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Taihoro Nukurangi

A review of the fishery for freshwater eels in New Zealand

D.J. Jellyman

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by

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Taihoro Nukurangi

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SUMMARY

The commercial eel fishery in New Zealand is based on two eel species, the shortfinned eel (*Anguilla australis*) and the longfinned eel (*Anguilla dieffenbachii*). The former contributes about two-thirds of the total annual catch. The Ministry of Agriculture and Fisheries has responsibility for management and regulation of the commercial eel fishery, whereas the Department of Conservation is responsible for the protection of both eel species and their habitats. Other agencies also have statutory responsibilities that impinge upon the fishery.

Maori have strong traditional ties to eels and their harvest, and the Government is committed to giving Maori an increased involvement in management of the eel resource. Maori have a number of concerns about the status of eels stocks and management of the commercial eel fishery. Their primary concerns are the high level of commercial fishing, the reduced availability of large eels, the need for recognition by fishery managers of areas of traditional importance, loss and degradation of eel habitat, and the need for Maori to have increased opportunities to participate in management decisions.

There have always been significant differences between the reported catch of eels and the quantity exported. The lack of a sound database is of major concern when trying to determine trends in the fishery. The best estimator of annual catch was found to be a combination of catch from fishers (1965-1974, 1983-1986), quantities exported (1975-1982), quantities processed (Licenced Fish Receiver returns, 1987-1988), and processors' estimates (1989-1992). Using these data, the annual catch over the past 10 years has averaged 1362 tonnes, and has shown a steady increase over the past five years. Virtually all eels are caught with fyke nets. Areas producing the largest catches over the 1983/84 - 1990/91 fishing seasons were (in descending order) Waikato, Northland, Southland, Lake Ellesmere, Otago, Hawkes Bay, and Manawatu.

Regulation of the commercial fishery is by restrictions on entry and limitations on gear. The present moratorium on issuing new permits was introduced on 1 October 1988 as a short-term control on effort, pending the outcome of the present more extensive review of the fishery. Due to the moratorium, the number of permits has remained reasonably constant over recent years, with about 240 permits currently issued.

A total of 12 North Island, 10 South Island, and one Chatham Island fish processors handled >1000 kg of eels during 1990 and 1991. The principal importing countries for New Zealand eel products are Holland, Germany, United Kingdom, Belgium, Italy, and France. Approximately 60% of eel product is whole frozen eels, with other chilled or frozen products amounting to about 15%, and live flown eels about 20%.

Research has shown that both our eel species are generally very slow growing (the slowest of any anguillid eels studied to date). Female shortfins are 20-40 years old at migration, while female longfins are 30-60 years old. Such longevity and associated vulnerability to capture means that conservative management practices must be adopted to protect eel stocks and maintain a viable fishery. There is clear evidence from processors' data that the average size of eels has decreased significantly over the past 20 years.

The Government has recently announced an increase in the national minimum capture size of eels from 150 to 220 g (with the exception of Lake Ellesmere). Although various processors have agreed upon higher minimum sizes in the past, the entry of new fishers or new processors into an area, has usually resulted in the breakdown of such voluntary agreements. A maximum size limit is suggested as a means of protecting migratory females of both species. For instance, an upper size limit of 4 kg would protect up to 50% of migratory female longfins and is considered a worthwhile proposal. A 1 kg maximum size limit would protect about a quarter of shortfin female migrants, and should be considered if it is not possible to significantly increase the area of shortfin habitat free from commercial fishing.

By law, commercial eel fishing is not permitted in various types of reserve. Prohibitions are strictly enforced within National Parks, but enforcement in other reserves is variable. The ability of waterways within National Parks to provide reserve breeding stock has been reviewed; conclusions were that these waterways provide an inadequate reserve area for longfins and a very inadequate area for shortfins. Banning commercial eel fishing in all reserves would provide substantial assistance to shortfins, but the increase in reserve area is still considered insufficient.

1. INTRODUCTION

New Zealand has two species of freshwater eel - the shortfinned eel (*Anguilla australis*) and the longfinned eel (*A. dieffenbachii*). The latter is endemic to New Zealand, whereas the former is also found in south-east

Australia and Tasmania, New Caledonia, and some South Pacific islands. There have been several studies on the biology of the two species, and these have been reviewed by Skrzynski (1974), Jellyman and Todd (1982), and McDowall (1990). Both eel species form the basis of an important commercial fishery, which has averaged 1400 tonnes annually over the past three years. The fishery was reviewed by Town (1985), who also considered future management options (Town 1986).

Most commercially exploited marine fisheries in New Zealand are managed by the Quota Management System (QMS), whereby individual fishers are allocated a specific quota. Town (1986) suggested that freshwater eels should become part of the QMS; at the time of writing, eels are not part of the QMS although they are being considered as one of a number of species that may enter. At present, eels are managed by a variety of constraints on fish size and gear type. In 1987, Maori successfully obtained an injunction prohibiting the issuing of further Individually Transferable Quota (ITQ). It was not until the passing in 1992 of the Treaty of Waitangi (Fisheries Claim) Settlement Act 1992 that it was possible to reconsider placing eels within the QMS.

In response to widespread concerns about the level of exploitation of eels throughout the country, on 1 October 1988 the Ministry of Agriculture (MAF) introduced a moratorium on the issuing of new eel fishing permits. This action was a short-term measure, pending a more extensive review of the commercial fishery. The need for this review has been made more urgent by the current upsurge of interest by Maori in becoming more involved in management of the fish and shellfish species that they harvested traditionally. Also, the Fisheries Amendment Act 1990 inadvertently created a situation whereby an unrestricted number of fishers could operate on a single permit; this led to a rapid increase in the number of persons engaged in eel fishing, a situation that MAF was trying to avoid. This situation has since been rectified with the passing of the 1992 Fisheries Amendment Act.

This report is, in part, an update of Town's (1985) review. It reviews the commercial catch data for eels and comments on recent trends in these data. It also seeks to highlight the main concerns of Maori and outlines some of their concepts of management. While catch and export data describe the overall yield of the fishery, they do not identify any changes in the size of eels being caught. To obtain this information, several eel processors were contacted. It is expected that this report will provide useful information on which to base management decisions about the commercial eel fishery

2. MANAGEMENT RESPONSIBILITIES

Management responsibilities for eels and eel fisheries are jointly vested in both MAF and the Department of Conservation (DOC). Several other agencies also have statutory responsibilities which involve eels in various ways. A summary of respective responsibilities follows.

2.1 Ministry of Agriculture and Fisheries

Eels are the only significant commercial freshwater fishery managed by MAF. The fishery is covered by the Fisheries Act 1983 which provides for the management and conservation of fisheries and fishery resources. Administration is via various commercial and amateur fishing regulations (see Section 5.1). Liaison with industry and non-commercial sectors is maintained via regional Fishery Liaison Committee meetings, and regular huis take place with some Maori groups.

Eels have historical, cultural, and spiritual value to Maori. Through the Maori Fisheries Act 1989, the Crown recognises the right of iwi to control the management and use of some local fisheries that have traditionally been important to Maori. A recent decision of the Waitangi Tribunal (Waitangi Tribunal 1991) in response to the Ngai Tahu claim (that the Crown enter into joint management of Lake Ellesmere with Ngai Tahu, or that ownership of the lake be vested in Ngai Tahu with the Crown remaining as trustee), has obvious implications for the eel fishery on that lake. The Tribunal's report on the Ngai Tahu sea fisheries claim (Waitangi Tribunal 1992) recommended that the commercial eel fishery on the lake be discontinued in favour of the traditional eel fishery, and that the displaced commercial fishers be compensated by the Crown. With the Treaty of Waitangi (Fisheries Claim) Settlement Act 1992, the tribunal is precluded from further deliberations about commercial eel fisheries, although there may be future claims for mataitai (traditional fishing areas). Should eels become part of the QMS, then 20% of quota will be allocated to Maori.

MAF also has responsibility for conducting research on freshwater fish, and historically has made a substantial commitment to eel research. Present research is contracted to NIWA Freshwater (National Institute of Water and Atmosphere Ltd). There is a good understanding of most of the freshwater phase of eel's life histories, and future research should concentrate more on the impacts of exploitation on stocks, and on

restoration methods where these are considered to be appropriate.

2.2 Department of Conservation

Under the Conservation Act 1987, the Department of Conservation (DOC) is responsible for the preservation of native fish species, and for protection of recreational freshwater fisheries and freshwater fish habitats. As DOC manages about one-third of the land area of New Zealand, it is required to carry out various management planning exercises. Conservation Management Strategies are strategic plans for the integrated management of natural and historic resources in individual DOC conservancies. These plans will identify areas which need separate Conservation Management Plans, e.g., Lake Ellesmere. As well as Conservation Management plans, DOC may prepare Freshwater Fisheries Management Plans which "implement general policies and establish detailed objectives for the management of freshwater fisheries within any area or areas". These plans do not apply to sports fish (which are the responsibility of Fish and Game Councils), but could provide for the protection of eels and their habitats. Plans can be as general or specific as necessary; they can be area based (e.g., for a specific lake or catchment), or address a particular function or species. DOC also administers both the National Parks Act 1980 and the Reserves Act 1977.

2.3 Other agencies

Under the Resource Management Act 1991, **Regional Councils** have responsibilities for land and water management, including having regard for Maori values and traditions. In preparing river management plans, Councils must recognise the need to take into account the requirements for maintaining fish habitat.

Fish and Game Councils have responsibility for managing sports fish and their habitats. Although they have no direct management responsibility for native (indigenous) fish, their involvement with sports fish and their habitats means that they often have similar concerns to DOC regarding the general well-being of fisheries habitats. Historically, the precursors of the Fish and Game Councils (Acclimatisation Societies) actively promoted the destruction of eels; their rationale was that eels both competed with trout and consumed them, and hence any reduction in eel numbers would be advantageous for trout populations. However, with the findings of Burnet (1968) that eels could provide some restraint on over-production of trout in a small spring-fed system, Acclimatisation Societies came to appreciate the value of retaining some eels within waterways.

Historically, hydro dams have almost certainly deprived longfin eels, in particular, of more habitat than any other human activity. In recognition of this problem, the Electricity Corporation of New Zealand (ECNZ) is now involved with MAF in investigating ways of re-establishing eel passage to areas where the installation of hydro dams has prevented eel access. Likewise, ECNZ is interested in the possibility of providing for the downstream passage of migrating eels.

3. THE COMMERCIAL EEL FISHERY

3.1 Development of the fishery

Modern-day commercial fishing for eels began in the mid 1960s, though annual catches remained below 100 tonnes until 1967. Thereafter, catches increased dramatically to reach a peak of 2077 t in 1972. The largest annual quantity of eels exported was in 1975 (2434 t). That year, eels were the most valuable fish export, after rock lobsters. Export data for eels have been available since 1975.

Although catch data are available both from fishers and from processors, the former is the longer term data set. It is separated by species and is available on a regional basis. For the period 1975-1982, eel catches were reported by Acclimatisation Society districts. However, this proved unsatisfactory because, in many cases, rivers formed the boundaries between the districts. Eels captured from opposite banks of the same river could thus be recorded in different districts. In 1983, the former Catchment Authority boundaries were adopted as eel fishing return areas. This catchment-based system is still in use (Figure 1).

For reasons discussed later (Section 5.2.4), the best estimate of annual catch seems to be a composite of data from fishers (catch effort landing returns (CELR) 1965-1974, 1983-1986), exports (1975-1982), processors (Licenced Fish Receivers returns 1987-1988), and processors' estimates (1989-1992).

The "best estimate" of annual catch from 1965-1992 is shown in Figure 2. Following a rather unstable period from 1970 to 1978, the fishery showed a progressive decline until 1983. The last 10 years (1983-1992) have been relatively stable, with an average annual catch of 1362 t.

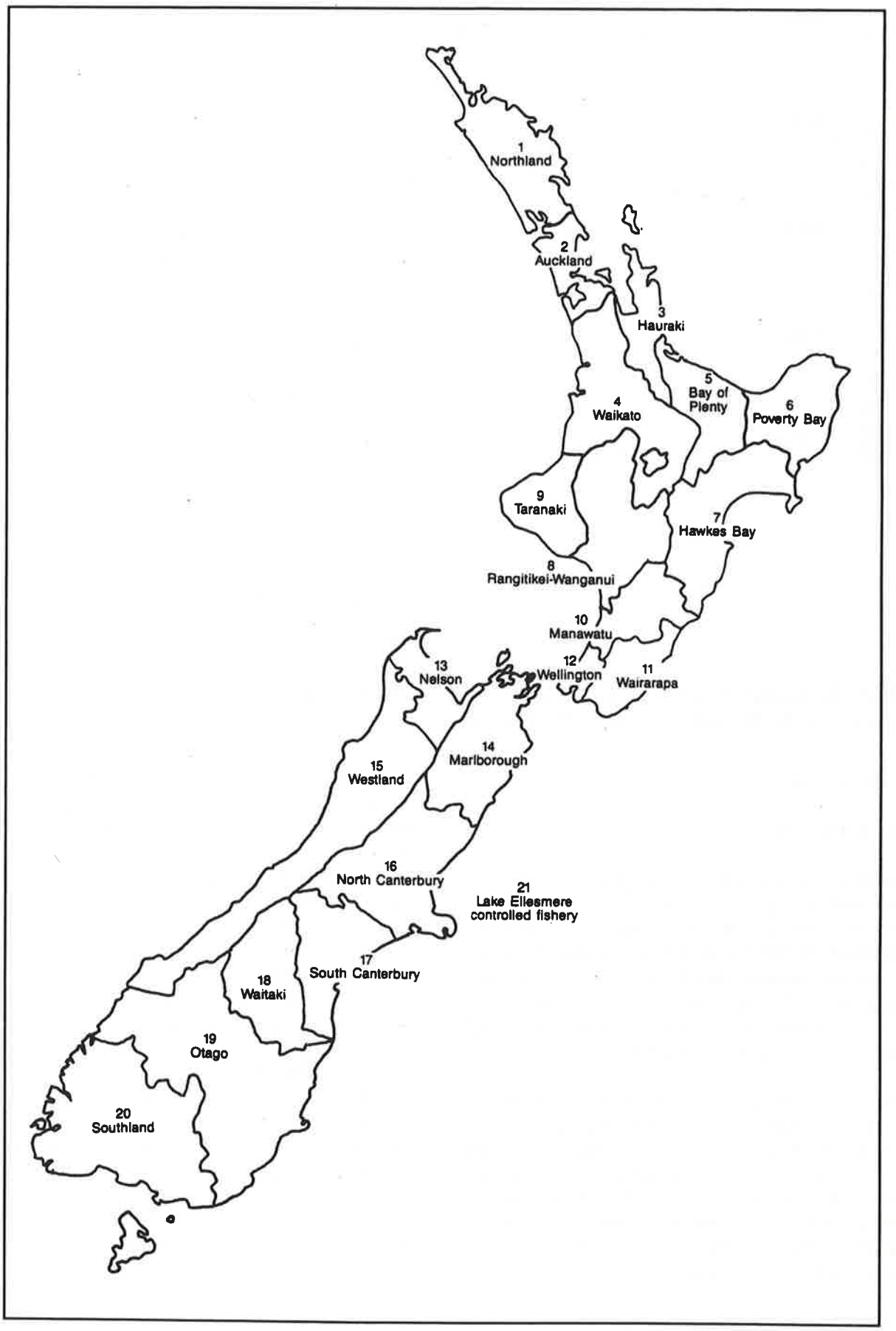

FIGURE 1. Eel fishing return areas (excluding area 22, which is the Chatham Islands).

