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EXECUTIVE SUMMARY

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This report provides the results of a catch-per-unit-effort (CPUE) analysis for freshwater eels (*Anguilla australis* and *A. dieffenbachii*) throughout New Zealand for the fishing years 1990–91 to 1998–99. Catch effort data from catch effort landing forms (CELR) were extracted from the Ministry of Fisheries catch effort database, error checked, and sorted by Eel Return Area (ERA). Some adjacent ERAs were combined for the analyses because of insufficient data, resulting in a total of 10 datasets. Unstandardised CPUE analyses were carried out for total catch (sum of shortfin, longfin, and unidentified eels) using a CPUE index of kg per lift for all datasets except Te Waihora, where kg per day was used. Standardised CPUE analyses using a Generalised Linear Model (GLM) were carried out for all 10 datasets for total catch and individual species where there were sufficient data.

The most important areas, in order of catch, were ERAs 4 (Waikaṭo), 1 (Northland), 21 (Te Waihora, Lake Ellesmere), 20 (Southland), 2 (Auckland), 7 (Hawke's Bay), 15 (Westland), 19 (Otago), and 10 (Manawatu). Shortfin catch was greater than longfin catch in all North Island ERAs except 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington), where it was comparable. In contrast, longfin catch was greater in all South Island ERAs except 14 and 16 (Marlborough, North Canterbury) and 21 (Te Waihora). Nationally, the mean number of lifts per set was 27 and the mean catch per set was 123 kg, excluding Te Waihora where the mean number of nets per set has dropped from about 50 in 1990–92 to about 15 in the last three years while mean catches have remained at about 200 kg per set. Fishers' estimates of catch for all areas are, on average, about 80% of the mean of the independent estimates for each year and 67% for Te Waihora. Bycatch was analysed but the results are misleading since most fishers do not record their bycatch on CELR forms.

Excluding Te Waihora, unstandardised CPUE for total catch varied from a mean of 3.4–7.7 kg per lift and were 1–3 kg less than CPUE for the mid to late 1980s, although areas with highest and lowest catch rates appear to be largely unchanged. In the standardised CPUE analyses, permit and month were consistently included in the GLM model that explained the most variation in CPUE. Permit explained between 30 and 61% of the variability in CPUE and other variables were included in the model to various degrees, but their explanatory power was negligible in comparison. This indicates that fisher experience has a large influence on catch rates. The only ERAs where shortfin CPUE indicated a statistically significant decline were 14 and 16 (Marlborough, North Canterbury). Statistically significant declines in longfin CPUE were found in ERAs 2 and 3 (Auckland, Hauraki), 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington), 17–19 (North Canterbury, Waitaki, Otago), and particularly 20 (Southland). Te Waihora CPUE showed no overall indications that CPUE is declining or increasing.

There was a trend of declining abundance of longfins throughout the country. It is recommended that CPUE analyses be carried out for individual species annually for areas of concern, and less frequently for other areas, to monitor eel stocks within each ERA.

1. INTRODUCTION

This report provides the results of a catch-per-unit-effort analysis (CPUE) for freshwater eels (*Anguilla australis* and *A. dieffenbachii*) throughout New Zealand for the fishing years 1990–91 to 1998–99.

For the successful management of any fishery it is desirable to have some index of relative abundance to monitor the effects of fishing on the population. Many conventional fisheries sampling and survey techniques for determining relative abundance indices cannot validly be applied in the freshwater eel fishery, with the notable exception of CPUE analysis. Quality catch effort data are a valuable tool for monitoring trends in abundance in many marine fisheries, and for the freshwater eel fishery it may be the only index of relative abundance that can be practically and cost effectively measured. There is some evidence that longfins have been overfished and that this is significantly affecting recruitment (Jellyman et al. 2000). In view of these findings CPUE analyses are of particular importance.

Commercial eel fishers are obliged to record catch and effort data on catch-effort-landing-returns (CELR) as a part of their daily reporting requirements. The quality of the catch effort data has generally been perceived by Ministry of Fisheries (MFish) and industry as being of a low standard. This is perhaps why it has not been previously analysed, except by Jellyman (1994) who carried out a preliminary analysis of unstandardised CPUE data for 1983–84 to 1988–89.

Before CPUE can be used as an index of relative abundance there must be confidence in the quality of the data. The introduction of the CELR form in October 1989 replaced the Fisheries Statistics Unit (FSU) eel return and resulted in a few years when reporting was confused and effort was not properly recorded (Jellyman 1993). This is understandable given that the original FSU form was eel fishery specific while the CELR applies to all inshore marine fishing methods. Therefore the years before 1990–91 were not used in these analyses. As a precursor to this report, Beentjes (1998) addressed the issue of whether the CELR form is appropriate for freshwater eels, quantified recording errors, and suggested the most appropriate measures of fishing effort for the eel fishery. An important outcome from this review was an understanding of how to best interpret catch and effort data in the eel fishery. Following this, Beentjes & Willsman (2000) determined whether freshwater eel catch and effort data could be meaningfully used in a CPUE analysis. We concluded that although errors exist in the data, many of these can be corrected or excluded from any analysis, resulting in 90% of the original data being available for analysis. The experience gained from this exercise was applied to error check the data used in the current analyses.

CPUE should be provided at a level of detail that is relevant to the management and/or stock separation of the species concerned. For eels this would ideally be for each catchment since these represent independent fisheries and CPUE is a function of location (Beentjes 1998). However, catch location on CELR forms is given only by Eel Return Area (ERA) (Figure 1) which includes multiple catchments. CPUE data are therefore expressed by ERA.

Catch data for the commercial freshwater eel fishery are derived from three sources; Ministry of Fisheries CELR forms (estimated and landed catch), Licensed Fish Receivers (LFR) records and New Zealand Fishing Industry export data (Annala et al. 2000). The commercial fishery developed in the 1960s with catches peaking in 1975. From 1975 to 1981 reported annual catches averaged about 2000 t but have since declined and the average catch over the last 10 years is about 1400 t.

This report was carried out for the Ministry of Fisheries under Project EEL1999/02: *To analyse the CPUE data for 1990 to 1998 as a measure of stock abundance.*

2. METHODS

2.1 Abbreviations and conventions

AIC – Akaike's information criterion
CELR – catch effort landing return
CPUE – catch per unit effort
EEU – eel, unidentified (either shortfin or longfin)
ERA – eel return area
FSU – Fisheries Statistics Unit
GLM – generalised linear model
LFR – licensed fish receiver
MLS – minimum legal size
LFE – longfinned eel
SFE – shortfinned eel

Where fishing years are referred to by a single year this represents the second year, i.e., 1991 = 1990–91 fishing year.

2.2 Catch effort data extraction

Fishers' record estimates of catch and effort for each days fishing on CELR forms and these data are entered into the Ministry of Fisheries (MFish) catch effort database. For each daily record for 1990–91 to 1998–99, the following variables were extracted.

- Date nets were lifted
- Permit number (encoded)
- Eel Return Area (ERA)
- Number of net lifts
- Target species
- Total weight (weight of SFE, LFE, EEU, and bycatch)
- Weight of individual species (includes SFE, LFE, and bycatch species)

– Vessel specifications were not considered relevant.
– Permit numbers extracted from the catch effort database were encoded by MFish, ensuring anonymity of fishers.

2.3 Environmental variables

Mean daily river flow data for the main rivers from each ERA were obtained from regional councils, Trust Power, and the NIWA hydrological database (NIWA Water Resources and Climate Archive) (Appendix 1). The phase of the moon was divided into four quarters and each record (= days fishing) was assigned to the appropriate phase. Both river flow and moon phase were included as predictor variables because they have been shown to affect eel catch rates (Jellyman 1991). When river flow from more than one river per area was used in standardised CPUE analyses, they were treated as separate variables.

2.4 Error checking data

Catch effort data were error checked and groomed using the criteria of Beentjes & Willsman (2000) . Errors were corrected where possible, or the record was deleted. Numbers of corrections and deletions are shown in Appendix 2.

The variables *net lifts*, *catch*, and *area* were intensively checked as these variables have the most effect on CPUE. Corrections and deletions were made as follows.

Net lift errors

Records without an entry for number of nets lifted were deleted, or corrected where ancillary data such as nets in the water at midnight allowed an estimate to be made. Records with more than 200 nets were either deleted, or the correct value was found in the midnight nets column.

Catch weight errors

Records were deleted if there was no total weight and no weights in the species column to allow the correct values to be entered. Where species weights were present they were checked against the total weight and corrections were made where there was an obvious error. (The sum of individual species should add up to total weight: see Beentjes & Willsman (2000) for types of catch weight errors.)

Location errors

Records where location (ERA) was outside the range 1 to 21 were deleted and no attempt was made at correction as the landing description varied from geographical locations to processor factory names and these could not be deciphered easily.

2.5 Analysis of CPUE data

There were insufficient data to analyse all 21 ERAs independently (excluding Stewart Island, ERA 23 and Chathams Islands, ERA 22 where catches have been negligible) (Table 1), therefore some adjacent ERAs (Figure 1) were combined for analysis, resulting in 10 data sets as follows:

ERA	Region	No. records (= days fishing)
1	Northland	13 243
2 and 3	Auckland, Hauraki	8 030
4	Waikato	21 294
5–7	Bay of Plenty, Poverty Bay, Hawkes Bay	5 724
8–12	Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington	5 565
13 and 15	Nelson, Westland	6 815
14 and 16	Marlborough, North Canterbury	4 662
17–19	South Canterbury, Waitaki, Otago	7 710
20	Southland	5 016
21	Te Waihora (Lake Ellesmere)	4 449

For all datasets, analyses were conducted for both species combined (SFE, LFE, and EEU) because the proportion of catches that were unidentified varied between areas and was as high as 80% for ERA 4 (Waikato) (Table 2). However, for some ERAs, where catches were predominantly longfin or shortfin and/or a high proportion of catches were identified to species, separate analyses were undertaken for each species.

2.5.1 Unstandardised CPUE analyses

Unstandardised CPUE analyses using raw data were carried out for nine datasets (excluding Te Waihora) using total catch (sum of SFE, LFE, and EEU excluding weight of bycatch). A daily index of CPUE (kg per lift) was calculated, averaged for each year and 95% confidence intervals calculated. For Te Waihora, the daily index of CPUE was kg/day (see explanation in results).

2.5.2 Standardised CPUE analyses

Standardised CPUE analyses provide a more accurate representation of trends in CPUE because they take into account factors that can affect catch rates. Standardised analyses were conducted using total catch (SFE, LFE, and EEU excluding weight of bycatch) and, where there were sufficient data, for SFE and LFE catch separately.

For Te Waihora, additional analyses for total catch and for shortfin were conducted excluding the concession area months (February and March for all years), and thus the confounding influence of migrating male catches on CPUE. A separate CPUE analysis was not feasible for the concession area fishery because we could not obtain accurate information from MFish on which fishers elected to fish in the concession area each year. The concession area, introduced in 1996, allows undersized migrating shortfinned males to be legally harvested during February-March; Te Waihora fishers choosing to fish in the concession area during this time must register with MFish and are not permitted to fish outside the concession area during this period.

Before standardised analysis a selection criterion was applied to each dataset restricting data for analysis to fishers with at least 30 landings and total landings over 1000 kg over the nine fishing years. For individual analyses of SFE and LFE the data were further restricted to fishers that identified more than about 60% of their catch each year to species level. Winter months were excluded for most areas because catch was usually very low compared to other months.

Estimates of year effects were obtained using a stepwise Generalised Linear Model (GLM) (McCullagh & Nelder 1989). The GLM model used the log-link and constant coefficient of variation. This implies a multiplicative model, i.e., the combined effect of two predictors is the product of their individual effects. The predictor variables used in the model were fishing year, permit number (fisher), month (season), area (ERA where more than one), river flow, and moon phase. All variables were entered into the model as categorical, except daily mean river flow which was entered as a continuous variable. The relationship between daily mean river flow and the CPUE index was examined and it was found that a linear relationship was most appropriate. A stepwise regression procedure was used to fit the GLM of CPUE (daily catch per no.lifts) on these predictor variables. The CPUE index resulting from this procedure is termed relative year effect and is generally expressed with ±2 standard errors.

The stepwise fitting method used forwards selection, i.e., began with a basic model in which the only predictor was the year, and iteratively added the best predictor until no predictors made a sufficient improvement. For analyses of both eel species combined, the improvement in R^2 was used as the criterion for including predictors. In the GLM model, the R^2 is defined as the proportional improvement in the residual deviance, (new deviance – old deviance) / (saturated deviance – null deviance). The predictor with the greatest improvement in R^2 was included, providing that the improvement was at least 0.005. Single eel species could not be analysed by this method because the catch per lift data contained zeros, as a result of which the saturated deviance is undefined. As a substitute, the Akaike's Information Criterion (AIC) (Venables & Ripley 1999) was used. The AIC is defined as the residual deviance plus twice the number of predictors (the latter term acts to penalise models with many predictors). The predictor with the greatest decrease in AIC was included, and the stepwise procedure finished when there was no predictor whose inclusion decreased AIC. Unlike the R^2 statistic the AIC is not an indication of the proportion of variance or deviance explained.

The inclusion of first order interaction terms was considered, but it was found that they would generally require many degrees of freedom and be impractical to estimate. This is because the fisher (permit number) was typically the most important predictor, and the large number of fishers crossed with the numbers of levels of another variable would produce a very large number of levels for the interaction term, for many of which there would be no data.

Model fits were investigated using standard residual diagnostics. Plots of residuals and fitted values were investigated for evidence of departure from model assumptions.

Linear regression was used to determine if the slope of the CPUE trends were significantly different from zero.

3. RESULTS

3.1 Descriptive analysis

Descriptive data by ERA data set and fishing year are given in Table 1. The total number of fishing days and total catch for 1991 to 1999 are shown in Figures 2 and 3 for each ERA. ERAs with most effort (days fishing) tended to have the highest catches. The most important areas, in order of catch, are ERAs 4 (Waikato), 1 (Northland), 21 (Te Waihora), 20 (Southland), 2 (Auckland), 7 (Hawkes Bay), 15 (Westland), 19 (Otago), and 10 (Manawatu).

For all ERAs except Te Waihora the number of net lifts per set is variable but predominantly between 1 and 70 and most commonly between 11 and 30 net lifts per set (mean = 27 net lifts per set) (Figure 4). The size of catches also varies greatly, with the bulk of catches ranging between 20 and 120 kg and most commonly between 100 and 120 kg (mean = 123 kg) (Figure 5).

The number of net lifts per set in Te Waihora has tended to decline from 1990–91 to 1998–99 as fishers have moved away from using large numbers of small fyke nets in favour of using fewer larger nets (Clem Smith, Te Waihora commercial fisher, pers. comm.) (Figure 6). The mean number of nets per set dropped from about 50 in 1990 to 1992 to about 15 in the last three years. In contrast, the mean daily catch from 1991 to 1999 displays no similar declining trend (Figure 7) and mean catches, although variable between years, have remained at about 200 kg per set. For this reason it was not sensible to use catch per lift as an index of CPUE since the change in gear type, and subsequent reduction in the number of nets required to sustain the same catch, would introduce a bias. Therefore, for Te Waihora we used catch per day as an index of CPUE with the assumption that fishers will optimise effort to take their annual quota.

3.2 Catch estimates

Catch data used in the catch effort analyses are estimated weights taken from the catch-effort section of the CELR form. For all ERAs, including Te Waihora, comparison with catch landing weights (catch-landing section of CELR), processors' data (LFR), and export weights indicates that fishers estimates of catch were consistently less than the independent catch figures (Figure 8); there is some debate about which catch data are the more accurate. The estimated weights were on average about 80% of the mean of the independent estimates for each year. For Te Waihora, on average, fishers' estimates of catch were about 67% of processors' estimates, the only independent estimate of catch (Figure 9). The estimates of catch for all ERAs, and for Te Waihora separately, follow the same general trend as the independent estimates, indicating that the data are acceptable for catch effort analyses.

3.3 Species proportions

The percentage of records where EEU was entered as the target species varied between 83% (ERA 4, Waikato) and 0.2% (ERA 21, Te Waihora) (Table 1) for all years combined. The percentage of actual estimated catches that were entered as SFE, LFE, or EEU for all years combined is given in Table 2. The ERAs where EEU was entered as a target species also had high proportions of EEU entered in the catch of individual species; for example, ERA 4 (Waikato) and ERA 1 (Northland). For a few areas such as ERAs 17–19 (South Canterbury, Waitaki, Otago), and 20 (Southland) almost all catch was recorded by species (LFE or SFE) and for Te Waihora the figure was 100%.

Shortfin catch was greater than longfin catch in all North Island ERAs except 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington), where it was comparable (Table 2). In contrast, longfin catch was greater in all South Island ERAs except 14 and 16 (Marlborough, North Canterbury) and 21 (Te Waihora), New Zealand's largest shortfin fishery, where catches were nearly all shortfin.

The breakdown of annual estimated catches by ERA data set that were entered as SFE, LFE, or EEU is covered below in the section CPUE analyses.

3.4 Bycatch

Bycatch entered on the CELR forms was insignificant except for ERAs 4 (Waikato) and 21 (Te Waihora) where the percentages of the total estimated catch that was bycatch were about 1.6% and 0.1% respectively (Table 2). For all other ERA data sets the percentage bycatch was less than or equal to 0.01% of the total catch and for five ERA data sets no bycatch was recorded. The key bycatch species include catfish and koi carp in ERA 4 and flatfish in Te Waihora.

3.5 CPUE analyses

Analyses are presented separately for each ERA dataset and for simplicity in interpretation the same presentation outline has been used for each ERA.

Results of unstandardised CPUE analyses for total catch (SFE, LFE, and EEU) are given in Table 1.

The number of records, number of fishers, and catch used in standardised GLM CPUE analyses, together with details of excluded records, are presented in Table 3. Results of these analyses including predictor variables used and included in the model, R^2/AIC values, and year effects are presented in Table 4.

3.5.1 ERA 1 (Northland)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 10. Catches of SFE were generally more than twice that of LFE. Between 47 and 74% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of SFE and LFE showed similar trends, declining until 1997 and then increasing. Total estimated catch showed a broadly similar trend, although there is a marked decline in catches followed by a stable period between 1994 and 1998 before catch increased in 1999.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 3.7 and 5.4 kg per lift with indications that CPUE has generally increased between 1991 and 1999 (Table 1, Figure 11).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) follows the same general trend as unstandardised CPUE and has tended to increase over time (Table 4, Figure 11). The slope is significantly different from zero ($p<0.05$) (Table 5). The variables permit followed by month explained 35% of the variation in CPUE and both variables were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for SFE catch follows the same general trend as unstandardised CPUE and standardised CPUE for total catch, but in contrast has increased markedly in the last two years (see Table 4, Figure 11), however the slope is not significantly different from zero (see Table 5). The variable permit followed by month explained the most variation in CPUE and these were included in the model. There were insufficient data to carry out a standardised analysis for LFE.

3.5.2 ERAs 2 and 3 (Auckland, Hauraki)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 13. Between 51 and 87% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of SFE were between 2 to 6 fold greater than those of LFE. There was no trend in LFE catches, whereas SFE catches increased markedly after 1994 and have remained high. Total estimated catch showed a broadly similar trend to SFE catch but overall appears stable.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 4.4 and 5.3 kg per lift with no apparent trend (Table 1, Figure 14).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) follows the same general pattern as unstandardised CPUE with no apparent trend (see Table 4, Figure 14) and the slope is not significantly different from zero (see Table 5). The variable permit (fisher) explained 31% of the variation in CPUE and was the only predictor variable included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for SFE catch follows the same general pattern as unstandardised CPUE and standardised CPUE for total catch with no apparent trend (see Table 4, Figure 14) and the slope is not significantly different from zero (see Table 5). The variables permit, Piako River flow, and moon phase, in that order, explained the most variation in CPUE and were included in the model.

