North Island, estimates are only available for the years prior to when the species was introduced into the QMS (2004-05). Fishing years are referred to by the second year (e.g., 1990–91 is referred to as 1991).

ESA	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
North Island																
AA	0.81	0.76	0.79	0.72	0.91	0.97	0.92	1.13	1.24	1.27	1.27	0.99	1.01	1.14	–	–
AB	1.49	0.91	0.77	0.87	1.07	1.16	0.88	1.21	1.33	0.96	0.90	0.71	0.77	0.81	–	–
AC	0.99	0.96	1.14	1.07	1.11	1.17	0.83	0.76	0.78	0.91	0.87	1.19	1.01	1.16	–	–
AD	1.05	1.14	1.16	1.23	1.25	1.31	1.02	1.09	0.96	0.80	0.76	0.80	0.71	0.95	–	–
AE/AF	1.60	1.01	0.85	0.96	1.21	1.43	0.95	0.71	1.02	0.64	0.72	0.48	0.73	0.90	–	–
AG	1.41	1.47	1.40	1.31	1.35	1.03	0.81	0.64	0.89	0.74	1.01	0.49	0.54	0.70	–	–
AH	0.96	0.87	0.91	1.09	1.03	1.61	1.13	0.99	1.11	0.93	0.97	0.77	0.99	0.28	–	–
AJ	1.45	1.74	0.66	0.58	0.84	0.91	0.84	1.00	1.24	1.12	0.97	1.01	0.96	1.00	–	–
AK	3.29	4.97	2.14	0.68	0.66	0.50	0.48	0.71	0.92	0.71	0.72	0.83	0.44	-	–	–
AL	1.58	–	1.29	1.48	1.46	1.27	0.86	1.23	1.10	0.88	0.98	0.60	0.56	0.51	–	–
South Island																
AN	0.40	-	1.27	0.31	0.70	0.58	0.78	0.60	0.83	2.42	2.02	2.86	–	–	–	2.84
AP/AQ	1.46	1.34	1.20	0.98	0.89	0.55	0.46	0.16	0.33	0.42	1.52	2.10	2.36	1.90	1.90	3.16
AX	0.84	0.63	1.03	0.78	0.83	0.44	0.44	1.11	1.37	1.17	1.12	1.41	1.15	1.54	1.69	1.74
AR	1.32	1.15	0.99	1.09	0.99	1.19	1.06	1.17	1.37	1.11	–	1.66	0.54	0.48	0.69	0.92
AT	1.64	0.91	0.73	0.77	0.71	0.99	0.91	1.40	0.66	0.94	–	1.31	1.23	1.32	–	–
AU	1.58	0.73	0.61	0.74	0.76	1.37	1.07	0.89	1.53	1.17	–	–	–	1.10	–	–
AV	1.54	1.16	0.88	0.83	0.87	0.84	0.87	0.95	0.60	1.06	1.23	0.96	0.99	1.01	1.28	1.29
AW	1.13	1.31	1.29	1.74	1.12	1.33	1.15	1.54	1.28	1.22	0.55	0.49	0.56	0.61	1.02	0.77
AS1/ AS2	0..81	1.19	0.92	0.63	0.53	0.88	1.03	0.97	1.04	0.73	0.89	0.81	1.01	1.40	1.75	2.78

Table 14: CPUE indices for longfin eels according to Eel Statistical Area (ESA). For the North Island, estimates are only available for the years prior to when the species was introduced into the QMS (2004-05). Fishing years are referred to by the second year (e.g., 1990–91 is referred to as 1991).