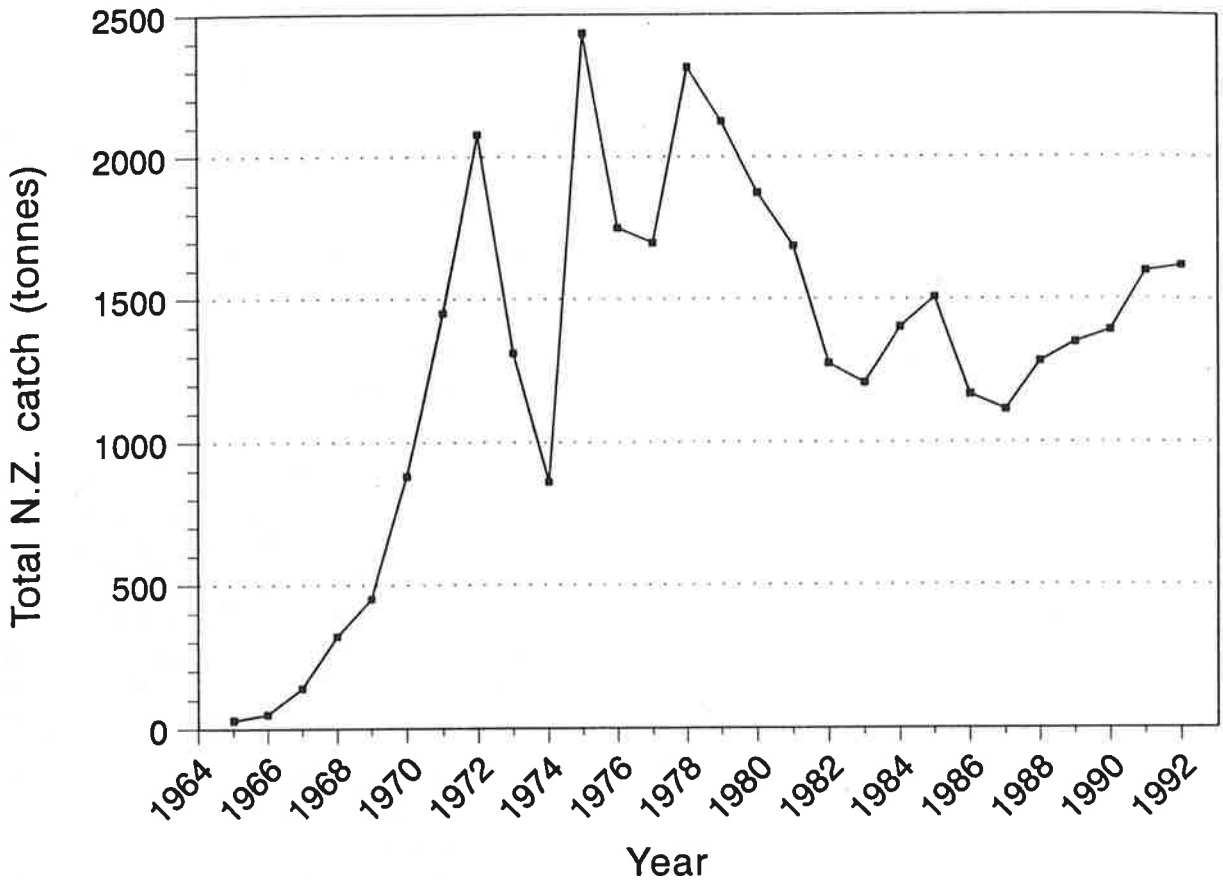

FIGURE 2. Annual eel catches 1965-1992, from fishers' returns (1965-74, 1983-86), exports (1975-86), processors' returns (1987-88), and processors' estimates (1989-92).

3.2 Present status

3.2.1 Eel species

The relative contributions of each species of eel to the annual catch are given in Table 1. Prior to 1975, catches were not recorded by species. Changes in the way that fishery statistics were recorded were made that year, and the calendar year for recording catches was changed to a "fishing year", i.e., 1 October - 30 September. However, for ease of comparison, annual catches have been presented by calendar year.

For each year, the quantity of shortfins exceeds that of longfins. Average proportions over the past 17 years have been 65.1% shortfin and 34.9% longfin. Over the past five years the dominance of shortfins has been less marked, with the catch averaging 58.1% shortfin and 41.9% longfin. The coefficient of variation in annual catch (1975-1991) is similar for both species (0.32 for shortfin and 0.33 for longfins).

The relative proportion of each species in the eel catch is quite different between islands (Table 2). The North Island (1983/84 - 1987/88) averaged 66.5% shortfin and 33.5% longfin, compared to the South Island's 47% shortfin and 53% longfin. Longfin catches exceed shortfin catches in five North Island areas (Poverty Bay, Rangitikei/Wanganui, Taranaki, Wairarapa, Wellington) and in four South Island areas (Marlborough, Westland, Otago, Southland).

An unfortunate trend in the CELR data over recent years has been the increasing quantity of unidentified eels listed, i.e., eels not separated into either shortfins or longfins. For the fishing years 1983/84 - 1988/89, 6.2% of eels, on average, were unidentified. However, for the following three seasons the average was 27.0%. The Waikato area has recorded the highest proportion of unidentified eels, averaging 94.7% over the past two seasons. The explanation for this change is that a code for "unidentified eels" has been available on the CELR forms only since 1989. Prior to this, the reported catch of each species represents the fishers' "best guess" of the weight of each species caught.

3.2.2 Fishing methods

Although Maori used a variety of methods to capture eels, including weirs, traps (hinakis), and spears

TABLE 1. Reported annual eel catch, by calendar year, 1965-1992.

Year	Shortfin	Longfin	Unid.	Total
1965	-	-	30	30
1966	-	-	50	50
1967	-	-	140	140
1968	-	-	320	320
1969	-	-	450	450
1970	-	-	880	880
1971	-	-	1450	1450
1972	-	-	2077	2077
1973	-	-	1310	1310
1974	-	-	860	860
1975	678	210	297	1185
1976	1167	315	19	1501
1977	750	156	-	906
1978	1211	355	17	1583
1979	1052	584	4	1640
1980	954	440	1	1395
1981	685	351	7	1043
1982	545	317	10	872
1983	703	461	42	1206
1984	768	571	62	1401
1985	788	640	77	1505
1986	643	450	73	1166
1987	536	428	80	1044
1988	561	354	74	989
1989	497	265	132	894
1990	424	379	311	1114
1991	537	418	317	1272
1992	608	410	352	1370

(Downes 1918, Best 1929), the modern eel fishery is based on the Dutch fyke net. In areas too deep for conventional fyke netting, baited traps or eel pots are used, e.g., in South Island high country lakes (Jellyman and Todd 1982). In some intertidal areas, small-meshed set nets are sometimes set parallel to the shore to capture eels moving out on the ebb tide. Fishers report that good catches of reasonably large shortfins can be made under these conditions; the by-catch of juvenile marine species is reported to be small, as eels move out from cover late on the ebb tide, after other species have left. The "set net" category in Table 3 includes this method, although it is likely that most of the catches allocated to "set nets" are, in fact, fyke net captures. In the 1990/91 fishing year there was a marked increase in the percentage of eels caught by traps and eel pots (18.6% of the total catch) although it is thought that this apparent increase is probably due to coding errors rather than to substantial changes in fishing methods.

3.2.3 Fishing effort

Annual fyke net catch and catch per unit effort (CPUE) for each eel fishing return area, from 1983/84 - 1988/89, are given in Table 2. (Note: changes to the method of collecting effort data for the 1989/90 season mean that comparable data to those presented in Table 2 are not available for that season. However, the situation has recently reverted to that used previously, where fishers are required to list the number of nets fished nightly.) Fyke net catches by area for the 1989/90 and 1990/91 fishing years are presented separately in Table 4, because the 1989/90 data are probably incomplete and there was no measurement of effort.

The CPUE data (Table 2) show considerable variation and few recognisable trends. Between areas there is a wide range in CPUE (3.1-13.1 kg/net/night), although there is an even wider range between years for the same site (e.g., North Canterbury = 4.9-18.0 kg/net/night). Although the Waikato basin has traditionally been one of the main eel-producing areas of the country, it has a consistently low CPUE (4.1-4.8 kg/net/night). In contrast, CPUE for the Wairarapa is relatively high. There is no significant relationship (linear regression; $p < 0.05$) between mean annual CPUE and mean annual catch, indicating that areas of high or low catch are not characterised by either consistently high or low CPUE. Over the period of record (1983/84-1988/89) the national catch from CELR ranged from 841-1475 t (a 75% variation), whereas the mean annual CPUE remained relatively constant (5.7-6.8 kg/net/night; 19% variation). Such relative stability of CPUE is an indication that stocks are able to sustain those levels of harvest.

Of particular importance is the relationship between the national catch and the total effort expended. There was an overall decline in fishing effort over the 1983/84 - 1988/89 fishing years, which resulted in a corresponding decline in the overall catch. However, the decline in effort was proportionately greater than the decline in catch (e.g., comparison of the 1983/84 data with the 1988/89 data show a 49% decline in effort and

TABLE 2. Fyke net catches (tonnes) of eels and catch per unit effort (CPUE) (kg/net/night) for each eel return area, for the fishing years 1983/84 - 1988/89.

	1983/84		1984/85		1985/86		1986/87		1987/88		1988/89		Mean		Species		
Area	Total	CPUE	Total	CPUE	Total	CPUE	Total	CPUE	Total	CPUE	Total	CPUE	Total	CPUE	% SF	% LF	% Unid.
Northland	151.1	6.6	200.2	6.2	198.7	6.3	160.1	4.7	130.9	5.5	75.7	4.8	152.9	5.7	68.8	27.9	3.3
Auckland	61.9	4.7	71.4	8.7	51.2	8.8	26.3	9.2	29.2	5.8	79.2	7.4	53.2	7.0	63.8	36.0	0.2
Hauraki	67.2	4.8	57.6	6.5	53.3	7.3	24.4	8.5	26.6	6.4	32.1	6.7	43.5	6.2	74.7	24.0	1.3
Waikato	252.3	4.1	249.1	4.4	197.2	4.2	96.1	4.1	91.6	4.8	77.4	4.4	160.6	4.3	71.9	24.9	3.2
Bay of Plenty	18.1	6.0	33.9	4.2	32.8	3.1	11.6	3.0	10.0	3.1	7.2	2.9	18.9	3.6	60.4	26.8	12.8
Poverty Bay	15.2	2.2	9.0	5.4	0.2	1.7	0.1	3.5	4.1	11.4	<0.1	7.2	4.8	3.1	31.5	68.5	0.0
Hawkes Bay	84.2	9.1	95.8	11.1	86.2	15.6	61.2	9.2	68.2	13.9	26.4	7.7	70.3	11.0	80.5	15.9	3.6
Rangitikei-Wanganui	18.3	9.5	22.8	10.1	28.1	6.8	14.9	6.0	27.9	16.2	28.0	8.4	23.3	8.7	23.1	61.5	15.4
Taranaki	33.1	8.0	27.1	8.3	55.4	10.2	43.9	9.4	42.0	7.4	12.8	5.1	35.7	8.3	7.5	80.4	12.1
Manawatu	83.8	12.9	72.3	9.9	65.0	12.6	59.5	7.1	49.8	8.3	71.7	9.8	67.0	9.9	73.8	17.4	8.8
Wairarapa	29.0	17.6	29.6	11.2	44.5	12.5	58.9	12.7	54.7	11.4	23.0	22.4	40.0	13.1	32.6	67.4	0.0
Wellington	3.4	5.3	0.3	-	5.7	8.3	0.0	-	0.0	-	0.0	-	1.6	7.1	2.1	97.9	0.0
North Island total	818.0	-	869.1	-	818.3	-	557.0	-	535.0	-	433.5	-	671.7	-	63.6	32.0	4.4
Nelson	2.5	32.3	8.6	8.0	10.4	7.4	11.7	5.9	3.8	3.5	16.1	6.0	8.9	6.4	69.1	28.4	2.5
Marlborough	19.7	19.0	52.7	8.0	43.6	9.1	40.4	10.0	29.8	9.9	13.6	7.2	33.3	9.4	41.3	47.9	10.8
Westland	18.0	10.0	38.3	10.1	45.9	11.2	24.3	5.3	31.6	4.9	40.6	6.5	33.1	7.4	41.8	57.5	0.7
North Canterbury	32.6	4.9	26.2	7.5	29.4	8.2	31.1	7.9	30.1	18.0	73.9	15.7	37.2	9.3	71.9	27.2	0.9
South Canterbury	72.3	5.3	59.6	4.0	14.8	7.2	8.8	8.1	16.9	4.5	9.1	3.1	30.3	4.7	84.4	13.6	2.0
Waitaki	3.5	5.0	3.1	19.3	1.5	11.4	0.0	-	5.0	8.4	8.9	6.5	3.7	7.4	44.1	40.5	15.4
Otago	144.7	5.0	130.8	6.7	71.4	6.8	91.3	5.9	111.5	5.3	75.0	5.8	104.1	6.1	8.4	77.4	14.2
Southland	88.3	9.8	171.9	7.8	98.5	6.5	174.8	7.4	102.4	7.0	70.9	7.3	117.8	7.5	12.9	86.9	0.2
Lake Ellesmere	117.6	4.1	98.4	3.7	82.0	3.8	114.1	4.8	100.0	8.0	99.9	7.1	102.0	4.8	97.2	1.1	1.7
South Island total	499.2	-	589.6	-	397.5	-	496.5	-	431.1	-	408.0	-	470.4	-	44.8	50.5	4.7
Chatham Islands	13.9	5.2	17.0	11.1	0.0	-	0.0	-	12.3	7.5	0.0	-	7.2	7.4	88.9	11.1	0.0
New Zealand total	1331.1	5.7	1475.7	6.1	1215.8	6.3	1053.5	6.1	978.4	6.8	841.5	6.7	1149.3	6.5	56.1	39.4	4.5
Total effort (net-nights)	223 038		232 805		184 194		162 891		138 503		113 508		175 823				

a 37% decline in catch), indicating that the CPUE showed a slight net increase over this period.

Virtually all eel fishing permits are held by individuals, although a few are held by companies. Most of the latter are eel processing companies who are able to employ people to work under their licences. Table 5 shows the number of eel fishing permit holders for the fishing years 1987/88 to 1990/91; also given is the total number of permits issued for the whole country. Since a number of fishers or fishing companies have more than one permit, the total number of permits issued exceeds the number of individual permit holders.

Eel permits are normally issued by Quota Management Area (QMA), although there have been some inconsistencies in this approach, with the result that some permits have been issued by eel return area rather than by QMA. Fishers are restricted to areas of historical usage, which is almost always the fishers'

TABLE 3. Eel catches (tonnes) by fishing method, 1983-1988.

Year	Total catch	Percentage caught by Fyke net	Trap	Set net
1983	1206	97.9	0.5	1.6
1984	1401	97.5	0.8	1.7
1985	1505	98.3	0.1	1.6
1986	1166	98.9	0.1	1.0
1987	1044	98.5	0.1	1.4
1988	989	97.9	0.1	2.0
Average		98.1	0.3	1.6

local QMA. QMAs were drawn up for management of marine fisheries, and the landward extensions of boundaries do not appear to have been precisely determined. Figure 3 has been compiled partly from MAF administrative boundaries. A breakdown of permits issued for each QMA for the 1990/91 fishing year is given in Table 6. The total number of permits in this table, 278, exceeds the 239 for the equivalent year (1990/91) in Table 5 as a permit may allow a fisher to fish in more than one QMA.

A total of 161 permits was issued for the North Island, compared with 117 for the South Island. The top half of the North Island is the area with, by far, the largest number of permits, followed by the east coast of the South Island.

3.2.4 Annual and regional characteristics

The mean annual catch of eels for all areas is illustrated in Figure 4. The raw data and the average catch per area for the same period are given in Appendices I and II. Over this period, the Waikato remained the largest contributor (13.7% of the national total), followed in descending order by Northland (12.6%), Southland (9.5%), Lake Ellesmere (8.9%), Otago (7.8%), Hawkes Bay (6.8%), and Manawatu (5.5%).

The Waikato fishery showed a substantial decline for the first six years of this period, falling from 252.3 tonnes in the 1983/84 season (Table 2) to 86.5 tonnes in the 1988/89 season. Local processors have queried these data (A. Teklenburg, J. Jameson, pers. comm.). A likely explanation is that an unknown proportion of the Waikato catch has been incorrectly coded to the adjacent area, Auckland, where it was processed.

TABLE 4. Fyke net catches for the 1989/90 and 1990/91 fishing years. (* = incomplete data.)

Area	Reported catch (tonnes) 1989/90	1990/91
Northland	99.4	155.6
Auckland	44.2	81.0
Hauraki	14.7	32.4
Waikato	58.5	73.5
Bay of Plenty	1.6*	20.6
Poverty Bay	<0.1	2.5
Hawkes Bay	18.7	38.1
Rangitikei-Wanganui	22.8	49.1
Taranaki	2.4*	4.8
Manawatu	63.9	45.2
Wairarapa	36.6	42.8
Wellington	0.0	<0.1
North Island total	362.8	545.6
Nelson	5.0	17.1
Marlborough	17.2	38.0
Westland	61.6	78.9
North Canterbury	50.5	32.4
South Canterbury	11.1	32.0
Waitaki	29.6	11.9
Otago	42.4	55.4
Southland	63.6	115.3
Lake Ellesmere	98.7	117.9
South Island total	379.7	498.9
Chatham Islands	31.0	26.4
New Zealand total	773.5	1070.9

TABLE 5. Number of eel fishing permit holders and total number of permits issued for the fishing years 1987/88 - 1990/91.