Standardised CPUE analysis for LFE catch does not follow the same general pattern as unstandardised CPUE and standardised CPUE for total catch and there was a clear trend of declining CPUE (see Table 4, Figure 14). The slope was significantly different from zero ($p<0.05$) (see Table 5). All predictor variables (permit, Piako River flow, month, moon phase, and area, in that order) explained some variation in CPUE and were included in the model.

3.5.3 ERA 4 (Waikato)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 15. Between 9 and 50% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of SFE and LFE were similar between 1991 and 1995, after which SFE catches were about two fold greater; catches of both species have increased since 1996. Total estimated catch showed no trend consistent trend.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 2.9 and 3.9 kg per lift with no apparent trend (Table 1, Figure 16).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) follows the same general pattern as unstandardised CPUE with no apparent trend (see Table 4, Figure 16) and the slope is not significantly different from zero (see Table 5). The variables permit followed by month and Waikato River flow, explained 31% of the variation in CPUE and these variables were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for SFE catch showed considerable variation between years, particularly 1992–94, but there was no consistent trend in CPUE (see Table 4, Figure 16) and the slope is not significantly different from zero (see Table 5). The variables permit, month, and Waikato River flow, in that order, explained the most variation in CPUE and were included in the model.

Standardised CPUE analysis for LFE catch showed considerable variation between years, particularly 1994 and 1995 where CPUE was relatively high, but overall there was no consistent trend in CPUE (see Table 4, Figure 16) and the slope is not significantly different from zero (see Table 5). The variables permit, month, moon phase, and Piako River flow, in that order, explained the most variation in CPUE and were included in the model.

3.5.4 ERAs 5–7 (Bay of Plenty, Poverty Bay, Hawke's Bay)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 17. Between 86 and 99% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of SFE were two to four times greater than LFE, with the exception of 1999 when they were almost equal. LFE catches increased until 1995 and have since declined. SFE catches, variable between 1991 and 1995, have generally declined since 1996. Total estimated catch showed a similar pattern to SFE catch and displays a trend of declining catch.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 4.1 and 9.4 kg per lift with an apparent trend of declining CPUE (Table 1, Figure 18).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) follows the same general pattern as unstandardised CPUE, but the trend in declining CPUE is less marked (see Table 4, Figure 18). The slope is significantly different from zero ($p<0.01$) (see Table 5). The variables permit, area, and month, in that order, explained 63% of the variation in CPUE and were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for SFE catch showed considerable variation between years, with peaks in 1992 and 1996 (see Table 4, Figure 18). CPUE in the last two years is the lowest of the nine years, but a clear trend in CPUE is not apparent and the slope is not significantly different from zero (see Table 5). The variables permit, area, month, and Bay of Plenty River flow, in that order, explained the most variation in CPUE and were included in the model.

Standardised CPUE analysis for LFE catch showed a decline until 1997 after which CPUE increased and there is no clear trend in CPUE (see Table 4, Figure 18). The slope is not significantly different from zero (see Table 5). The variables permit, month, area, and Bay of Plenty River flow, and moon phase, in that order, explained the most variation in CPUE and were included in the model.

3.5.5 ERAs 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 19. Between 53 and 75% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of SFE and LFE were about equal. LFE catches have increased while SFE catches were stable. Total estimated catch peaked in 1995 and displays a trend of increasing catch.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 5.7 and 13.2 kg per lift with a clear trend of declining CPUE (Table 1, Figure 20).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) follows the same general pattern as unstandardised CPUE but the trend in declining CPUE is more evident (see Table 4, Figure 20) and the slope is significantly different from zero ($p<0.001$) (see Table 5). The variables permit, month, and area, in that order, explained 48% of the variation in CPUE and were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for LFE catch is more variable but shows a clear decline in CPUE (see Table 4, Figure 20) and the slope is significantly different from zero ($p<0.05$) (see Table 5). The variables permit, month, moon phase, and Wanganui River flow, in that order, explained the most variation in CPUE and were included in the model. There were insufficient data to carry out a standardised analysis for SFE.

3.5.6 ERAs 13 and 15 (Nelson, Westland)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 21. Between 74 and 91% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of LFE were 2 to 15 fold greater than SFE. LFE and total estimated catches have declined, while SFE catches were stable.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 4.1 and 6.8 kg per lift with no clear trend in CPUE (Table 1, Figure 22).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) follows the same general pattern as unstandardised CPUE and there was also no trend in CPUE (see Table 4, Figure 22). The slope is not significantly different from zero (see Table 5). The variables permit followed by month explained 44% of the variation in CPUE and were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for LFE catch showed no trend in CPUE (see Table 4, Figure 22) and the slope is not significantly different from zero (see Table 5). The variables permit, month, area and moon phase, in that order, explained the most variation in CPUE and were included in the model. There were insufficient data to carry out a standardised analysis for SFE.

3.5.7 ERAs 14–16 (Marlborough, North Canterbury)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 23. Between 64 and 77% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of SFE were 1.5 to 2 fold greater than LFE with the exception of 1996 and 1999 when catches were roughly equal. There were no clear trends in catches of SFE, LFE, or total catch.

Unstandardised CPUE analyses – CPUE for total catch fluctuated between 6.3 and 8.6 kg per lift with no apparent trend in CPUE (Table 1, Figure 24).

Standardised CPUE analyses – Standardised CPUE analysis for total catch (SFE, LFE, and EEU) does not follow the same pattern as unstandardised CPUE and there is a trend of declining CPUE (see Table 4, Figure 24). The slope is significantly different from zero ($p<0.05$) (see Table 5). The variables permit followed by month explained 46% of the variation in CPUE and were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for SFE catch displays a strong declining trend in CPUE (see Table 4, Figure 24) and the slope is significantly different from zero ($p<0.001$) (see Table 5). The variables permit followed by month explained the most variation in CPUE and were included in the model.

Standardised CPUE analysis for LFE catch showed a sharp decline in 1992 followed by a steady increase in CPUE (see Table 4, Figure 24) and the slope was not significantly different from zero (see Table 5). The variables permit followed by month explained the most variation in CPUE and were included in the model.

3.5.8 ERAs 17–19 (South Canterbury, Waitaki, Otago)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 25. Between 87 and 100% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of LFE were 2 to 4 fold greater than SFE. There was no clear trend in SFE catch, but there was a trend of declining LFE and total catch.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 3.9 and 6.6 kg per lift with a trend of declining CPUE (Table 1, Figure 26).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) followed the same general pattern as unstandardised CPUE, displaying a trend of declining CPUE (see Table 4, Figure 26). The slope is significantly different from zero ($p<0.05$) (see Table 5). The variables permit followed by month explained 32% of the variation in CPUE and were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for SFE catch is variable, no trend is evident (see Table 4, Figure 26) and the slope is not significantly different from zero (see Table 5). All predictor variables (permit, month, Clutha River flow, area, Waitaki River flow, and moon phase, in that order) explained some variation in CPUE and were included in the model.

Standardised CPUE analysis for LFE catch showed an overall decline in CPUE (see Table 4, Figure 26) and the slope is significantly different from zero ($p<0.05$) (see Table 5). The variables permit, month, moon phase, and Clutha River flow, in that order, explained the most variation in CPUE and were included in the model.

3.5.9 ERA 20 (Southland)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 27. Between 98 and 100% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Recorded catches of LFE were 3 and 22 fold greater than SFE. There was no clear trend in SFE catch, but there was a clear trend of declining LFE and total catch.

Unstandardised CPUE analyses: Results of unstandardised CPUE analyses for total catch (SFE, LFE, and EEU) are tabulated in Table 1 and plotted in Figure 28. CPUE fluctuated between 4.6 and 9.2 kg per lift with a general trend of declining CPUE (Table 1, Figure 28).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) followed the same general pattern as unstandardised CPUE but the trend of declining CPUE was more pronounced (see Table 4, Figure 28). The slope is significantly different from zero ($p<0.001$) (see Table 5). The variables permit followed by month explained 51% of the variation in CPUE and were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for LFE catch showed a consistent decline in CPUE (see Table 4, Figure 28) and the slope is significantly different from zero ($p<0.01$) (see Table 5). The variables permit, month, and moon phase, in that order, explained the most variation in CPUE and were included in the model. There were insufficient data to carry out a standardised analysis for SFE.

3.5.10 ERA 21 (Te Waihora)

Catch: The annual estimated catches of SFE and LFE are plotted together with total estimated catch in Figure 29. Between 99 and 100% of the total estimated catch was identified to species and the remainder was recorded as EEU (unidentified). Between 95 and 99% of all catches were SFE. There was no trend in LFE catch, and apart from one very good year in 1992 and a poor year in 1994 SFE catches have been stable. Total catch mirrors that of SFE catch.

Unstandardised CPUE analyses: CPUE for total catch fluctuated between 113 and 269 kg/day with no trend in CPUE (Table 1, Figure 30).

Standardised CPUE analyses: Standardised CPUE analysis for total catch (SFE, LFE, and EEU) followed the same general pattern as unstandardised CPUE with no trend in CPUE (see Table 4, Figure 30). The slope is not significantly different from zero (see Table 5). The variables permit followed by month explained 31% of the variation in CPUE and were included in the model. A second analysis on total catch, excluding the concession area months (February and March for all years), gave a similar result but only up until and including 1995. The variables permit followed by month explained 30% of the variation in CPUE and were included in the model. Plots of residuals versus fitted values and observed values versus fitted values for total catch are shown in Figure 12. There was no heteroscedacity or other departure from model assumptions.

Standardised CPUE analysis for SFE catch followed the same general pattern as unstandardised CPUE and standardised analysis for total catch with no trend in CPUE evident (see Table 4, Figure 30) and the slope is not significantly different from zero (see Table 5). Permit followed by month explained the most variation in CPUE and were included in the model. A second analysis on SFE catch, excluding the concession area months (February and March for all years), gave a similar result but only up until and including 1995 and the slope is not significantly different from zero (see Table 5). Permit followed by month explained the most variation in CPUE and were included in the model. The results of the SFE analyses excluding the concession area months were essentially the same as the equivalent analysis for total catch, a result of the high proportion of SFE in catches from Te Waihora. Again the slope is not significantly different from zero (see Table 5). There were insufficient data to carry out a standardised analysis for LFE.

4. DISCUSSION

This report represents the first attempt at a standardised CPUE analysis for the commercial freshwater eel fishery in New Zealand.

4.1 Catch and species distribution

Analysis of the eel fishery catch effort data indicated that all ERAs support both shortfin and longfin catches, but the North Island is predominantly shortfin and the South Island longfin (see Table 2). This is consistent with commercial catch sampling results carried out between 1996 and 1998 (Beentjes & Chisnall 1997, 1998, Beentjes 1999, Chisnall & Kemp 2000). Exceptions include the shortfin fishery in Te Waihora and the northeast of the South Island (ERAs 14 and 16, Marlborough and North Canterbury), although 1997 catch sampling results from the latter area indicate that longfin and not shortfin are the dominant species in this region (Beentjes & Chisnall 1998).

The proportion of the national catch contributed by ERA is consistent with that determined by Jellyman (1994) for 1984 to 1992, i.e., ERAs contributed the same proportion of catch in the 1980s as in the 1990s and the key areas are still Northland, Waikato, Southland, and Te Waihora. However, the proportion of eels reported as unidentified increased dramatically after the introduction of the CELR form in 1989. For example, Jellyman (1994) noted that in ERA 4 (Waikato) only 3.3 % of the catch was unidentified compared with 80% in this study (see Table 2). The degree to which LFE or SFE, rather than EEU, was entered in the target field and in the individual weights fields of the CELR varied substantially between areas. Fishers from ERAs 4 (Waikato) and 1 (Northland) were particularly poor at entering individual species in contrast to ERAs 21 (Te Waihora) and 20 (Southland) where nearly all the catch was recorded by species. In the latter two ERAs catches are predominantly shortfin or longfin respectively, compared to other areas where a mixture of both species makes it harder to estimate the true proportion. Inaccurate reporting is also a reflection of fisher behaviour in different parts of the country, compounded by the lack of feedback from catch effort database managers to ensure correct and accurate reporting.

The introduction of South Island freshwater eels into the Quota Management System in October 2000 has required fishers to be more diligent in completing the CELR form and should see an improvement in quality of catch effort data. In addition, the CELR form, which has been shown to be inappropriate for the freshwater eel fishery (Beentjes & Chisnall 1998), was replaced by an eel fishery specific catch effort reporting form in October 2001 (Kim Duckworth, Ministry of Fisheries, pers. comm.). These changes should also improve the quality of catch effort data and thereby future CPUE analyses by providing more accurate catch data by individual species.

4.2 Catch used in analysis

Fishers' estimates of daily catch were about 80% of independent catch figures (export, CELR catch landing, and processors') except for Te Waihora where the figure was about 67% of processors estimates (see Figures 8 and 9). Because the data extract used in these analyses contained all eel catch data for 1991 to 1999, the shortfall in fishers' estimates of catch compared to independent estimates was wholly a result of fishers' under-estimating catch when completing the catch effort section of the CELR. This contrasts with other species where the proportion of actual landings included in CPUE analyses is often dependent on the target species selected and whether the species is one of the top five caught (Beentjes 2000).

4.3 Bycatch

The results of the bycatch analysis are misleading since most fishers do not record their bycatch on CELR forms (see Table 2). By comparison, in a catch and effort diary completed by 10 South Island fishers in ERAs 19 and 20 (Otago and Southland) in 1996–97 and by 8 North Island fishers in ERAs 2–6 (Auckland, Hauraki, Waikato, Bay of Plenty, Poverty) and 8 (Taranaki) in 1997–98, 8 bycatch species were recorded in the South Island and 17 in the North Island (Beentjes & Chisnall 1998) (Appendix 3). In the South Island, brown trout, perch, and freshwater crayfish accounted for about 80% of the total numbers of bycatch species caught compared to the North Island where catfish and goldfish accounted for about 90% of the total weight. The new freshwater eel catch effort return introduced in October 2001 requires only the top three bycatch species for a months fishing to be recorded (Kim Duckworth, Ministry of Fisheries, pers. comm.). This may result in improved compliance but less information can potentially be recorded on less common bycatch species.

4.4 Unstandardised CPUE (excluding Te Waihora)

Unstandardised CPUE for total catch varied from a mean of 3.4 kg per lift in ERA 4 (Waikato) to 7.7 kg per lift for ERAs 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington) (see Table 1). Analyses by Jellyman (1994) using an index of kg per lift per night and data that had not been error checked revealed that in all ERAs examined, excluding Te Waihora, catch rates were higher in 1984 to 1989 by about one to several kilograms per lift compared to 1991–99 in this study. This is despite the inclusion of nights in the CPUE index which would result in relatively lower estimates of CPUE than the index used in this study (kg per lift). The areas with highest and lowest catch however, were similar to those of this study.

4.5 Standardised CPUE (excluding Te Waihora)

Standardised CPUE analyses using the GLM model accounted for the effects that variables fisher, season, area, moon phase, and river flow may have had on catch rates. The variables permit and month were consistently included in the model that explained the most variation in CPUE (see Table 4). Permit, or fisher explained between 30 and 61% of the variability in CPUE and other variables were included in the model to varyious degrees, but their explanatory power was negligible in comparison. This indicates that catch rates are very dependent on fisher experience and/or ability. Although permit was used as the variable in these analyses, many permits are fished by persons other than the permit holder using fishing agreements. In the late 1980s and early 1990s there was a proliferation of fishing agreements that led to an increase in participants in the eel fishery. This was not considered to be a factor in these analyses because in about 1992–93 a moratorium was placed on the number of fishing agreements that could be attached to each permit. Thus there was not a continual turnover of inexperienced fishers over time that might explain some declines in CPUE. The finding that month (season) was an important variable affecting catch rates is understandable since water temperature varies seasonally and eel catch rates are related to water temperature (Jellyman 1991, 1997).

Apart from ERA, we know nothing about catch location, only the effort involved in maintaining catches. In the interpretation of the results we assume that fishers are not traveling to increasingly remote areas to maintain catch rates. For many areas we know from speaking with fishers and processors that our assumption is correct.

CPUE for total catch followed the same general trend as unstandardised CPUE in nearly all analyses. Interpretation of total catch (SFE, LFE, and EEU) CPUE trends is complicated because CPUE analyses for shortfin and longfin individually sometimes resulted in very different trends in the data. For example, in ERAs 2 and 3 (Auckland, Hauraki) there was no apparent trend in total catch or shortfin CPUE, but in contrast, longfin CPUE appears to be declining (see Figure 14). In this case the longfin data had little effect on the total catch CPUE because catches were small compared to shortfin. It was for this reason that we conducted the standardised analyses on individual species only where there were sufficient data. If catch effort analyses are to be useful for assessing sustainability of eel stocks, it is essential therefore that shortfin and longfin be analysed separately. The introduction of the new eel fishery catch effort form in October 2001 will ensure that this is possible in future.

The only ERAs where shortfin CPUE indicated a statistically significant decline were 14 and 16 (Marlborough, North Canterbury) (see Table 5). Discussion with fishers indicated that these areas have been affected by drought in recent years and this is more likely to affect shortfin catches. CPUE for total catch in ERA 1 (Northland) showed a statistically significantly increase over time and this was attributed by fishers to an increase in rainfall in recent years. Statistically significant declines in longfin CPUE were found in ERAs 2 and 3 (Auckland, Hauraki), 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington), 17–19 (North Canterbury, Waitaki, Otago), and particularly 20 (Southland), where catches of LFE have been steadily declining since 1992. Thus for individual species analyses, one of eight ERAs had a declining trend in shortfin abundance and four of eight ERAs showed a decline in longfin abundance. Declines in longfin abundance are consistent with the conclusions by Jellyman et al. (2000) that longfins are being overfished and that this has significantly affected recruitment. Additionally, length frequency distributions from the catch sampling programme indicate that longfin eels are heavily fished compared to shortfin (Beentjes & Chisnall 1997, 1998, Beentjes 1999).

In 1996, the minimum legal escape tube diameter was 25 mm, but in the South Island a code of practice encouraged fishers to use 28 mm, increased to 31 mm in 1998. The effect of this was to increase the minimum size of eels landed. In addition, a maximum legal size of 4 kg was introduced in the South Island to protect large female longfins. Examination of CPUE for South Island areas indicates that neither of these increases in escape tube sizes has visibly affected CPUE for either species.

4.6 Te Waihora

CPUE for total catch and shortfin catch in Te Waihora declined and then increased again after 1995 with no overall indications that CPUE is declining or increasing. The observed pattern in CPUE is also mirrored by the catch. The patterns in CPUE that exclude the concession area data are similar, except that CPUE remains low for several years before increasing. Interpretation of CPUE analysis in Te Waihora needs to consider the introduction of the concession area in 1996 to harvest undersize migrating males between February and March each year, and the introduction of a minimum legal size (MLS) of 140 g at the start on the 1993–94 fishing year. This increased annually by 10 g per year until September 2001 when it was equivalent to the national MLS of 220 g. Prior to 1993–94 there was no MLS and eels as small as 110 g were taken (Town 1985). Results of the CPUE analyses that include the concession area data may initially reflect the introduction of a MLS, causing CPUE to decline, followed by the introduction of the concession area in 1996 that caused an increase in CPUE. By contrast the CPUE analysis that excludes the concession area data may only reflect the impact of the MLS.