ESA	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
North Island																
AA	1.31	1.20	1.27	1.22	1.22	1.37	1.05	1.34	1.50	1.04	1.04	0.77	0.67	0.81	–	–
AB	1.28	2.04	1.93	1.88	1.90	1.67	1.14	1.40	1.48	1.39	1.66	0.97	0.83	1.00	–	–
AC	2.53	2.30	2.01	1.04	1.22	1.14	1.30	0.93	0.71	0.93	0.61	0.78	0.68	0.59	–	–
AD	1.17	1.48	1.04	1.23	1.30	1.12	1.20	0.85	0.88	0.96	0.98	0.83	0.87	0.87	–	–
AE/AF	2.03	2.03	1.22	1.25	0.93	0.77	1.02	1.22	2.23	0.79	1.73	0.99	0.87	0.89	–	–
AG	2.52	2.44	2.61	2.53	1.99	1.95	1.05	1.24	1.73	1.53	1.38	0.77	0.93	0.65	–	–
AH	1.87	2.08	1.60	1.79	1.46	1.39	1.40	0.82	0.79	0.90	0.67	0.64	0.60	0.50	–	–
AJ	1.55	1.80	1.31	1.15	1.38	1.26	1.16	1.02	0.90	0.81	0.82	0.68	0.68	0.80	–	–
AK	–	–	1.73	1.26	1.10	0.76	1.20	1.22	3.66	0.68	1.45	0.67	0.48	-	–	–
AL	1.03	–	1.67	0.91	1.69	1.21	1.55	1.16	1.05	0.89	0.92	0.57	0.48	0.96	–	–
South Island																
AN	-	-	1.46	-	0.94	0.77	1.0	0.79	1.02	0.94	0.60	1.91	–	–	–	1.10
AP/AQ	2.05	1.71	0.97	1.22	1.30	1.35	0.85	0.69	0.61	0.35	1.09	1.04	0.94	0.96	1.07	-
AX	1.04	1.07	0.78	0.84	1.07	1.04	0.99	0.99	1.10	1.36	1.06	0.86	0.90	0.91	1.03	1.10
AR	2.10	0.82	1.00	1.11	0.77	2.06	1.86	1.40	1.58	2.18	0.61	0.50	0.78	0.53	0.36	0.81
AT	1.97	0.59	0.80	1.19	1.00	0.98	1.14	0.91	0.94	1.84	–	0.70	0.72	1.02	–	–
AU	1.09	1.97	0.76	1.06	0.69	1.06	1.05	0.84	1.10	0.96	–	–	–	0.84	–	–
AV	1.37	1.19	1.09	1.28	0.88	0.81	0.85	0.92	0.79	0.86	0.87	0.94	0.96	1.01	1.27	1.14
AW	1.57	1.25	1.20	1.25	1.02	1.05	0.94	0.85	0.71	0.88	0.79	0.93	0.90	0.80	1.11	1.10
AS1/ AS2	6.70	2.39	1.19	1.14	0.95	0.57	0.80	1.07	0.93	0.84	0.91	1.00	0.61	0.65	0.69	0.51

Biological parameters relevant to stock assessment are given in Table 15.

Table 15: Estimates of biological parameters

Fishstock	Estimate	Source
1. Natural mortality (M)		
Unexploited shortfins (Lake Pounui)	M = 0.038	Jellyman (unpub. Data)
Unexploited longfins (Lake Pounui)	M = 0.036	Jellyman (unpub. Data)
Unexploited longfins (Lake Rotoiti)	M = 0.042	Jellyman (1995a)
2. Weight (g) 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

4.2 Biomass estimates

Estimates of current and reference biomass for any eel fish stock are not available. Recent estimates of approximately 12 000 t have been made for longfin eels (Graynoth et al. 2008, Graynoth and Booker 2009), but these are based on limited data on density, growth and sex composition of longfin eel populations in various habitat types, including lakes and medium to large rivers.

4.3 Estimation of Maximum Constant Yield (MCY)

The Eel Working Group considered it inappropriate to include estimates of MCY in this report.

4.4 Estimation of Current Annual Yield (CAY)

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

4.5 Other yield estimates and stock assessment results

No information is available.

4.6 Other factors

Yield-per-recruit

Yield-per-recruit (YPR) models have been run on Te Waihora (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 Te Waihora 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

A key component to ensuring the sustainability of eels is to maintain spawner escapement. Graynoth et al. (2008) estimated that, under catch levels prior to 2002, longfin spawning escapement was possibly sufficient to maintain existing depleted stocks but not sufficient for rebuilding stocks. However there is uncertainty in this assumption, even though catch limits have since been introduced and commercial catches reduced. As a sustainability measure, the Mohaka, Motu and much of the Whanganui River catchments were closed to commercial fishing to aid spawning escapement. 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.