Fishing year	No. of permit holders	Total no. of permits issued
1987/88	180	248
1988/89	174	290
1989/90	163	239
1990/91	159	239

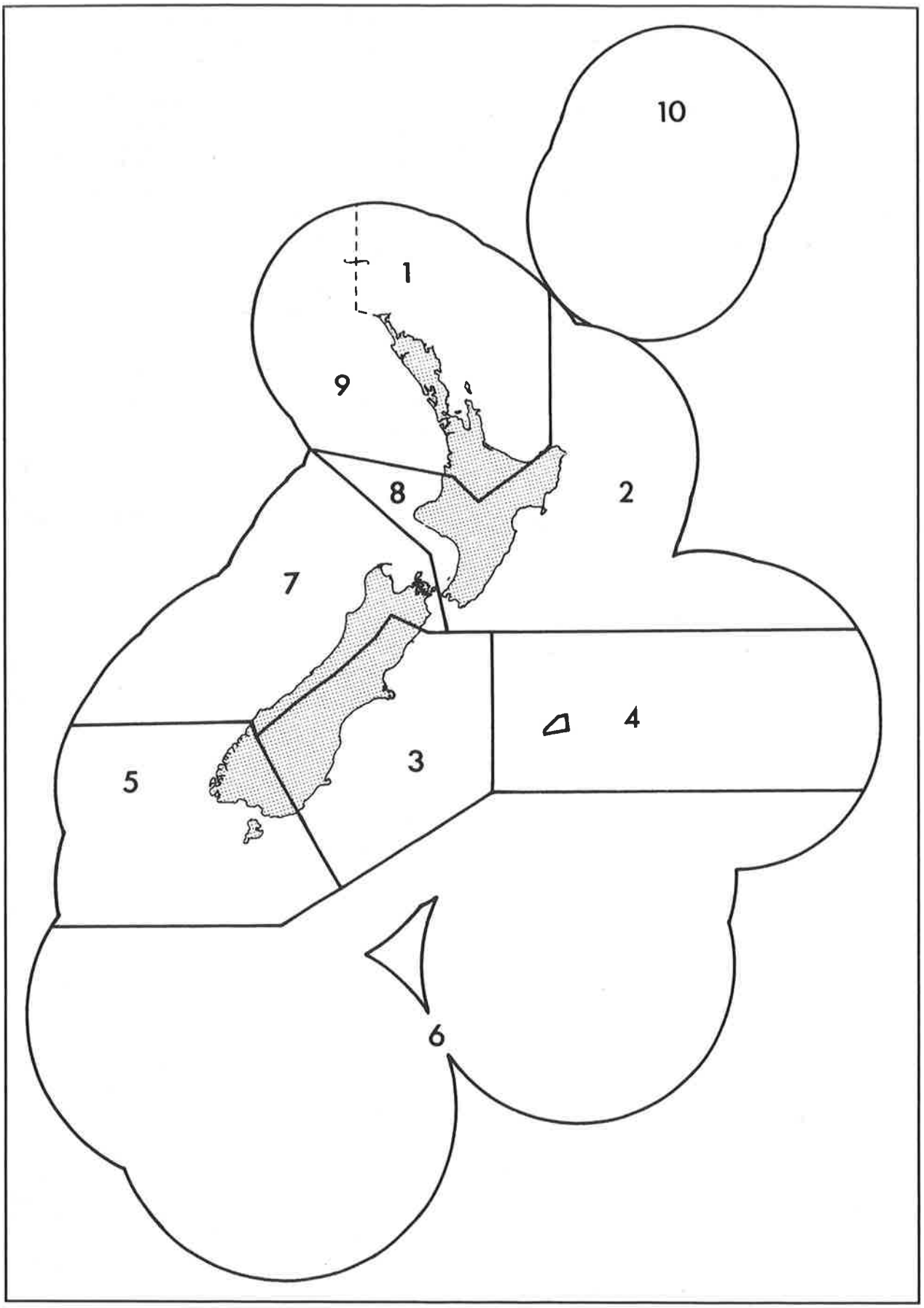

FIGURE 3. New Zealand's Quota Management Areas.

TABLE 6. Number of permits issued for each Quota Management Area (QMA) during the 1990/91 fishing year.

	QMA									
	1	2	3	4	5	6	8	9	El.	Total
No. of permits	57	30	52	3	34	17	23	51	11	278

El. = Lake Ellesmere

Most of the major eel producing areas showed an overall decline in catch from 1983/84 onwards, generally reaching a low in 1988/89 or 1989/90 (Appendix I). During the 1990/91 season, there were some substantial rises in catch compared with the previous year (Table 4); the only areas not to show an increase were Manawatu, North Canterbury, Waitaki, and the Chatham Islands. Similarly, during the 1991/92 season, all areas except Rangitikei-Wanganui, Manawatu, Marlborough, Westland and South Canterbury, showed increased catches over 1990/91. Being fyke net catches only, Table 4 does not indicate the full extent of some of the increased catches recorded, as an additional 20% of the 1990/91 catch came from other methods. This was particularly evident in the Waikato and Rangitikei/Wanganui areas, where more eels were recorded from traps and pots than were recorded from fyke nets. However, it is considered that this apparent change in methods is in fact due to incorrect method codes being used by fishers. The North Island catch of 858 t for the 1991/92 season considerably exceeded that of the South Island (585 t).

For reasons of both exploitation and conservation, it is desirable to manage any quota allocations by small areas. In practice, the lack of knowledge of local stocks and fishing yields mean this is not warranted. Consequently, recommendations of a MAF Fisheries Working Group (Annala 1993) are that the three North Island and four South Island areas suggested by Town (1986) be adopted. Industry members commented that established fisheries have generally agreed upon territorial boundaries within which individuals operate. Also, most commercial eel fishing within the country takes place on, or requires access through, private land; established fishers have negotiated arrangements with landowners, and these act as a further safeguard in excluding would-be fishers.

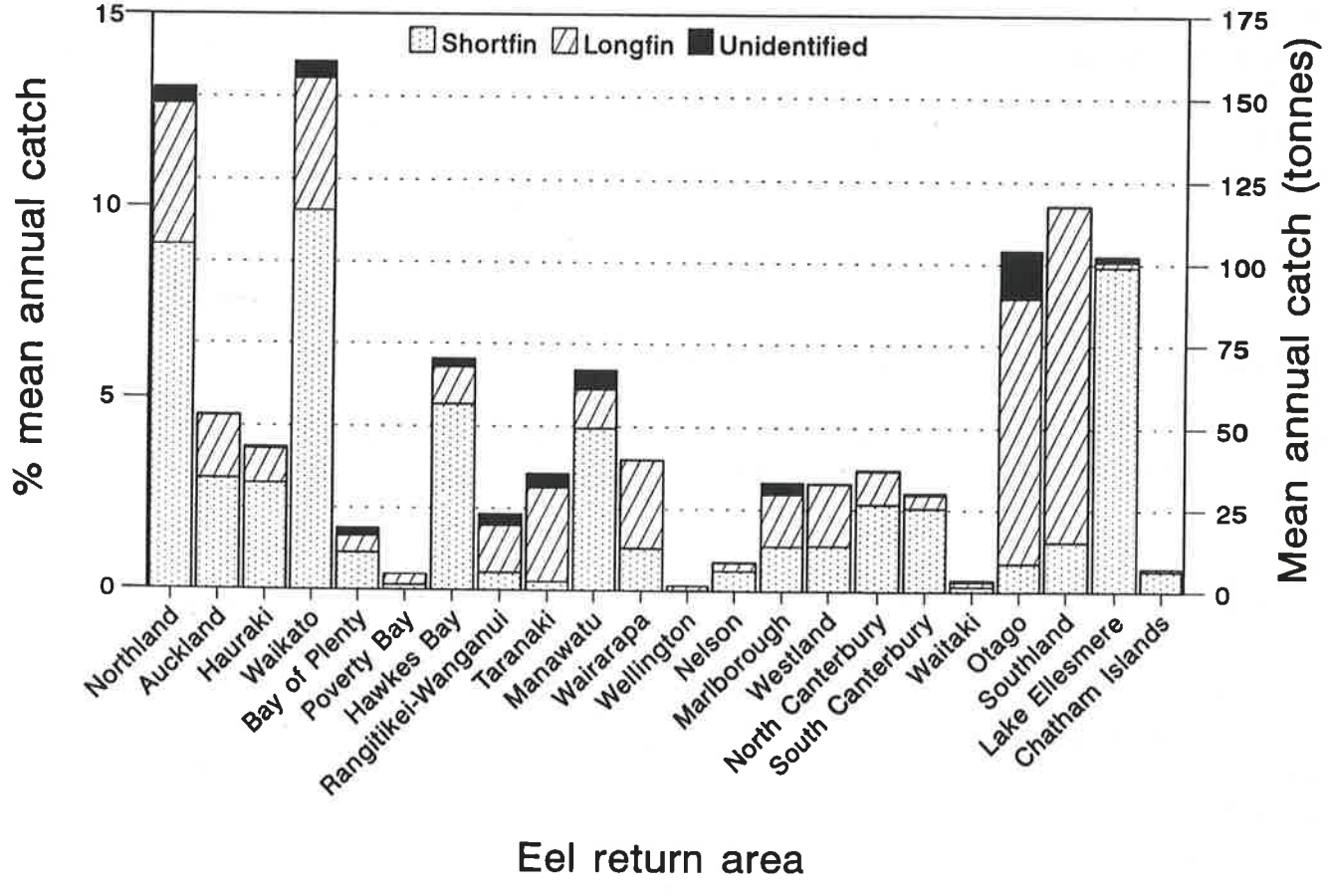

FIGURE 4. Mean annual catch of eels, by area, for the 1983/84 - 1990/91 fishing years.

3.3 Processing industry

3.3.1 Processors

Eel fishers may sell to any processor (Licenced Fish Receiver - LFR), though some loyalties, commitments, and agreements do exist. Eel processors are licenced under the Fisheries (Licensed Fish Receiver) Regulations 1986, and the whole fish processing industry is now moving towards a series of "Industry Agreed Standards". MAF Quality Management is contracted to perform quality checks, and inspects and approves factories. Air transport of live eels requires only that a facility be licenced as a "Whole Fish Premises", not for fish packing. Industry-agreed standards will, in future, also apply to these premises. To safeguard and raise processing standards and quality, the industry has co-operated to produce a code of practice for processing (New Zealand Fishing Industry Board 1981).

LFRs may process all types of fish, so it is difficult to know the exact number of eel processors currently operating. Due to occasional data input errors, a listing of companies who have processed "eels" can also include those who have processed conger eels. However, if companies handling less than one tonne of "eels" are excluded, 12 North Island, 10 South Island, and one Chatham Island processors operated during 1990 or 1991 (Appendix III). The nine companies (five North Island and four South Island) who processed >50 t per year, accounted for 90%, 95% and 96% of the 1990, 1991 and 1992 production, respectively. By comparison, in 1985, there were seven North Island and six South Island companies operating (Town 1985).

3.3.2 Products and destinations

Eels are processed in a variety of ways, according to the importers' requirements. Appendix IV lists the quantities of eel products by country of import for the 1990 calendar year. The major countries importing New Zealand eels (1987-1992 calendar years) are given in Table 7, and the contribution of various types of product is given in Table 8.

TABLE 7. Principal countries importing New Zealand eel products, 1987-1992.

	% of total export (by weight)					
Country	1987	1988	1989	1990	1991	1992
Holland	28.8	26.7	27.7	26.7	32.5	35.1
Germany (Federal Republic)	12.3	14.9	12.1	20.6	20.8	18.3
United Kingdom	27.8	22.7	20.9	18.4	17.1	13.5
Belgium	12.5	11.8	16.3	15.1	11.6	8.8
Italy	1.7	3.0	8.2	4.5	5.2	4.4
France	6.9	6.8	3.8	4.3	4.4	9.5
Australia	2.2	3.4	2.9	4.1	1.5	1.6

TABLE 8. Percentage of various eel products exported, 1987-1992.

Product	1987	1988	1989	1990	1991	1992
Live	14.7	15.0	21.8	15.0	14.0	16.4
Whole frozen	75.2	80.3	57.6	65.2	49.9	42.1
Frozen, headed and gutted	-	-	6.2	3.8	8.3	11.0
Frozen fillets, etc.	1.6	-	5.0	12.2	23.5	24.1
Frozen (other)	1.4	-	-	-	-	-
Chilled whole	-	1.0	2.2	0.3	0.5	0.7
Chilled, headed and gutted	-	-	0.1	0.1	0.4	0.1
Chilled (other)	-	-	0.2	0.3	0.2	1.1
Smoked	7.1	-	-	-	-	-
Smoked, whole	-	2.3	5.2	1.8	1.5	2.7
Smoked fillets, etc.	-	1.4	1.7	1.3	1.7	1.8

TABLE 9. Conversion factors to convert eel products to landed (green) weight.

Product	Conversion factor
Live/whole frozen	1.0
Gutted	1.1
Gilled and gutted	1.2
Headed and gutted	1.6
Fillets	2.5
Whole smoked	1.5
Smoked halves	2.3
Smoked fillets	3.0
Skinned pieces	1.5

Note that the weights used to prepare Tables 7 and 8 are processed weights and not "green" (unprocessed, landed) weights. Town (1986) gave approximate conversion factors for some products, while the MAF Fisheries QMS files contain similar factors. Table 9 lists factors from the QMS system, supplemented by factors supplied by industry. These factors differ from those of Town (1986) and have been used throughout this report, including reconverting the export data contained in Town (1985, 1986).

Using these conversion factors, we can convert the eel export data compiled by the Fishing Industry Board, to landed weights. Estimated landed weights for the years for which a breakdown of eel exports by product were available (1975 onwards) are given in Table 10. Since 1987, LFRs have been required to send MAF monthly

TABLE 10. Comparison of eel catch data from various sources.

	Reported catch			Exports°		
Year	CELR*	LFR†	Processors' estimate	Processed weight	Converted weight	Value# ($m)
1970	880	-		825	-	0.53
1971	1450	-		1640	-	1.03
1972	2077	-		1994	-	1.59
1973	1310	-		1686	-	1.19
1974	860	-		1365	-	1.15
1975	1185	-		2363	2434	2.76
1976	1501	-		1681	1750	2.30
1977	906	-		1567	1697	2.02
1978	1583	-		2177	2314	4.07
1979	1640	-		2082	2124	4.36
1980	1395	-		1771	1873	3.94
1981	1043	-		1160	1686	2.59
1982	872	-		932	1274	2.75
1983	1206	-		873	941	3.03
1984	1401	-		885	951	3.50
1985	1505	-		917	1011	4.50
1986	1166	-		1044	1094	5.39
1987	1044	1114		883	1065	4.83
1988	989	1281		1025	1067	5.19
1989	894	1315	1348	1150	1312	6.34
1990	984	1412	1383	1255	1455	7.77
1991	1272	1523	1596	1223	1516	8.72
1992	1370	1557	1617	1283	1592	9.66

*CELR data supplied by fishers.
†LFR data supplied by processors.
°Export data supplied by N.Z. Fishing Industry Board.
#Value, $NZ in millions, f.o.b. (free-on-board).

returns of eels received from fishers. Annual totals for the calendar years 1987-1992 are given in Table 10.

During preparation of the Working Group Report (Annala 1993), industry members expressed concern about possible missing data from the MAF LFR database. Consequently representatives of the New Zealand Eel Industry Association contacted all major processors and derived a further estimate of annual catch for 1989-1992. These data, together with CELR/Fisheries Statistics Unit (FSU) data, LFR data (ex MAF Fisheries) and export weight and value, are also given in Table 10. Separate processors estimates for Lake Ellesmere are given in Table 11.

TABLE 11. Lake Ellesmere catch data 1973-1991*. Reported catch per calendar year and quota year, estimated catch from processors, and total allowable catch (TAC) per quota year.

Year	Reported catch per: calendar year	quota† year	Estimated catch from processors	Seasonal TAC
1973	251.0			
1974	256.0			
1975	566.0			
1976	847.0			
1977	441.0			
1978	524.0			256.0#
1979	359.0			250.0#
1980	299.0			300.0#
1981	208.0			300.0
1982	109.0			200.0
1983	107.5	100.9		150.0
1984	89.6	92.3		150.0
1985	99.4	105.2		150.0
1986	81.6	102.9		136.5
1987	103.1	101.4		136.5
1988	103.7	96.2		136.5
1989	104.5	110.0	186.1	136.5
1990	89.3	93.1	169.5	136.5
1991	129.4	128.3	179.7	136.5
1992	167.6	142.3	199.9	136.5

* data for 1973-1984 are from Town (1985).
† the quota year is from 1 February - 31 January, so the TAC applies to this period.
# TAC excludes migrant eels; for all other years, the TAC includes migrants.

There are some obvious discrepancies between these data, e.g., the converted export weight exceeds the reported landed weight for 15 of the 18 years. The mean converted export weight for these years was 1509 t, compared with a mean reported catch of 1220 t, i.e., there was an average of 20% more eels exported per annum than were reported caught. Town (1985) also recorded differences between catch data (now referred to as CELR) and export data, and considered the latter a more realistic measure of actual commercial landings (Town 1987).

Over the years for which the LFR data have been available (1987 onwards), there has been generally good agreement between the LFR and converted export data, which gives some confidence in adopting the LFR data as a more accurate measure of the total annual catch than the CELR data. The resulting estimated total annual catch (CELR data to 1986, LFR data 1987 onwards), is shown with converted export data in Figure 5. Large variations between the two sets of data are apparent until 1986. Estimated catch and export value are shown in Figure 6. Both data sets show roughly parallel trends, although the gradual increase in price per product (1970 = $0.60/kg, 1992 = $6.07/kg) means that the graph for value intersects, then exceeds, that for catch.