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Table 1: Summary of catch and effort data for eel return areas. See Figure 1 for locations of ERAs. ERA, eel return area; EEU, eels unidentified; SFE, shortfinned eel; LFE, longfinned eel; CPUE, catch per unit effort; s.e., standard error.

Fishing year	No. fishing days	Total estimated catch (kg)	No. of lifts	% records target			Unstandardised CPUE (kg/lift)	s.e.
				EEU	LFE	SFE		
ERA 1								
1990–91	1 713	161 407	40 294	52.1	11.2	36.8	4.3	0.08
1991–92	1 854	168 129	47 333	59.0	8.0	33.0	3.7	0.06
1992–93	1 782	153 518	45 286	58.9	10.3	30.8	3.7	0.07
1993–94	1 419	103 300	31 698	60.2	6.4	33.4	3.7	0.07
1994–95	1 356	122 696	30 561	57.4	8.1	34.5	4.4	0.08
1995–96	1 317	120 451	29 616	63.4	7.3	29.3	4.6	0.11
1996–97	1 340	118 773	30 774	61.2	3.6	35.2	4.2	0.08
1997–98	1 152	106 872	26 391	41.8	12.3	45.9	4.4	0.08
1998–99	1 310	156 526	31 460	35.0	25.3	39.6	5.4	0.11
Total	13 243	1 211 672	313 413	54.5	10.1	35.5	4.2	0.03
ERAs 2 and 3								
1990–91	1 018	127 019	26 382	70.3	7.0	22.7	5.1	0.18
1991–92	950	98 067	22 006	53.8	6.7	39.5	4.9	0.13
1992–93	900	110 493	23 649	46.0	9.3	44.7	4.4	0.09
1993–94	482	48 179	11 300	37.1	8.3	54.6	4.4	0.13
1994–95	1 028	137 192	27 935	36.8	8.3	54.9	4.7	0.10
1995–96	860	135 317	24 963	35.9	6.6	57.4	5.3	0.13
1996–97	1 058	125 239	28 106	26.1	16.5	57.4	4.7	0.10
1997–98	832	111 531	21 906	34.7	21.7	43.5	5.2	0.16
1998–99	902	139 212	24 361	31.4	13.6	54.9	5.0	0.11
Total	8 030	1 032 249	210 608	41.8	10.9	47.2	4.9	0.04
ERA 4								
1990–91	2 088	172 272	58 751	89.8	7.7	2.5	3.5	0.06
1991–92	2 280	184 707	71 947	89.0	6.4	4.5	3.1	0.06
1992–93	2 052	172 979	62 273	92.6	2.4	5.0	3.4	0.07
1993–94	2 199	166 550	69 627	91.0	4.2	4.7	2.9	0.05
1994–95	2 552	262 030	79 301	87.9	4.8	7.4	3.7	0.05
1995–96	2 901	292 402	89 482	83.7	7.7	8.6	3.9	0.13
1996–97	2 607	228 064	77 151	78.5	10.4	11.1	3.4	0.06
1997–98	2 313	203 196	68 209	76.0	7.8	16.2	3.4	0.07
1998–99	2 302	169 776	63 739	60.9	16.2	22.8	3.1	0.06
Total	21 294	1 851 976	640 480	83.0	7.6	9.3	3.4	0.03

Table 1 – *continued*

Fishing year	No. fishing days	Total estimated catch (kg)	No. of lifts	% records target EEU	LFE	SFE	Unstandardised CPUE (kg/lift)	s.e.
ERAs 5–7								
1990–91	356	84 009	9 091	17.6	18.4	64.0	9.4	0.36
1991–92	817	194 765	21 586	15.8	22.9	61.4	8.9	0.28
1992–93	747	182 362	22 875	41.9	21.2	36.9	8.2	0.23
1993–94	474	108 656	14 310	30.0	25.7	44.3	7.7	0.26
1994–95	1 444	214 248	42 832	18.5	18.5	63.0	5.2	0.16
1995–96	542	82 382	15 060	19.6	16.4	64.0	6.6	0.26
1996–97	506	61 101	16 304	18.5	24.6	57.0	4.4	0.20
1997–98	578	52 765	15 798	20.0	24.0	56.0	4.1	0.16
1998–99	260	39 011	7 340	13.1	37.7	49.2	6.1	0.27
Total	5 724	1 019 299	165 196	22.5	22.3	55.1	6.7	0.24
ERAs 8–12								
1990–91	484	102 241	15 891	60.7	17.1	22.1	7.0	0.29
1991–92	352	108 475	9 735	50.9	27.8	21.3	13.2	0.63
1992–93	500	124 755	13 506	88.6	9.0	2.4	10.4	0.42
1993–94	649	156 715	16 405	67.4	19.2	13.3	9.7	0.43
1994–95	782	164 619	19 156	67.5	13.3	19.2	7.7	0.22
1995–96	600	113 244	17 473	70.7	18.7	10.7	6.8	0.25
1996–97	692	112 878	18 873	61.4	22.6	15.9	5.9	0.26
1997–98	704	136 302	23 818	62.4	18.5	19.2	5.7	0.19
1998–99	802	127 646	21 133	64.5	25.1	10.5	6.3	0.16
Total	5 565	1 146 875	155 990	66.2	19.1	14.7	7.7	0.32
ERAs 13 and 15								
1990–91	797	106 601	18 033	20.1	68.1	11.8	6.8	0.26
1991–92	796	85 508	20 542	36.9	59.2	3.9	4.6	0.15
1992–93	907	94 608	22 274	40.8	54.7	4.5	4.1	0.14
1993–94	1 032	108 156	24 202	32.1	61.1	6.8	4.2	0.13
1994–95	823	105 172	19 582	27.3	63.8	8.9	5.5	0.22
1995–96	674	71 525	14 559	24.3	71.7	4.0	5.1	0.23
1996–97	678	62 376	15 454	27.0	67.0	6.0	4.2	0.15
1997–98	478	64 008	12 282	18.6	70.7	10.7	5.2	0.20
1998–99	630	71 276	14 960	7.1	81.6	11.3	4.7	0.16
Total	6 815	769 230	161 888	27.3	65.4	7.3	4.9	0.32

Table 1 – *continued*

Fishing year	No. fishing days	Total estimated catch (kg)	No. of lifts	% records target EEU	LFE	SFE	Unstandardised CPUE (kg/lift)	s.e.
ERAs 14 and 16								
1990–91	333	63 106	8 851	37.5	30.6	31.8	8.0	0.34
1991–92	462	74 721	12 364	39.8	16.7	43.5	7.0	0.24
1992–93	352	54 159	8 429	52.0	17.3	30.7	7.5	0.48
1993–94	720	96 712	14 756	43.1	16.8	40.1	7.5	0.25
1994–95	718	101 328	20 914	41.0	17.0	42.0	6.5	0.25
1995–96	711	88 369	18 102	50.2	20.8	29.0	6.5	0.26
1996–97	551	65 905	11 785	55.4	15.1	29.6	7.2	0.27
1997–98	418	47 695	9 319	53.2	15.0	31.7	8.6	0.77
1998–99	397	48 159	8 508	65.5	19.6	14.9	6.3	0.25
Total	4 662	640 154	113 028	48.1	18.3	33.6	7.1	0.32
ERAs 17–19								
1990–91	716	96 728	17 766	0.0	75.1	24.9	6.6	0.18
1991–92	888	118 374	24 674	1.2	63.8	35.0	5.4	0.16
1992–93	971	127 047	28 172	1.9	60.8	37.3	5.0	0.12
1993–94	882	122 366	26 757	6.8	66.1	27.1	4.9	0.14
1994–95	1117	124 831	34 209	2.1	60.0	37.9	3.9	0.09
1995–96	1 072	105 568	26 485	19.9	52.7	27.4	4.3	0.13
1996–97	832	76 876	19 763	16.0	54.3	29.8	4.5	0.23
1997–98	646	57 083	16 129	6.3	69.3	24.3	4.6	0.23
1998–99	586	61 594	15 509	6.3	62.3	31.4	3.9	0.11
Total	7 710	890 467	209 464	6.9	61.9	31.2	4.7	0.32
ERA 20								
1990–91	544	99 165	18 042	0.0	95.8	4.2	9.2	0.49
1991–92	801	133 706	27 114	0.0	83.8	16.2	6.3	0.20
1992–93	766	114 105	26 106	0.1	83.4	16.4	5.2	0.15
1993–94	616	103 721	20 433	0.2	82.5	17.4	7.4	0.41
1994–95	507	77 213	17 258	0.0	85.5	14.5	5.1	0.20
1995–96	384	62 451	12 758	3.1	82.8	14.1	5.3	0.17
1996–97	443	68 835	14 699	0.2	86.7	13.1	4.9	0.13
1997–98	461	63 925	14 125	0.4	87.0	12.5	4.9	0.17
1998–99	494	58 051	14 381	1.0	79.4	19.6	4.6	0.16
Total	5 016	781 172	164 916	0.4	85.1	14.5	6.0	0.32

Table 1 – *continued*

Fishing year	No. fishing days	Total estimated catch (kg)	No. of lifts	% records target EEU	LFE	SFE	Unstandardised CPUE (kg/day)	s.e.
ERA 21								
1990–91	457	94 233	22 956	0.0	0.2	99.8	206.0	7.97
1991–92	683	168 957	37 349	0.0	1.3	98.7	246.8	7.34
1992–93	510	119 726	21 506	2.0	0.0	98.0	234.8	7.96
1993–94	329	47 315	8 097	0.0	3.6	96.4	143.8	7.64
1994–95	773	87 390	24 924	0.0	1.8	98.2	113.1	3.39
1995–96	453	101 939	12 747	0.0	0.4	99.6	225.2	10.41
1996–97	332	89 356	4 639	0.0	0.0	100.0	269.2	12.08
1997–98	373	87 571	4 990	0.0	0.0	100.0	234.8	10.92
1998–99	539	108 994	8 592	0.0	0.6	99.4	202.3	6.68
Total	4 449	905 481	145 800	0.2	0.9	98.9		

Table 2: Catch of eels and bycatch from CELRs from 1990–91 to 1998–99. ERA, eel return area; SFE, shortfinned eel, LFE, longfinned eel, EEU, unidentified; CAT, catfish; CAR, carp; KOI, koi carp; MUL, mullet; PER, perch; *FLA, flatfish; YBF, yellow belly founder*; SFL, sand flounder; BFL, black flounder.

	Catch (kg)		% of eel catch			Bycatch (kg)									% of total catch
ERA	Eels and bycatch	Eels only	SFE	LFE	EEU	CAT	CAR	KOI	MUL	PER	FLA	YBF	SFL	BFL	bycatch
ERA 1	1 211 672	1 211 672	42.7	15.8	41.5										0.00
ERAs 2&3	1 032 249	1 032 249	61.9	13.2	24.9	80									0.01
ERA 4	1 881 637	1 851 976	13.5	6.7	79.8	27 463	198	1 828	12	160					1.58
ERAs 5-7	1 020 449	1 020 449	68.9	25.9	5.3										0.00
ERAs 8-12	1 146 935	1 146 875	32.5	30.1	37.4					60					0.01
ERAs 13&15	769 230	769 230	17.1	64.9	18.0										0.00
ERAs 14&16	640 304	640 304	43.9	27.4	28.7										0.00
ERAs 17–19	890 547	890 467	29.0	68.6	2.4					80					0.01
ERA 20	781 172	781 172	16.7	82.9	0.3										0.00
ERA 21	903 512	902 441	98.5	1.5	0.0						951	40	47	33	0.12

Table 3: All data and a subset of data used in CPUE analyses (total catch, SFE, LFE) where only fishers with with at least 30 landings and total landings over 1000 kg were included. For individual analyses of SFE and LFE the data were further restricted to fishers that identified more than about 60% of their catch each year to species level. For some analyses selected months were excluded if catches were low. Months 2 and 3 in ERA 21 (Te Waihora) are the concession area period.

ERA	Dataset	No. records	No. fishers	Catch (kg) in analysis	Months excluded
ERA 1	all data	13 243	49	1 211 672	
	total catch	13 086	28	1 196 690	
	SFE	5 160	8	393 544	
	LFE	–	–	–	
ERAs 2&3	all data	8 030	60	1 032 249	
	total catch	7 796	31	974 761	
	SFE	3 770	10	542 688	
	LFE	1 376	8	86 153	
ERA 4	all data	21 294	45	1 851 976	
	total catch	21 211	24	1 843 376	
	SFE	1 618	5	84 130	
	LFE	1 740	6	92 739	
ERAs 5–7	all data	5 724		1 019 299	
	total catch	5 146	17	927 059	6–7
	SFE	2 284	7	516 078	6–7
	LFE	1 592	7	208 262	6–8
ERAs 8–12	all data	5 565	49	1 146 875	
	total catch	5 422	25	1 126 239	
	SFE	–	–	–	
	LFE	1 707	10	241 591	
ERAs 13&15	all data	6 815	27	769 230	
	total catch	6 175	15	7 099 930	5–8
	SFE	–	–	–	
	LFE	4 249	10	394 132	5–8
ERAs 14&16	all data	4 662	34	640 154	
	total catch	4 161	12	571 635	5–8
	SFE	1 925	5	219 419	5–9
	LFE	1 425	5	132 826	5–8
ERAs 17–19	all data	7 710	40	890 467	
	total catch	7 317	28	851 493	5–8
	SFE	2 567	16	178 552	5–8
	LFE	4 300	18	465 577	5–8
ERA 20	all data	5 016	35	781 172	
	total catch	4 689	17	740 744	5–8
	SFE	–	–	–	–
	LFE	3 946	14	607 072	5–8

Table 3 – *continued.*

ERA 21	all data	4 449	14	905 481	
	total catch	2 381	14	396 506	2,3, 5–8
	total catch	4 402	14	898 105	5–8
	SFE	1 929	10	297 005	2,3, 5–8
	SFE	3 663	10	717 121	5–8
	LFE	–	–	–	–

Table 4: Predictor variables used in the GLM stepwise regression analysis. Only variables within borders were entered into the final model. Year effects and standard errors are also shown. 1991 represents 1990–91 fishing year. AIC, Akaike's Information Criterion; BOP, Bay of Plenty. Rivers listed indicate river flow (see Appendix 3).

ERA 1 (Northland)

Catch is sum of SFE, LFE, and EEU

Variable	r-square	Year	Year effect	s.e.
year	0.0318	1991	1.000	0.000
permit	0.3408	1992	0.896	0.032
month	0.3480	1993	0.892	0.032
moon phase	0.3481	1994	0.829	0.032
Manganui R.	0.3497	1995	1.040	0.040
		1996	1.050	0.041
		1997	0.981	0.038
		1998	1.120	0.046
		1999	1.269	0.050

Catch is SFE

year	-266.40	1991	1.000	0.000
permit	-2075.50	1992	0.941	0.049
month	-2100.78	1993	0.848	0.045
Manganui R.	-2101.81	1994	0.825	0.045
moon phase	-2099.45	1995	1.080	0.059
		1996	0.942	0.053
		1997	0.865	0.049
		1998	1.315	0.077
		1999	1.612	0.093

ERAs 2&3 (Auckland, Hauraki)

Catch is sum of SFE, LFE, and EEU

year	0.0136	1991	1.000	0.000
permit	0.3098	1992	1.041	0.055
Piako R	0.3101	1993	1.000	0.052
moon phase	0.3105	1994	1.005	0.063
area	0.3111	1995	1.058	0.055
month	0.3142	1996	1.088	0.059
		1997	0.923	0.048
		1998	1.055	0.057
		1999	1.057	0.057

Catch is SFE

Variable	AIC	Year	Year effect	s.e.
year	-18.12	1991	1	0
permit	-449.52	1992	0.971	0.091
Piako R.	-455.36	1993	0.951	0.085
moon phase	-456.02	1994	1.019	0.096
month	-448.77	1995	1.062	0.090
area	-455.00	1996	1.037	0.092
		1997	0.848	0.074
		1998	0.899	0.082
		1999	1.006	0.090

Table 4 – ***continued***

Catch is LFE

Variable	AIC	Year	Year effect	s.e.
year	-66.94	1991	1	0
permit	-1914.23	1992	0.758	0.073
Piako R.	-2008.69	1993	0.865	0.079
month	-2044.09	1994	0.506	0.049
moon phase	-2058.79	1995	0.700	0.061
area	-2071.04	1996	0.276	0.025
		1997	0.535	0.048
		1998	0.488	0.046
		1999	0.449	0.042

ERA 4 (Waikato)

Catch is sum of SFE, LFE, and EEU

Variable	AIC	Year	Year effect	s.e.
year	0.0131	1991	1	0
permit	0.2918	1992	0.864	0.027
month	0.3010	1993	0.900	0.029
Waikato R.	0.3062	1994	0.833	0.026
Piako R.	0.3065	1995	1.031	0.032
moon phase	0.3082	1996	1.014	0.031
		1997	0.981	0.030
		1998	0.957	0.030
		1999	0.892	0.028

Catch is SFE

Variable	AIC	Year	Year effect	s.e.
year	-219.60	1991	1	0
permit	-1070.08	1992	0.625	0.068
month	-1096.74	1993	1.510	0.176
Waikato R.	-1096.81	1994	0.985	0.112
Paiko R.	-1094.85	1995	1.272	0.136
moon phase	-1092.16	1996	1.139	0.121
		1997	1.085	0.113
		1998	1.292	0.141
		1999	1.193	0.125

Catch is LFE

Variable	AIC	Year	Year effect	s.e.
year	-100.51	1991	1	0
permit	-3052.20	1992	0.648	0.060
month	-3328.26	1993	0.805	0.083
moon phase	-3364.71	1994	1.814	0.183
Piako R.	-3373.94	1995	2.310	0.216
Waikato R.	-3371.94	1996	0.939	0.085
		1997	1.011	0.090
		1998	1.208	0.112
		1999	0.868	0.075

Table 4 – *continued*

ERAs 5–7 (Bay of Plenty, Poverty Bay, Hawke's Bay)

Catch is sum of SFE, LFE, and EEU

Variable	r-square	Year	Year effect	s.e.
year	0.1017	1991	1	0
permit	0.5930	1992	0.876	0.062
area	0.6083	1993	0.723	0.056
month	0.6156	1994	0.737	0.061
BOP R.	0.6156	1995	0.778	0.060
Hawke's Bay R.	0.6156	1996	0.784	0.066
moon phase	0.6158	1997	0.559	0.048
		1998	0.524	0.045
		1999	0.620	0.063

Catch is SFE

year	-265.12	1991	1	0
permit	-781.99	1992	1.171	0.109
area	-876.87	1993	0.921	0.083
month	-926.81	1994	0.678	0.067
BOP R.	-929.61	1995	0.688	0.063
Hawke's Bay R.	-927.82	1996	1.269	0.132
moon phase	-928.81	1997	1.092	0.119
		1998	0.628	0.066
		1999	0.624	0.073

Catch is LFE

year	-164.23	1991	1	0
permit	-2105.59	1992	0.810	0.077
month	-2310.88	1993	0.649	0.060
area	-2371.00	1994	0.793	0.080
BOP R.	-2380.09	1995	0.764	0.072
moon phase	-2388.58	1996	0.650	0.069
Hawke's Bay R.	-2386.88	1997	0.342	0.038
		1998	0.593	0.063
		1999	0.840	0.100