Based on GIS modelling it has been estimated 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. Therefore, about 30% of longfin habitat in the North Island and 34% in the South Island is either in a reserve or in rarely/non-fished areas, with ~ 49% of the national longfin stock estimate of ~ 12 000 t being contained in these waterways (Graynoth et al. 2008). These estimates do 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. However, the longevity and fecundities of large female eels, combined with a general lack of natural predators, means that it is possible that glass eel recruitment in the past exceeded what was needed to maintain stocks, and that eel recruitment might be maintained with only 10% of the virgin biomass (Graynoth et al. 2008). Some evidence also suggests that the survival of juvenile and adult eels is density dependent, and reductions in eel recruitment (resulting from lower spawner escapements) may consequently be compensated for by increased survival of juveniles and adults.

Sex ratio

The shortfin fishery is based on the exploitation of immature female eels, as 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 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. Because 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.

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; see Table 8) on their upriver migration. Elvers were collected at Roxburgh Dam and transferred to Lake Dunstan for the first time in 1997.

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 Te Waihora (Lake Ellesmere), tagged and transferred to Cooper's Lagoon a few kilometres away. Only ten tagged 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 original transfer site.

5. STATUS OF THE STOCKS

The Eel Fishery Assessment Working Group has focused its attention in recent years on the stock status of longfin eels. This species is more susceptible to overexploitation than shortfins because of their limited geographical distribution (confined to New Zealand and offshore islands) and longevity.

Longfin eel
The Working Group recognises that there are no stock assessments on which to base specific recommendations on longfin catch levels. Nevertheless, recruitment data, CPUE indices, and information on spawner escapement allow for a cautioned assessment to be made of longfin and shortfin stock status.

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, and there is anecdotal evidence that glass eel runs are now substantially smaller in the Waikato River that in the 1970's. Nevertheless, results from 2007–08 show that, with the exception of 1997-98, the number of longfin elvers at two of the main monitoring stations (Karapiro and Matahina dams) was the highest that has been recorded in the past 16 years.

The only reliable estimates of relative abundance are based on CPUE data. For the North Island, the ESAs with the largest longfin commercial catches (ESAs AA, AD, and AH) all showed declines of 25-75% in CPUE indices from 1990-91 to 2003-04, with the largest reduction occurring in Rangitikei-Wanganui (ESA AH). By contrast, although the main commercial longfin fisheries in the South Island (ESAs AX, AV, and AW) had either relatively stable or decreasing CPUE indices from 1990-91 to 2000-01 (the year eels were introduced into the QMS on the South Island), these generally increased from 2001-02 to 2005-06.

A key component to ensuring the sustainability of eels is to maintain spawner escapement, and to that end approximately 30% of available longfin habitat in the North Island and 34% in the South Island is either in reserves or in rarely/non-fished areas. If hydro development and habitat loss 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.

Following concerns that exploitation rates of longfin eels were unsustainable, in 2007 management actions to reduce this risk included reductions in TACCs and the introduction of an upper size limit for longfin eels in the North Island, as well as three areas being closed to commercial fishing (the Mohaka, Motu and much of the Whanganui River catchments).

Shortfin eel

Based on available information, the Working Group does not consider that the same level of risk applies to shortfin eels. For example, shortfins have a wider geographic distribution than longfins, and their recruitment into New Zealand waters could be supplemented by juveniles which originate from other sources (e.g., South Australia, Tasmania, and New Caledonia stocks). Furthermore, the CPUE indices for the main commercial shortfin fisheries in the South Island (ESAs AX, AR, AV, AW, and AS) generally increased from 2001-02 to 2005-06, especially in ESAs AX (Westland) and AS (Te Waihora/Lake Ellesmere). By contrast, the North Island ESAs with the largest commercial catches (ESAs AA, AD, and AG) showed less consistent trends in CPUE indices, with ESA AA (Auckland) showing a general increase from 1990-91 to 2003-04 whereas those for ESA AD (Waikato) and AG (Hawke's Bay) generally decreased. Caution is therefore required in managing shortfin stocks given the nature of their biology and the fact that they are harvested before they can spawn.

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