4. MAORI CONCERNS

4.1 Value of eels to Maori

Historically, eels constituted a very important food to Maori. As a result, Maori developed sophisticated and effective methods of harvest, as well as gaining a good understanding of the habits and life-history of eels. This included various conservation methods, including seeding areas with juvenile eels, and imposing restrictions on times and harvest methods through a system of tapu and rahui. Best (1929) reviewed eel fishing methods used by Maori, while Marshall (1987) discussed their contemporary methods of eel capture and demonstrated the relationship of these methods to pre-European methods. McDowall (1990) commented on the extent of the past fishery and stated:

> *"Without doubt, eels were the most important fish for the early Maori. This is no surprise - eels were ubiquitous, large, abundant, easily caught and highly nutritious".*

Over recent decades, eels have become less of a necessity for Maori, but retain their strong historic and

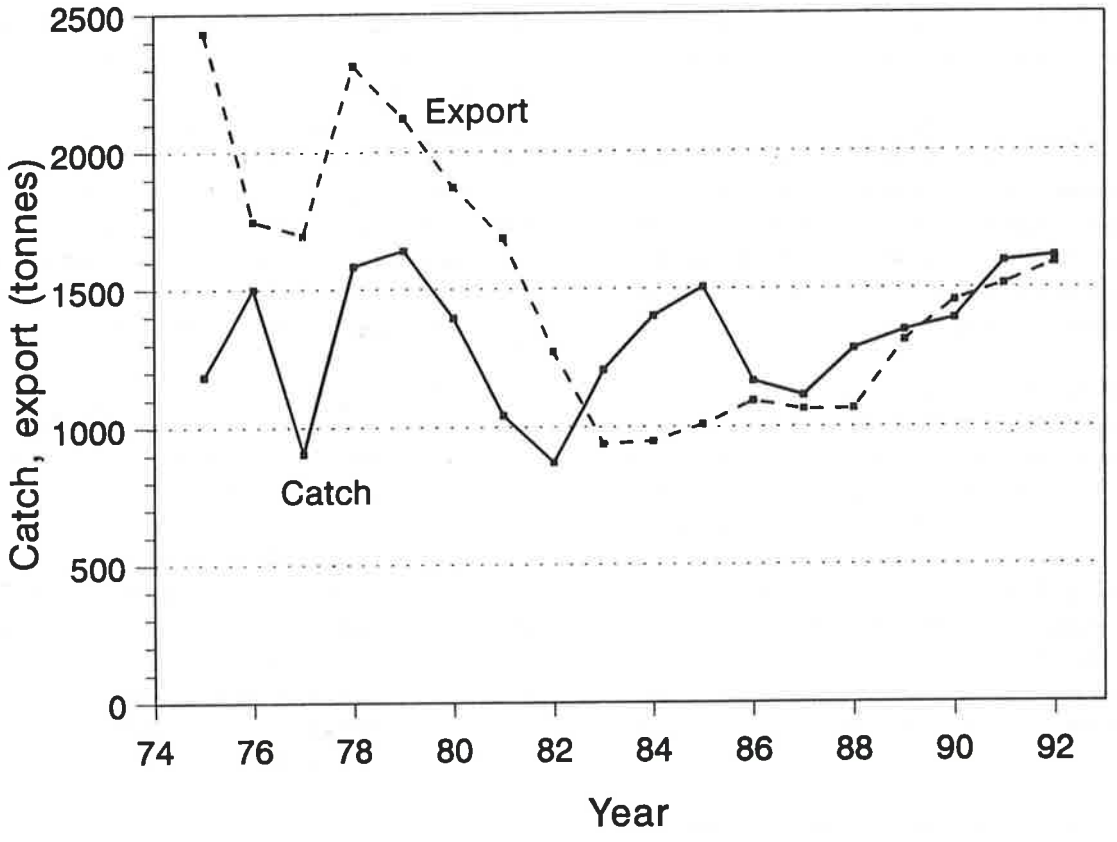

FIGURE 5. Estimated catch of eels (data sources as per Figure 2, 1987-1992) and quantity exported (converted to landed weight), 1975-1992.

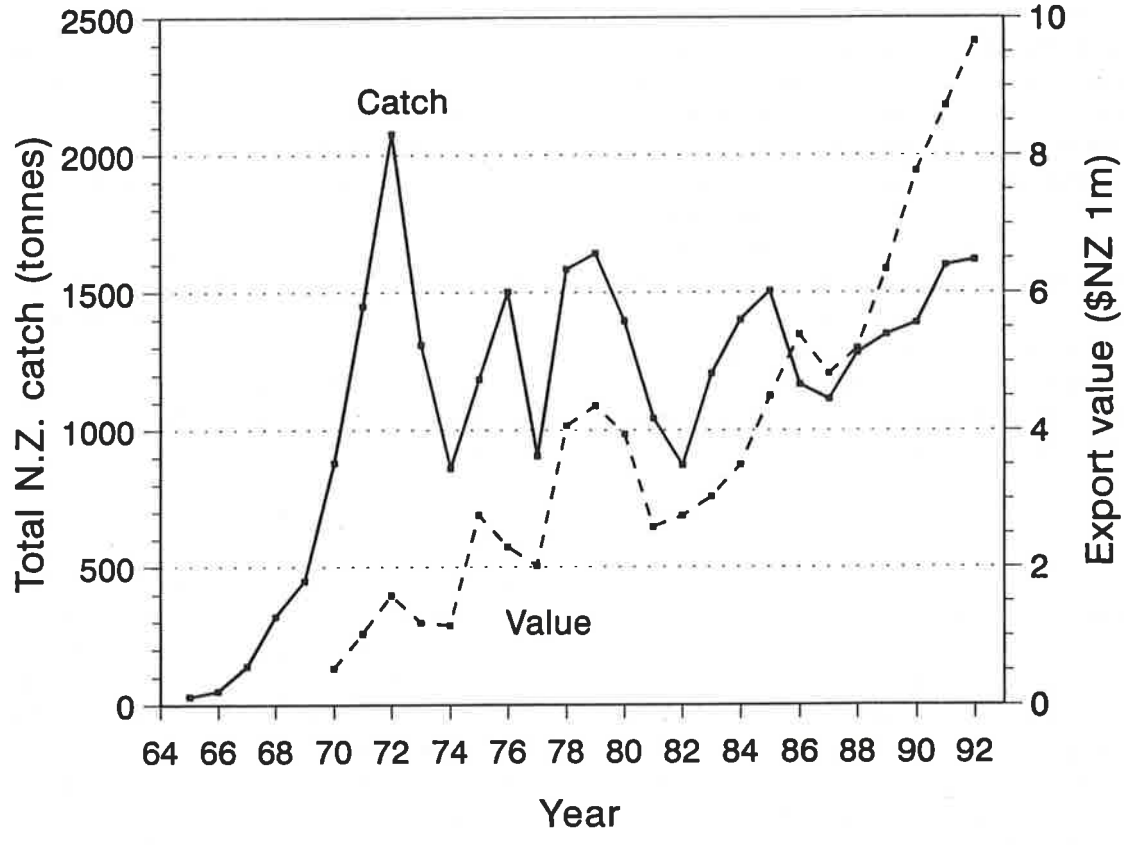

FIGURE 6. Estimated catch of eels (data sources as per Figure 2, 1987-1992) and export value.

cultural associations. Periodically over the past 100 years, Maori have petitioned the Government, expressing concern over eel fishing. For instance, an appeal in 1881 to the House of Representatives complained that the eel fisheries of Lake Ellesmere were being destroyed by drainage, while a petition in 1887 complained that eel weirs and eel fisheries in the Whanganui River were being destroyed by the passage of river steamers (there were at least 90 weirs on the Whanganui River) (Young 1990).

With the passing of the Maori Fisheries Act in 1989, the Crown recognised the legitimacy of Maori fishing rights secured by the Treaty of Waitangi, and sought to facilitate the increased entry of Maori into the fishing industry. The Crown is currently considering various Waitangi Tribunal recommendations, including the recommendations from consideration of the Ngai Tahu sea fisheries claims (Waitangi Tribunal 1992) "that all existing annual eel fishing licences on Waihora (Lake Ellesmere) be not renewed on expiry so that the lake can be returned to Ngai Tahu as a Ngai Tahu eel fishery."

The terms of the more recent Treaty of Waitangi (Fisheries Claim) Settlement Act 1992, preclude commercial eel fisheries from being a part of any future tribunal deliberations. However, Ngai Tahu claim that the current commercial fishery prejudices their ability to operate a traditional fishery at former levels which, they claim, may have been as much as 100 t annually (T. Lynch, MAF Fisheries, pers. comm.). Consequently they consider that the Crown should adopt the Tribunal's recommendations and close the commercial fishery. MAF is addressing ways of further involving Maori in management of the fishery. As the commercial fishery is considered to be fully developed, there is no obvious opportunity for the Crown to utilise any uncaught portion to satisfy Treaty claims, meaning that an agreement with Maori would require reallocation of activity from existing fisheries. As previously mentioned, should eels enter the QMS, then 20% would be allocated to Maori. Presumably, non-commercial/traditional fishing requirements would need to be taken into account prior to the setting of any total allowable commercial catch (TACC).

4.2 Current concerns

Maori have a number of specific concerns about the status and management of the eel fishery. Perhaps the most common grievance is that Maori can no longer catch enough large eels to satisfy their requirements, especially for important ceremonial occasions. Apparently, with the exception of shortfin males (haumate or puhi), Maori seldom harvest eels less than about 250 g. Under specified conditions within the Amateur Fishing Regulations, local maraes can be granted special dispensation to gather or catch quantities of shellfish and fish in excess of that allowed under the regulations, for the purpose of holding a hui, tangi etc. Although there is presently no daily limit on the number of eels that amateurs can take, it is often not possible for local iwi to obtain eels of sufficient size, and there is a resultant loss of mana. Tau *et al.* (1990) claimed that Ngai Tahu traditionally harvested the smaller non-breeding eels rather than the larger "pou tuna" breeding stock. How this practice related to the extensive fishery for migratory eels at both Lake Forsyth and Lake Ellesmere is unknown.

The reduced availability of eels in general, is a major concern. For example, in a submission to the Ngai Tahu Sea Fisheries hearings, Kelvin Anglem recorded catching a winter's supply of eels (about 300) on the Opihi River during one night's fishing. Over 40 years later, three expeditions yielded a total of 24 eels, most of which were considered too small (Waitangi Tribunal 1992).

There are apparently many locations around the country which have particular significance to Maori. While some of these areas may have been important fisheries, others may have had particular spiritual significance. For instance, a recent report discussing a proposed resource management strategy for the Canterbury region by Ngai Tahu (Tau *et al.* 1990), highlighted the importance of such areas as Wairewa (Lake Forsyth), Te Waihora (Lake Ellesmere), and Wainono (Wainono Lagoon) as traditional eel fishing areas. Ngai Tahu are concerned that the present management of eel fishing does not recognise the significance of such areas to Maori. While it is understood that should eels enter the QMS system then 20% of quota would be allocated to Maori, there has been some concern expressed by Maori that this represents their rights for access to the commercial fishery but should not be seen as compensation for loss of opportunities to carry out traditional fishing.

While Ngai Tahu (who represent most South Island Maori) are not opposed to the setting of national and regional total allowable catches (TACs), Maori as a whole are known to be opposed to the concept of Individual Quota let in perpetuity, as they regard fishery resources as common rather than private property. It is also understood that Maori are concerned about overall fishing pressure on the eel resource, which is exacerbated by the practice of more than one person fishing on one permit. (n.b. This was a "loophole" created by introduction of the Fisheries

Amendment Act 1990, and has been redressed by an amendment to the Fisheries Act 1991.) The practice of some commercial fishers of "saturation fishing" an area and then moving on to another, is a matter of particular concern to Maori, who have a tradition of managing eel waters to maintain a sustainable fishery. Small streams and creeks are regarded as areas of special importance, as tradition indicates that these were areas where eels spawned and over-wintered.

Other concerns include the general reduction in both the quantity and quality of available eel habitat that has occurred through modifications to waterways and land management practices. For example, Tau *et al.* (1990) comment "Today the bottom of Wainono is covered in a thick mud which, in some parts, is knee-deep. The area of Wainono has been reduced by drainage activities which have also caused the destruction of the fish and waterfowl habitat". The concept of effluent disposal into waterways has always been of particular concern to Maori, as it is considered disrespectful to the spirits who inhabit such areas. There is also concern about the number of Maori involved in the eel industry, as the exclusion of part-time fishers in 1984 meant that many Maori who supplemented their income with eel fishing were excluded. For example, none of the 11 commercial eel licence holders on Lake Ellesmere are Maori. Finally, Maori have expressed concern at the division of management responsibilities for eels between MAF and DOC as, to Maori, this is contrary to the concept of a holistic approach to management, inherent in the principle of mahinga kai (James 1991).

5. MANAGEMENT OF THE EEL INDUSTRY

5.1 Review of present management

Historically, eels were plentiful, readily available, and accessible - fishers merely required a small boat and fyke nets, and so the fishery was a relatively low-cost one to exploit. In the early 1970s, management of the industry was concerned more with minimising the by-catch of trout than with monitoring the eel fishery itself. For example, the 1973 reprint of the Fisheries (General) Regulations contained a prohibition on setting fyke nets in water where the flow exceeded 40 feet/minute (0.2 m/s). However, with the rapid increase in eel fishing in the 1970s, there was recognition that the industry would need specific management to enable it to become a sustainable, long-term fishery. Present management is limited to controls on netting practices and minimum size, with the addition of the 1988 moratorium on issuing licences, which was introduced as an interim measure to limit expansion of the fishery.

Non-commercial fishing for eels is controlled by The Fisheries (Amateur Fishing) Regulations 1986. Under these regulations, the minimum mesh size of nets for capturing eels is set at 12 mm, although there is no minimum size of eel or maximum daily number of eels that may be taken. Amateur fishers are restricted to the use of only one fyke net or hinaki at any time. Maori can apply for exemptions to these regulations for the purpose of catching eels for ceremonial occasions. Both amateur and commercial operators are prohibited from setting nets that extend more than a third of the width of a waterway.

Lake Ellesmere is the only eel fishing area in the country for which an annual quota is specified for eels. Owing to concerns about over-exploitation, a moratorium was declared on issuing new permits for the lake in December 1977. On 1 December 1978, the lake was declared a controlled fishery, and the eel fishery is now controlled through individual licence quotas and a TAC (total allowable catch). The TAC and quotas are reviewed annually by the Controlled Fisheries Authority. The initial TAC was set at 256 t in 1978. At present, there are 11 licence holders and a TAC of 136.5 t. This TAC has held for the past six seasons and, until 1992, catches of this size or greater had not been recorded since 1981 (Table 11) according to the CELR data. Accordingly, it could reasonably be argued that a decrease in quota is now warranted. Such a recommendation is contrary to that of the Controlled Fisheries Authority, who recently recommended an increase to 150 t. However, it is widely accepted that the CELR data are a substantial under-estimate of the actual catch. The average catch over the past four years, according to processors' estimates, is 183.8 t, well in excess of the TAC. Even these estimates are conservative, since processors receive a proportion of eels of "uncertain origin". For the estimates, only 50% of these eels have been allocated to Lake Ellesmere. However, it is very likely that most of them are from the lake.

The controlled fishery year runs from 1 February to 31 January, and migrant eels are included within quotas (i.e., present quotas do not differentiate between migrant and non-migrant eels). The 1 February commencement allows fishers access to migrants, but, should these eels be unavailable due to the lake being open to the sea, fishers are still able to fill their quota with non-migrant (feeding) eels the following season.

During the past decade, the number of fishers involved in the eel fishery has been affected by several management decisions. Firstly, part-time fishers (those not earning 80% or more of their annual income from fishing) were excluded from all commercial fisheries in 1984. Secondly, in recognition that the fishery was considered to be fully developed, an internal policy was adopted by MAF on 1 October 1986 whereby no new permits were issued. For the MAF Fisheries North administrative area (equivalent to QMA 1 in Figure 3), permits were issued on a replacement basis only, while for Central and Southern Areas (QMAs 2,7,8 and 3-6, respectively), no further permits were issued. Thirdly, this internal management measure was strengthened nationally when a moratorium was placed on issuing fishing permits for eels on 1 October 1988. This effectively stopped the issuing of new permits to enter the fishery, but did not constrain the activities of existing permit holders.

Individual fishers may operate as much equipment as they wish. An earlier regulation had stipulated that fyke nets had to be lifted daily, providing some limit to the number of nets an individual fisher could operate. Likewise, baiting fyke nets was prohibited, since fyke nets were defined as "unbaited trap nets". Today this regulation is no longer in place and the baiting of nets is widespread, to the extent that some fishers remove the wings from fyke nets and rely solely on the bait to attract eels to enter nets.

Present regulations affecting commercial eel fishing are as follows: Under Section 21 of the Fisheries (Commercial Fishing) Regulations 1986, the minimum size of eels that may be taken or possessed by commercial fishers is 150 g (except for Lake Ellesmere, where there is currently no minimum size), and the minimum net mesh size is 12 mm. All fyke nets are required to have a float attached, giving the owner's vessel number (Section 34), and no net, or part of a net, can extend across more than a third of the width of a waterway (Section 38). All fyke nets are required to have two escapement tubes fitted (Section 49). Under new regulations, which will be effective for the 1993/94 fishing year, the minimum size of eel for everywhere except Lake Ellesmere, is increased to 220 g, with a corresponding change in escapement tube to 25 mm internal diameter. A minimum size of 140 g is to be introduced to Lake Ellesmere, with increments of 10 g/year, to bring the lake up to the national limit in eight years. Eels may be caught only by fyke nets, hinakis, or set nets (Section 50), with the permitted method(s) reflecting the fisher's fishing history.

Lake Horowhenua and the adjacent Hokio Stream are reserved for Maori fishing, and commercial eel fishing is therefore prohibited (Section 15 of the Fisheries (Central Area Commercial Fishing) Regulations 1986). Similarly, the taking of eels from Lake Forsyth is reserved for Maori (Section 7 of the Fisheries (South-East Area Amateur Fishing) Regulations 1986). The same regulations and the equivalent commercial regulations (Fisheries (South-East Area Commercial Fishing) Regulations 1986) prohibit use of nets other than fyke nets in parts of the Kaiapoi River and lower Waimakariri River during February and March each year (Section 4), and also prohibit the use of nets within a 1.2 km radius of the main tributaries of Lake Ellesmere (Section 6). These regulations are designed to avoid the accidental capture of salmon (Kaiapoi and Waimakariri Rivers) and brown trout (Lake Ellesmere tributaries). Regulations for each of the four relevant commercial fishing regulatory areas prohibit the taking of eels by fyke nets in National Parks.