ERAs 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington)

Catch is sum SFE, LFE, and EEU

year	0.1164	1991	1	0
permit	0.4447	1992	1.259	0.096
month	0.4737	1993	1.139	0.081
area	0.4815	1994	0.964	0.065
Wanganui R.	0.4815	1995	0.813	0.059
Wairarapa R.	0.4817	1996	0.780	0.054
moon phase	0.4818	1997	0.639	0.043
		1998	0.555	0.037
		1999	0.500	0.034

Table 4 – *continued*

Catch is LFE

Variable	AIC	Year	Year effect	s.e.
year	-77.90	1991	1	0
permit	-566.44	1992	1.093	0.152
month	-578.00	1993	1.430	0.180
moon phase	-579.81	1994	0.659	0.084
Wanganui R.	-581.17	1995	0.847	0.101
area	-578.56	1996	0.930	0.114
Wairarapa R.	-579.80	1997	0.637	0.074
		1998	0.676	0.083
		1999	0.455	0.055

ERAs 13&15 (Nelson, Westland)

Catch is sum of SFE, LFE, and EEU

Variable	r-square	Year	Year effect	s.e.
year	0.0370	1991	1	0
permit	0.4325	1992	0.835	0.049
month	0.4419	1993	0.765	0.043
Buller R.	0.4420	1994	0.839	0.045
area	0.4424	1995	0.981	0.055
moon phase	0.4430	1996	0.906	0.053
		1997	0.820	0.049
		1998	0.851	0.056
		1999	0.948	0.057

Catch is LFE

year	-74.09	1991	1	0
permit	-1751.44	1992	0.950	0.061
month	-1771.28	1993	0.729	0.046
area	-1791.31	1994	0.829	0.050
moon phase	-1794.73	1995	0.937	0.059
Buller R.	-1792.79	1996	0.954	0.060
		1997	0.945	0.062
		1998	0.782	0.058
		1999	0.849	0.056

ERAs 14 &16 (Marlborough, North Canterbury)

Catch is sum SFE, LFE, and EEU

year	0.0144	1991	1	0
permit	0.4447	1992	0.721	0.059
month	0.4601	1993	0.754	0.071
Rakaia R.	0.4604	1994	0.718	0.056
Wairau R.	0.4604	1995	0.631	0.048
area	0.4604	1996	0.662	0.051
moon phase	0.4607	1997	0.621	0.049
		1998	0.649	0.054
		1999	0.667	0.057

Table 4 – *continued*

Catch is SFE

Variable	AIC	Year	Year effect	s.e.
year	-45.97	1991	1	0
permit	-2468.93	1992	0.725	0.096
month	-2486.44	1993	0.740	0.114
area	-2484.95	1994	0.628	0.073
Wairau R.	-2486.22	1995	0.486	0.056
Rakaia R.	-2484.64	1996	0.462	0.052
moon phase	-2485.80	1997	0.300	0.035
		1998	0.270	0.032
		1999	0.355	0.046

Catch is LFE

Variable	AIC	Year	Year effect	s.e.
year	-90.45	1991	1	0
permit	-565.00	1992	0.270	0.039
month	-596.69	1993	0.361	0.059
area	-594.78	1994	0.458	0.059
Wairau	-596.38	1995	0.294	0.036
Rakaia	-595.89	1996	0.445	0.055
moon phase	-591.77	1997	0.589	0.077
		1998	0.577	0.077
		1999	0.608	0.084

ERAs 17–19 (South Canterbury, Waitaki, Otago)

Catch is sum SFE, LFE, and EEU

Variable	AIC	Year	Year effect	s.e.
year	0.0403	1991	1	0
permit	0.3076	1992	0.772	0.043
month	0.3190	1993	0.764	0.041
Waitaki	0.3190	1994	0.816	0.045
Clutha	0.3190	1995	0.607	0.032
area	0.3190	1996	0.629	0.034
moon phase	0.3211	1997	0.722	0.042
		1998	0.671	0.042
		1999	0.596	0.038

Catch is SFE

Variable	AIC	Year	Year effect	s.e.
year	-266.45	1991	1	0
permit	-3120.19	1992	0.825	0.059
month	-3367.93	1993	1.464	0.101
Clutha R.	-3405.83	1994	1.014	0.073
area	-3445.38	1995	0.807	0.055
Waitaki R.	-3474.89	1996	1.317	0.096
moon phase	-3477.38	1997	0.941	0.070
		1998	0.820	0.066
		1999	0.861	0.068

Table 4 – *continued*

Catch is LFE

Variable	AIC	Year	Year effect	s.e.
year	-463.89	1991	1	0
permit	-1930.32	1992	0.814	0.057
month	-2073.57	1993	0.687	0.046
moon phase	-2078.08	1994	0.879	0.061
Clutha R.	-2078.65	1995	0.663	0.044
area	-2074.98	1996	0.460	0.032
Waitaki R.	-2077.76	1997	0.534	0.039
		1998	0.677	0.054
		1999	0.646	0.050

ERA 20 (Southland)

Catch is sum SFE, LFE, and EEU

year	0.0740	1991	1.000	0.000
permit	0.5013	1992	0.754	0.046
month	0.5124	1993	0.707	0.044
Mataura R.	0.5125	1994	0.829	0.054
moon phase	0.5138	1995	0.660	0.045
		1996	0.588	0.043
		1997	0.557	0.039
		1998	0.546	0.037
		1999	0.498	0.034

Catch is LFE

year	-325.07	1991	1.000	0.000
permit	-1196.19	1992	0.656	0.041
month	-1273.76	1993	0.562	0.035
moon phase	-1280.78	1994	0.537	0.035
Mataura R.	-1280.51	1995	0.502	0.034
		1996	0.467	0.034
		1997	0.446	0.032
		1998	0.450	0.031
		1999	0.310	0.022

ERA 21 (Te Waihora)

Catch is sum of SFE, LFE, and EEU

year	0.0996	1991	1	0
permit	0.2775	1992	1.323	0.087
month	0.3063	1993	1.090	0.076
moon phase	0.3076	1994	0.798	0.062
		1995	0.668	0.043
		1996	1.091	0.079
		1997	1.370	0.110
		1998	1.239	0.098
		1999	1.211	0.090

Table 4 – *continued*

Catch is sum of SFE, LFE, and EEU (excluding Concession Area months Feb–Mar)

Variable	r-square	Year	Year effect	s.e.
year	0.0939	1991	1	0
permit	0.2772	1992	1.260	0.108
month	0.2970	1993	0.984	0.096
moon phase	0.2973	1994	0.753	0.081
		1995	0.751	0.064
		1996	0.734	0.071
		1997	0.784	0.096
		1998	0.934	0.124
		1999	1.158	0.120

Catch is SFE

Variable	r-square	Year	Year effect	s.e.
year	-257.91	1991	1	0
permit	-698.6002	1992	1.285	0.090
month	-778.7847	1993	1.011	0.077
moon phase	-776.3747	1994	0.763	0.060
		1995	0.669	0.044
		1996	1.114	0.083
		1997	1.415	0.116
		1998	1.355	0.115
		1999	1.160	0.090

Catch is SFE (excluding Concession Area months Feb–Mar)

Variable	r-square	Year	Year effect	s.e.
year	-81.76	1991	1	0
permit	-252.77	1992	1.238	0.113
month	-261.43	1993	0.837	0.088
moon phase	-256.01	1994	0.676	0.073
		1995	0.732	0.064
		1996	0.729	0.071
		1997	0.829	0.105
		1998	1.362	0.218
		1999	1.090	0.117

Table 5: Summary of trends in standardised CPUE for each area and species. * indicates that the slope of the trend is significantly different from zero at the following levels of significance: *p<0.05, **p<0.01, ***p<0.001; ns, not signifcant; – insufficient data.

ERA	Total catch (SFE, LFE, & EEU)	SFE	LFE
ERA 1	*	ns	–
ERAs 2 & 3	ns	ns	*
ERA 4	ns	ns	ns
ERAs 5–7	**	ns	ns
ERAs 8–12	***	–	*
ERAs 13 & 15	ns	–	ns
ERAs 14 & 16	*	***	ns
ERAs 17–19	*	ns	*
ERA 20	***	–	**
ERA 21	ns	ns	–
Exclude concession area	ns	ns	–

All slopes were negative except ERA1 total catch.

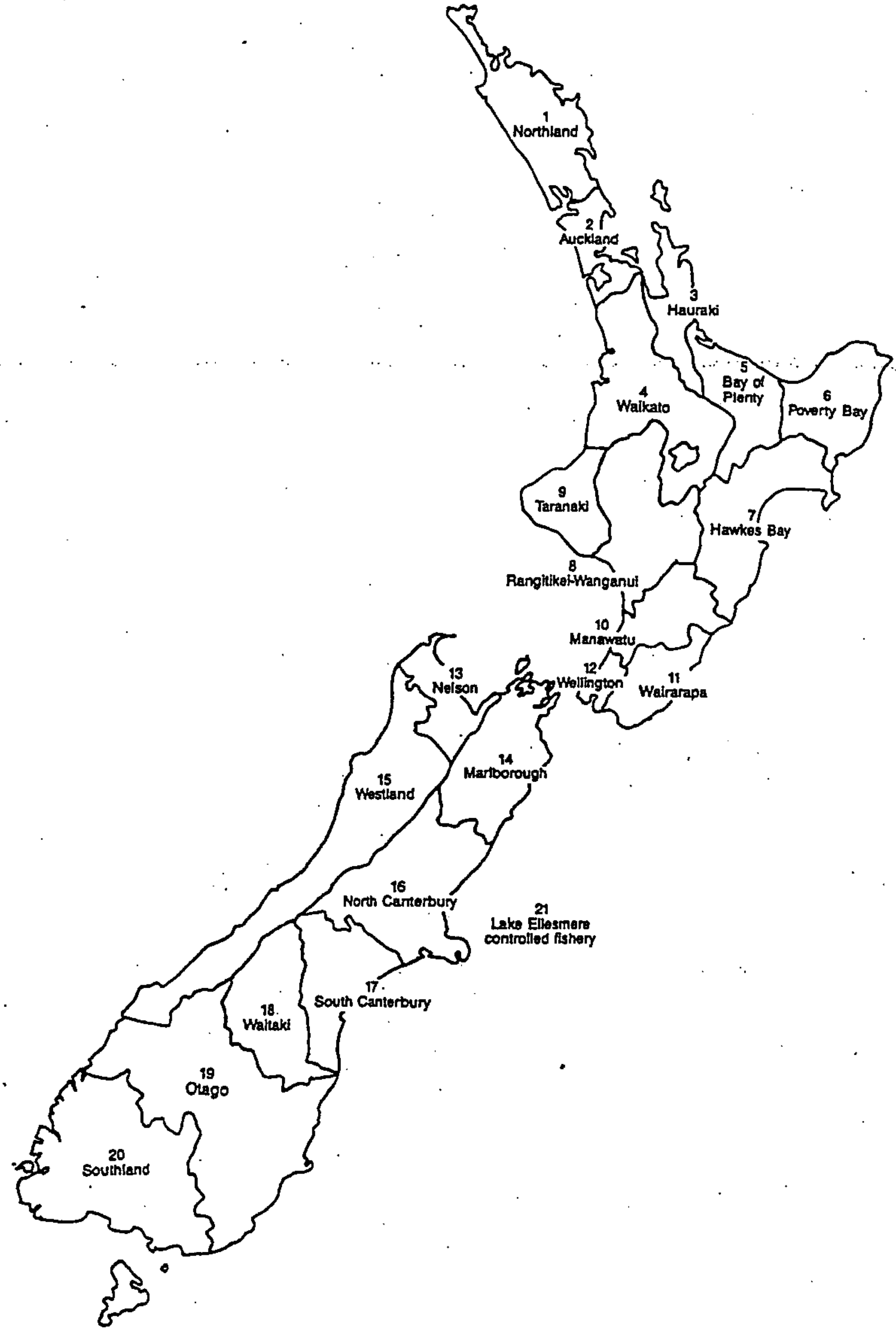


Figure 1: Eel Return Areas (ERA).

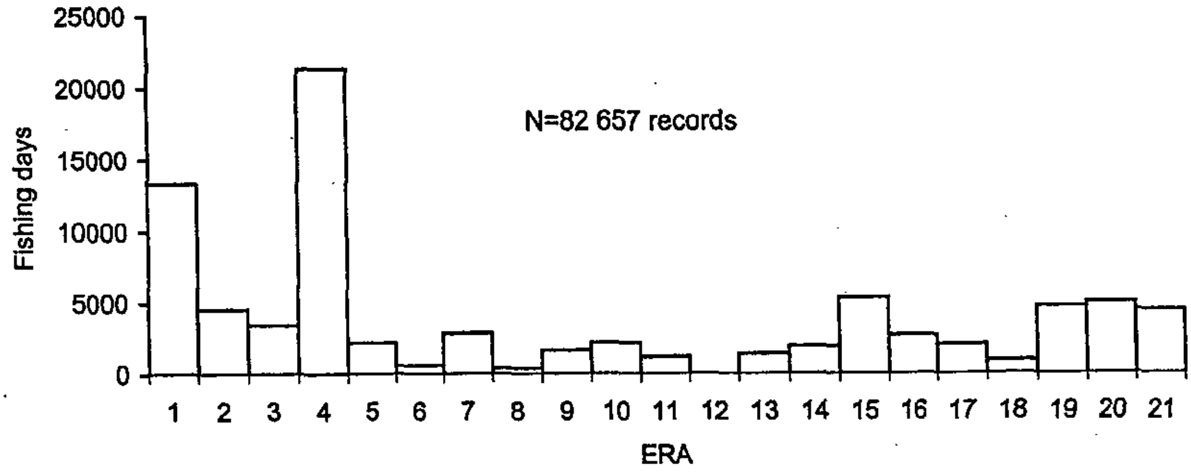


Figure 2: Number of fishing days by ERA for fishing years 1990–91 to 1998–99.

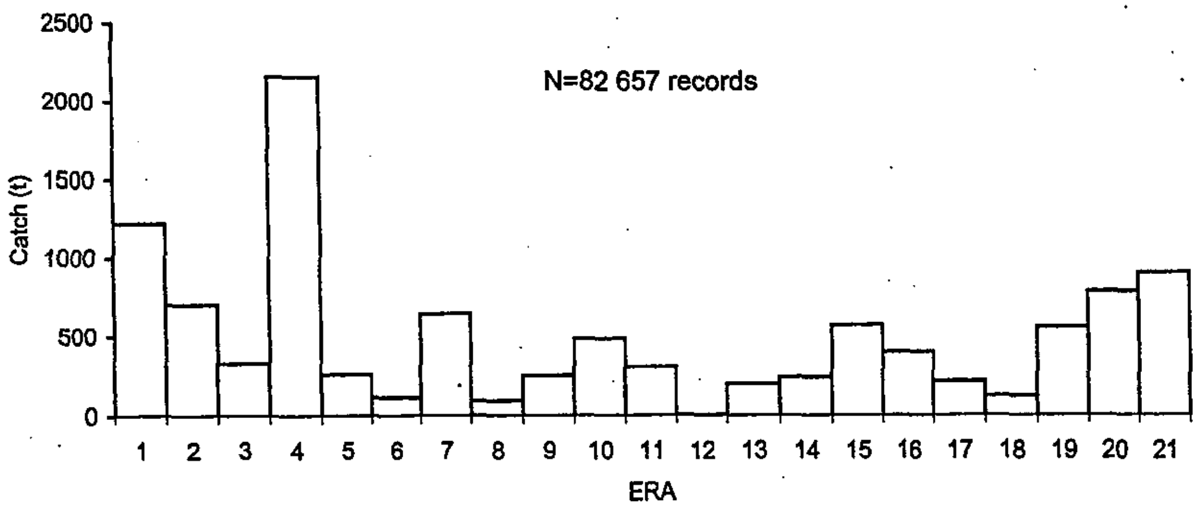


Figure 3: Total estimated catch (t) by ERA for fishing years 1990–91 to 1998–99. (see Table 2 for species mix).

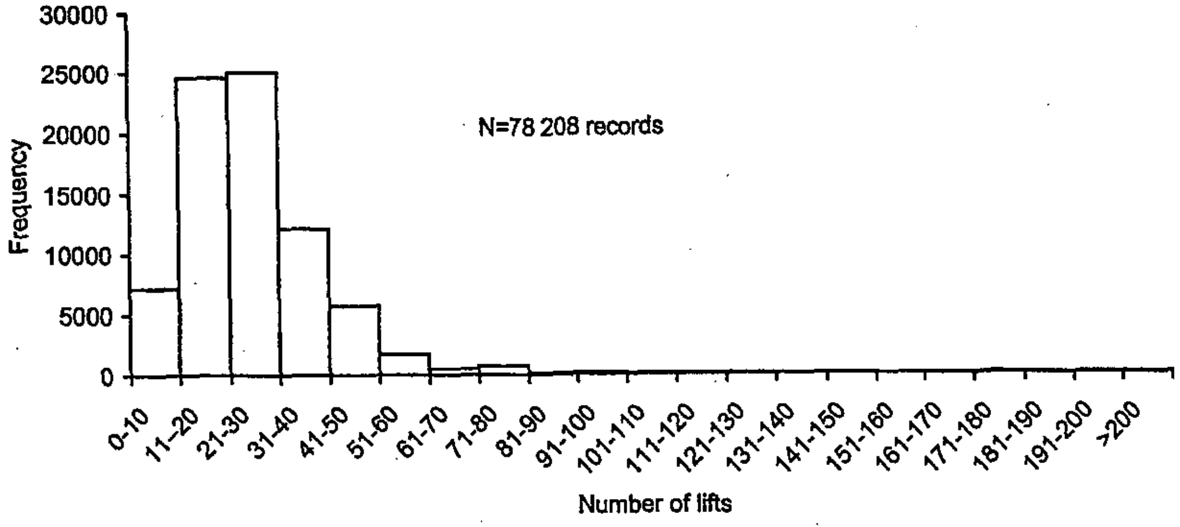


Figure 4: Number of net lifts per set for all ERAs (excluding ERA 21) for fishing years 1990–91 to 1998–99.

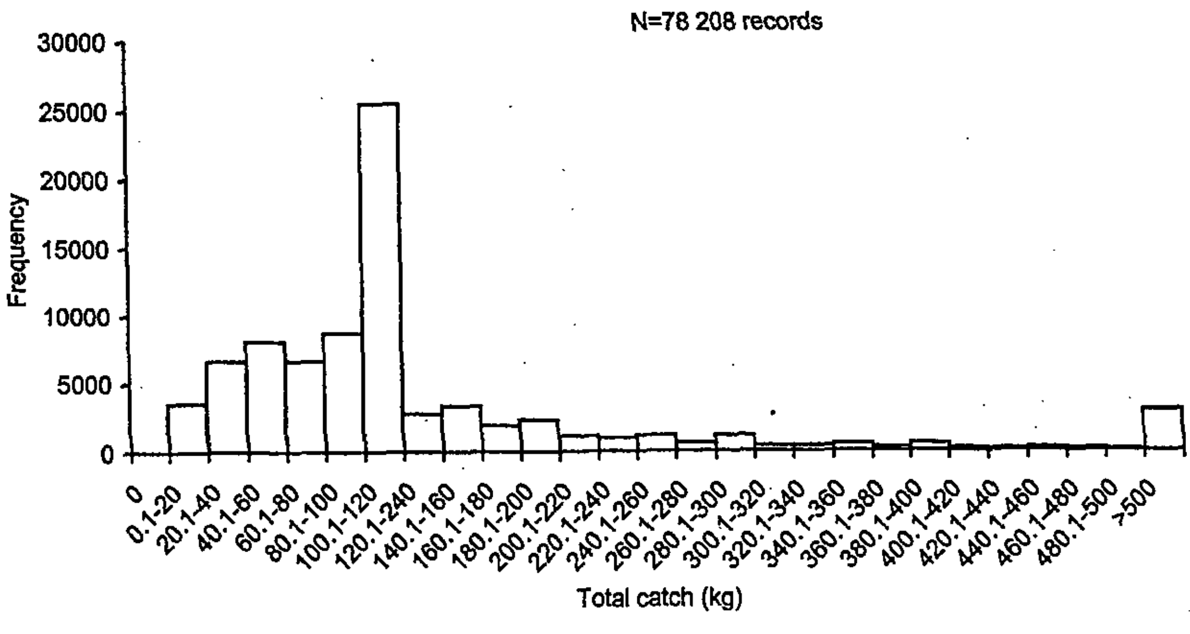


Figure 5: Catch per set for all ERAs (excluding ERA 21) for fishing years 1990–91 to 1998–99.