The present MAF Fisheries review of the eel fishery recognises that current management needs a more rational basis to promote the sustainability of both the fishery and access to it. Changes brought about by the 1990 amendment to the Fisheries Act (to legitimise the naming of employees of a permit holder fishing from other than a vessel), have been used by some eel permit holders to add additional employees to permits that were previously operated by a single fisher. This effectively increased the number of fishers involved in the fishery, and so contravened the intention of the present moratorium on permits. As from January 1992, new legislation allowed a restriction on the number of people able to fish on a permit. It is MAF Fisheries' intention to limit participants in the eel fishery to the numbers involved during the 1989/90 fishing year. In August-September 1991, eel permit holders were consulted about this process and most agreed that the proposed redress was fair.

Various other statutes may impinge on eel fishing practices. For instance, the transfer or release of eels or other forms of aquatic life to new locations where they do not already exist requires the approval of the Minister of Conservation (Section 26ZM of the Conservation Act). Under the same section, the Minister controls any transfers onto the DOC estate, whether new releases or restocking. To control the spread of disease, approval of the Minister of Fisheries is required for restocking in other areas or for transfers between islands.

DOC administers the Conservation Act, which requires them to protect the freshwater eel resource through protection and conservation of the species and their habitats. DOC also administers and manages the various categories of reserves throughout the country,

i.e., National Parks, scenic reserves, historic reserves, wildlife reserves, recreation reserves, scientific reserves, nature reserves, faunistic reserves, Government Purpose and Local Purpose reserves, and unallocated Crown land. Under the relevant Acts, commercial eel fishing is prohibited in all National Parks, and, by law, should not be permitted in Scenic and Government Purpose Reserves. Prohibition of fishing in these latter reserves has not been rigorously enforced. DOC currently declines all new applications to fish Government Purpose Reserves, but there are some cases of fishing within reserve areas. DOC "inherited" this situation from the former Department of Lands and Survey, and resolution will require time and consultation with the various parties involved. DOC regions have expressed concern at the status of eels within waters under their control. Limiting or prohibiting commercial eel fishing in other areas managed by the Department would need to be considered in consultation with MAF. If this were to come about, it would generally be welcomed by Maori, and would be consistent with DOC's statutory requirements to give effect to the principles of the Treaty of Waitangi.

The Conservation Act requires persons undertaking a "trade, business or occupation" on land managed by DOC to have the approval of the regional conservator (Section 17(1)(f)). This applies to commercial eel fishers, but most fishers are apparently unaware of this requirement. Education of commercial eel fishers is needed.

5.2 Fishery managers' concerns

The concerns of fishery managers fall into three main areas:

- slow growth rates of eels, and their consequent vulnerability to over-fishing;
- loss of eel habitat;
- effects of the current level of exploitation.

5.2.1 Growth rates

Research has shown that slow growth rates and consequent longevity are typical for both eel species. Table 12 gives average ages for migratory eels. There are exceptions to this, for instance Mitchell and Chisnall (1992) reported on a sample of very large (90-117 cm) migratory shortfinned eels from Lake Ainiwhenua, that were between 7-12 years old.

TABLE 12. Size and age of migrating eels (from Jellyman and Todd 1982).

Species	Length range (cm)	Average length (cm)	Average weight (kg)	Average age (years)
Shortfin				
male	38-55	44	0.2	14
female	50-100	74	0.8	22
Longfin				
male	48-74	62	0.6	23
female	75-180	115	4.0	34

More recent research by Jellyman (in prep. a,b) has indicated much greater variability in age at migration. In Lake Pounui, Wairarapa, migrating shortfin males averaged 22 years and shortfin females 41 years. From these studies, migrant longfin females of average length (i.e., 115 cm, Table 12) would average 66 years of age. These data, together with previous growth studies (Burnet 1969b, Chisnall 1989), indicate that New Zealand eels have the slowest growth rates of any species of freshwater eel studied to date. Consideration of such data must inevitably lead to a conservative approach to management.

Although growth rates of wild eels are generally slow, New Zealand eels also have the potential to grow extremely rapidly. Thus Jellyman and Coates (1976) reported that under culture conditions, a small percentage of eels of both species grew to 150 g within a year. Both these authors and Jones *et al.* (1983) emphasise the variability in growth achieved during culture, with Jones (loc. cit.) recording an average length range of 11-46 cm and an average weight range of 10-180 g after one year's culture.

5.2.2 Loss of eel habitat and eel access

Of concern to both fishery managers and fishers is the diminishing area of eel habitat. For the past 20 years attention has been directed to the loss of wetlands (e.g., McDowall 1975). There is now a growing awareness of their importance as refuges for a wide range of plants and animals (e.g. Buxton 1991). Nowhere has this loss been greater than in the Waikato, where a report of the former Wildlife Service estimated that 84% of wetlands had been drained over the past 140 years. The extent of the loss nationally is unknown, although the Environmental Council (Anon. 1983) estimated that, at that time, only 10% of New Zealand's original area of wetland remained.

Vast areas of eel habitat, especially for shortfins, have been lost through drainage of wetlands throughout the country. Often the remaining areas may have some partial or complete barrier to the annual recruitmentt of juvenile eels, owing to the installation of floodgates, weirs, or dams.

Installation of hydro-electric dams on many of our largest rivers also has created barriers or complete impasses to elvers (juvenile eels). Likewise, there is a corresponding loss of downstream migrating eels when they enter turbines. Following the rationale of the early "eel destruction campaigns" of the 1920s and 1930s (Cairns 1942b), there was a prevailing belief in the 1960s that exclusion of eels would benefit trout and salmon fisheries. Hence, when Roxburgh dam was built on the Clutha River in the mid 1950s, the exclusion of eels from upstream waters was seen as having an overall beneficial effect (Jellyman 1987a). Since that time, there has been a gradual shift in opinion. Today, the Freshwater Fisheries Regulations 1983 state that the Director of Conservation may require the installation of a fish pass on new dams and weirs. Co-operative work by ECNZ, MAF Fisheries, and DOC is attempting to re-establish elver access to waters from which they have been excluded by hydro stations.

5.2.3 Impact of commercial fishing

It is difficult to quantify how well the eel resource is standing up to the current level of exploitation. Estimated catches over the past six seasons have shown a small, but steady, increase (Figure 2), yet such increases could be maintained by increased catches of progressively smaller eels. Neither the CELR data nor the export data indicate the size of eels being taken; such information must come from measurement of actual catches or from the processors themselves. NIWA has recently commenced an extensive netting programme in the lower Waikato catchment to investigate the size distribution of eels in various areas.

The rapid influence of commercial fishing on an eel stock can be gauged from Figure 7. The histograms (P.R. Todd unpublished data) show the length frequencies of two samples of shortfin eels from the same area of Lake Ellesmere taken three years apart. When the 1974 sample was taken, there had been virtually no fishing at the site, but extensive fishing commenced shortly afterwards. The 1977 data show the virtual absence of eels longer than 43 cm, which equates to 150 g, the minimum size of eel being harvested from Lake Ellesmere at that time.

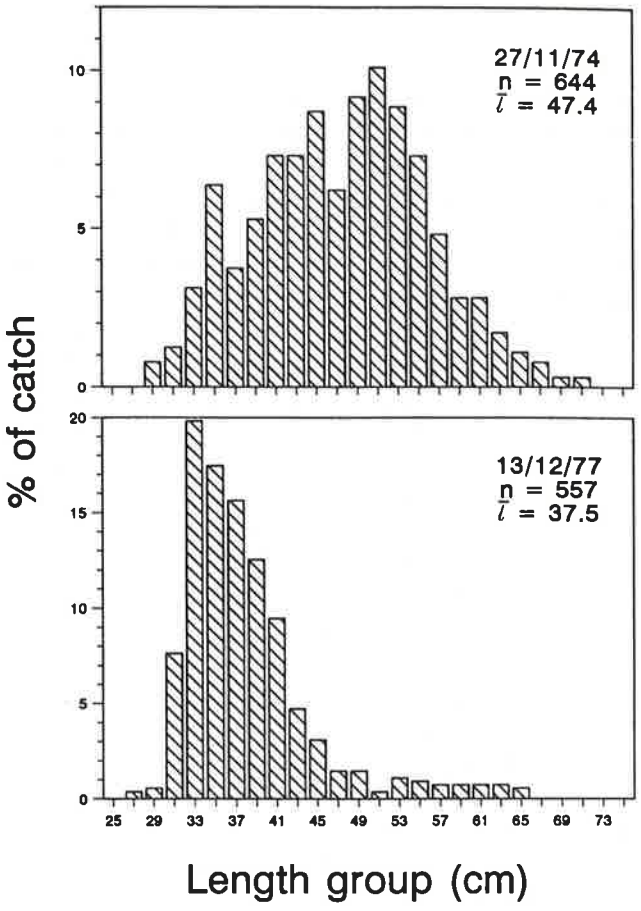

FIGURE 7. Length frequency of two samples of shortfin eels from Kaituna Lagoon, Lake Ellesmere, showing the decline in the proportion of larger eels following the commencement of commercial harvesting in 1975.

In 1979, I wrote to the main eel processors requesting a breakdown of their output of processed eels by % of eels in various size classes. Six replies were received, although the quality of information varied considerably. At present, five of these processors are still operating, so I recently wrote to them again, asking for the same information. Of the three replies received, the most comparable information was from a South Island company (Table 13). (Note: as the original data were in imperial measures, the recent data are given in the same units, with kg equivalents shown.)

There has been a very obvious decrease in the average size of eel processed between the two periods. The most marked difference is in the smallest size category, where there has been a three-fold increase. The fact that there are still reasonable numbers of large eels being processed may be because the factory operates an eel tanker and travels over about half of the South Island to collect eels (i.e., it is now possible to fish in

TABLE 13. Percentage of eels of different size categories processed by a South Island eel processor, 1975-1979 and 1984-1990.

Size category (lb)	(kg)	1975-1979	1984-1990
½ - 1	0.2 - 0.5	14.4	41.9
1 - 2	0.5 - 0.9	27.2	23.4
2 - 3	0.9 - 1.4	21.4	12.0
3 - 4	1.4 - 1.8	15.9	8.0
4 - 5	1.8 - 2.3	10.3	5.3
>5	>2.3	10.8	9.6

areas which were once too far from processing facilities). Fishers also claim that, even in a heavily fished area, there are always some larger eels available at the beginning of each season, presumably having moved into the area from adjacent ones.

A reply from a Waikato eel processor also highlights the decline in eel size that has occurred there (Table 14). This processor commented that the data refer to the total turnover from the factory, whereas the proportion of eels solely from the Waikato fishery, that are under 500 g, would be 90%. However, during recent meetings of the MAF Working Group considering eels, a number of processors remarked that a decline in average size was a localised phenomenon; while true of the lower Waikato and Lake Ellesmere, they disputed that it was true for the country as a whole.

TABLE 14. Percentage of eels less than 500 g in weight processed by a Waikato factory.

Years	% eels
1970	3.1
1971	5.1
1972	16.1
1978	25.2
1982 - 1984	30.3
1985 - 1987	35.0
1988 - 1990	61.3

5.2.4 Quality of catch data

In recent years, the differences between the quantities of eels that fishers indicate that they caught, and the quantities that fish receivers indicate that they processed, are of particular concern. To understand how these differences might come about, the following paragraphs outline the data collection scheme as it currently operates.

CELR data are estimates made by the fishers of their daily catch. In addition, at the end of each month, LFRs provide each fisher with the weight of fish received from them during the month. Both weights are recorded on the fisher's form and, if there is a significant discrepancy in either direction, MAF Fisheries will query the return. The LFRs also furnish their own monthly returns, being the sum of the weight data that they provide to individual fishers.

There are several stages at which the weight of eels caught can reduce before the LFR weight is calculated. For instance, catches of eels taken over several nights will often be held for several days in a net-bag or perforated drum until there are enough for either the fisher to deliver to the factory, or the factory to pick up by tanker. During this time undersized eels will continue to escape. Most eels are then held at the factory for up to 10 days before processing, and any injured eels may die during this period. These eels, together with any further under-sized ones graded out by the factory, will further reduce the weight recorded on the LFR return.

Thus, it is quite reasonable to expect that the weight of eels recorded by fishers would normally exceed, but never be less than, that recorded by LFRs. However, the reverse is happening: LFR weight exceeds CELR weight. Possible explanations are that fishers grossly and consistently underestimate their catches (considered to be unlikely), that the CELR data are consistently incomplete, that fishers deliberately understate their catches, or that processors are receiving eels from fishers who do not furnish returns. While the completeness of the CELR data is suspect, the latter explanation has also been suggested.

There are also differences between export data and either CELR or LFR data. Some differences would be expected as 70-80% of eel exports are of frozen product which can be "held over" in storage for several months to take advantage of better prices, etc. Thus, eels caught in a particular fishing year might not be exported until the following year. Likewise, differences between the LFR data and export data could be due to the unknown amount of eel sold on the domestic market;

some processors indicate that this might be 5-10% of their total production.

The major discrepancies in catch estimates are of concern to fishery managers. As a result of the differences, there can be little confidence in the accuracy of the CELR data since implementation of the CELR return scheme in October 1989. Prior to 1989, the monthly catch information reported by fishers was simply the weight of fish processed by the LFR, who provided this information to each fisher. So we would expect these fishers' returns (for convenience referred to as CELR in this discussion even though this system was not implemented until 1989) to have been a reasonably accurate measure of the total catch, varying little from either the LFR data or the export data. Since 1989, some disparity between CELR and both LFR and export data is more likely and almost certainly the LFR and export data are more accurate descriptions of the actual catch than are the catch figures themselves. With the change from a centralised MAF Fisheries statistics unit to regional ones in 1988/89, there appear to have been major omissions from the CELR data entered for that fishing year.

There are ongoing problems with eels being coded to wrong areas. Firstly, past confusion has resulted in some eels being coded to marine QMA areas instead of eel fishing return areas. Secondly, fishers sometimes wrongly code eels to the return area where the LFR is located, rather than to the area where the eels were caught. There are also problems with marine conger eels being coded as freshwater eels, although the quantities involved are small.

5.2.5 By-catch of other freshwater fish

An ongoing concern to fishery managers is the by-catch of other freshwater fish during eel fishing. Several species, including the relatively rare giant and short-jawed kokopu (*Galaxias* spp.) are liable to be caught in fyke nets (McDowall 1973). Care should be taken to return these alive to the water. The by-catch of non-target species was highlighted by Mathieson and Sutton (1981), who recorded catches from 73 fyke nets; in addition to eels, the nets contained 173 other fish from six species, and 61 birds, of which 58 were ducks. Of more recent concern is the potential for eel fishers to inadvertently spread undesirable fish like the brown bullhead catfish (*Ictalurus nebulosus*) and koi carp (*Cyprinus carpio*). Both species are present in the lower Waikato River. Bullhead are a relatively hardy species and can survive out of water for short periods; this means that juveniles could be transported unnoticed between catchments if fyke net catches are not sorted adequately at the point of capture. Koi are aggressive colonists of new habitats (McDowall 1990), and could be spread when their adhesive eggs are transported to new areas via attachment to water weeds, boats, fyke nets, etc.

5.2.6 Potential spread of undesirable water weeds

A new threat to lowland eel habitats is the spread of an undesirable aquatic alga called "water net" (*Hydrodictyon reticulatum*). This plant is extremely prolific. It can regenerate from a single fragment or even spores, making it very difficult to control or eradicate. If left unchecked, it will completely choke a water system, making it unsuitable for commercial fishing, recreation, and even much aquatic life. The present known distribution of "water net" is some coastal Bay of Plenty waterways, the Rotorua lakes, a marina in Taupo, and a wetland in the upper Waikato River (Clayton *et al.* 1991). Because spread of this plant can have very undesirable effects on freshwater ecosystems, eel fishers must be particularly careful to clean fragments from nets to avoid spreading the plant more widely. Similarly, the problem "oxygen weeds", *Egeria* and *Lagarosiphon*, can be spread inadvertently from fragments in nets. As these "oxygen weeds" do not produce seeds in New Zealand, and are only spread through dispersal of fragments, eel fishing is likely to be a major cause of weed dispersal and colonisation. Ideally, to contain the further spreading of water weeds, fyke nets should be thoroughly dried before they are used in a different catchment.

5.2.7 Recognition of intrinsic value of eels

In addition to their economic and cultural values, eels have certain intrinsic and scientific values. Although there are 15 species of the genus *Anguilla* distributed worldwide, only Australia and New Zealand have coexisting populations of temperate species. Eels constitute two of the 27 species of New Zealand's sparse native freshwater fish fauna (McDowall 1990); as stated previously, the longfin is found only in New Zealand, while the shortfin also occurs in south-east Australia and Tasmania, New Caledonia, and some South Pacific islands. While their diets are flexible and generalised (Jellyman 1989), eels are the top predators within our freshwater fish fauna. Although there were allegations that "... the eel is a serious predator on trout, especially in the nursery streams, and that the competition between the two fish extends to the main items of food which are common to both" and "... the absence of eels is of great benefit to trout stocks" (Cairns 1942a), research on eel–trout inter-relationships

in a small Canterbury stream (Burnet 1968) showed that the presence of eels was generally beneficial; eels certainly reduced overall numbers of trout but the growth rate of trout increased, meaning there were fewer, but larger, trout available to the angler.

5.3 Industry concerns

During compilation of this report, the concerns of the industry as a whole have not been canvassed. Hence the following discussion is not comprehensive, but it is hoped that it addresses the main concerns.

Eel fishers have no exclusive rights to fish particular areas (other than within broad geographic areas, i.e., QMA or eel return areas), unless he/she has established an access agreement with a landowner. Therefore, although a fisher may deliberately fish an area "lightly", or even on a rotational basis, the fact that other fishers may also fish the same place provides little incentive for conservative fishing practices. There is particular concern that "out-of-area" fishers can move into a new area and fish it heavily. Town (1986) illustrated the importance of local knowledge when he reported that West Coast fishers deliberately avoided fishing areas where farm livestock were known to be prone to liver fluke. In these areas, eels provide some regulation of the numbers of water snails which are a vector in the liver fluke's life cycle.

Most fishers have some company loyalty. In some instances, this may be due to the company supplying nets, or because an individual may fish under the authority of the company's fishing permit. There is some price variation between processors and this can result in some instability within the industry, especially early in the season when prices are being determined. For example, it was quoted to me that a "price war" in the Waikato area at the beginning of the 1990/91 season, resulted in a price increase of 75¢/kg within a week.

The industry has been able to establish some "gentlemen's agreements" to promote geographic partitioning of the resource. In some instances, agreements appear to have been quite successful, although the following commentary, provided from industry sources, indicates something of the fragility of such arrangements. Apparently, the average size of eels from the lower Waikato fishery continued to decline until 1987, when up to 90% of the eels in the catch in some areas weighed less than 200 g. At that time, all factories operating in the area agreed to a voluntary size restriction of 220 g. This was partly in response to the continuing trend to smaller-sized eels, and also due to growing buyer resistance in Europe to eels less than 220 g in weight. Although there was a drop in the weight of eels per net for the most heavily fished areas for the following 12-18 months, there was a partial recovery after this period and the CPUE increased. However, the arrival of a new processor who was not party to the agreement and who is accepting eels down to the minimum permitted size of 150 g, has caused a great deal of concern to the longer-established fishers and processors alike. A similar report comes from the West Coast of the South Island, where the arrival of fishers from other areas is reported to have led to the breakdown of an unwritten agreement not to harvest eels of less than 400 g.

There has always been concern about non-permitted fishers taking eels, and Town (1985) suggested that this was one of the reasons that eel export figures sometimes exceeded reported catches. Certainly, there are still allegations that illegal fishing is continuing although processors would contend that this must be on a small scale. There is also a possibility that permit holders obtain eels from non-permitted fishers, or allow a number of other people to fish under the authority of their permit, to provide a good catch history. This could become important if an ITQ system of management was introduced, as previous catch history could be used to allocate quota. The increase in reported landings from CELR returns during 1984 and 1985 is thought to be due to fishers wishing to establish a good catch history, as eels were then being considered as possible entrants into the ITQ system.

Other concerns of eel fishers include continued access to waters on private or Crown lands, the increasing by-catch of brown bullhead catfish in the Waikato, and periodic theft of gear. There is widespread concern about the implications of giving Maori increased involvement in the management of eel fisheries, as this could conceivably mean that certain areas would no longer be available for commercial fishing, or that fishing rights may have to be negotiated with Maori. Also, if eels became part of the QMS, then, in keeping with marine quota species, Maori would be given a percentage of the total quota.

Different processors supply different markets, so there will inevitably be some differences in the preferred sizes and species of eel and also some variation in prices paid. Processors sometimes complain that they are forced to accept smaller eels than they prefer, to retain the loyalty of particular fishers. Town (1985) noted that there was widespread agreement (at that time) to an increase in the minimum size of eel harvested, and it is known that this is still favoured today by many processors and fishers. Results from a recent MAF

Fisheries proposal sent to permit holders and Maori groups showed that most were in favour of an increase in the minimum size, although 220 g was generally preferred to 250 g. A 220 g minimum size has since been imposed.

Replies from processors about the size categories of eel that they are currently processing (see Section 5.2.3), indicated an overall concern at the reduced sizes of eels available in many areas. In at least one instance, a company is investigating the feasibility of transplanting elvers into an area to which eels no longer have access, as a long-term means of stock conservation.

The exclusion of part-time eel fishers from the industry in 1984, and the moratorium on new permits, has meant that fishers forced to leave the industry generally have not been replaced. For some factories, this has resulted in a significant reduction in the supply of eels. Hence, the availability of permits issued to processing factories has become particularly important. The present high levels of unemployment have led to renewed interest in eel fishing. This is seldom to the advantage of processors, as such persons tend not to have a long-term commitment to the industry.

5.4 Future management options

It is not the purpose of this report to deal in detail with the various options that exist for managing the eel fishery, although an outline of possible alternatives is given in Appendix V. Town (1985,1986) discussed options extensively, and recommended that a national TAC and individual ITQs be set for the fishery. However, these recommendations were never considered, owing to an injunction brought against the Crown by Maori in 1987, which effectively stopped further species being added to the QMS system. The passing of the Treaty of Waitangi (Fisheries Claim) Settlement Act 1992 again allowed for the addition of further species to the QMS. Eels are one of several species currently being considered by Government. In anticipation of this, MAF has incorporated eels into the stock assessment programme, and a working group has put forward a report on eels for consideration by the Fishery Assessment Plenary Session (Annala 1993).

Estimation of a sustainable total allowable commercial catch (TACC) from biological data requires a considerable amount of information (i.e., data on growth rates, natural and fishing mortality, age frequencies, densities, recruitment, and emigration). There are significant problems in setting a biologically-based sustainable yield for eels. Firstly, much of the required information does not exist; assembling and processing the data would be both time consuming and expensive. Secondly, and more importantly, a national TACC would be based on extrapolations from data derived from discrete populations. Given the large variability in parameters such as growth rates and density that exist between populations, it would be unwise to assume that country-wide averaged data have much biological validity. Certainly, such calculations would be open to considerable debate. Consequently, the MAF Working Group Report on eels (Annala 1993) decided to recommend an MCY (Maximum Constant Yield) based on the mean catch over the past 10 years, a period of relative stability.

5.4.1 Management objectives

Town (1986) proposed a series of objectives for management of the eel industry, to:

- maintain eel stocks at levels that can sustain optimum long-term yields;
- maintain long-term maximum economic benefits to New Zealand from the resource;
- enable the industry to attain maximum economic efficiency;
- allow fishers the flexibility to determine how they conduct their fishing business;
- provide a stable management framework to enable each individual fisher to undertake long-term financial planning;
- develop a management framework which can be administered from each fishery management area to account for differing regional circumstances;
- ensure a satisfactory recreational and traditional fishery.

Given the greater commitment by the Crown towards Maori fishery interests, it would be appropriate to add a further objective:

- to gain a greater appreciation and understanding of the needs of Maori, and to provide opportunities for Maori participation in the eel management process and in the eel fishery.

It must be emphasised that the above objectives relate to the eel industry, and do not specifically address the issue of maintaining and sustaining the eel resource as

a whole, which has values beyond the economic and cultural ones described above.

5.4.2 Lake Ellesmere

Lake Ellesmere has long been an important commercial eel fishery. Although the fishery is currently controlled, it is likely that the lake will lose this classification in future, consistent with MAF's emphasis on reducing specific regulations in favour of the QMS. However, until the year 2001, when the minimum size in Lake Ellesmere becomes equivalent to that for the rest of the country, the lake will need to be managed separately. As mentioned (Section 2.1) although the Waitangi Tribunal (1992) recommended that the commercial eel fishery on the lake be discontinued, the fishers be compensated, and the fishery revert to a traditional Maori one, in light of the Treaty of Waitangi (Fisheries Claim) Settlement Act 1992, this may not be possible.

A short-term reduction in catch would accompany any regulatory increase in the present (voluntary) minimum weight of about 120 g. The length of this period of reduced catch would depend upon the minimum weight adopted. Using data from Timberyard Point, Lake Ellesmere (MAF Fisheries unpublished data), it is possible to derive an age–weight relationship, i.e.

$$\log A = 0.486 + 0.438 (\log W) \quad (n = 1438, r = 0.81)$$

where A = age in years, W = weight in g.

Thus, eels would take an average of 0.9 years from 120 g to the new minimum size of 140 g whereas growth from 120 g to 220 g, would take 4.0 years.

While some fishers are convinced that the lake never had a substantial stock of larger (female) shortfins, but has always been dominated by shortfin males, historic information does not support this. For example, the pre-fishing length frequency data (Figure 7) indicate a relatively high proportion of shortfin females. Also, Hobbs (1947) estimated that 977 000 migrant shortfins left the lake annually, of which 82% were females. (However, this could partly reflect the fact that his census was carried out at a time when females dominated the samples.)

5.4.3 National minimum size limits

In evaluating the likely effect on yield from the fishery of possible new size limits, Sullivan (1992) found that results of yield-per-recruit analysis varied between sites and between species. For Lake Ellesmere shortfins he concluded that an increased size limit could result in small gains in yield, although this depended on the proportion of male migrants that would then be below the minimum size. For shortfins in Lake Pounui, an increase in minimum size would result in a reduced yield-per-recruit at all levels of fishing mortality, but increased yield-per-recruit for longfins.

While the new national size limit of 220 g will go some way to appeasing the concern of Maori that available eels are too small for their purposes, it will mean that a substantial part of the migrant male shortfin population will be unavailable to fishers. For instance, a 220 g limit will exclude over three-quarters of all shortfin males, whereas a 250 g limit would exclude virtually all shortfin males; shortfin females and longfins of either sex would be unaffected. In Lake Ellesmere the average size of shortfin males has declined over time (Todd 1980); during the 1992 migration it was estimated that 60% of males were less than the new minimum size of 140 g while no males exceeded the final proposed minimum of 220 g (author's unpublished data).

It can be reasonably argued that some harvest of shortfin males should be allowed. Being the youngest of the migratory eels of either species, shortfin males will be the least vulnerable to over-fishing. Failure to allow some harvest would result in additional fishing pressure on the larger and older female eels.

5.4.4 National maximum size limits

Freshwater eels breed only once, at the end of their lives. This means that conventional management practices, which impose a size limit which allows some spawning to have taken place prior to a fish reaching takeable size, are inappropriate for eels. While various strategies can be implemented to control the overall catch, sustainability of the fishery ultimately depends on whether enough migratory eels escape. Given the fragmented nature of the fishery, and the variable growth rates, it is unlikely that the required level of escapement could ever be quantified. Rather, conservative management is required, to set aside areas that are totally or substantially free from eel fishing.

One way of affording some protection to migrant eels is to impose an upper size limit. This is especially applicable to longfin female migrants. Given their considerable average age at migration (say 30-40 years), they are likely to be vulnerable to capture at some stage during their lives. Also, although female longfins may reach maturity within the shelter of a reserve area, once

they leave this area on their downstream migration, they are vulnerable to capture.

Using the length frequency and length–weight data in Todd (1980) it is possible to calculate the proportion of migrant longfin females above certain sizes and hence the effect of certain upper size limits. These data are given in Table 15. Although length is provided, weight is the more practical management statistic.

TABLE 15. The proportion of migratory longfin female eels that would be protected from capture by adoption of various size limits.

Weight	Length (mm)	% protected
3.0 kg (approx. 7 lb)	1040	68
3.5 kg (approx. 8 lb)	1085	58
4.0 kg (approx. 9 lb)	1130	53
4.5 kg (approx. 10 lb)	1160	43
5.0 kg (approx. 11 lb)	1195	40
5.5 kg (approx. 12 lb)	1230	33
6.0 kg (approx. 13 lb)	1256	30
6.5 kg (approx. 14 lb)	1284	26
7.0 kg (approx. 15 lb)	1310	20

The regression for these data is:

$$Y = -11.467\,X + 98.555 \; (r = -0.99)$$

where Y = % of stock protected and X = weight in kg.

Thus, a maximum commercial weight of 4 kg would ensure escapement of half the longfin females, which seems a reasonable management option. Using the fecundity data available in Todd (1981a), it is possible to calculate that the potential egg production of the females larger than 4 kg would be almost three times greater than that of the females smaller than 4 kg. Reference to the catch data supplied by a South Island eel processing company (whose catch is 90% longfin), shows that about 3% of the annual turnover would be affected; equivalent percentages for 3.0 and 5.0 kg limits are 5% and 2% of annual turnover respectively.

Equivalent calculations have been carried out for female shortfins. For these calculations, several sets of length-frequency data were available, but there is considerable variation between them. The largest data-set is for Lake Ellesmere (Todd 1980), although reference to Hobbs (1947) indicates that a decline in mean length of females of 80 mm, has occurred. The next largest data-set is for Lake Pounui (Jellyman in prep. b), where the mean length of 738 mm is similar to that for the Makara Stream (737 mm), less than that for Lake Onoke (764 mm, Todd 1980), but considerably more than that for the South Branch of the Waimakariri River (641 mm, Burnet 1969a). For the following exercise, the Lake Pounui data have been used, partly because of the size of the data-base, but also because they represent something of a mid-point between the ranges in mean length of the available data. The resultant information is given in Table 16.

TABLE 16. The proportion of migratory shortfin female eels that would be protected from capture by adoption of various size limits.

Weight	Length (mm)	% protected
0.7 kg (approx. 1.5 lb)	685	54
0.8 kg (approx. 1.8 lb)	715	41
0.9 kg (approx. 2.0 lb)	745	32
1.0 kg (approx. 2.2 lb)	771	26
1.1 kg (approx. 2.4 lb)	798	21
1.3 kg (approx. 2.9 lb)	845	15
1.6 kg (approx. 3.5 lb)	908	10
2.0 kg (approx. 4.4 lb)	980	6

The regression for these data is:

$$Y = -33.118\,X - 64.539 \; (r = -0.99)$$

where Y = % of stock protected and X = weight in kg.

Given the shorter life-history of shortfin females compared with longfin females, a correspondingly smaller level of protection could be considered. A maximum weight of 1 kg would protect about a quarter of migrants, and is suggested as an appropriate figure. Due to the much greater fecundity of larger eels compared to smaller eels, eels larger than 1 kg would provide about 80% of the potential egg production of the species.

5.4.5 Closed areas

Appendix VI is a review of the adequacy of areas where commercial eel fishing is prohibited by law. The conclusion is that "protected" areas for longfins are barely adequate, but areas for shortfins are quite

inadequate. A priority for management must be to set aside further lowland areas as protected habitat for shortfins. This could be done for conservation purposes under either the Fisheries Act or Conservation Act.

The longfin is endemic to New Zealand. Thus, no stocks elsewhere could contribute to the breeding population. The well-being of this species is solely dependent upon management practices within New Zealand.

The shortfin has a wider distribution. Preliminary electrophoretic studies have indicated no biochemical (genetic) differences between Australian and New Zealand eels (Jellyman 1987b), although there are small meristic differences. The suggested explanation is that there is a single breeding area for shortfins (probably in the vicinity of Vanuatu), but those larvae which hatch in the western half of this area are transported to Australia, while larvae further east are transported to New Zealand. If this is correct, then New Zealand stocks of shortfins are, in part, maintained by migratory eels from Australia. Given the increasing commercial eel fishery which exists in Tasmania (Sloane 1982) and in mainland Australia (Merrick and Schmida 1984), it would be very unwise to assume that the escapement of migratory eels from Australia would be sufficient to provide enough progeny to maintain the stocks of New Zealand shortfins.

5.4.6 "Seeding" waters with juvenile eels

Liberation of glass-eels and elvers into eel-less waters is practised widely in Europe (Tesch 1977), and forms the basis of several very important fisheries. In New Zealand there is considerable interest in the potential of this technique to "seed" waterways, especially in those areas where weirs and dams impede or prevent regular recruitment of elvers. For the 1993 calendar year, permits were issued to allow up to 0.5 t of elvers to be transferred, mainly within the Waikato catchment. It is important that fishery managers develop a policy to cover the transfer of elvers to other waterways. Of course, unless the seeding is carried out on private property and the persons concerned have an access agreement with the landowner, then there can be no exclusive rights to harvest. If substantial bodies of public waterway are involved, then interested parties may agree to work co-operatively for their mutual benefit.

6. RECOMMENDATIONS

1. That the quality of commercial catch data currently collected, be substantially improved.

At present, the discrepancies between fishers' and processors' returns make it impossible to know the true yield of the eel fishery. Also, there is no usable catch-effort data for the past four fishing years following changes to the effort data collected. More care should be taken to investigate disparities between the CELR and LFR data on fishers returns to ensure that the data sets correspond more closely than at present. Increasing quantities of eels are not being coded by species. At present it appears that fishers are not accurately adhering to method codes; considerable quantities of eels caught by fyke net are apparently being listed as caught by "eel pots". Also, conger eels are still being coded to freshwater eels. Eels have been incorrectly coded to marine QMAs rather than eel fishing return areas, and also coded to the area of sale (LFR) rather than the area where they were caught. Finally, the difficult issue of apparent under-reporting of catch by fishers needs to be addressed.