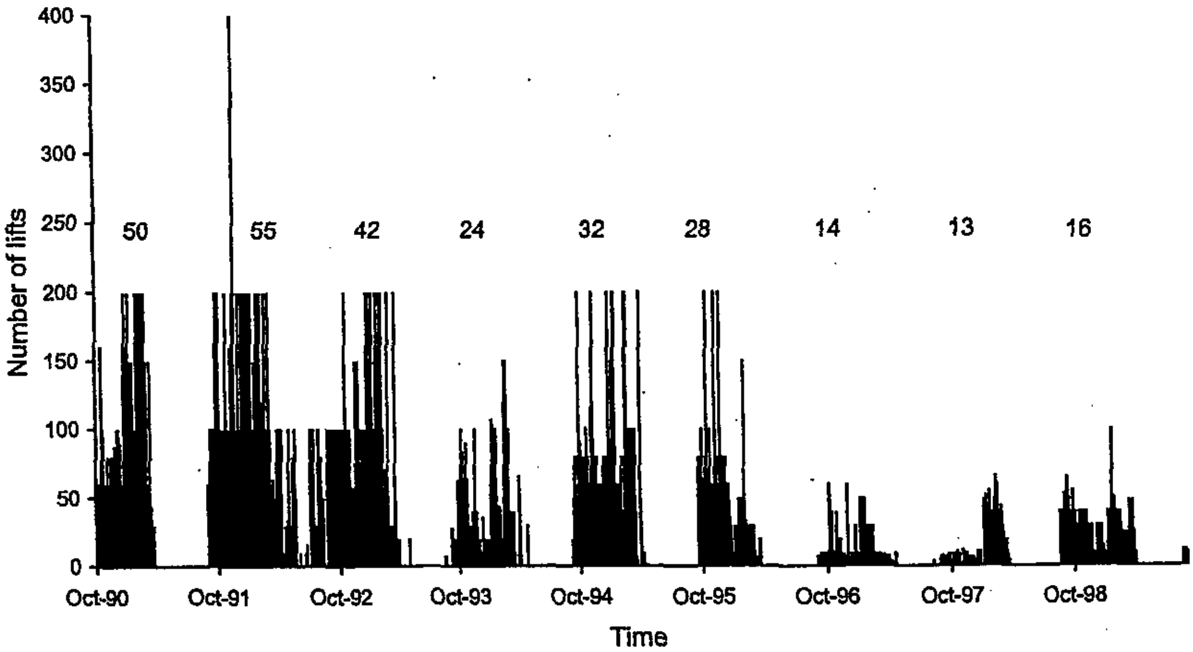


Figure 6. Number of lifts per set for fishing years 1990–91 to 1998–99 for ERA 21 (Te Waihora). Numbers represent mean number of lifts per set for each fishing year.

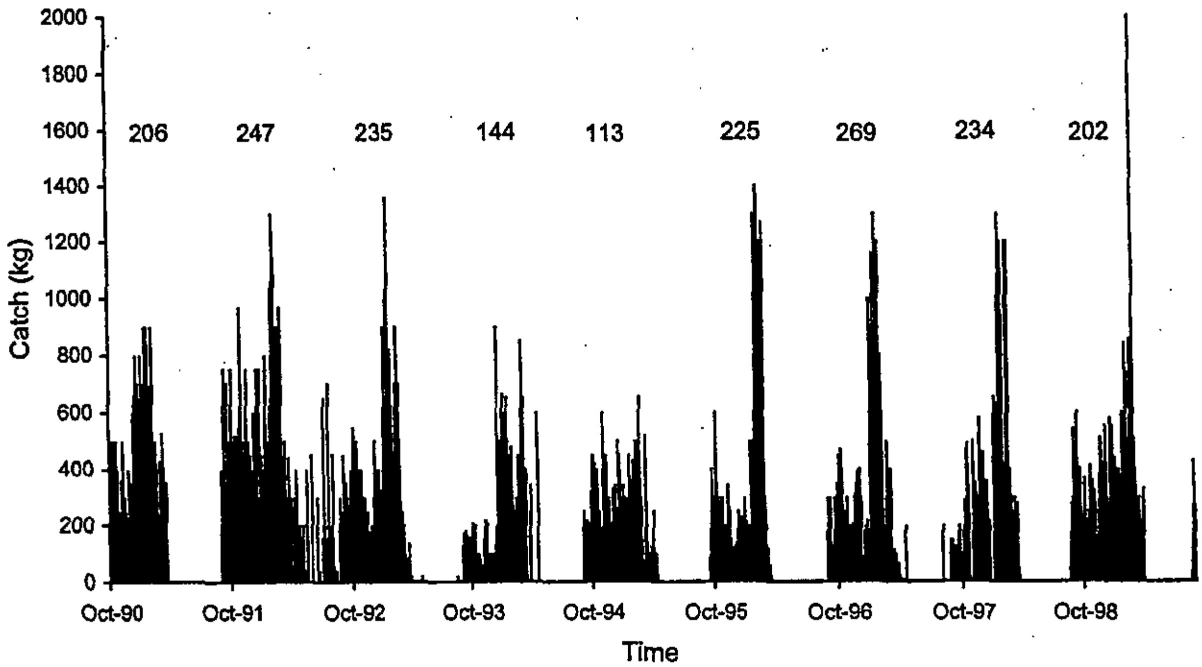


Figure 7. Catches per set for fishing years 1990–91 to 1998–99 for ERA 21 (Te Waihora). Numbers represent mean daily catch for each fishing year.

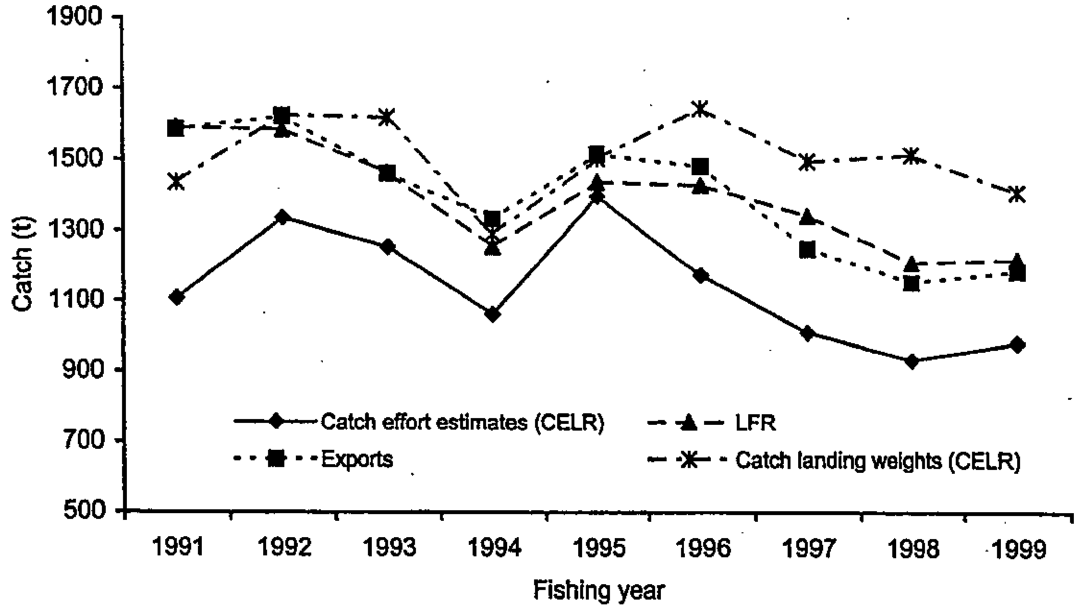


Figure 8: Comparison of total estimated annual eel catch (including Te Waihora) from CELR with landed weight (CELR), LFR, and export data. 1991 represents 1990–91 fishing year.

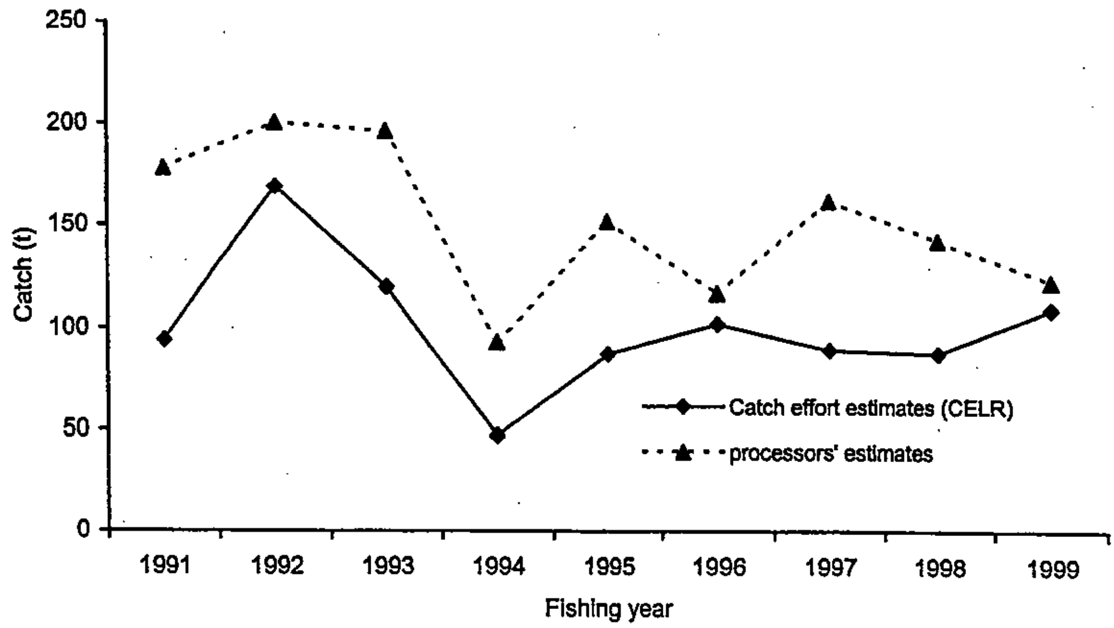


Figure 9: Comparison of total estimated annual eel catch (CELR) with processors' catch for Te Waihora. 1991 represents 1990–91 fishing year.

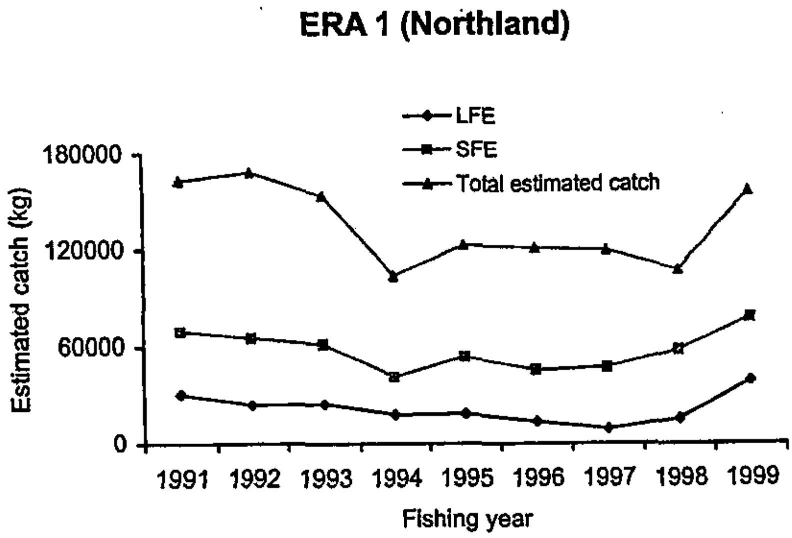
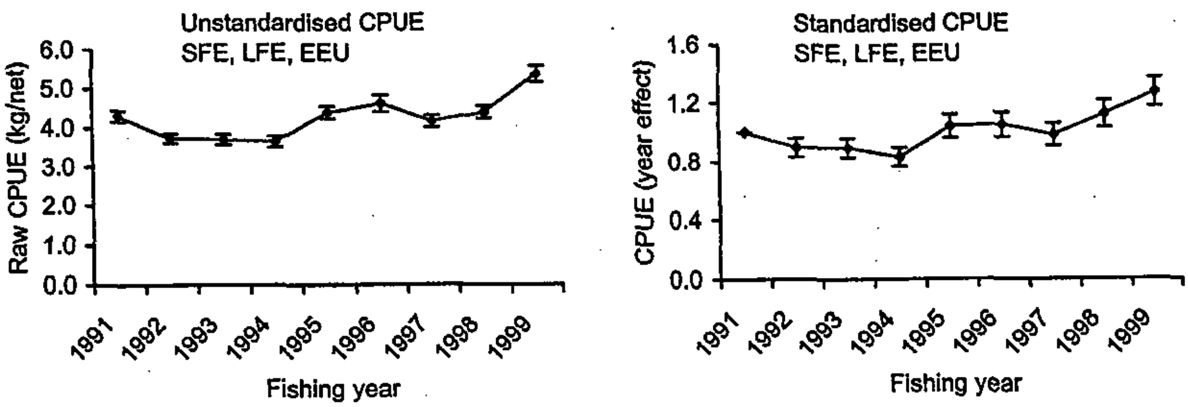


Figure 10: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERA 1. 58% of catch identified to species, remainder unidentified.



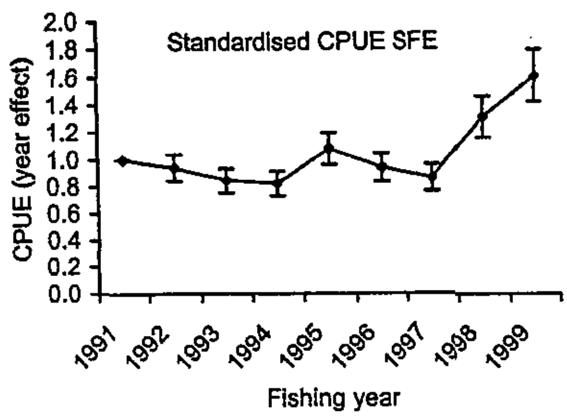


Figure 11: CPUE indices for ERA 1. Unstandardised for total catch and standardised for total catch and SFE. 1991 represents 1990–91 fishing year. Error bars are 95% confidence intervals.

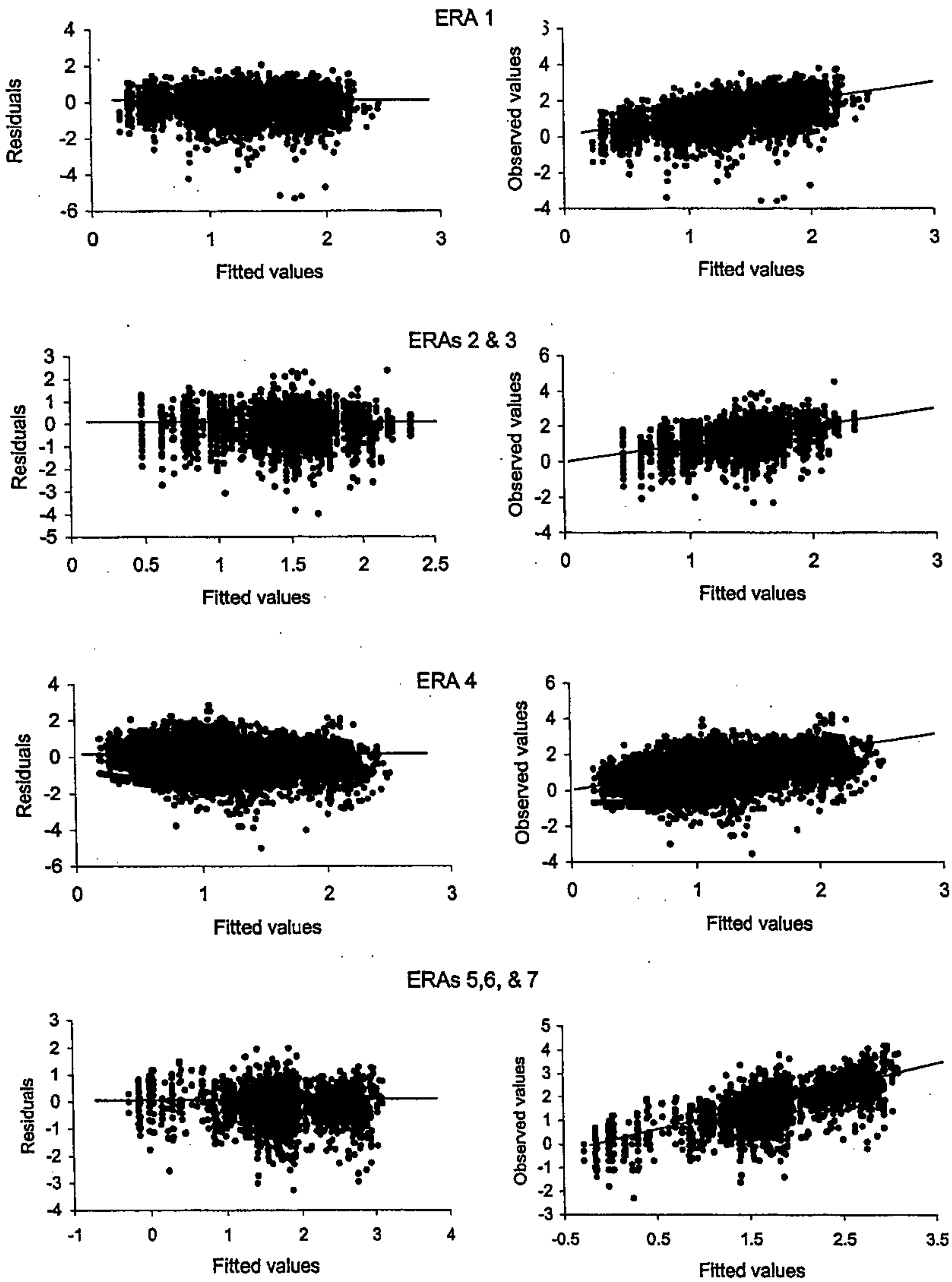


Figure 12: Fitted versus residuals (log scale) and fitted versus observed of the GLM model for ERAs from total catch of SFE, LFE, and EEU.