2. That, during the present review of the eel fishery, the responsibilities, desires and concerns of all interested parties be ascertained and taken into account.

MAF Fisheries, DOC, Regional Councils, Fish and Game Councils, Maori, and the commercial sector, have various responsibilities and interests in the eel fishery. It is important that the present review by MAF of the commercial fishery be aware of these, and integrate them as far as possible when developing future management strategies.

3. That, in the absence of a quantifiable sustainable annual yield, the fishery be managed on a conservative basis.

New Zealand eels are generally slow growing, and hence relatively old at migration. Commercial fishing can significantly reduce stocks, and there are signs of localised over-fishing. Management must aim to ensure the availability of adequate stocks to provide for the long-term maintenance of the fishery.

4. That additional areas free from commercial eel fishing be designated, especially areas for shortfins.

The prohibition of commercial fishing in those reserves defined under the Reserves Act 1977 would go a

reasonable way to achieving the suggested aim of establishing 10% of the national area of lakes and lagoons as areas free from commercial fishing (see Appendix V).

5. **That, in addition to an increase in the minimum commercially harvestable size of eel, that upper limits also be established, preferably for both species.**

Implementation of upper size limits has the potential to protect a proportion of female migrating eels from capture. Because of their high fecundity, protection of a proportion of large females results in protection of a much larger proportion of egg production. Being long-lived, female eels are particularly vulnerable to capture at some time during their lives. Hence implementing of an upper size limit alone may not provide much additional protection for the species; such a measure should be linked to the establishment of additional areas free from commercial fishing.

6. **That there be increased recognition of the importance of maintaining existing eel habitat and access to that habitat, especially where structures have impeded or denied access.**

The national loss of wetlands through channelisation and drainage has drastically reduced the available habitat for eels, especially shortfins. The quality of remaining lowland habitat is sometimes reduced by organic pollution, siltation, etc. Hydro dams and weirs often present partial or complete obstacles to elvers, resulting in limited or even non-existent upstream recruitment. Fortunately the general issue of wetland conservation is receiving national recognition; the requirement under the Resource Management Act for Electricorp to apply for water rights for hydro stations, has provided additional incentive for recognition of fish passage needs at such installations.

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APPENDIX I. Annual catch of eels, by species and area, for the fishing years 1983/84 - 1991/92. (SF = shortfin, LF = longfin, Unid. = unidentified.)

Year	Eel return area	SF (kg)	LF (kg)	Unid. (kg)	Total (kg)	Year	Eel return area	SF (kg)	LF (kg)	Unid. (kg)	Total (kg)
1983/84	01	94797	56364	319	151480	1984/85	01	129603	70652	0	200255
	02	48571	17478	135	67184		02	35848	35836	360	72034
	03	52147	15003	0	67150		03	43779	11749	2084	57612
	04	193225	58280	813	252318		04	181893	69231	0	251124
	05	7476	2849	7788	18113		05	15466	11593	6837	33896
	06	4178	11065	0	15243		06	1334	7628	0	8962
	07	72430	11046	21623	105099		07	84259	10952	26461	121672
	08	4420	17398	0	21818		08	4011	12991	5870	22872
	09	4569	28516	0	33085		09	1412	25677	0	27089
	10	63450	13694	6685	83829		10	43668	17870	10778	72316
	11	7841	21186	0	29029		11	6272	23359	0	29631
	12	159	3240	0	3399		12	0	280	0	280
	13	1010	1480	0	2490		13	7537	1062	0	8599
	14	5741	14002	0	19743		14	20276	26058	6328	52662
	15	6201	10651	1131	17983		15	16443	21854	0	38297
	16	16064	14578	1970	32612		16	13790	12366	0	26156
	17	61328	9180	2370	72878		17	53856	5902	0	59758
	18	1364	2150	0	3514		18	3087	0	0	3087
	19	11264	120197	13280	144741		19	5248	116416	9133	130797
	20	9194	79104	0	88298		20	19066	152844	0	171910
	21	115184	2213	245	117642		21	94872	2373	1200	98445
	22	10170	3742	0	13912		22	16052	994	0	17046
	Total	791783	513416	56359	1361558		Total	79772	637687	69041	1504500
1985/86	01	126836	51182	20697	198715	1986/87	01	117606	38367	5013	160986
	02	28532	22727	0	51259		02	18260	8070	0	26330
	03	37682	15651	0	53333		03	17691	6498	204	24393
	04	142613	43678	11754	198045		04	65807	29146	1143	96096
	05	26218	6576	0	32794		05	7868	3742	0	11610
	06	200	0	0	200		06	35	71	0	106
	07	68902	13395	17031	99328		07	54353	6891	15971	77215
	08	2518	25627	0	28145		08	1068	13788	0	14856
	09	1970	51318	2090	55378		09	2428	29322	12161	43911
	10	39248	17782	7974	65004		10	42682	7976	8866	59524
	11	11273	33264	0	44537		11	18965	39968	0	58993
	12	0	5693	0	5693		13	9632	2098	0	11730
	13	7471	2934	0	10405		14	16414	20328	3691	40433
	14	20161	23401	0	43562		15	6032	18268	0	24300
	15	23271	22632	0	45903		16	27336	3768	0	31104
	16	23404	6021	0	29425		17	7377	1191	225	8793
	17	11498	3254	0	14752		18	0	0	86	86
	18	386	186	901	1473		19	6568	61686	23055	91309
	19	9025	49376	13012	71413		20	30311	144532	0	174843
	20	7410	91105	0	98515		21	104490	621	8966	114077
	21	81468	565	0	82033		Total	554923	436331	79381	1070635
	Total	670086	486367	73459	1229912						
1987/88	01	100254	31683	0	131937	1988/89	01	61955	8665	4599	75219
	02	20150	9037	7	29194		02	54433	24199	1949	80581
	03	18948	7615	0	26563		03	24921	6322	2057	33300
	04	55027	22807	13729	91563		04	57797	18129	10579	86505
	05	5754	4204	0	9958		05	5819	1474	570	7863

Year	Eel return area	SF (kg)	LF (kg)	Unid. (kg)	Total (kg)	Year	Eel return area	SF (kg)	LF (kg)	Unid. (kg)	Total (kg)
1987/88	06	3306	883	0	4189	1988/89	06	39	44	189	272
	07	46194	22014	21213	89421		07	22627	2736	14362	39725
	08	13925	12487	1472	27884		08	6627	7355	14294	28276
	09	2682	27584	11745	42011		09	3526	11055	118	14699
	10	43497	5120	1232	49849		10	64014	7682	0	71696
	11	22315	32393	0	54708		11	11582	11440	0	23022
	13	1673	2164	0	3837		13	9426	5365	1278	16069
	14	13695	8819	7246	29760		14	6221	3050	4340	13611
	15	11332	20269	0	31601		15	19834	20632	85	40551
	16	28632	1491	0	30123		16	51369	22496	203	74068
	17	10764	5092	1058	16914		17	8588	508	41	9137
	18	245	2279	2447	4971		18	4556	4320	40	8916
	19	11887	81613	18522	112022		19	8410	55404	11537	75351
	20	16924	84340	1100	102364		20	8687	62438	123	71248
	21	99240	879	0	100119		21	99562	348	0	99910
	22	12296	536	0	12832		22	0	0	90	90
	Total	538740	383309	79771	1001820		Total	529993	273662	66552	870207
1989/90	01	52183	12995	42691	107869	1990/91	01	61048	29707	59741	150496
	02	45917	4179	12364	62460		02	49239	20266	47581	117086
	03	8079	5275	11990	25344		03	20255	6429	5257	31941
	04	4646	2273	145594	152513		04	3480	5443	140064	148987
	05	1233	72	9589	10894		05	18405	3353	6376	28134
	06	0	0	138	138		06	1860	399	124	2383
	07	17578	8740	14575	40983		07	50474	6498	1800	58772
	08	29878	46430	12317	88625		08	50187	49197	6262	105646
	09	2722	8140	12943	23805		09	1430	15804	8717	25951
	10	62219	2699	0	64918		10	44874	800	867	46541
	11	8218	10745	386	19349		11	4888	6744	16282	27914
	13	2345	898	1520	4763		12	0	0	60	60
	14	4500	2580	10555	17635		13	90	8115	8936	17141
	15	9982	44196	4783	58961		14	13320	7575	17685	38580
	16	18024	34707	0	52731		15	10971	61380	5738	78089
	17	2611	8541	0	11152		16	14298	13167	5036	32501
	18	300	28525	69	28894		17	11102	19655	0	30757
	19	3078	38643	65	41786		18	683	10872	0	11555
	20	2538	61055	585	64178		19	10854	46233	0	57087
	21	98575	306	0	98881		20	5255	108350	50	113655
	22	33745	600	270	34615		21	118698	0	0	118698
	Total	408371	321599	280434	1010404		22	20989	5250	50	26289
							Total	512400	425237	330626	1268263
1991/92	01	64525	23662	76244	164431	1991/92	12	0	0	86	86
	02	54425	11048	74392	139865		13	773	10137	17375	28285
	03	16669	6204	9099	31972		14	3635	3536	14255	21426
	04	7107	12294	160330	179731		15	3207	47370	3232	53809
	05	26135	10745	3238	40118		16	25688	9622	9200	44510
	06	8041	8795	137	16973		17	13165	11519	740	25424
	07	92146	21435	2060	115641		18	988	14110	0	15098
	08	33584	47635	347	81556		19	8349	67433	0	75782
	09	2784	18820	5452	27056		20	28070	113702	35	141807
	10	42093	702	30	42825		21	172439	6746	0	179185
	11	5022	1410	11192	17624		22	25735	1477	319	27531
							Total	634580	448402	387794	1470745

APPENDIX II. Mean annual eel catch by area for the 1983/84 - 1991/92 fishing years. (s.d. = standard deviation; c.v. = coefficient of variation.)

Eel return area	Mean	s.d.	c.v.	Eel return area	Mean	s.d.	c.v.
01 Northland	149	40	0.27	12 Wellington	1	2	2.00
02 Auckland	72	38	0.53	13 Nelson	10	8	0.80
03 Hauraki	39	16	0.41	14 Marlborough	31	14	0.45
04 Waikato	162	64	0.40	15 Westland	43	19	0.44
05 Bay of Plenty	22	12	0.55	16 North Canterbury	39	16	0.41
06 Poverty Bay	5	7	1.40	17 South Canterbury	28	23	0.82
07 Hawkes Bay	83	31	0.37	18 Waitaki	9	9	1.00
08 Rangitikei-Wanganui	47	35	0.74	19 Otago	89	34	0.38
09 Taranaki	33	12	0.21	20 Southland	114	41	0.36
10 Manawatu	62	13	0.21	21 Lake Ellesmere	112	28	0.25
11 Wairarapa	34	15	0.44	22 Chatham Islands	15	13	0.87

APPENDIX III. Major eel processors (Licenced Fish Receivers) currently operating in New Zealand. (Only companies who processed > 1 tonne during 1990 or 1991 have been included.)

A. Companies who processed > 100 t/year

New Zealand Eel Processing Co. Ltd, Te Kauwhata
Thomas Richard and Co. Ltd, Whenuapai, Auckland
Mossburn Enterprises Ltd, Kennington, Southland
Independent Fisheries Ltd, Christchurch
Levin Eel Trading Company, Levin

B. Companies who processed 50 - 100 t/year

F. Ketelaar, Wellsford
Gould Aquafarms Ltd, Leeston, Christchurch
Rainbow Fisheries Ltd, Dunedin
E.N. Vanderdrift Ltd, Patea, Taranaki

C. Companies who processed 1 - 50 t/year

Halma Holdings, Dargaville
Eagle Exports, Ngaruawahia
Talleys Fisheries Ltd, Motueka
Polar Products, Auckland
Westbay Seafoods Ltd, Hokitika
Westland Processors Ltd, Hokitika
New Zealand Salmon Company Ltd, Blenheim
Kamberra Holdings Ltd, Pakuranga, Auckland
Aqua Ventures Ltd, Gisborne
Chatham Islands Fishermen's Co-operative Ltd, Chatham Islands
L. Kerr, Ohope
Moana Fishing Ltd, Nelson
Pacific Salmon Processors Ltd, Nelson
Fletcher Fishing, Auckland

APPENDIX IV. Exports of New Zealand eels by product type and destination, 1991.

Product type	Country	Weight (kg)	Value (f.o.b.) ($NZ)
Live	Australia	31	295
	Belgium	75 771	573 985
	Canada	764	6 599
	Hong Kong	4 620	46 921
	Malaysia	367	4 372
	Netherlands	7 670	75 364
	Singapore	298	2 158
	Taiwan	10 292	67 047
	United Kingdom	71 008	557 752
	United States of America	156	1 020
	Total	170 977	1 335 513
Frozen whole	Australia	1 580	10 124
	Canada	16	170
	France	54 395	375 606
	Federal Republic of Germany	153 278	959 230
	Hong Kong	1 040	1 100
	Italy	63 433	347 398
	Netherlands	217 523	1 395 324
	Reunion	3 078	26 928
	Sweden	7 373	54 197
	Taiwan	2 092	9 900
	United Kingdom	106 505	441 675
	Total	610 313	3 621 652
Chilled whole	Australia	824	5 902
	Belgium	2 460	19 200
	Canada	130	1 127
	Finland	762	9 149
	United Kingdom	1 112	7 500
	United States of America	408	2 896
	Total	5 696	45 774
Chilled headed and gutted	Australia	122	1 230
	Belgium	3 498	25 382
	Canada	272	2 200
	United States of America	736	5 530
	Total	4 628	34 342
Frozen headed and gutted	Belgium	15 080	166 538
	Finland	10 155	100 000
	Federal Republic of Germany	42 115	346 260

Product type	Country	Weight (kg)	Value (f.o.b.) ($NZ)
	Hong Kong	2 998	28 122
Frozen headed and gutted	Netherlands	24 156	180 919
	Reunion	5 134	45 000
	United Kingdom	777	6 165
	United States of America	1 091	10 711
	Total	101 506	883 715
Chilled other form (e.g., sides)	Australia	1 439	12 203
	Canada	467	4 600
	United States of America	1 213	8 977
	Total	3 119	25 780
Frozen other form (e.g., sides)	Australia	2 329	18 527
	Belgium	44 647	433 983
	Canada	3 457	38 500
	Federal Republic of Germany	60 009	549 129
	Hong Kong	3 224	25 088
	Netherlands	147 767	1 004 618
	United Kingdom	25 122	153 624
	United States of America	855	8 437
	Total	287 410	2 231 906
Fillets, smoked	Australia	2 940	49 126
	Austria	746	15 171
	Canada	250	2 000
	Denmark	73	1 904
	Finland	11 049	186 668
	Guam	7	224
	Hong Kong	171	3 531
	Malaysia	1	39
	New Caledonia	8	187
	Samoa	111	555
	Singapore	1 498	29 255
	Switzerland	11	194
	Thailand	9	232
	Tonga	28	167
	United Kingdom	4 070	77 887
Fillets, smoked	United States of America	295	4 276
	Vanatu	18	300
	Total	21 285	371 716
Whole, smoked	Australia	8 884	71 159
	Austria	399	6 702

Product type	Country	Weight (kg)	Value (f.o.b.) ($NZ)
	Denmark	105	1 142
	Finland	5 596	60 575
Whole, smoked	Hong Kong	265	2 340
	Japan	7	48
	Malaysia	387	762
	New Caledonia	212	5 798
	Norway	1 048	11 420
	United Kingdom	92	2 100
	United States of America	1 258	10 917
	Total	18 253	172 963
Grand total		1 223 187	8 723 361

APPENDIX V. Summary of possible types of regulation to manage the commercial eel fishery.

Note: The following possible regulations are listed to provide some scope of the various ways that the fishery could be managed. Some of these regulations already exist in some form, while others would be clearly impractical, but are listed for the sake of completeness.

1. CONTROLS ON EFFORT

1.1 Restricted entry

1.1.1 Maximum number of permitted fishers (regionally and nationally)

This could provide a limitation on total effort within the industry and could be implemented to comply with MAF's goal of ensuring economic viability of fishers. The present moratorium on issuing of new permits and the endorsement of permits for specific areas, largely achieves this; the former has been a "stop-gap" measure pending a more extensive review of the fishery, while the latter needs to be applied with more national consistency.

1.1.2 Only permit holders or a nominated fisher able to fish permits

This avoids the recent practice of allowing multiple fishers per permit and has been addressed by a recent change in regulations.

1.1.3 Various economic controls (eg. charging of a substantial permit fee; deposit of annual "bond", etc).

As part-time fishers have been excluded from the industry, there would seem to be little scope in providing any economic controls.

1.2 Restrictions on type of gear

1.2.1 Mesh sizes of nets

Already implemented. The main method of ensuring under-sized eels are not captured is via escapement tubes in fyke nets.

1.2.2 Escapement tubes

Already implemented. Size of tube needs to reflect the minimum legal size.

1.3 Restrictions on operating gear

For example:

1.3.1 Designating how gear must be operated

There are already various procedures for setting nets in waterways, marking of nets, etc. Further restrictions could include a limit on the maximum amount of gear individual fishers are permitted to operate at any one time, and/or restrictions on length of time gear can be left unattended. However, monitoring of such regulations would be almost impossible.