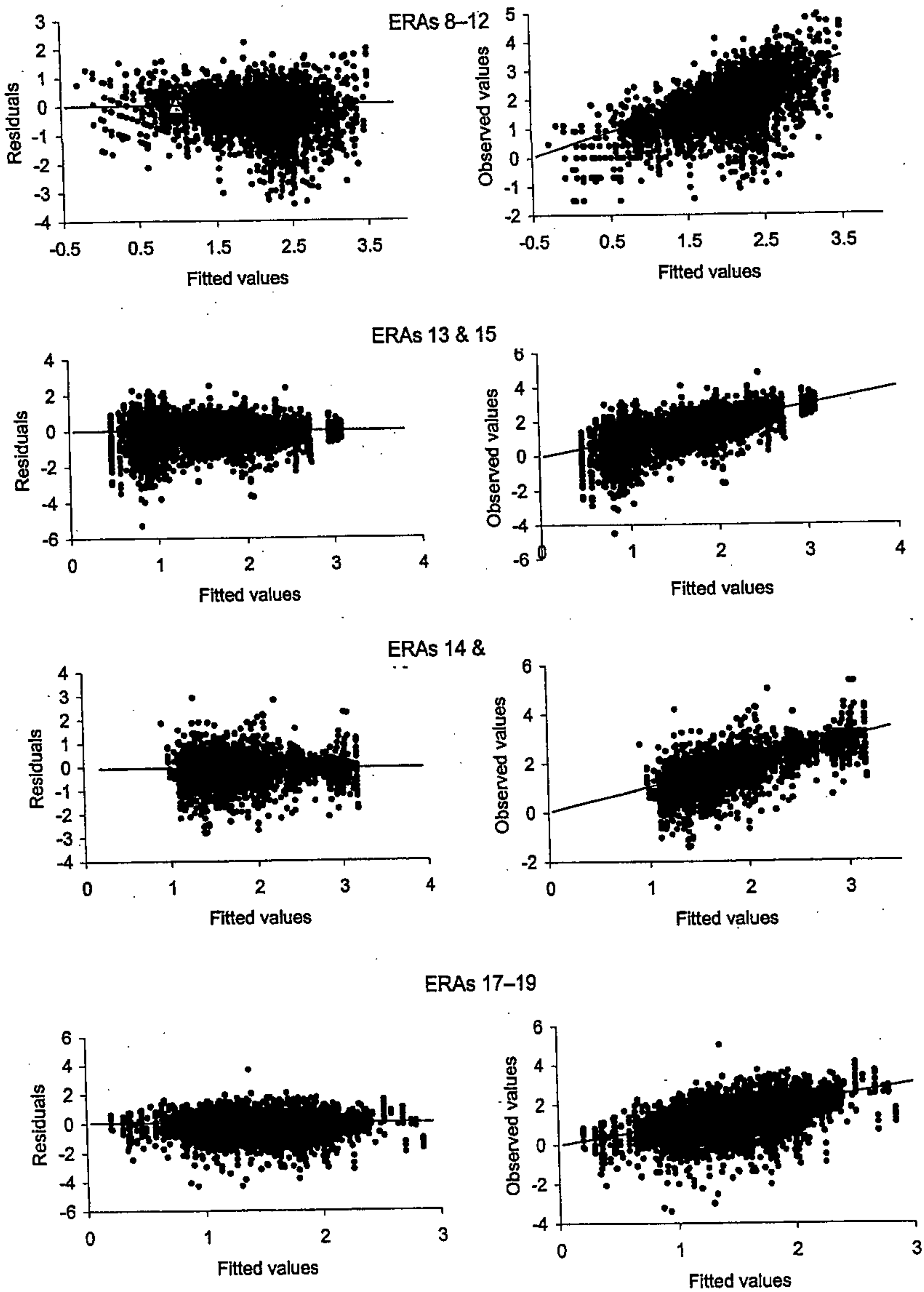


Figure 12 – *continued.*

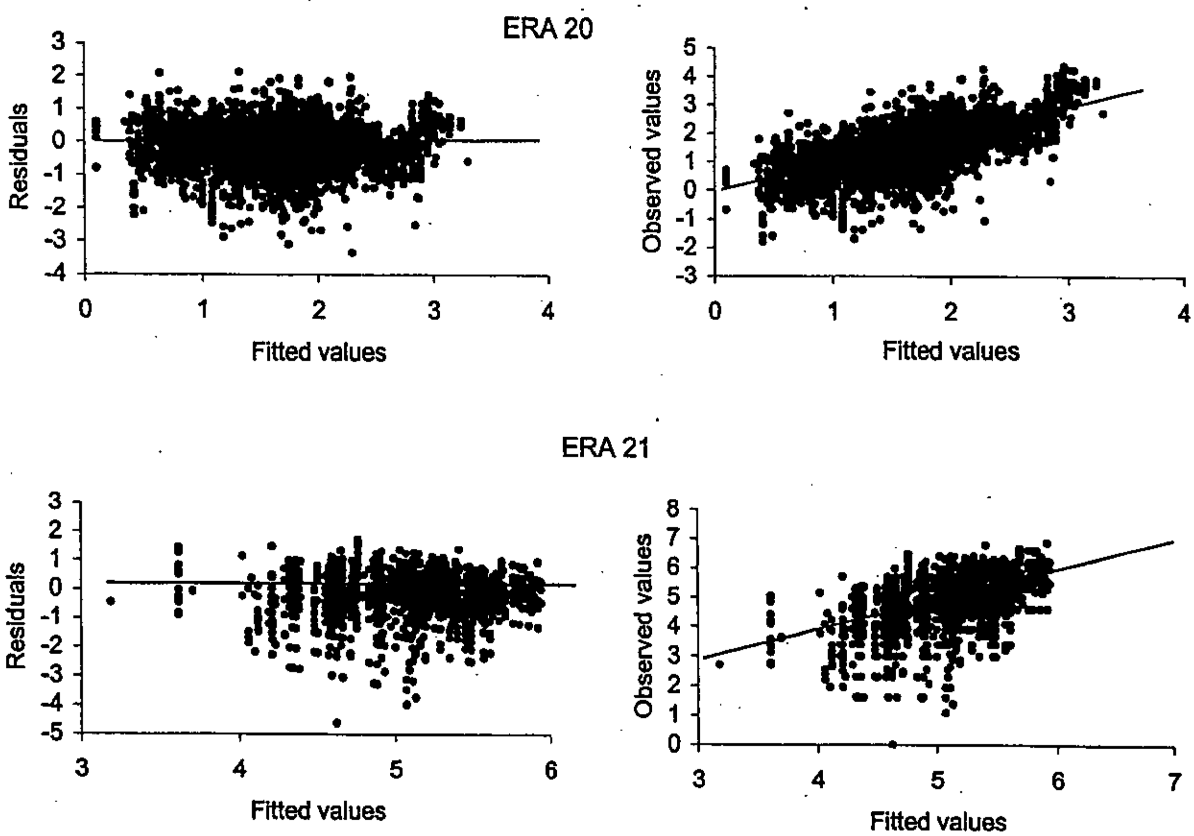


Figure 12 – ***continued.***

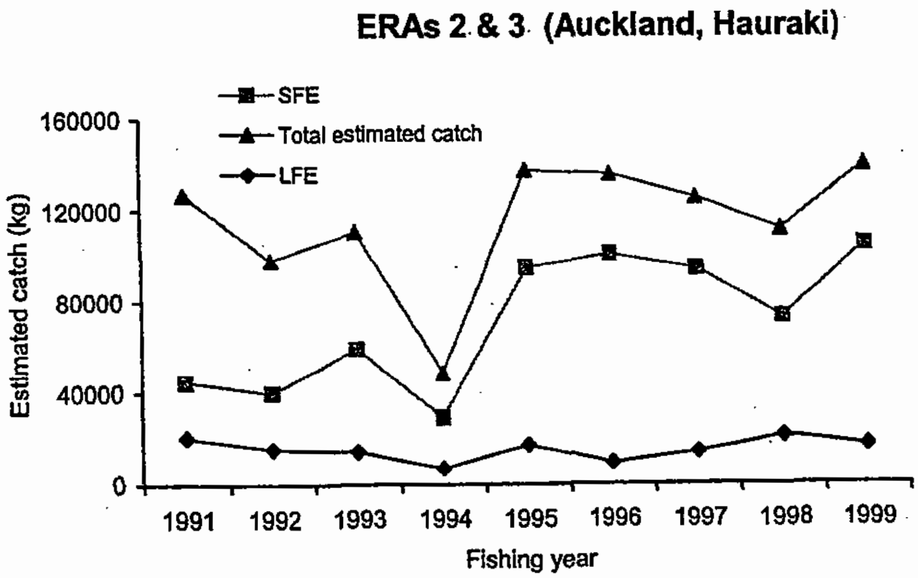


Figure 13: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERAs 2 & 3. 75% of catch identified to species, remainder unidentified.

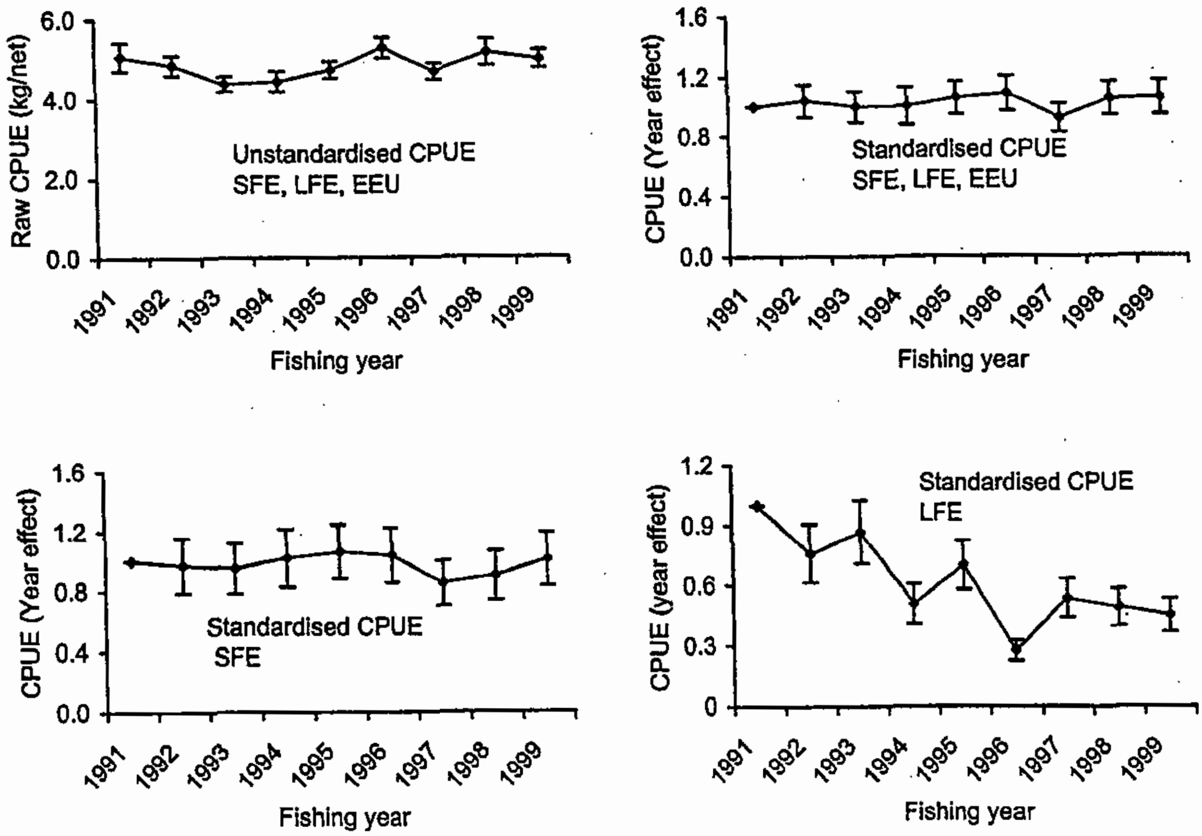


Figure 14: CPUE indices for ERAs 2 & 3. Unstandardised for total catch and standardised for total catch, SFE, and LFE.

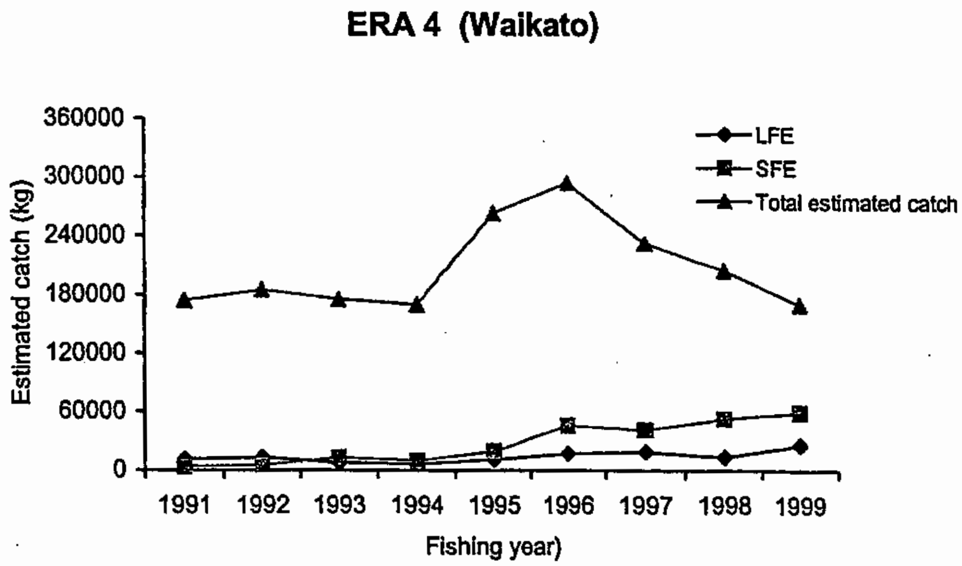


Figure 15: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERA 4. 20% of catch identified to species, remainder unidentified.

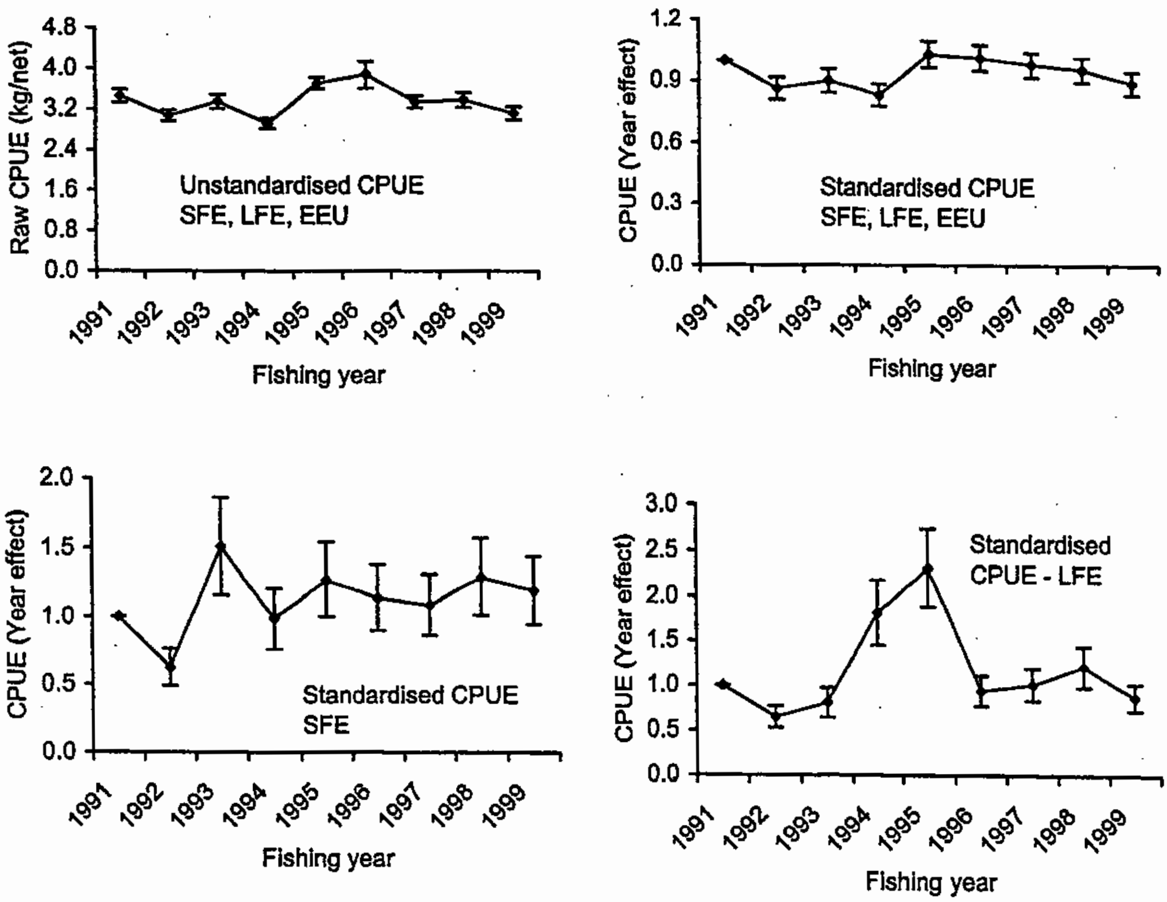


Figure 16: CPUE indices for ERA 4. Unstandardised for total catch and standardised for total catch, SFE, and LFE.

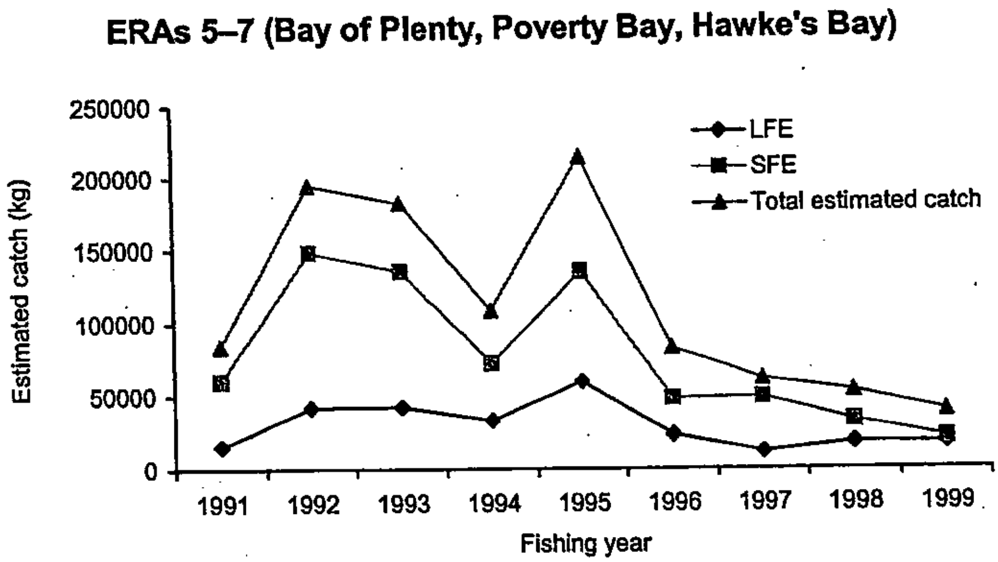


Figure 17: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERAs 5–7. 95% of catch identified to species, remainder unidentified.

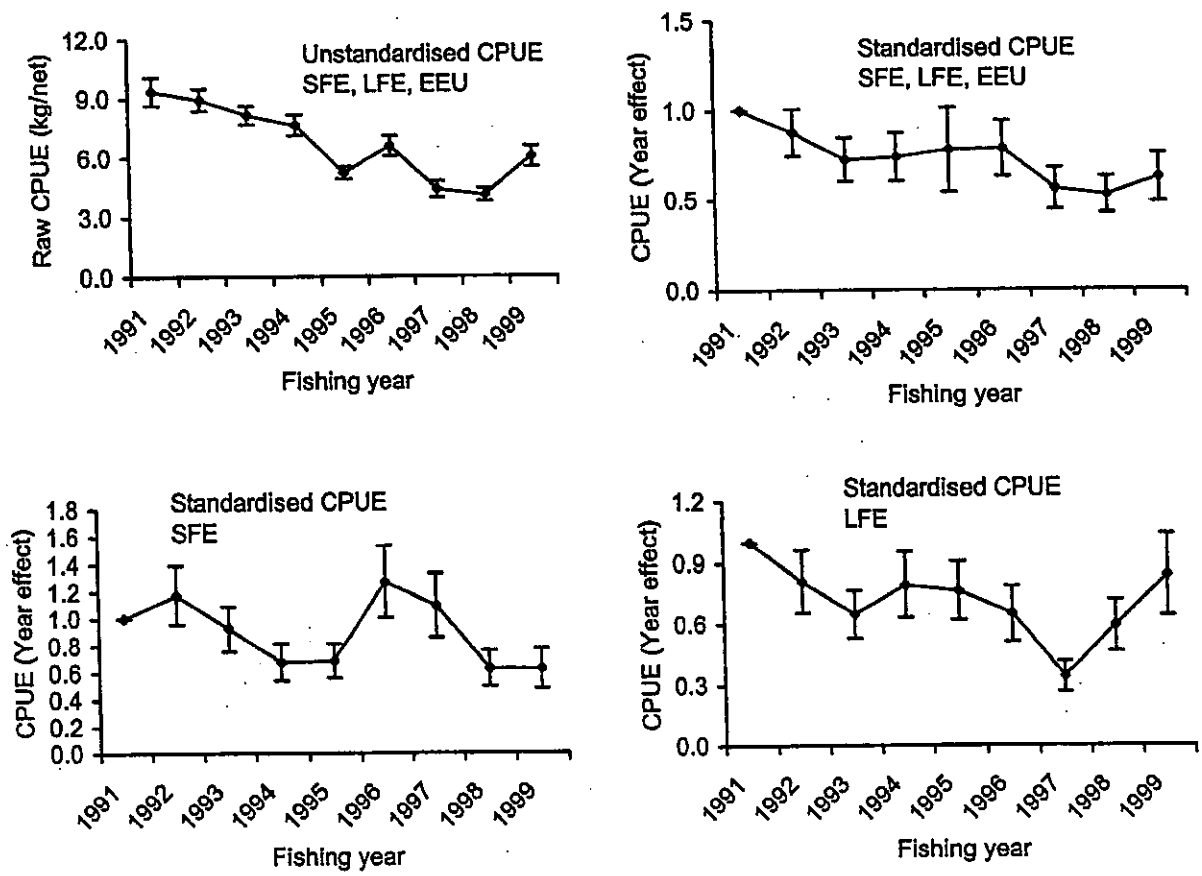


Figure 18: CPUE indices for ERAs 5–7. Unstandardised for total catch and standardised for total catch, SFE, and LFE.

ERAs 8–12 (Rangitaiki-Wanganui, Taranaki, Manawatu, Wairarapa, Wellington)

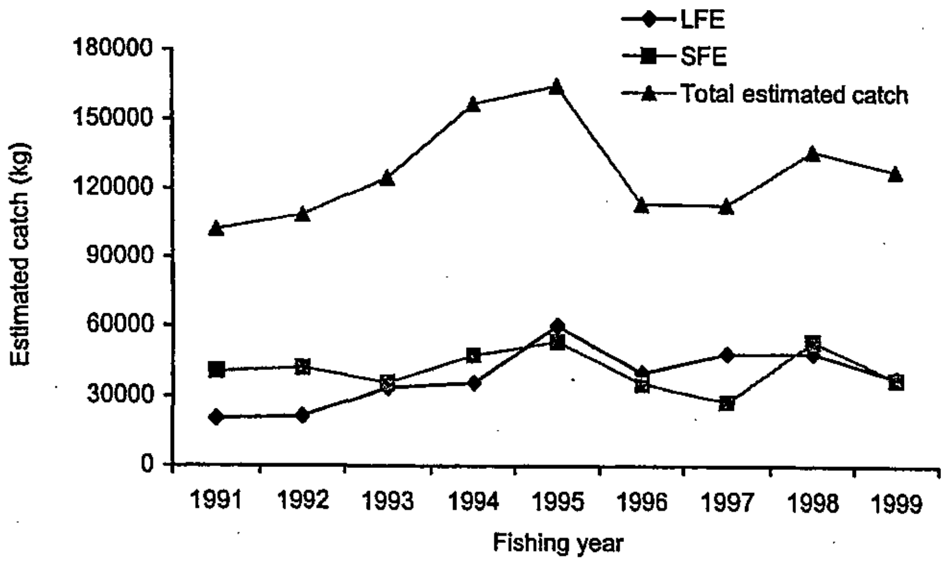


Figure 19: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERAs 8–12. 63% of catch identified to species, remainder unidentified.

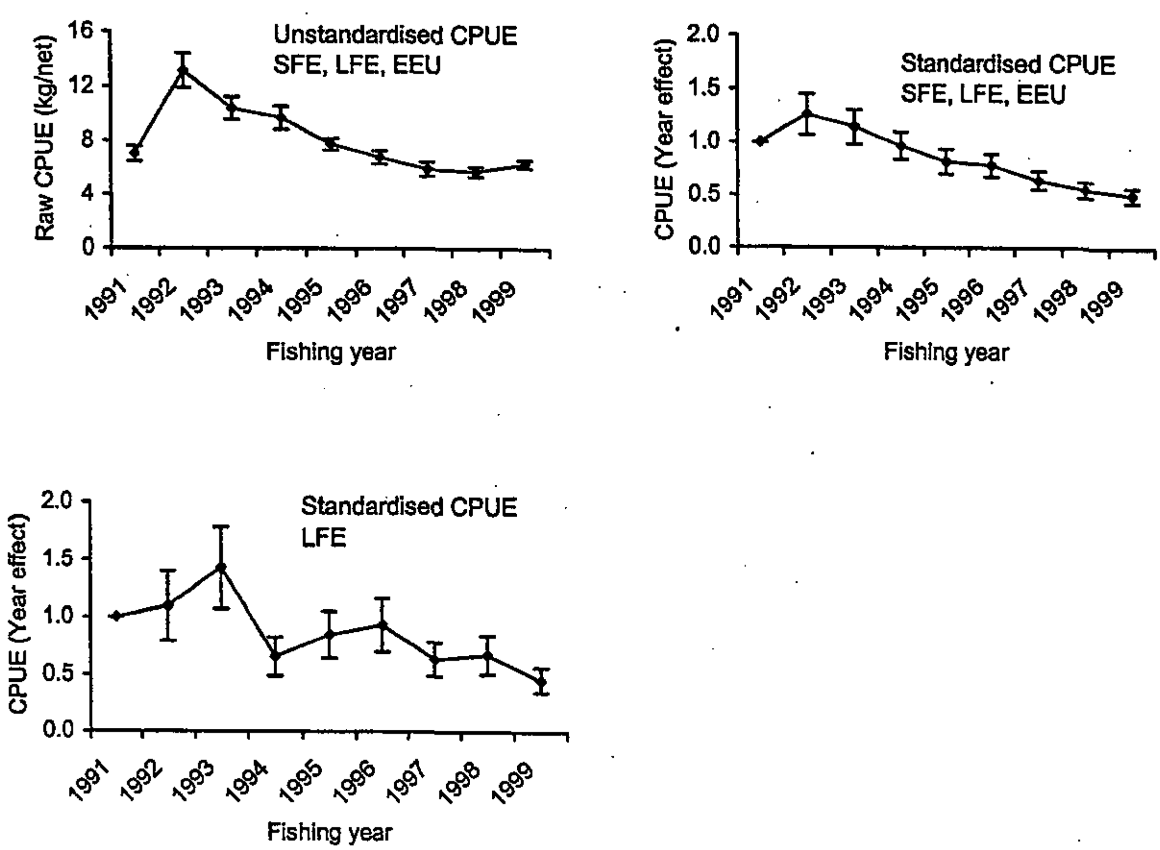


Figure 20: CPUE indices for ERAs 8–12. Unstandardised for total catch and standardised for total catch and LFE.

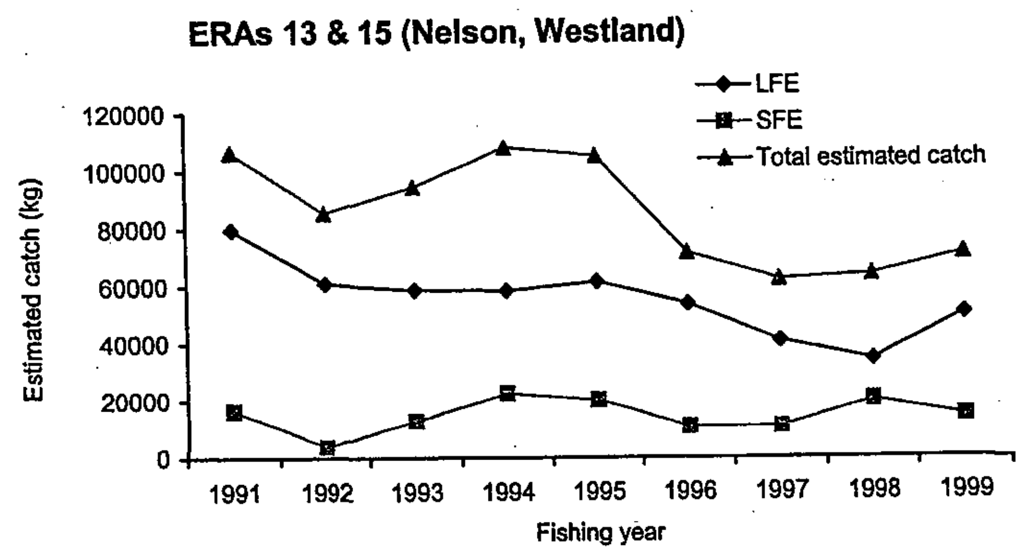
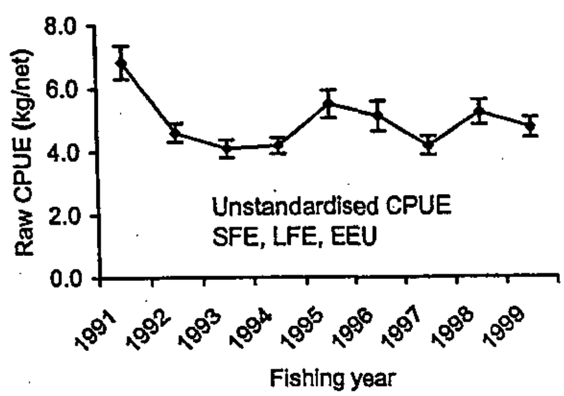
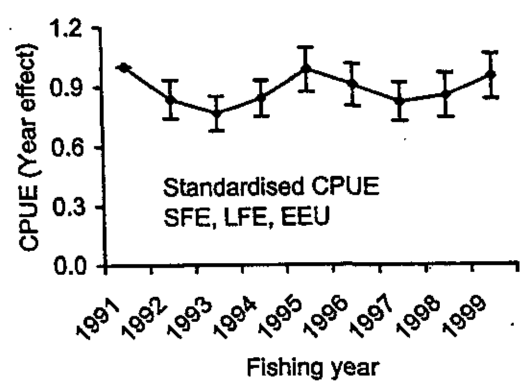


Figure 21: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERAs 13 & 15. 82% of catch identified to species, remainder unidentified.





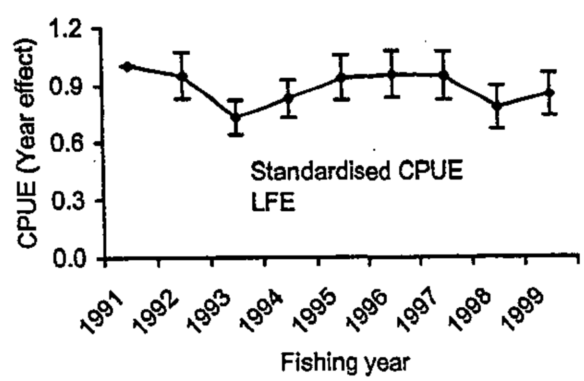


Figure 22: CPUE indices for ERAs 13 &1 5. Unstandardised for total catch and standardised for total catch and LFE.

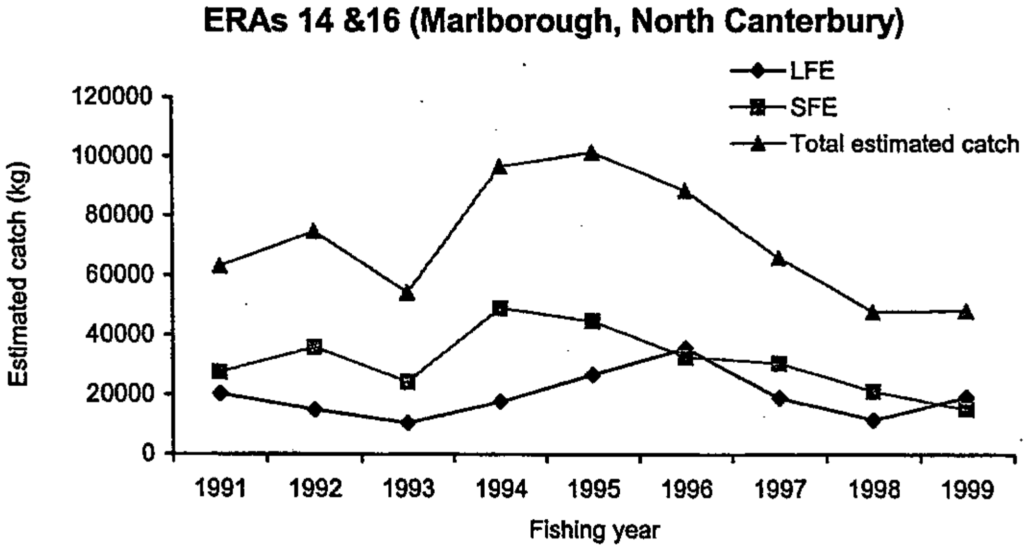


Figure 23: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERAs 14 & 16. 71% of catch identified to species, remainder unidentified.

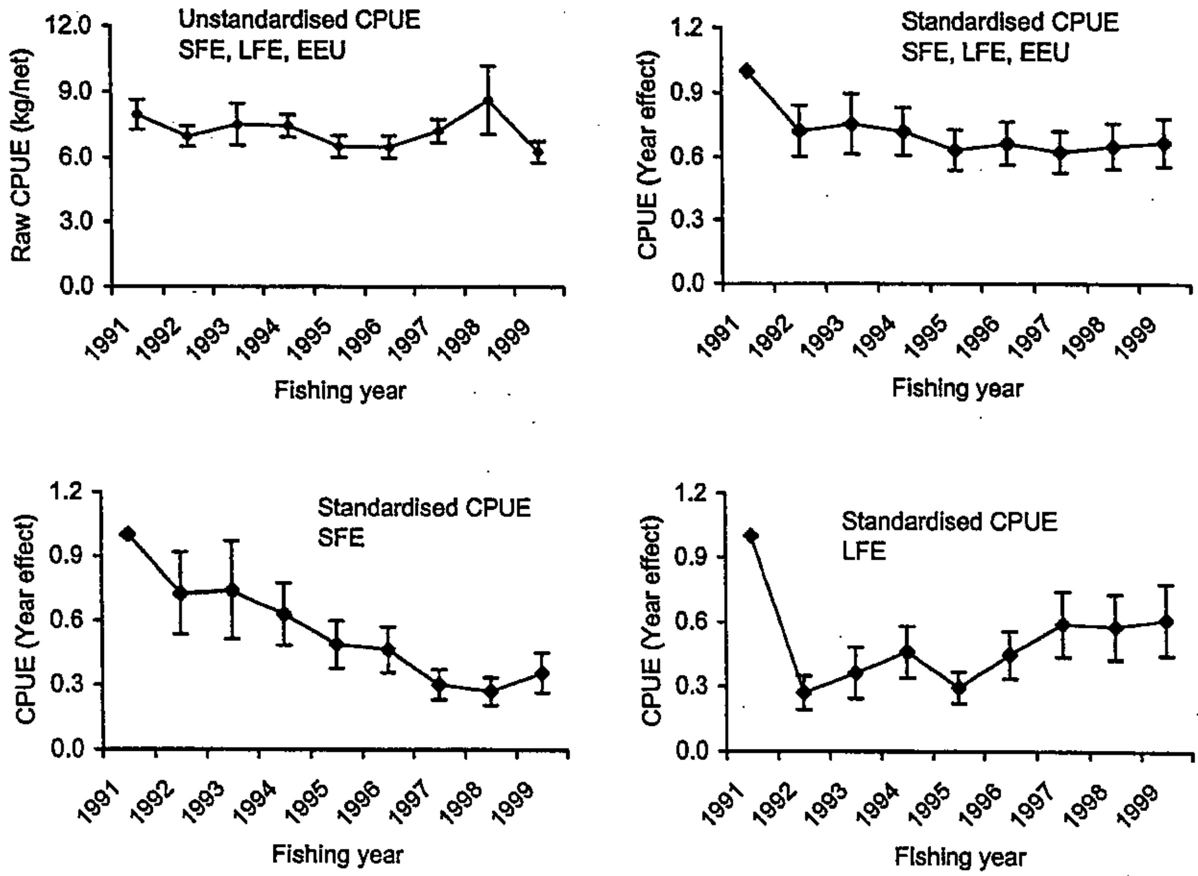


Figure 24: CPUE indices for ERAs 14 & 16. Unstandardised for total catch and standardised for total catch, SFE, and LFE.

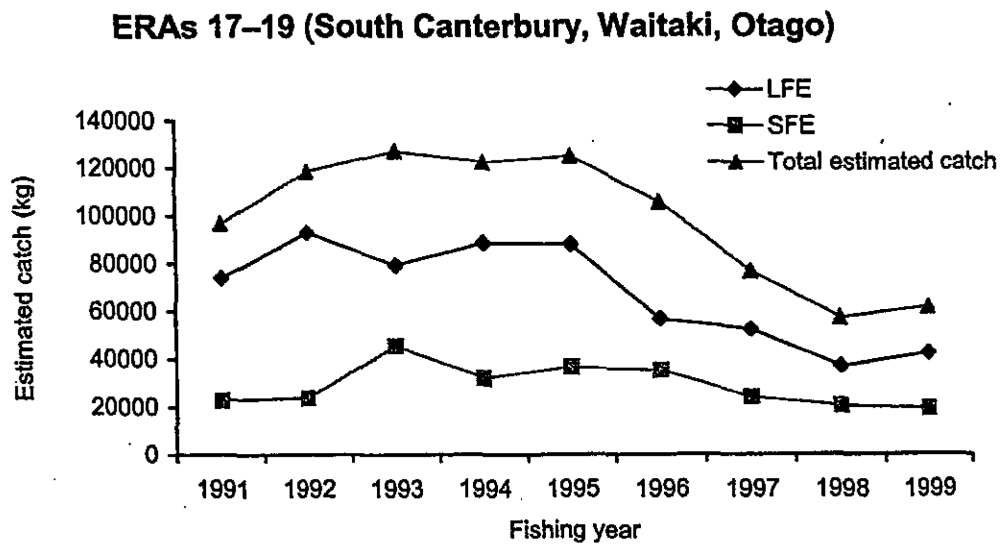


Figure 25: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERAs 17–19. 98% of catch identified to species, remainder unidentified.