1.3.2 Closed seasons

Closure of the season during autumn would allow migratory eels to escape unimpeded. However, it could be argued that there is no evidence of annual escapement of migrant eels being a limitation on recruitment and hence there is no justification for such a move at present. Also, there are several fisheries where migratory eels are a very important component of the annual catch (e.g. Lake Ellesmere).

1.3.3 Closed areas

Provision of closed areas is seen as the single most effective way of protecting eel stocks. The existing closed areas are considered inadequate for both species.

1.3.4 Allocation of specific waterways to fishers/processors to manage the rate of exploitation

This is consistent with a property/allocation right philosophy but would mean a substantial change in management policy and would be unlikely to receive support from Maori.

2. CONTROLS ON CATCH

2.1 Size limits

2.1.1 Minimum sizes

Already implemented and under review. Depending on levels of natural and fishing mortality, an increased minimum size could increase the yield from the fishery. An increase in minimum size would generally be in accord with the desires of industry and Maori.

2.1.2 Maximum sizes

This has been recommended. In combination with an increase in reserve areas, it could provide considerable extra protection to both species.

2.2 Types of eel (restrictions on catching migratory eels)

This would require a description to distinguish between migrants and non-migrants. Given that the onset of physical changes accompanying maturation (and ultimately migration) are sequential, this has proved virtually impossible to achieve in the past.

2.3 Amount taken

2.3.1 Allocation of specific quotas to fishers

While there may be political reasons why quota options cannot be implemented at present, this remains the most desirable management option.

2.3.2 National total allowable commercial catch

This would be the sum of individual quotas. As previously stated, it is not possible to derive a biologically-based TACC, but this should not preclude a conservative one being set.

2.3.3 Allocation of quotas to processors

As for 1.3.4, this would require a change in management philosophy and would be unlikely to receive the support of fishers.

3. LIBERALISE CONTROLS

3.1 Reduced/no controls on effort

Allow entry of further fishers into the fishery. Allow fishers to fish where they wanted and operate as much gear as they were able. This approach and the following one, could put considerably more strain on the existing fishery and as such would be unacceptable to managers and industry alike.

3.2 Reduced/no controls on catch

Similar to 3.1, this could allow market forces to dictate the exploitation of the eel resource, with the possibility of over-exploitation.

4. RETAIN PRESENT MANAGEMENT

This "do nothing" option would also be unacceptable to both managers and industry. There is a clear undertaking by Government to review present legislation with a view to providing greater controls on the fishery should these be warranted; the concept of further controls for long-term benefit to the fishery is generally welcomed by industry.

APPENDIX VI. The extent of areas closed to commercial eel fishing.

As outlined in Section 5.4.5, the most practical way to ensure sufficient annual escapement of migratory eels is to set aside adequate areas free from commercial eel fishing. A previous evaluation of the extent of closed areas (Todd and Dodgshun 1982) concluded that insufficient areas were available, especially for shortfin eels. The present re-examination of closed areas is a more comprehensive survey than that of Todd and Dodgshun (1982), but utilises more accurate information on river length (Collier 1992). Like Todd and Dodgshun (1982), the present survey obtained lake areas from Irwin (1975). In the absence of any national register of reserves, Scenic Reserves and Government Purpose Reserves containing waterways were identified from the Register of Protected Natural Areas (Timmins and King 1984). As detailed maps of reserves are not given, the index was searched for lakes, lagoons, etc. Once identified, the reserve descriptions were searched to ensure that reserves did, in fact, incorporate bodies of water; as such reserves normally include areas of land surrounding the water body, it was often necessary to determine actual lake areas from Irwin (1975). In a few instances, it is understood that the reserve status applies to the lake shore only and not the lake bed. In such cases the above restriction would not apply. Identification of such areas involves searching of cadastral maps etc and was not carried out. While the resulting list will not be comprehensive (as some areas may have been missed and new areas added since the register was compiled), it is considered that major reserves will have been identified.

The designation of particular areas as exclusively shortfin or longfin habitats is obviously an over-simplification, given that the two species frequently coexist. In designation of habitats, it was assumed that shortfins would predominate in lowland coastal lakes/lagoons and rivers, while longfins would predominate in stony rivers and in upland areas. The distribution of species from CELR data was also used to assist with this designation.

Commercial eel fishing is prohibited in National Parks (under the 1980 National Parks Act). Section 50 of the Reserves Act 1977 empowers the Minister of Conservation (in the case of scenic, historic, nature and scientific reserves) or the appropriate administering body (in the case of recreational, Government Purpose and Local Purpose reserves), to permit the taking or killing of specified fauna from reserves, but with the proviso (subsection 1) that "no such authorisation shall be given for taking or killing for commercial purposes of any indigenous fauna". Hence commercial eel fishing should be banned from reserves also. As stated in Section 5.1, this regulation is not rigorously enforced throughout the country as there are some reserves where the former Department of Lands and Survey allowed commercial eel fishing to take place.

Wildlife Reserves, created under the Wildlife Act 1953, are not specifically included in the above prohibition, and need to be reviewed on a case-by-case basis. State Forest Parks and associated reserves created under Forestry legislation, are now considered Conservation Areas under Section 39 of the Conservation Act. Nothing in this Act prevents commercial eel fishing in these areas.

A total of 53 Government Purpose Reserves and 15 scenic reserves were identified as having bodies of water likely to contain eels (Appendix VI.1.). Wildlife Reserves were not included in this analysis.

The sum of assumed shortfin habitat in the above table is 10 825 ha, an area 60% the size of Lake Ellesmere, or a little more than Lake Pukaki. The area of longfin habitat is 3672 ha, slightly larger than Lake Rotoiti in the North Island.

The areas of lakes and lagoons and the lengths of waterways within National Parks and Scenic and Government Purpose Reserves, are given in Appendix VI.2. This table shows that 30% of New Zealand lake habitat regarded as suitable for eels is in National Parks (72 770 ha). The majority of this area is regarded as longfin habitat. However, all longfin lake habitat in the North Island is within the Urewera National Park (ie. Lakes Waikaremoana and Waikareiti). As the outflow of Lake Waikaremoana is now used for hydro generation and other seepage areas have been plugged, elvers are no longer able to enter these lakes, meaning that they have no long-term significance as a reserve areas.

Of the 66 860 ha of longfin lake habitat within the South Island National Parks, 53 290 ha (80%), is within the Waiau River catchment (Fiordland National Park); eel access to Lakes Monowai, Manapouri and Te Anau is affected by the installation of dams and control structures, leaving a total area of habitat where access is unimpeded of 13 570 ha (5.4% of the total available lake habitat. Addition of "unimpeded" areas within Wildlife Refuges and Sanctuaries,

Appendix VI.3, would increase this to 5.8%). Recent changes to the Monowai River bypass may mean that this lake becomes available to elvers again. The extent to which the Mararoa Weir below Lake Manapouri restricts elver passage is unknown, although elvers do congregate here in large numbers and, at the time of writing, the fish pass is completely choked with gravel. Also, the recent diversion of the Mararoa River into the basin immediately above the weir will mean that any elvers negotiating the weir will tend to swim up the Mararoa River rather than swim with the flow and into Lake Manapouri. It is likely that most elvers arriving at Te Anau do manage to negotiate the control gates as these are often fully open for extended periods. However, for eels resident in lakes Manapouri and Te Anau, when they migrate seaward to spawn, there is a high probability of them entering the penstocks of the Manapouri power scheme and being killed during passage through the turbines. Approximately 86% of the outflow of these lakes will be diverted to the power scheme (Jowett and McKerchar 1983) and Francis turbines have been known to kill up to 100% of migratory eels 50-52 cm in length (Monten 1964). The tendency for eels to migrate during floods would offset the loss of migratory eels to some extent, as both Manapouri and Te Anau have limited flood storage; depending upon lake levels, most inflow resulting from a substantial flood would be discharged down the Waiau River.

The total amount of shortfin lake habitat available within National Parks is very small (1% of total New Zealand area), reflecting the inland location of almost all parks. The inclusion of the additional habitat available within reserve areas listed in Appendix VI.1, means that 5.3% of available area could potentially be free from commercial fishing. A total of 130 km of river habitat is available to shortfins within parks and reserves, but this is also a very small percentage (0.07%) of the national total (cf. 0.56% for longfins).

"On paper" National Parks seem to provide a reasonable level of protection for longfins, although there are some concerns regarding the impacts of control structures. However, the reality is that all the North Island lake area within National Parks is presently inaccessible to eels, while 73% of the South Island area (Lakes Manapouri and Te Anau) may provide very few spawning eels because of turbine mortality during migration. The remaining "unaffected" area is 17 780 ha (7.1% of the total New Zealand area of lakes/lagoons), equivalent in size to Lake Ellesmere. The addition of areas within reserves increases the lake habitat available to longfins to 8.6% of the national total. Given the longevity of longfins, even this is considered inadequate. If some way could be found to protect migrating eels from Lakes Manapouri and Te Anau, then the total area protected, including reserves, would amount to a respectable 28.3% of the total New Zealand area of lakes and lagoons.

The situation for shortfins is a cause for even greater concern. National Parks provide little shortfin habitat, meaning that the addition of areas within reserves is of particular importance. Even if commercial eel fishing is excluded from those reserves created under the Reserves Act (Government/Local Purpose, Scientific, and Scenic Reserves), the additional area (10 820 ha) means that only 5.3% of the total national area of lakes and lagoons is protected. Although it is not possible to validate a specific area that would provide appropriate protection for either species, a figure of 10% of the national total is suggested. Even the addition Wildlife Refuges and Sanctuaries results in a total area equivalent to 6.0% of the national total of lakes and lagoons. Consequently, the reservation of further lowland areas is regarded as high priority. Exclusion of commercial eel fishing from Forest Parks would be of little benefit. Although the area within these 19 parks is considerable (17 754 km^2; Levack 1986), it contains no significant lakes (note: Lake Sumner is not within the boundary of Lake Sumner Forest Park). Also, the parks are almost all located inland in high-country areas, meaning that the eel stocks would be dominated by longfins.

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APPENDIX VI.1. List of Government Purpose Reserves and Scenic Reserves containing lakes or lagoons.

Name	Location latitude	Location longitude	Lake area (ha)	Main species
GOVERNMENT PURPOSES RESERVES				
North Island				
Lake Taeore	34 03 S	173 01 E	18	SF
Waitangi wetlands*	35 14 S	174 01 E	159	SF
Patterson's Lagoon	37 27 S	175 31 E	26	SF
Flax Blocks	37 27 S	175 31 E	811	SF
Lake Waikare	37 27 S	175 10 E	63	SF
Waemaro	37 27 S	175 31 E	57	SF
Black Lake	37 29 S	175 08 E	303	SF
Lake Kopeura	37 25 S	175 08 E	83	SF
Lake Okowhao	37 31 S	175 08 E	23	SF
Lake Whangape	37 27 S	175 05 E	1200	SF
Lake Rotongaro	37 27 S	175 06 E	330	SF
Lake Tamurenui	38 02 S	176 43 E	17	SF
Tauhoa*	38 24 S	174 25 E	301	SF
Jobson Swamp	39 03 S	177 51 E	7	SF
Lake Patetonga	37 22 S	175 30 E	35	SF
Lake Kohata	39 58 S	175 05 E	14	SF
Matawhero Loop	38 40 S	177 55 E	48	SF
Pukepuke Lagoon	40 29 S	175 16 E	90	SF
Boggy Pond	41 15 S	175 16 E	141	SF
J.K. Donald reserve	41 14 S	175 18 E	165	SF
Allsops Bay	41 15 S	175 09 E	215	SF
Ruamahanga	41 16 S	175 13 E	52	SF
Mathews Lagoon	41 16 S	175 16 E	202	SF
South Island				
Kongahu Swamp	41 22 S	172 05 E	51	SF
Lake Rotorua	42 25 S	173 34 E	73	SF
Kline Swamp	42 27 S	171 17 E	33	SF
Back Creek	42 48 S	171 01 E	205	SF
Lake Pratt	43 21 S	170 10 E	25	LF
Totara Lagoon	42 51 S	170 50 E	181	SF
Hart's Creek	43 46 S	172 21 E	232	SF
Woodend Lagoon	43 20 S	172 42 E	49	SF
Wilson Swamp	43 27 S	172 38 E	10	SF
Coopers Lagoon	43 52 S	172 18 E	97	SF
Te Awa Lagoon	44 14 S	171 15 E	1	SF
Milford Lagoon	44 16 S	171 20 E	32	SF
Lake Wainono	44 42 S	171 09 E	330	SF
Waihao Box	44 45 S	171 10 E	36	SF
Diamond Lake	44 46 S	168 23 E	283	LF
Cruickshanks Pond	44 87 S	171 08 E	4	SF
Kakapo Swamp	45 27 S	167 47 E	166	LF

Name	Location latitude	Location longitude	Lake area (ha)	Main species
Merton Tidal Arm	45 37 S	170 38 E	6	SF
Hawkesbury Lagoon	45 36 S	170 41 E	61	SF
Tomahawk Lagoon	45 65 S	170 33 E	31	SF
Lake Waipori	45 58 S	170 07 E	51	SF
Waipori River	45 58 S	170 08 E	11	SF
Inch Clutha	46 16 S	169 44 E	3	SF
Puerua Estuary	46 22 S	169 47 E	240	SF
Lake Luxmore	45 28 S	167 51 E	17	LF
Lagoon Creek	45 29 S	167 53 E	81	LF
Home Creek Swamp	45 35 S	167 37 E	102	LF
Lake George	46 17 S	167 51 E	379	SF
Waimatuku River mouth	46 21 S	168 10 E	100	SF
Waituna wetlands*	46 37 S	168 40 E	3557	SF
SCENIC RESERVES				
North Island				
Lake Papaitonga	40 38 S	175 13 E	111	SF
Lake Rotokohu	39 32 S	174 47 E	13	SF
Corbett Lake	39 13 S	173 56 E	4	LF
South Island				
Kaihoka Lakes	40 33 S	172 36 E	45	SF
Lake Guyon	42 18 S	172 39 E	66	LF
Lake Tennyson	42 12 S	172 44 E	238	LF
Lady Lake	42 36 S	171 34 E	125	LF
Lake Ryan	42 24 S	171 13 E	5	LF
Lake Kaniere	42 46 S	171 05 E	1330	LF
Lake Ianthe	43 02 S	170 36 E	440	LF
Lake Paringa	43 43 S	169 21 E	397	LF
Lake Moeraki	43 44 S	169 17 E	220	LF
Lake Rotokino	43 10 S	170 26 E	140	LF
Saltwater Lagoon	43 03 S	170 19 E	500?	SF
Waituna	46 30 S	168 33 E	56	SF

* = scientific reserve.

APPENDIX VI.2. Estimated available eel habitat (lakes and rivers) within all New Zealand, National Parks, and Scenic and Government Purpose Reserves for shortfin (SF) and longfin (LF) eels. Data for the total amount of lake/lagoon habitat within New Zealand is calculated from Irwin (1975), while data for river length is from Collier (1992).

		Available eel habitat within			
		National Parks		Reserves	
Site	all New Zealand	SF	LF	SF	LF
North Island					
lakes/lagoons (ha)	35 460	0	5910	4480	0
rivers (km)	80 453	0	150	0	5
South Island					
lakes/lagoons (ha)	213 880	2330	66 860	6340	3670
rivers (km)	105 894	120	850	10	30
Totals					
lakes/lagoons (ha)	249 340	2330	72 770	10 820	3670
rivers (km)	186 347	120	1000	10	35

APPENDIX VI.3. List of Wildlife Refuges and Wildlife Sanctuaries containing lakes or lagoons.

Name	Location		Lake area (ha)	Main species
	Latitude	Longitude		
North Island				
Lake Waikare	37 26 S	175 11 E	254	SF
Lake Hakanoa	37 37 S	175 10 E	64	SF
Waewaetutuki	37 47 S	176 28 E	6	SF
Matata Lagoon	37 53 S	176 47 E	10	SF
Lakes Tutira, Orakei and Waikopiro	39 14 S- 39 14 S	176 52 E- 176 53 E	219	SF?
Lake Westmere	39 54 S	175 00 E	20	SF
Horseshoe Lake	39 55 S	176 46 E	20	SF
Lake Kaitoke	39 58 S	175 04 E	32	SF
South Island				
Waimeha	40 52 S	175 00 E	13	SF
Wairau River lagoons	41 30 S	174 04 E	1040	SF
Lake Elterwater	41 57 S	174 08 E	80	SF
Lake Matiri	41 39 S	172 20 E	68	LF
Buller River estuary	41 45 S	175 35 E	44	LF
Lake Kaupiri	41 34 S	171 43 E	70	LF
Lake Heron	43 27 S	171 11 E	686	LF
Maori Lakes	43 34 S	171 10 E	29	LF
Washdyke Lagoon	44 22 S	171 15 E	147	SF
Lake Alexandrina and McGregors Lagoon	43 56 S- 43 58 S	170 26 S- 170 28 E	2200	LF*
Lake Hayes	44 59 S	168 46 E	270	LF**
Waimatuku River mouth	46 21 S	168 10 E	100	LF

* = remnant population due to downstream hydro development.
** = reduced population due to downstream hydro development.

A total of 1905 ha of shortfin habitat is available, and 3467 ha of longfin habitat; of the longfin habitat, access is denied or impeded to 2470 ha, leaving a total of 997 ha.