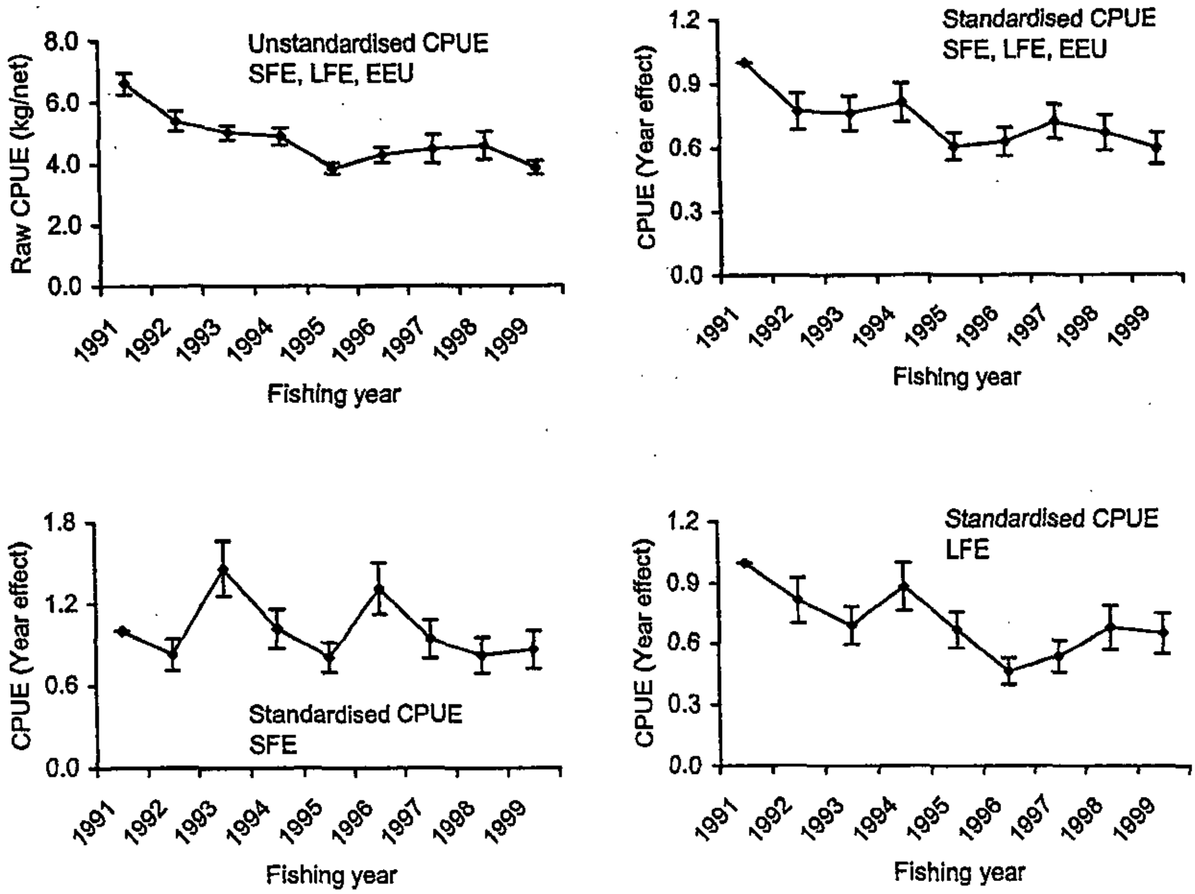


Figure 26: CPUE indices for ERAs 17–19. Unstandardised for total catch and standardised for total catch, SFE, and LFE.

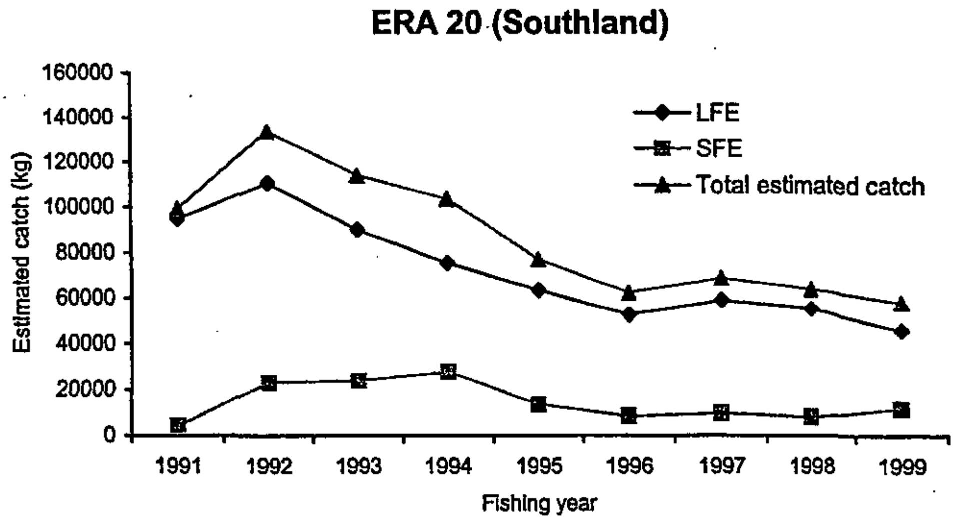


Figure 27: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERA 20. 99% of catch identified to species, remainder unidentified.

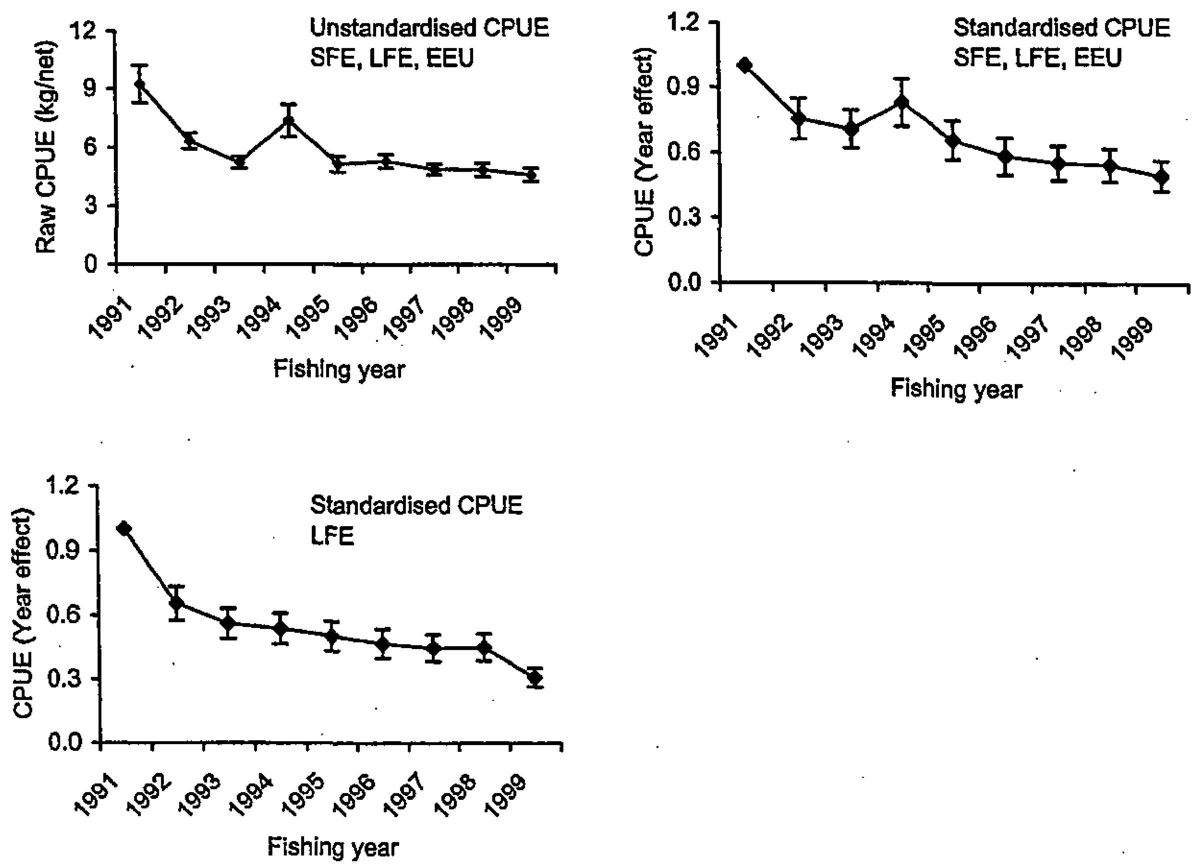


Figure 28: CPUE indices for ERA 20. Unstandardised for total catch and standardised for total catch and LFE.

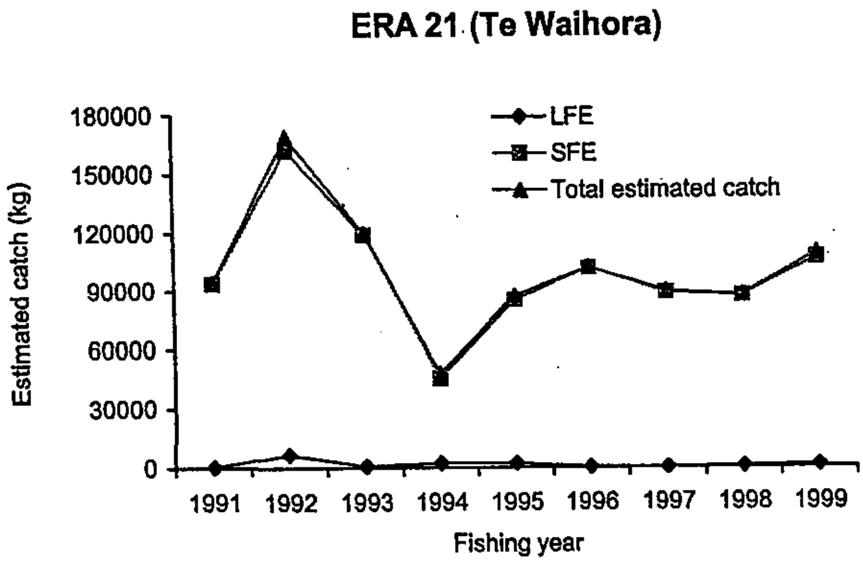


Figure 29: CELR estimates of LFE and SFE catch (where species identifed), and total estimated catch for ERA 21. 99% of catch identified to species, remainder unidentified. SFE, shortfinned; LFE, longfinned.

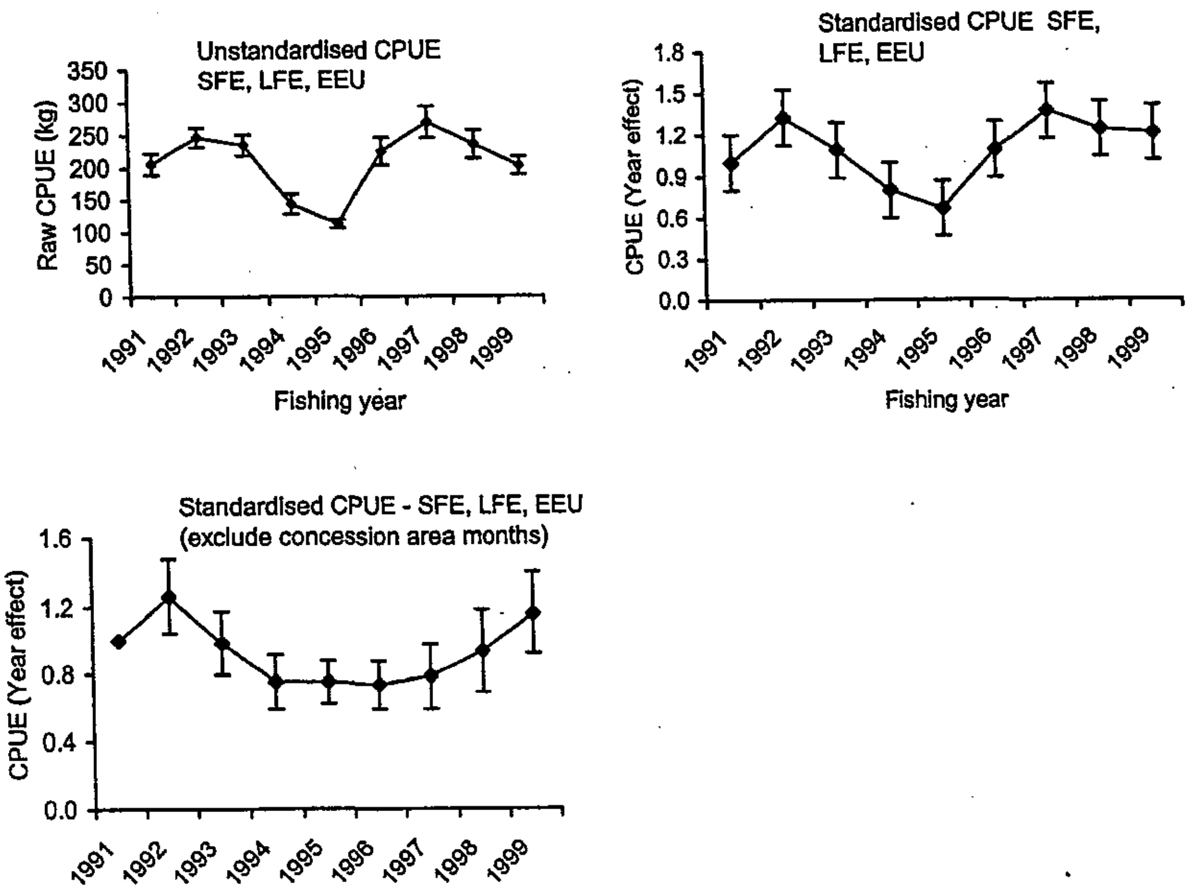


Figure 30: CPUE indices for ERA 21. Unstandardised for total catch and standardised for total catch and SFE.

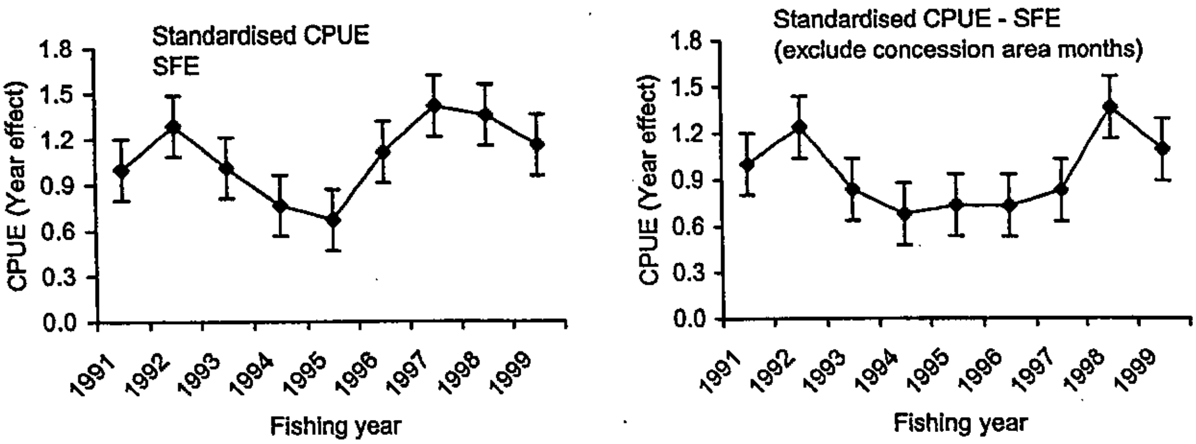


Figure 30 – *continued*.

Appendix 1: Daily river flow data used in the standardised CPUE analyses.

ERA	River	Location	Source
1	Manganui River	Site 46651, permanent station	Northland Regional Council
2–3, 4	Piako River	Site 9175, Kiwatahi	Environment Waikato
4	Waikato River	Site 43402 Ngaruawahia C/W	Environment Waikato
5–7	Mohaka River	Site 21801, Raupunga	NIWA
	Whirinaki River	Site 15410, Galatea	Trustpower
8–12	Wanganui River	Site 33301, Paetawa	NIWA
	Ruamahanga River	Site 29202, Waihenga	Wellington Regional Council
13 & 15	Buller River	Site 93203, Te-Kuha	NIWA
14 & 16	Wairau River	Site 60108 Tuamarina	Marlborough Regional Council
	Rakaia River	Site 68526, Fighting Hill	NIWA
17–19	Waitaki River	Site 71104, Kurow	Canterbury Regional Council
	Clutha River	Site 75207, Balclutha	NIWA
20	Mataura River	Site 77505, Parawa	Environment Southland

Appendix 2. Corrections (C) and deletions (D) to commercial eel fishery raw catch effort data for the fishing years *1990–91 to 1998–99*.

	1990–91		1992–93		1993–94		1994–95		1995–96		1996–97	
Original cases		9 947		10 313		9 866		1 1170		1 1139		10 336
	C	D	C	D	C	D	C	D	C	D	C	D
Net lifts	150	786	301	353	412	312	371	356	348	466	388	462
Catch weights	65	50	81	77	136	128	99	65	318	100	331	376
Area		110	0	176	0	240	0	457	0	245	0	213
Remaining cases		9 001		9 707		9 186		10 292		10 328		9 285
% corrections	2.2		3.7		5.6		4.2		6.0		7.0	
% deletions		9.5		5.9		6.9		7.9		7.3		10.2
% original cases		90.5		94.1		93.1		92.1		92.7		89.8

	1997–98		1998–99	
Original cases		9 310		9 693
	C	D	C	D
Net lifts	377	535	309	521
Catch weights	527	198	353	271
Area	0	284	0	339
Remaining cases		8 293		8 562
% corrections	9.7		6.8	
% deletions		10.9		11.7
% original cases		89.1		88.3

Appendix 3: Total numbers and percent of bycatch species caught in fyke nets recorded by South Island eel fishers filling out a catch and effort diary in 1996–97, and total weight and percent of bycatch species caught in fyke nets recorded by North Island eel fishers filling out a catch and effort diary in 1997–98 (data from Beentjes 1998).

South Island (ERAs 19 and 20)

Bycatch species	Total number	Percent total number
Brown trout	2 179	42.5
Perch	1 217	23.8
Freshwater crayfish	1 004	19.6
Kokopu	334	6.5
Bully	224	4.4
Flounder	135	2.6
Rainbow trout	17	0.3
mullet	4	0.1
Other	8	0.2
Total	5 122	100%

North Island (ERAs 2–6 and 8)

Bycatch species	Weight (kg)	Percent weight
Catfish	15 568.9	80.16
Gold fish	1 854.8	9.55
Koi carp	961.8	4.95
Rudd	562.3	2.89
Brown trout	167.5	0.86
Freshwater crayfish	93.3	0.48
Bully	61.4	0.32
Flounder	45.0	0.23
Mullet	27.0	0.14
Carp	26.8	0.14
Yelloweyed mullet *	24.0	0.12
Kokopu	9.6	0.05
Rainbow trout	9.0	0.05
Perch	4.0	0.02
Yellowbelly flounder *	3.8	0.02
Tench	2.3	0.01
Sand flounder *	2.0	0.01
Total	19 423.3	100%

* Identification not certain